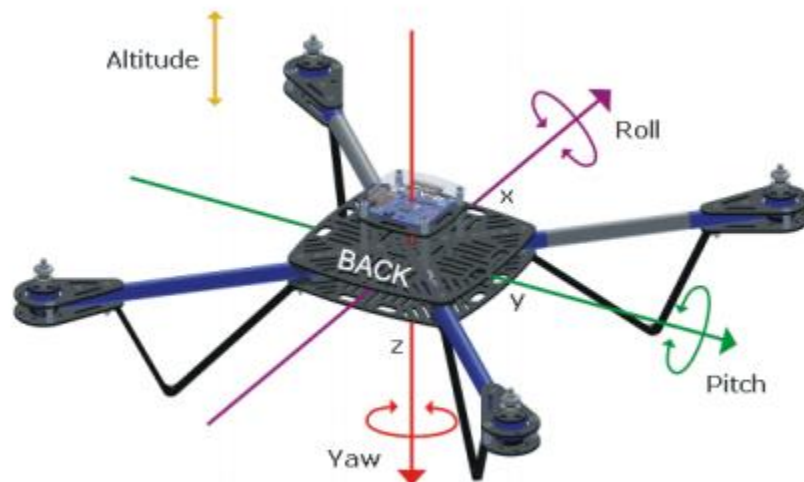


Quad Copter

Flight modes

➤ Reference System

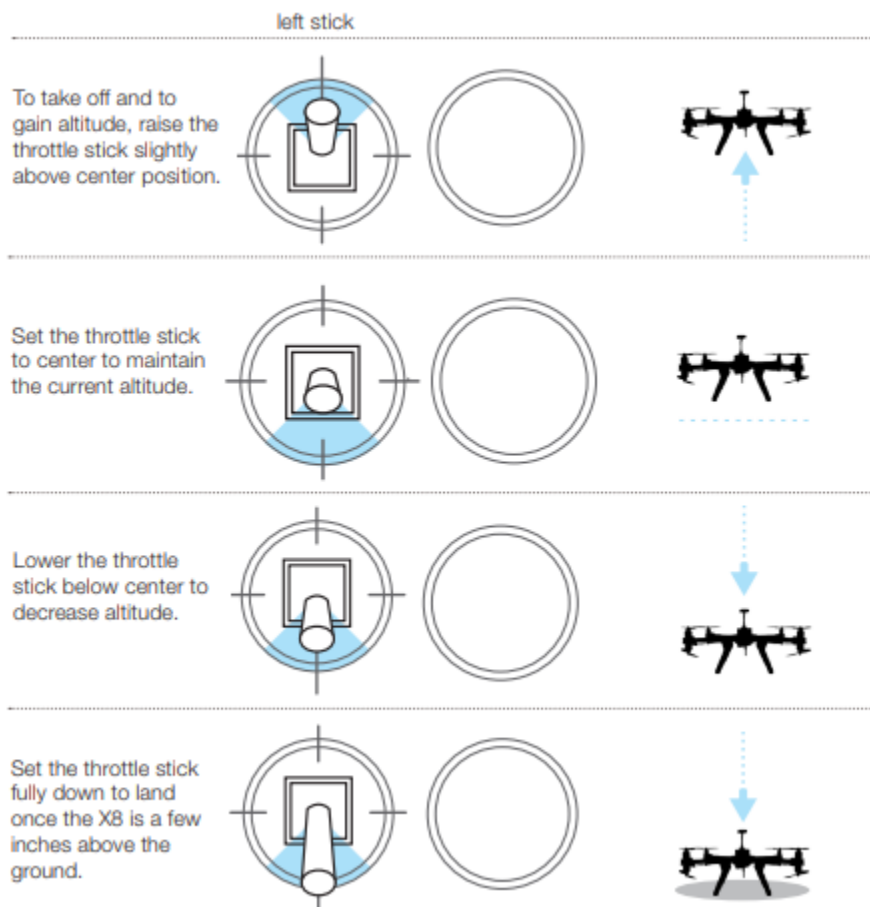
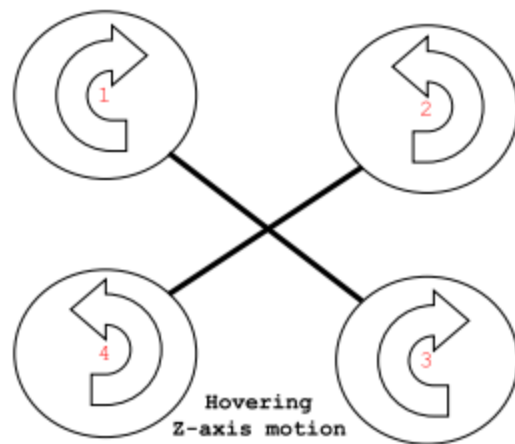
- The body reference system usually employed is the one in figure
- The system also define the Euler angles that represents the attitude:
 - ❖ roll, ϕ
 - ❖ pitch, θ
 - ❖ yaw, ψ
- The pose of the multirotor is represented by:
- $\{X, Y, Z, \phi, \theta, \psi\}$, in the Earth frame



