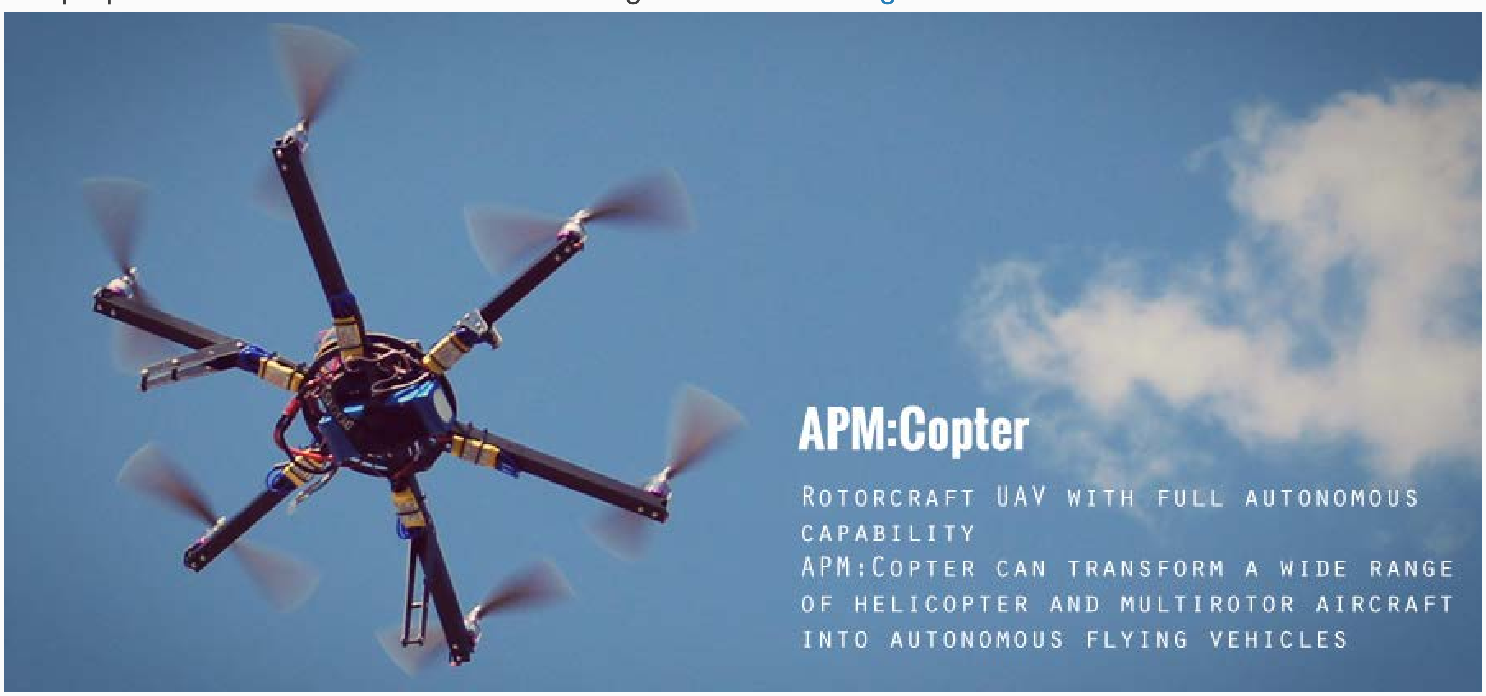
Copter

Copter Home

Tip

Keep up with the latest ArduPilot related blogs on ArduPilot.org!



This is the full-featured, open-source multicopter UAV controller that won the Sparkfun 2013 and 2014 Autonomous Vehicle Competition (dominating with the top five spots). A team of developers from around the globe are constantly improving and refining the performance and

Copter is capable of the full range of flight requirements from fast paced FPV racing to smooth aerial photography to fully autonomous complex missions which can be programmed through one of 4 elegant and well-developed software ground stations. The entire package is capabilities of Copter.

designed to be safe, feature rich, open-ended for custom applications and increasingly easy to use even for novice users.

System components

- A Pixhawk or other autopilot loaded with the latest version of the Copter firmware.
- Mission Planner software – gives you an easy point-and-click setup/configuration, and a full-featured ground control interface.
- This Copter Wiki provides all the information you need to set up and operate a multicopter or traditional helicopter.
- A suitable MultiCopter or Helicopter for your mission.
- Plus many other useful options: e.g. data radios, which allow two-way wireless telemetry and control between the vehicle and your computer.

Rotor Craft types

Multicopters:

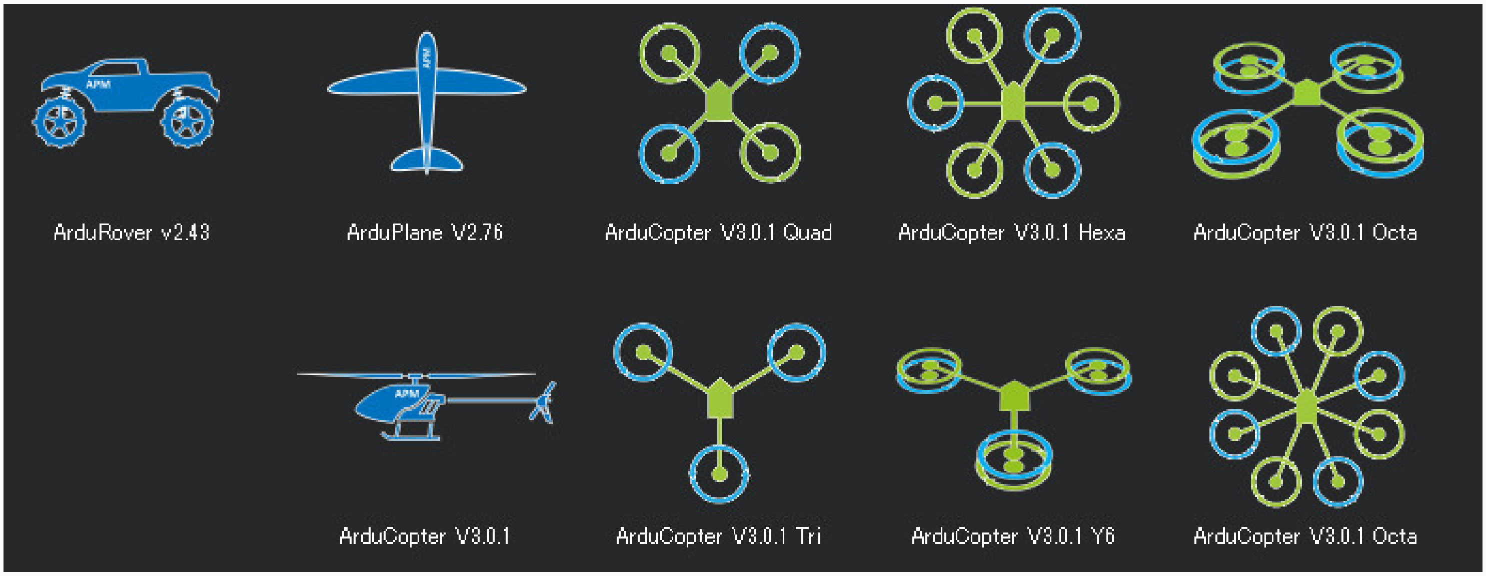
- Utilize differential thrust management of independent motor-prop units to provide lift and directional control
- Benefit from mechanical simplicity and design flexibility
- A capable payload lifter that’s functional in strong wind conditions
- Redundant lift sources can give increased margin of safety
- Varied form factor allows convenient options for payload mounting.

Helicopters:

- Typically use a single lifting rotor with two or more blades
- Maintain directional control by varying blade pitch via servo-actuated mechanical linkage (many versions of these craft exist and it is beyond the scope of this manual to cover them all – the mechanical systems used in helicopters warrant special study and consideration)
- Strong, fast and efficient – a proven-worker suitable to many missions.

Because of its open design, Copter also supports more unusual frame types including the Single and

Coax-Copters. Put this together with Plane, Rover and Antenna Tracker and you have a system of robotic vehicles that can be controlled through very similar interfaces to accomplish a wide variety of tasks.



Getting more info

- Continue to the Introduction section of this wiki.
- Use the ArduPilot Discuss Server Forums to ask support questions and advice.
- Read or join the drones-discuss email list once you're ready to get involved with the development of the software platform.

Introducing Copter

Copter is an advanced open-source autopilot system for multicopters, helicopters, and other rotor vehicles.

Overview

Copter is a complete open-source autopilot solution for multi-rotor vehicles, offering both enhanced remote control flight (via a number of intelligent flight modes) and execution of fully autonomous missions.

As part of the wider ArduPilot software platform it works seamlessly with Ground Control Station software that can monitor vehicle telemetry and perform powerful mission planning activities. It also benefits from other parts of the Ardupilot ecosystem, including simulators, log analysis tools, and higher level APIs for vehicle management and control.

Copter is on the cutting edge of aerial robotics and intended for those people who want to try advanced technology, leading edge techniques and new flight styles. It is already a preferred platform for numerous commercially available ready-to-fly vehicles, and can easily be added to enhance your own DIY multirotor craft.

Key features

Key features include:

- *High quality auto-level and auto-altitude control*: Fly level and straight or use the awesome “simple” or “super simple” flight modes, which make Copter one of the easiest multicopters to fly.

  Don’t worry about keeping an eye on your multicopter’s orientation - just push the stick the way you want to go, and the autopilot figures out what that means for whatever orientation the copter is in, using its onboard compass. “Front”, “back” ... who cares!

- *Automatic takeoff and landing*: Flick a switch and watch Copter execute its mission completely autonomously, returning home and landing by itself when it’s done.
- *“Loiter” mode*: Copter will hold its position using its GPS and altitude sensors.
- *Return to launch*: Flip a switch to have Copter fly back to the launch location automatically.
- *Fail safety:* Automatically detect when the vehicle loses transmitter contact (or is outside a defined geofence) and return to the launch point. Will also attempt to land safely if hardware failures are detected.
- *No programming required*: Use the desktop *Mission Planner* software to load the autopilot (with just one click) and set up Copter. The Mission Planner (and other compatible ground stations) deliver visual displays for vehicle state, settings and telemetry, including a point-and-click mission planning interface.
- *Missions with hundreds of GPS waypoints*: Just point and click waypoints in a Mission Planner, and Copter will fly itself to them. You can automate entire missions, including camera control! The only endurance limits are those of your vehicle power supply.
- *Mission planning while in flight*: Using a two-way wireless connection, waypoints, mode changing, even changing the values of every control parameter can be done from your laptop or mobile device - even while Copter is in the air!

Getting started

If you’re using Copter on a ready-to-fly vehicle then it is likely that it will be already setup, configured and tuned, ready for your first flight. We recommend you *read your manufacturer’s instructions*, particularly those related to safety, before flying.

Once you’re familiar with the default setup of your vehicle you may want to configure your RC transmitter/vehicle to use more challenging flight modes, or choose a ground station and start flying automated missions.

Tip

Whether using an RTF or DIY vehicle, autonomous vehicles are potentially dangerous! Always follow best safety practices and pay close attention to all safety warnings.
If you’re working on a DIY project, this wiki has everything you need! You should start by reading this section in order to understand what a multicopter can do, and how to select a frame, flight controller board, and other essential components. You can then proceed to First Time Setup to learn how to assemble your Copter and then First Flight to learn how to configure and tune it.

The development team

Copter is developed and maintained by a dedicated group of volunteers from the open source community. Follow their continuing efforts and read about new project developments at ArduPilot's Discuss Server.

All of us involved with this project care a great deal about the privacy and safety of those whom we share this planet with. Please be a good steward of this technology. It is the product of many evenings and weekends, we make it available for benevolent use.

Learn more about Copter

To find out more about Copter and your main configuration decisions, please see the topics below:

What is a MultiCopter and How Does it Work?

A multicopter is a mechanically simple aerial vehicle whose motion is controlled by speeding or slowing multiple downward thrusting motor/propeller units.

Overview

MultiCopters are aerodynamically unstable and absolutely require an on-board computer (aka flight controller) for stable flight. As a result, they are “Fly by Wire” systems and if the computer isn’t working, you aren’t flying. The flight controller combines data from small on-board MEMs gyroscopes, accelerometers (the same as those found in smart phones) to maintain an accurate estimate of its orientation and position.

The quadcopter shown above is the simplest type of multicopter, with each motor/propeller spinning in the opposite direction from the two motors on either side of it (i.e. motors on opposite corners of the frame spin in the same direction).

A quadcopter can control its roll and pitch rotation by speeding up two motors on one side and slowing down the other two. So for example if the quadcopter wanted to roll left it would speed up motors on the right side of the frame and slow down the two on the left. Similarly if it wants to rotate forward it speeds up the back two motors and slows down the front two.

The copter can turn (aka “yaw”) left or right by speeding up two motors that are diagonally across from each other, and slowing down the other two.

Horizontal motion is accomplished by temporarily speeding up/slowing down some motors so that the vehicle is leaning in the direction of desired travel and increasing the overall thrust of all motors so the vehicle shoots forward. Generally the more the vehicle leans, the faster it travels.

Altitude is controlled by speeding up or slowing down all motors at the same time.

What is the difference between a MultiCopter and a UAV/Drone?

A multicopter becomes a UAV or Drone when it is capable of autonomous flight. Normally this means taking the accelerometer and gyro information and combining it with barometer and GPS data so the flight controller understands not only its orientation but also its position.

MultiCopter Demo illustrating Manual and Automatic Control

The demo begins in Stabilize Mode which provides inertial stabilization and permits manual flight control.

In Loiter Mode the Copter automatically maintains position and altitude but permits manual override.

Simple Mode enables the copter to be flown without regard to the copters orientation (the direction it is facing).

“Auto Land” causes the copter to descend and disarm its motors when it has landed.

High wind demonstration

A video by Robert Lefebvre showing how well our firmware can allow a multicopter to operate even in 60 to 90 kmh gusting winds. This video illustrates operation under conditions near the physical limits of the copter and should not be attempted by non-experts.

What You Need to Build a MultiCopter

This article provides an overview of the main components you will need when building a Copter-based multicopter.

Multicopter frame including motors, ESCs and propellers

There are numerous frames, ESCs and motors available. Some components you might consider are discussed in Choosing a Multicopter Frame and the Detailed Vehicle Builds.

Many other designs and configurations including Traditional Helicopters are also supported.

6+ channel RC transmitter and receiver

You’ll need a radio control transmitter to manually control your Copter and to activate its flight modes. You can use any RC transmitter/receiver system with at least six channels. Some of the options are discussed in the topic Compatible RC Transmitter and Receiver Systems (Pixhawk/PX4).

Flight Controller board (Autopilot hardware)

Copter’s autopilot board determines its capabilities for autonomous flight. At time of writing (December 2015) Pixhawk is highly recommended for general use.

Developers creating UAV vision applications should consider using a separate Companion Computer, or a Linux based autopilot board (e.g. NAVIO+ or Erle-Brain) which is capable of running both Copter and the image processing code.

For more options, see the topic Choosing a Flight Controller.

GPS module

Your Copter will *require* a GPS module. The recommended module is 3DR UBlox GPS + Compass Module which also includes an a compass. You can check out other GPS solutions here.

LiPo batteries and charger

Copter requires a rechargeable lithium polymer (LiPo) battery. A good rule of thumb is to use 1,000 mAH (milliamp hours) per motor. For a Quad copter, a 4,000 mAH LiPo like this one would work well. While your copter can use only one battery at a time, we recommend having at least two batteries in stock; more batteries means more flight time. You'll also need a charging station for your batteries such as this one.

Ground Control Station

The (free and open source) Mission Planner is required if you're going to be loading new versions of Copter onto the flight controller, and for first-flight tuning and calibration. It runs on a PC and can also be used for planning missions.

Once your Copter is configured, you may find it more convenient to choose a different ground station - running on the tablet, phone or computer of your choice. The main options are discussed in the topic Choosing a Ground Station.

Telemetry Radio

A telemetry radio allows your Copter to communicate with your ground station from the air using the MAVLink protocol. This allows you to interact with your missions in real time and receive streaming data from your copter's cameras and other components. This adds considerable convenience to your missions!

We recommend the telemetry radio solutions linked from the Telemetry Landing Page. Remember that if using the SIK Radio you will need the version at the permitted frequency for your country - 915 MHz (Americas) and 433 MHz (Europe).

MultiCopter Safety

Warning

Your first priority must be the safety of people!

1. **Crashes can happen, because of pilot error or hardware or software malfunction.**
2. **If you are flying anywhere near other people, you are putting them at risk!**

1. Be sure to maintain safe distances between yourself, and spectators and your copter.
2. Circumstances will require that you will need to make your own determination of what is a “safe distance” from people and property.
3. At a minimum, consider: at least 10ft (3m) but not further than 30ft (10m) from you.
4. Keep all other people, property and obstacles considerably further away from your copter.
5. Ensure that no one gets between you and your copter.
6. Spectators should always be a safe distance behind the pilot.
7. If people intrude beyond what you have determined to be the “safe” area, land immediately and do not take off until they are clear.
8. At full power, an average sized multi-copter can exceed 20 mph (32 km/h), can ascend to hundreds of feet and easily travel more than a mile in distance before running out of battery.

3. **If you are flying too high or near airports you are putting manned aircraft and the people on them at risk!**
    1. Get to know where your nearest airports are and do not fly anywhere near them

4. **Always ensure the battery cable is NOT connected to the power distribution board or harness until you are ready to fly.**
    1. Always Turn on the transmitter and ensure the throttle stick is all the way down **BEFORE** connecting the battery.
    2. After landing the first thing you should do is disconnect your battery cable.
    3. Do not turn off the transmitter until after you have disconnected the battery.
    4. Always remove your props while you are testing motors, your hands, arms and face and those of your friends will thank you.
    5. When the battery is connected, always assume the motors are armed; you can check with a short throttle pulse.
    6. Don’t pick up the model and the radio at the same time, you may bump the throttle.
    7. Do not attempt to fly longer than your battery’s safe capacity, it is very bad for the battery and can cause a crash.

5. **The APM and PX4 flight controllers we use incorporate a motor arming safety feature.**
    1. Immediately prior to flight after the battery has been connected, the RC transmitter’s throttle stick needs to be held down and to the right for several seconds to arm the motors.
    2. After landing your first response should be to hold the throttle down and to the left for several seconds to “Disarm” the motors. Disarm condition can be tested by moving the throttle stick up, if the motors do not move it is probably disarmed.
    3. Even when disarmed, the throttle stick should always be kept in the full down position except when flying.

6. **Get used to switching back to Stabilize mode from other modes and reassuming full manual**

control.

1. This is the single most important recovery technique (practice it).
2. Stabilize mode can have Simple mode added to it, but if you do you should then practice with it till you are proficient.
3. Do not start using any other modes than Stabilize or Stabilize plus Simple until you are VERY comfortable flying your copter.

7. **It is very important to have excess power available.**
   1. If you have insufficient power, the automatic controls can require more throttle than is available and destabilization may result.
   2. Ideally your copter should be able to hover at about 50% throttle (mid stick).

8. **Especially while you are learning, it is recommended that you avoid expensive, stiff, ultra-sharp carbon fiber props.**
   1. Get cheaper, more flexible and more breakable plastic propellers.
   2. Some of the super carbon fiber ones can cut better than a Ginsu and while they are almost indestructible - you are not.

9. **Important primary response to a crash, inadequate landing or unknown flight controller state.**
   1. The first thing to do is throw a towel over your copters propellers (Propellers may start spinning unexpectedly).
   2. Then immediately disconnect the battery.
   3. A large towel is your most important piece of safety equipment followed by a fire extinguisher and a first aid kit.
   4. Generally better to use the first one than the last one.

10. **When testing or flying any of the (waypoint) navigation modes (using GPS):**
    1. Ensure that your GPS has “Lock” before arming and takeoff.
    2. Check that your home position on the Mission Planner is in fact correct.
    3. If the GPS does not accurately report your home position, reboot and wait for 8 or more satellites (not just 3D lock) and check again.

11. **Always follow the law:**
    1. Our personal use of MultiCopters (models in general) is continually under attack by those who fear ‘drones’ and invasion of privacy. If you break the law, or invade someone’s privacy, or put them in harm’s way, you threaten the future of our personal use of models. Please, understand the law and the rights of others - and fly accordingly.
    2. Most countries have a prominent model aircraft organization. In the USA that is the AMA. Review the AMA safety code. Working with the FAA and other government organizations, the AMA has established (and continues to update) rules for UAV’s and for FPV flight. If you are in the USA (or

not), read these documents! The AMA has a strong lobbying group that will help protect our rights. Get involved and support your country's model aircraft organizations - and help protect our right to fly.

Warning

Most important: Keep a safe distance between your Copter and People!
Tip

These tips can also help protect your multicopter from damage.

1. **Avoid sudden or extreme transmitter control stick deflections.**
   1. Move the control sticks in small measured increments and don't "yank" on them.
   2. If the copter is properly calibrated and balanced it should require only small stick inputs to control altitude, direction and speed.

2. **Your copter should be more or less stable on the horizontal plane without any control inputs.**
   1. If you are "fighting" the copter, land and fix it - something is not right - Hardware adjustment or software calibration may be required.

3. **Be especially careful of large throttle inputs, as a copter can gain (or lose) altitude very rapidly.**
4. **Because MultiCopters are symmetrical it is especially easy to lose Visual Orientation.**
   1. For manual flight modes, maintaining a clear vision of the Copters Orientation (direction it is facing) is the most critical part of successful flight.
   2. Especially while learning it is very important to keep your copter appropriately close to you to aid in maintaining visual orientation.
   3. Generally: more than 10ft (3m) but not further than 30ft (10m) from you.
   4. If the copter gets further than about 100ft (30m) it starts getting difficult to be able to maintain **orientation** and can easily crash.
   5. If you lose Yaw orientation while flying in Stabilize mode, try only flying forward and using yaw to steer like a car.
   6. It is much better to simply descend and land rather than have an **orientation-induced** crash or worse still - a **fly away**.
   7. Fly-Aways often happen when the copter is commanded to tilt back towards the pilot but has rotated in the meantime and is so far away that orientation is lost.
   8. Result: the copter flies further away and crashes or is lost.

5. **Always have Stabilize mode as the (Go To) one of your mode switch options.**
6. **High or unexpected winds or gusts can make flight considerably more difficult.**
   1. High winds can prevent forward progress or spin the copter around causing you to become

disoriented.
2. The higher you are, the more likely high winds will be a problem.
3. Switching to Stabilize mode and landing before you reach your skill limits can help you save your copter.
4. Avoid flying at high speed or high altitude until you have gained considerable confidence in both manual and automatic modes.
5. When flying around trees or buildings it is very easy to lose visual orientation or even to lose sight of the copter completely.
6. Gusting winds around objects can also worsen the problem.
7. Radio signal loss can also occur.
8. If your copter is approaching a potentially interfering object, immediately switch to Stabilize mode and land or retrieve the copter to your location.

7. **ArduPilot specific safety modes: RTL, FailSafe and GeoFence.**
   1. RTL can provide a safe **Return to Launch** if it starts to get away from you.
   2. Set up a **FailSafe** on Radio Fail with an RTL or Descend response to save your Copter and prevent Injury.
   3. **GeoFence** establishes an automatic flying perimeter that will force your copter to stay in a safe proximity.
   4. Do not rely solely on the above safety modes, always be ready to take back control in Stabilize and set the copter down.
   5. Especially do not rely on the above safety modes to perform maneuvers or training that you would otherwise consider dangerous.
   6. These modes are a supplement to, not a replacement for sound safety practices.

8. **On your first takeoff after tuning or hardware setup:**
   1. In Stabilize mode advance the throttle very slowly until the copter is almost hovering.
   2. If the copter is trying to flip over turn it off and correct the problem.
   3. A motor could be turning the wrong direction.
   4. Or a wrong direction prop could be installed.
   5. If it tries to rotate on it’s axis or fly off in some direction.
   6. The transmitter or RC setup in Mission Planner may be incorrect.
   7. A motor or ESC may not be performing properly.
   8. The wrong props may be on the wrong motors.
   9. When all problems are fixed it should be fairly easy to get the copter to hover a foot or 2 above the ground.
   10. If a stable and stationary hover a foot or 2 above the ground cannot be achieved, land and fix the problem until it can.

9. **When flying FPV “First Person View” (with a video camera), Have your modes set to:**

STABILIZE, SIMPLE, and RTL.

1. Ensure RTL is working properly before using FPV.
2. Use Stabilize mode to fly FPV.
3. If you lose your FPV video, you can switch to Simple or RTL to get back.

10. **Make sure your battery can't fall out.**
    1. Use a Velcro Strap to hold it in place.
    2. You can also use adhesive backed velcro under the battery.

Note

Get a Printable PDF Safety Sheet: MultiCopter_Safety
The Copter Forum permits the developers to respond to your questions and enables you to research similar issues, Please choose the sub-forum that is most appropriate to the wiki page and issues you are having.

Choosing a MultiCopter Frame

One of the first steps in using Copter is to decide on the frame. Shown below are three options from 3DRobotics but there are hundreds of other choices. This page will hopefully give some guidance on the choices available.

Note

This section of the wiki is a work-in-progress.

Decide what you want it for

Some common uses of multi-copters include:

- Taking aerial videos
- FPV (first person view)
- Sport & Social (racing, aerobatics, impressing your friends)
- More professional uses such as 3D mapping, package delivery, agriculture
- For research or personal robotics development

Ready-To-Fly, Kits or Build your Own

The choice of Ready-to-fly (RTF) vs Build-your-Own mostly comes down to how much time you are happy to spend building up your copter and how personalised you wish it to be. With the growing number of low-cost RTF copters on the market, there is likely little cost advantage to building your own, especially for the smaller copters and if you factor in some missteps along the way (like buying the wrong parts).

Continued Reading

Below are more work-in-progress pages with general information that may be useful when selecting or building a frame.

- Build your own multicopter
- Improving the capabilities of your multicopter
- Advanced multicopter design

Copter Use-Case Overview

This article provides an overview of some of the main use cases for Copter.

Overview

The Copter autopilot provides a stable flying platform that enables precise manual and automated control over vehicle position, speed, orientation and actions. The supported control behaviours are made available using autopilot flight/control modes:

- Manual flight modes like Stabilize, Alt Hold and Loiter provide different types of stabilisation and make vehicles easier to fly and position. Other manual modes like Follow Me and RTL (Return-to-Launch) automate tasks that would otherwise require complex manual adjustments.

- AUTO Mode allows you to run complex missions that you can define using a ground control station.
- A companion computer on the vehicle can communicate with/control Copter (for example, using DroneKit-Python) and perform computationally intensive low-latency tasks like computer-vision.

This stability and precision, and the flexibility in terms of manual and automated control, make Copter the ideal platform for many UAV applications.

This article provides an overview of some of the main use cases, with special emphasis on those requiring photographic/video inspection or payload delivery in difficult-to-reach places.

Tip

Additional use cases and information are covered in the section Use Cases and Applications.

Still and Video Photography

Copter allows you to easily get to locations and take pictures/video that would otherwise be difficult (or impossible) to reach. For this reason, photography applications are currently the most highly developed use-case.

Copter provides a stable platform for photography, with additional stability and independent control of camera position (relative to the vehicle) provided by brushless camera gimbals. Copter supports camera-friendly flight modes like Follow Me and allows you to control/maintain the camera target at a specific region of interest.

Advanced systems like 3DR Solo implement even more advanced vehicle/camera control (“smart shots”) using DroneKit-Python running on a Companion Computer.

First Person View (FPV)

First Person View allows you to fly your copter from the perspective of an actual on board pilot. This use case is discussed in the topic First Person View (FPV).

Disaster response

Copters can help save lives/provide relief in the event of major disasters (fires, flood, tornadoes, earthquakes, volcanic eruptions etc).

They are particularly useful for search and survey tasks, and for delivery of low-weight critical supplies, information and assistance. They can do this relatively cheaply without putting additional lives at risk (freeing up other resources to do actual recovery).

Search (and rescue)

Copter makes an excellent platform for locating missing individuals and groups. Vehicles can perform a grid search and take photographs for either on-board (using a companion computer) or later analysis. Copter can search in hard-to-reach areas, and may be used in large numbers due to their low cost.

Tip

Fixed wing vehicles have much greater range than Copter, and may be more suitable for searching large areas with low ground-cover.

Agricultural applications

Agricultural inspection is a growing field for UAV applications. Examples include:

- Tile and drainage inspections
- Barn roof and silo inspections
- Irrigation pivot inspections
- Hail and cattle damage inspection for crop insurance claims
- Scare off pest-wildlife that eat crops
- Patrol for hunters on your private land
- Locate missing cattle (This is where a thermal camera comes in handy.)
- Video check-ins for landlords

Tip

This promises to be one of the most important and earliest adopted civilian uses of Multicopters. One benefit is that there are fewer restrictions when flying over private land.

Forest fire mitigation

Copter has great potential for fire monitoring and detection (with an infrared camera, a Plane or Copter UAV can detect small camp fires even in heavy tree cover).

Hazard/danger mitigation

More generally, Copter and Plane are useful for other hazard mitigation as a cost-effective alternative to patrolling using airplanes, helicopters, or ground-based services.

They are already being used for shark patrols in beach areas, and there is no reason they could not similarly be used in any other “patrol” activity.

3D Mapping and GIS (Geographic Information Systems)

Copter makes an effective 3D Mapping platform with a wide variety of potential applications. For more information see the topic 3D Mapping.

Inspection, Verification and Sample Collection

Architectural and building inspection/verification are possibly the fastest growing UAV use case - due to the obvious benefits to being able to check construction quality and condition without having to create expensive scaffolding and other safety infrastructure. Copter is similarly useful for contour analysis, drainage and verifying adherence to plans.

Copter is also useful for sample collection in difficult to reach or hazardous areas (this requires that the vehicle is fitted with a small probe or other sample device). The Modcopter Sample Collection System is an excellent government-backed student project for accessing a variety of samples.

Payload Based Applications

Copter is suitable for delivery of low-mass emergency supplies, including flotation devices, communications devices, shark repellent etc.

There are active investigations into other commercial applications including crop spraying and package delivery.

Other applications

Copters are being used or considered in many other applications:

- Initial “pilot line” stringing for power lines from hilltop to hill top.
- Painting, touch up and maintenance.
- Tree trimming and spraying.
- Building and home cleaning.

More detail and additional use case information is covered in the section Use Cases and Applications.

First Time Setup

First-time setup of the autopilot includes downloading and installing the *Mission Planner* GCS, mounting the flight controller to the frame, connecting it to the receiver, power and motors, and then performing initial configuration and calibration.

Note

This section assumes that you've already chosen and built a frame and have selected your flight controller.
For more information on each of these tasks (sorted by flight controller within the sections) see the topics below:

Assembly Instructions

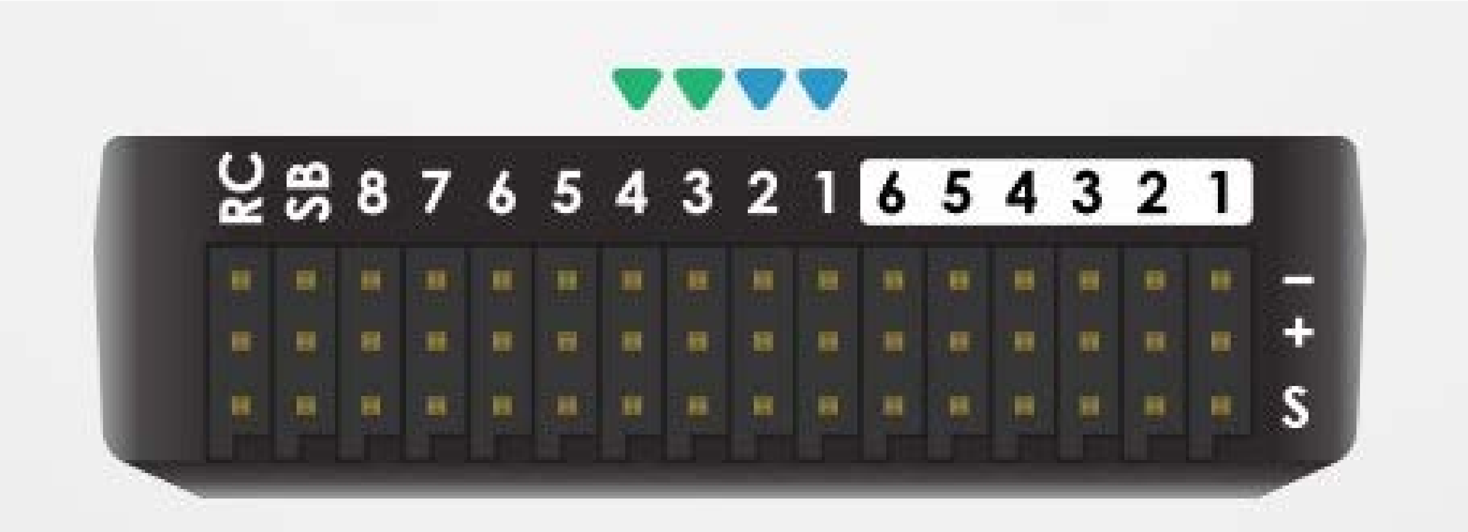
This section contains the instructions for assembling the "essential components" of Copter on Pixhawk and other flight control boards. The instructions for adding other hardware are covered in Optional Hardware.

Connect ESCs and Motors

This article explains how to connect the ESCs, Motors and Propellers for Pixhawk, PX4, APM 2.x. and Erle-Brain2.

Connect motor PWM signal outputs (Pixhawk/PX4)

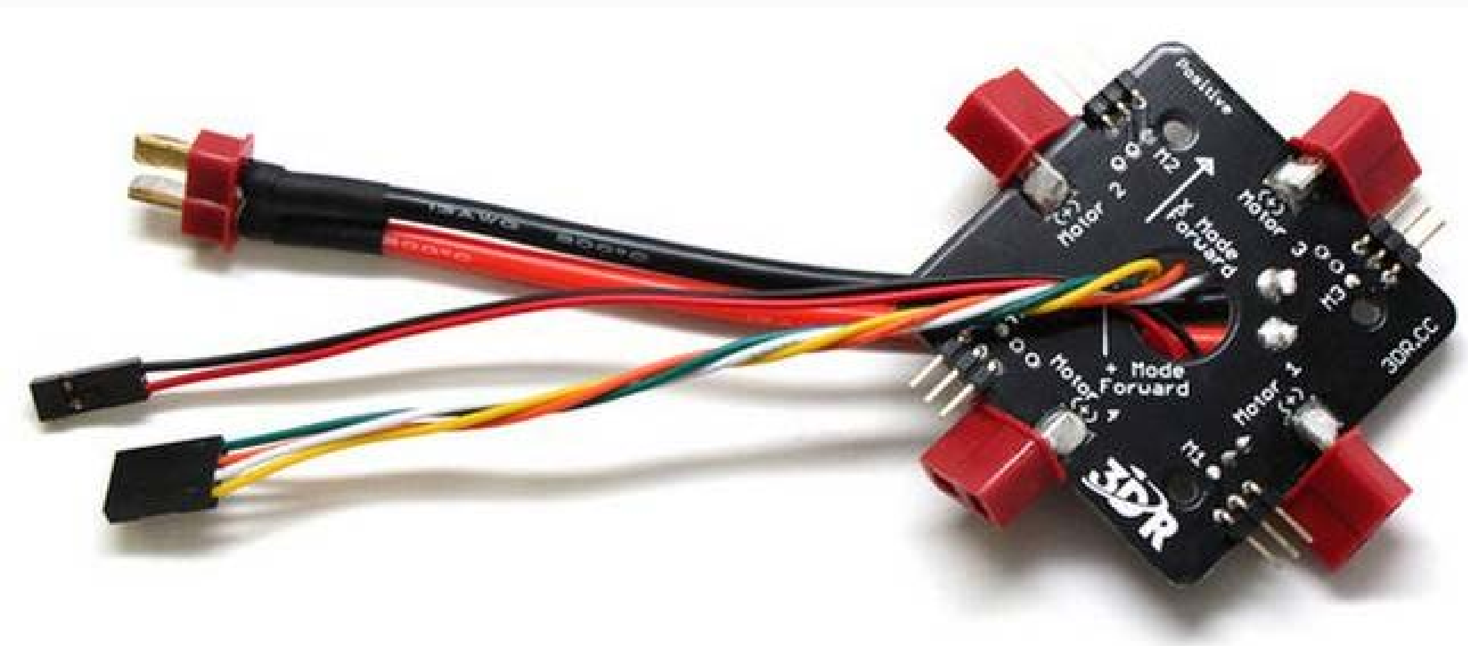
Connect the power (+), ground (-), and signal (s) wires for each ESC to the controller main output pins by motor number. Find your frame type below to determine the assigned order of the motors.



Pixhawk Outputpins (numbered). First 4 pins are colour-coded for connecting a Quadframe

Connect motor PWM signal outputs (Erle-Brain2)

When connecting the ESCs directly to autopilot board, connect the power (+), ground (-), and signal (s) wires for each ESC to the controller main output pins by motor number. Find your frame type below to determine the assigned order of the motors.



Note

Be sure you connect the ESC connector in the right way. Signal goes on the top of the rail (white or orange color wire) and ground at the bottom (black or brown color wire)

Connect motor PWM signal outputs (APM2)

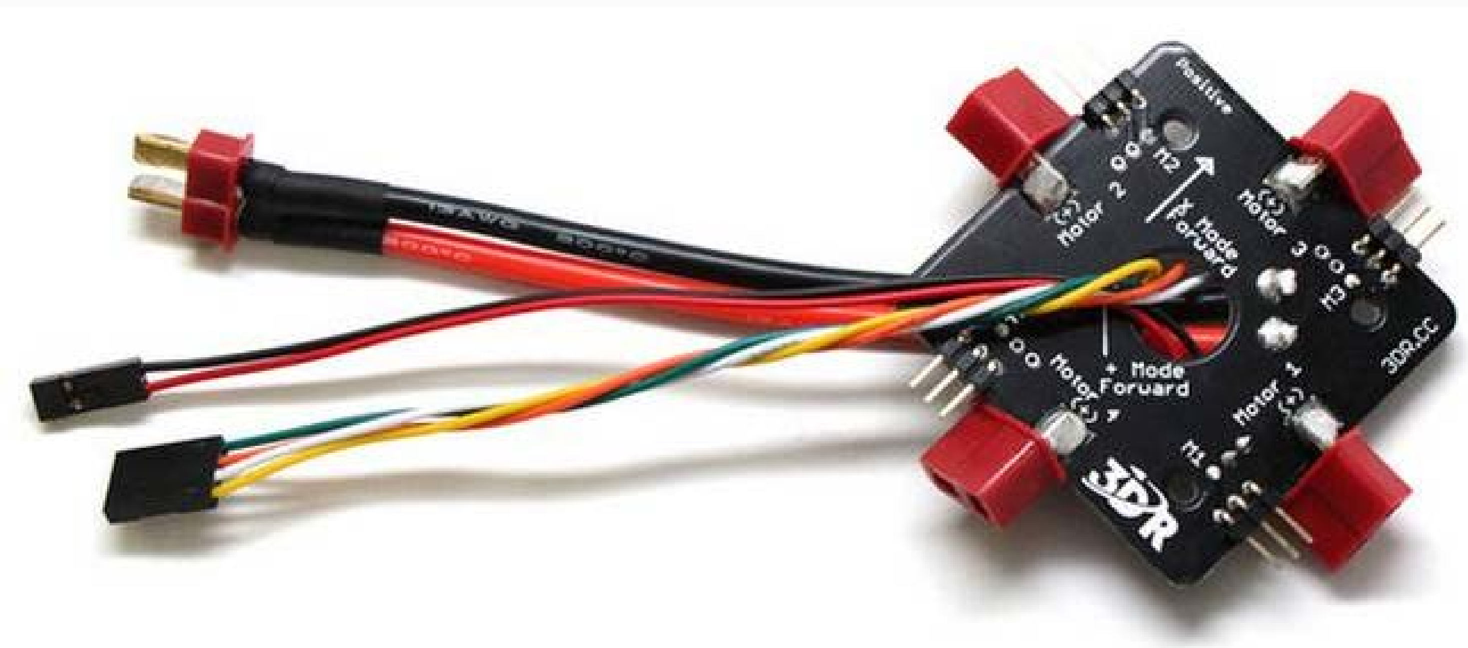
There are two methods of connecting the motor outputs: connect the electronic speed controllers (ESCs) to autopilot controller board directly or use a power distribution board (PDB).

Warning

The APM power distribution board PDB described here is not compatible with the Pixhawk, PX4 or Erle. When using a PDB, connect the power (+), ground (-), and signal (s) wires for each ESC to the PDB according to motor number. Find your frame type below to determine the assigned order of the motors. Then connect the signal wires from the PDB to the main output signal pins on the flight controller board (ensuring that the motor order numbers match the main output pin numbers on the controller). If you are using a power module, it is optional to connect the power and ground wires from the PDB to the flight controller board. If you would like to use these cables in addition to or instead of the power module or as a common point for low current servos, connect the ground (-) wire to a main output ground (-) pin and the power (+) wire to a main output power (+) pin.

Note

Information on assembling PDB is found here for Quad and here for Hexa.



When connecting the ESCs directly to autopilot board, connect the power (+), ground (-), and signal (s) wires for each ESC to the controller main output pins by motor number. Find your frame type below to determine the assigned order of the motors.

APM Output Pins (numbered)

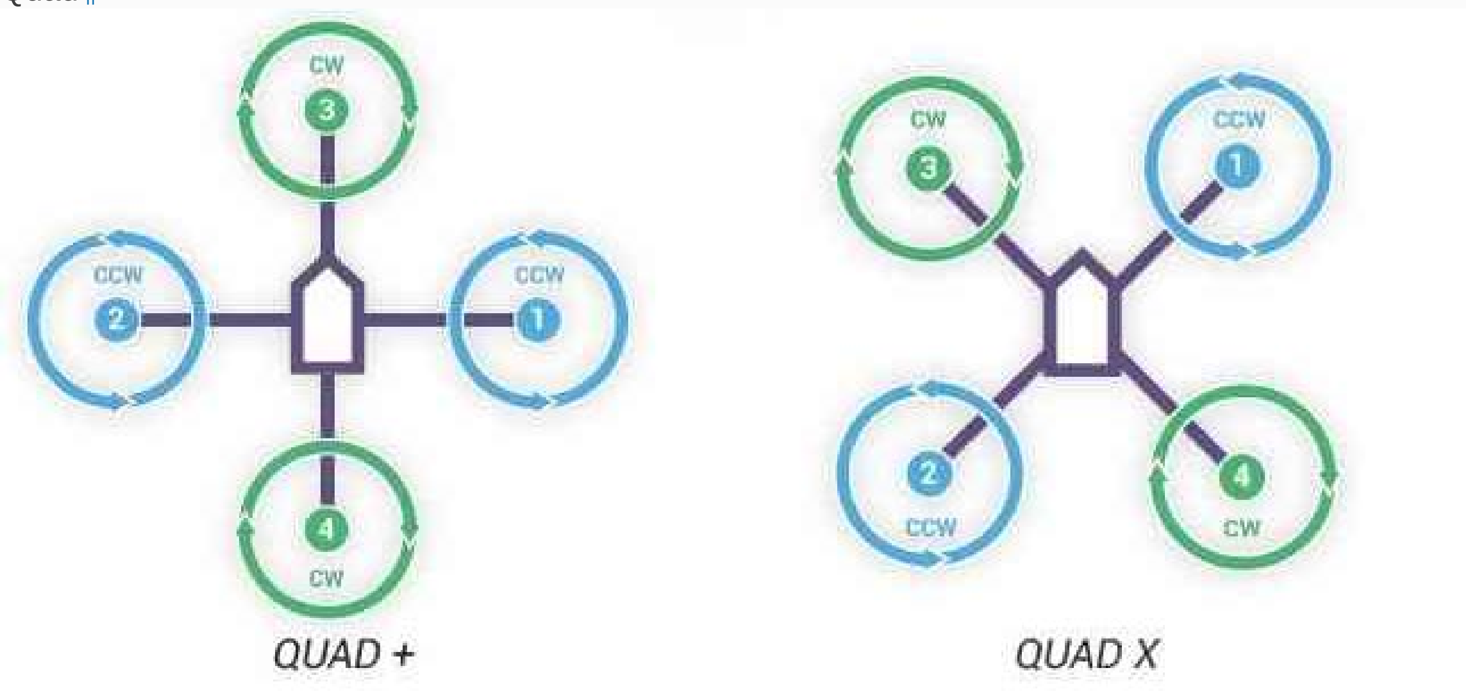
Motor order diagrams

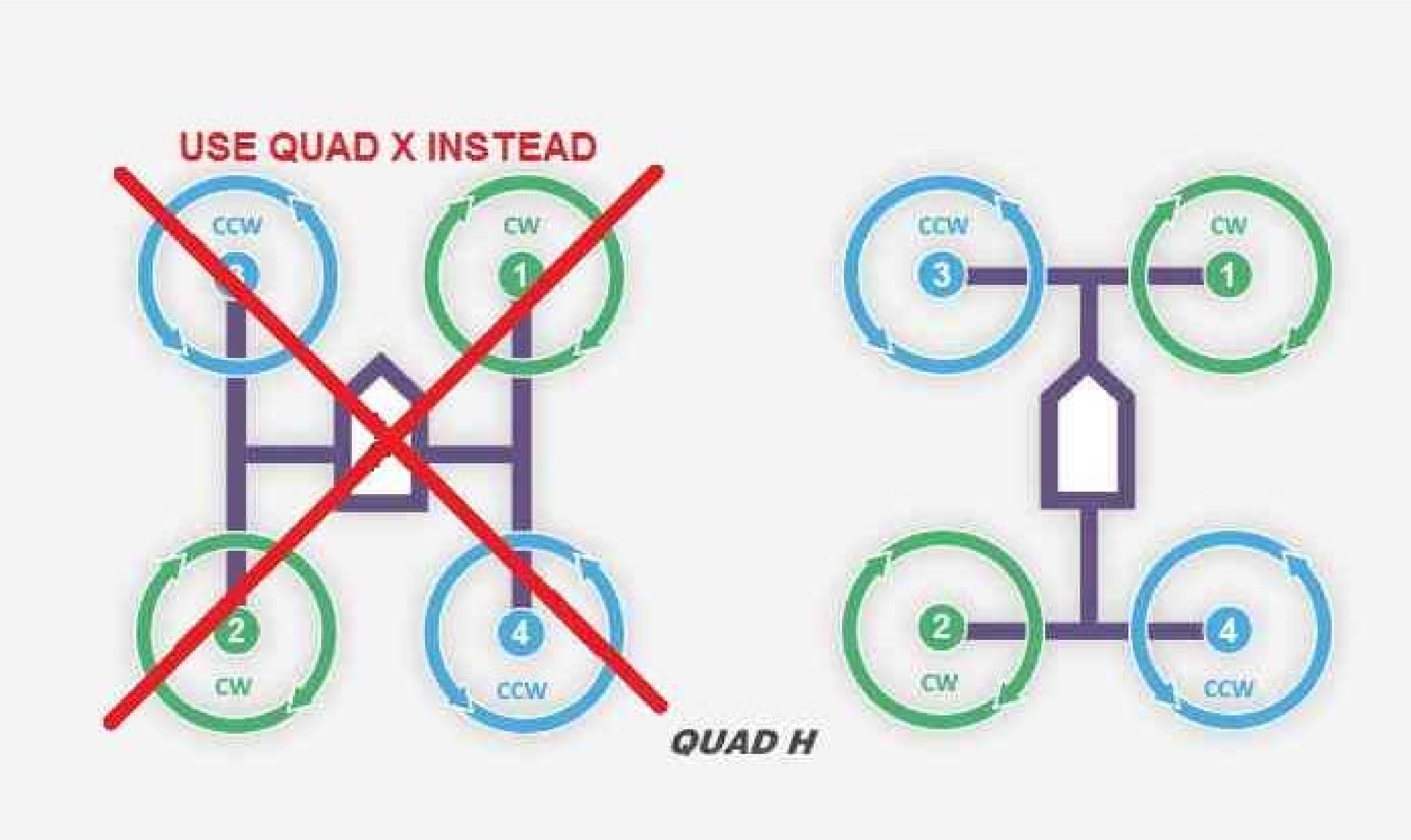
The sections below show motor order for each frame type (the numbers indicates the connected autopilot output pin) and the propeller direction (clockwise (CW) motors are shown in green and take pusher propellers,counterclockwise motors (CCW) are shown in blue and take puller propellers.

Use the diagram for your frame type, and wire the motors as shown.

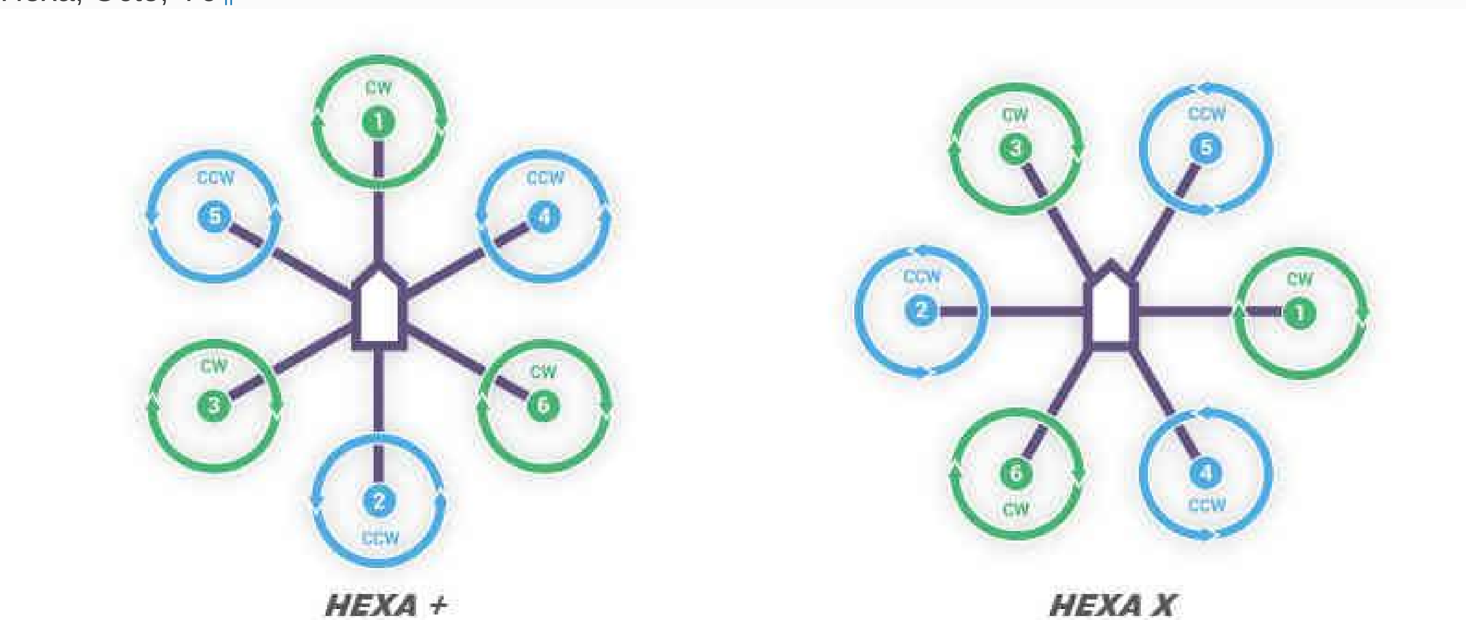
Legend for motor-order diagrams

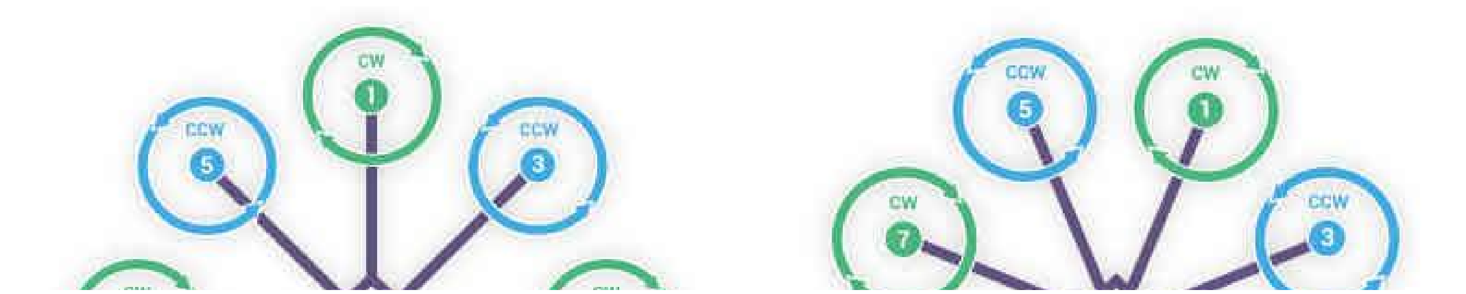
Quad¶

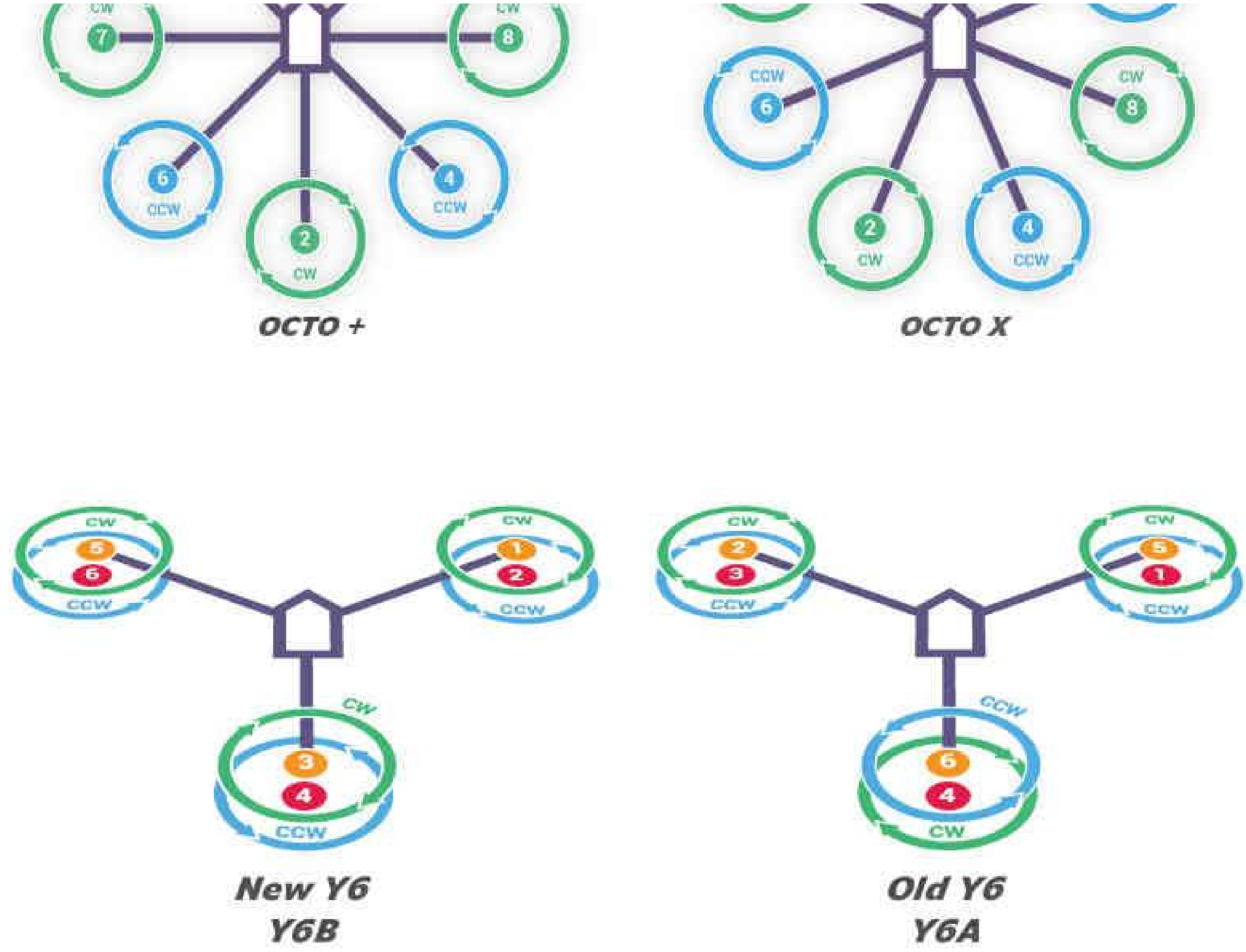



USE QUAD X INSTEAD
CCW
CW
3
1
2
4
CW
CCW
QUAD H

Hexa, Octo, Y6¶


CW
1
CCW
5
CCW
4
CW
3
CW
6
2
CCW
HEXA +
CW
3
CCW
5
CCW
2
CW
1
6
CW
4
CCW
HEXA X

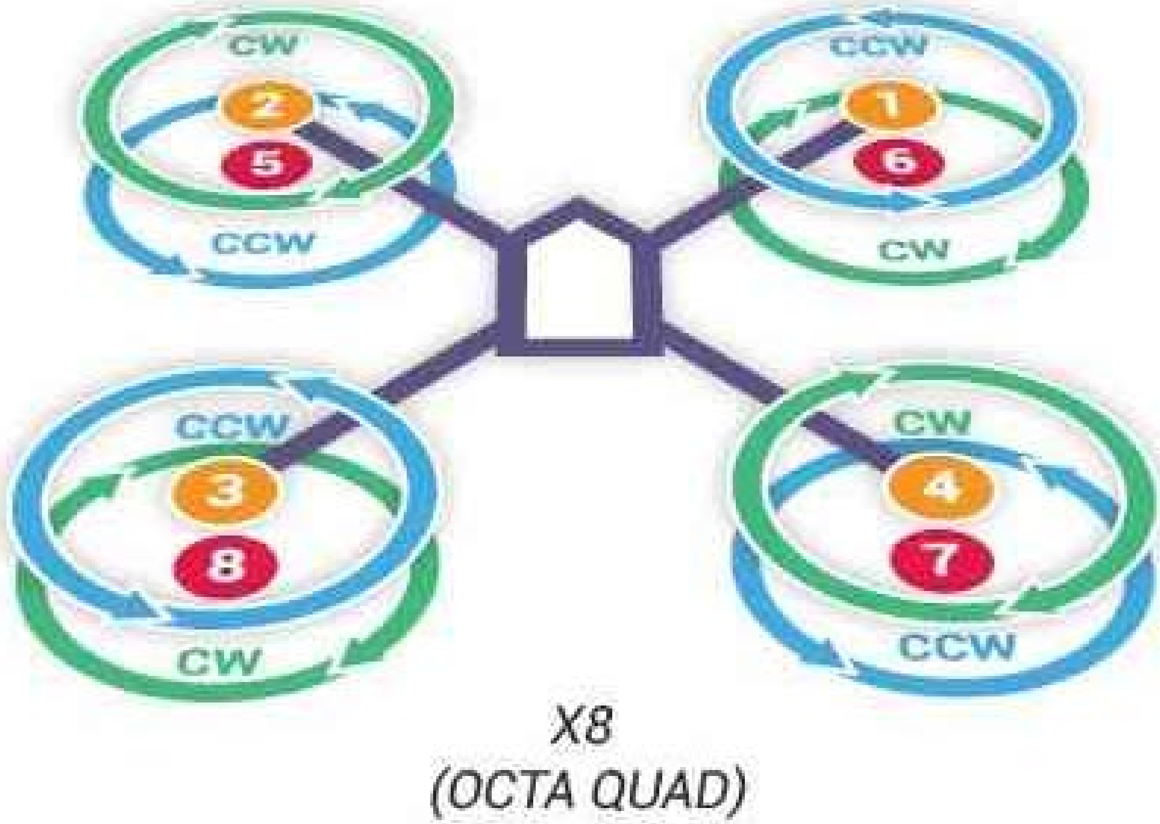

CW
1
CCW
5
CCW
3
CCW
5
CW
1
CW
7
CCW
3



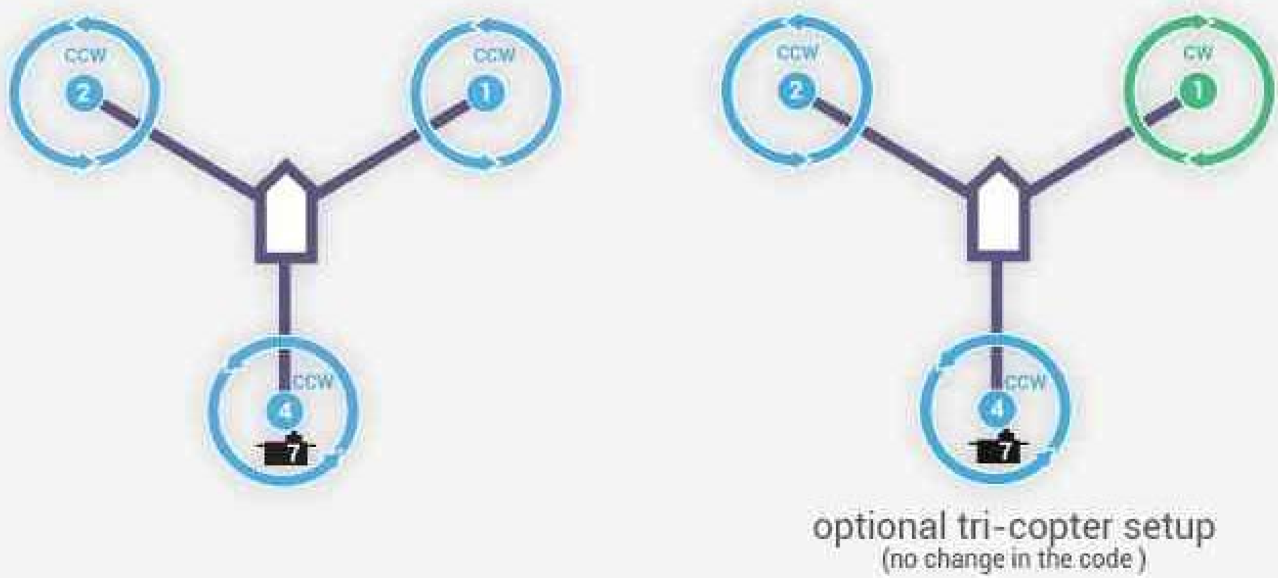
Note

2014 3DR RTF Y6 uses the Y6B configuration.

X8¶



Tricopter¶



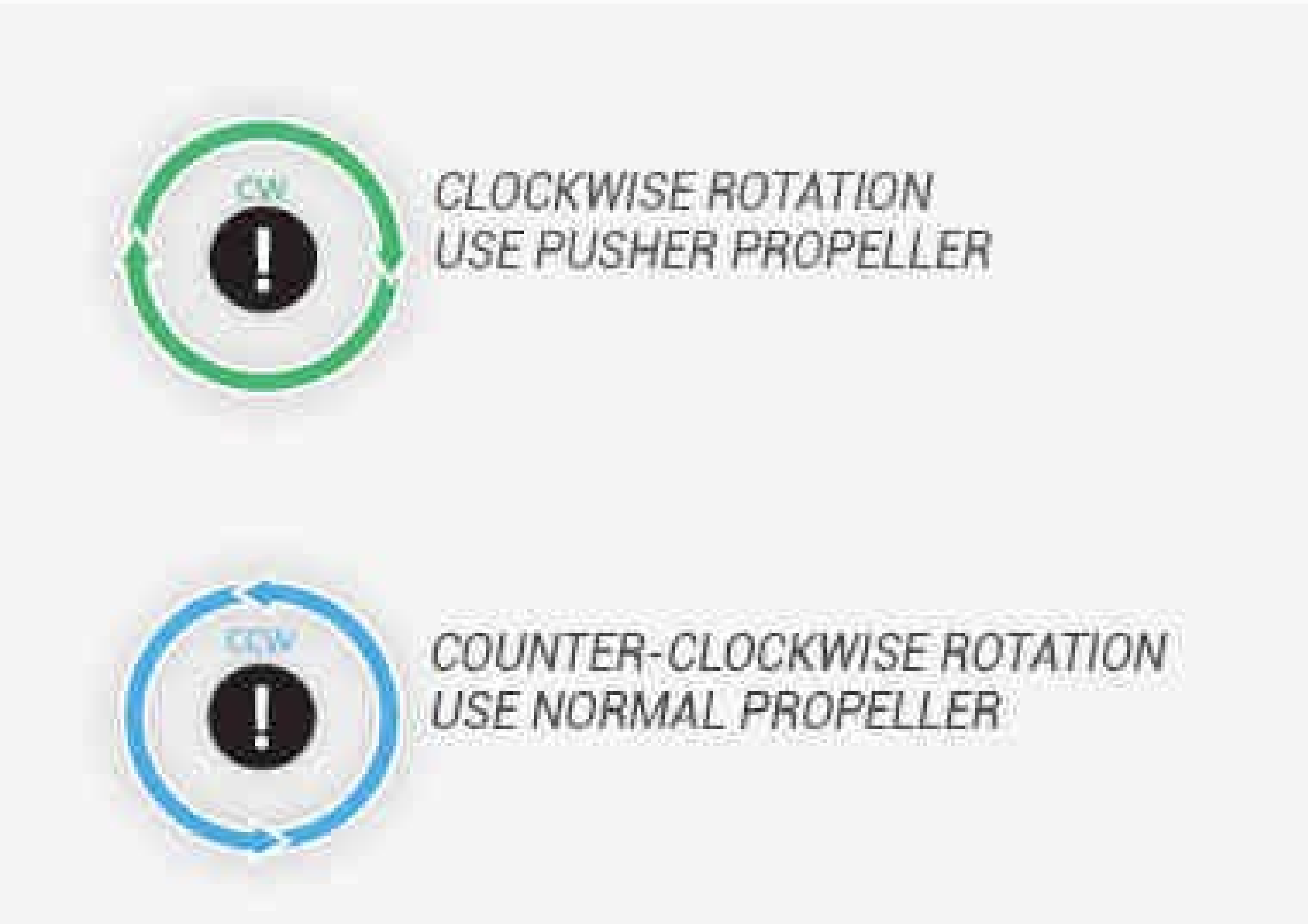
Note

If the direction of your tail servo is going the wrong way in response to yaw then either the RC7_REV or

MOT_YAW_SV_REV parameter should be set to -1 (from 1), See TriCopter setup page for details.)

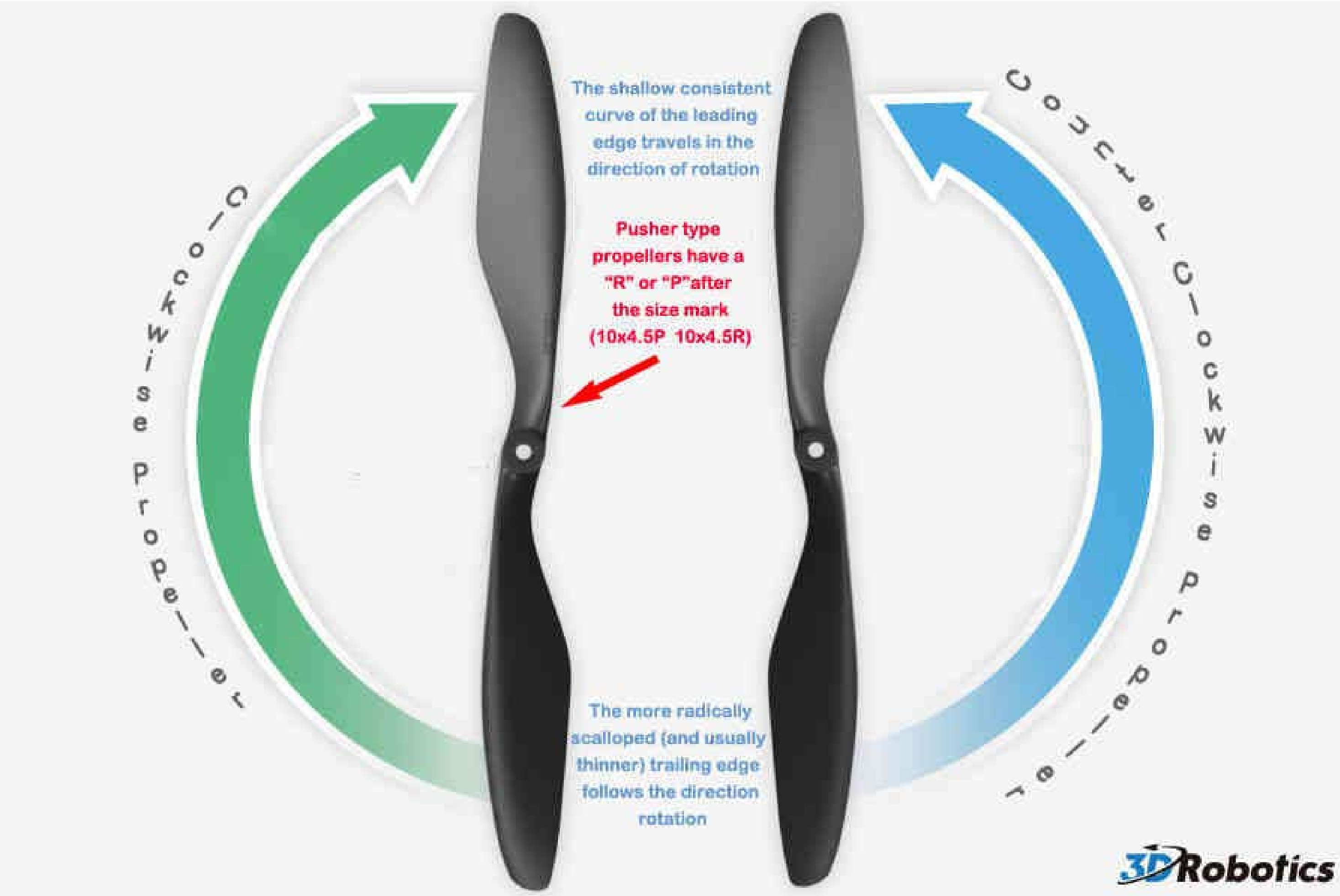
Attach propellers

Find your frame in the motor order diagrams above. Clockwise motors are shown in green, marked CW, and take pusher propellers. Counterclockwise motors are shown in blue, marked CCW, and take puller propellers. Use the diagram for your frame type, and attach propellers to your vehicle as shown. For copters, attach propellers with the writing facing towards the sky. For more information on recognizing the different types of propellers, see the next section.



Recognizing clockwise and counterclockwise propellers¶

The diagrams above show two types of propellers: clockwise (called pushers) and counterclockwise (called pullers). Pusher propellers are often marked with a P. However not all propellers are marked and both types are often available in either rotational direction. Therefore, it is most reliable to recognize the correct propeller type by its shape as shown below. Note that the propellers below have the edge with the shallow consistent curve at the leading edge in direction of rotation and the more radical scalloped (and usually thinner edge) as the trailing edge. You can use these features to recognize propellers of the correct direction of rotation.



Choosing propellers

Propellers come in many varieties and are suited to different needs.

Note

Have experience choosing propellers? Help us by editing this section!

Testing motor spin directions

If you have completed the Radio and ESC calibration, you can check that your motors are spinning in the correction direction:

1. Make sure there are no propellers on your copter!
2. Turn transmitter on and ensure the flight mode switch is set to Stabilize.
3. Connect battery.
4. Arm copter by holding the throttle down and rudder right for five seconds.

5. If it fails to Arm with the throttle down and to the right and the motors will not spin, it has probably failed the Pre-Arm Safety Check.
   - Pre-Arm safety check failure is also indicated by the red arming light double flashing and then repeating.
   - If the Pre-Arm check fails go to the Prearm Safety Check Page and correct the problem or disable the check before continuing.
6. When you can Arm successfully, apply a small amount of throttle, and observe and note spin direction of each motor. They should match directions shown in the images above for the frame you've chosen.
7. Reverse any motor spinning in the wrong direction.

   Tip

   Motor Direction is reversed simply by interchanging two of the
   three ESC to motor power leads.

Checking the motor numbering with the Mission Planner Motor test

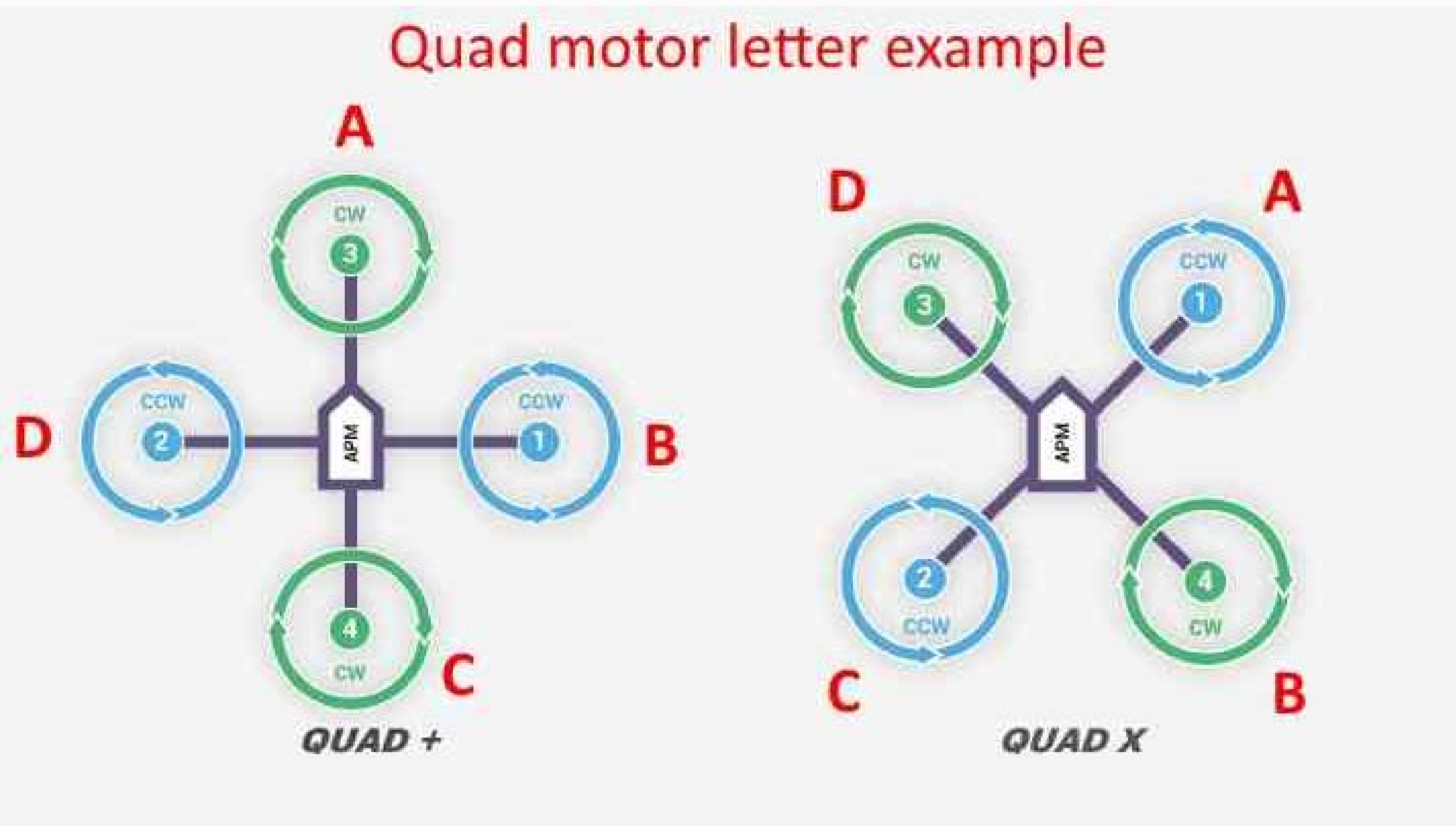
An alternative way to check that the motors have been hooked up correctly is to use the "Motors" test in the Mission Planner Initial Setup menu.

Mission Planner: Motor Test

When connected to the vehicle via MAVLink, you can click on the green buttons shown above and the corresponding motor should spin for five seconds. Letters correspond to motor numbers as shown in the example below.

- Take off your props first!
- If no motors turn, raise the “Throttle %” to 10% and try again. If that doesn’t work, try 15%

The first motor to spin will be the one located directly forward in the case of + configuration, or the first motor to the right of straight forward in the case of X configuration. The motor test will then proceed in a clockwise rotation.

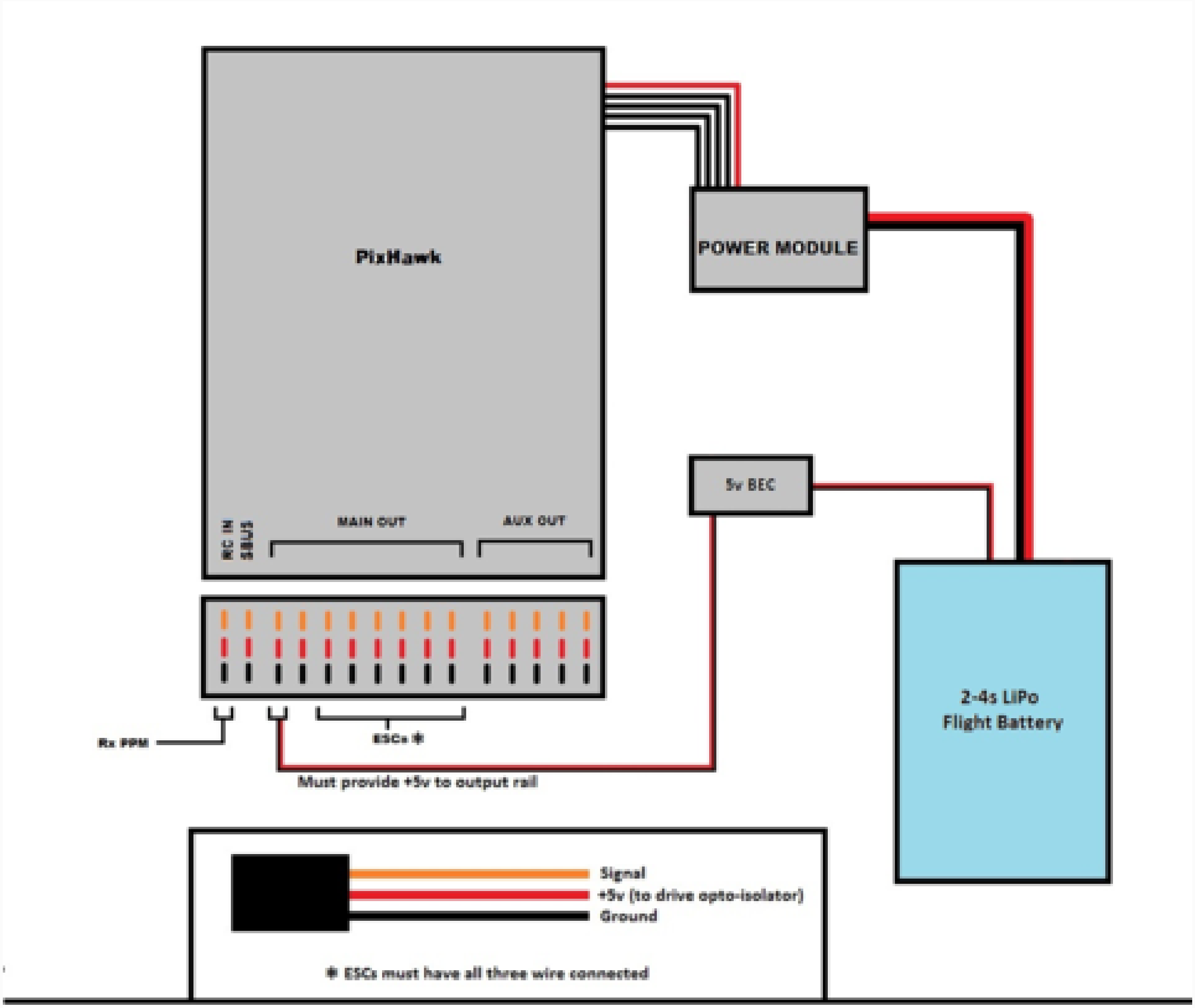


In the case of X8, it will spin the top front-right motor first, then the bottom front-right, and proceed around with the same pattern.

OctoV will spin the front-right motor first, and then again, proceed clock-wise until reaching the front left motor.

KDE (and other) Opto Isolated ESCs

The KDEXF-UAS and KDEF-UASHV Series are opto-solated and do not provide BEC power output for the peripheral equipment. They require +5V to power the opto-isolator and while the Pixhawk can be powered from the servo rail, it does not provide +5V to the servo rail. The ESCs must be powered by a BEC or with a jumper from an unused connector on the board. It is strongly recommended that you use a BEC to power the rail rather than a jumper.



Pixhawk with traditional power module setup

The KDE ESCs have fixed PWM ranges so you must manually set the output range of each PWM signal so that RCx_MIN is 1100 and RCx_MAX is 1900us using the Advanced Parameter or Full Parameter Settings Page in the planner.

Pixhawk ESC issues

Some ESCs have been reported as not working with Pixhawk.

The Pixhawk should work with every ESC that works with a normal RC receiver (because it sends the same type of signal) but there is one known exception, the EMAX ESC.

In most cases problems are due to incorrect wiring. Always connect signal and ground. Check your ESC type to decide how to connect the +5V line. On APM2.x you could get away with using the power ground as the signal return with the APM but for Pixhawk you must connect both the signal and the signal ground in order to make the ESC work.

For more information see this page and the video here.

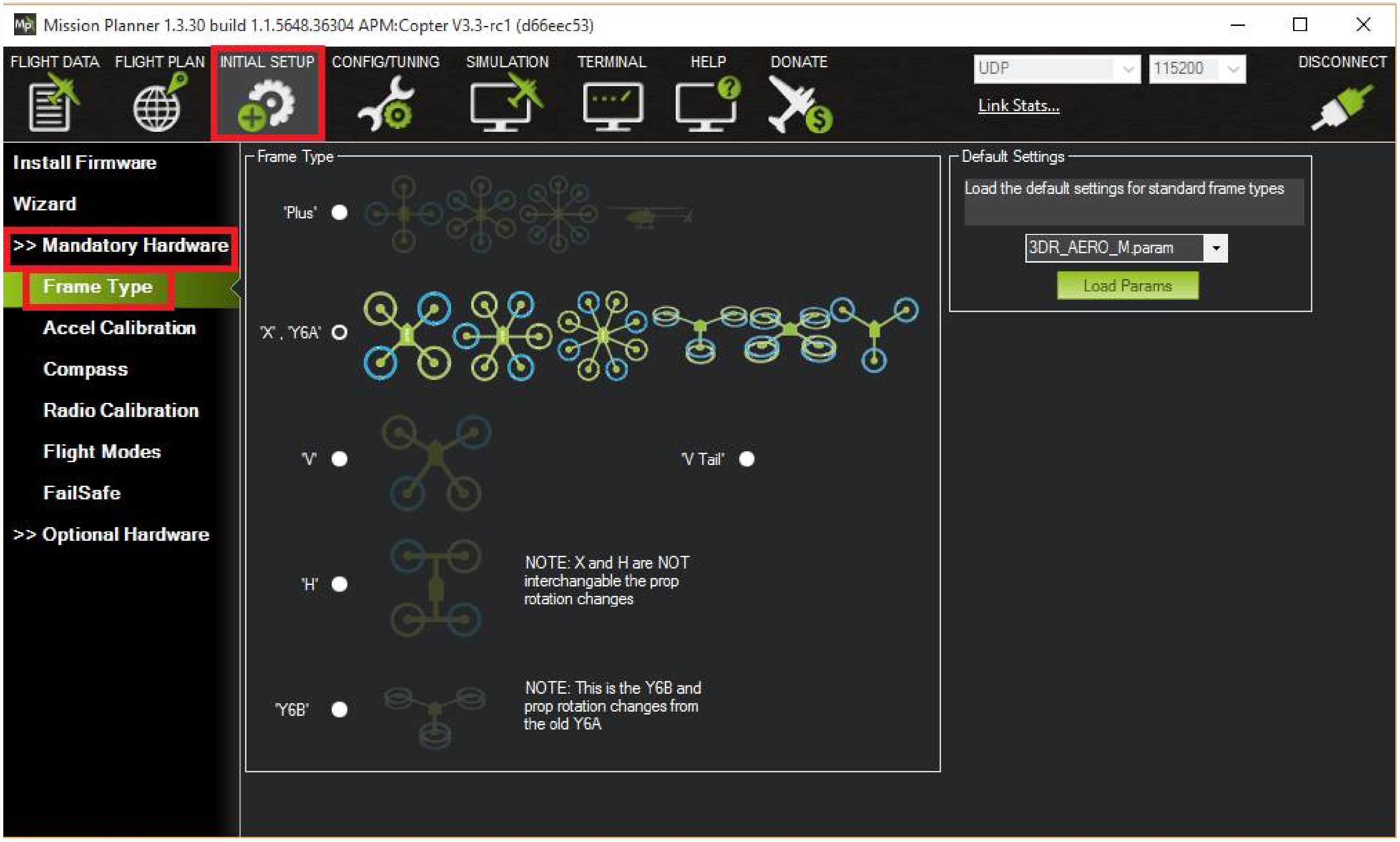
Mandatory Hardware Configuration

As part of first time setup, you'll need to configure some required hardware components. The linked articles describe the process for selecting frame orientation and configuring the RC transmitter/receiver, compass, and accelerometer using *Mission Planner* and how to configure the ESCs.

In addition to mandatory calibration, you may also choose to Configure Optional Hardware including battery monitor, sonar, airspeed sensor, optical flow, OSD, camera gimbal, antenna tracker etc.

Frame Type Configuration in Mission Planner

On the *Mission Planner*'s Initial Setup screen select **Mandatory Hardware | Frame Type**. Select the frame for your copter. The default configuration is **X**. If you want one of the arms to serve as the exclusive front-facing direction, select the **Plus** configuration. For Tricopters, Traditional Helis and Y6s, the frame type is ignored.



Mission Planner:Select Frame Type

Note

For an H-Frame quadcopter use the option to set the frame type to ‘3’ in the *Advanced Parameter* Tab. To apply the H-frame configuration, swap the left rear and right rear props and reverse the motor direction for each of those motors (by swapping any two motor wires). Repeat the same process for the front two motors.

Electronic Speed Controller (ESC) Calibration

Electronic speed controllers are responsible for spinning the motors at the speed requested by the autopilot. Most ESCs need to be calibrated so that they know the minimum and maximum pwm values that the flight controller will send. This page provides instructions for calibrating ESCs.

Note

Please complete radio calibration before performing ESC calibration.

About ESC Calibration

ESC calibration will vary based on what brand of ESC you are using, so always refer to the documentation for the brand of ESC you are using for specific information (such as tones). “All at once” calibration works well for most ESCs, so it is good idea to attempt it first and if that fails try the “Manual ESC-by-ESC” method.

- Some ESCs like the DJI Opto ESCs do not require and do not support calibration, so skip this page completely
- Some brands of ESC do not allow calibration and will not arm unless you adjust your radio’s throttle end-points so that the minimum throttle is around 1000 PWM and maximum is around 2000. Note that if you change the end-points on your TX you must re-do the Radio Calibration. Alternatively with Copter-3.4 (and higher) you may manually set the MOT_PWM_MIN to 1000 and MOT_PWM_MAX to 2000.
- If using OneShot ESCs set the MOT_PWM_TYPE to 1 (for regular OneShot) or 2 (for OneShot125). Note only supported in Copter-3.4 (and higher).
- Begin this procedure only after you have completed the radio control calibration and Connect ESCs and motors part of the Assembly Instructions. Next follow these steps:

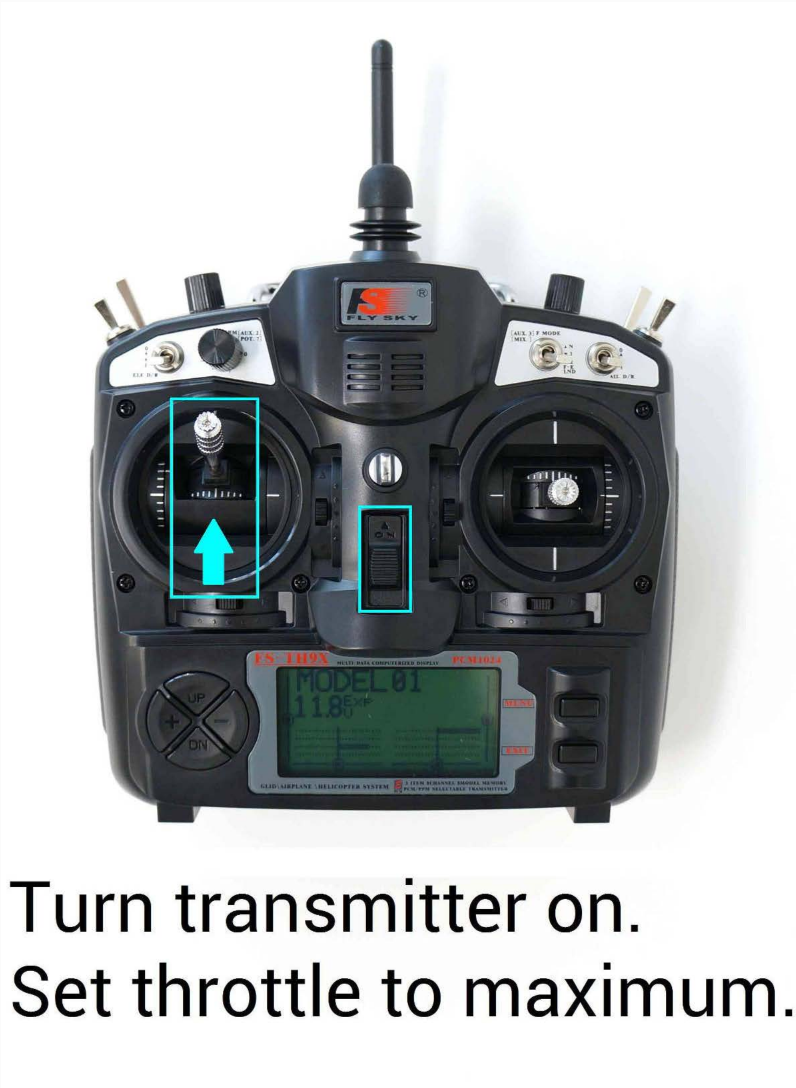
Warning

Safety Check!

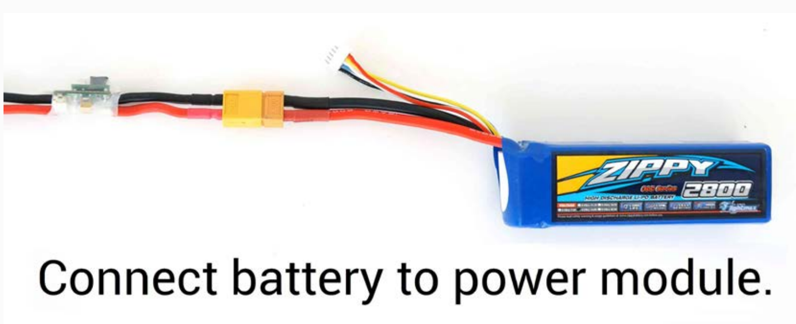
Before calibrating ESCs, please ensure that your copter has NO PROPS on it and that the APM is NOT CONNECTED to your computer via USB and the Lipo battery is disconnected.

All at once calibration

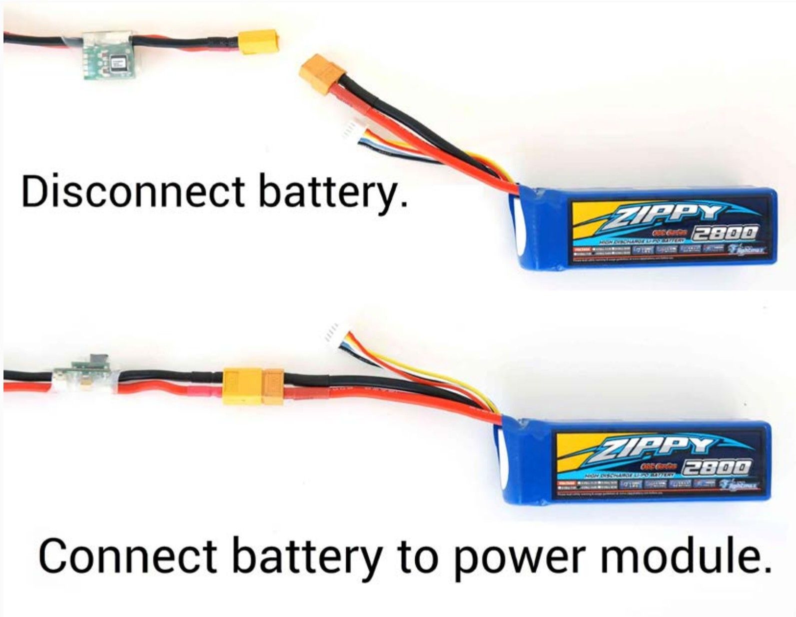
1. Turn on your transmitter and put the throttle stick at maximum.



2. Connect the Lipo battery. The autopilot’s red, blue and yellow LEDs will light up in a cyclical pattern. This means the it’s ready to go into ESC calibration mode the next time you plug it in.



3. With the transmitter throttle stick still high, disconnect and reconnect the battery.



4. For **PX4 or Pixhawk,** press and hold the safety button until it displays solid red.
5. The autopilot is now in ESC calibration mode. (On an APM you may notice the red and blue LEDs blinking alternatively on and off like a police car).
6. Wait for your ESCs to emit the musical tone, the regular number of beeps indicating your battery's cell count (i.e. 3 for 3S, 4 for 4S) and then an additional two beeps to indicate that the maximum throttle has been captured.
7. Pull the transmitter's throttle stick down to its minimum position.

Set throttle to minimum.

8. The ESCs should then emit a long tone indicating that the minimum throttle has been captured and the calibration is complete.
9. If the long tone indicating successful calibration was heard, the ESCs are “live” now and if you raise the throttle a bit they should spin. Test that the motors spin by raising the throttle a bit and then lowering it again.
10. Set the throttle to minimum and disconnect the battery to exit ESC-calibration mode.

Here is a video demonstrating the process:

Demonstration of ESC calibration process with Pixhawk:

Manual ESC-by-ESC Calibration

1. Plug one of your ESC three-wire cables into the throttle channel of the RC receiver. (This is usually channel 3.)
2. Turn on the transmitter and set throttle stick to maximum (full up).
3. Connect the LiPo battery

4. You will hear a musical tone then two beeps.
5. After the two beeps, lower the throttle stick to full down.
6. You will then hear a number of beeps (one for each battery cell you're using) and finally a single long beep indicating the end points have been set and the ESC is calibrated.
7. Disconnect battery. Repeat these steps for all ESCs.
8. If it appears that the ESC's did not calibrate then the throttle channel on the transmitter might need to be reversed.
9. If you are still having trouble after trying these methods (for example, ESCs still beep continuously) try lowering your throttle trim 50%.
10. You can also try powering your APM board via the USB first to boot it up before plugging in the LiPo.

Semi Automatic ESC-by-ESC Calibration

1. Connect to the flight controller from a ground station such as the Mission Planner and set the ESC_CALIBRATION parameter to 3
2. Disconnect the battery and USB cable so the flight controller powers down
3. Connect the battery
4. The arming tone will be played (if the vehicle has a buzzer attached)
5. If using a flight controller with a safety button (like the Pixhawk) press it until it displays solid red
6. You will hear a musical tone then two beeps
7. A few seconds later you should hear a number of beeps (one for each battery cell you're using) and finally a single long beep indicating the end points have been set and the ESC is calibrated
8. Disconnect the battery and power up again normally and test as described below

Testing

Once you have calibrated your ESCs, you can test them by plugging in your LiPo. Remember: no propellers!

- Ensure your transmitter's flight mode switch is set to "Stabilize Mode".
- Arm your copter
- Give a small amount of throttle. All motors should spin at about same speed and they should start at the same time. If the motors do not all start at the same time and spin at the same speed, the ESC's are still not properly calibrated.
- Disarm your copter

Notes / Troubleshooting

The All-at-once ESC calibration mode simply causes the APM to pass through the pilot's throttle directly through to the ESCs. If you power up the APM while in this mode you'll send the same PWM signal to all the ESCs. That's all it does. Many ESCs use full throttle at startup to enter programming mode, full throttle postition is then saved as the upper end point and when you pull the throttle down to zero, that position is saved as the lower end point.

If after calibration your motors do NOT spin same speed nor start at the same time, repeat the calibration process. If you tried the auto calibration above and it didn't work or the ESCs do not drive the motors identically, try the manual calibration method described above. That should work almost every time. (Rarely after a full manual calibration you will also need to do an additional final automatic calibration).

Finally, there are a huge number of brands and types of ESCs available and some of them do not adhere to the normal programming conventions (sometimes even though they claim to) and they may simply not work with the APM the way it is now. This is an unfortunately necessary but true disclaimer.

Recommended ESC settings as follows:

1. Brake: OFF
2. Battery Type: Ni-xx(NiMH or NiCd) (even if you're using Li-po batteries this setting reduces the likelihood that the ESC's low voltage detection will turn off the motors)
3. CutOff Mode: Soft-Cut (Default)
4. CutOff Threshold: Low
5. Start Mode: Normal (Default)
6. Timing: MEDIUM

Setting Motor Range

Most ESCs have a dead zone at the bottom of their range. This page outlines how to test the size of the range and then set the spin-when-armed and min throttle values appropriately.

Although not required, advanced users may wish to take the next step by measuring and adjusting the motor thrust curve.

Note

Please complete the ESC calibration before setting the motor range

Measuring the deadzone

- Remove the propellers from the vehicle
- Connect the lipo battery
- Connect the flight controller to the Mission Planner using a USB cable or telemetry
- Open the Mission Planner’s Initial Setup >> Optional Hardware >> Motor Test page

- Increase the “Throttle %” field and push each of the “Test motor” buttons to determine what percentage is required for each of the motors to spin. If all ESCs are from the same manufacturer they will likely all have similar dead zones, but having one or two different by 1% ~ 2% is common. Pick the highest percentage of all the motors - we will use this below.

Setting Spin-Armed and Min Throttle

By default, when the vehicle is armed but not flying, the motors will spin at a slightly slower than normal speed. This speed can be configured using MOT_SPIN_ARMED or MOT_SPIN_ARM paramter (depending upon the version). Once the vehicle is flying, we want to ensure that we never output a value that causes the motors to stop spinning, this lower limit can be configured with the THR_MIN or MOT_SPIN_MIN parameter (depending upon the version).