➤ **Motion**

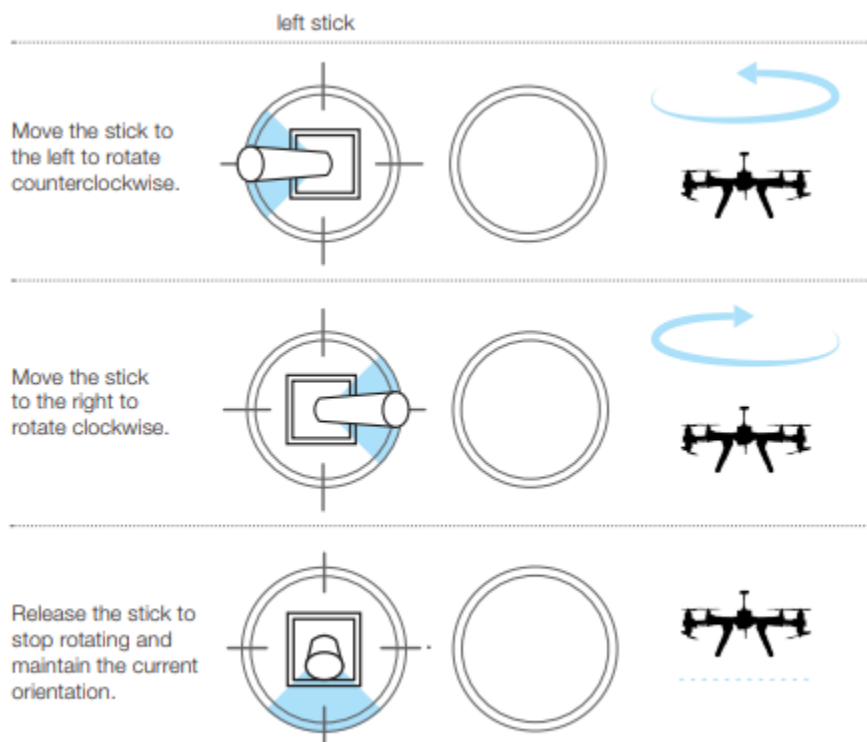
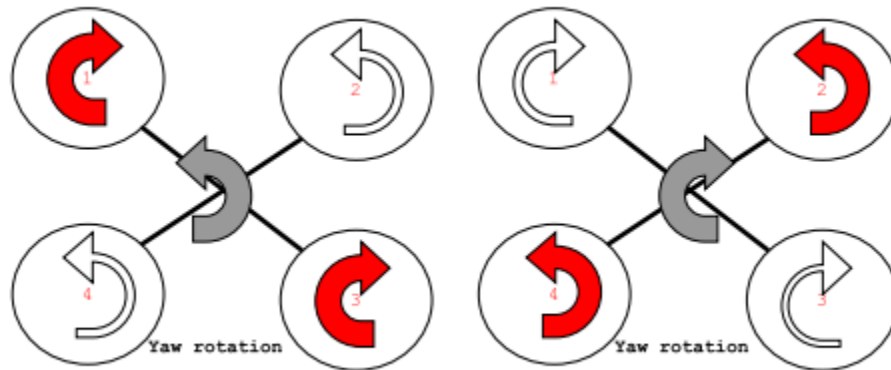
- Motion is achieved by modulating propeller speeds
- We can assume a virtual pilot able to give the commands (as in an airplane):
 - ❖ Thrust, the “power” to the motors (throttle control)
 - ❖ Roll and Pitch, the “control joke”
 - ❖ Yaw, the “pedals”

➤ **Motion: Hovering and Z-translation**



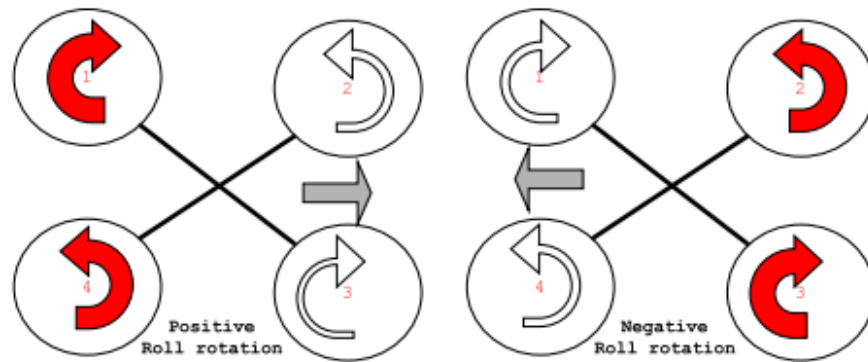
- Vertical motion is achieved by keeping all propeller speeds the same and proportional to a thrust command

➤ Motion: Yaw rotation in X-shaped quads



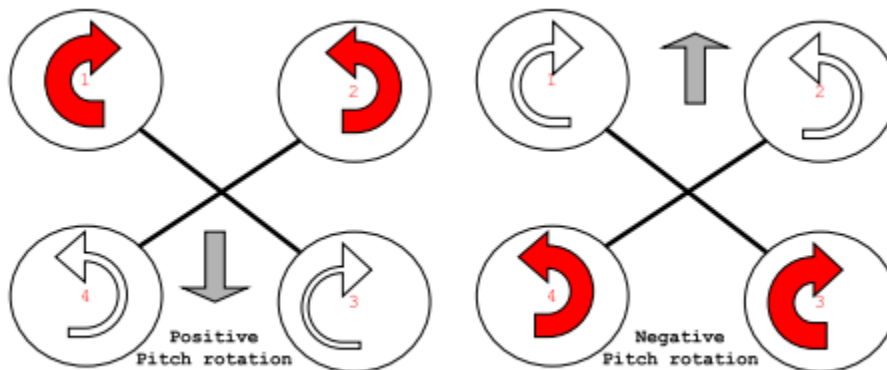
- Yaw rotation is achieved by modulating propeller speeds in-pairs 1 – 3/2 – 4, proportional to a yaw command