If using Copter-3.3 (or earlier):

- set the MOT_SPIN_ARMED parameter to **(the percentage discovered above + 2%) * 10**. I.e. if you found the deadzone of the ESCs was 7%, set MOT_SPIN_ARMED to 90 (i.e. (7 + 2) * 10).
- set the THR_MIN parameter to at least 30 higher than MOT_SPIN_ARMED. I.e. if MOT_SPIN_ARMED was 90, set THR_MIN to 120.

If using Copter-3.4 (or higher):

- set the MOT_SPIN_ARM parameter to **(the percentage discovered above + 2%) / 100**. I.e. if you found the deadzone of the ESCs was 7%, set MOT_SPIN_ARM to 0.09 (i.e (7 + 2) / 100).
- set the MOT_SPIN_MIN parameter to at least 0.03 higher than MOT_SPIN_ARM. I.e. if MOT_SPIN_ARM was 0.09, set MOT_SPIN_MIN to 0.12.

Note

Setting THR_MIN or MOT_SPIN_MIN even higher than recommended above is fine especially because we want to account for voltage drop of the battery but setting it too high reduces the lower range of the motors which reduces control which could be important especially on powerful copters with a low hover throttle.
Note

Copter 3.4 (and higher) also includes the MOT_SPIN_MAX parameter to account for the very top of the ESC/motor range which generally produces no additional thrust. By default this value is 0.95 (i.e. top 5% of the range produces no additional thrust).
Tip

The next section (First Flight) explains how to start flying using Copter, and further tuning and configuration required for new systems.

First Flight with Copter

This section covers the information you will need to know for your first flight and also some basic configuration to get your copter flying reasonably well.

Some of this contents is also covered in this “first flight checks” video

Please follow each of the links below.

Flight Modes

This article provides an overview of the available flight modes for Copter and instructions for how to configure which modes are available through the RC Transmitter.

Overview

Copter has 14 flight built-in flight modes, 10 of which are regularly used. There are modes to support different levels/types of flight stabilization, a sophisticated autopilot, a follow-me system etc.

Flight modes are controlled through the radio (via a transmitter switch), via mission commands, or using commands from a ground station (GCS) or companion computer.

Recommended Flight Modes

In general when first starting to use Copter you should progress through the flight modes in the order listed below, being sure that you are comfortable with each before progressing to the next (click the links for more details):

- Stabilize
- Alt Hold
- Loiter
- RTL (Return-to-Launch)
- Auto

Additional flight modes:

- Acro

- AutoTune
- Brake
- Circle
- Drift
- Guided (and Guided_NoGPS)
- Land
- PosHold
- Sport
- Throw
- Follow Me
- Simple and Super Simple
- Avoid_ADSB for ADS-B based avoidance of manned aircraft. Should not be set-up as a pilot selectable flight mode.

Most transmitters provide a 3 position switch but you can find instructions here for setting up a 6-position flight mode switch.

GPS Dependency

Flight modes that use GPS-positioning data require an active GPS lock prior to takeoff. To see if your autopilot has acquired GPS lock, connect to a ground station or consult your autopilot's hardware overview page to see the LED indication for GPS lock. Below is a summary of GPS dependency for Copter flight modes.

Requires GPS lock prior to takeoff:

- Loiter
- RTL (Return-to-Launch)
- Auto
- Guided
- Drift
- PosHold
- Follow Me
- Circle
- Throw

Do not require GPS lock:

- Stabilize
- Alt Hold

Acro Mode

Acro mode (Rate mode) uses the RC sticks to control the angular velocity of the copter. Release the sticks and the vehicle will maintain its current attitude and will not return to level. Acro mode is useful for aerobatics such as flips or rolls, or FPV when smooth and fast control is desired.

Overview¶

- The throttle is completely manual with no compensation for tilt angle of the vehicle. If the pilot puts the throttle completely down the motors will go to their minimum rate.
- AC3.1 and higher include an Acro Trainer functionality that can be turned on/off to make learning to fly Acro easier.
- Stick inputs are interpreted in the “body frame” (as opposed to Sport mode in which they are “earth frame”). The difference between “body frame” and “earth frame” is most obvious when the vehicle is leaned over. For example when pitched forward at 45 degrees, when left yaw is applied if using an earth frame controller (i.e. Sport mode) the copter will maintain it’s pitch and roll angles as it’s heading changes. With a body frame controller like Acro it will rotate about the vehicle’s vertical axis meaning the pitch angle will become the roll angle and the roll angle will become the pitch angle.

Warning

Acro is the most difficult flight mode to master and you can look forward to crashing multiple times before you get the hang of it.
The above video was filmed with a Pixhawk running AC3.2 in ACRO mode using FPV goggles.

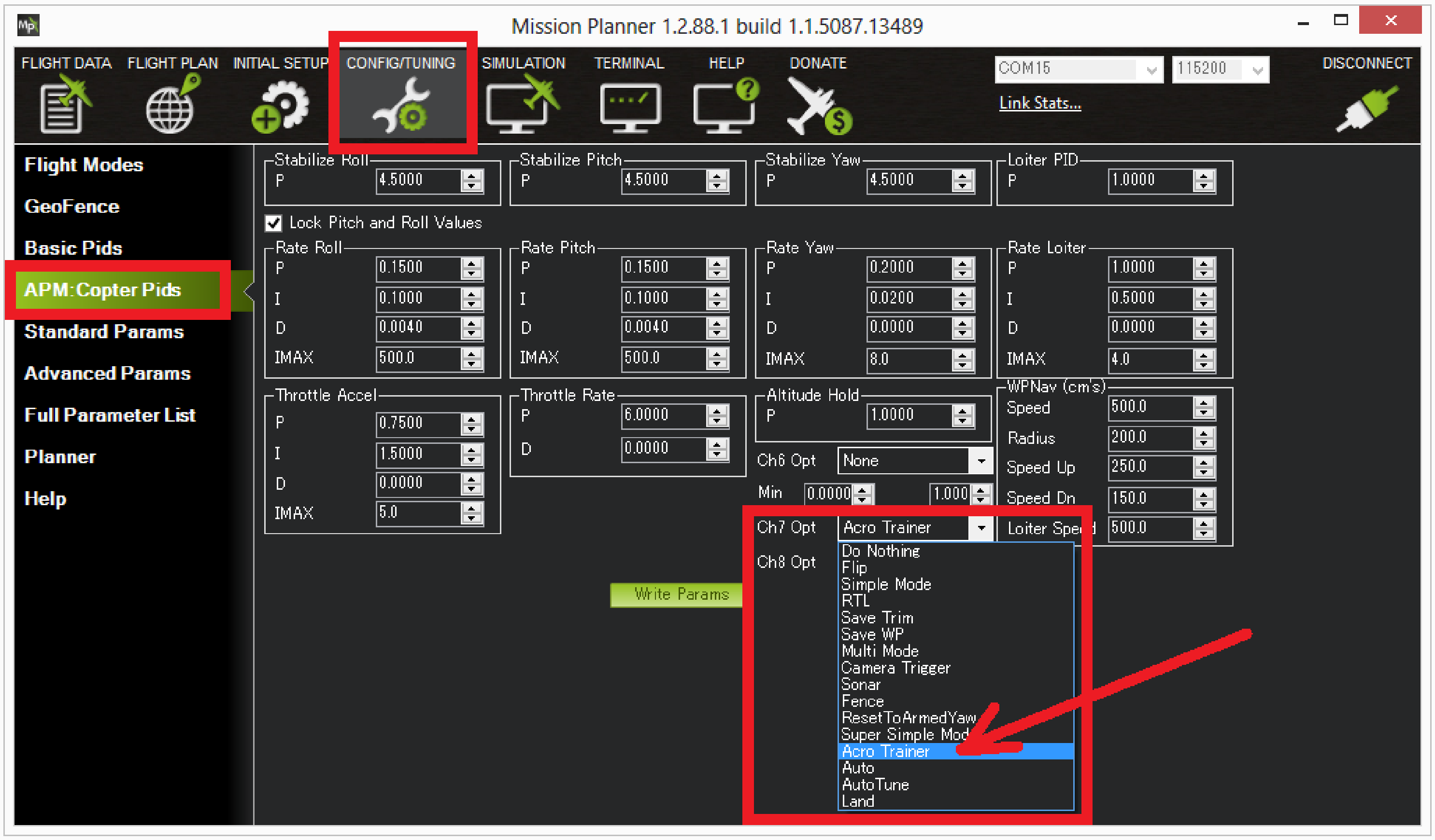
Acro Trainer¶

The ACRO_TRAINER parameter can be set to:

- 0 = disabled. This means the pilot operates in full Rate control with no automatic leveling nor angle-limiting performed by the autopilot.
- 1 = automatic leveling. The vehicle will automatically return to the level when the pilot releases the sticks. The aggressiveness with which it returns to level can be controlled with the ACRO_BAL_ROLL and ACRO_BAL_PITCH parameters. The default of 1.0 will cause it to return to level at up to 30deg/sec. Higher values will make it return more quickly.
- 2 (Default) = automatic leveling and lean angle limited. Includes the automatic leveling as option #1 but in addition the vehicle will not lean more than 45 degrees (this angle can be configured with the

ANGLE_MAX parameter).

The trainer can be enabled/disabled using the Ch7/Ch8 switches. With a 3 position switch the off position (i.e. PWM < 1200) will disable the trainer, middle position will enable option #1 (automatic leveling) and the top position (i.e. PWM > 1800) will enable option #2 (leveling and lean angle limited). With a 2 position switch only options #0 (disabled) and option #2 (leveling & limited) are possible.



Tuning Parameters¶

- ACRO_RP_P controls the rotation rate for the roll and pitch axis. The default, 4.5, will command a 200deg/sec rotation rate. Higher values lead to higher rotation rates, lower to slower rotation rates.
- ACRO_YAW_P controls the rotation rate for the yaw axis. The default, 4.5, like roll and pitch, will command a 200deg/sec rotation rate.
- ACRO_EXPO is an amount of Exponential to apply to the pilots stick inputs that only applies to ACRO mode. By default, ACRO mode is much more responsive, even in the center-sticks positions, than the other modes, so this parameter allows the pilot to fine-tune stick response in the control to match what they feel when they are in other modes such as Stabilize, AltHold, PosHold, etc. The default value of 0 applies 30% expo to Roll and Pitch demands from the pilot.

Advanced Tuning Parameters¶

After you have become very confident with flying in ACRO mode, you may want to go deeper in to tuning it based on your vehicle’s performance characteristics. These parameters should be adjusted by advanced users only with the intent of removing “bounce” after very fast roll or flip maneuvers on a vehicle that you are confident is very well tuned. Note that these parameters are global parameters that apply to all flight modes, not just ACRO.

- ATC_ACCEL_R_MAX and ATC_ACCEL_P_MAX: Maximum acceleration in roll/pitch axis measured in Centi-degres/sec/sec. Let’s say you have a highly nimble quadcopter and you have your ACRO_RP_P parameter set to 9, which translates to a roll request of ~400deg/sec. The copter is not physically capable of going from 0deg/sec to 400deg/sec without a brief moment of acceleration. During that time, error is building up in the controller in order to get you to 400deg/sec. When you let off the sticks, that error can still be present, resulting in an overshoot of desired attitude, followed by a bounce-back. This parameter can be tuned to help remove that error during the maneuver and soften if not remove the bounce-back. Note that this is completely different from tuning the Rate D terms for Pitch and Roll, and should come only after those terms are properly tuned.
- ATC_ACCEL_Y_MAX: Maximum acceleration in Yaw axis measured in Centi-degress/sec/sec. Same principle as `ATC_ACCEL_R_MAX` and ATC_ACCEL_P_MAX: Acceleration Max for Pitch but on the YAW axis based on the *ACRO_YAW_P <ACRO_YAW_P>* parameter value (likely a much lower, more attainable value.)

User Videos¶

Altitude Hold Mode

In altitude hold mode, Copter 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 AltHold) is selected, the throttle is automatically controlled to maintain the current altitude. Roll, Pitch and yaw operate the same as in Stabilize 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 (Loiter, Sport, etc) so the information here pertains to those modes as well.

Note

The flight controller 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 copter will follow the air pressure change rather than actual altitude (unless you are within 20 feet of the ground and have SONAR installed and enabled). Below 26 feet, SONAR (if enabled) will automatically provide even more accurate altitude maintenance.

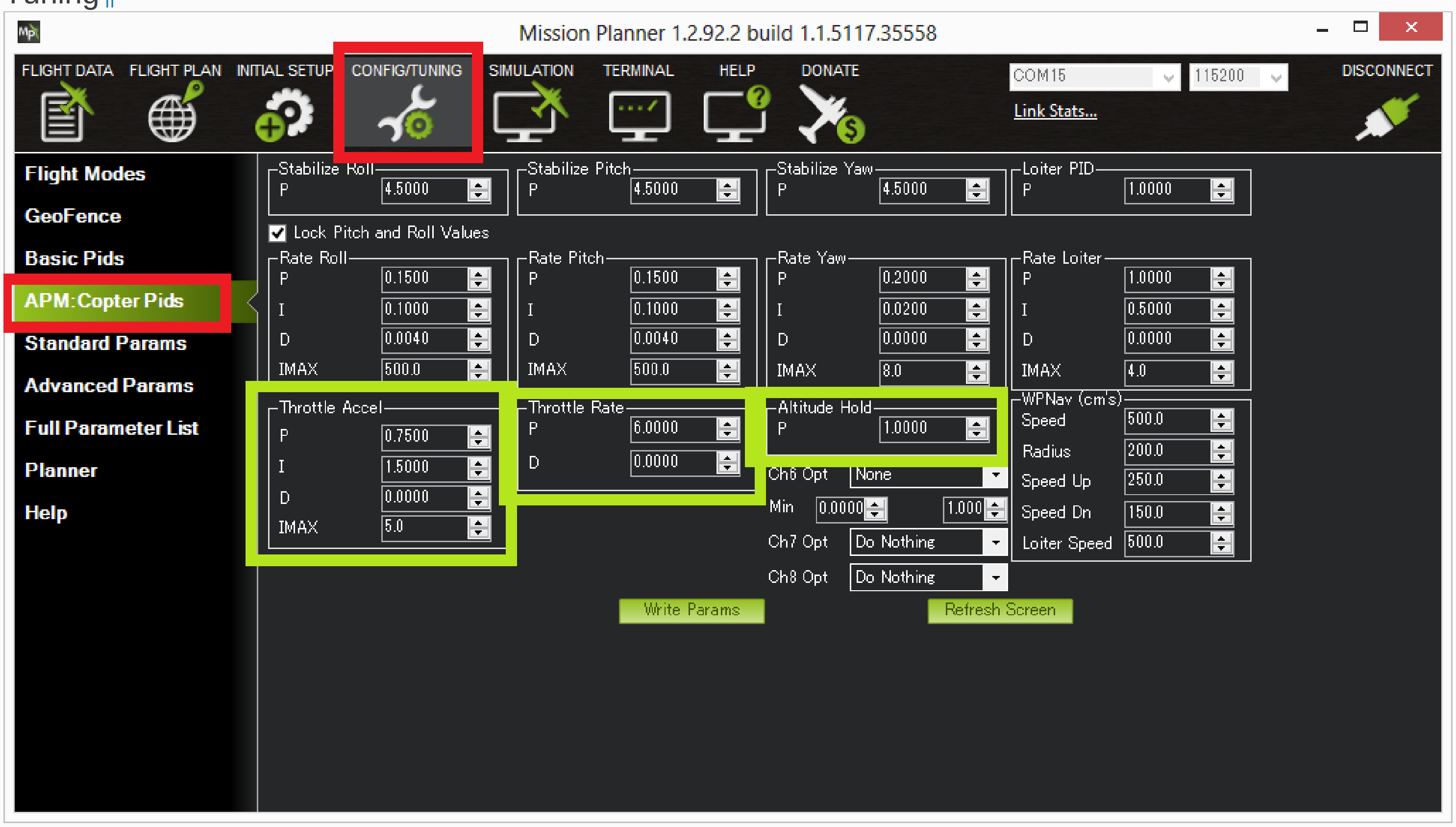
Controls¶

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

- If the throttle stick is in the middle (40% ~ 60%) the vehicle will maintain the current altitude.
- Outside of the mid-throttle deadzone (i.e. below 40% or above 60%) the vehicle will descend or climb depending upon the deflection of the stick. When the stick is completely down the copter will descend at 2.5m/s and if at the very top it will climb by 2.5m/s. These speeds can be adjusted with the `PILOT_VELZ_MAX` parameter.
- The size of the deadband can be adjusted with the THR_DZ parameter (AC3.2 and higher only). This params value should be between "0" and "400" with "0" meaning no deadband. "100" would produce a deadband 10% above and below mid throttle (i.e. deadband extends from 40% to 60% throttle stick position).

AC3.1 and later allow arming and disarming in altitude hold mode. When disarming, the copter may need to rest in the landing position for a few seconds to allow the "landing checker" to verify that the copter has landed before you are able to disarm.

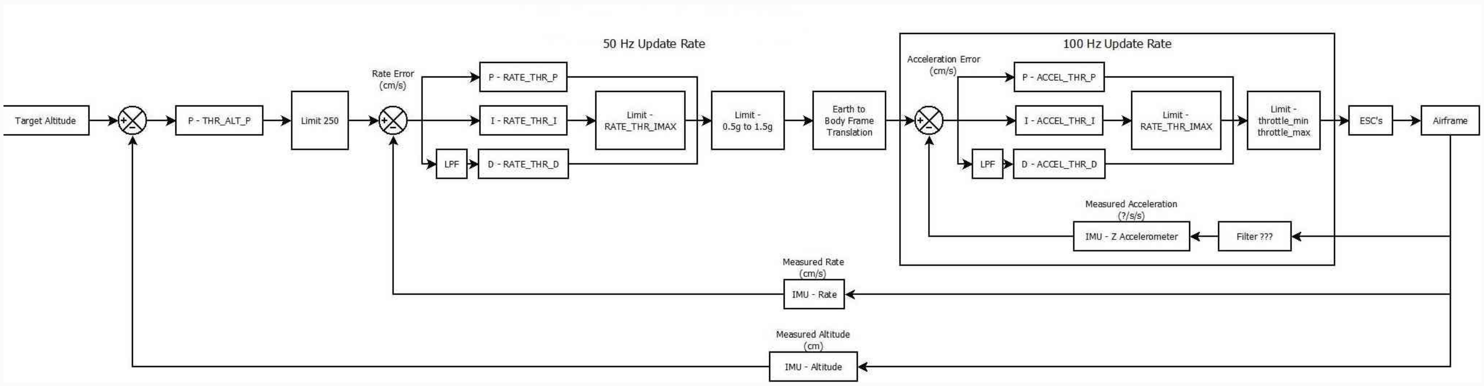
Tuning¶



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

The Throttle Accel 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 copters you may get better response by reducing both by 50% (i.e P to 0.5, I to 1.0).



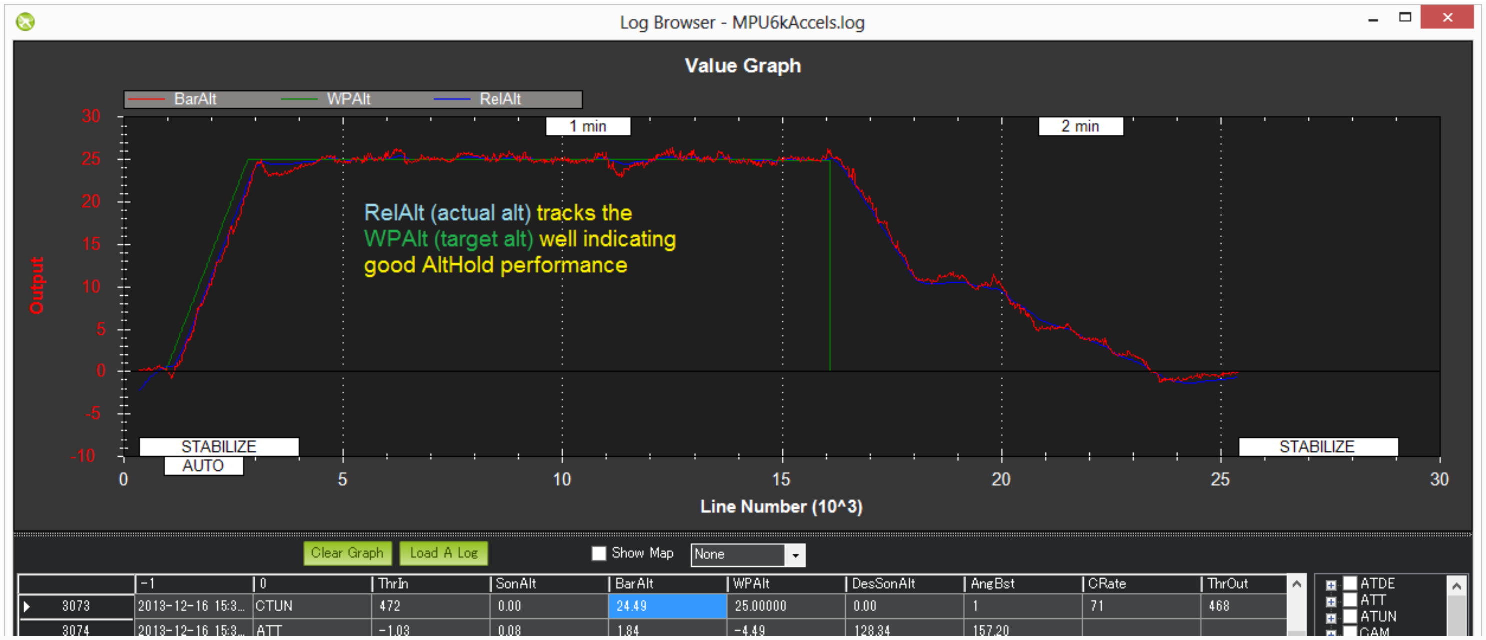
Verifying AltHold performance with dataflash logs¶

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. This data is found in slight different columns depending upon the version and board.

APM running AC3.1: graph CTUN’s BarAlt (baro alt), WPAlt (desired altitude) and the GPS message’s RelAlt (inertial nav alt estimate)

APM running AC3.2 or Pixhawk running AC3.1 or AC3.2: CTUN’s BarAlt (baro alt), DAlt (desired alt) and Alt (inertial nav alt estimate)

The three should track well as shown below.



Common Problems¶

1. High vibrations can lead to the copter 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. Copter 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 AltHold from a manual flight mode (like Stabilize) on a copter that does not hover at mid throttle. See the wiki page related to setting the mid throttle position.
3. The motors seem to stop for a moment just as AltHold is engaged but then it soon recovers. This normally occurs when the pilot enters AltHold 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 copter begins falling back to the target altitude. The workaround is to enter AltHold while the copter is flying at a stable altitude.
4. 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).
5. Momentary altitude loss of 1m ~ 2m when the copter 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 copter where the flight controller is mounted which leads the altitude hold controller to believe it is climbing so it responds by descending. There is no cure for this behaviour at the moment although increasing the `INAV_TC_Z` parameter to 7 (default is 5) reduces the effect but increases the change of Common Problem #1 listed above.
6. 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 flight controller out of the prop wash effect or shield it within an appropriately ventilated

enclosure.

7. Sudden altitude changes caused by light striking the barometer. APM2.x sold after mid 2013 come with black tape on the inside of the case to protect against this.

Adequate Power¶

It is very important that the vehicle has enough power available. Without this the AltHold 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

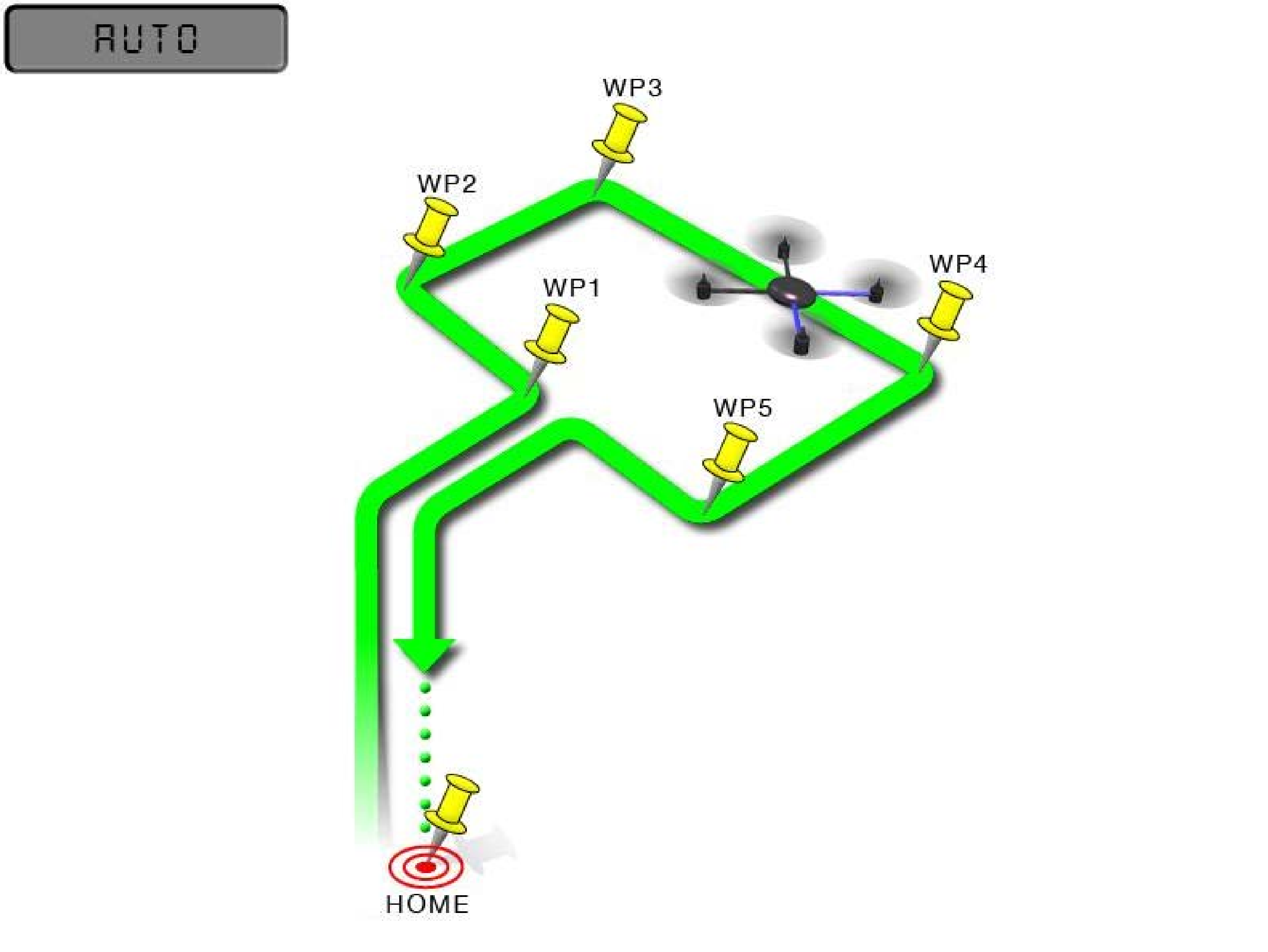
If you incorporate expo on your transmitter, that directly increases the size of the Alt Hold throttle dead band.

Auto Mode

In Auto mode the copter will follow a pre-programmed mission script stored in the autopilot which is made up of navigation commands (i.e. waypoints) and “do” commands (i.e. commands that do not affect the location of the copter including triggering a camera shutter). This page provides an overview of Auto mode.

Information on creating a mission script, can be found on the Planning a mission with waypoints and events page. A full list of supported commands can be found on the Mission Command List page.

Overview¶



AUTO mode incorporates the altitude control from AltHold mode and position control from Loiter mode and should not be attempted before these modes are flying well. All the same requirements apply including ensuring that vibration levels and compass interference levels are acceptable and that the GPS is functioning well including returning an HDOP of under 2.0.

Controls¶

AUTO should be set-up as one of the Flight Modes on the flight mode switch.

If starting the mission while the copter is on the ground the pilot should ensure the throttle is down, then switch to the Auto flight mode, then raise the throttle. The moment that the throttle is raised above zero, the copter will begin the mission.

If starting the mission from the air the mission will begin from the first command the moment that the flight mode switch is moved to Auto. If the first command in the mission is a take-off command but the vehicle is already above the take-off command's altitude the take-off command will be considered completed and the vehicle will move onto the next waypoint.

At any time the pilot can retake control from the autopilot by returning the flight mode switch to another flight mode such as Stabilize or Loiter. If the pilot then switches to AUTO again, the mission will restart from the first command.

During the mission the pilot's roll, pitch and throttle inputs are ignored but the yaw can be overridden with the yaw stick. This allows the pilot to for example aim the nose of the copter (which might have a hard mounted camera on it) as the copter flies the mission. The autopilot will attempt to retake yaw control as the vehicle passes the next waypoint.

Missions can be entered, amended through the Mission Planner's Flight Plan screen. Please refer to the Mission Command List wiki page for a full list of supported commands along with a short description of each.

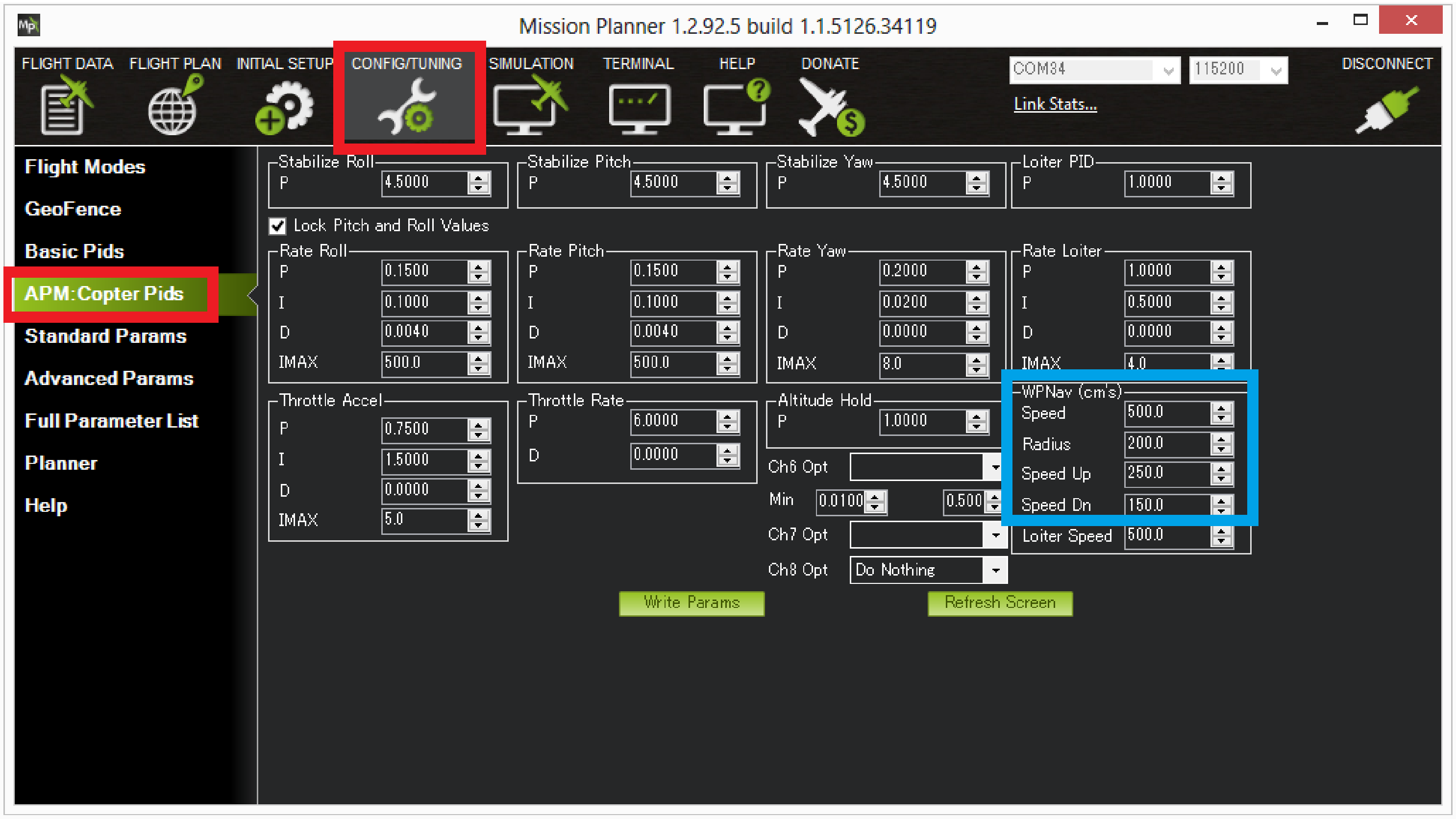
Ending a Mission¶

Missions should normally have an RTL as their final command to ensure the copter will return after the mission completes. Alternatively the final command could be a LAND with a different location. Without a final RTL or LAND command the copter will simply stop at the final waypoint and the pilot will need to retake control with the transmitter.

Remember that when using RTL, the copter will return to the "home" position which is the location where the copter was armed.

As the copter touches down at the end of the mission the pilot should move the throttle to zero at which point the autopilot will disarm the motors if it also believes that it has landed.

Tuning¶



AUTO mode incorporates the altitude control from AltHold mode and position control from Loiter mode.

The maximum horizontal speed of the copter can be adjusted with the **Speed** (aka WPNAV_SPEED) parameter from the Mission Planner's Config/Tuning >> Copter Pids screen (see blue box above). The default is 500 meaning 5m/s. A typical copter can reach top speeds of 10m/s ~ 13m/s (i.e. 1000 ~ 1300) before it becomes unable to both maintain altitude and horizontal speed.

The vertical speeds up and down can similar be adjusted with the **Speed Up** (WPNAV_SPEED_UP) and **Speed Dn** (WPNAV_SPEED_DN) parameters.

The **Radius** allows you to control how close the copter must come to the exact waypoint position before the waypoint is considered "complete" and the copter moves onto the next waypoint. This only applies when the waypoint command includes a delay of 1 second or more. Without a delay the waypoint is considered a "fast waypoint" and the copter will begin towards the next waypoint once the intermediate target that it is chasing has reached the waypoint. This intermediate target can be 10m or more ahead of the copter (it's distance ahead of the copter increases with the Speed parameter).

Brake Mode

This very simple flight mode simply stops the vehicle as soon as possible using the Loiter controller.

Once invoked, this mode does not accept any input from the pilot. This mode requires GPS.

Note

The Brake flight mode was introduced in AC3.3.

Overview¶

When switched on, Brake mode will attempt to stop the vehicle as quickly as possible. Good GPS position, low magnetic interference on the compassand low vibrations are all important in achieving good performance.

If the vehicle is landed in Brake mode it will immediately disarm.

Controls¶

The pilots controls are ignored in this mode. The vehicle must be switched out of this mode before the pilot can re-take control.

Circle Mode

Circle will orbit a point of interest with the nose of the vehicle pointed towards the center.

The radius of the circle can be controlled by modifying the CIRCLE_RADIUS parameter.

Note

The units are **centimeters** from AC 3.2 (previously metres). Mission Planner reports the units as cm for all versions of the code.
Setting the CIRCLE_RADIUS to zero will cause the copter to simply stay in place and slowly rotate (useful for panorama shots).

The speed of the vehicle (in deg/second) can be modified by changing the CIRCLE_RATE parameter. A positive value means rotate clockwise, a negative means counter clockwise. The vehicle may not achieve the desired rate if this requires the acceleration towards the center of the circle to surpass the maximum acceleration held in the WPNAV_ACCEL parameter (units are cm/s/s).

The pilot does not have any control over the roll and pitch but can change the altitude with the throttle stick as in AltHold or Loiter mode.

The pilot can control the yaw of the copter, the autopilot will not retake control of the yaw until circle mode is re-engaged.

The mission command LOITER_TURNS invokes Circle mode during a mission.

Drift Mode

This page provides tips for flying in Drift Mode and methods for tuning your copter to fly optimally in Drift Mode.

Overview¶

- Drift Mode allows the user to fly a multi-copter as if it were a plane with built in automatic coordinated turns.
- The user has direct control of Yaw and Pitch, but Roll is controlled by the autopilot. This allows the copter to be controlled very intuitively with a single control stick if using a Mode 2 transmitter
- The user has completely manual control over the throttle as in Stabilize mode.
- **Drift Mode is available as of release 3.1 of the Copter firmware.**

How Drift Mode works¶

- You “fly” the MultiCopter with the right stick (on Mode 2 controllers) controls Pitch and Yaw.
- You use the left stick primarily for altitude control but not for yaw directly.
- When you push the right stick forward or back the copter will pitch (and accelerate) in the appropriate direction.
- When you push the right stick towards one side or the other the right or to the left the copter will turn in the direction specified.
- The copter will also bank at the same time so as to make a coordinated turn in that direction.
- When turning with the right stick yaw is automatically applied and sufficient roll is added to cancel the copters velocity in the roll axis.
- This allows you to maintain a coordinated (non-skidding) turn.
- Letting go of the sticks effectively turns on a speed brake in the Pitch axis that slows the copter to a stop over a two second period.
- A copter in Drift Mode with the right stick in the center will loosely hold horizontal position (It will slowly drift in the wind.)
- 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 (MOT_SPIN_ARMED) and if the vehicle is flying it will lose attitude control and tumble.
- Drift Mode relies on your GPS for control.
- If you lose your GPS signal in flight while in Drift Mode, your copter will either land or enter altitude hold based on your failsafe_gps_enabled setting.
- You should also be prepared to switch back to Stabilize Mode for manual recovery if necessary.

Whats it Useful For¶

- FPV flyers who are looking for a dynamic, plane like flight as well as loiter-like position hold.
- New flyers who want to try a more intuitive and easy to learn flight mode.
- Anybody who would like to try an easy to fly and easy to learn and very fun mode.
- Photographers and especially videographers who want a smoother and more coordinated filming result.

Setting up Drift Mode¶

- In the Mission Planner Configuration Section under flight modes select Drift Mode to to apply to an appropriate switch setting.
- More information on tuning Drift mode is expected to be forthcoming shortly as are additional enhancements to Drift Mode itself.

Follow Me Mode (GSC Enabled)

Follow Me mode makes it possible for you to have your copter follow you as you move, using a telemetry radio and a ground station.

Note

Unlike “proper” autopilot modes, this feature is implemented in the Ground Station. The ground station controls the movement by reading the vehicle position using MAVLink Telemetry and sending GUIDED mode instructions to move the vehicle appropriately. Currently this sort of functionality is supported by *Mission Planner* for Windows laptops, APM Planner for OS X laptops, and DroidPlanner for Android devices.

What you’ll need¶

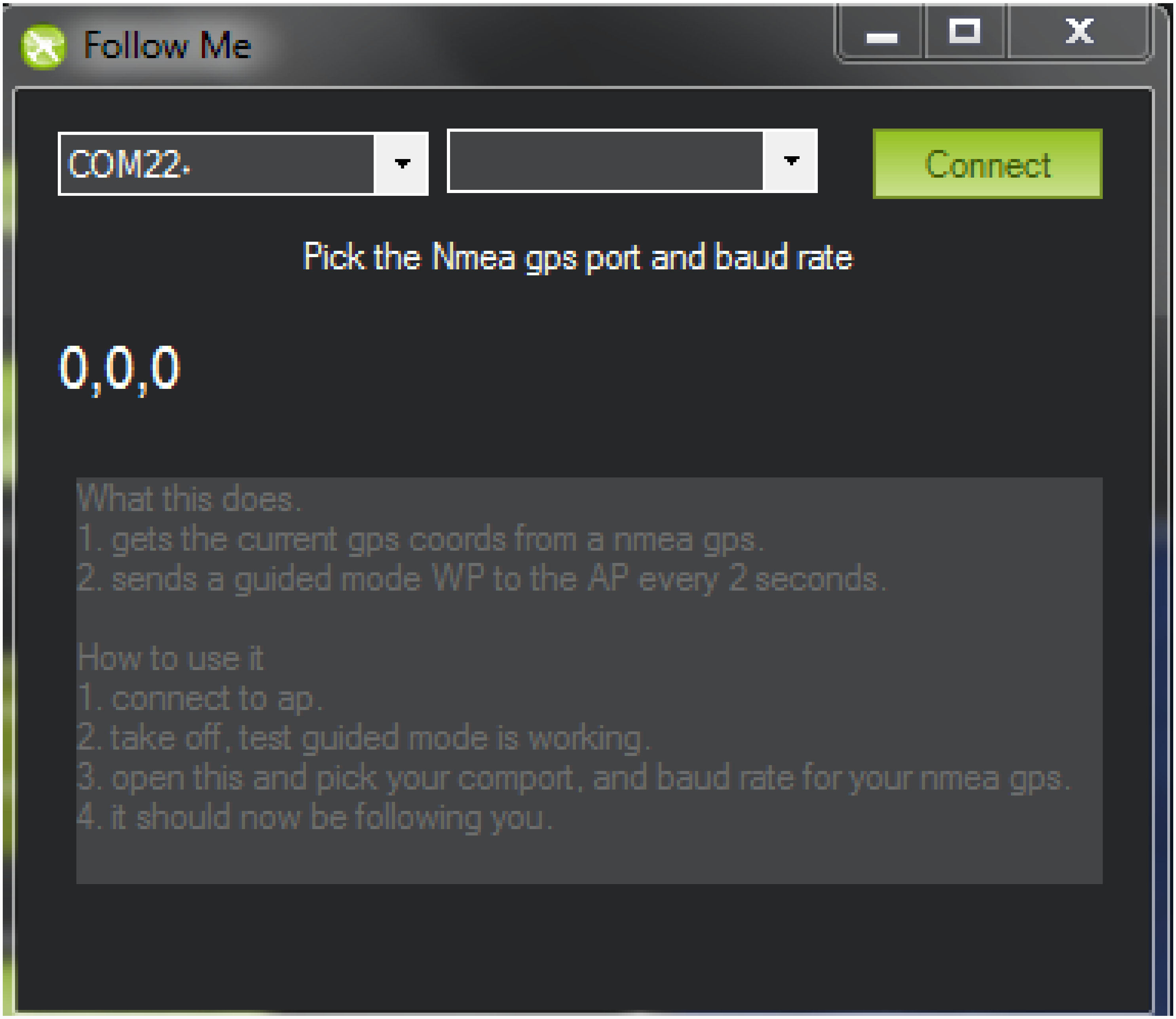
1. An Copter with telemetry
2. A laptop
3. A GPS USB dongle like this or Bluetooth GPS module like this.

Instructions for Mission Planner¶

1. Set one of your flight modes to “Loiter”
2. Set up your Copter at the field and establish a MAVLink connection over wireless telemetry
3. Ensure that your GPS USB dongle or Bluetooth device is plugged into to your laptop and showing up as a serial port. Using the software that came with the module, make sure that it’s working and that you have GPS lock.
4. Take off, and once in the air switch to Loiter. (Sufficient altitude to ensure that while it is following you it isn’t attacking you might be a good idea).

5. In the Mission Planner Flight Data screen try right-clicking on a nearby spot and select “Fly to Here”. If this works, you’re ready to try Follow Me mode.
6. In the Mission Planner, enter Control-F, which will open the following window. Click on “Follow Me”

- This will bring up this window. Select the serial port that is assigned to your GPS device and whatever baud rate it uses.



- Once you click “Connect”, the Mission Planner will read the GPS data from your device and send it to your Copter as “fly to here” commands every two seconds.
- Now pick up your laptop and start walking around.
- The Copter should follow you!
  - If you have set the altitude to 5 feet it might be a good idea to see if you can out run it.
  - As mentioned before, sufficient altitude to prevent injury is useful.
  - Seriously this is a great capability, but safety is really important when using Follow Me mode especially with an open bladed Multicopter.
- **Warning:** Like all other modes in which the autopilot is responsible for altitude hold (Loiter, AltHold), the barometer is used in the altitude calculation meaning that it can drift over time and the copter will follow the air pressure change rather than actual altitude above ground.

Guided Mode

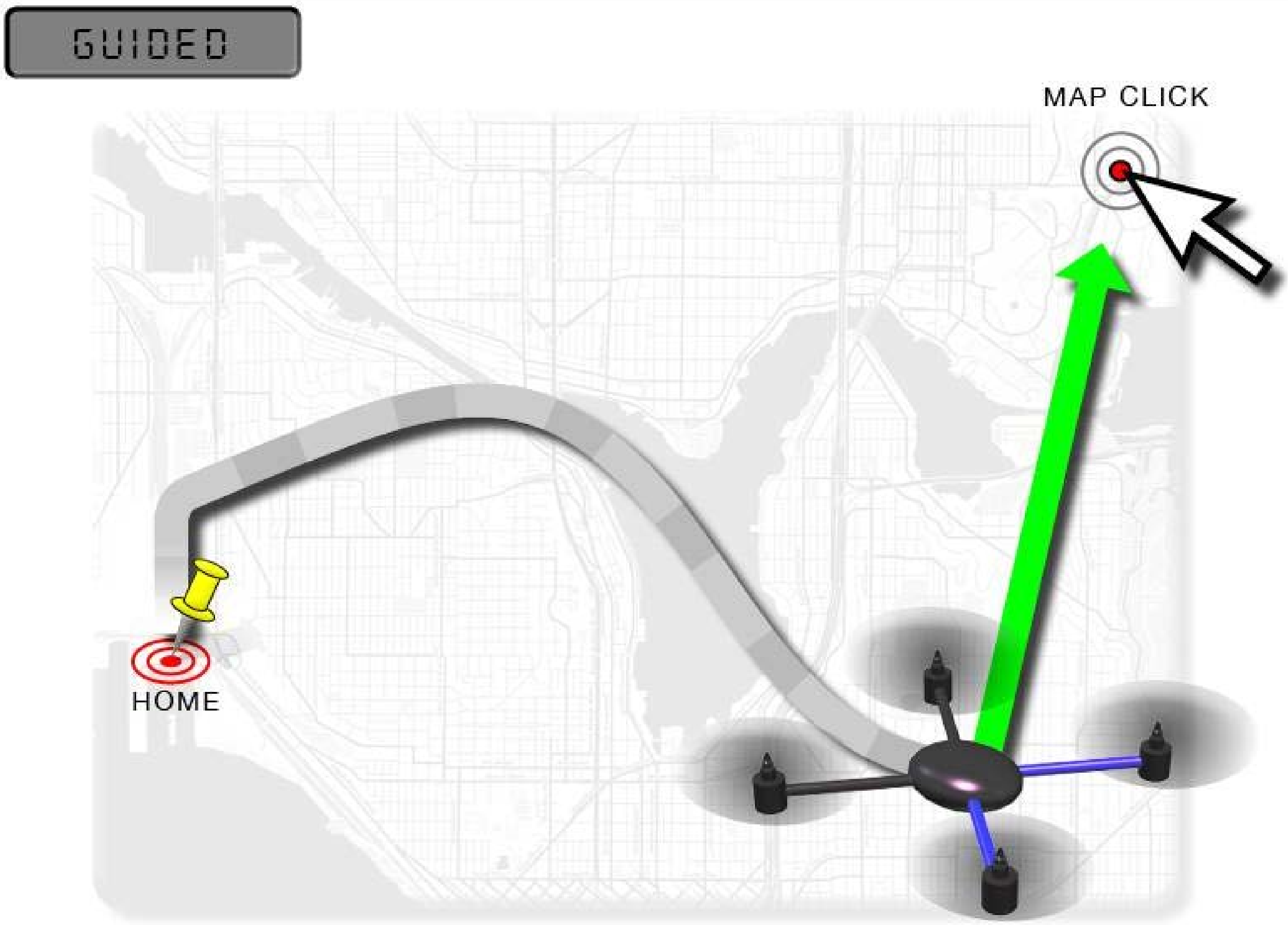
Guided mode is a capability of Copter to dynamically guide the copter to a target location wirelessly using a telemetry radio module and ground station application. This page provides instructions for using guided mode.

Note

Copter-3.4 (and higher) include Guided_NoGPS which is meant for developer use only.

Overview¶

Guided mode is not a traditional flight mode that would be assigned to a mode switch like other flight modes. The guided mode capability is enabled using a ground station application (such as Mission Planner) and telemetry radio (such as a SiK Telemetry Radio). This capability allows you to interactively command the copter to travel to a target location by clicking on a point on the Mission Planner Flight Data map. Once the location is reached, the copter will hover at that location, waiting for the next target. Follow Me mode also uses Guided Mode to make the copter follow the pilot around the field.