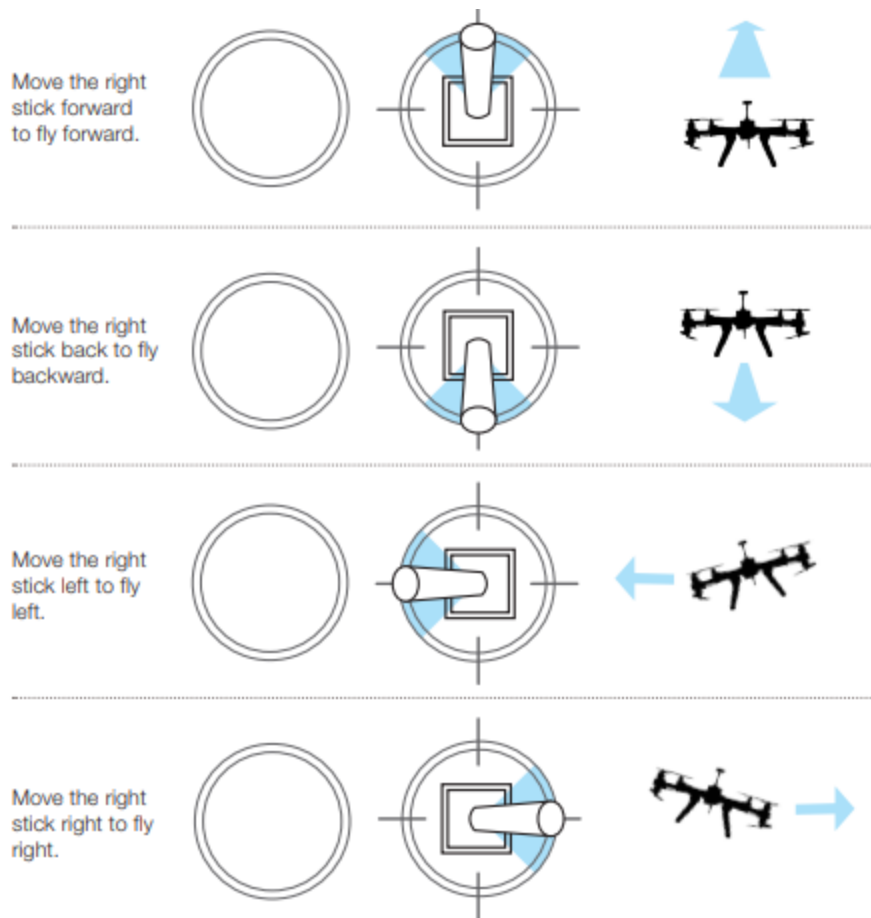
➤ Motion: Roll rotation in X-shaped quads



- Roll rotation is achieved by modulating propeller speeds in-pairs 1 – 4/2 – 3, proportional to a roll command
- Roll rotation implies a decomposition of the thrust force: a drag force appears that drives the frame in a translated flight along Y axis

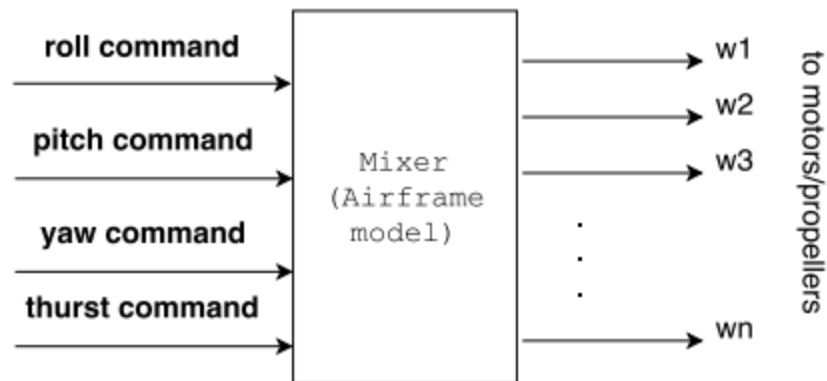
➤ Motion: Pitch rotation in X-shaped quads





- Pitch rotation is achieved by modulating propeller speeds in-pairs 1 – 2/3 – 4, proportional to a pitch command
- Pitch rotation implies a decomposition of the thrust force: a drag force appears that drives the frame in a translated flight along X axis

➤ Motion: the Mixer



- The mixer is the software component that translates attitude commands to motor commands

➤ Rate and Attitude Control

- The control of stability is achieved by means of two control loops:
 - ❖ Rate Control, controls angular speeds $\dot{\phi}$, $\dot{\theta}$, $\dot{\psi}$, by means of a 3-axis gyro
 - ❖ Attitude Control, controls Euler angles ϕ , θ , ψ , by means of a 6-DOF or 9-DOF IMU

➤ Flight Modes

- Copter has 20 flight built-in flight modes, 10 of which are regularly used.

- 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

Symbol	Definition
-	Manual control
+	Manual control with limits & self-level
s	Automated stabilized control
A	Automatic control

Mode	Alt Ctrl	Pos Ctrl	GPS	Summary
Acro	-	-		Holds attitude, no self-level
Alt Hold	s	+		Holds altitude and self-levels the roll & pitch
Auto	A	A	Y	Executes pre-defined mission
AutoTune	s	A	Y	Automated pitch and bank procedure to improve control loops
Brake	s	A	Y	Brings copter to an immediate stop
Circle	s	A	Y	Automatically circles a point in front of the vehicle
Drift	-	+	Y	Like stabilize, but coordinates yaw with roll like a plane
Flip	A	A		Rises and completes an automated flip
Follow	s	A	Y	Follows another GPS on the ground
Guided	A	A	Y	Navigates to single points commanded by GCS
Land	A	s	(Y)	Reduces altitude to ground level, attempts to go straight down
Loiter	s	s	Y	Holds altitude and position, uses GPS for movements
PosHold	s	+	Y	Like loiter, but manual roll and pitch when sticks not centered
RTL	A	A	Y	Retruns above takeoff location, may also include landing
Simple/Super Simple			Y	An add-on to flight modes to use pilot's view instead of yaw orientation
SmartRTL	A	A	Y	RTL, but traces path to get home
Stabilize	-	+		Self-levels the roll and pitch axis
Sport	s	s		Alt-hold, but holds pitch & roll when sticks centered
Throw	A	A	Y	Holds position after a throwing takeoff

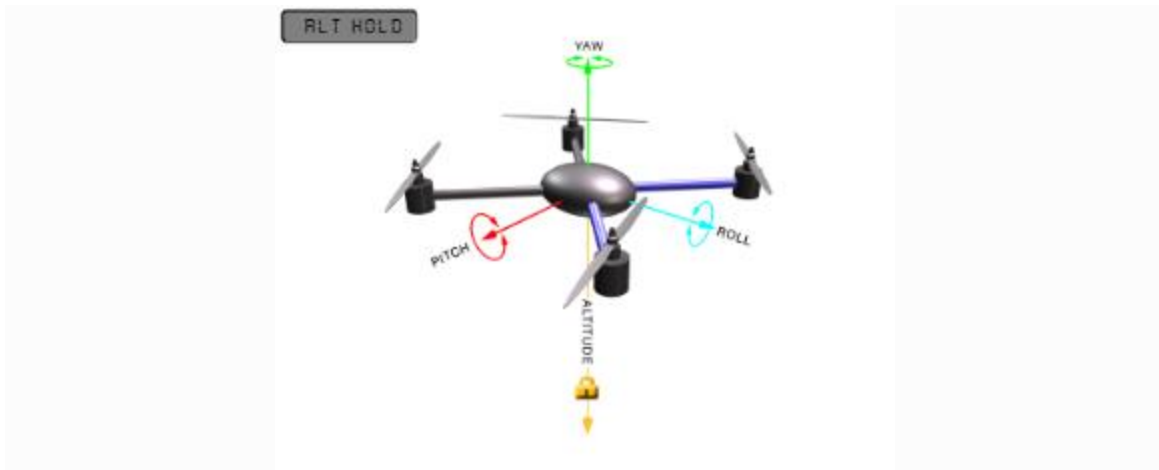
- In general when first starting to use Copter you should progress through the flight modes in the order listed below, being sure that you are comfortable with each before progressing to the next