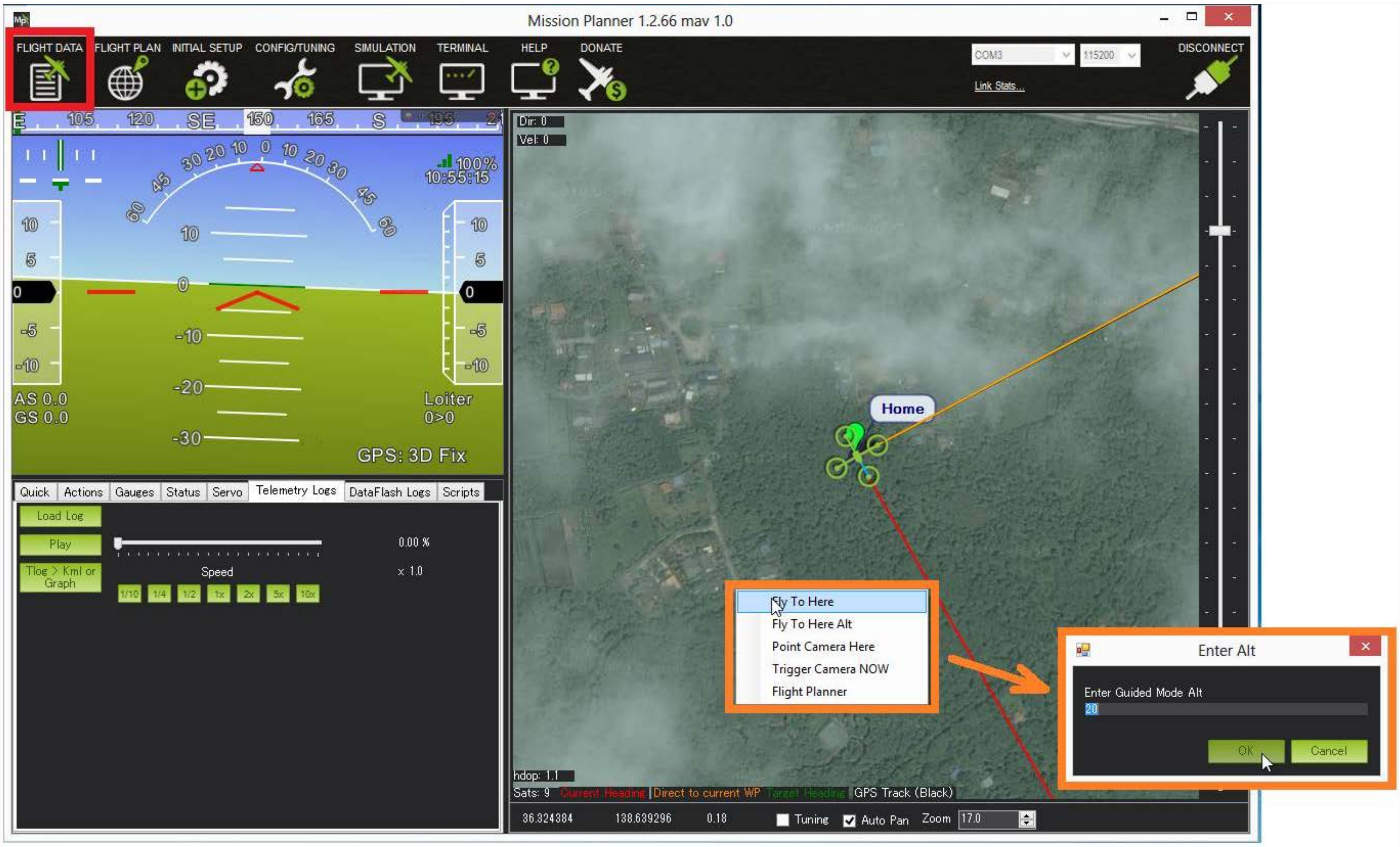


What you'll need¶

To use guided mode, you'll need a telemetry radio allowing your computer and autopilot to communicate during flight, a ground station computer or tablet, and a ground station application such as Mission Planner.

Instructions¶

- Set up your copter at the field and establish a MAVLink connection over wireless telemetry between your copter and your laptop.
- On your laptop, using the software that came with the telemetry module, make sure that it's working and that you have a GPS lock.
- Take off in Stabilize Mode and once at a reasonable altitude, switch to Loiter.
- In the Mission Planner Flight Data screen map, try right-clicking on a nearby spot and select "Fly to Here".
- You will be asked for a guided mode altitude. Enter an above home altitude in meters.



- A “Guided” target should appear on the map and the orange line (which indicates the target heading) should point to this guided target.

- The vehicle should fly to the target location and wait there until you enter another location or switch to another mode.

Note

On *Mission Planner* there is no need to set up one of your flight modes as "Guided". This may not be the case for other Ground Control Stations.

Guided_NoGPS¶

This variation of Guided mode does not require a GPS but it only accepts attitude targets. Because it does not accept position or velocity targets like regular Guided mode it is generally not useful for regular users. This mode was created for use by companion computers that may want to fly the vehicle as if it was in AltHold mode.

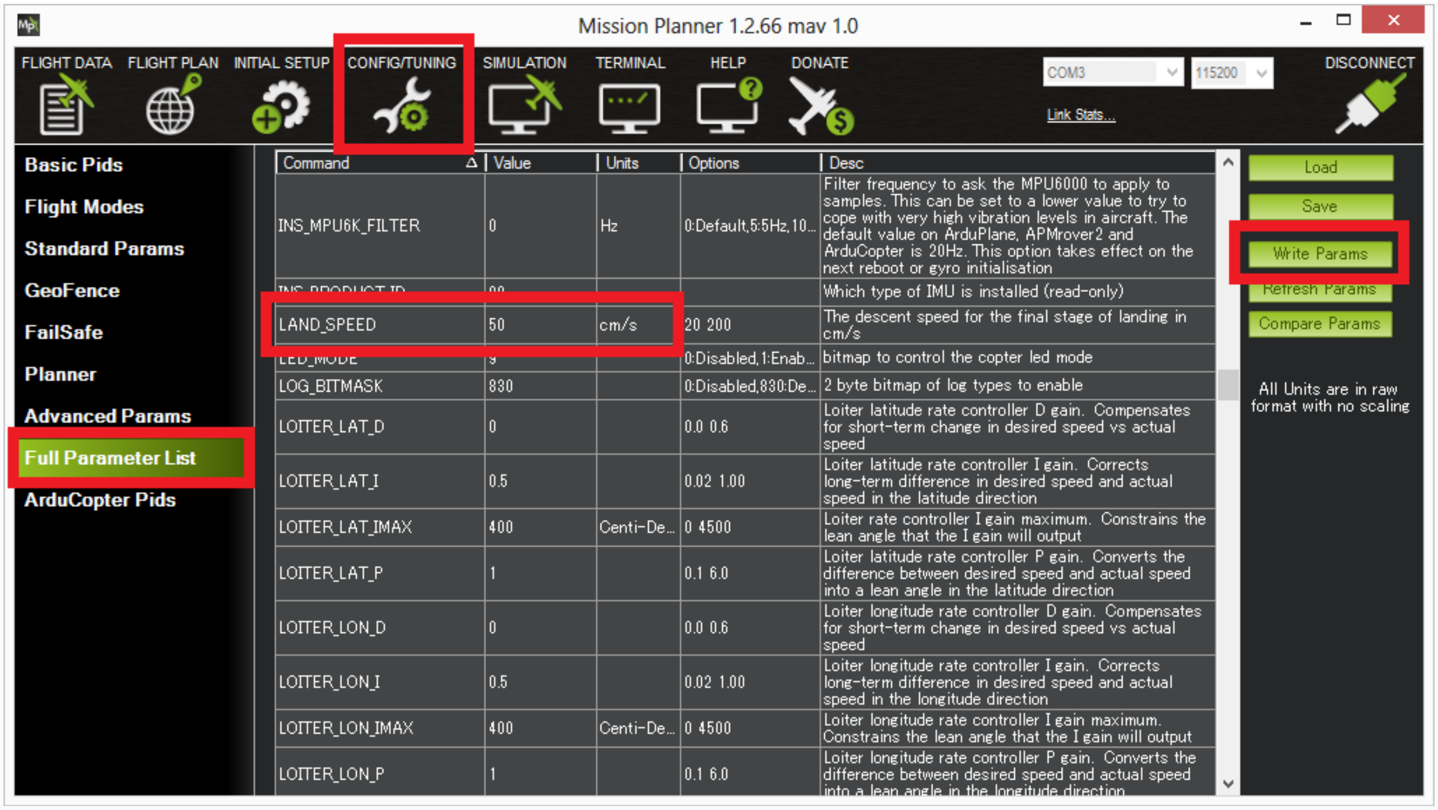
This mode is only available in Copter-3.4 (and higher).

Land Mode

LAND Mode attempts to bring the copter straight down and has these features:

- descends to 10m (or until the sonar senses something below the copter) using the regular Altitude Hold controller which will descend at the speed held in the WPNAV_SPEED_DN parameter which can be modified on the Mission Planner's Config/Tuning > Copter Pids screen.

- below 10m the copter should descend at the rate specified in the LAND_SPEED parameter which defaults to 50cm/s.



- Upon reaching the ground the copter will automatically shut-down the motors and disarm the copter if the pilot’s throttle is at minimum.

Note

Copter will recognise that it has landed if the motors are at minimum but it’s climb rate remains between -20cm/s and +20cm/s for one second. It does not use the altitude to decide whether to shut off the motors except that the copter must also be below 10m above the home altitude.

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

Warning

In any Alt Hold based mode including: Alt Hold, Loiter, Auto, AutoLand or RTL if your copters 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 fight controller situated such that it’s barometer (altimeter) is being affected by the pressure created by the copters prop-wash against the ground.

- This is easily verified by looking at the Altimeter reading in your logs and seeing if it spikes or oscillates when near the ground.

- If this is a problem, move the flight controller out of prop wash effect or shield it with an appropriately ventilated enclosure.
- Success can be verified by flight test and by log results.

Loiter Mode

Loiter Mode automatically attempts to maintain the current location, heading and altitude. The pilot may fly the copter in Loiter 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 loiter performance.

Controls¶

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

- Horizontal location can be adjusted with the 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 copter will slow to a stop.
- Altitude can be controlled with the Throttle control stick just as in AltHold mode
- The heading can be set with the Yaw control stick

The vehicle can be armed in Loiter mode but only once the GPS has 3D lock and the HDOP has dropped below 2.0. More details on LED patterns here.

Tuning¶

Loiter mode incorporates the altitude controller from AltHold mode. Details for tuning AltHold are on this wiki page.

WPNAV_LOIT_SPEED : max horizontal speed in cm/s. I.e. 500 = 5m/s. By default, the maximum acceleration is 1/2 of the Loiter speed (i.e. 2.5m/s/s).

WPNAV_LOIT_MAXA : max acceleration in cm/s/s. Higher values cause the copter to accelerate and stop more quickly.

WPNAV_LOIT_MINA : min acceleration in cm/s/s. Higher values stop the copter more quickly when the stick is centered, but cause a larger jerk when the copter stops.

WPNAV_LOIT_JERK: max change in acceleration in cm/s/s/s. Higher numbers will make the vehicle more responsive, lower numbers will make it smoother.

POS_XY_P : (shown as “Loiter PID P” at the top right of the screen shot above) 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.**

VEL_XY_P (shown as “Rate Loiter P, I and D”) 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 Stabilize mode. **It is generally not required to adjust this.**

Common Problems¶

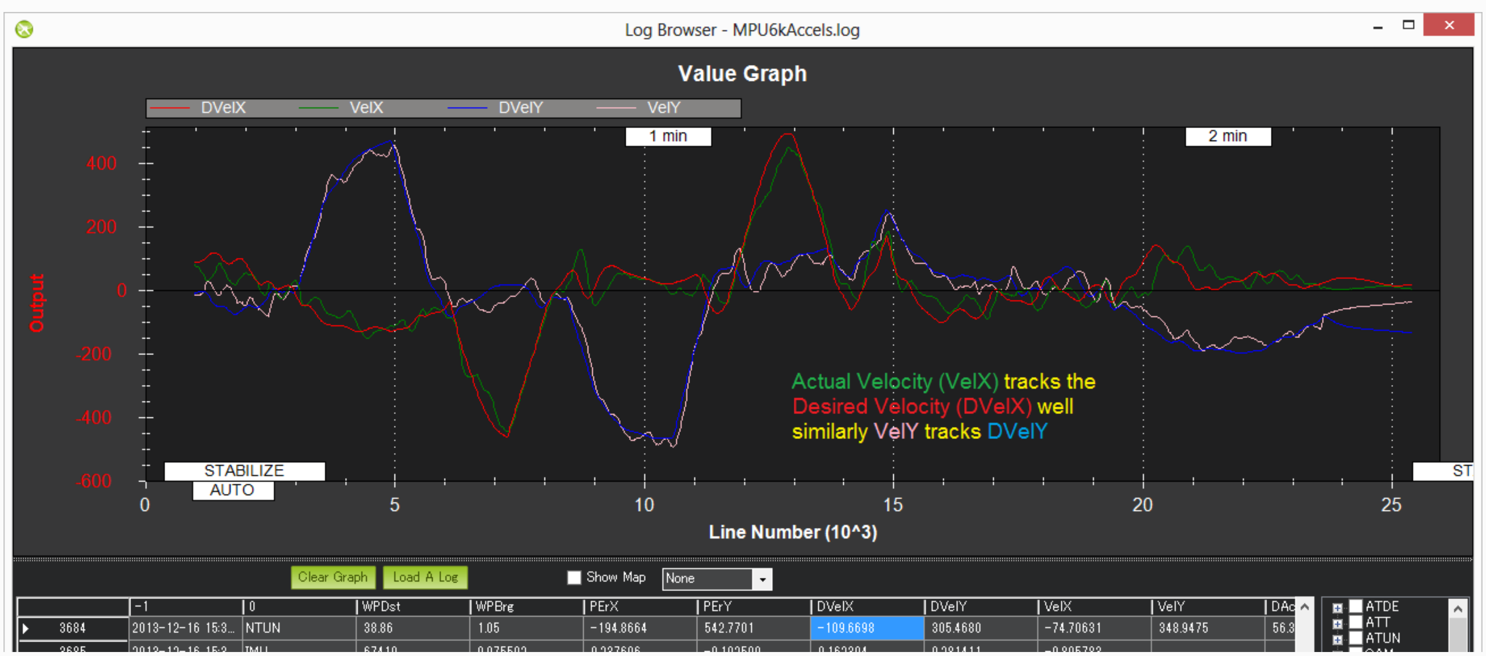
1. The vehicle slows to a stop very slowly after the pilot releases the sticks (aka “freight train stop”). This can be resolved by increasing WPNAV_LOIT_MAXA (to perhaps 500), WPNAV_LOIT_MINA (to perhaps 100) and WPNAV_LOIT_JERK (to perhaps 4000).
2. The vehicle circles (aka “toiletbowls”). This is normally caused by a compass problem the most likely being magnetic interference from the power cables under the flight controller. Running compassmot or purchasing a GPS+compass module normal resolves this. Other possibilities include bad compass offsets set during the live calibration process or incorrect compass orientation.
3. The vehicle takes off in the wrong direction as soon as loiter is engaged. The cause is the same as #2 except that the compass error is greater than 90deg. Please try the suggestions above to resolve this.
4. The vehicle is loitering 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 GPSGLITCH_RADIUS and/or GPSGLITCH_ACCEL parameters (see GPS glitch wiki page for details) to tighten up on the glitch detection.

Display HDOP on Mission Planner¶

The HDOP value can be made clearly visible through the mission planner’s Quick screen by double clicking and then selecting “gpshdop” from the large grid of checkboxes.

Verifying Loiter performance with dataflash logs¶

Viewing the loiter'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 copter 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).



Checking altitude hold performance is the same as for AltHold mode.

OF_LOITER Mode (Deprecated)¶

OF_LOITER has been deprecated. In older version of Copter (i.e. 3.2.1 and earlier) it was a special version of Loiter mode used the Optical Flow device to maintain position. Newer versions of Copter (3.3.3 and higher) use the PX4Flow sensor in regular Loiter.

PosHold Mode

The PosHold flight mode (previously known as “Hybrid”) is a new mode for AC3.2. It is similar to Loiter in that the vehicle maintains a constant location, heading, and altitude but is generally more popular because the pilot stick inputs directly control the vehicle’s lean angle providing a more “natural” feel.

Overview¶

When switched on, PosHold mode will automatically attempts to maintain the current location, heading and altitude. Good GPS position, low magnetic interference on the compassand low vibrations are all important in achieving good loiter performance.

Controls¶

The pilot can control the copter’s location horizontally and vertically with the control sticks.

- Horizontal location can be adjusted with the the Roll and Pitch control sticks with the default maximum lean angle being 45 degrees (angle can be adjusted with the ANGLE_MAX parameter). When the pilot releases the sticks the copter will lean back to bring the vehicle to a stop.
- Altitude can be controlled with the Throttle control stick just as in AltHold mode
- The heading can be set with the Yaw control stick
- You may arm in PosHold mode but only once the GPS has 3D lock and the HDOP has dropped to 2.0 or lower.

On an APM2 the board’s blue light will become solid when 3D lock is attained. On a Pixhawk the LED will become green (more details on LED patterns here).

The HDOP value can be made clearly visible through the mission planner’s Quick screen by double clicking and then selecting “gpshdop” from the large grid of checkboxes.

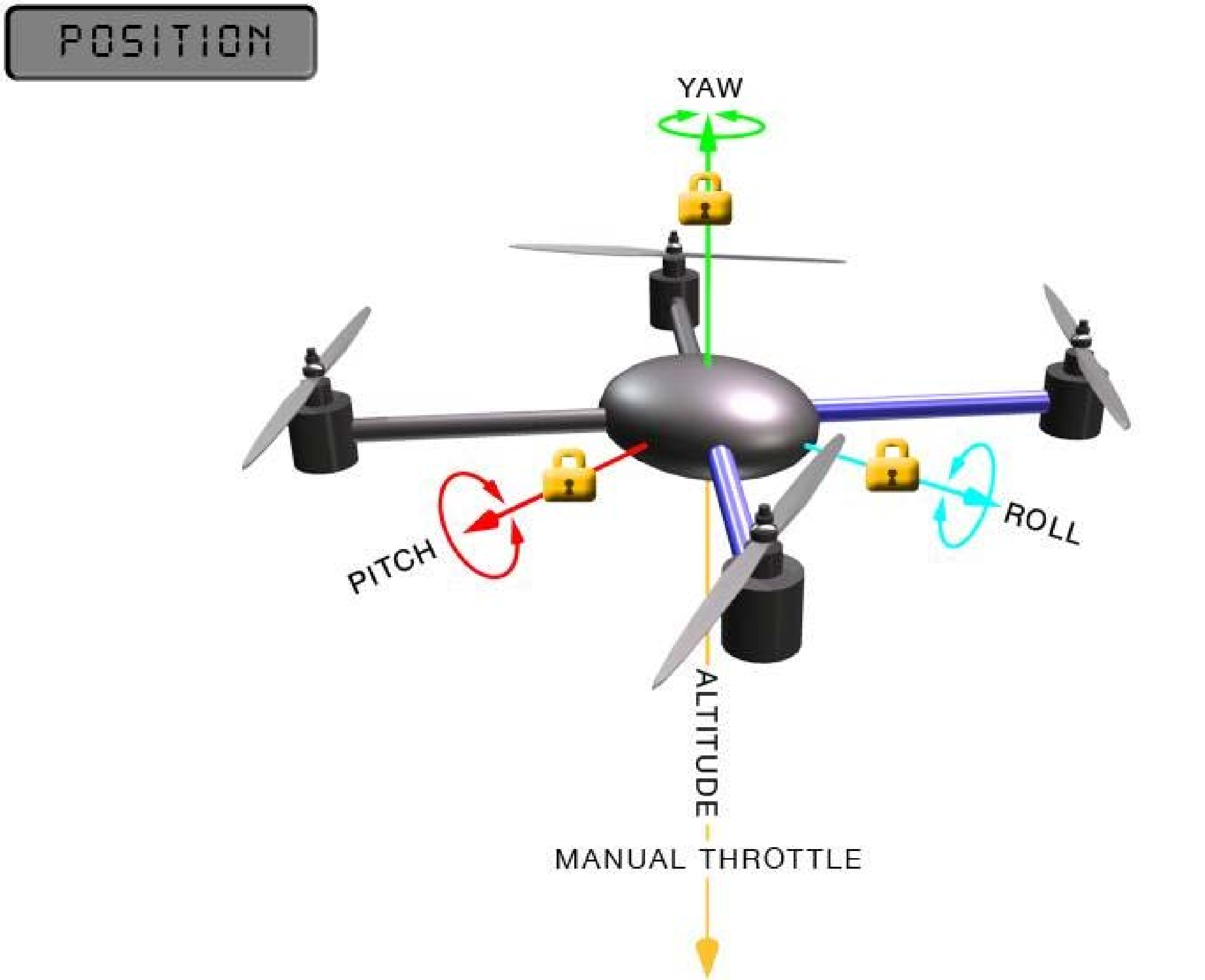
- The maximum brake-angle can be set with the PHLD_BRAKE_ANGLE parameter (i.e. 3000 = the vehicle will lean back up to 30degrees)
- The speed the vehicle rotates back to the maximum angle can be set with the PHLD_BRAKE_RATE parameter (i.e. 8 = rotates back at 8 degrees per second))

Position Mode

Position mode is the same as loiter mode, but with manual throttle control. This means that, in position mode, the copter maintains a consistent location and heading, while allowing the operator to control the throttle manually.

Warning

This mode is not available in AC3.2 and higher.



Position mode is GPS dependent, so it is important to ensure that GPS is locked before arming the copter when using this mode. GPS lock is indicated by the following LED states:

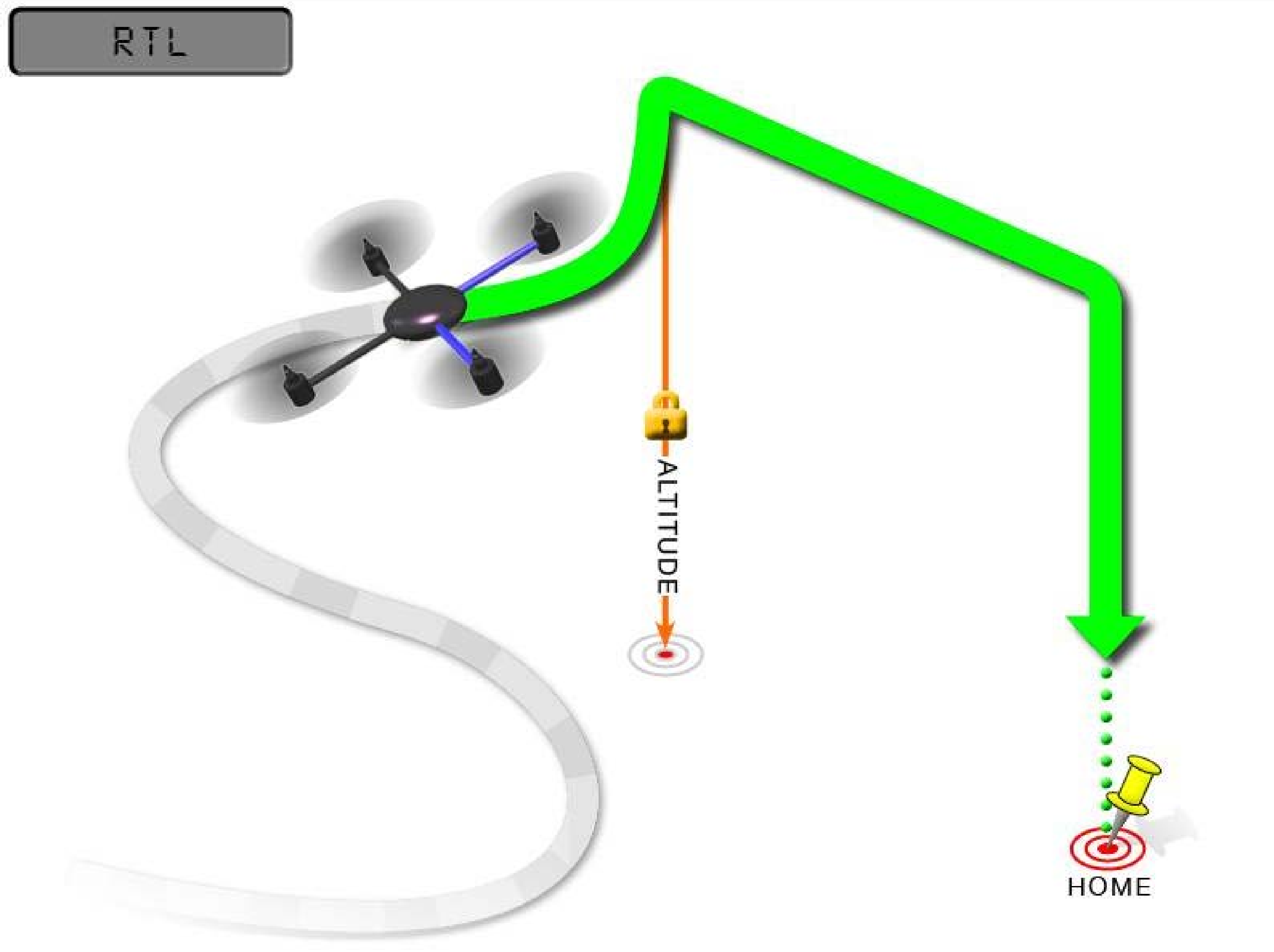
- Blue LED on APM is solid.
- Blue LED on GPS module is solid.
- Blue LED on GPS+Compass module is blinking.

RTL Mode

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

Overview¶

When RTL mode is selected, the copter will return to the home location. The copter will first rise to RTL_ALT before returning home or maintain the current altitude if the current altitude is higher than RTL_ALT. The default value for RTL_ALT is 15m.



RTL is a GPS-dependent move, so it is essential that GPS lock is acquired before attempting to use this mode. Before arming, ensure that the APM's blue LED is solid and not blinking. For a GPS without compass, the LED will be solid blue when GPS lock is acquired. For the GPS+Compass module, the LED will be blinking blue when GPS is locked.

RTL will command the copter to return to the home position, meaning that it will return to the location where it was armed. Therefore, the home position is always supposed to be your copter's actual GPS takeoff location, unobstructed and away from people. For Copter if you get GPS lock and then ARM your copter, the home position is the location the copter was in when it was armed. This means if you execute an RTL in Copter, it will return to the location where it was armed.

Warning

In RTL mode the flight controller 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 (unless you are within 20 feet of the ground and have SONAR installed and enabled).

Options (User Adjustable Parameters)¶

- RTL_ALT: The minimum altitude the copter will move to before returning to launch.
  - Set to zero to return at the current altitude.
  - The return altitude can be set from 1 to 8000 centimeters.
  - The default return altitude Default is 15 meters (1500)
- RTL_ALT_FINAL: The altitude the copter will move to at the final stage of “Returning to Launch” or after completing a Mission.
  - Set to zero to automatically land the copter.
  - The final return altitude may be adjusted from 0 to 1000 centimeters.
- RTL_LOIT_TIME: Time in milliseconds to hover/pause above the “Home” position before beginning final descent.
  - The “Loiter” time may be adjusted from 0 to 60,000 milliseconds.
- WP_YAW_BEHAVIOR: Sets how the autopilot controls the “Yaw” during Missions and RTL.
  - 0 = Never change Yaw.
  - 1 = Face Next Waypoint including facing home during RTL.
  - 2 = Face Next Waypoint except for RTL (i.e. during RTL vehicle will remain pointed at it’s last heading)
- LAND_SPEED: The descent speed for the final stage of landing in centimeters per second.
  - The landing speed is adjustable from 20 to 200 centimeters per second.
- RTL_CLIMB_MIN: The vehicle will climb at least this many meters at the first stage of the RTL. By default this value is zero. (only Copter-3.3 and above)
- RTL_SPEED: The horizontal speed (in cm/s) at which the vehicle will return to home. By default this value is zero meaning it will use WPNAV_SPEED. (only Copter-3.4 and higher)
- RTL_CONE_SLOPE: Defines the slope of an inverted cone above home which is used to limit the amount the vehicle climbs when RTL-ing from close to home. Low values lead to a wide cone meaning the vehicle will climb less, High values will lead to the vehicle climbing more. (supported in Copter-3.4 and higher)

Notes¶

- Other navigation settings also have an influence over RTL mode:
  - WPNAV_ACCEL
  - WPNAV_SPEED_DN
  - WPNAV_SPEED_UP
- To use RTL, GPS lock needs to be achieved (Blue GPS LED and Blue APM LED on solid not blinking) before arming and takeoff to establish the home or launch position.
- Landing and re-arming the copter will reset home, which is a great feature for flying at airfields.

- If you get lock for the first time while flying, your home will be set at the location of lock.
- If you set the `RTL_ALT` to a number at other than 0 it will go to and maintain that altitude while returning.
- RTL uses WPNAV_SPEED to determine how fast it travels.
- Once the copter arrives at the home location the copter will pause for `RTL_LOIT_TIME` miliseconds, timeout (AUTO_LAND), then land.

Simple and Super Simple Modes

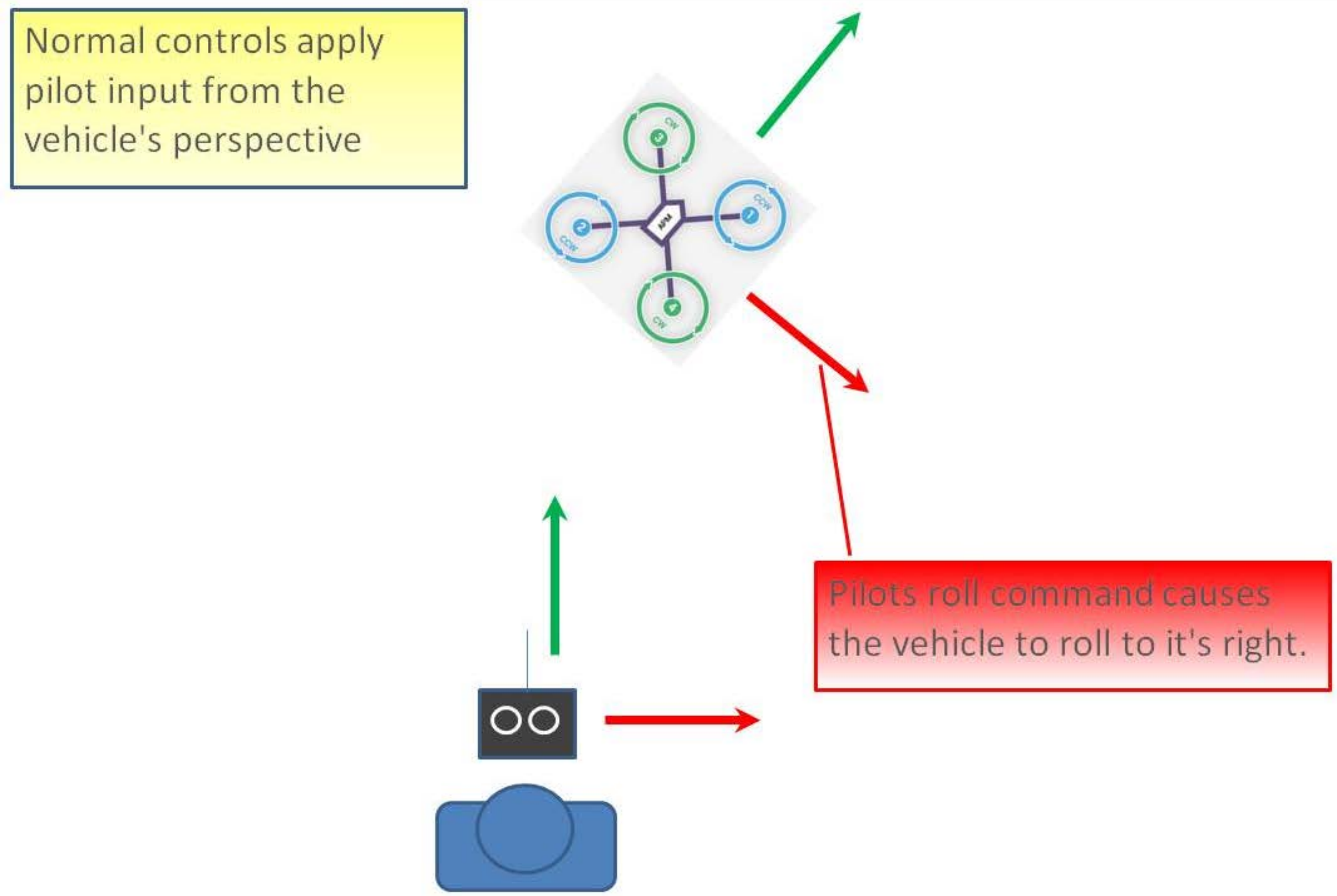
This article describes the behaviour of the *Simple* and *Super Simple* modes and explains how you can set up selection of these modes from your RC Transmitter.

Overview¶

“Simple” and “Super Simple” modes allow the pilot to control the movement of the copter from the pilot’s point of view regardless of which way the copter is facing. This is useful for new pilots who have not mastered adjusting their roll and pitch inputs depending upon which way the vehicle is facing and for cases when the copter is far enough away that it’s heading is not apparent.

- “Simple” and “Super Simple” modes can be used in combination with nearly all flight modes except the Acro and Drift (in these flight modes the setting is ignored).
- Simple Mode allows you to control the copter relative to the copters heading at take off and relies only on a good compass heading.
- Super Simple Mode allows you to control the copter relative to it’s direction from home (i.e. where it was armed) but requires a good GPS position.
- Either mode can be assigned to a particular flight mode switch position or can be enabled/disabled from the Ch7/Ch8 switches.

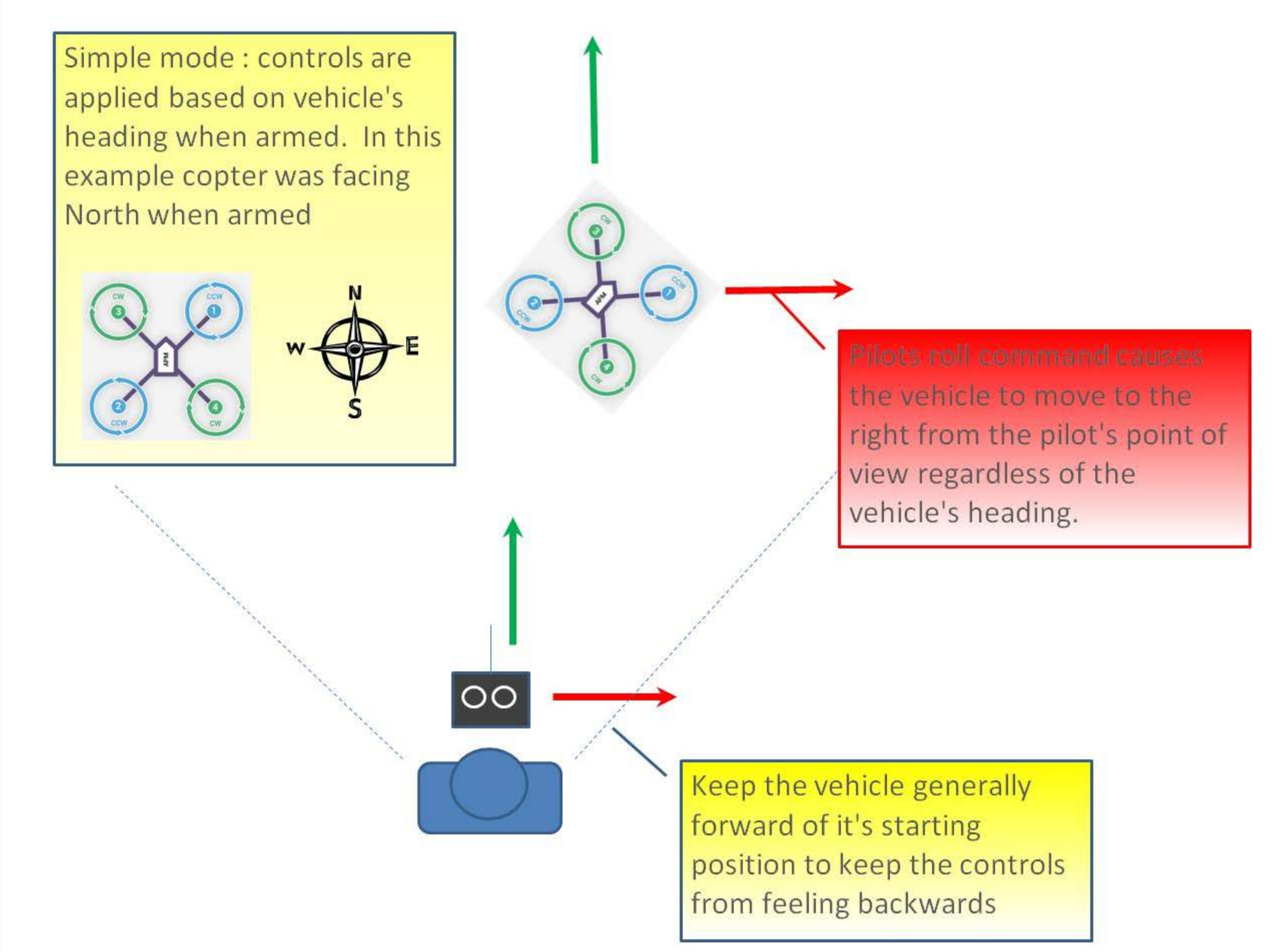
Normal Mode¶



Without Simple or Super Simple enabled, the pilot’s transmitter stick inputs are applied in the orientation of the copter. For example in the diagram above when the pilot applies roll input right (red) the vehicle rolls to it’s right.

With the copter is facing in the same direction as the pilot, it is relatively easy to control the vehicle but when the vehicle is facing towards the pilot an inexperienced pilot will feel that the controls are all reversed. I.e. if the pilot inputs right roll, the vehicle will move to the left from the pilot’s point of view.

Simple Mode¶

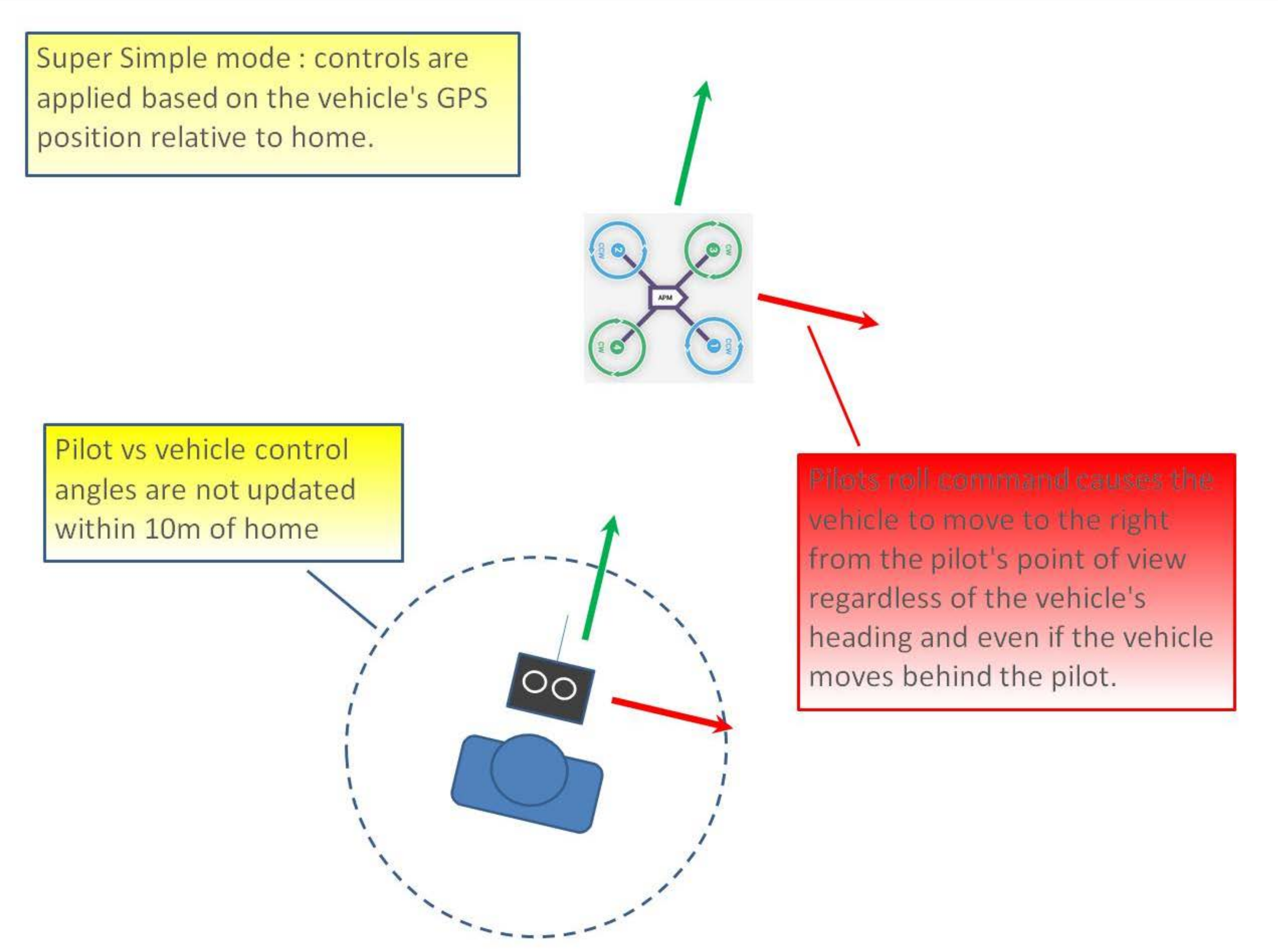


Similar to the “care free” mode on other systems, this mode allows you to fly your copter as though it were pointed in the direction it was pointed when it was armed regardless of its current heading orientation. So if you hold the pitch stick forward the copter will fly away from you, pull the pitch stick back and it will come back towards home. You can even apply yaw to spin the copter in any direction but the movement of the copter’s position relative to the stick inputs will behave exactly as it did at take off.

Generally when arming you should stand behind the vehicle with it’s nose pointing directly away from you. While flying you should try to keep the vehicle flying in front of it’s starting position because if it flies behind you all the controls will feel reversed.

As mentioned above simple mode is also very useful in emergency situations where the copter is far enough away that it is very difficult to determine it’s heading.

Super Simple Mode¶



Super Simple mode is the same as simple mode except that it uses the vehicle’s position relative to home instead of the vehicle’s initial heading when it was armed. This means that no matter where the vehicle is, pulling the pitch back will cause it to return towards home regardless of the vehicle’s actual heading.

The advantage over simple mode is that the controls are applied from the pilot’s point of view even when the copter flies behind the pilot/home location.

If the pilot holds full right roll the vehicle will fly a circle clockwise around the pilot (although the circle’s radius may tend to grow slightly with each orbit due to “lag”).

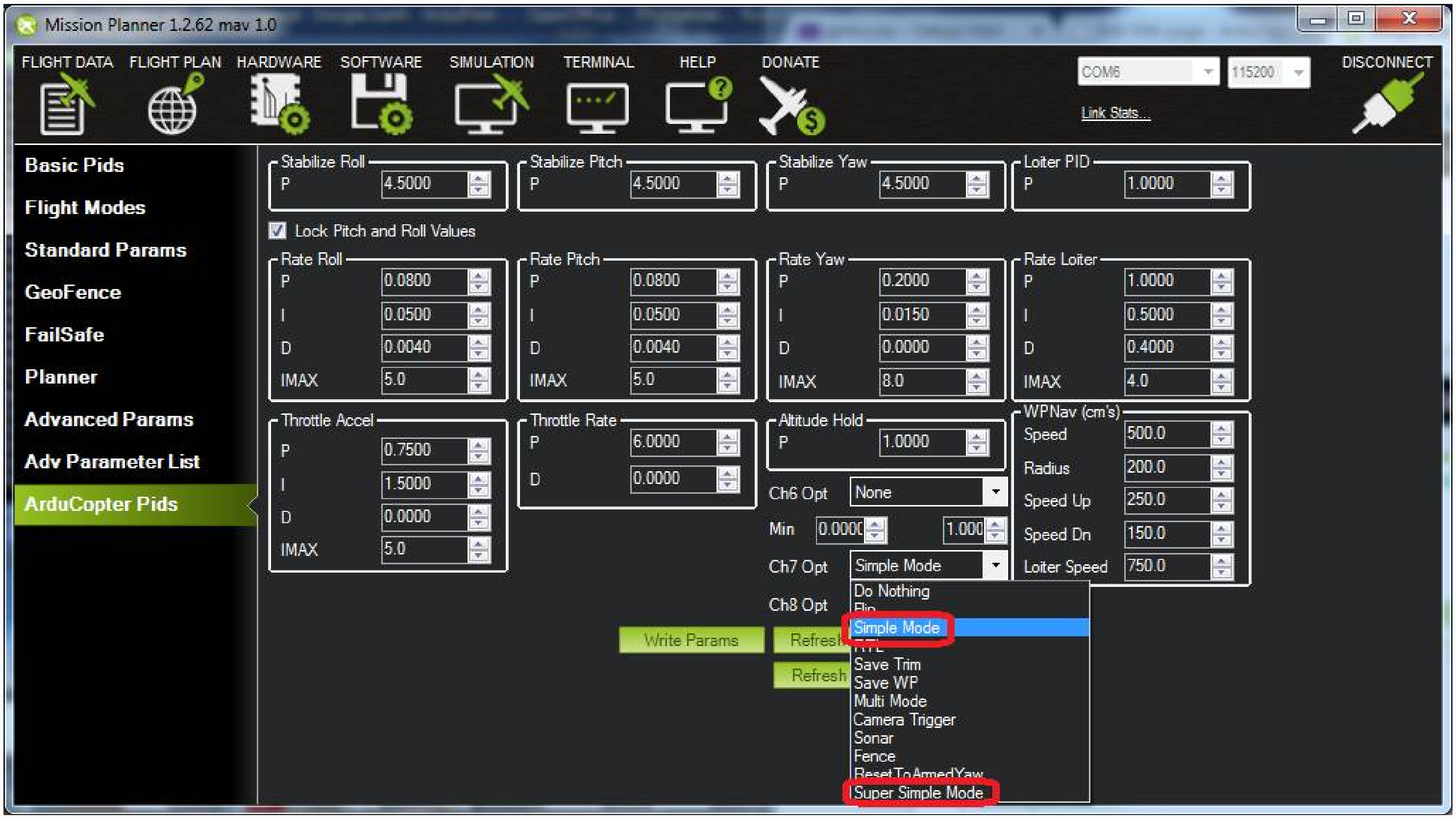
The disadvantage is that mode require a GPS lock because so you should ensure you have GPS lock before take-off.

The orientation is not updated when the vehicle is within 10m of home meaning close fly-bys of the home location should be avoided.

To ensure the controls are correct right at take-off, as with simple mode, you should arm with the pilot standing behind the vehicle and with both pilot and vehicle pointing in the same direction.

Selecting the modes from a transmitter¶

The transmitter's auxiliary channels can be set-up to enable selection of Simple mode, Super Simple mode or both. Only one auxiliary channel should be set for these modes, and this channel will override the simple/super-simple options selected on the Flight Modes screen.



Mission Planner: Channel 7 options for Simple andSuperSimple modes

To support selection of just one of the modes from the transmitter, assign the mode to a channel that is mapped to a 2-position switch (high = enables the selected mode, low disables it). To enable both modes from the same switch, select *Super Simple mode* for a channel that is mapped to a 3-position switch (high position = Super Simple mode, middle position = Simple mode, low position = disabled).

Sport Mode

Sport Mode is also known as "rate controlled stabilize" plus Altitude Hold.

Overview¶

- It was designed to be useful for flying FPV and filming dolly shots or fly bys because you can set the vehicle at a particular angle and it will maintain that angle.
- The pilot's roll, pitch and yaw sticks control the rate of rotation of the vehicle so when the sticks are released the vehicle will remain in it's current attitude.
- The vehicle will not lean more than 45 degrees (this angle is adjustable with the ANGLE_MAX parameter)
- The altitude is maintained with the altitude hold controller so the vehicle will attempt to hold it's current altitude when the sticks are placed with 10% of mid-throttle. It will climb or descend at up to 2.5m/s (this speed is adjustable with the PILOT_VELZ_MAX parameter)

Stabilize Mode

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

Tip

If you're learning to fly, try Alt Hold or Loiter instead of Stabilize. You'll have fewer crashes if you don't need to concentrate on too many controls at once.

Overview¶

- Pilot's roll and pitch input control the lean angle of the copter. 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 it's 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 (MOT_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 stabilize if the autopilot fails to control the vehicle. Maintaining control of your copter is your responsibility.

Tuning¶

AC3.1 (and higher) includes AutoTune which may allow you to automatically determine the best

Stabilize and Rate PID values. It is highly suggested running AutoTune on your vehicle rather than manually adjusting PIDs.

- ANGLE_MAX controls the maximum lean angle which by default is 4500 (i.e. 45 degrees)
- ANGLE_RATE_MAX controls the maximum requested rotation rate in the roll and pitch aixs which by default is 18000 (180deg/sec).
- ACRO_YAW_P controls how quickly copter rotates based on a pilot's yaw input. The default of 4.5 commands a 200 deg/sec rate of rotation when the yaw stick is held fully left or right. Higher values will make it rotate more quickly.
- Stabilize Roll/Pitch P controls the responsiveness of the copter's roll and pitch to pilot input and errors between the desired and actual roll and pitch angles. The default of 4.5 will command a 4.5deg/sec rotation rate for each 1 degree of error in the angle. A higher gain such as 7 or 8 will allow you to have a more responsive copter and resist wind gusts more quickly.
  - A low stabilize P will cause the copter to rotate very slowly and may cause the copter to feel unresponsive and could cause a crash if the wind disturbs it. Try lowering the RC_Feel parameter before lowering Stability P if smoother flight is desired.
- Rate Roll/Pitch P, I and D terms control the output to the motors based on the desired rotation rate from the upper Stabilize (i.e. angular) controller. These terms are generally related to the power-to-weight ratio of the copter with more powerful copters requiring lower rate PID values. For example a copter with high thrust might have Rate Roll/Pitch P number of 0.08 while a lower thrust copter might use 0.18 or even higher.
  - Rate Roll/Pitch P is the single most important value to tune correctly for your copter.
  - The higher the P the higher the motor response to achieve the desired turn rate.
  - Default is P = 0.15 for standard Copter.
  - Rate Roll/Pitch I is used to compensate for outside forces that would make your copter not maintain the desired rate for a longer period of time
  - A high I term will ramp quickly to hold the desired rate, and will ramp down quickly to avoid overshoot.
  - Rate Roll/Pitch D is used to dampen the response of the copter to accelerations toward the desired set point.
  - A high D can cause very unusual vibrations and a "memory" effect where the controls feel like they are slow or unresponsive. A properly mounted controller should allow a Rate D value of .011.
  - Values as low as 0.001 and as high as .02 have all been used depending upon the vehicle.

Verifying performance with dataflash logs¶

Viewing the stabilize mode performance is best done by downloading a dataflash log from your flight, then open it with the mission planner and graph the ATT message's Roll-In or DesRoll (pilot desired roll angle) vs Roll (actual roll) and Pitch-In or DesPitch (desired pitch angle) vs Pitch (actual pitch angle). These two should track well as shown below.

Common Problems¶

- new copter 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 apm2 or pixhawk.
- copter wobbles on roll or pitch axis. This usually means the Rate P values are incorrect. See Tuning section above for some hints as to how to adjust these gains.
- copter wobbles when descending quickly. This is caused by the copter falling through it's own props wash and is nearly impossible to tune out although raising the Rate Roll/Pitch P values may help.
- copter yaw right or left 15degrees on take-off. Some motors may not be straight or the ESCs have not been calibrated.
- copter always tends to fly in one direction even in a windless environment. Try SaveTrim or AutoTrim to level the copter.
- copter 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 calibrating them.
- sudden flips during flight. This is nearly always caused by mechanical failures of the motor or ESCs.

Throw Mode

This slightly dangerous flight mode allows the pilot to throw the vehicle into the air (or drop the vehicle) in order to start the motors. Once in the air, this mode does not accept any input from the pilot. This mode requires GPS.

Warning

Use with caution! It is dangerous to get close to an armed multicopter as is required to throw the vehicle. It is recommended to takeoff normally instead of using throw mode whenever possible.

Note

The Throw flight mode was introduced in AC3.4.

How To Use¶

1. Disarm copter
2. Switch to throw mode
3. Check GPS light is green
4. Arm copter and listen for ready tune (if vehicle has a buzzer). The motors will not spin by default.
5. Pick up the vehicle and throw it up and away from you (it must climb by 50cm/s and reach a total speed of 5m/s)
6. Once the vehicle has stopped, switch the flight mode to Loiter (or other mode) to retake manual control

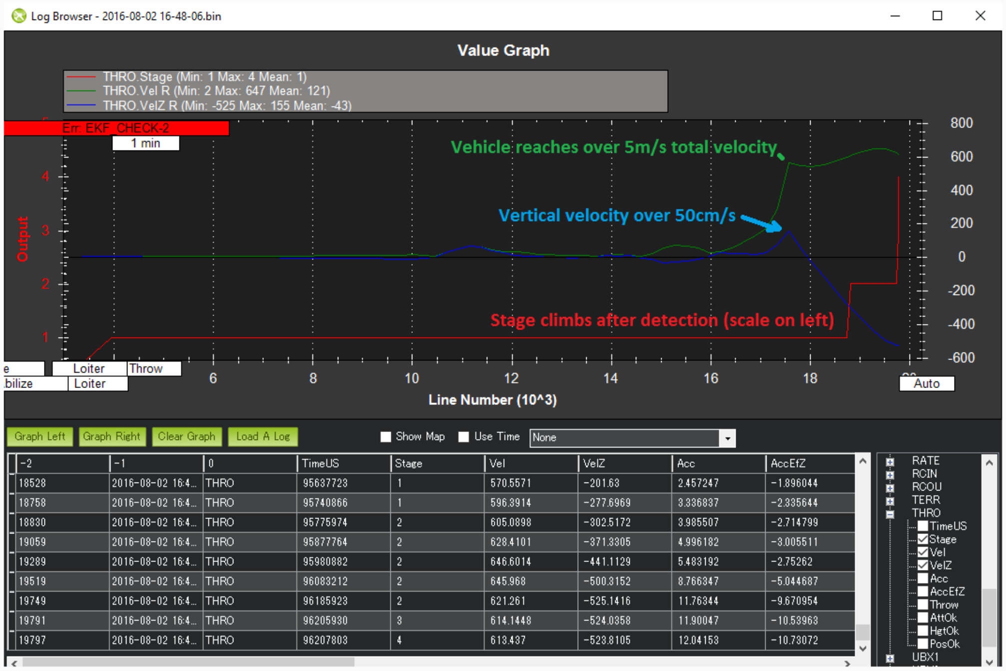
The motors should start when the vehicle reaches the apex of it’s trajectory. After the motors start this flight mode will first try to control it’s attitude (return to level and stop rotating), then stop descending and finally it will attempt to stop moving horizontally.

Settings¶

- THROW_TYPE : set to 0 if throwing the vehicle up, 1 if dropping the vehicle. If dropping, drop from a height of at least 10m.
- THROW_MOT_START : controls whether the motors will spin slowly or not at all while waiting for the throw (0 = stopped, 1 = spinning slowly). The default is 0 (will not spin after arming).
- THROW_NEXTMODE : the vehicle will switch into this flight mode after stopping (Auto, Guided, RTL, Land and Brake are support). Set to “Throw” (the default) to simply remain in Throw mode and wait for the pilot to switch modes manually

Log Analysis¶

During the throw, THRO messages are written to the dataflash log. These can be useful in diagnosing problems in case the motors failed to start as part of a throw. The graph below shows a successful throw in which the overall velocity climbs above 5m/s and the vertical velocity is over 0.5m/s.



Pre-Arm Safety Check

Copter includes a suite of Pre-arm Safety Checks which will prevent the vehicle from arming if any of a fairly large number of issues are discovered before take-off including missed calibration, configuration or bad sensor data. These checks help prevent crashes and fly-aways but they can also be disabled if necessary.

Recognising which Pre-Arm Check has failed using the GCS

The pilot will notice a pre-arm check failure because he/she will be unable to arm the copter and the LED will be flashing yellow. To determine exactly which check has failed:

1. Connect the Flight Controller to the ground station using a USB cable or Telemetry.
2. Ensure the GCS is connected to the vehicle (i.e. on Mission Plannerand push the “Connect” button on the upper right).
3. Turn on your radio transmitter and attempt to arm the vehicle (regular procedure using throttle down, yaw right)
4. The first cause of the Pre-Arm Check failure will be displayed in red on the HUD window

Failure messages

RC failures (i.e. transmitter/receiver failures):

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, the MIN must be less than 1300 and the MAX greater than 1700.

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. Acclerometer 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:

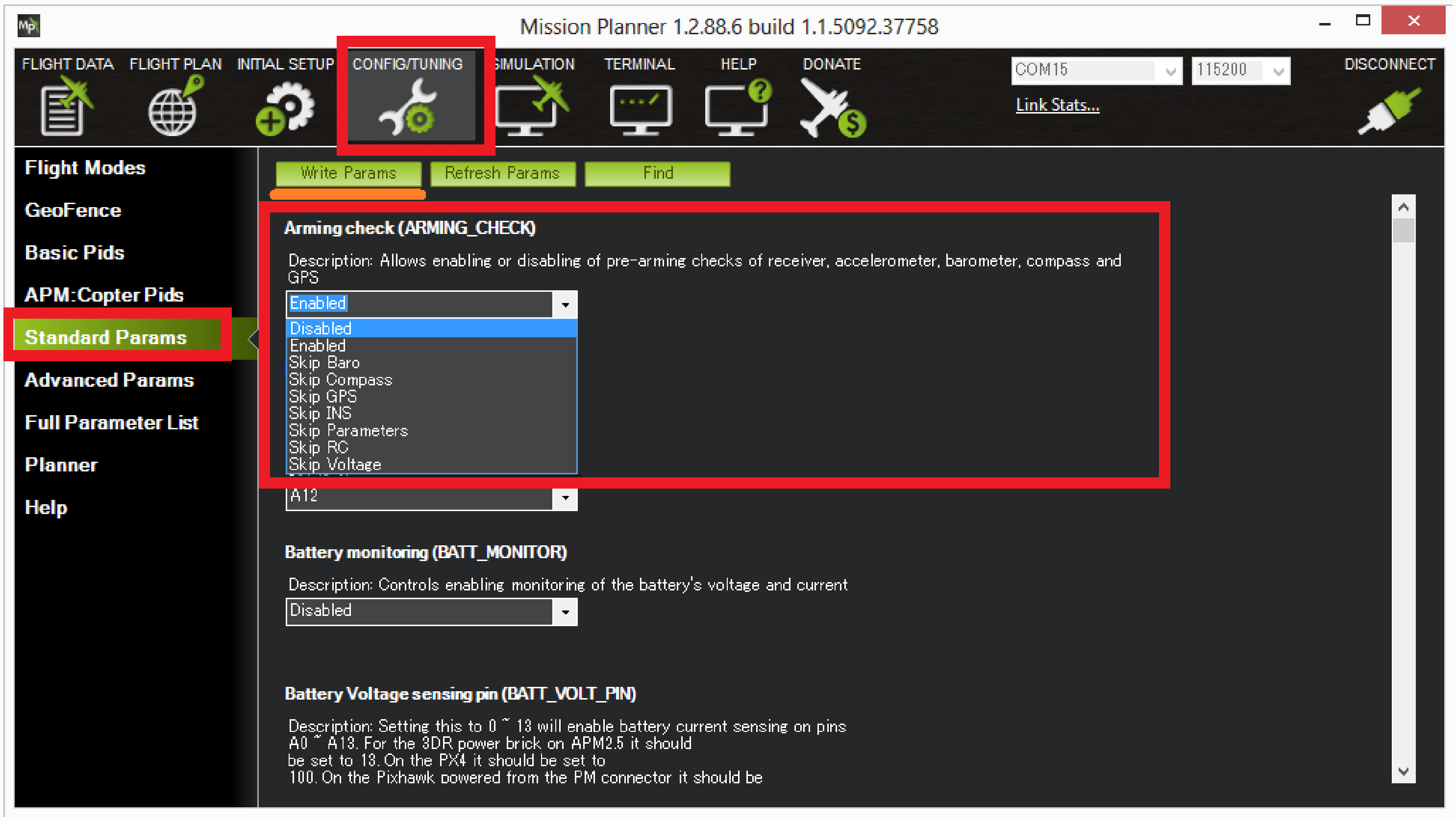
Ch7&Ch8 Opt cannot be same: Auxiliary Function Switches are set to the same option which is not permitted because it could lead to confusion.

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).

ACRO_BAL_ROLL/PITCH: the ACRO_BAL_ROLL parameter is higher than the Stabilize Roll P and/or ACRO_BAL_PITCH parameter is higher than the Stabilize Pitch P value. This could lead to the pilot being unable to control the lean angle in ACRO mode because the Acro Trainer stabilization would overpower the pilot's input.

Disabling the Pre-arm Safety Check



If you are confident that the pre-arm check failure is not a real problem you can disable the checks by:

- Connecting your Flight Controller to the Mission Planner
- Go to Mission Planner's Config/Tuning >> Standard Params screen
- set the Arming Check drop-down to "Disabled" or one of the "Skip" options which more effectively skips the item causing the failure.
- Push the "Write Params" button

Ideally however you should determine the cause of the pre-arm failure and if it can be resolved, return the Arming Check parameter back to "Enabled"

Arming the motors

Arming the motors

Before arming the motors, make sure all people and objects are clear of the propellers. Then do the following:

1. Turn on your transmitter
2. Plug in your LiPo battery. The red and blue lights should flash for a few seconds as the gyros are calibrated (do not move the copter)
3. The pre-arm checks will run automatically and if any problems are found an APM2.x will double blink the red arming light, on a Pixhawk the RGB led will blink yellow. Please refer tothis page.
4. Check that your flight mode switch is set to Stabilize, ACRO, AltHold or Loiter.
5. If using a PX4, press the safety button until the light goes solid.
6. If you are planning on using the autopilot (i.e. Loiter, RTL, Drift, Auto or Guided modes) you should wait for 30 seconds after the GPS has gotten 3d lock. This will give the GPS position time to settle. On APM2 the GPS lock is indicated by the blue LED going solid. On an Pixhawk the RGB LED will blink green.
7. Arm the motors by holding the throttle down, and rudder right for 5 seconds. It takes approximately 5 seconds the first time the copter is armed as it re-initialises the gyros and barometer. Do not hold the rudder right for too long (>15 seconds) or you will begin the AutoTrim feature.
8. Once armed, the red arming light should go solid and the propellers will begin to spin slowly. The speed they spin can be adjusted with the MOT_SPIN_ARMED parameter.
9. Raise the throttle to take-off.

Note

You can only arm or disarm in Stabilize, ACRO, AltHold and Loiter mode.
Note

If you leave the throttle at minimum for 15 seconds while in any of the above modes the motors will automatically disarm.

Disarming the motors

To disarm the motors do the following:

1. Check that your flight mode switch is set to Stabilize, ACRO, AltHold or Loiter
2. Hold throttle at minimum and rudder to the left for 2 seconds
3. The red arming light should start flashing on the APM2. On the Pixhawk the RGB LED will start

flashing green.

4. If using a PX4, press the safety button until the led begins flashing
5. Disconnect the Lipo battery
6. Turn off your transmitter

Tips For New Pilots

This page gives some advice on initial flying strategies for those with limited or no previous experience flying RC aircraft or multicopters.

First flight

Place the copter on level ground and connect the battery — do not move the copter until gyroscope calibration is completed (LED's flashing red and blue). Ensure that your RC mode toggle switch is in Stabilize mode. Slowly raise the throttle until the copter just lifts off the ground.

If it seems like it's going to flip or otherwise isn't lifting straight up it is possible that you've set the wrong +/x orientation, hooked up your motors in the wrong order or have the prop direction or pusher/puller order wrong. You can test this by following the instructions in Testing motor spin directions.

If any of the controls are reversed (pitch or roll are backwards, meaning the copter moves in the opposite direction as your stick), you'll need to reverse the affected channel at your RC transmitter side. Please see your RC transmitter's manual if you're not familiar with the process. It's a good idea to re-do your RC calibration in the Mission Planner after you've reversed a channel.

If it lifts off smoothly, you may see a little yaw. That shouldn't be more than about 30 degrees and will correct itself with more flying time. There should be no pronounced wobble (if there is, you may have an unbalanced prop or out-of-true motor).

The copter should also tend to stay in place, and you shouldn't have to fight strong tendencies to move left or right or forward or back. If you do see that behavior, do NOT use your RC trims to correct (this just throws off the calibration). Instead, it probably means that the copter may not have been completely flat during calibration or the airframe is out of true (one motor tilted). Land and correct that.

If you're having trouble and the copter is not hovering smoothly, run through the troubleshooting guide.

Assuming that all is fine so far, you're ready for more advanced modes, such as Alt Hold and Loiter.

Tips for your first flights

- Make sure you are in a wind free environment. (Wind will play against you on in air auto trim.)
- Make sure you have no trim on your Radio. (The APM is what we want to trim, the radio should never get trimmed.)
- Hold the copter still and level after connecting the battery to allow the gyroscopes to initialize.
- Get above ground effect, around 3-4 feet is enough on most models.
- Make sure to practice a lot before you actually try the auto trim to find the sweet spot on the Radio right stick to have the copter super stable and not moving. (This is where wind affect your inputs.)
- We recommend not starting in Simple mode. Begin your flying in the basic Stabilize mode.
- Copter establishes its home position at the time of arming, so arm your copter in the location you wish to designate as the home position.

Warning about low batteries

When flying Copter, you need to keep in mind that it flies much differently than a winged airplane. In an airplane, lift is generated by the wing and you still have control surfaces for maneuvering if the motor were to stop. Multicopters generate lift solely from the thrust of the motors, so if your battery is excessively depleted, you have no lift and no control over your Copter, and it may flip over and crash without a gradual warning. During first flights, fly only short durations until you know your battery consumption and use one of the following batteries monitoring methods to ensure that you always have enough power remaining to safely land your copter (and not ruin the battery).

- The APM 2.5 power module and PX4 have Battery voltage monitoring built in. For more information, visit the 3DR Power Module for Measuring Voltage and Current page.
- You may also program your ESCs to use a slow or no cutoff at low voltages.
- For APM 2 or 2.5 without power module it is HIGHLY recommended you install a Battery Voltage Monitor.
  - For 3S LiPo batteries, the two wires can be soldered to the P-PCB directly, or you can connect to the balancing plug of your battery.
  - The battery voltage monitor linked above has a buzzer and LEDs that function as follows:

Voltage	LED	Buzzer
11.0v	Solid Blue	Off
10.0v - 11.0v	Flashing Blue	Off
9.8v - 10.0v	Solid Red	Off

9.8v	Flashing Red	On

Note

If you are using a battery monitor, always connect the main LiPo battery wire before connecting the balancing port wire to the APM.

Basic Tuning

This topic covers basic Roll and pitch and throttle tuning.

Overview

After your first flight, you may notice that you copter doesn’t respond to control inputs the way you want it to or you may have trouble maintaining control of your copter. If you are familiar with PID controllers, check out the advanced tuning guide here. If you are an experienced operator, try out the autotune feature. This page will cover the basic tuning section of Mission Planner and APM Planner that simplified the complex tuning process into a few simple sliders. This is the best tuning method for new operators.

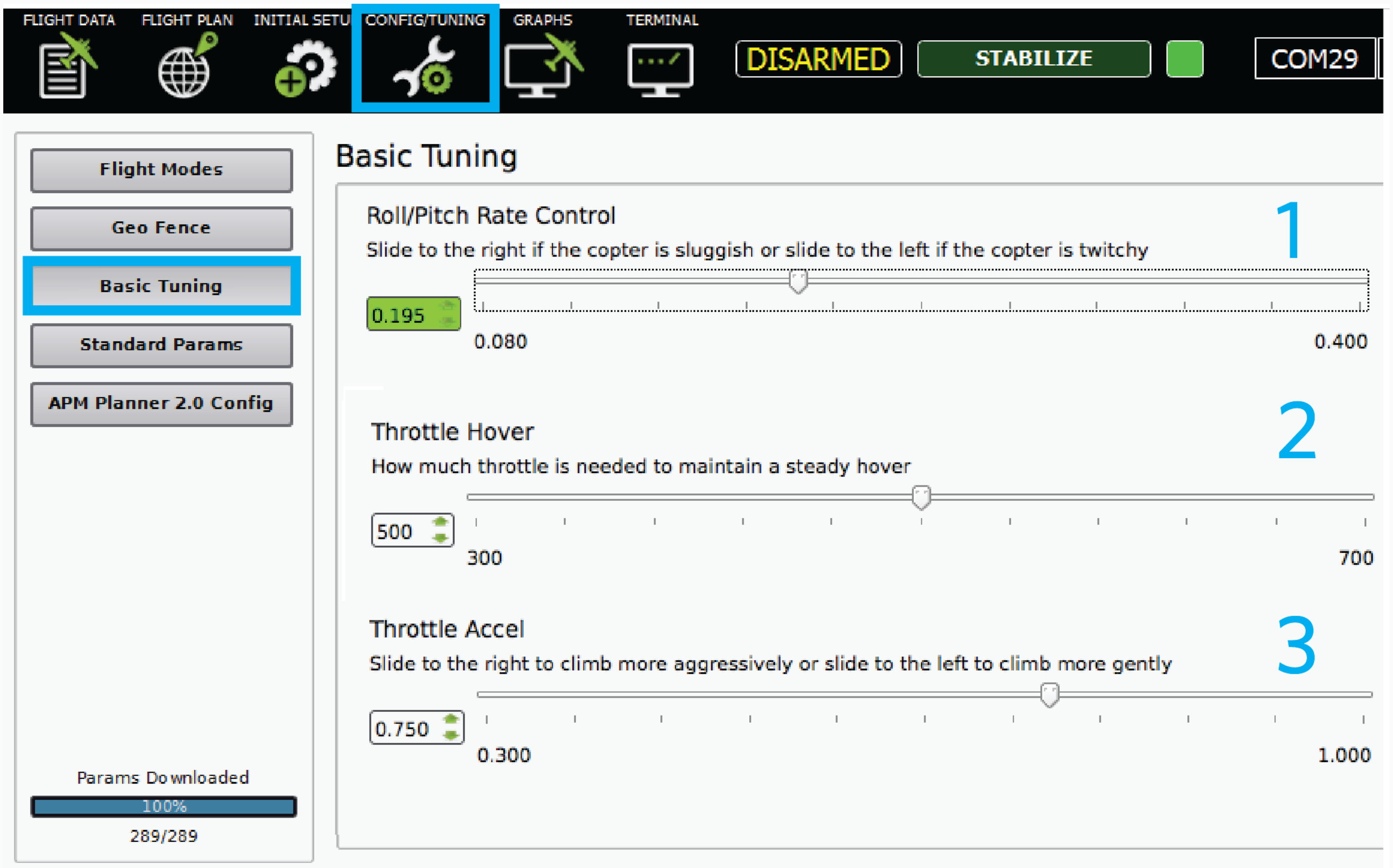
Roll and pitch tuning

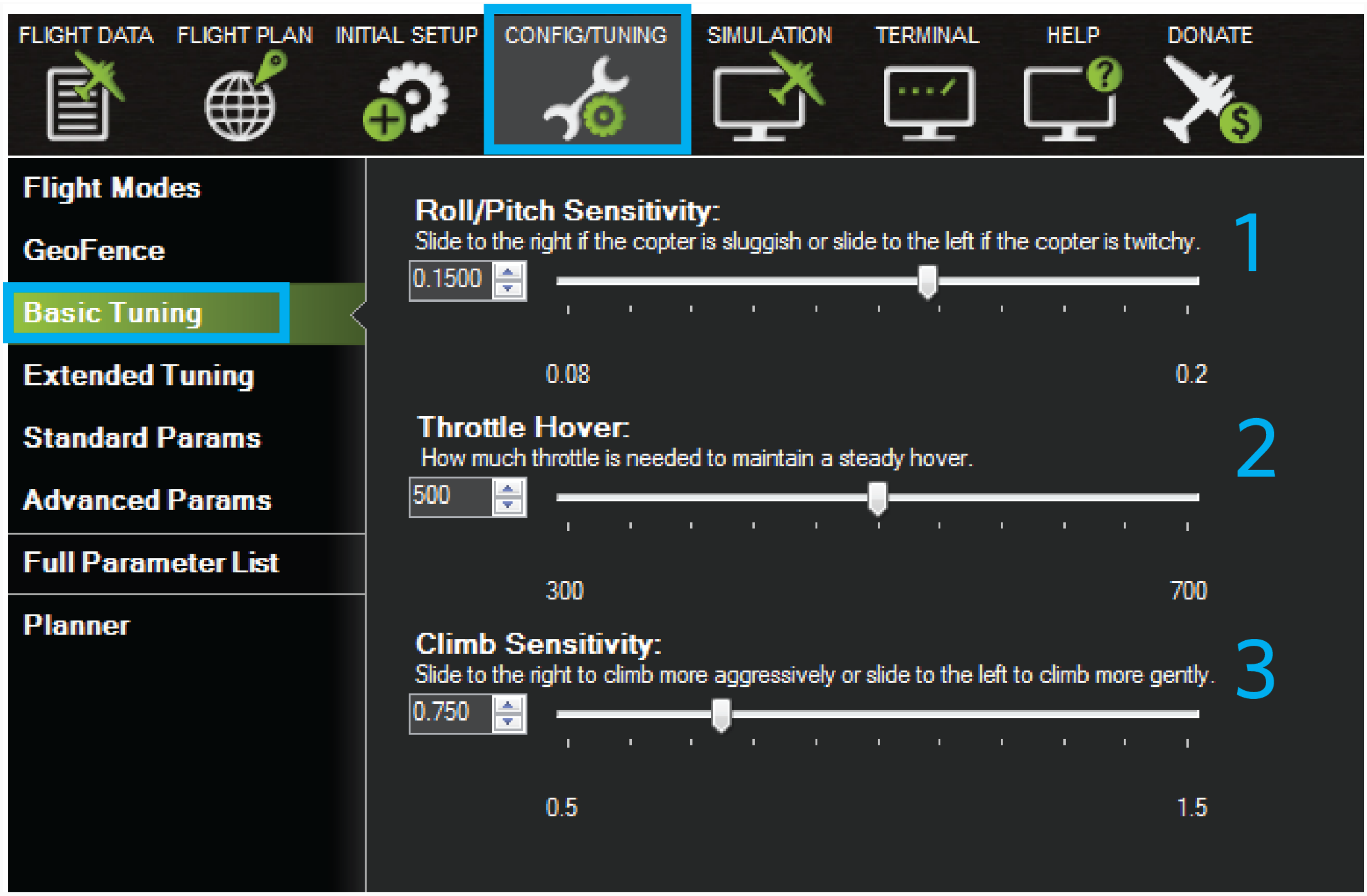
Tuning is easiest at the field using a telemetry radio. Perform an initial flight with the following questions in mind:

- How does the copter respond to roll and pitch? Is the response more sluggish or twitchy than you want?
- When the copter is hover, what level is the throttle set at? Does it hover at the middle position of the stick or is it above or below the center position?
- When raising the throttle, what rate does the copter accelerate at? Does it gain altitude more slowly or more quickly than you want?

Connect the telemetry radio ground module to your ground station computer and open either Mission Planner or APM Planner. Select the correct COM port and select Connect. You should see live data on the Flight Data screen. To begin tuning, select Config/Tuning and Basic Tuning.

Start with the Roll/Pitch slider at the top of the page. If you observed that your copter was too twitchy in response to roll and pitch controls, move the slider one tick mark to the left, or, if you observed that your copter was too sluggish, move the slider one tick mark to the right. Repeat your flight to determine if the change was beneficial. Repeat the process until you are satisfied with the way your copter responds to roll and pitch.





Throttle tuning

The bottom two sliders allows you to tune the throttle control. Adjust the slider marked Throttle Hover until the copter hovers at the throttle stick's middle position. If the copter hovers with the throttle stick above middle position, move the slider to the left by one tick-mark until it hovers at mid-stick, testing as you go. If the copter hovers with the throttle stick below middle position, move the slider to the right by single tick-mark increments until it does. Make sure to test each set of tuning settings as you go.

Move the slider marked Throttle Accel or Climb Sensitivity to the right to have the copter gain altitude more aggressively or to the left to have the copter gain altitude more gently. Test each increment after setting to evaluate the tune.

Setting Throttle Mid (aka Hover Throttle)

Note

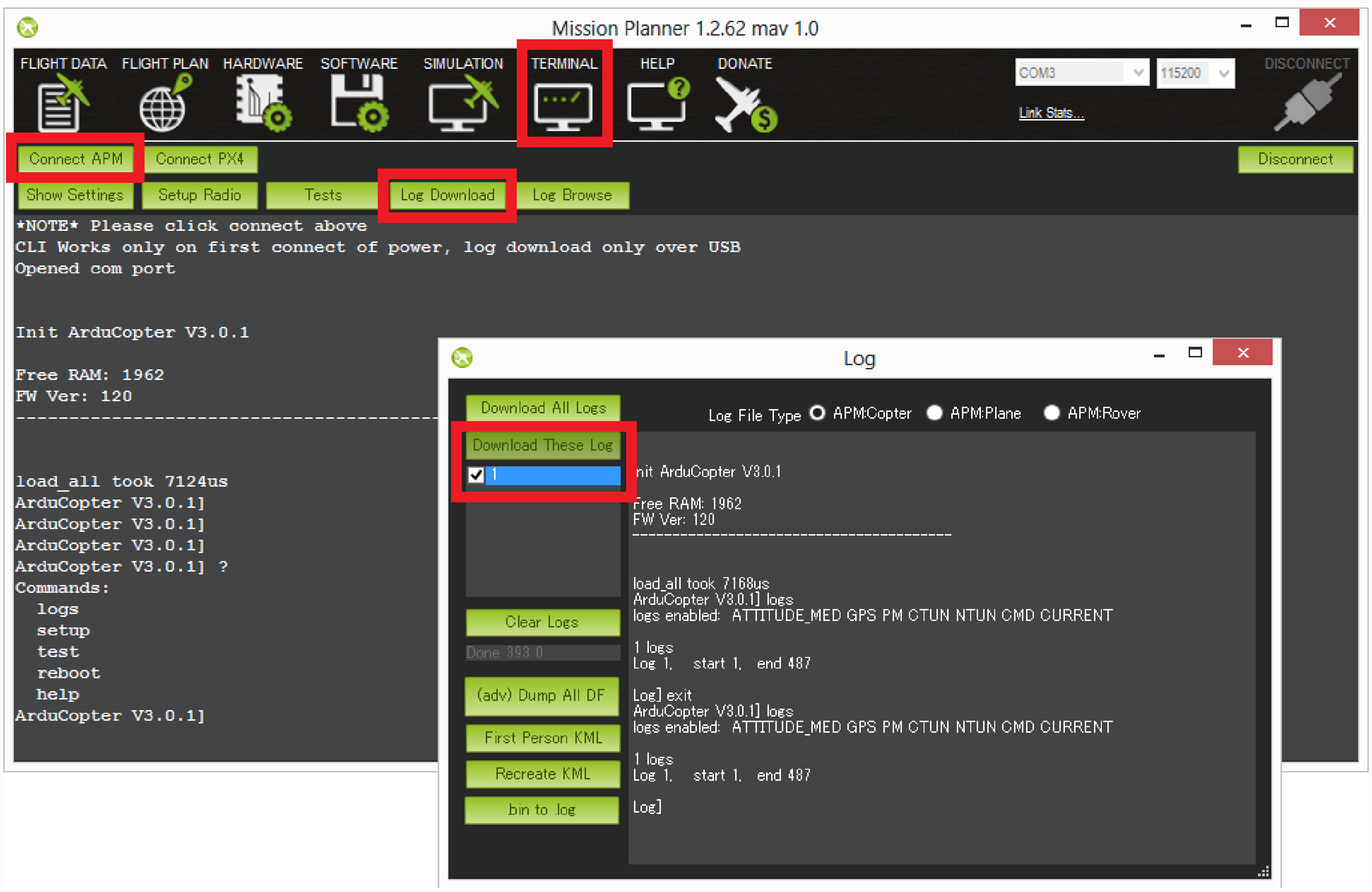
Copter-3.4 (and higher) includes automatic learning of hover throttle which means manually setting the parameter is generally not required.

If you have a slightly overpowered or underpowered copter the throttle required to keep the vehicle in a stable hover may be under 40% or over 60%. Although this is fine while flying purely stabilize mode it can lead to a rough transition to autopilot modes (Alt Hold, Loiter) where having the throttle outside of the 40% ~ 60% deadzone will be interpreted as meaning you want the copter to climb or descend.

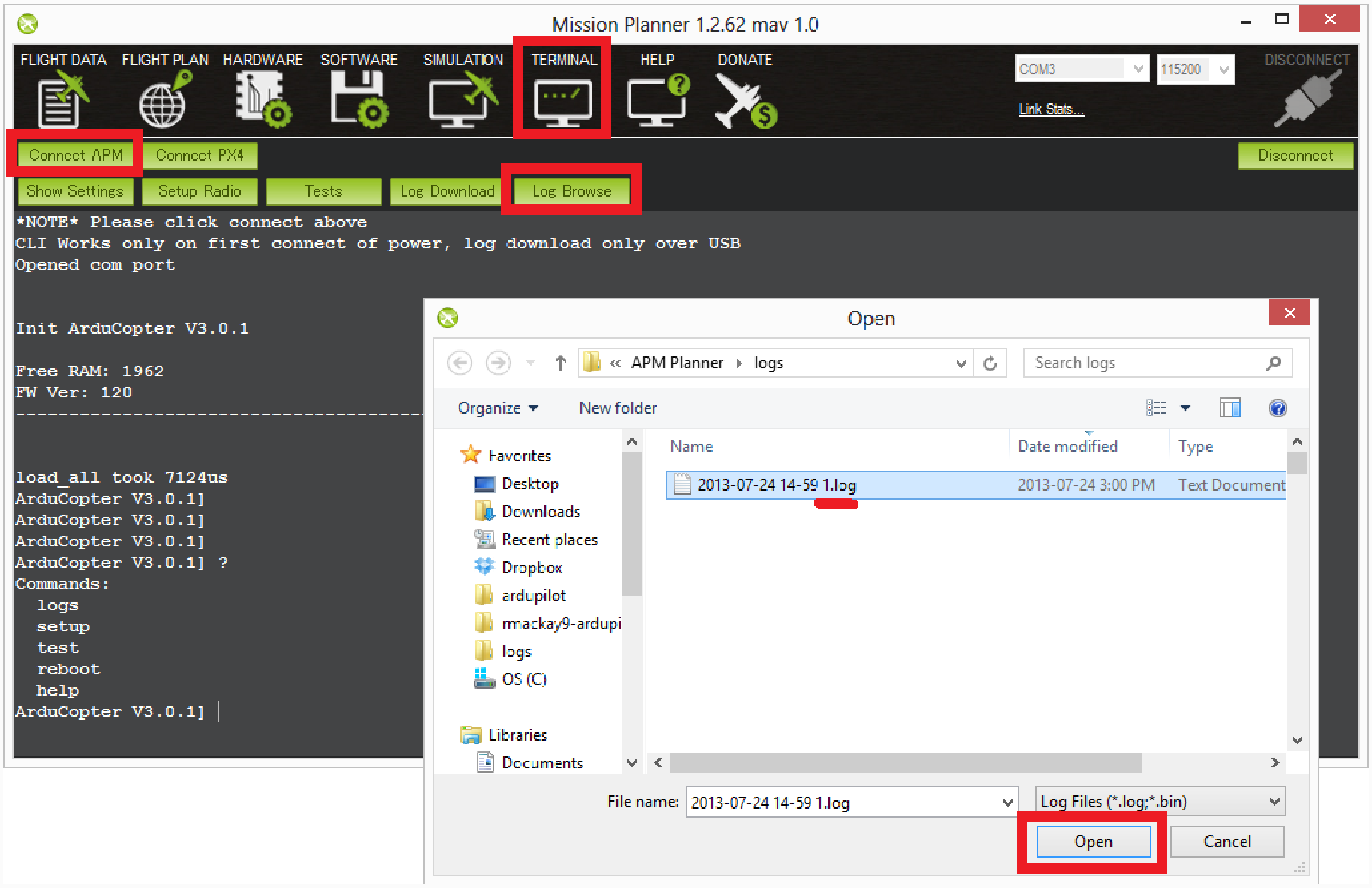
For this reason it is a good idea to adjust the Throttle Mid parameter (also known as THR_MID) so that your mid throttle while in stabilize mode is closer to 50%.

Please follow these instructions to adjust your manual throttle to so that your copter hovers at 50% throttle:

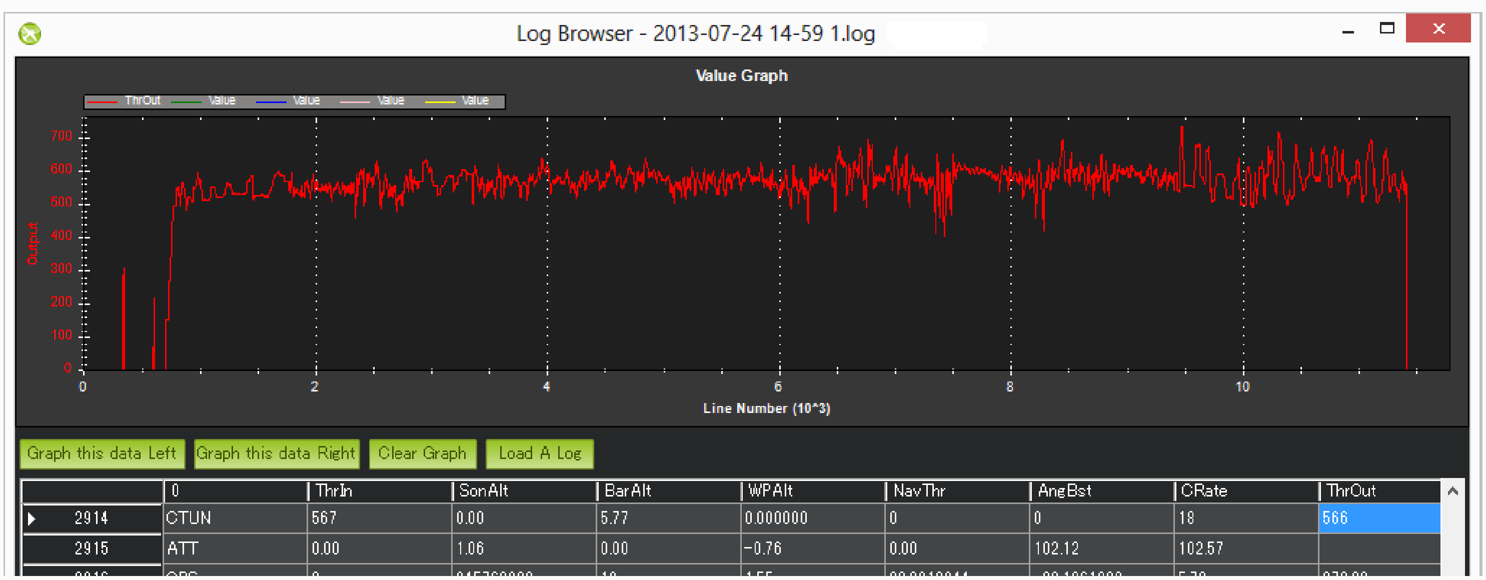
- Fly your copter in stabilize mode in a stable hover for at least 30 seconds
- Disconnect your lipo battery and connect your APM/PX4 to the Mission Planner
- Go to the Terminal screen and download your latest dataflash log file (more details on working with dataflash logs can be found here)



- After the download has completed, close the “Log” window and push the “Log Browse” button and open the latest file in the log directory (it’s last digit will be the Log number you downloaded so in the example above we downloaded Log #1 so the filename will end in 1.log)



- When the Log Browser appears, scroll down until you find any CTUN message. Click on the row's "ThrOut" column and push "Graph this data Left" button.



- While referring to the scale on the left of the graph, estimate approximately what the throttle level was during the hover. In the example above (which was an unnecessarily long flight) the mid throttle appears to be about 550.

- Note: if the average throttle is below 300 (i.e. 30%) then you have a very overpowered copter and it would be best to add a some extra weight (i.e. a bigger battery perhaps) or reduce the power in some other way (smaller motors, move from a 4S to a 3S battery, etc)
- If the average throttle is above 700 (i.e. 70%) then you have a very underpowered copter. You should consider increasing the power of the motors and ESCs or use a higher voltage battery (i.e. switch from a 3S to a 4S battery).

Open the Mission Planner's Software > Standard Params screen and update the Throttle Mid Position (THR_MID) to the value estimated above (you'll find it near the bottom of the list)

Push the Write Params button

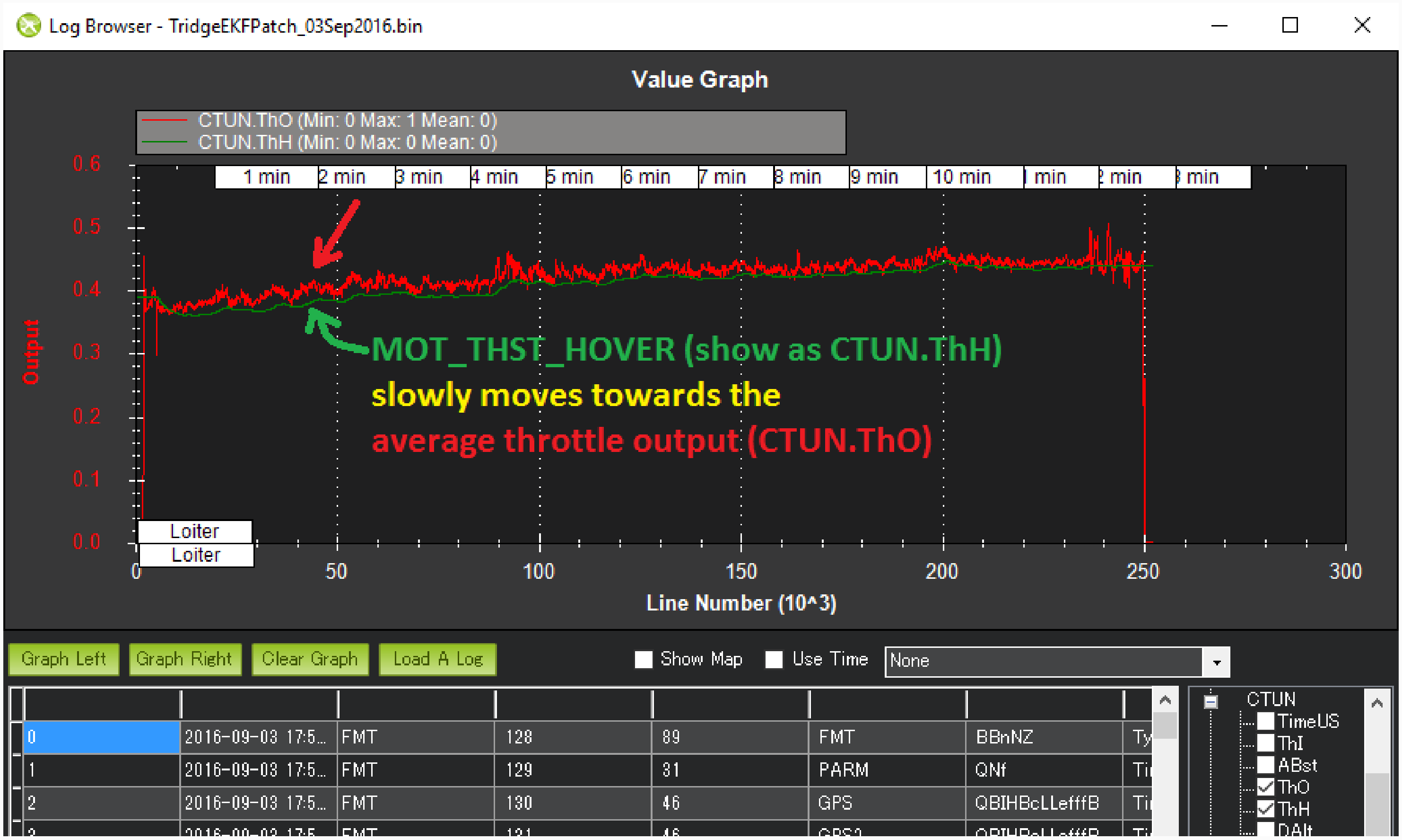
- On your next flight you should find the throttle is closer to mid while flying in stabilize mode

Automatic Learning of Hover Throttle

Copter-3.4 (and higher) includes automatic learning of mid throttle (aka "Hover Throttle"). The MOT_THST_HOVER value will slowly move towards the average motor output whenever the vehicle is holding a steady hover in non-manual flight modes (i.e. all modes except Stabilize and Acro).

If you wish to manually set the MOT_THST_HOVER value, it is best to download a dataflash log and set the value to what is seen in the CTUN.ThO field. The value should be between 0.2 and 0.8.

If for some reason you wish to disable learning, you can set the MOT_HOVER_LEARN parameter to 0.



AutoTrim

Wind of course has a strong effect on your copter and will push it around. However you may also find that while flying in stabilize mode, even in a windless environment your copter tends to always drift away in the same direction. This can largely be corrected using the “Save Trim” or “Automatic Trim” functions.

Save Trim

Save trim is the simpler method and involves essentially transferring your radio transmitter’s trims to the APM (video demo here).

1. Check that your CH7 switch goes above 1800 on the MissionPlanner’s Hardware > Mandatory Hardware > Radio Calibration screen.

2. Set the CH7 Option to Save Trim on the Software > Copter Pids screen and press the “Write Params” button.

|*MP_SaveTrim_Ch7*|

3. With your CH7 switch in the off position, fly your copter in Stabilize mode and use your transmitters’s roll and pitch trim to get it flying level.

4. Land and put your throttle to zero

5. Release the roll and pitch sticks and switch the CH7 switch high for at least 1 second.

6. Reset your transmitters roll and pitch trims back to the center and fly again and it should fly level now. If it does not repeat steps 3, 4 & 5.

Auto Trim

With auto trim the roll and pitch trim are captured as you fly in a stable hover.

1. Find a wind free environment with sufficient space to fly your copter without crashing into something.

2. Hold throttle down and rudder right for 15seconds or until you see the small red, blue and yellow leds

flash in a cyclic pattern.

3. Fly your copter for about 25 seconds in a stable hover

4. Land and put your throttle to zero and wait for a few seconds (the trims are being saved to eeprom)

5. Take off again in stabilize mode and check if your copter is flying level now. If not repeat steps 2, 3 and 4.

Note: you can also test these procedures above are operational on the ground with your battery disconnected. Connect your APM to the mission planner and observing the Flight Data screen as you simulate completing the steps above.

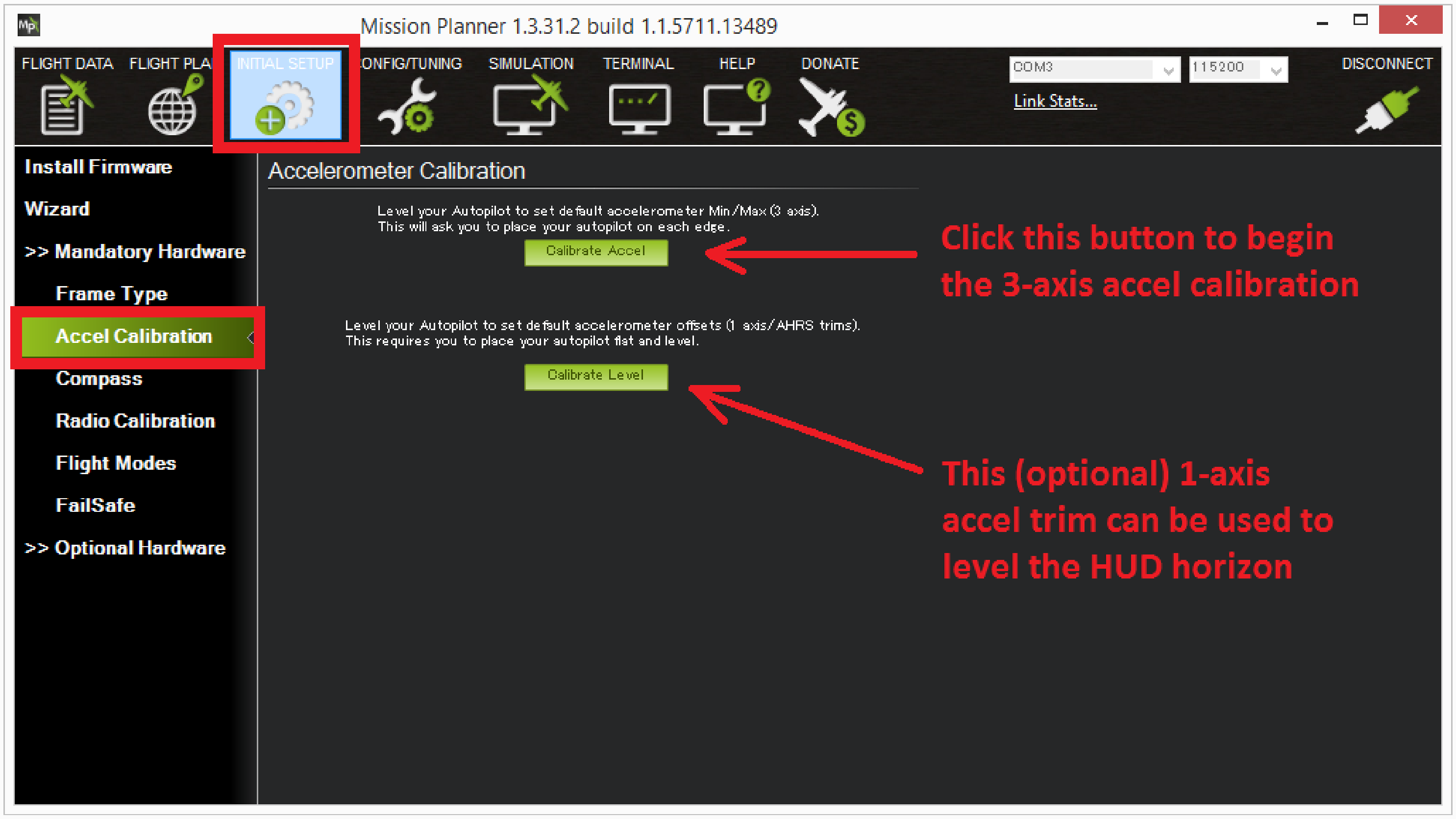
Note2: you can manuual set the trim through the mission planner's Adv Parameters List page. Roll trim is AHRS_TRIM_X, Pitch trim is AHRS_TRIM_Y. Both values are in radians with left roll and forward pitch being negative numbers.