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

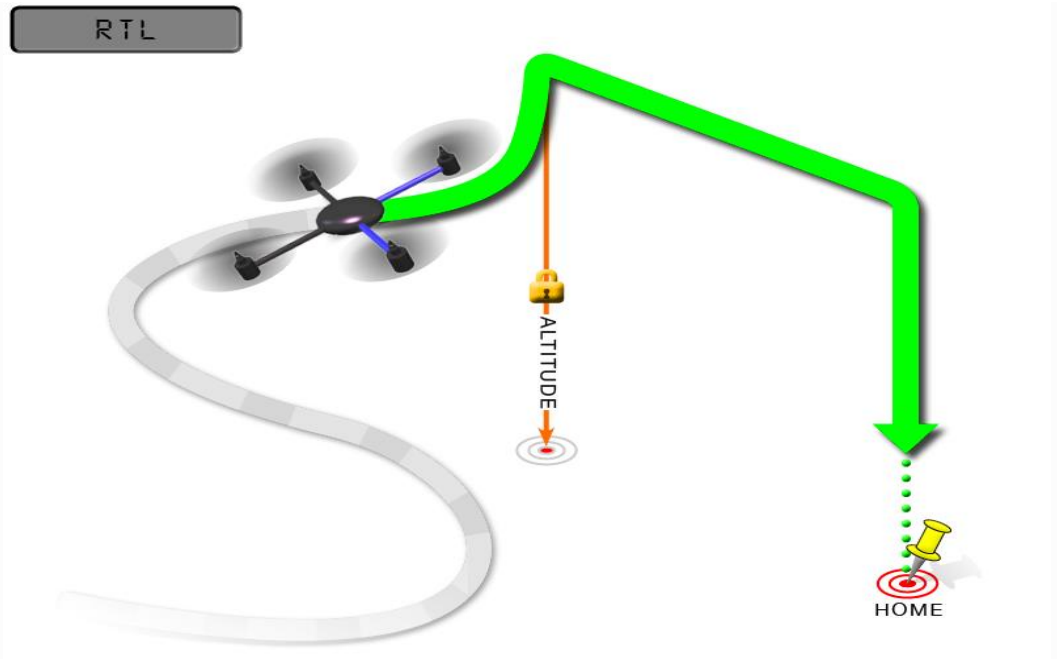
➤ Overview of Arducopter Flight Modes

- **Stabilize mode** is the primary operating mode for flying APM:Copter and can be considered its manual flight mode. Stabilize automatically levels the multi-copter and maintains the current heading, while allowing the pilot full control over the throttle.

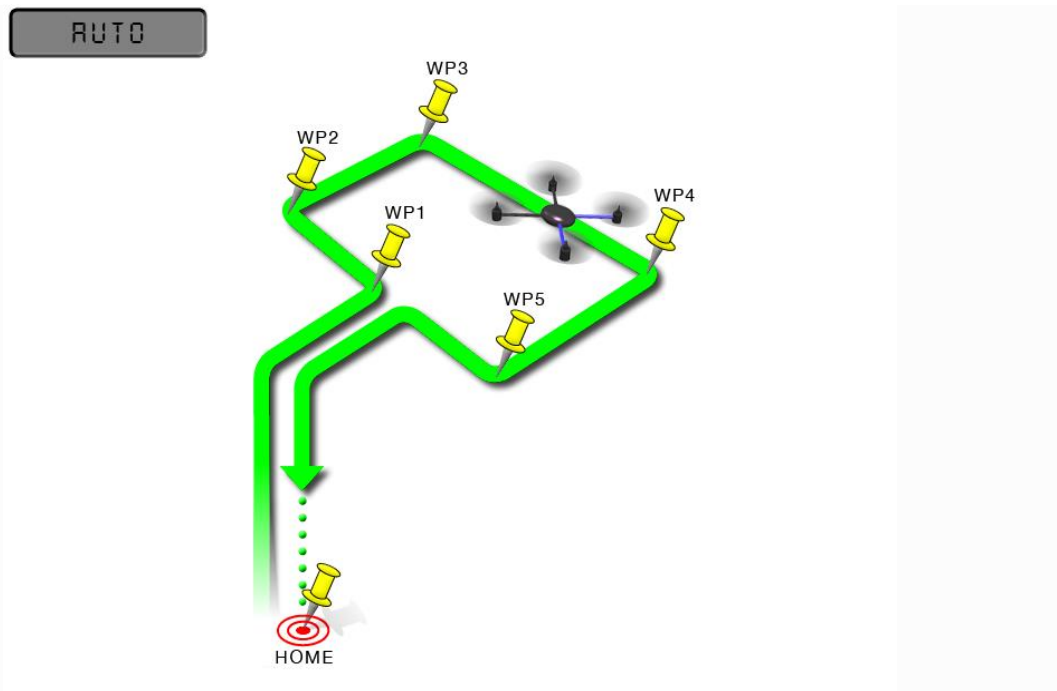
- In **altitude hold mode**, the copter maintains a consistent altitude while allowing roll, pitch, and yaw to be controlled normally.