Note3: it's nearly impossible to get rid of all drift so that your copter remains completely motionless without any input.

Video demonstrations of Save Trim and Auto Trim

Desktop method

The trim can also be updated by setting the vehicle level, connecting to the Mission Planner (or perhaps other ground stations) and selecting Initial Setup, Mandatory Hardware, Accel Calibration and pushing the lower "Calibrate Level" button.



Please note though that making the HUD level while the vehicle is on the ground does not necessarily mean it won't drift horizontally while flying because of other small frame issues including the flight controller not being perfectly level on the frame and slightly tilted motors.

Failsafe

Copter has a number of failsafe mechanisms to ease vehicle recovery/prevent wandering in the event that vehicle control is lost. The main failsafe topics are listed below.

Radio Failsafe

Copter 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.

Note

Copter also supports Battery, Ground Station and EKF/DCM failsafes.

When the failsafe will trigger

If enabled and set-up correctly the radio failsafe will trigger if:

- The pilot turns off the RC transmitter
- The vehicle travels outside of RC range (usually at around 500m ~ 700m)
- The receiver loses power (unlikely)
- The wires connecting the receiver to the flight controller are broken (unlikely). Note: with APM2 only the ch3 connection between receiver and flight controller will trigger the failsafe.

What will happen

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 with the mission if the vehicle is in AUTO mode and the FS_THR_ENABLE parameter is set to “Enabled Continue with Mission in Auto Mode”.

If the failsafe clears (i.e. transmitter and receiver regain contact) the copter will remain in its current flight mode. It will **not** automatically return to the flight mode that was active before the failsafe was triggered. This means that if, for example, the vehicle was in Loiter when the failsafe occurred and the flight mode was automatically changed to RTL, even after the transmitter and receiver regained contact, the vehicle would remain in RTL. If the pilot wished to re-take control in Loiter he/she would need to change your flight mode switch to another position and then back to Loiter.

Receiver and flight controller set-up

By default, a newly purchased receiver will be set-up to simply hold all channels at their last known position when the receiver and transmitter lose contact. This is not good because the flight controller has no way to know that the Pilot has lost control of the vehicle. Instead the receiver must be set-up to signal to the flight controller it has lost contact and there are two ways that it can do this (the method depends upon the receiver):

- “Low-Throttle” method - the receiver pulls the throttle channel (normally channel 3) to a value below the bottom of it’s normal range (normally below 975). This method is used by Futaba systems and many older systems.
- “No Signal” method - the receiver stops sending signals to the flight controller. This is the preferred method and is how most modern FrSky receivers operate.

Each brand of Transmitter/Receiver is slightly different so please refer to your transmitter’s user manual to determine which method is available and how to set it up.

Set-up for low-throttle method¶
Above is the setup method for a Futaba T7C Transmitter with R617FS or TFR4-B receiver which uses the “low throttle” method.

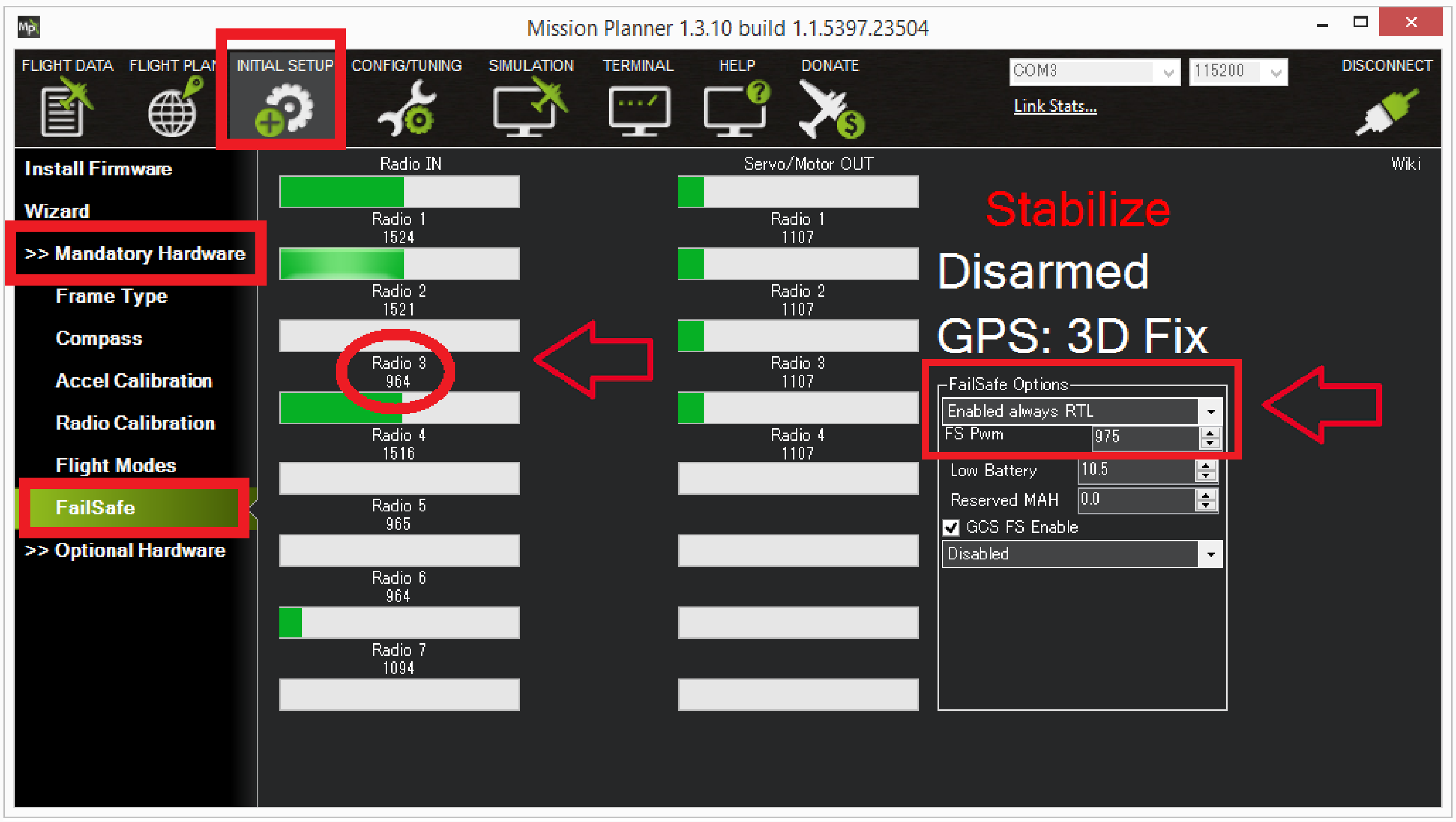
With the LiPo battery disconnected:

- Connect your flight controller to the mission planner and select Initial Setup >> Mandatory Hardware >> Failsafe.

- Set the Failsafe Options to one of the three options:
  - “Enabled always RTL” to force the vehicle to always RTL even if flying a mission in AUTO mode
  - “Enabled Continue with Mission in AUTO” to allow the vehicle to continue with missions even if it takes the vehicle outside of RC range (not recommended). In all other cases the vehicle will RTL.
  - “Enable always LAND” to force the vehicle to Land immediately if it loses RC contact

Set the “FS Pwm” value to be:

- at least 10 PWM higher than your Channel 3’s PWM value when the throttle stick is fully down and the transmitter is **off**
- at least 10 lower than your channel 3’s PWM value when the throttle stick is fully down and the transmitter is **on**
- *above 910*



Set-up for No-Signal method¶

Above is the setup method for a FlySky 9 channel transmitter with FrSky D4R-II receiver which uses the “No Signal” method.

Similar to the “Low-Throttle” method, with the LiPo battery disconnected:

- Connect your flight controller to the mission planner and select Initial Setup >> Mandatory Hardware >> Failsafe.

- Set the Failsafe Options to one of the three options:
  - “Enabled always RTL” to force the vehicle to always RTL even if flying a mission in AUTO mode
  - “Enabled Continue with Mission in AUTO” to allow the vehicle to continue with missions even if it takes the vehicle outside of RC range (not recommended). In all other cases the vehicle will RTL.
  - “Enable always LAND” to force the vehicle to Land immediately if it loses RC contact

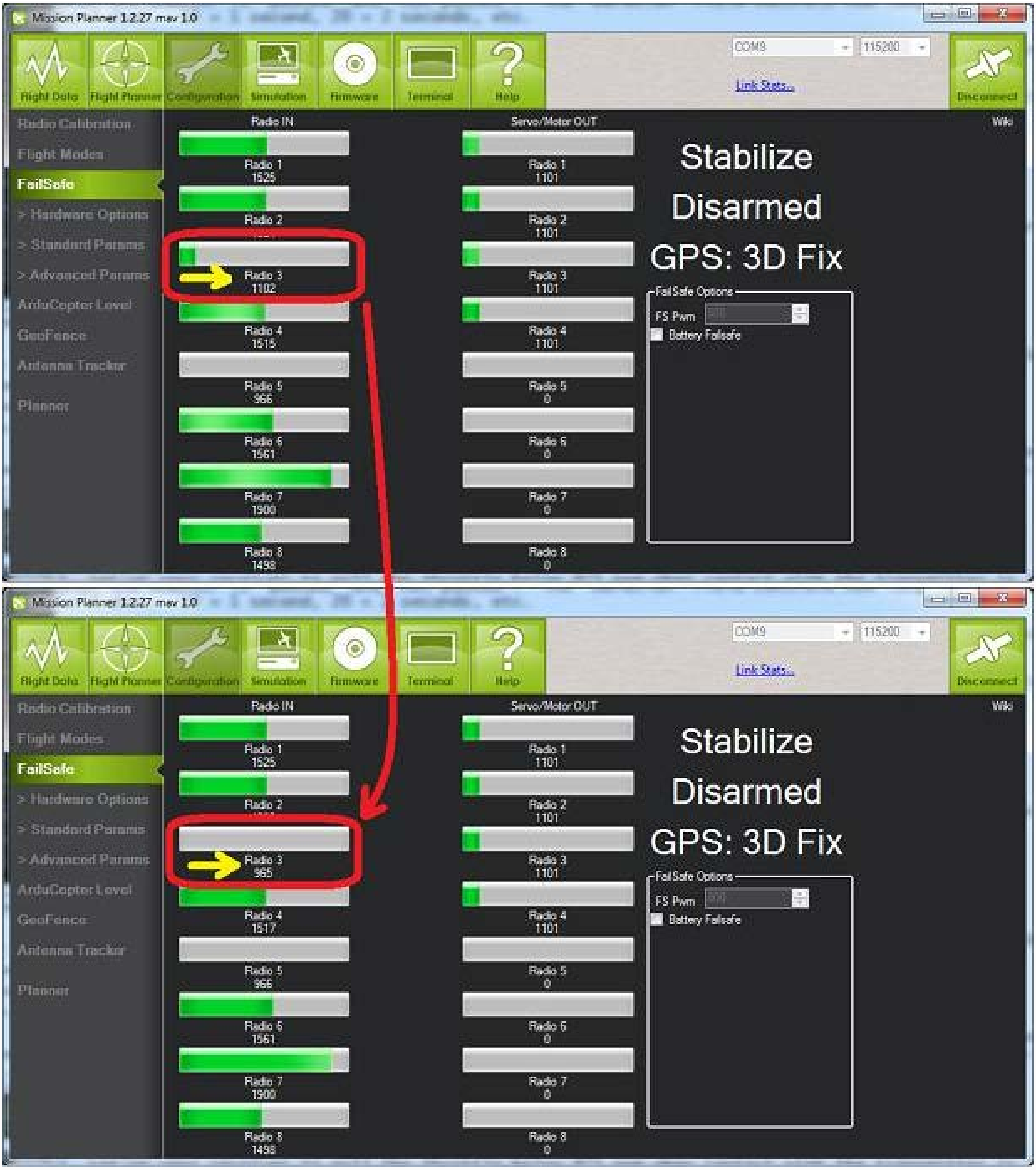
Because the throttle is not pulled low, there is normally no need to adjust the “FS Pwm” value from it’s default (975). Just ensure that it’s well below (i.e. at least 10pwm points below) the minimum value that channel 3 (throttle) can be.

Testing

You can check your failsafe by performing the following tests with the Pixhawk/APM connected to the Mission Planner either via a USB cable or telemetry link. You can complete these tests without plugging in your LiPo battery but if you do connect a battery you should first remove the propellers.

Test #1 : if using the “Low-Throttle” method, ensure the throttle channel drops with loss of radio contact

1. Ensure your RC transmitter is on and connected with the throttle all the way down and flight mode set to Stabilize
2. The throttle (channel 3) PWM value should be approximately as in first illustration below. It’s value may be higher or lower but it should definitely be at least 10 higher than the value held in the FS PWM field
3. Turn the transmitter off and the throttle PWM value should drop to be at least 10 below the FS PWM field value (as in the second illustration below) below



Test #2 : ensuring motors disarm if in stabilize or acro with throttle at zero

- Switch to stabilize mode, arm your motors but keep your throttle at zero. Turn off your transmitter. The motors should disarm immediately (red led will start flashing, DISARMED will be displayed in the Mission Planner's Flight Data screen).

Test #3 : ensuring flight mode changes to RTL or LAND when throttle is above zero

- Switch to stabilize mode, arm your motors and raise your throttle to the mid point. Turn off your transmitter. The Flight Mode should switch to RTL if you have a GPS lock or LAND if you do not have a GPS lock (the flight mode and GPS lock status are visible in the Mission Planner's flight data screen).

Test #4 : retaking control after the failsafe has cleared

- continuing on from test #3, turn your transmitter back on
- while the flight mode is still in RTL or LAND and armed, change the flight mode switch to another position and then back to stabilize mode. Ensure that the flight mode displayed on the Failsafe page is updating appropriately.

Test #5 (optional) : removing power from the receiver

- Switch to stabilize mode, arm your motors and keep your throttle above zero.
- Carefully disconnect the power wires connecting the receiver to the APM
- The Flight Mode should switch to RTL or LAND as described in Test #3
- Warning: unplug the APM so that it is powered down before reattaching the receiver's power

Using the receiver to set the flight mode (not recommended)

Instead of setting up the receiver and flight controller as described above (i.e. "Low-Throttle" and "No Signal" methods) the receiver can be set-up to set channel 5 (flight mode channel) to a flight mode slot that has been set to RTL. For example the receiver could be setup to move ch5's pwm value to 1700 which is "Flight Mode 5" which could then be set to RTL on the Mission Planner's Initial Setup >> Mandatory Hardware >> Flight Modes screen.

Although this mostly works it is not recommended because it will not trigger if the receiver loses power or if the wires between the receiver and flight controller are broken.

Warning to Copter 3.1.5 and FRSky receiver users and users of other receivers that modify channel 5 during a failsafe event

Some FRSky tx/rx systems receivers can only be set-up to modify all channels including the flight mode channel (channel 5) when a failsafe event occurs. For these receivers if using Copter 3.1.5 (or earlier) it is important to setup the receiver's channel 5 failsafe value so that the Pixhawk/APM is switched into

RTL, Loiter or LAND. This is critical because there is a very short period of time (3/50ths of a second) between when the receiver pulls the throttle low and when the Pixhawk/APM initiates the RTL or LAND. During this time, if the receiver also switches the flight mode channel to stabilize or acro the Pixhawk/APM may switch to stabilize momentarily and then because the copter is in stabilize with throttle at zero it will disarm the copter (i.e. Test #2).

Battery Failsafe

This article explains how to setup and test the battery failsafe.

Overview

The battery failsafe can be set-up to automatically trigger an RTL or LAND when the vehicle battery voltage or estimated remaining power has crossed a configurable threshold.

To use this failsafe the vehicle must have a Power Module or other voltage and (optionally) current monitor.

Note

Copter also supports other failsafes: Radio, GCS, and EKF / DCM Check.

When the failsafe will trigger

If enabled and set-up correctly the battery failsafe will trigger if the main battery:

- voltage drops below 10.5 volts (configurable) for more than 10 seconds
- remaining capacity falls below the configurable Reserved MAH

What will happen

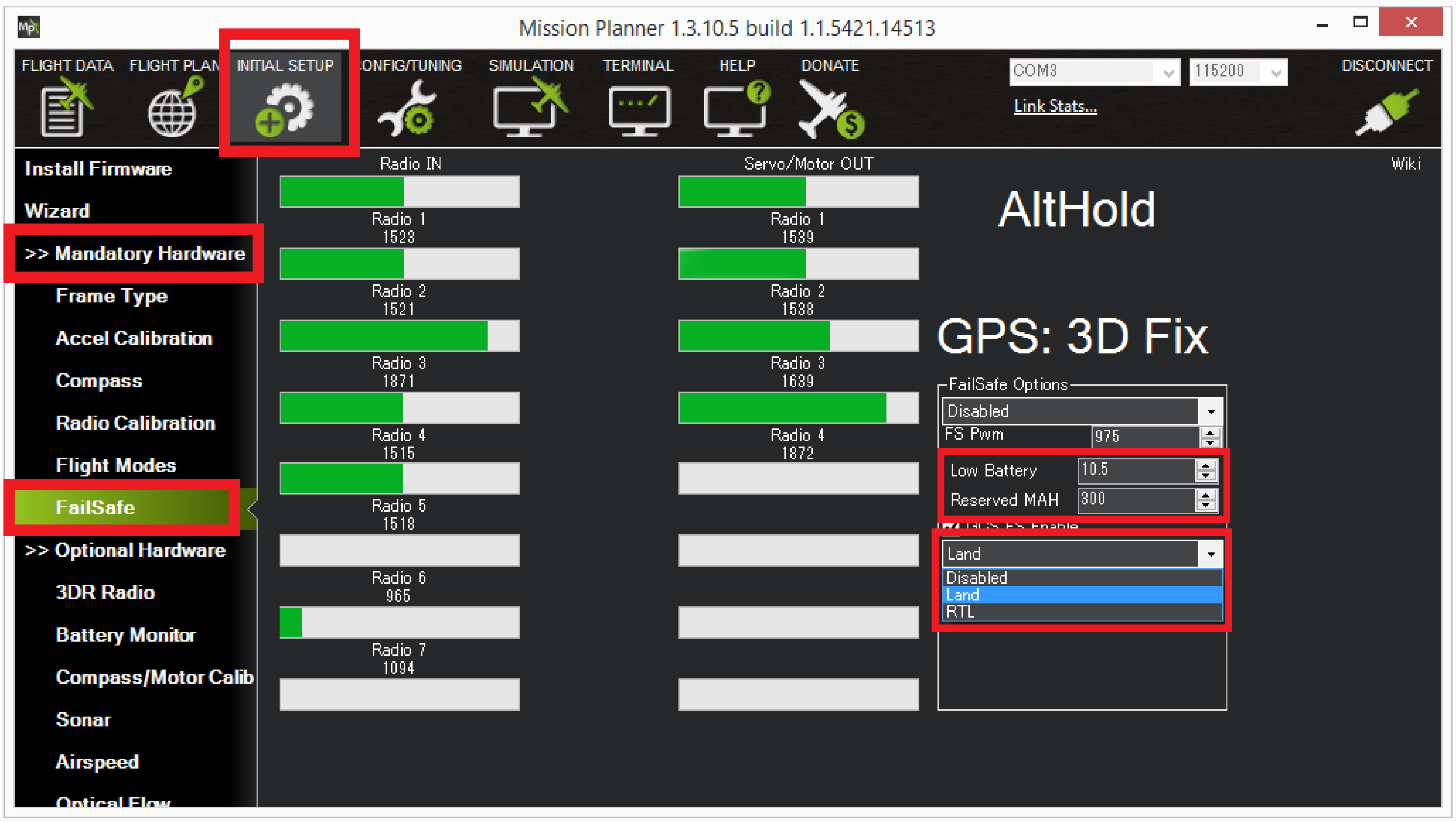
When the failsafe is triggered one of the following will happen:

- **Nothing** if the vehicle is already disarmed
- **Disarm motors** if the vehicle is in Stabilize or Acro mode and the throttle is at zero OR the vehicle is landed
- **Return-to-Launch (RTL)** if the `FS_BATT_ENABLE` param is set to “2” (“RTL”) OR the vehicle is in AUTO mode, has a GPS lock and are at least 2 meters from your home position

Land in all other cases

Setting up the battery failsafe

- Setup the power module as described in the Power Modules section of this wiki including setting the totally battery capacity if using a current monitor
- On the **INITIAL SETUP | Mandatory Hardware | Failsafe** page:
  - set the “Low Battery” threshold voltage (i.e. 10.5 volts)
  - set the “Reserved MAH” or leave as “0” if the failsafe should never trigger based on estimated current consumed. “600” would be an appropriate number to cause the vehicle to LAND or RTL when only 20% of a 3000mAH battery remains.
  - select the desired behavior as “Land” or “RTL” (Note: the placement of the drop-down is confusing but this will be corrected in a future version of the mission planner)



Low Battery warning (even with failsafe disabled)

Even if the battery failsafe is not enabled (i.e. `FS_BATT_ENABLE = 0`) the “Low Battery” voltage threshold and “Reserved MAH” numbers are used to issue a battery warning. This will result in:

- “Low Battery!” message appearing on the ground stations HUD (if using telemetry)
- Loud beeping if a buzzer is attached

- Flashing LEDs

The only way to disable this warning completely is to set the “Low Battery” voltage and “Reserved MAH” values to zero.

GCS Failsafe

This page covers the set-up and testing of the Ground Station Control (GCS) failsafe.

Note

Copter also supports other failsafes: Radio, Battery, and EKF / DCM Check.

Overview

The Ground Station Control (GCS) failsafe controls how Copter will behave if contact with the GCS is lost. Depending on the setting and vehicle position the failsafe will either RTL/LAND, or continue an active mission.

More specifically, if you have been using the GCS to control Copter (i.e. using a joystick) and then lose GCS contact for at least 5 seconds the following will happen:

- Disarm motors - if you are in stabilize or acro mode and your throttle is zero
- RTL - if you have a GPS lock and are more than 2 meters from your home position
- LAND - if you have no GPS lock or are within 2 meters of home
- Continue with the mission - if you are in AUTO mode and have set the GCS Failsafe Options to 2 (Enabled_continue_in_auto_mode).

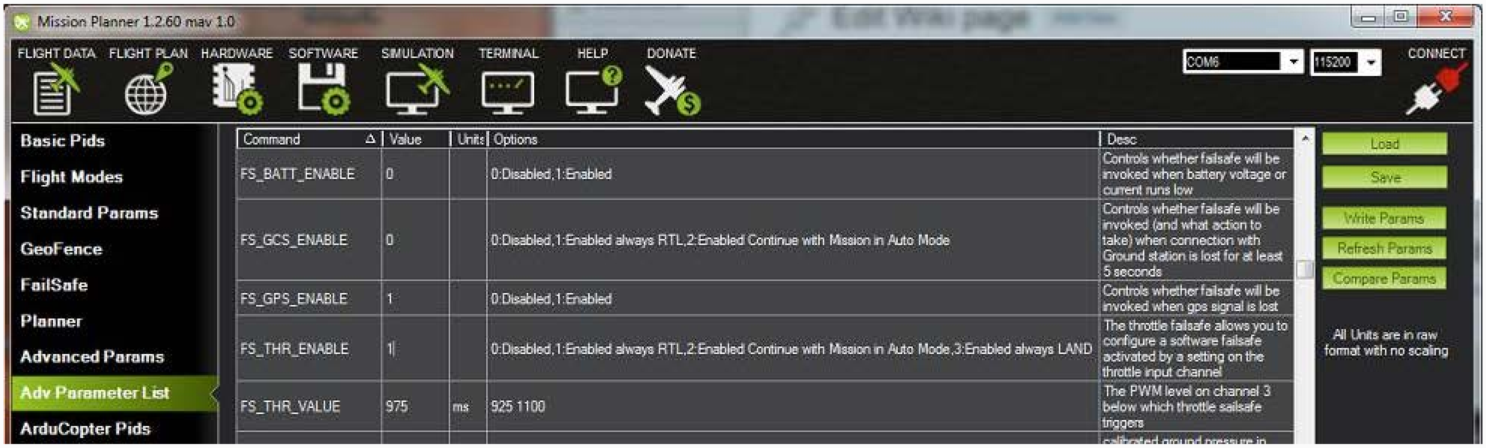
If the failsafe clears (contact with the ground station is restored) Copter will remain in it’s current flight mode. It will **not** automatically return to the flight mode that was active before the failsafe was triggered. This means that if, for example, you are flying in stabilize mode when the failsafe is triggered, and this causes the flight mode to change to RTL or LAND, if you wish to re-take control of the copter you will need to set your flight mode again back to stabilize.

Setting the failsafe

In Mission Planner’s Advanced Parameter List, set the FS_GCS_ENABLE parameter to:

- 0 to disable the GCS failsafe

- 1 to enable and always RTL in event of loss of contact
- 2 to RTL unless in AUTO mode in which case we should continue with the mission



Note

All Failsafe Parameters can be observed or set from the Advanced Parameter List.

EKF / DCM Check Failsafe

Copter 3.2 adds a DCM heading check and an EKF (Extended Kalman Filter - Pixhawk only) check to catch flyaways caused by a bad heading estimate.

Note

Starting in Copter 3.3 the EKF failsafe replaces the GPS Failsafe.

When will it trigger?

The DCM check runs by default on all boards and will trigger when the GPS implied heading and DCM's estimated heading disagree by at least 60 degrees (configurable with the DCM_CHECK_THRESH parameter) for a full second.

The EKF check runs only on the Pixhawk and only when the EKF is being used as the primary source for attitude and position estimates (i.e. AHRS_EKF_USE = 1). This check will trigger when the EKF's compass and velocity "variance" are higher than 0.8 (configurable with EKF_CHECK_THRESH parameter) for one second. This "variance" increases as the estimates become untrustworthy. 0 = very trustworthy, >1.0 = very untrustworthy. If both variances climb above the EKF_CHECK_THRESH parameter (default is 0.8) the EKF/Inav failsafe triggers.

What will happen when the failsafe triggers?

The Pixhawk's LED will flash red-yellow, the tone-alarm will sound.

If telemetry is attached "EKF variance" will appear on the HUD.

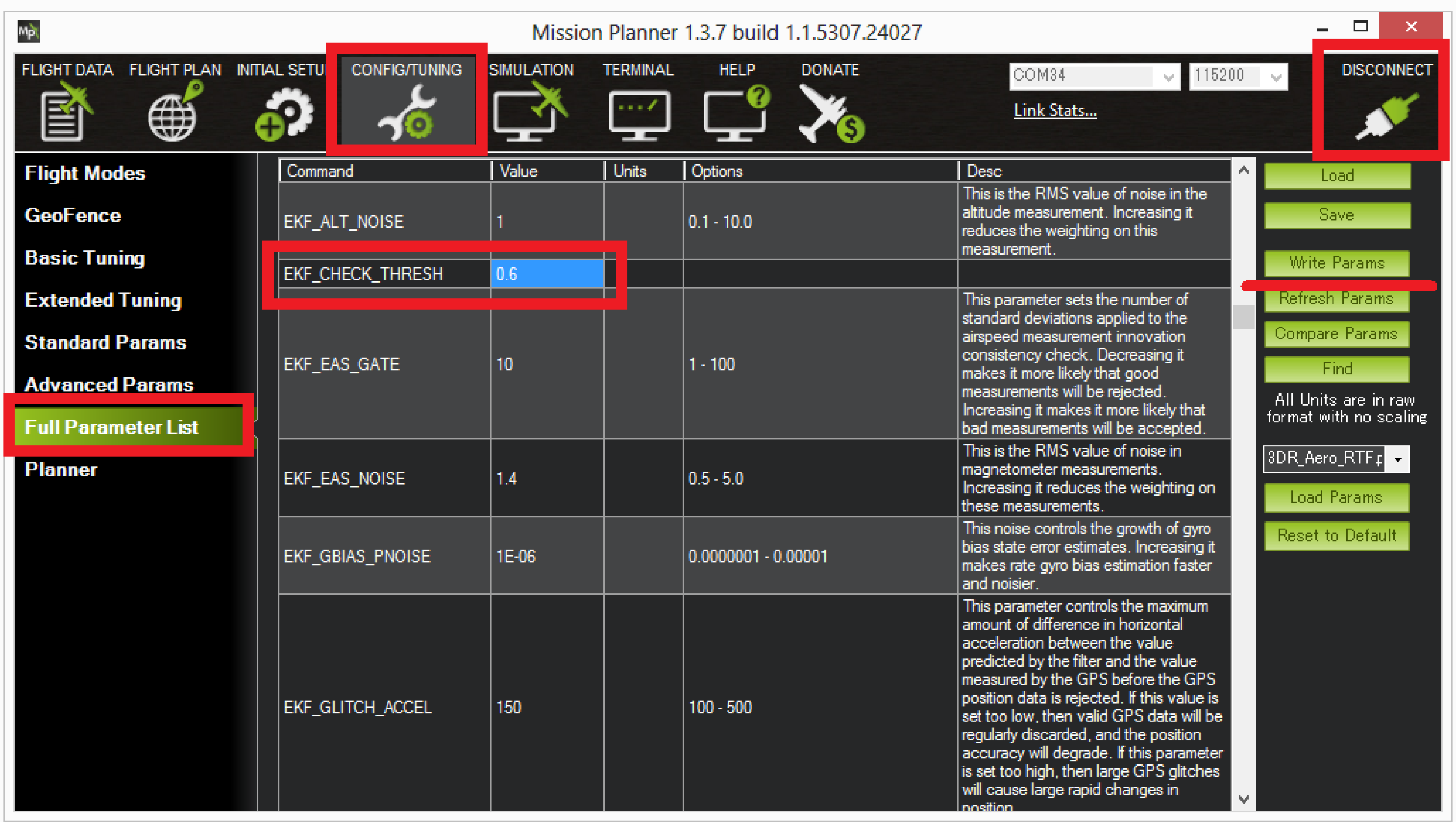
And EKF/DCM error will be written to the dataflash logs

If flying in a flight mode that does not require GPS nothing further will happen but you will be unable to switch into an autopilot flight mode (Loiter, PosHold, RTL, Guided, Auto) until the failure clears.

If flying in a mode that requires GPS (Loiter, PosHold, RTL, Guided, Auto) the vehicle will switch to "pilot controlled" LAND. Meaning the pilot will have control of the roll and pitch angle but the vehicle will descend, land and finally disarm it's motors. The pilot can, like always switch into a manual flight mode including Stabilize or AltHold to bring the vehicle home.

Adjusting sensitivity or disabling the check

The DCM and EKF check and failsafe can be disabled by setting the DCM_CHECK_THRESH or EKF_CHECK_THRESH to "0" through the Mission Planner's Config/Tuning >> Full Parameter List. Alternatively it can be made less sensitive by increasing this parameter from 0.8 to 0.9 or 1.0. The downside of increasing this parameter's value is that during a flyaway caused by a bad compass or GPS glitching, the vehicle will fly further away before the vehicle is automatically switched to LAND mode.



Video

GPS Failsafe and Glitch Protection¶

This article describes the glitch protection mechanisms used to trigger GPS Failsafe.

Overview¶

GPS Systems can occasionally drop the signal or provide significantly inaccurate position information (aka “glitches”). While errors are more likely in conditions where the GPS signal can bounce off multiple paths before reaching the receiver (multipathing), errors can occasionally occur even with clear sky.

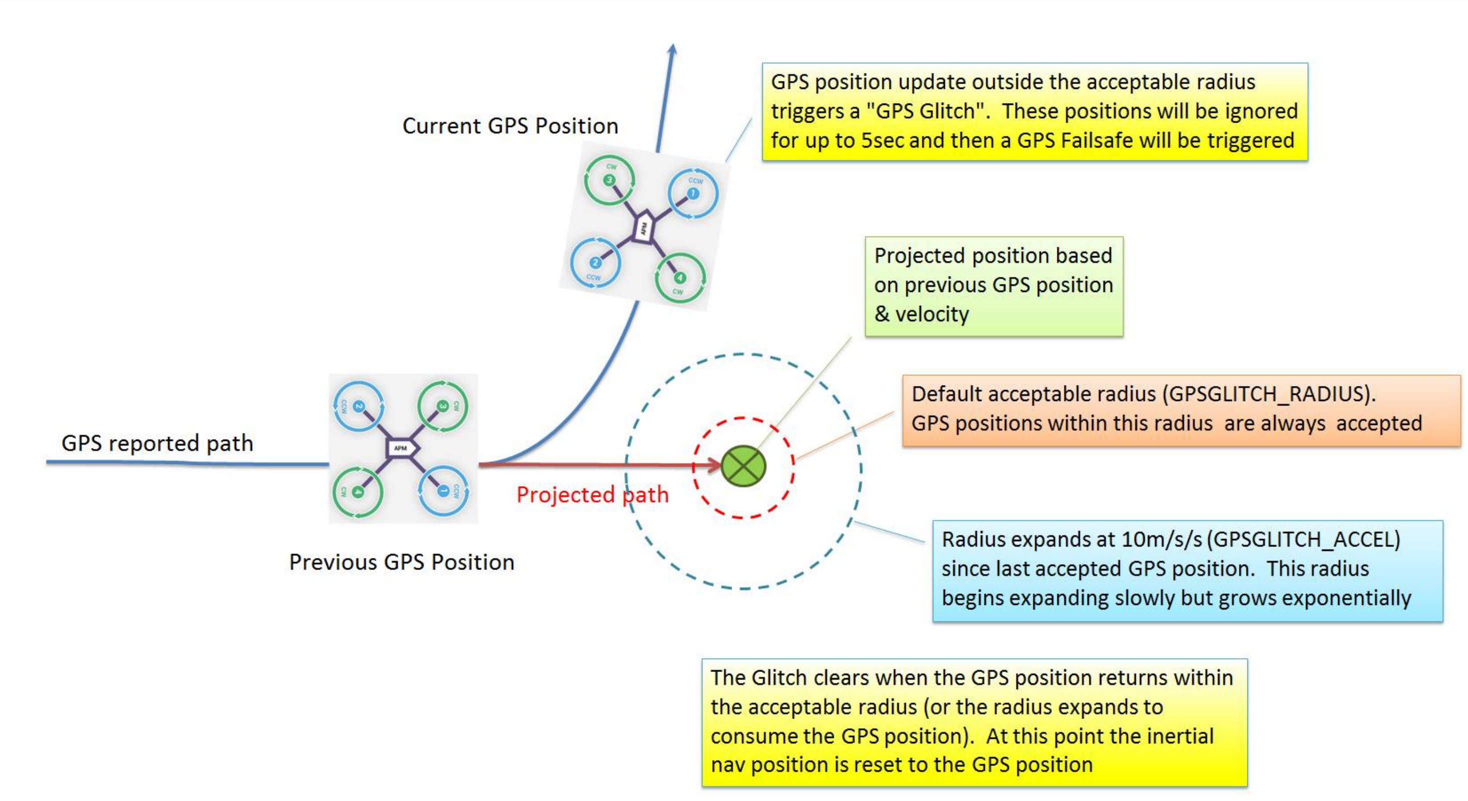
A *GPS failsafe* event will occur if GPS 3D lock or the position “Glitches” for at least 5 seconds while Copter is in a mode that requires the GPS (RTL, Auto, Loiter, Circle, Position, Guided or Drift). The GPS failsafe response can be set to Land or switch to AltHold mode (in AC3.1 and higher) so that you can retake manual control.

Without GPS updates, the inertial sensors allow approximately 10 seconds of accurate position information but after this the horizontal position drift becomes so large that the horizontal position cannot be maintained at all. At this point if you still have RC radio control it is recommended to take back control using Stabilize, Acro or AltHold as soon as possible.

This article describes two forms of GPS glitch logic. The first is used by the default navigation algorithm for AC3.1 and 3.2. The second (EKF) can be used in AC3.2, and is mandatory in AC3.3 and later.

Glitch Protection - Default¶

AC3.1 and AC3.2 include GPS glitch protection which can help alert the pilot to a bad GPS position, trigger a failsafe and reduce the incidents of fly-aways. Glitches are detected by comparing the each new position update received from the GPS with a position projected out from the previous update’s position and velocity.



The new position is accepted as “good” if:

1. the two positions are within the `GPSGLITCH_RADIUS` (defaults to 5m).
2. the new position is within a radius that is 10m/s/s (`GPSGLITCH_ACCEL`) * dt * dt. Where “dt” is the time difference between the two samples.

During a glitch, “Bad Position” will be written on the ground station’s HUD

Glitch Protection - EKF¶

AC3.2 introduced a new form of glitch protection, the ArduPilot Extended Kalman Filter (EKF).

Note

AC3.3 Enables EKF by default, and it cannot be turned off. On AC3.2 EKF is turned off by default - but you can enable it to run on the faster boards (using 32 bit micros) by setting `AHRS_EKF_USE = 1`.
Glitch protection using the EKF works as follows:

1. When new GPS position measurements are received, they are compared to a position predicted using IMU measurements.
2. If the difference exceeds a statistical confidence level set by `EKF_POS_GATE`, then the measurement won’t be used.
3. While GPS measurements aren’t being used, a circle defined by an uncertainty radius grows around

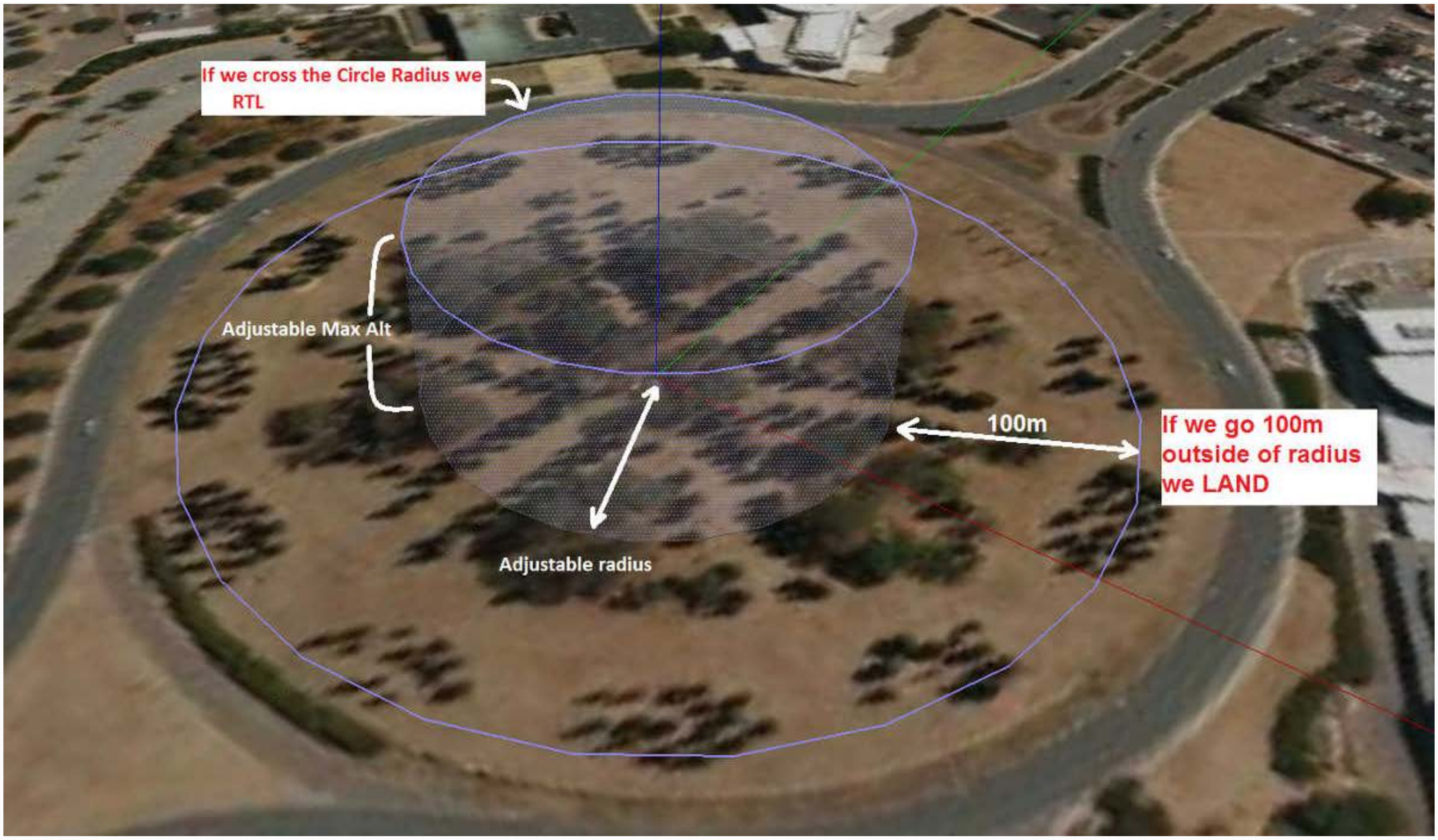
the predicted position. The rate at which this radius grows is controlled by `EKF_GLITCH_ACCEL`. This is similar to the circle defined by `GPSGLITCH_ACCEL`, the difference being it is centered around the trajectory predicted by the IMU rather than previous GPS measurements. Because this allows for deviations in trajectory due to maneuvers, the default value for `EKF_GLTCH_ACCEL` is smaller at 1.5 m/s/s. The acceleration growth of the circle is also increased when the vehicle is accelerating or turning to allow for the increase in IMU errors during maneuvers.

4. If subsequent GPS measurements fall inside the circle, they will be accepted and the circle is reset back to the minimum radius controlled by `EKF_POS_GATE`.
5. If the GPS glitch is large enough and lasts long enough, the GPS measurements will continue to be rejected until the circle radius exceeds a value set by `EKF_GLITCH_RAD`. When this happens, an offset is applied to the GPS position so that it matches the estimated vehicle position and the GPS positions are used again. The GPS offset is then reduced to zero at 1 m/s. This means that large long duration glitches will cause the vehicle to drift at a 1 m/s rate. This is slow enough to give the operator plenty of time to react.

Simple GeoFence

Overview

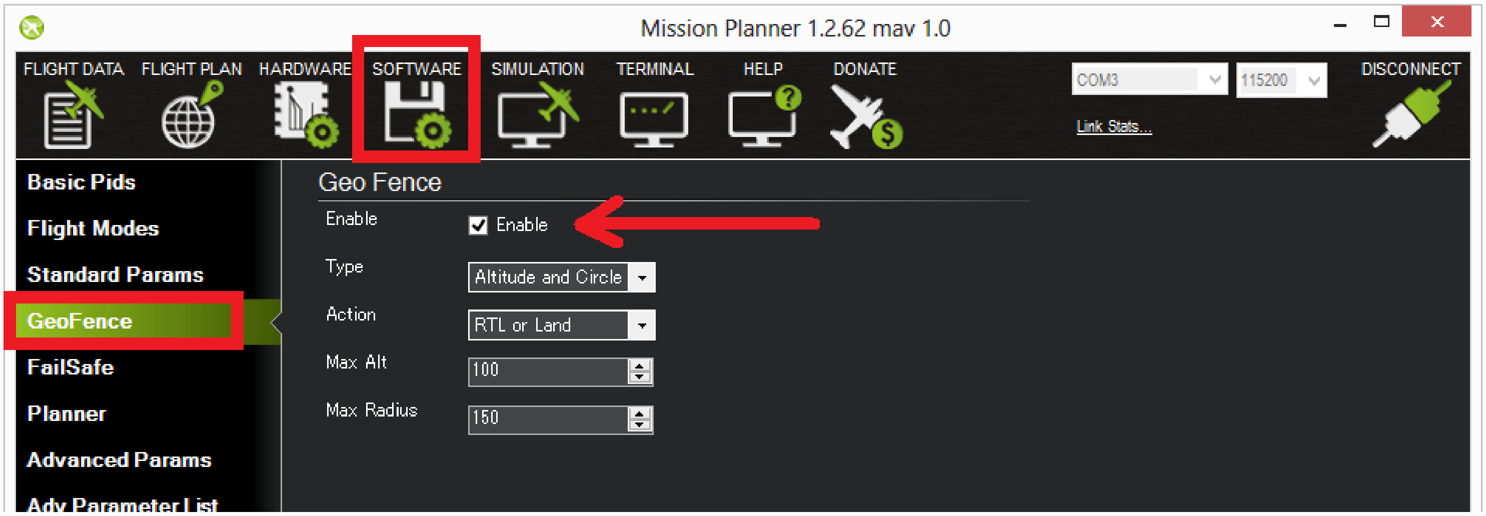
AC 3.0.1 (and higher) includes a simple “tin can” shaped fence centered on home that will attempt to stop your copter from flying too far away by initiating an RTL. The maximum circular distance and altitude and the vehicle behaviour when the fence is reached can be configured using Mission Planner.



If the vehicle strays outside these borders it will switch into RTL or LAND. At the moment the fence is breached a backup fence is erected 20m further out (or up). If the copter breaches this backup fence (for example if the the vehicle is not set up correctly or the operator takes control but is unable to bring the copter back towards home) the copter will be switched into RTL again (and another backup fence an additional 20m further out will be created).

If the copter eventually flies 100m outside the configured fence distance, the vehicle will switch into LAND mode. The idea being that it’s clearly impossible to get the copter home so best to just bring it down. The pilot can still retake control of course with the flight mode switches. Like with the earlier fences, another fence is erected 20m out which will again switch the copter to LAND if it continues away from home.

Enabling the Fence in Mission Planner



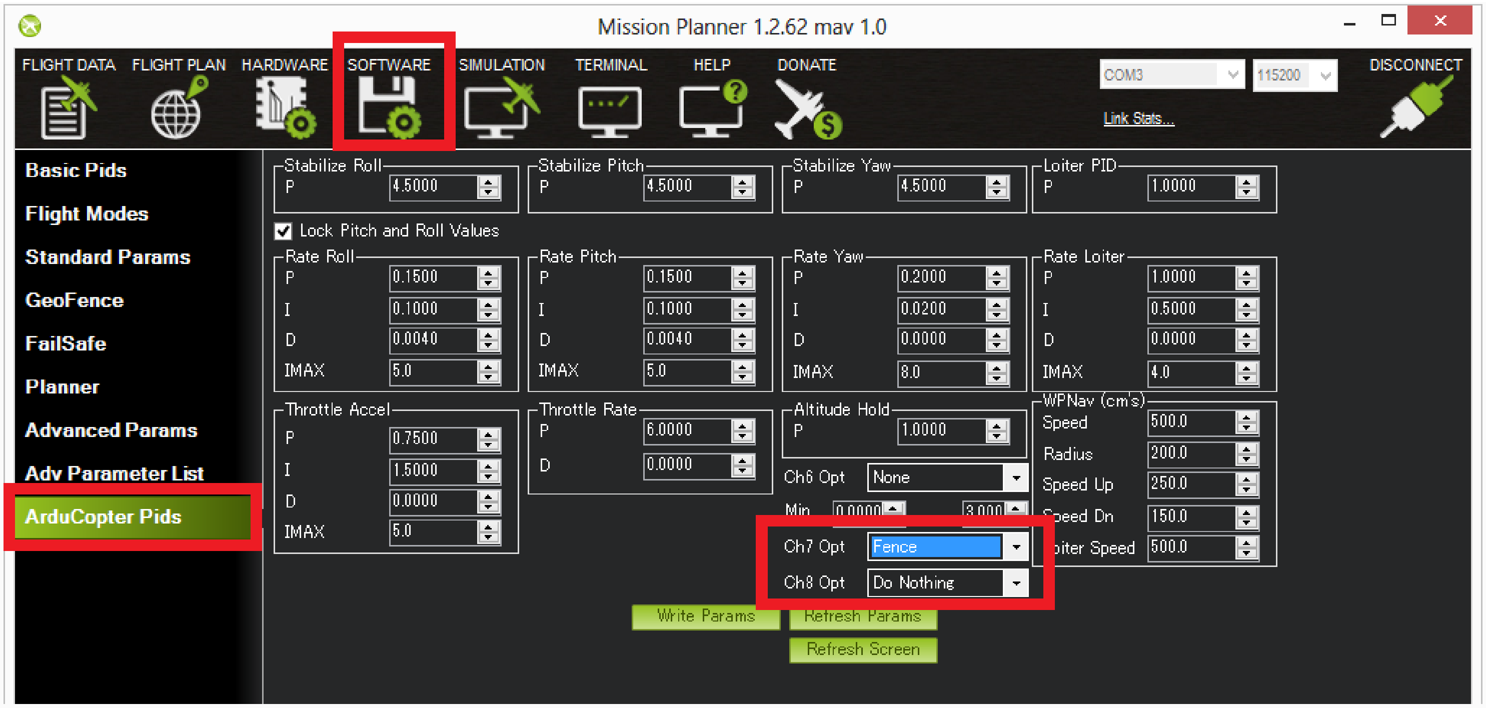
The Fence can be set-up by doing the following:

- Connect your APM/PX4 to the Mission Planner
- Go to the **Software | GeoFence** screen
- Click the **Enable** button
- Leave the "Type" as "Altitude and Circle" (unless you want only an Altitude limit or only a Circular fence in which case you can select "Altitude" or "Circle")
- Leave the Action as "RTL or Land"
- Set "Max Alt" to the altitude limit you want (in meters)
- Set "Max Radius" to the maximum distance from home you want (in meters). This should normally be at least 50m

Enabling the fence with Channel 7 or 8

It is not necessary to set-up a switch to enable or disable the fence but if you wish to control the fence with a switch please follow these steps:

- Go to the Mission Planner's Software > Copter Pids screen and set either "Ch7 Opt" OR "Ch8 Opt" to Fence.
- holding the switch high (i.e. PWM > 1800) will enable the fence, low (under 1800) will disable the fence.



Warnings:

- The minimum recommended fence radius is 30m
- The fence requires the GPS to be functioning well so do not disable the GPS arming check nor the EKF failsafe while the fence is enabled. Conversely if you disable either of these checks, disable the Fence.
- For the best results, ensure RTL is working on your vehicle.
- With the Fence enabled, the pre-arm checks will require you have GPS lock before arming the vehicle.
- If GPS failsafe is not enabled and the Fence is enabled and you loose GPS lock while flying the fence will be disabled.
- If GPS failsafe is enabled and the Fence is enabled and you lose GPS lock while flying the vehicle will switch to LAND because we no longer know the vehicle position and we want to ensure the copter never travels far outside the fence. This beahviour will occur regardless of the flight mode. If a LAND sequence is not desired, the pilot can retake control by moving the flight mode switch.
- The backup fences are created 20m out from the previous breached fence not 20m out from the vehicle’s position. This means if you choose to override the fence you may have less than 20m to regain vehicle control before the fence switches the copter to RTL (or LAND) again. If you really want to override the fence, you should be ready to switch the flight mode twice or alternatively set-up the enable/disable fence switch.

Video overview of the Fence setup and Operation

Polygon Fence

Overview

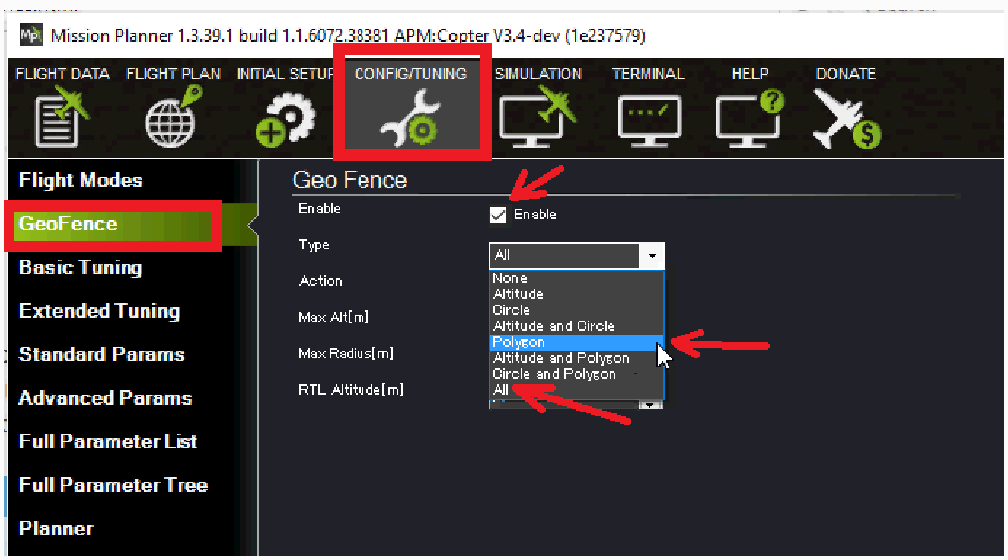
Copter 3.4 (and higher) include support for a polygon fence with up to 84 points. The purpose of this fence is to attempt to stop your vehicle from flying out of the polygon by initiating an RTL or, if flying in Loiter mode, the vehicle will normally stop before breaching the fence. This feature is an extension of the simpler circular fence.

Note

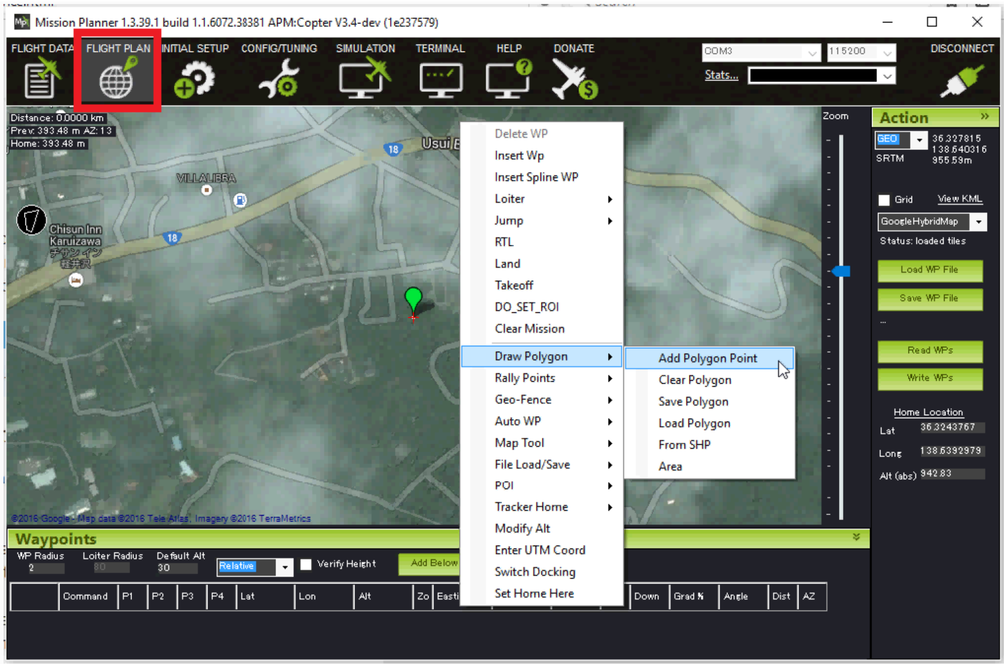
The Polygon fence was introduced in Copter 3.4.

Enabling the Fence in Mission Planner

- Connect your Flight controller to the Mission Planner
- Go to the **Config/Tuning | GeoFence** screen
- Click “Enable” and set Type to “All” or another option that includes “Polygon”



- Leave the Action as “RTL or Land”
- Go to the **Flight Plan** screen
- Right-mouse-button click on the map and select “Draw Polygon” >> “Add Polygon Point”
- Click on other points on the map to define the polygon

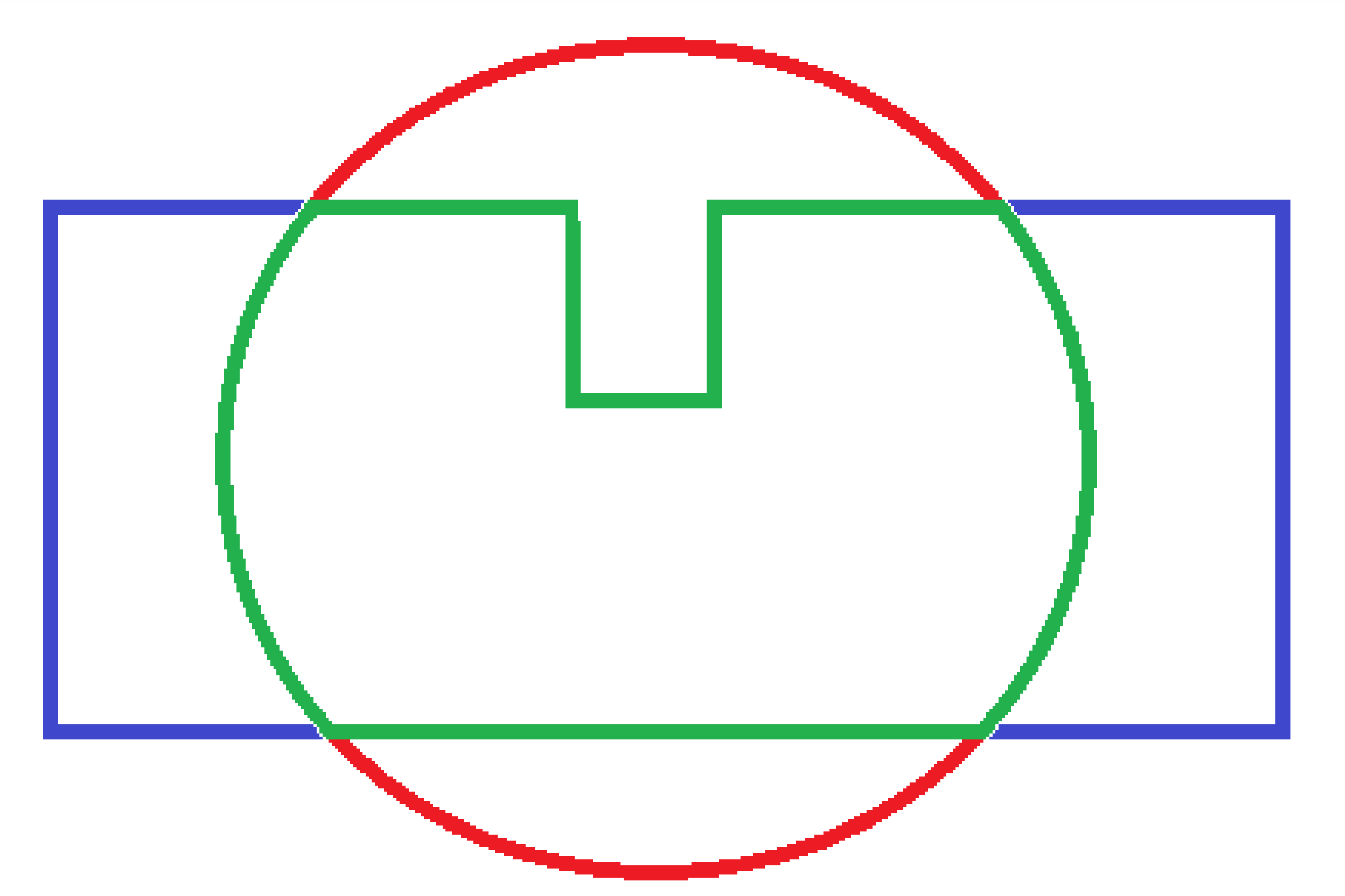


- After the polygon has been defined you must Right-mouse-button click and “Draw Polygon” >> “Set Return Location”. This location is not actually used by copter but it must be set because the same underlying library is used as Plane.

- Upload the polygon fence to the vehicle using Right-mouse-button click and “Geo Fence” >> “Upload”

Combining with the Circular and Altitude fences

The polygon fence can be used in combination with the circular and altitude fences and the failsafe behaviour (i.e. stop at the fence or RTL) will trigger at whichever barrier the vehicle reaches first (i.e. the green line shown below)



Please see the circular fence page for additional warnings and instructions including how to enable/disable the fence with the ch7/ch8 auxiliary switches.

Crash Check

Copter includes a crash check which disarms the motors in cases where the vehicle is likely out of control and has hit the ground. This reduces damage to the vehicle and also reduces the chance of injury to people near the vehicle.

The crash check is similar to the parachute release logic except that the parachute will normally release as the vehicle falls, while the crash check should trigger once the vehicle has hit the ground.

When will the crash check disarm the motors?

When all the following are true for 2 full seconds:

1. the vehicle is armed

2. the vehicle is not landed (as far as it can tell)
3. the current flight mode is *not* ACRO or FLIP
4. the vehicle is not accelerating by more than 3m/s/s
5. the actual lean angle has diverged from the desired lean angle (perhaps input by the pilot) by more than 30 degrees

What will happen when the crash check fires?

1. the motors will disarm
2. “Crash: Disarming” will be displayed on the Ground Station
3. a crash event will be written to the dataflash logs (look for EV, 12 in the logs)

How and when should the crash check be disabled?

In general the crash check should be left enabled but if the vehicle is likely to suffer from lean angle errors of over 30 degrees for a second or more it should be disabled. This includes applications where the vehicle is being used to carry a guide wire from one mountain peak to another or being used for “drone boarding”.

Image courtesy of The Verge

In Copter-3.3.3 (and higher) the crash check can be disabled by setting FS_CRASH_CHECK to 0.

Below is a video describing the crash check from Copter-3.1 (the logic has changed in 3.3 and higher)

Parachute

This topic describes how to set up manual and automatic parachute release.

Warning

Support for this feature was introduced in Copter 3.2. This feature is still experimental and should be used with caution.
Video above is from Henri's DIYDrones discussion that led to this feature being added to Copter.

What you will need

A complete parachute mechanism like one of these:

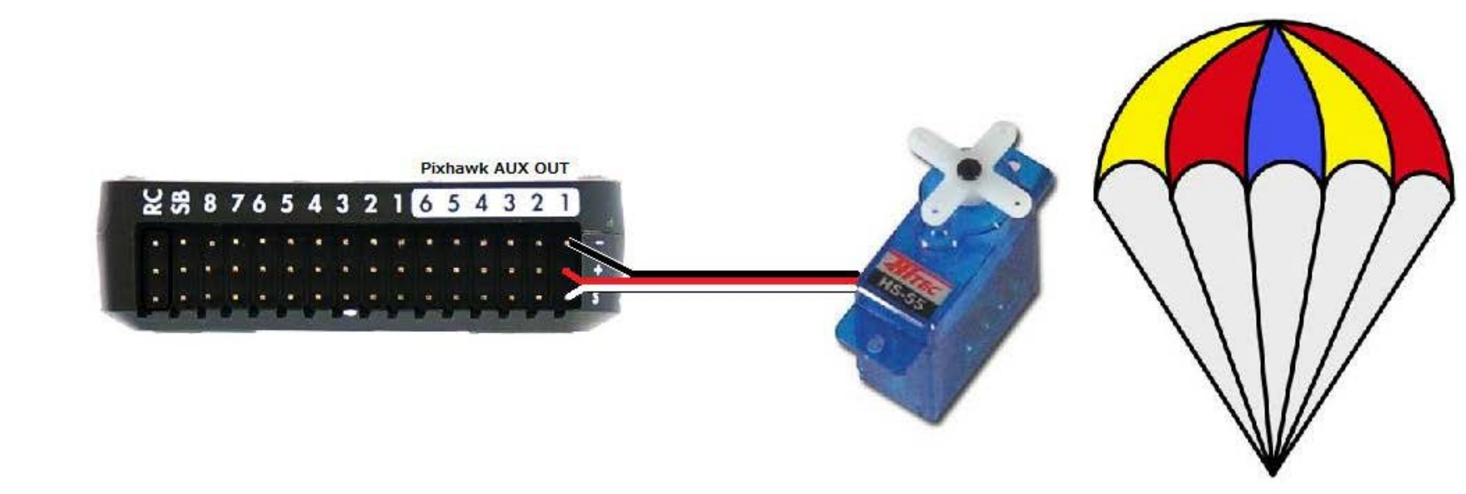
- SkyCat
- CAD Drones

OR if you prefer a DIY solution, parachute release mechanism that can be triggered by a PWM signal (i.e. a Servo) and a parachute large enough to slow your multicopter's decent to less than 5m/s. Some recommended parachute vendors:

- Fruity Chutes
- Opale Paramodels
- Mars Mini

Connecting to the Pixhawk

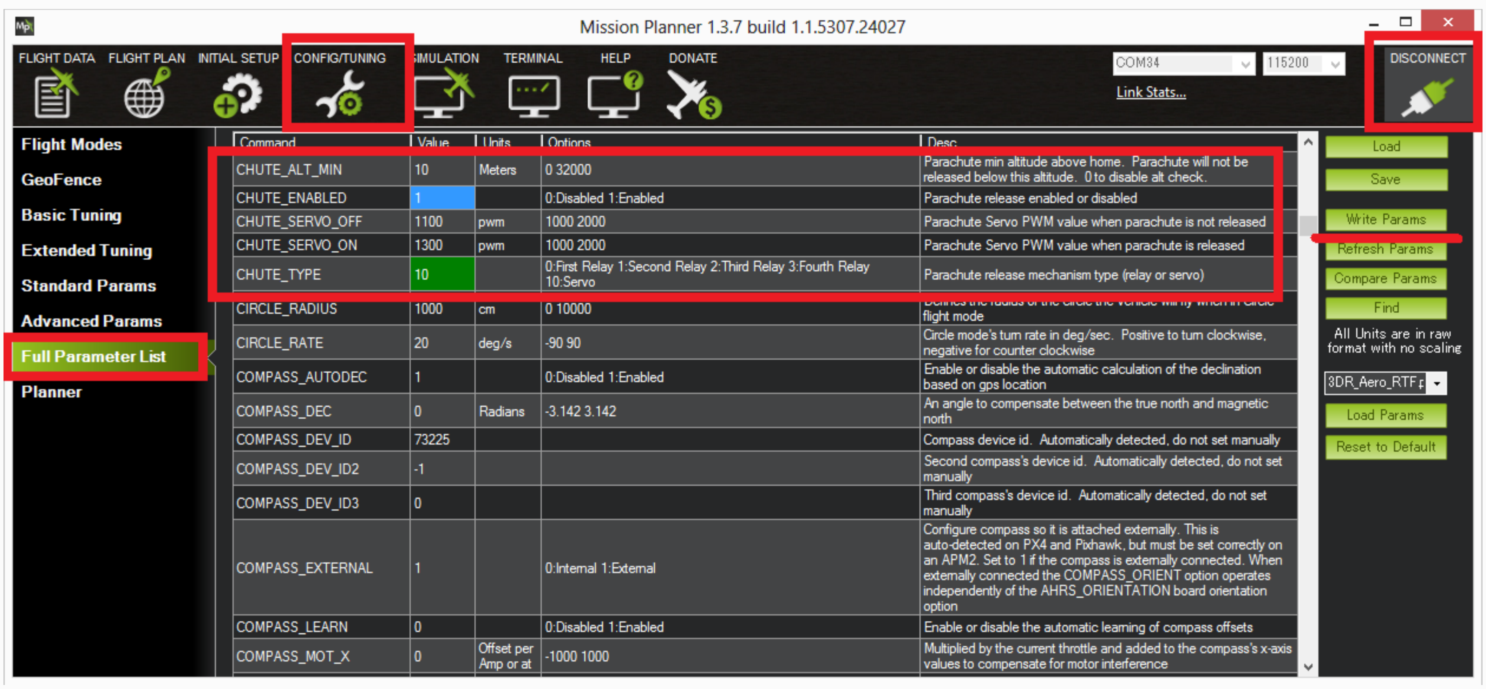
The parachute release mechanism can be triggered from either a Relay or a PWM (i.e. Servo) but because of an issue with the Relay pins being pulled high at start-up, we recommend using PWM, in particular any of the Pixhawk's AUX OUT 1 to 4 pins.

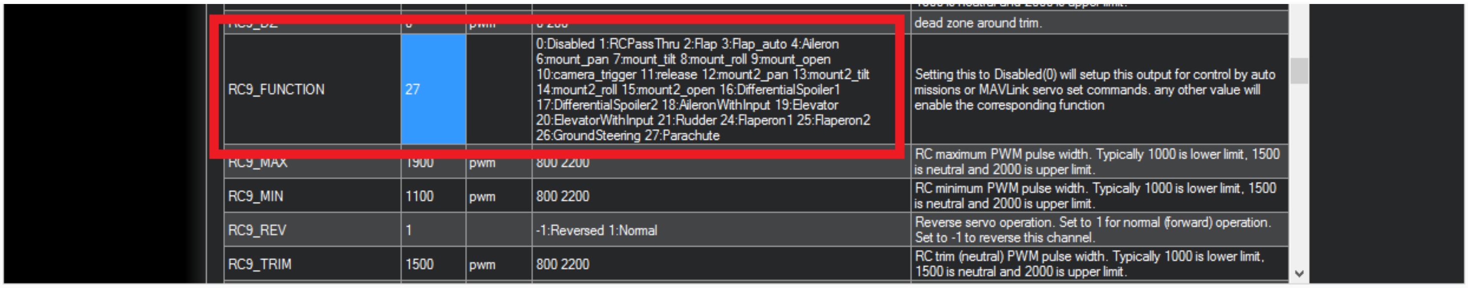


Setup through the mission planner

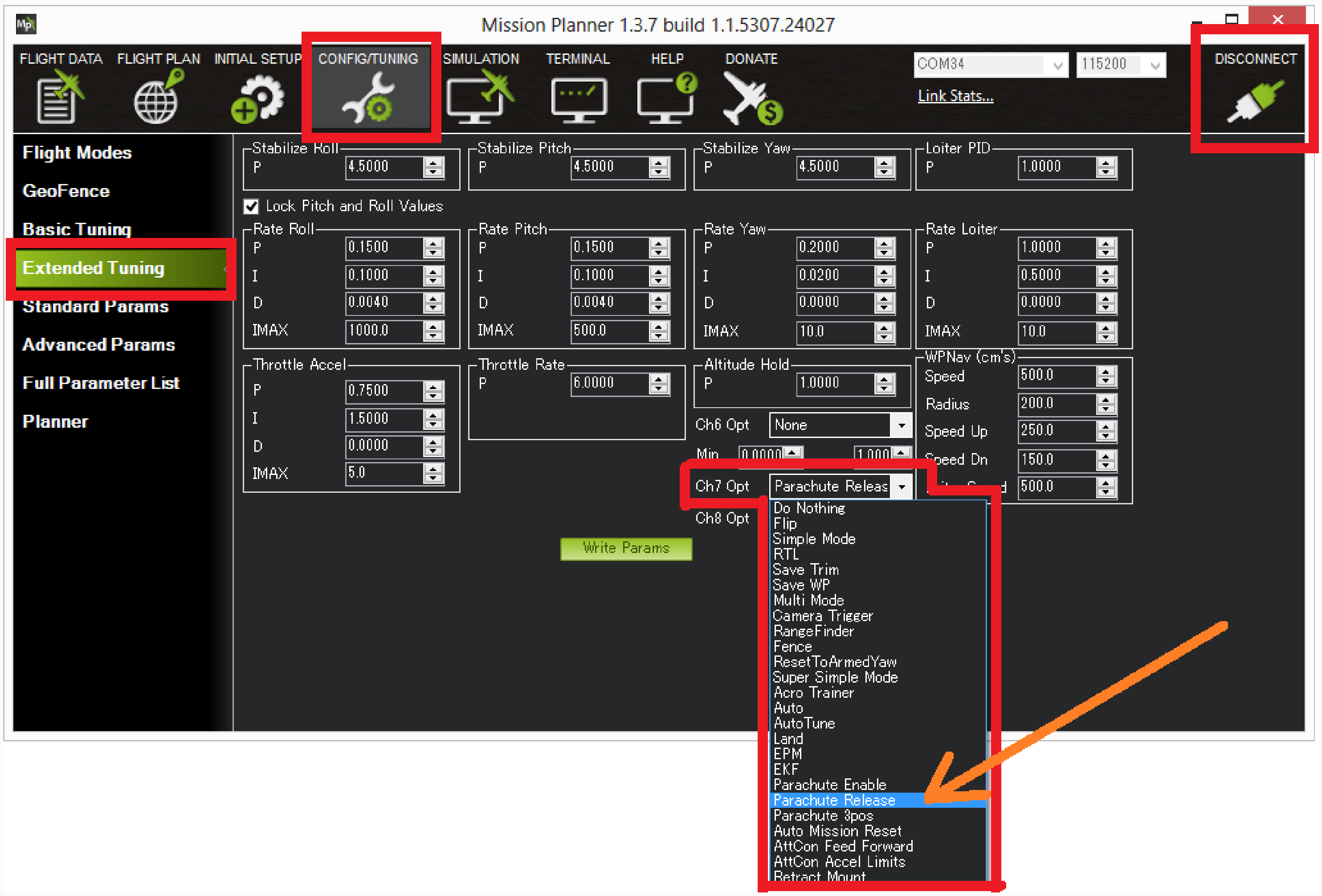
To configure the parachute release please first connect with the Mission Planner and then open the Config/Tuning >> Full Parmeter List page and set the following parameters.

- CHUTE_ENABLED = “1”
- CHUTE_TYPE = “10” to release with a servo
- CHUTE_SERVO_ON should be set to the servo position required to release the parachute
- CHUTE_SERVO_OFF should be the “resting” servo position. I.e. the position the servo is in before the parachute is released
- RC9_FUNCTION = “27”. RC9 refers to the Pixhawk’s AUX OUT 1. To use AUX OUT2 instead set RC10_FUNCTION to 27, etc.





Setup Ch7 to manually deploy the parachute from the Mission Planner’s Extended Tuning page.



When will the parachute deploy?

When the “Crash Check” feature determines that the vehicle has lost attitude control and has begun falling, the motors will be stopped and the parachute will deploy automatically. The following must all be true for a full 2 seconds for the crash checker to trigger the parachute release:

- The motors are armed
- The vehicle is not “landed” (the vehicle will consider itself landed if the output throttle is less than 25%, the motors have hit their lower limit, the vehicle is not rotating by more than 20deg/sec and the

pilot is not requesting a climb. All this must be true for 1 second for the vehicle to consider itself landed)
- The vehicle is not in FLIP or ACRO flight mode
- the roll and/or pitch angle of the vehicle is 20 degrees off from the target lean angle
- the barometer shows the vehicle is not climbing
- the vehicle is above the CHUTE_ALT_MIN altitude

Testing the chute

Depending upon the release mechanism a parachute deployment can be dangerous so please take care when performing these tests, removing the parachute and vehicle propellers as is appropriate.

To test manual deployment:

- Set the CHUTE_ALT_MIN parameter to zero to disable the minimum altitude check
- Arm the vehicle in stabilize mode and raise the throttle above minimum
- move the Ch7 switch to the high position

You should see the motors stop, the parachute servo move and if telemetry is attached, “Parachute: Released!” should appear on the Flight Data screen’s HUD.

To test the automatic deployment:

- Set the CHUTE_ALT_MIN parameter to zero to disable the minimum altitude check
- Arm the vehicle in stabilize mode and raise the throttle above minimum
- somehow tilt the vehicle over by at least 20 degrees

After 2 seconds, the motors should stop, the parachute servo will move and if telemetry is attached, “Parachute: Released!” should appear on the Flight Data screen’s HUD.

After the test is complete, return the CHUTE_ALT_MIN to the desired altitude (default is 10m)

Pre-Flight Checklist (Copter)

This page is provides a list of things to check following configuration, and before your first flight.

Summary Checklist

V1.0

APM-Copter
Flight Ops Checklist

PREFLIGHT

Groundstation

Laptop.................... Power On
Laptop Battery.................... Confirm Battery Lifespan
Mission Planner.................... Start
Telemetry Module.................... Connect USB
Telemetry Module Antenna.................... Orient Vertically
Com Settings.................... Com Port Select, Baud 57600

Aircraft

Airframe/Landing Gear.................... No Damage
Props.................... Secure, Undamaged, Correct Direction
Motors.................... Secure, Undamaged
ESCs.................... Secure, Undamaged
GPS Receiver & Cable.................... Secured
RC Rx & Connections.................... Secured
RC Satellite Rx and cable.................... Secured
Telemetry Module & Cable.................... Secured
APM.................... Secured
APM Connections.................... Verify All secured
Battery.................... Install in AV

Velcro Battery Straps........ Secure

FLIGHT

RC Tx........ Verify Throttle at Minimum
RC Tx........ Power On
RC Tx........ Verify Battery Voltage
RC Tx........ Verify Correct Model Selected
RC Tx Mode Switch........ Stabilize
Aircraft........ Place at RTL Location
Battery........ Connect (Don't move AV)
Telemetry Comms........ Connect with MP
Battery Cables........ Secure
RC Rx Antennas........ Straight
Telemetry Antenna........ Straight & Vertical
Telemetry Signal Strength........ >75%
Pitch & Roll AV.. Ensure Correct response on AH
Airspeed........ Verify 0 (+/-3)
Home Altitude........ Set
Altitude........ Verify 0 (+/-3)
Battery Voltage........ Fully Charged
GPS........ 3D Fix
Flight Plan........ Verify

Configuration

- Spin up the propellers on the ground and check they are all moving in the correct orientation.
- Check that your copter knows what level is. With the copter on a flat surface connect to Mission Planner and ensure the artificial horizon display shows level.
- Check all failsafe settings are enabled. Instructions are here for radio, battery, and ekf/gps.

Flying

- Make sure you have a GPS lock before flying if you intend to use any auto modes. Even if you're only flying in Stabilized mode this is a good idea so you can invoke Return To Launch if you get into trouble.
- Test RTL before sending your copter off on an auto waypoint flight. This is to check that the compass and GPS are working, and that it knows where home is before heading off on a more complex flight.
- Ensure that flight in Stabilize works well before you attempt any more complex flight modes. Ensure loiter works before trying RTL. Ensure RTL works before trying auto.
- Once armed stand 3m-6m away from the arming point as when in RTL the copter will be returning to this point.
- When testing more complex flight modes, be ready to switch back to Stabilize mode at any moment if it does anything strange. Stabilize or Acro are the only modes which can save you from a problem with the software or sensors. RTL is a good mode to save you from human error, but relies on the copter being able to locate and fly itself, so this should not be used as an emergency mode if other auto flight modes go wrong.
- Be sure you have a way of knowing when your battery is getting low, and land before you have used more than 80% of your battery capacity.

Traditional Helicopters

Copter supports conventional electric helicopters including all the same features as multicopters. The majority of the set-up is the same as for multicopters but please follow the links below for helicopter specific information.

- Suggested Parts List
- Mounting the APM/Pixhawk
- Connecting your TX/RX, servos and motors
- Configuration through the mission planner
- Tuning
- Pre-Flight Testing

Videos:

Altitude Hold Testing

Fast Forward Flight

Traditional Helicopter – Suggested Parts List

Electronics including flight controller

- APM2.6 (side pins) or Pixhawk with GPS and external compass.
- Extra long GPS cable (APM uses 5 to 6 position cable, Pixhawk uses6 position cable).
- Extra long compass (i2c) cable (both APM and Pixhawk use 4 position cables).

- 1mm carbon fibre sheets and 3 or 4cm stand-offs to build your own mounting plate or order a pre-made board from Japan Drones

Flybarless electric RC helicopter frame

At this time, only conventional single-rotor collective pitch helicopter types are supported such as the Trex450.

The program can be configured to fly flybarred, flybarless, with CCPM swash mixing or single-servo (H1) swash types. Many different commonly available electric helicopters have been flown, from a 450 size, all the way up to 700 size. The system has not yet been proven to work on fuel powered helis, but it should be possible assuming adequate vibration damping is provided for the APM/Pixhawk.

8-channel Transmitter / Receiver

Your transmitter & receiver should ideally support 8 channels (elevator, aileron, collective pitch, rudder, flight mode, tuning knob, auxiliary function switch, main rotor speed) although it’s possible to fly with as few as 5.

A discussion of which frequencies are legal to transmit on in which region is outside the scope of this wiki.

ESC with built in governor

If you intend to use any Copter flight control modes other than Acro and Stabilize, it is recommended than the speed controller you purchase should have a governor mode. This is because Copter will be controlling the pitch of the main blades automatically, but does not have an internal throttle control system. As such, when AC is commanding high rates of blade pitch, the rotor disk will slow if increased throttle is not be applied. A governor mode in the ESC can be employed to automatically compensate for this. The radio throttle curve and ESC governor can be set up so that the rotor speed will be held at an appropriate speed in all cases.

Digital servos

You should use digital servos instead of analog. There are a number of important reasons for this. First and foremost is because analog servos do not center nearly as well as digital servos. They will always stop on either side of true center, depending from which side they approach center. This phenomenon will cause the PID control system used in Copter to struggle to accurately control the helicopter. Furthermore, digital servos respond much faster to small input changes than analog servos do. This effect is over and above specified transit speed of the servos which is measured for a 60° sweep. If two servos, analog and digital both have the same specified transit time (eg: 0.20sec/60°), and both are asked to move only 5°, the digital servo will move faster than the analog. This also has an effect on how well AC can control the helicopter. Similarly, faster servos will also benefit AC control. The only downside to fast digital servos, besides cost, is that they will naturally have a higher power requirement. This means you will need a larger BEC, and more battery capacity if using a seperate radio system battery. Make sure that your power supply system is capable of providing the power they need.

Batteries

There are no special requirements for flight batteries. However, as a general rule, it is safer if you can have a separate motor battery and radio battery. Not only does this help prevent radio and Copter power loss when the motor battery drains, but also because disconnecting the power to the motor is one easy method to be absolutely sure that your motor will not turn while you are configuring the Copter system.

Traditional Helicopter – Mounting APM/Pixhawk to the Frame

The recommended method for mounting your APM/Pixhawk is to build an extra layer for the APM/Pixhawk between the main body and the landing gear as show in the image below.

- Separate the helicopter's main body from it's landing gear
- Attach one carbon fibre plate to the body, the other to the landing gear
- Drill holes in the upper and lower mounting plates so that the plates can be attached with four strong 3cm or 4cm stand-offs
- Mount the APM/Pixhawk to the bottom mounting plate using vibration dampening foam (see Vibration Dampening wiki page for ideas on mounting methods to isolate the flight controller from vibrations)

Traditional Helicopter — Connecting the APM

Transmitter programming versus APM programming

The APM does a lot of processing internally to fly your heli while the Tx stick inputs are only *pilot requests* which the APM uses to figure out what to do with the servos. Putting radio mixes into the APM, or trying to run an ESC manually goes against the whole idea that the APM **is in control**. You can use some **expo** , or possibly dual-rates, in your Tx but that's it, everything else must be done inside the APM.

Basic configuration of your receiver and servos

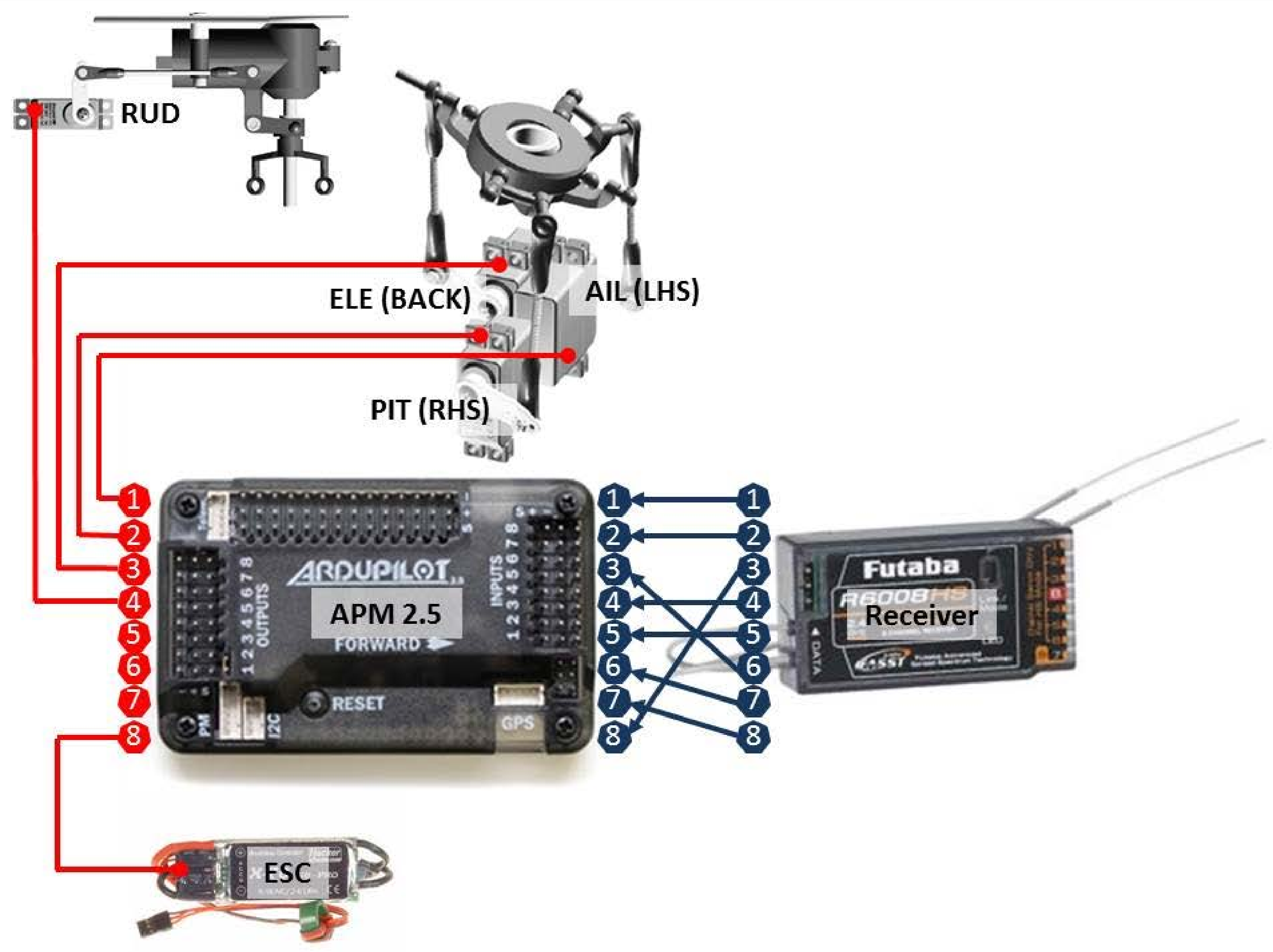
The basic radio set-up is very similar to the Multirotors. Although you will be flying a helicopter, the setup is easier if you do not use your RC transmitter in helicopter mode. Instead, setup your radio in normal airplane mode. Some radios call this “Acro” or “Fixed wing” mode. The Copter electronics and software takes care of all needed swash plate mixing.

Differences compared to the Multirotor set-up are:

- APM Output Channels 1~4 are connected to servos and the servos draw significant power from the power rails. Ensure your ESC and/or voltage regulator can provide enough power for the APM electronics and 4 power hungry servos.
- APM **Output** Channel 7 can be used as the (optional) external gyro gain
- APM Channel 8 can be used for the motor throttle using the Rotor Speed Control (RSC) function. This requires the rotor control signal from the Tx to be sent to the Input Ch8, and the ESC or governor to be plugged in to the Output Ch8.

Note

Check that your ESC outputs 5V (and not 6V!). If it’s 6V you will need to place a 5V regulator between the ESC and receiver (this is required because although servos are happy with 6V, you risk burning out the APM if you power them with 6V).
Connect up your Radio and ArduPilot Mega generally as shown in the diagram below for a Futaba radio system.



Note the **very important** cross-overs: Rx Channel 6 is connected to APM Channel 3 and Rx Channel 3 is connected to APM Channel 8.

Here is a comprehensive connection table for a Futaba Rx:

Channel	Futaba Rx	AMP2.5 Input
1	Aileron	Aileron
2	Elevator	Elevator
3	Throttle	Collective Pitch (i.e. swash plate height)
4	Rudder	Rudders
5	Aux1	Aux1
6	Pitch	Aux2
7	Aux2	Aux3

8	Aux3	Throttle

NB: We need info on channel settings for other radio systems! Some systems route different functions to different channels, and have little flexibility to move them within the radio program. In this case, you will need to make different channel cross-overs to suit your system. What is important is to match up the correct control function to the correct APM input!

For example, the Futaba 9CAP/CHP outputs the Collective Pitch control on Channel 6 so you need to connect that to input 3 on the APM. The throttle/ESC control is on channel 3 of the Rx, so that needs to be connected directly to the ESC or throttle servo or in v2.9.1 of the software to Channel 8. Please consult your radio manual to determine which function is routed on which Rx channel.

The diagram below might be useful in trying to understand how to connect your particular receiver to the APM. It has generic names for the inputs which might help you relate them to your system.

If you can, it’s best to use an 8 channel receiver because the APM2.5 has 8 input channels all of which have important functions.

APM Channel 5 (Rx Ch5): Aux 1

If you don't understand what **Mission Planner** is then this section may be worth returning to once you have that software loaded and you've familiarised yourself with it.

Everything you need to know about downloading Mission Planner for use with your Apm2.5+ can be found here!.

Ch 5 should be set up using a 3 position switch with possible mixing added later to get more than three outputs and this is used to select the mode you want to fly. There are 12 modes from 0 to 11.

0=stab 1=acro 2=alt_hold 3=auto 4=guided 5=loiter 6=RTL 7=circle 8=pos_Hold 9=land 10=of_loiter 11=Toy

Please note that of_loiter is for the optical flow sensor. Don't use it if you don't have one.

You set the modes you want using Channel 5 on your Tx and can find much more information on this here!.

APM Channel 6 and 7 (Rx Ch7 and 8): Aux 2 and Aux 3

Please refer back to the layout diagram above to remind yourself of the wiring of Rx Ch7 and Ch8 to APM channel 6 and 7.

In Mission Planner go to Configuration Tab>Standard Params>Copter Config and you will see at the bottom-middle of the screen a **Ch6 Opt**and a **Ch7 Opt** pull down menu. It is best to set Ch7 in your Tx up with a knob or slider. You can then choose a parameter you want to test over a range from the drop down menu and set the Min and Max values just below the Ch6 Opt drop down to the extreme values of the parameter range you want to test.

Ch8 in your Tx should be set up with a two position switch and you can activate the function in the drop down menu of the **Ch7 Opt** with this switch. Have a look at the Mission Planner options for Ch7 here!

Rotor Speed Control (RSC) using Output Channel 8 on APM2.5

To use the APM to control the rotor speed (ie.throttle/ESC), all you have to do is send whatever throttle signal you want in on Ch8(in) and then plug the throttle servo or ESC into Ch8(out) on the APM. Ch8 throttle control is important because it forces you to arm the APM before you can fly. Without arming, the motor will not start nor will the collective servos work. So Ch8 is used for switching the motor/collective on and off something like a throttle-hold. See a detailed explanation of the RSC set up here! which is part of the Configuration section of this Wiki.

Updating the PPM encoder on the APM2.5+

If you are using an 8 channel Rx it is important to have the latest version of the APM PPM encoder firmware iinstalled on the APM board. If you are having difficulties with it, information on upgrading the PPM encoder can be found on the Copter wiki.

NOTE TO FUTABA USERS:

If you experience a “twitch” while flying, it is likely because of an issue where the Futaba Rx is not working well with the PPM Encoder firmware. Please be sure your PPM Encoder firmware is properly updated.

External Gyro

An external gyro is not required with v2.9.1 of the Copter software and the external gyro performance is unknown and has not been tested. We don’t recommend using an external gyro and in time support for it will be removed.

Advanced Configuration of your Receiver and Servos

Copter can be configured to function properly with your radio set up with a helicopter profile. The reason for using this setup is to gain the benefit of helicopter functions pre-programmed into your radio, such as Idle-Ups and Throttle Hold. It is mandatory to set your swash plate to a non-CCPM mixing type. This is because the Copter program performs the CCPM mixing internally, and it must see discreet radio commands for Aileron, Elevator, Rudder and Collective Pitch.

The full details of this setup is outside the scope of this Wiki page. Chances are if you have been flying RC helicopters for a while, you know exactly what you need to do already.

With a Futaba radio this would be an H-1 or SW1 depending on your radio model. Other brands of radio will use a different nomenclature such as NOR, NORM, or 1SERVO. It is critical that CCPM mixing is turned off, please consult your radio manual to ensure you have it set up correctly.

Please note that many of the helicopter mixing functions in your radio (such as Revo Mixing) need to be turned off. This is why this setup is only recommended for advanced users.

Traditional Helicopter - Connecting RC Input, Servos and Motors

Basic Configuration of your transmitter/receiver

The basic radio set-up is very similar to the Multirotors. Although you will be flying a helicopter, you should setup your radio in normal airplane mode. Some radios call this “Acro” or “Fixed wing” mode. The Copter electronics and software takes care of all needed swash plate mixing.

As shown in the picture below you should connect your 8-channel receiver to the APM’s inputs. Alternatively you may use an PPM-Sum receiver.

The APM2’s input channel mapping is:

Channel 1: Aileron (aka Roll)

Channel 2: Elevator (aka Pitch)

Channel 3: Collective Pitch

Channel 4: Rudder (aka Yaw)

Channel 5: Flight Mode

Channel 6: In-flight tuning knob

Channel 7: Aux function switch (i.e. Camera trigger, Sonar on/off)

Channel 8: Main rotor speed

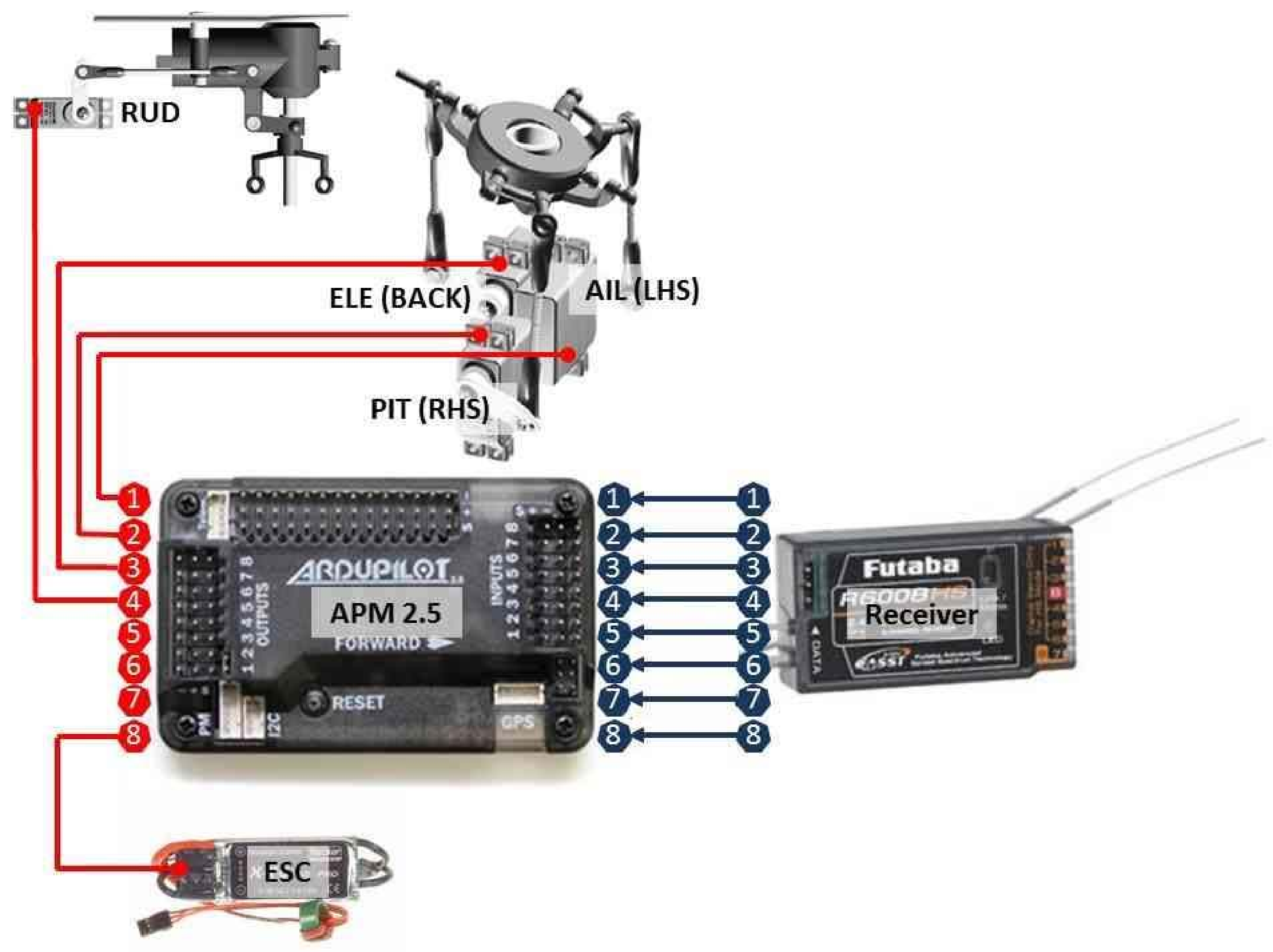
Powering the APM/Pixhawk

- If your main battery is a 3S or 4S (i.e. under 18V) and the total current draw will be no more than 90amps it is highly recommended that you use the APM2.5 Power unit with XT60 connectors. If the voltage or current is higher than this, you will need a separate 5V BEC to power the APM/Pixhawk and receiver.
- On the APM, remove the JP1 jumper to separate the output pin’s power from the APM’s CPU. The servos will be powered from the main rotor’s ESC (see below)

Connecting the servos

- Outputs #1,#2 and #3 should be connected to the 3 swash plate servos. The order is not critical although set-up is slightly easier later if you connect #1 to the front right servo, #2 to the front left servo and #3 to the swash plate’s rear most servo.

- Output 4 should be connected to the rudder servo.
- Main rotor's ESC should be connected to Output #8.



Notes:

- An external tail gyro is not required but if you choose to use one you should connect the gyro's gain wire to APM's output #7. The gyro's main signal wire should connect to the APM's output #4 and of course the tail servo should be connected to the gyro itself.
- If using a direct drive variable pitch tail the tail rotor's ESC should be connected to output #7

Traditional Helicopter – Configuration using Mission Planner

Setup using AP Mission Planner

Connect your APM to your computer using the USB, set the COM port and the baud rate and then press “Connect” and wait for the parameters on the APM to be transferred to your computer. Now, from the Firmware screen, push the “APM Setup (Plane and Quad)” button, then click on the Radio Calibration tab.

Radio Calibration

When it comes to calibrating your radio in Mission Planner, all the physical sticks should move in the same direction as the green bars on the Radio Calibration Screen with the exception of Pitch which should move in the opposite direction to the physical sticks.