- In **loiter mode**, the copter maintains a consistent location, heading, and altitude. This can be adjusted by using the sticks on your transmitter.
- **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.
- In **return to launch (RTL) mode**, the copter navigates from its current position to hover above the home position.

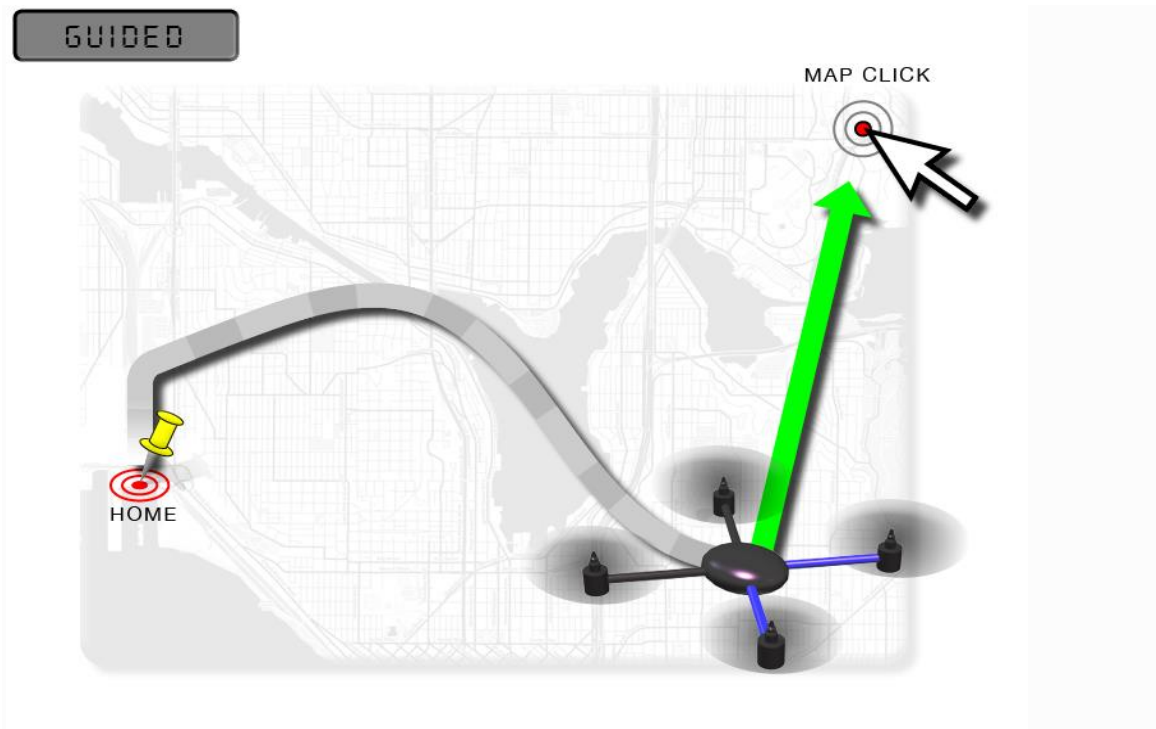


- In **autonomous (auto) mode**, the copter will follow a pre-programmed mission script stored by the autopilot, including autonomously navigated waypoints, commands, and events.



- In **Acro mode** the rate of rotation of the copter (roll, pitch and yaw) is controlled by the angle of the sticks. Ideal for stunt flying (not recommended for beginners) and it does not self level.

- **Guided mode** is a capability of APM:Copter to dynamically guide the copter to a target location wirelessly using a telemetry radio module and ground station application.



- When **circle mode** is engaged the vehicle will begin flying in a 10m radius circle (value can be set in the arducopter settings) with the nose of the vehicle pointed towards the center.
- **LAND mode** attempts to bring the copter straight down. This will land your copter and turn off the motors once its on the ground.

- Most transmitters provide a 3 position switch but you can set 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.
- Do not require GPS lock:
 - ❖ Stabilize
 - ❖ Alt Hold
 - ❖ Acro
 - ❖ Sport
 - ❖ Land

Pre-Flight Checklist (Copter)

APM-Copter Flight Ops Checklist

V1.0

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