To get the bars moving in the right direction you may need to reverse a channel in your radio but you really shouldn’t have to with the exception of throttle/collective for Futaba radios.

Accelerometer calibration

Before you attach your APM to the heli I would recommend you do an accelerometer calibration which is well described here. It’s easier to do if the APM is not mounted in the heli and it’s essential when running firmware 2.9 or higher.

Configuring the Servos

1. Ensure the Collective pitch bar moves up as you move your collective pitch up. If it does not, repeat the Radio Calibration. You may need to reverse the collective pitch setting on your radio.

2. Check that all your servos are moving in the correct direction as you move your collective pitch up and down. If any move in the opposite direction, click the rev check box beside the appropriate servo. Don’t be surprised or concerned if one or two of the servos move in the wrong direction just click the rev check box. I sure to be needed on at least one servo.

3. Type in the correct positions of each servo around the swash plate in degrees. 0 = at the front of the swash. Refer to the compass image on the set-up screen if necessary. Note: after updating one of the position values you must leave the field (or click on the compass) and you should then notice the swash twitches momentary as it is reinitialised.

Capturing the Swash Plate Range

4. Push the **Manual** button. This will momentarily allow the servos to move freely and input from the radio will directly control the servos.

Change the collective pitch on your radio to move the swash to it’s upper and lower limits. If you accidentally move the swash too far so the servos bind, manually set the Top and Bottom of the range in the field provided.

Push the **Zero** button after making sure your main blade’s pitch is zero. If you want to tune your heli even better, set the pitch at hover pitch, say 3 or 4 degrees, and your heli won’t climb when you switch modes but this is a refinement that you may want to come back to after your initial set-up.

Push the **Save** button.

If you want to re-do this step, close the setup window and re-open it.

5. Update the maximum roll and pitch values into the fields provided as a number of degrees. Default is 45 degrees which is what most people use.

Note

Avoid reversing the collective pitch channel (RC_3) in Mission Planner because it will affect the way the arming system works. Instead, reverse your *servos* in Mission Planner OR reverse the *channel* in your radio.

Configuring the Rudder

6. Tick the Rev check box if you find the tail moves in the wrong direction. Again, its not atypical to have to reverse this function. Remember, stick to the right, heli should rotate clockwise, Stick to the left, heli should rotate anti-clockwise (when viewed from above).

7. Push the **Manual** button and move the rudder channel on your radio to it’s full range to capture the min and max rudder range while avoiding any binding.

Push the **Save** button.

As with the collective pitch you can update the Min and Max manually if necessary.

8. If you have an external gyro, click the Gyro **Enable** button. Enter the Gain manually. This is a value from 1000~2000. this servo value is simply output on Channel 7 which should be connected to your external gyro's gain channel (thus freeing up a radio channel for other purposes). An external gyro really is not needed and this is a legacy option. The APM2.5+ will lock the tail beautifully.

Rotor Speed Control (RSC) using Output Channel 8 on APM2.5

To use the APM to control the rotor speed (ie.throttle/ESC), all you have to do is send whatever throttle signal you want in on Ch8(in) and then plug the throttle servo or ESC into Ch8(out) on the APM. Ch8 throttle control is important because it **forces you to arm the APM before you can fly.** Without arming, the motor will not start nor will the collective servos work. So Ch8 is used for switching the motor/collective on and off something like a throttle-hold.

RCS can be set on the Heli Setup Tab of Mission Planner

There are three settings to control how the APM sets up Ch8 control:

Note the following error on Mission Planner: Mode 1 is a direct pass through of the throttle input signal and Mode 2 is for an ESC with built in governor. MP asks you for the "Mode 1 Setpoint" This is a typo and it should ask for the "Mode 2 Setpoint". Please test with caution. Hopefully this will be rectified in the next release.

Disable (H_RSC_MODE set to 0)

If you don't want to use Ch8 control then set H_RSC_MODE to 0. Now you can arm the APM without Ch8 but the collective will only work once armed. Hopefully you can live with that and it achieves the important step of insuring that you do not fly unarmed.

Mode_1 (H_RSC_MODE set to 1)

With H_RSC_Mode set to 1, you have a direct Ch8 pass-through; however it is still set low when disarmed. The motor will ramp-up subject to H_RSC_RAMP which can be set to 0 if you want to rely solely on your ESC's start-up characteristics. Once ramped up Ch8(out) it is slaved to the Ch8(in) so you can pass through a variable throttle signal if you want.

All H_RSC_RAMP does is, after arming, when you first engage the throttle in Mode 1 **or** 2, it ramps up the output slowly. It’s like a super-soft-start.

RSC_Ramp set to 1000 = 10 seconds.

Also note the APM won’t arm in Mode 1 or 2 unless Ch8 is within 10 of RC8_Min.

Mode_2 (H_RSC_MODE set to 2)

When H_RSC_MODE is set to 2 the APM now only sets Ch8(out) to be high or low and, when high, it sends out H_RSC_SETPOINT (this is the setpoint in MP) while when low it sends out RC8_Min.

Plug the ESC into Ch8 on the APM and put it in governor mode.

Ch8 can be driven by a 2 position switch. When the switch is down, it outputs whatever the minimum is (endpoint is set to -100%) and when the switch is up it sends the maximum signal, so endpoint +100%.

The only trick is to “calibrate” the ESC to the signal which is easily done if you can plug the ESC into the Rx.

To calibrate it using the APM, take the blades off or loosen off the pinion. First make sure you have done a radio calibration in APM using the 100%/100% endpoint on Ch8. Unplug the ESC from the APM. Boot the system up, the ESC should be beeping at you because no signal. Now, make sure the Ch8 switch is low or you can’t arm the APM. Now arm it, set the collective stick to the middle (this prevents it disarming due to inactivity) and then switch the Ch8 switch high and wait about 15 seconds. It should now be outputting a high signal on Ch8. Plug the ESC in. It should give you a confirmation that it has gotten a high signal and waiting for low. Now, turn Ch8 off. The PWM output will immediately drop to the minimum. Your ESC should beep to tell you it has read the minimum, and is ready to go. Now, if you switch Ch8 high again, the motor should go to full power. It will ramp slowly over 10 seconds if you have left the R_RSC_RAMP at 1000. You could set this to 0 if you have a good soft-start on your ESC. Or you could change it to 500 for 5 seconds, 2000 for 20 seconds, whatever you want.

Then after all this is done, go into the endpoints and I change the high endpoint so that it is outputting only 80% throttle when it’s switched on. Now the governor gets an 80% signal when running and you get a nice even head speed while flying.

Now it’s really easy to use. Put Ch8 off, collective down. Arm the heli, switch Ch8, the motor starts and gets to the target speed. Now you can take off.

The only catch here is that if you arm and leave the collective at full negative it will disarm after 10 to 15 seconds. When this happens the APM will immediately shut down the motor. So it’s safe but it can be a nuisance. To avoid this, while waiting for spool up, move the collective up just off the bottom, not enough to fly and this will prevent the disarming.

The APM will always arm with the stick down/right and disarm with down/left.

Getting to your First Flight

So here is what you need to do to get to your first flight.

Swash Set-up

What flight mode should you have your radio set to while tuning the servos?

Usually Stab mode but sometimes it’s worth looking at Acro mode too, depending on what you’re doing. But NEVER in auto mode. If you are trying to adjust the collective you should be using the button for that in the Mission Planner Heli tab. If you are trying to do it the manual way, by just twiddling the settings in the Advanced Param tab, then you should use Acro for collective adjustments. This ensures that the STAB_COL params are not in play. So you would set your ABSOLUTE min and max in Acro mode. Then set the STAB_COL in Stab mode.

Remember, any time you change any of the numbers in the Advanced Parameter list you must got to H_SV_MAN, set it to 1, then “write”, back to 0, then “write”. This resets the swash calculations. If you don’t do that, it messes things up. If you modify the swash through Mission Planner this is done automatically by the Mission Planner software.

Set your heli up with +/-10° pitch. Then, you will need to go to Configuration>Advanced Parameters>Parameters List and find H_STAB_COL_MIN and H_STAB_COL_MAX and set these to 30 and 90 respectively. This will give you a collective pitch range of about -2° to +8° in Stabilisation mode.

Now, any time you change these numbers (ie: change them in Mission Planner and “Write” to the APM), they won’t take effect right away. There’s a number that gets calculated and it is only recalculated when you reset the swash. The swash is reset any time you reboot, however, you can force it by finding H_SV_MAN in the Parameter List and setting it to 1, “write” and then set it back to 0, and “write”. This forces it to reset the swash and you’ll see the effect of the H_STAB_COL changes immediately. Hopefully this will be changed in a future version of Mission Planner with all of this in the heli setup tab.

You should be able to switch between Acro and Stab, move your throttle and see the difference in the swash plate movement.

We do recommend setting up the swash with lots of negative pitch and then set the H_STAB_COL_MIN for whatever negative pitch you are comfortable with. Even if you never use negative pitch, this still allows the Alt_Hold controller to have access to full negative pitch will sometimes be needed.

Set H_COL_MID to be hover point rather than 0° pitch to avoid having the heli ascend when you switch to Loiter or Alt Hold Mode. So that covers the swash plate setup.

Flybar Mode

So here's what Flybar_Mode does.

First, in Acro mode, it skips ALL stabilization/rate controllers. Your stick inputs go DIRECTLY to the servos. The only thing the APM does is the CCPM mixing. It becomes completely dumb. So Acro = Full Manual. The only real issue with this is that there is basically no trim. If you are trying to hover, and the swash isn't setup right mechanically, it'll roll. The only way you could stop that is by adjusting your swash linkages, or using radio trim. Using radio trim is not good, because then that will mess up all your other modes because the APM will think you are holding the sticks.

So the second big thing Flybar_Mode does is that it makes the Rate I term only "active" near zero rate command. It won't move whenever you're asking the heli to move. It will only move the Integrator, basically in a hover. So it's sort of like an auto-trim for hover. Whenever you are moving the sticks, it's frozen. Again, I did that because I didn't want the Integrator doing whacky things to the flybar, because the flybar and the rate integrator do the exact same thing, but neither one of them knows what the other is doing!

Traditional Helicopter – Tuning

PID Tuning

Now, we come to the PID tuning. This part is a bit trickier. The first tip is that whenever you go into the Copter PID configuration screen; make sure that Lock Pitch/Roll is unchecked. Helis need separate pitch/roll values because the moment of inertia of the airframe is very different in the two different axes. This is because the tail boom is so long and there's a lot more mass in the fore/aft axis, so it's slower.

On the Copter Config tab, the STB_RLL_P value should be the default of 4.5 and STB_PIT_P value should be the default value of 3.5. This softens the pitch axis a bit compared to the roll axis and helps prevent bouncing. The I-term on both should be zero.

Now, the Rate part is a little trickier.

You will need to change the RATE_PIT_P and RATE_RLL_P to get your heli to fly properly but to start with, set these to zero. They should be zero by default.

Something to keep in mind here, the Rate PID numbers you come up with will be heavily influenced by the following: # Your swash servo speed # Your swash servo motion ratio i.e. servo arm length, swash plate dimensions and blade grip arm length # H_PIT_MAX and H_ROL_MAX values.

Any time you change these you'll probably have to retune your Rate PID's a bit. We expect that with faster servos you'll be able to tune Rate P up and get better control without oscillation. Start with RATE_RLL_I of 0.1000 (default) and RATE_PIT_I of 0.0500 (default is 0.1000).

Now set Ch6 tuning in the Copter Config tab to CH6_RATE_KP and set the Min to 0.0100 and the Max to 0.0750 and make sure you turn your Ch6 knob all the way down. Refresh parameters and make sure that RATE_PIT_P and RATE_RLL_P show up as 0.0100 so that you know the Ch6 tuning is working properly.

Here's where it gets tricky and we really recommend you do this in a large area with no wind. Maybe indoors in a 20m by 20m area, but only if you're a good pilot.

Spool up your heli **VERY CAREFULLY**. Don't just take off because you will have very little control over the heli! It might be best to do this with training gear if you can. Lift off just one inch but be ready to put it down because you will have little or no control. It's going to be bad, so be ready for it! You should have no oscillation with a P-term of 0.0100.

If you do, you have big problems and will need to consult the specialists on DIYDrones!

Now try turning the knob up a bit, maybe to 0.0200. Try just lifting off remembering that you will still have little control but hopefully you will have no oscillation. Keep doing this, testing more and more P-term until you get oscillation. Be careful with that P-term because once you find the point where it oscillates, it gets bad REALLY fast and you could destroy your helicopter! You will find that the oscillation will always happen in the roll direction first. This is because of its lower moment of inertia.

You should get to a RATE_RLL_P of about 0.0400 (on a 450 size heli) or maybe even a little bit more but hopefully you end up in this range. However, you will find that you still have very little control, even up to the point where it starts to oscillate!

Once you find the oscillation point, back off a bit, maybe 0.005 to 0.010. Now, set the Ch6 tuning to "None", and make sure you have a good Rate P-term in the RATE_RLL_P and RATE_PIT_P window. If you fly right at the limit of oscillation you will find that sometimes if you bump the skids or there's a wind gust, it can start to oscillate. That's why you want to back off a bit.

Remember that when you get your P value to high the heli will **rock and roll** something fierce. Be careful and only lift of the ground a few inches or a foot at most and be ready to put it down if it starts to oscillate out of control.

Now you have established your RATE_RLL_P value, your RATE_PIT_P value can be a little higher. For example, use 0.050 with 0.040 for Roll and remember to unchecked “Lock Pitch/Roll”!

Now you can play with the I-term. You can do so similarly, with Ch6. It’s important to remember the RATE_PIT_I term will be LOWER than the RATE_RLL_I. Try using Roll I = 0.250 and Pitch I = 0.150. These I-values are less critical than the P-values - you’re not likely to destroy your heli with a high value, more likely to just get a “bounce”. So, at this point, you should have a heli that will fly without shaking but it still flies like it’s “drunk”. It’ll just wander around with you chasing it but now it’s time to fix that.

Go into Advanced Parameters>Parameters List and find RATE_RLL_FF and set it to maybe 0.020 to start. Do the same for RATE_PIT_FF. Write these and then give it a test fly. You should now find that it flies much better, you will have more control, it should hover better. Play with these numbers a bit and always remember to “write” the parameters to the APM. For a 450 size heli try using 0.040 on Roll and 0.050 on Pitch. It’s not clear how high you can push these but it will start to oscillate eventually.

Here’s a question that might come up as you begin to fly more: It it’s a little windy and I do not have enough control over the swash, what can I do?

Increase STB_RLL_P from, say, 3.8 to 4.5 is probably a step in the right direction... sort of. It will make the heli try to make bulk moves more strongly, which is good for fighting winds but maybe not so good for camera work as it could jerk the camera around. It does indirectly increase the servo movement.

Yes, increasing your RATE_RLL_P will cause it to shake. That’s not a great solution. Fill your plate with RATE_RLL_FF? This gives you much more control authority with less chance of shake you get with P-term. It can still crop up however.

RATE_RLL_I and I_MAX are also important. You should be able to increase I and get more travel without getting the shakes.

Moving the control link out on the servo horn will have the exact same effect as increasing the PID terms, so it’s not a solution. You’ll find you just have to back off the rate PID’s to avoid shake again. And then you can get into a situation where you don’t have enough resolution on the servo.

One part of this situation is the fact that the Rate I term is not a classic I-term, but a “leaky” I term. It bleeds down 2% every 100ms... it’s complicated but it’s there for a few reasons. One of these reasons is because if we use a standard I-term, and you leave your heli sitting on off-level ground, the swash will slowly tip over as the I-term builds up. If you spool up, the heli will tip over. It's not fun. The problem with this is it really limits how much control movement we can get out of the I-term. It's sort of a lesser of two evils. If we could use a regular I-term, it would help. But we can't... well, we're working on something but it will only work if you are using the Ch8 rotor speed controller so make sure you have this set up properly.

Rudder Tuning

At the same time, think about adding some RATE_YAW_FF. Maybe try using 0.040 here. You might expect to back-off on the RATE_YAW_P just a bit as RATE_YAW_FF increases. Start with a RATE_YAW_P value of 0.25 (default) and move downward to say P=0.120 or even P=0.100. Try I = 0.02 and D = 0.002

For a 600 size heli the rudder (yaw) settings may look like this:

RATE_YAW_D	0.004
RATE_YAW_FF	0.05
RATE_YAW_I	0.15
RATE_YAW_IMAX	2000
RATE_YAW_P	0.38

You're not finished fiddling with this yet but what you will find is that these settings make the yaw control much stronger then on previous versions of the software and also help reduce the very small oscillation it used to have.

Acro Mode Tuning

The AXIS_ENABLE parameter should be set to 1 otherwise Acro mode will be unflyable. AXIS_ENABLE basically turns on a 3-D "heading lock" gyro mode that works very well.

There are a few other parameters you should know about:

ACRO_BAL_PITCH and ACRO_BAL_ROLL: These create a "virtual dihedral" which attempts to return the heli to level. This is what Leonard calls "Acro with training wheels". 200 makes it feel almost like stabilize. If you fly with it on 50 it feels nice. 0 would obviously turn it off completely.

ACRO_TRAINER: This is in addition to ACRO_BAL_ROLL and prevents the heli from rolling past 45°.

You can push it a bit beyond but it won't go too far. If you don't want it, just turn it off.

If you want to speed up the angular rate, you will want to play with ACRO_P which defaults to 4.5 which gives you a rate of 202°/s. Set at 6 will give about 270°/s and 8 will give about 360°/s. The gyros have a full scale of 2,000°/s

Stabilization Mode Tuning

One of the things you should look at is your STAB_PIT_P and STAB_RLL_P numbers? These were probably quite low in version 2.7.3, probably less than 1, and they should now be 3.5 to 4.5. This is a really big factor in getting the servo movement you are expecting.

Throttle Tuning

THR_MID convert's the pilot's throttle input (0~1000) to the motor output (130~1000). It has two different scales so that the pilot's 0~500 input maps to the 130~THR_MID value...then another scale so pilot's 501~1000 input is mapped to the THR_MID~1000 output for the motor.

Essentially THR_MID should be the throttle setting for hover.

For a 600 size heli a possible throttle set up could be:

THR_ACCEL_D	0.001
THR_ACCEL_I	0.6
THR_ACCEL_IMAX	500
THR_ACCEL_P	0.3
THR_ALT_I	0
THR_ALT_IMAX	300
THR_ALT_P	2
THR_MAX	1000
THR_MID	500
THR_MIN	130
THR_RATE_D	0.001
THR_RATE_I	0
THR_RATE_IMAX	300

THR_RATE_P	3

Aerobatics in Acro Mode

Acro Mode in APM:Copter now supports full acrobatic flight! The function is similar to any other acrobatic FBL controller available on the market. The performance might not be suitable for helicopter competition, but it certainly adequate for sport flying.

Many maneuvers have been fully tested, loops, rolls, inverted flight, etc. Caution should be exercised if aggressive 3D type maneuvers are attempted, such as tic-tocs, etc. While the control algorithms are fine, it’s unproven if the system is able to maintain it’s orientation relative the ground. In other FBL controllers, if this were to happen, the controller would simply turn off the self-leveling function but the acrobatic flight can continue as normal. But with APM:Copter, this could lead to loss of control even in Acro mode. We will attempt to remedy this situation in the future so that all maneuvers can be performed.

ACRO_BAL_PITCH = 50

ACRO_BAL_ROLL = 50

ACRO_P = 4.5

ACRO_TRAINER = 0

AXIS_ENABLE = 1

ACRO_P is basically the angular rate. 4.5 gives you 202.5°/s. 9 would give you 405. But nobody has pushed that high.

ACRO_BAL_ROLL is like a faked “dihedral” effect. It makes the copter return to level gently at center stick. 50 is fairly low, 200 makes it feel almost like Stabilize.

ACRO_TRAINER is an addition thing that makes the heli not want to roll past 45°.

AXIS_ENABLE turns the whole angle-lock thing on. Sort of like Futaba AVCS in all 3 axes. Without it, it’s pure rate control and your experience will be pretty bad.

Traditional Helicopter - Pre-Flight Testing

Before your first flight, please follow these pre-flight checks:

Warning

The engine should be disconnected to prevent injury. Be careful! A spinning propeller can cause serious injury!

- Ensure the miniUSB connector is disconnected from the APM
- Connect the battery to the ESC

Test leaning the helicopter in Stabilise mode

- By hand, roll the helicopter to the left. The swash plate should lean to the right.
- Roll the helicopter to the right. The swash plate should lean to the left.
- Pitch the helicopter down (i.e. nose down). The swash plate should lean backwards.
- Pitch the helicopter up (i.e. nose up). The swash plate should lean forwards.
- Rotate the helicopter quickly clockwise - the tail servo should move as if you had pushed the rudder control left (i.e. it’s should try to fight against the rotation)
- Rotate the helicopter quickly counter-clockwise - the tail servo should move as if you had pushed the rudder control right (i.e. it’s should try to fight against the rotation)
- Next rotate the helicopter slowly. You should find that in a certain direction the rudder stays in the middle. This is the APM trying to hold that heading.

Test the transmitter in Stabilise mode

- Using the transmitter, move the roll stick to the left. The swashplate should lean slightly to the left.
- move the roll stick to the right. The swashplate should lean slightly to the right.
- Move the pitch stick forward. The swashplate should lean slightly forward.
- Move the pitch stick back. The swashplate should lean slightly backwards.
- Move the yaw stick to the left or right. The tail should move in the same direction (and about the same amount) as when you are in manual mode.

Traditional Helicopter – Loading the Firmware

The easiest way to load the latest code is by using the Mission Planner much like you would for a quad. You can get the latest Mission Planner by following the topic Installing Mission Planner. The only difference being that after you click on the “Firmware” button, you click on the helicopter icon.

Developers may also want to build the code and upload their own firmware. See the Developer wiki for more information.

Traditional Helicopter – Using a Compass

Remote-mounted compass

If you have your APM2.x located on the bottom of the heli frame near to the motor you may well have a problem with your compass. On most helis its worth using an external compass with APM2.5+. It costs an extra $40 but it's worth it. So locate both the GPS and compass together either on top of the boom mount or ideally half-way back on the boom.

On a 450 it is best located on the boom mount because the heli is so small that the weight of the GPS on the tail will be significant and cause CG issues. However, on a 600 this is less of an issue so have both mounted on the boom, halfway back. You still have to consider the CG, but it's manageable. This sets the compass quite far away from all the interference from the motor and works very well.

A good thing to test your compass is to use the Mission Planer and have a GPS fix. Then go to the Google map and verify if the red line of the Quad symbol fits the physical orientation of your Heli. If not adjust the Declination in the hardware Compass setup. There is also a website to show the Declination of your location.

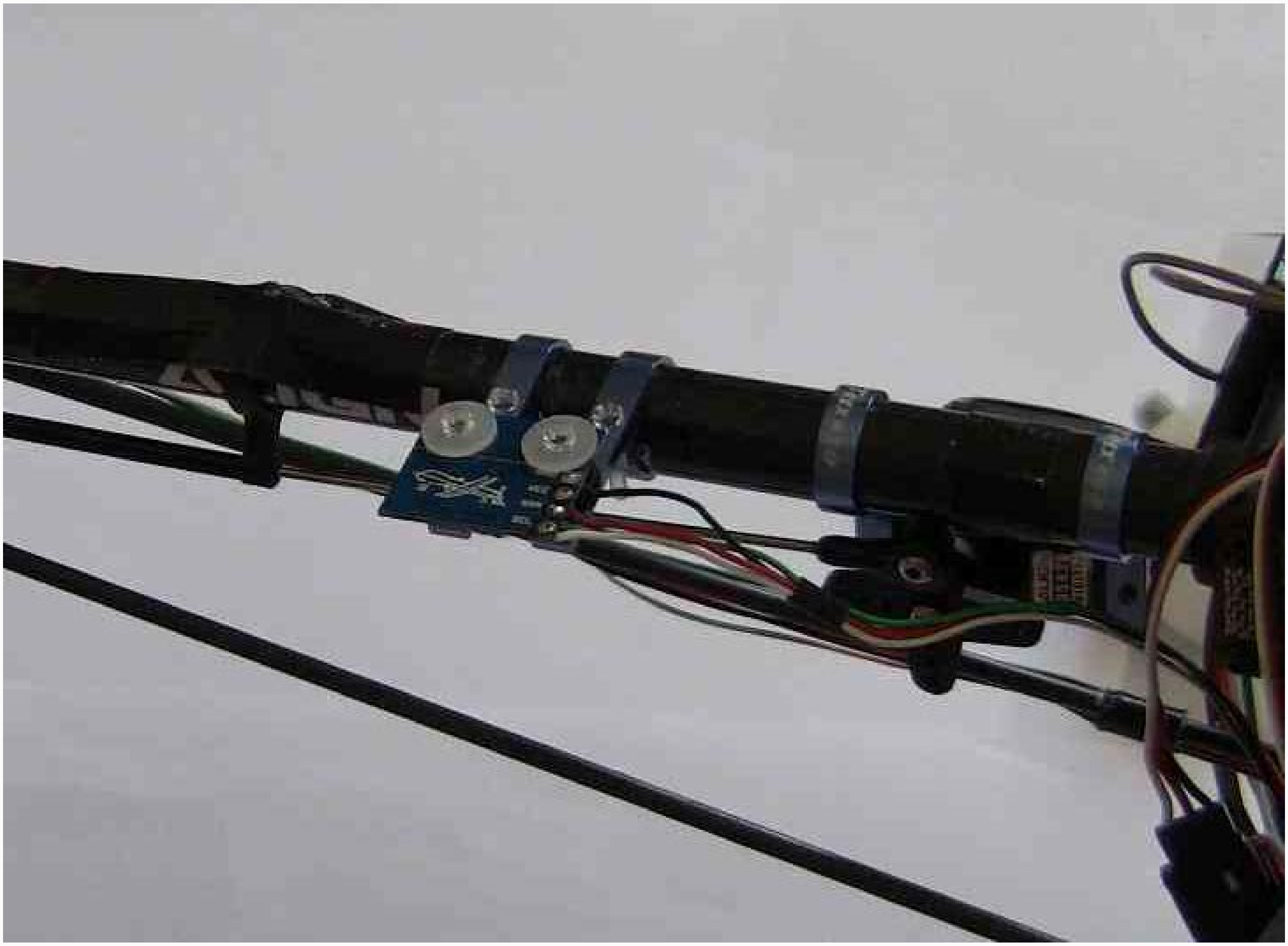
Using a compass

In order to correct for yaw gyro drift and to allow GPS position hold to function, it is highly recommended that you use a HMC5883L magnetometer (compass).

The best way to mount the compass is to modify a GPS cable, cutting off the connector on one side and soldering the wires to the pads on the compass board. The pins are even in the correct order but if there is any doubt, you can look at the bottom of the shield where you should see "SCL", "SDA", "+5V", "GND" written. These should be matched up to the pins on the compass. You will need to make the cable approximately 55cm long to reach from the APM to the compass on the tail.

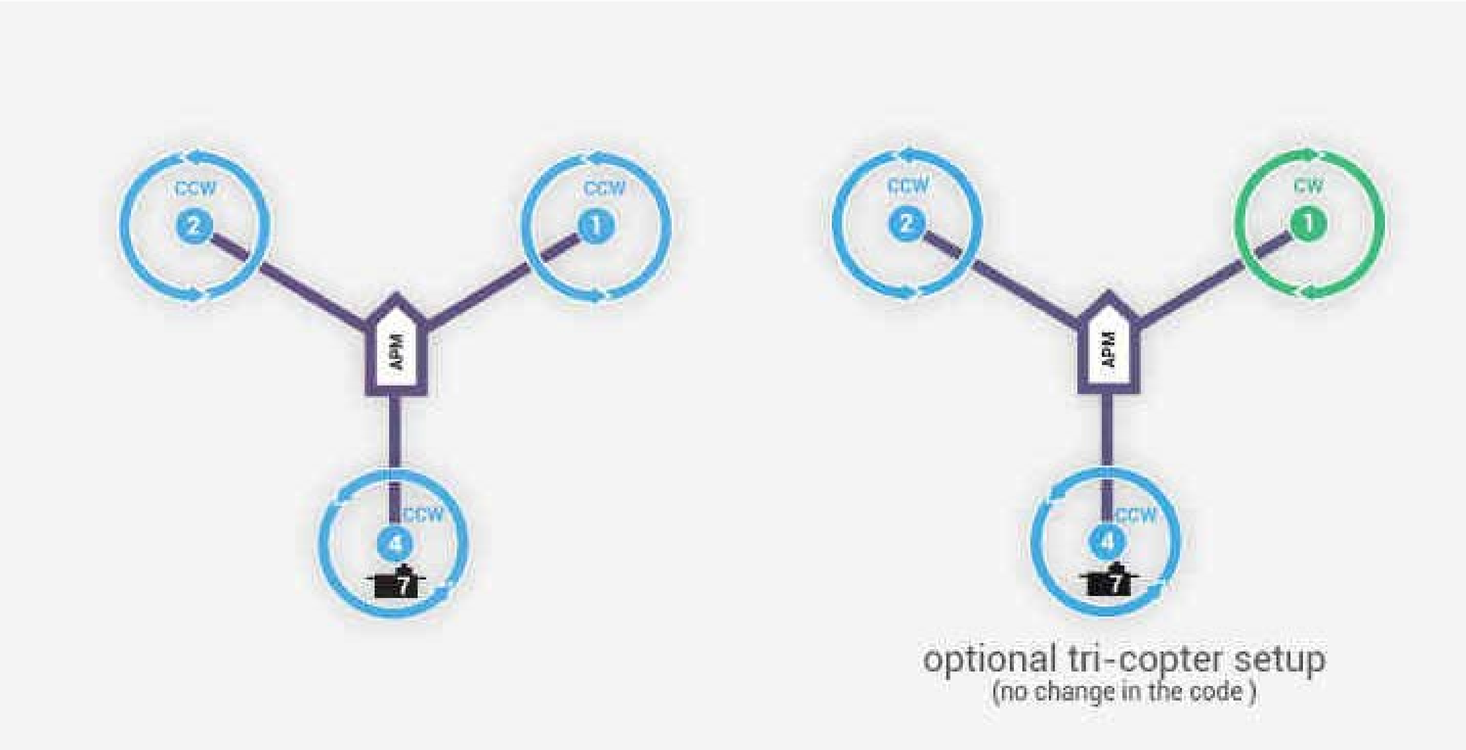
When mounting the compass, try to keep it as far away from any magnetic, ferro-metallic (ie: steel), or electro-magnetic sources (ie: servos, motors) as you can. In particular, do not use steel screws to mount the board. Aluminum screws have been tested and do work, and of course nylon screws would be an excellent choice.

The best place to mount the compass is on the tail boom close to the body with components down and pins forward.



Tricopter Configuration

This page outlines the special settings required to get a TriCopter flying. The more general instructions for setting up a multicopter should be used for all other aspects of the setup.



Copter 3.4 (and higher)

- MOT_YAW_SV_ANGLE : yaw servo's maximum lean angle in degrees. This allows for the rear motor's thrust to be adjusted appropriately depending upon the lean angle. The default is 30 degrees. "0" would mean the rear servo can only point directly up (which would not allow the vehicle to fly), "90" means the rear servo can point horizontally.

The channel used for the tail servo can be changed from it's default (channel 7) by setting the appropriate RCX_FUNCTION to 39. For example the Pixracer only has 6 output channels so the tail servo can be moved to output channel 5 by setting RC5_FUNCTION to 39.

See Copter 3.3 section below for more parameters that can be adjusted.

Copter 3.3 (and higher)

- MOT_YAW_SV_MIN: yaw servo's lowest PWM value before binding occurs.
- MOT_YAW_SV_MAX: yaw servo's highest PWM value before binding occurs.
- MOT_YAW_SV_TRIM: yaw servo's PWM value close to what is required to keep the tail from spinning.
- MOT_YAW_SV_REV: yaw servo's reverse setting. +1 = servo moves in default direction, -1 to reverse direction of movement.

Copter 3.2.1 (and earlier)

- RC7_MIN: yaw servo's lowest PWM value before binding occurs.
- RC7_MAX: yaw servo's highest PWM value before binding occurs.
- RC7_MIN: yaw servo's PWM value close to what is required to keep the tail from spinning.
- RC7_MIN: yaw servo's reverse setting. +1 = servo moves in default direction, -1 to reverse direction of movement.

SingleCopter and CoaxCopter

Warning

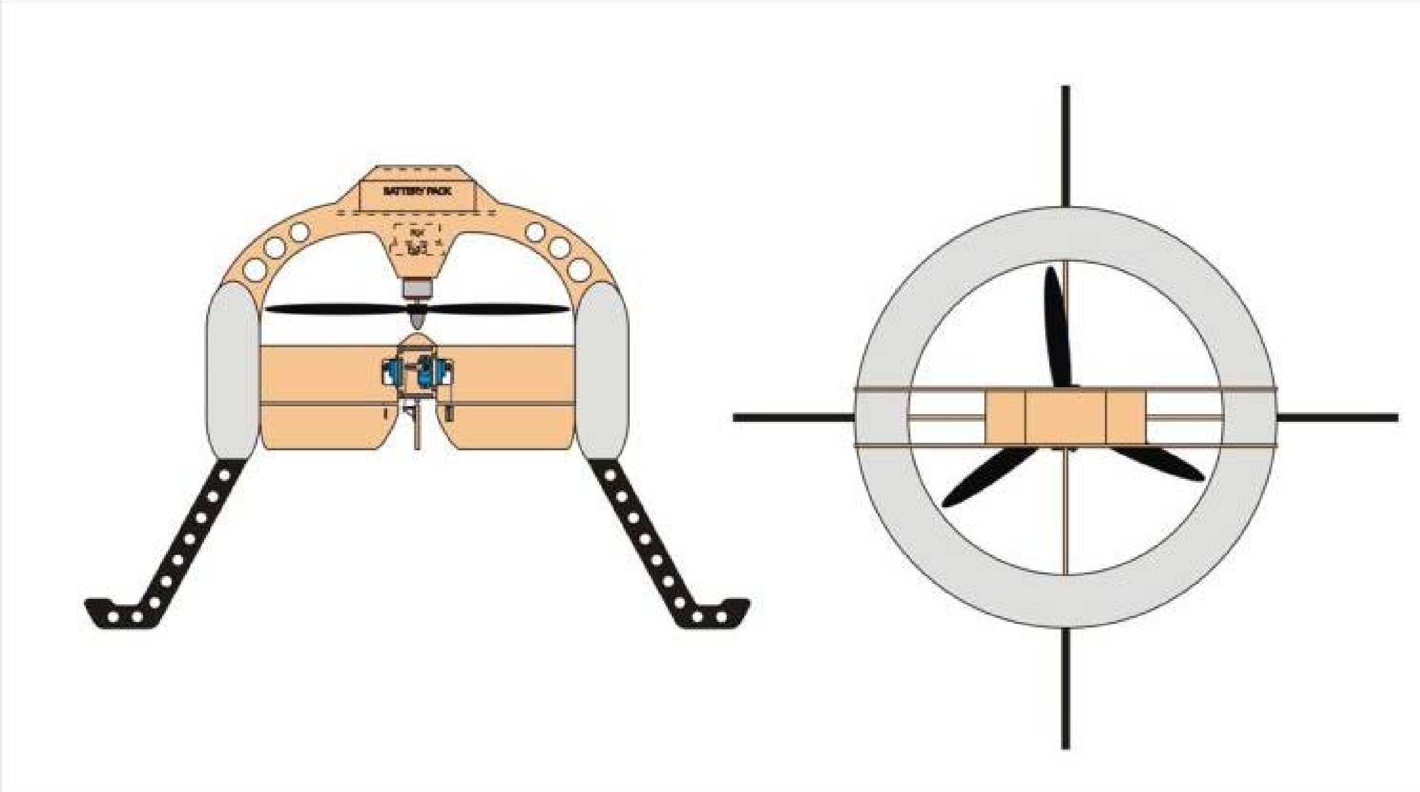
Warning the SingleCopter (available since AC3.1) and CoaxCopter (available since AC3.2) are not regularly used and have not been extensively tested!
As this is VERY new many of the Single copters shown here use either mil-spec or very simple stabilize mode controllers.

The First Video of a SingleCopter using an APM 2.5

https://vimeo.com/77850133

SingleCopter

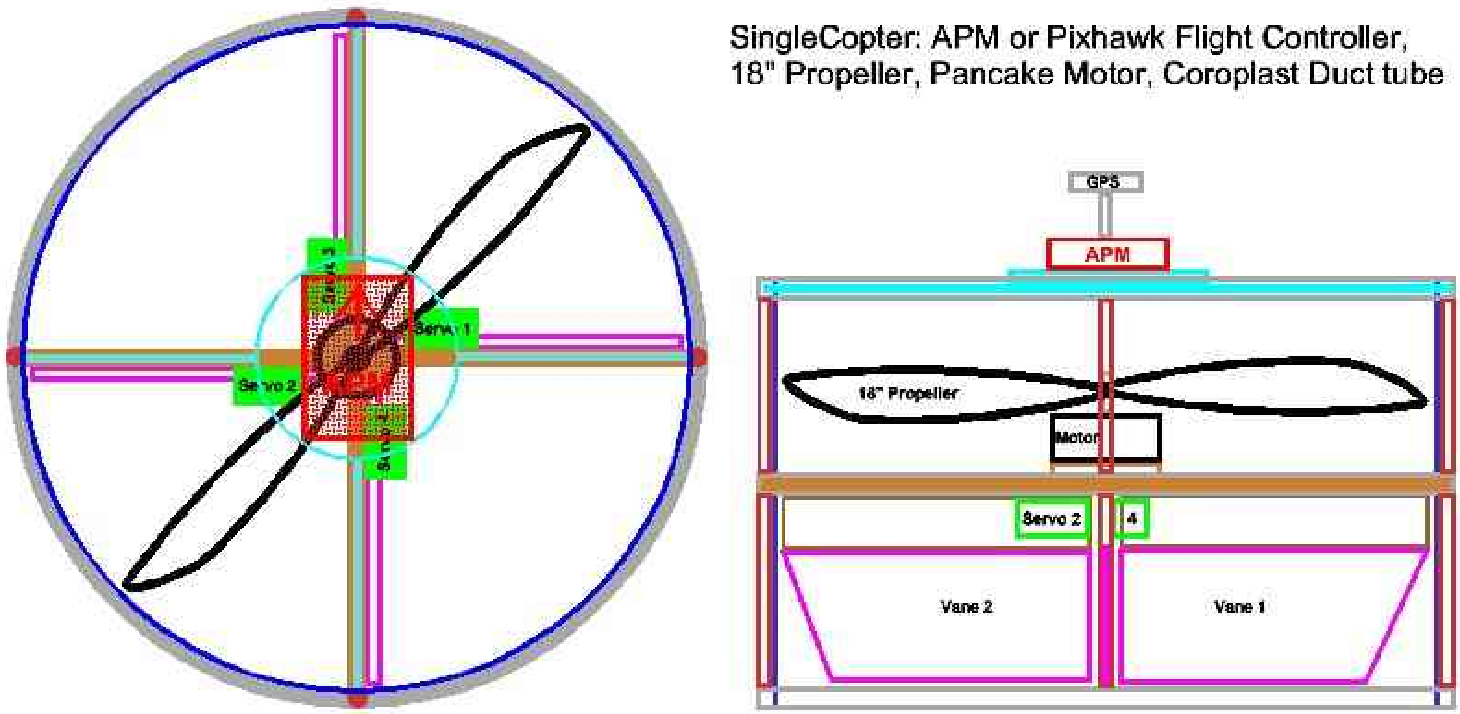
- A SingleCopter is an aerial vehicle with one central rotating propeller thrusting downward past 4 controllable vanes.
- The 4 control vanes (one in each quadrant) permits the control of the vehicles roll, pitch and yaw.
- The vanes also permit real time compensation for the motors direction of rotation.
- Altitude is controlled by adjusting the motor / propeller speed.



An innovative and quite successful hobbyist SingleCopter

Connecting the Flight Controller to the SingleCopter:

- Connect the APM, PX4 or Pixhawk servo output channels 1-4 to the SingleCopters 4 control fins as shown.
- Connect the APM, PX4 or Pixhawk servo output channel 7 to the ESC for the brushless motor that powers the main single rotor
- The 4 fins are attached to four arms and it’s a bit like a Plus quad.
- Looking down on the APM from above as in the attached diagram. “servo1” would be attached to the APM’s output channel #1, etc.



Load the Firmware

- For the time being, the user needs to compile the source code themselves.
- Add this line to the APM_Config.h: **#define FRAME_CONFIG SINGLE_FRAME**
- In the near future this will be added as a downloadable binary to **firmware.ardupilot.org** and likely as a Mission Planner loadable icon.

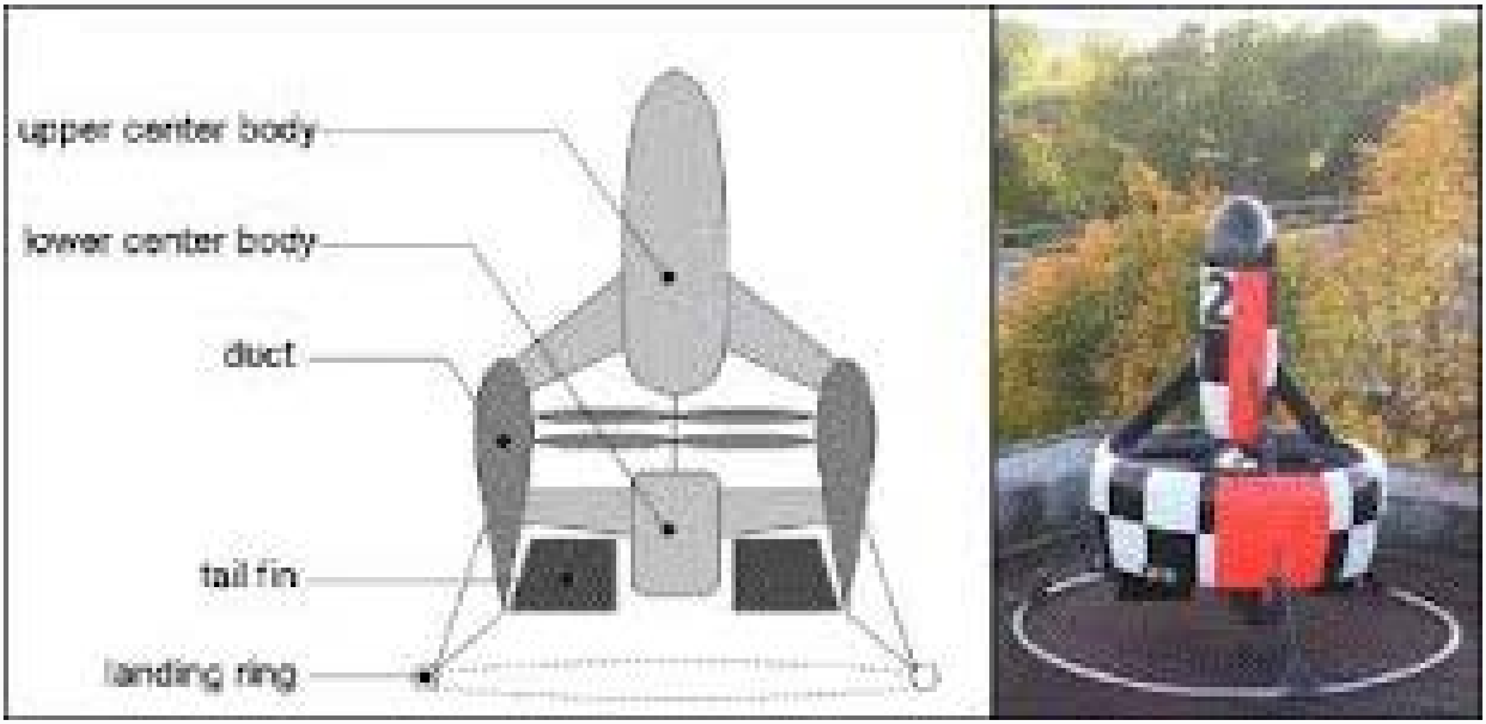
Configuration

If digital servos are used the SV_SPEED parameter can be set to 125 (or even higher). If slower analog servos are used set this parameter to 50.

CoaxCopter

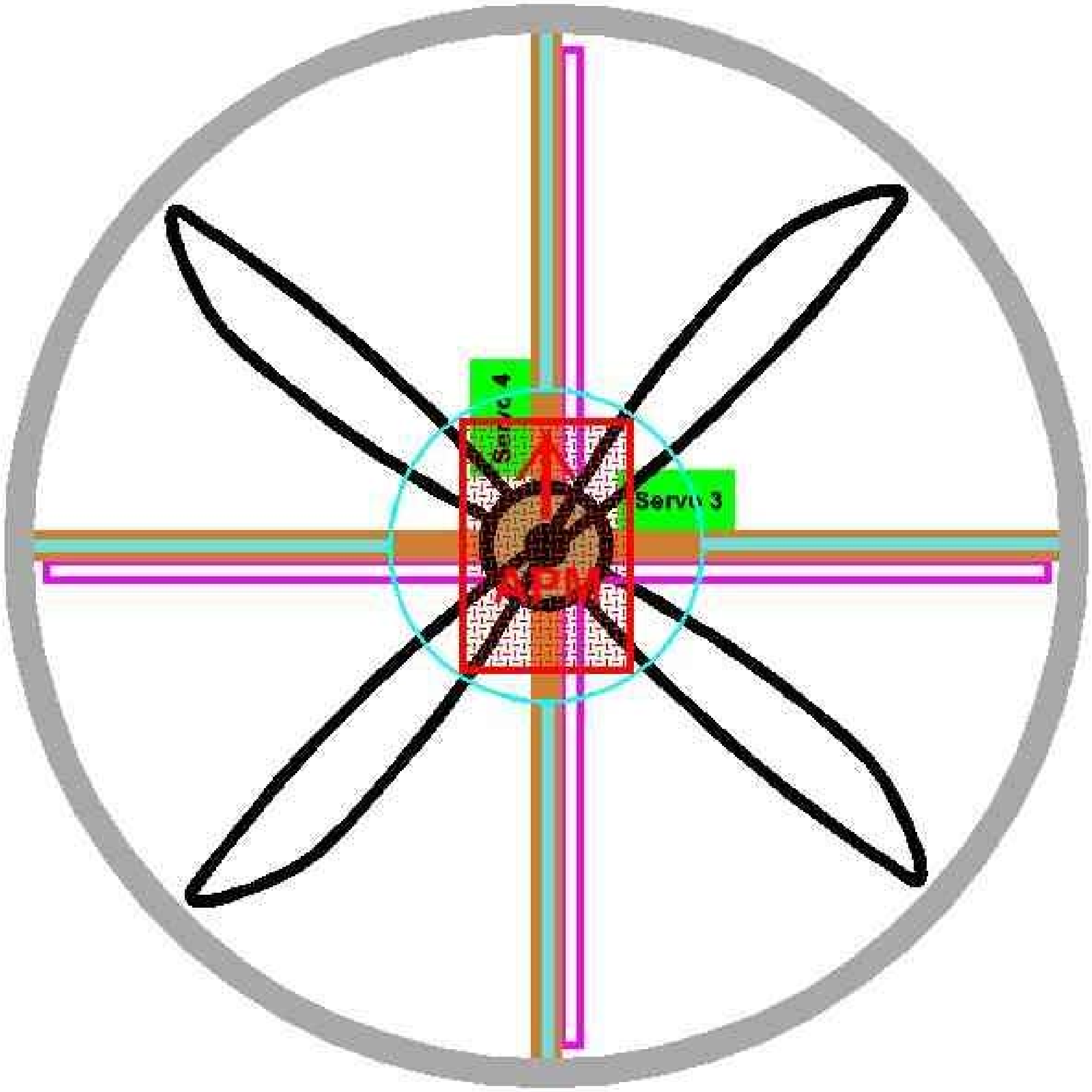
- A CoaxCopter is an aerial vehicle with two counter rotating central propellers thrusting downward past 2 controllable vanes (one side to side and the other from front to back) that permit control of roll and pitch.

- Yaw is controlled by varying top and bottom propeller speeds relative to each other.
- There are two variant motor configurations of the CoaxCopter:
  - A contra-rotating motor pair with both Propellers on top and the shaft of the bottom motor passing up through the hollow shaft of the top motor
  - And two motors mounted back to back with one propeller above and the other beneath with appropriate support struts.
  - Both variations are illustrated below.



Connecting the Flight Controller to the CoaxCopter:

- Connect the APM, PX4 or Pixhawk servo output channels 1 and 2 to the CoaxCopters two control fins servos as shown (Note: the diagram below is incorrect, “Servo3” should be “Servo1” and “Servo4” should be “Servo2”).
- Connect the APM, PX4 or Pixhawk servo output channel 3 and 4 to the ESC for the brushless motors that power the main dual rotors.
- The two wide fins are attached to two cross arms and works a bit like the elevator and ailerons of a fixed wing plane.
- Below is an illustration looking down on an APM/Pixhawk mounted on the frame. Note the warning re Servo3 and Servo4 being mislabelled.



Load the Firmware

- For the time being, the user needs to compile the source code themselves.
- Add this line to the APM_Config.h: **#define FRAME_CONFIG COAX_FRAME**
- In the near future this will be added as a downloadable binary to **firmware.ardupilot.org** and likely as a Mission Planner loadable icon.

And a Video of a Research SingleCopter in action:
