Montgomery County Community College

Step by step instructions for highly skilled pilots and dummies –R6

Document number: G07

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Introduction

It is not an easy task to prepare a single document that can replace many days of training and dialog with actual people. This step by step document is an attempt to summarize information and tips from a mixture of wiki pages, blogs and forums. This document is a sort of "Reader's Digest" where hundreds of pages are reduced to tens of pages – and you may get an idea of what it takes to prepare a quad for a mission and get you started. The result may not please the highly skilled pilots or the dummies; for some it will be too underdeveloped and for others too elusive. In the coming weeks and months, we will improve on this document; you will tell us what's good and what's bad or missing, in order that we improve our writing.

This document is divided in five parts, one appendix and one glossary:

1. Part 1 – Basic assembly and abridged rules
2. Part 2 – Wiring setup
3. Part 3 – Pre-flight check
4. Part 4 – Manual flight check
5. Part 5 – Autonomous flight
6. Appendix – Lithium Polymer (LiPo) battery charging
7. UAV Glossary of terms

Credits

The EGR299 class students

Aaron Wilz
Daniel Rowe
Jacob Simon
Jason Cassel
Kevin Healy
Michael Marino
Michelle Gavan
Scot Kantner
William Fellmeth

The engineering faculty

Andrew Ippolito
Bill Brownlowe
Jean-Jacques Reymond

Last, but not least, the community at DIYDrones.com

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Part 1 – Basic assembly and abbreviated rules

Propellers, arms, motors, and Electronic Speed Controllers (ESCs)

All parts of the quad should be numbered for rapid repairs and maintenance as per Figure 1.

- Number **1** propeller goes with number **1** motor which is placed on arm **1** and so on.
- All nuts connecting propellers to motors should be tight.

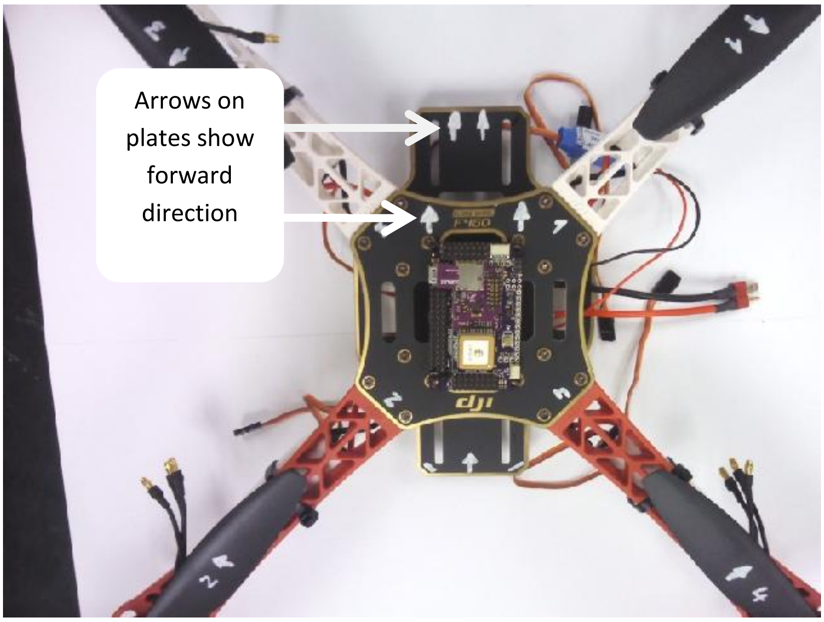


Figure 1 – Unassembled quad showing propeller and arm numbered 1 thru 4

- All ESCs should also be numbered for rapid repairs and maintenance as per Figure 2.

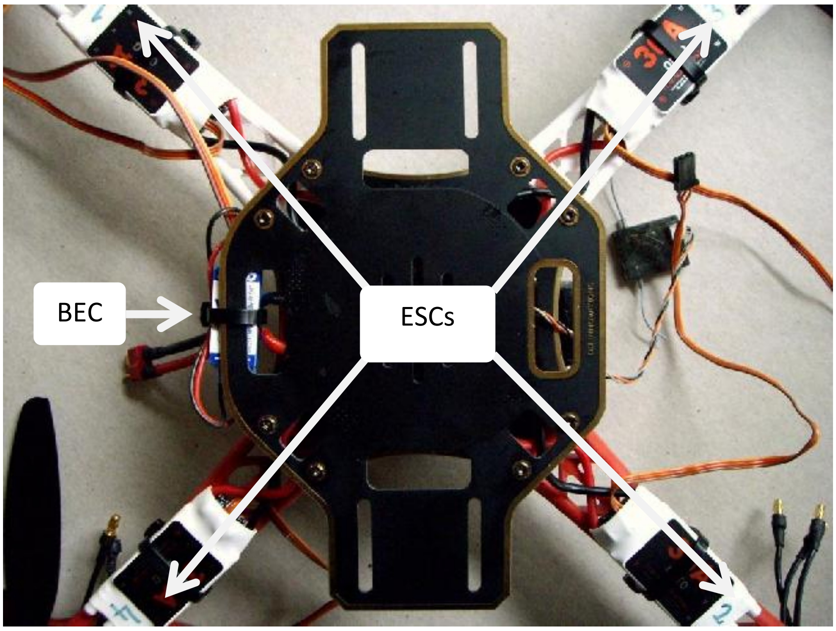


Figure 2 – Unassembled quad showing ESCs numbered 1 thru 4 and BEC strapped to bottom plate

Propellers direction

Check that your **DJI** propellers are correctly identified and in the proper direction. Clockwise (**CW**) use pusher props engraved with a "**1045 R**" and counterclockwise (**CCW**) use normal props engraved only with "**1045**" as per Figure 3.

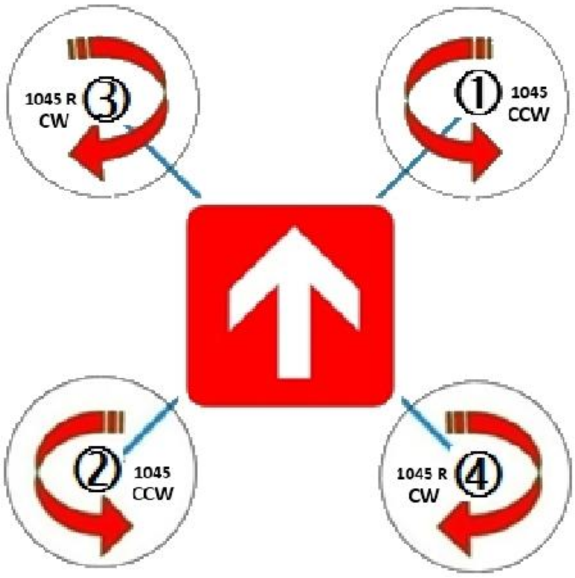


Figure 3 – Propeller identification and direction

APM2 orientation

- The APM2 must be placed as close to the center of the quad as possible.
- The APM2 must be placed so that it is facing forward as per Figure 4.
- All electronics must be placed securely on the quad.

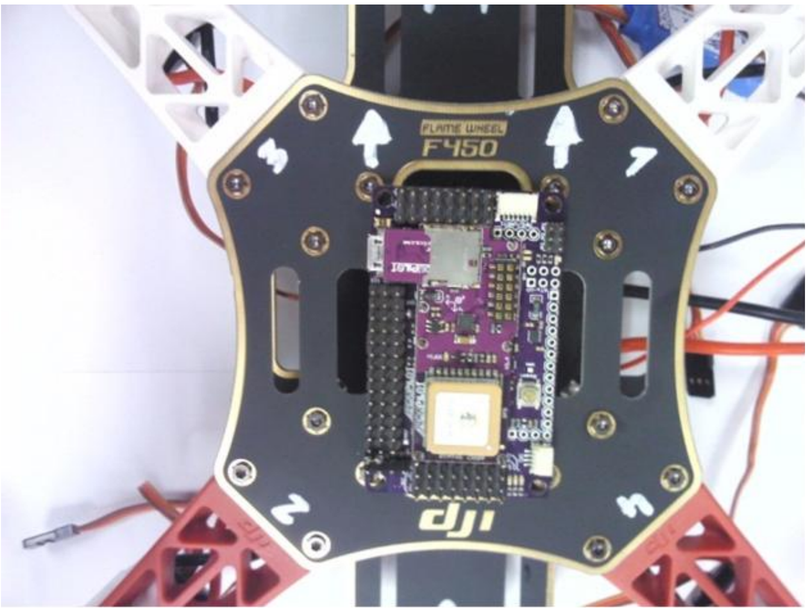


Figure 4 – Orientation of APM2 on Quad

Telemetry orientation

The telemetry module should be placed on the bottom of the base plate with the antenna pointing down, see Figures 5 and 6. This decreases the range of communication while the quad is on the ground and it increases the range while the quad is in the air.

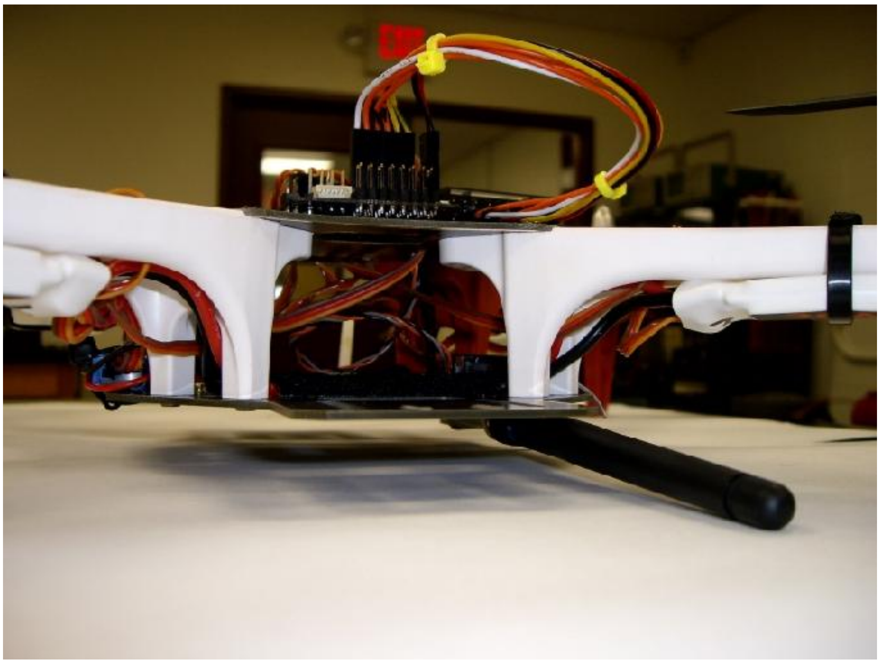


Figure 5 – Showing position of telemetry antenna on quad

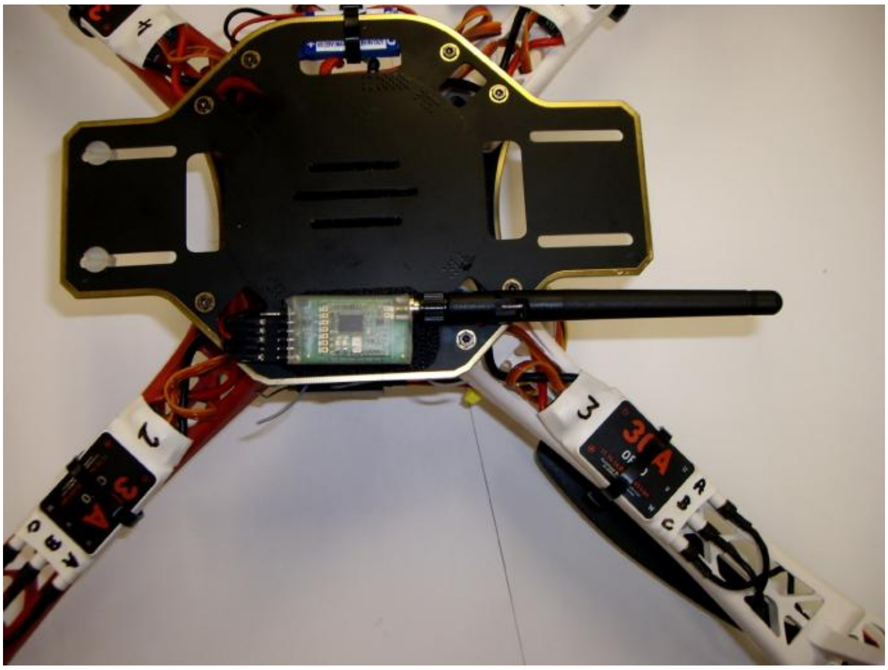


Figure 6 – Showing telemetry attached to bottom plate

Spektrum AR8000 radio receiver orientation

The primary radio receiver should be placed on top of the top plate next to the APM2; the remote receiver should be placed on top of the base plate, see Figures 7a and 8b.

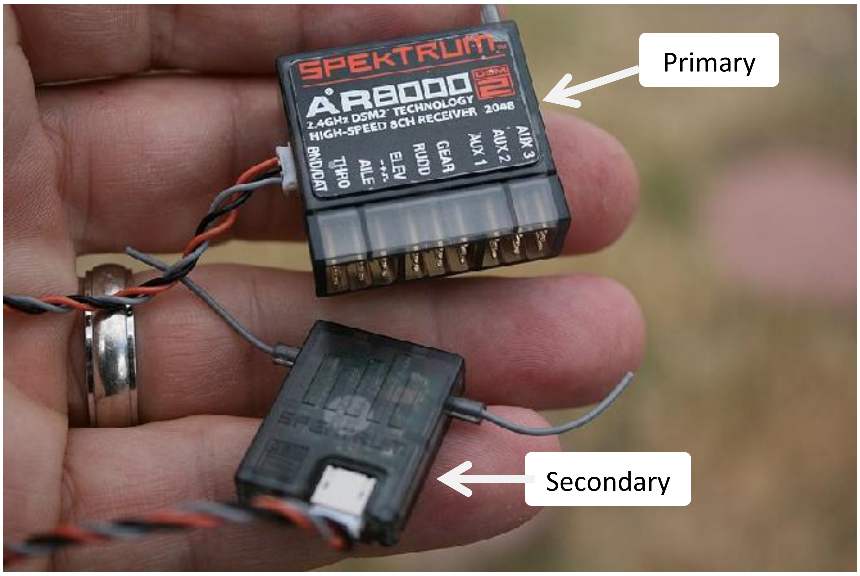


Figure 7a –Primary and secondary receivers

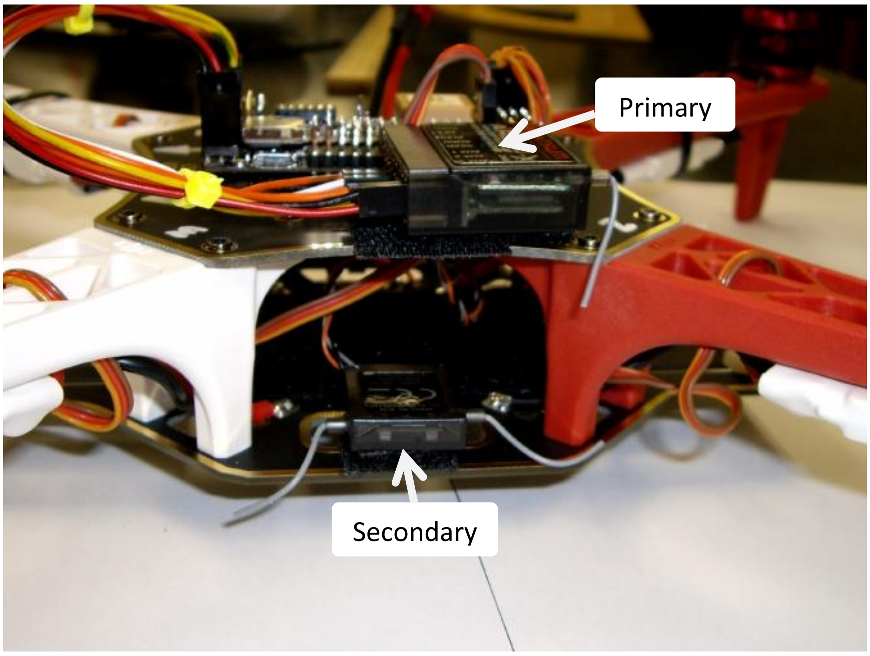


Figure 7b – Orientation of primary and secondary receivers

Camera orientation

To be added in the next revision.

LiPo battery

- Check that the LiPo battery is firmly secured; all four battery holding screws must be tight to prevent the battery from falling out.
- To release the battery only unscrew the screws in the front. Do not unscrew the screws in the back, see Figure 8.

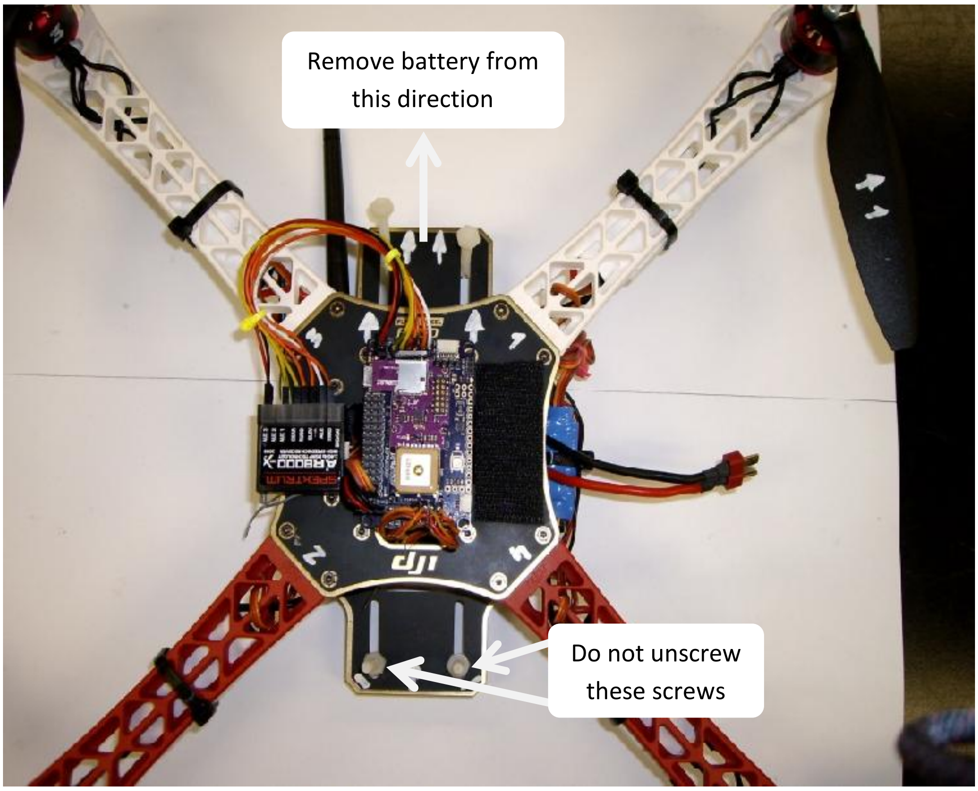


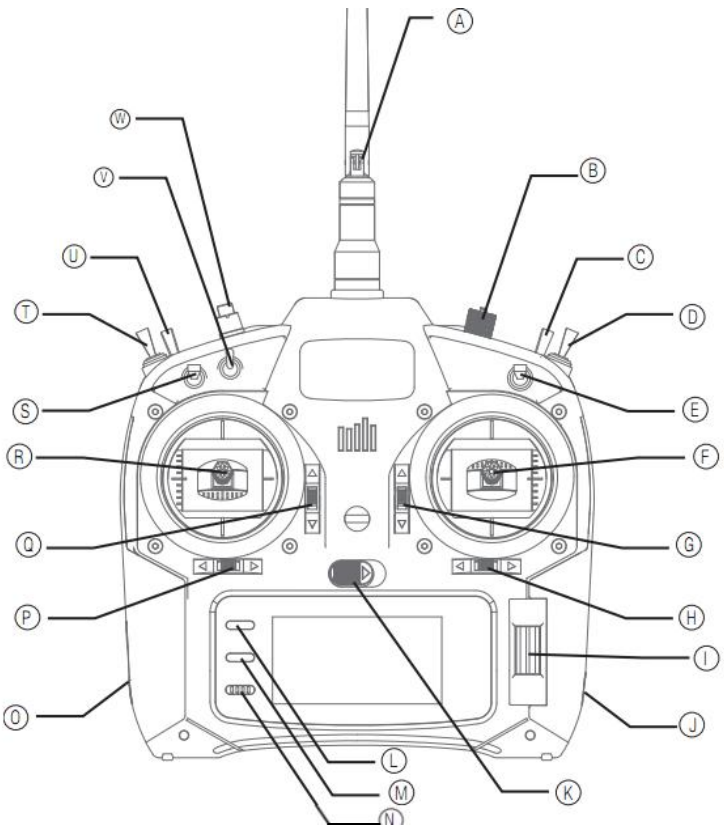
Figure 8 – Unassembled quad showing battery markings

Spektrum radio controller layout

The Spektrum radio controller is programmed for the initial quad settings and emergency landing for cutting the power to all four motors. The programs are preloaded on the radio controller and stored, as a backup, on an SD memory card; see the Spektrum user’s manual to reload these settings.

Function	
A	Antenna
B	Aux 2 Pot
C	Mix (ACRO) /Throttle Hold (HELI)
D	Rudder Dual Rate *(Mode 2)*
E	Aileron Dual Rate
F	Aileron/Elevator Stick *(Mode 2)*
G	Elevator Trim *(Mode 2)*
H	Aileron Trim
I	Roller
J	Charge Port
K	On/Off Switch
L	Clear Button
M	Back Button

Function	
N	Speaker Grill
O	SDI - SD Card
P	Rudder Trim
Q	Throttle Trim *(Mode 2)*
R	Throttle/Rudder Stick *(Mode 2)*
S	Elevator Dual Rate
T	Flight Mode *(Mode 2)*
U	Gear (ACRO)/Mix (HELI)
V	Flap (ACRO)/Gyro (HELI)
W	Trainer/Bind



Part 2 – Wiring setup

Autopilot – ArduPilot Mega 2 (APM2) wiring

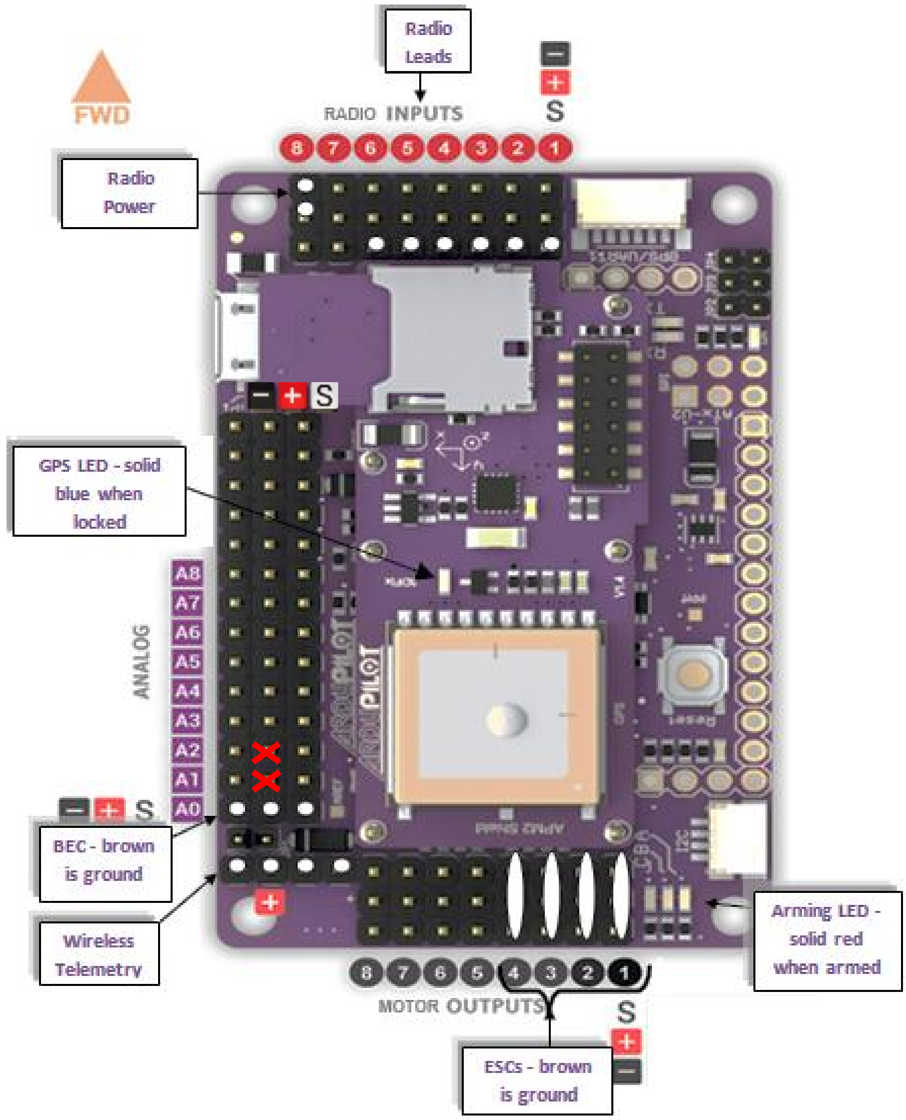


Figure 9 – APM2 wiring layout

Telemetry wiring

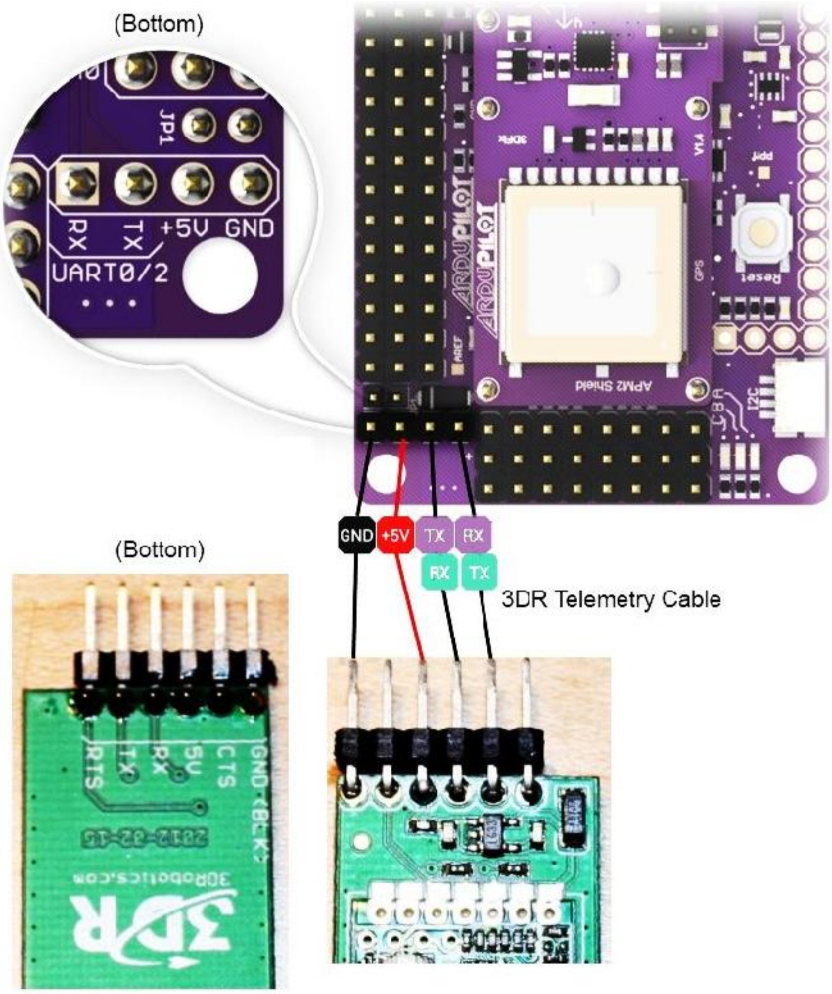


Figure 10 – Telemetry wiring layout

Spektrum AR8000 radio receiver wiring

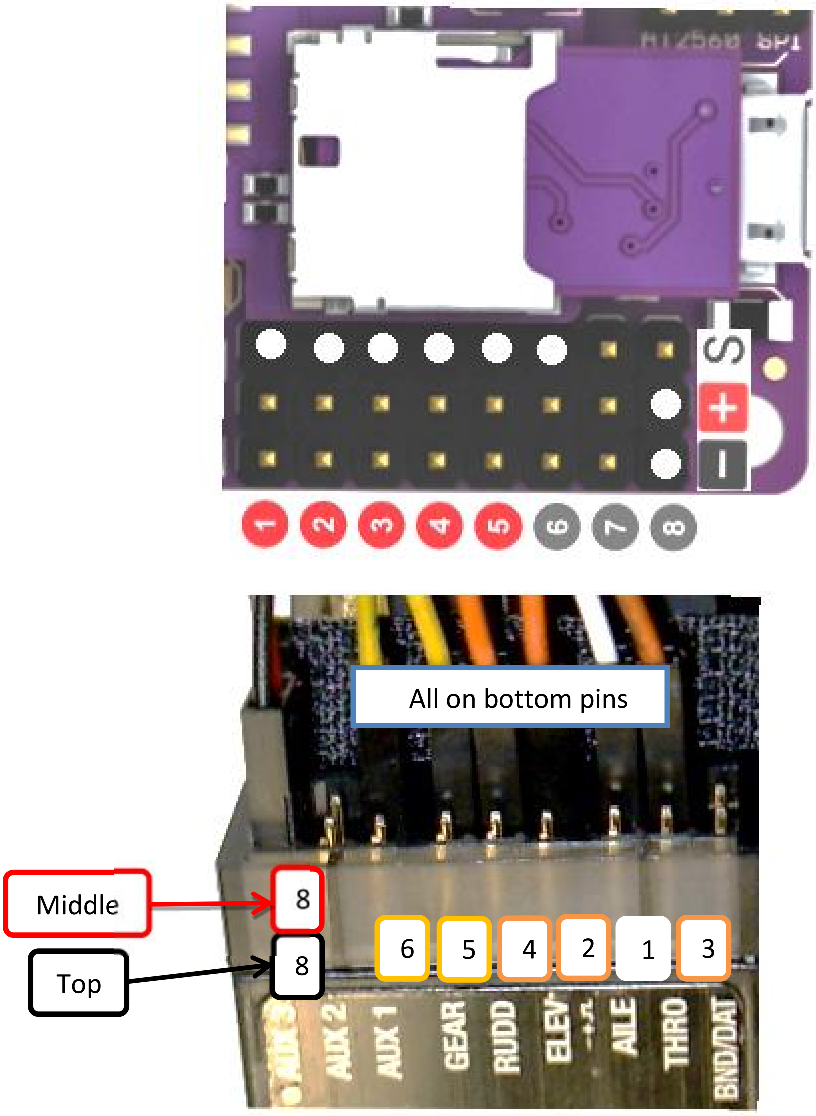


Figure 11 - Wiring of the radio receiver

ESC wiring

The DJI motors are three-phase brushless motors. We will be using the third phase of the motor, see Figure 12, for our wiring. As such, the wires coming from the motor will be called A, B, and C.

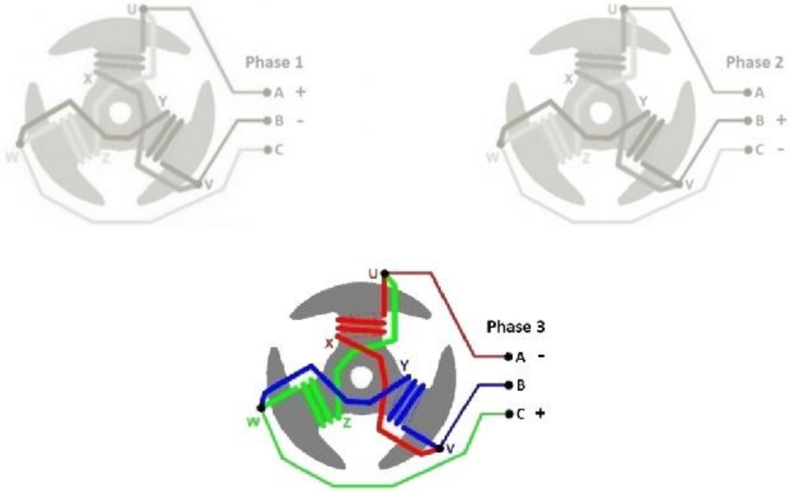


Figure 12 – The three phases of the motors.

Check each MOTOR-to-ESC wire, see Figure 13.

MOTOR 1 to ESC 1 (ccw)	A to U - C to W - B to V
MOTOR 2 to ESC 2 (ccw)	A to U - C to W - B to V
MOTOR 3 to ESC 3 (cw)	**C to U - A to W - B to V**
MOTOR 4 to ESC 4 (cw)	**C to U - A to W - B to V**

Figure 13 – The wiring of the number 2 ESC (A to U C to W B to V) and number 3 ESC (C to U A to W B to V)

Camera wiring

To be added in the next revision.

Part 3 – Preflight checks

Turning on the Spektrum radio controller

- Turn on the radio controller.
- ***NEVER have the quad on without the radio controller on as well. Without the input from the radio controller the quad can behave erratically.***
- Navigate through the radio controller's menus by scrolling and clicking the roller on the right of the radio controller. Make sure all settings are the same as those in Table 1.

Servo Setup	**THR**	**AIL**	**ELE**	**RUD**	**GER**	**AX1**	**AX2**
Reverse SW	Norm	Rev	Rev	Rev	Norm	Norm	Norm
Subtrim	0	0	0	0	0	0	0
Travel Adjust	100%	100%	100%	100%	100%	100%	100%
	100%	100%	100%	100%	100%	100%	100%
D/R and Expo	**AIL**	**ELE**	**RUD**				
D/R	100%	100%	100%				
EXP	0%	0%	0%				
Differential		**Throttle Cut**			**Flap System**		
Inhibit		Pos	0%		Inhibit		
		SW	Trainer				
Mixing	**RIGHT**	**LEFT**	**SW**				
AIL > RUD	0%	0%	INH				
	CHANNEL	**RATE**	**OFFSET**	**TRIM**	**SW**		
MIX 1	INH	0%, 0%	0%	INH	INH		
MIX 2	INH	0%, 0%	0%	INH	INH		
MIX 3	INH	0%, 0%	0%	INH	INH		
MIX 4	INH	0%, 0%	0%	INH	INH		
MIX 5	INH	0%, 0%	0%	INH	INH		
MIX 6	INH	0%, 0%	0%	INH	INH		

Table 1 – Spektrum radio controller setup

Power on

If the physical and wiring setups, Parts 1 and 2, of the quad are correct and the radio receiver is on, then turn on the quad by plugging in the battery to the red and black wires coming from the baseplate.

- For information on charging the LiPo batteries see "Appendix 1 – Lithium Polymer (LiPo) battery charging."

ESC check

- All ESCs should play a short jingle when the quad is powered on.
- If any ESCs are beeping consistently, they have not been calibrated.
  - Turn off the quad and calibrate these ESCs, see Part 3 "Preflight checks" to calibrate an ESC.

To calibrate an ESC

- With **NO BATTERY, PROPELLERS, or ESCs** plugged into the APM2, plug the three colored wire plug of the ESC you want to calibrate into the throttle (THRO) channel of the radio receiver with the brown wire on top.
- Turn on the radio controller and push the throttle stick to full up.
- Plug the LiPo battery into the quad.
- You will hear a musical note and then 2 beeps. After the 2 beeps drop the throttle all the way down. You will then hear 3 beeps for the 3-cell LiPo battery, which is the cell count of the supplied battery, and then a single longer beep indicating the end points have been set and the ESC is calibrated and ready to fly. You may now disconnect your LiPo battery.
- Repeat for all ESCs that need to be calibrated.

Connect to the telemetry

- The telemetry module should have a green LED on, this means it is powered.
- Open the Mission Planner.
  - Select the correct Com Port for the stationary telemetry module.
  - Select 57600 as baud rate to the right of the Com Port select.
- Hit the Connect button.
- In a few seconds the quad will connect to the computer.

Quad software setup

- With the radio controller on and the quad on and connected to the Mission Planner go into the Configuration tab.
- Go into Flight modes
    - Flight mode 1 is Stabilize.
    - Flight mode 6 is Auto.
    - All other modes are Stabilize.
    - To fly in manual mode the gear switch must be up, see Part 1 "Spektrum radio controller layout."
- Go into Standard parameters
    - Go into ArduCopter Config.
        - This screen should look like Figure 14.
        - The Write params writes the current numbers to the quad. Click Write Params after you change any of the numbers.
        - Refresh Params reads the numbers stored on the quad.

Figure 14 – ArduCopter configuration screen

Connect to camera

To be added in the next revision.

LED meanings

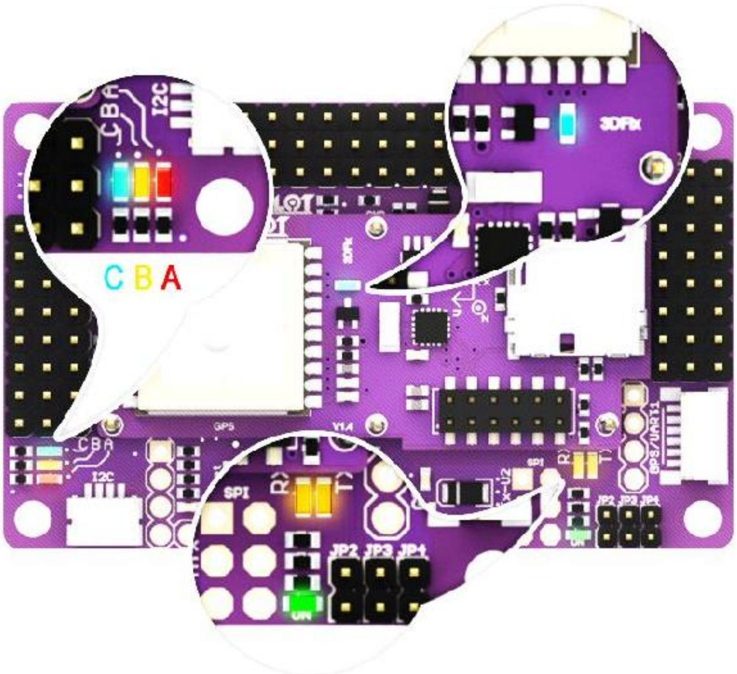


Figure 15 – LED layout

LED	Behavior
A (Red)	Solid = Armed, motors are live; Blink = Disarmed, motors will not spin with throttle up.
B (Yellow)	Flash during calibration, otherwise not used.
C (Blue)	Solid = Lock, Blink = Waiting for Lock, OFF = No GPS connected or Serial received.
3DFix	Directly connected to GPS module; blinking while waiting for fix, solid after fix.
Power "On"	On when powered.
RX,TX	Will flash during serial communications, such as loading code and telemetry.

We have found that the C (Blue) LED and the 3DFix LED are not synchronized. Therefore do not trust that you have a GPS lock until you can see your current position in the Mission Planner. This may take a minute after the C (Blue) LED and the 3DFix LED turn solid blue.

Part 4 – Manual flight check

These checks are to be done before every autonomous flight. **The Spektrum radio controller must be on before the quad is turned on.**

Calibrating the Spektrum radio controller

- Turn on the radio controller.
- Connect the quad to the Mission Planner using the USB.
    - Plug the USB cable into the APM2 and the computer.
    - In the Mission Planner, select the correct COM port.
    - Set the baud rate to 115200.
    - Click the Connect button.
- The ESCs will beep.
- Go into the Configuration tab.
    - Go into Radio Calibration
    - Click the Calibrate Radio Button in the lower right of the screen
    - Move the left stick all the way up and down, twice.
    - Move the left stick all the way to the left and right, twice.
    - Move the right stick all the way up and down, twice.
    - Move the right stick all the way to the left and right, twice.
    - Flip the gear switch up and down twice.
    - Hit the Done button in the lower right of the screen

The radio controller is now configured to correctly work with the quad.

Binding the Spektrum radio controller to the AR8000 radio receiver

- Place the throttle (left stick) on the radio controller to its lowest position.
- Plug the bind plug into the BND/BAT port, see Figure 16, of the radio receiver.
- Plug the BEC into the THRO port, see Figure 16 of the radio receiver.

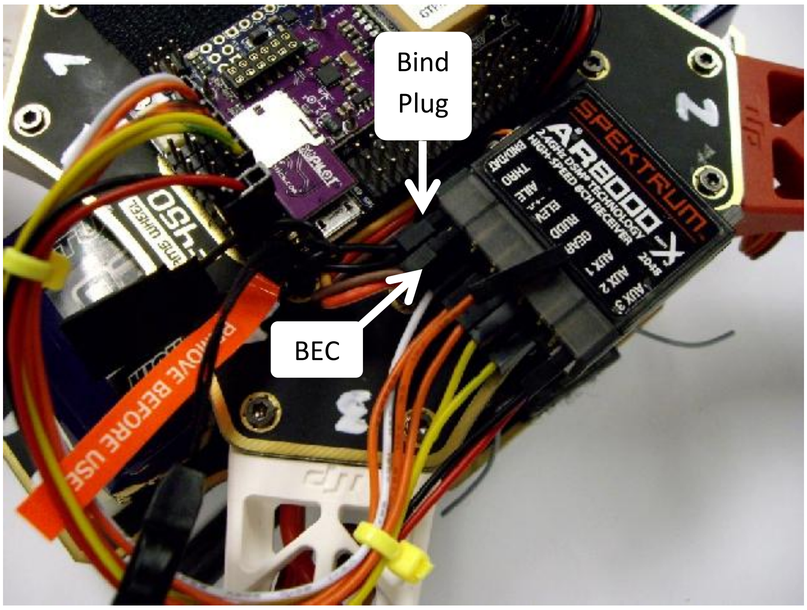


Figure 16 – How to setup up the AR8000 radio receiver for binding

- Plug the BEC into the LiPo battery. The radio receiver will blink rapidly.
- Push and hold the Trainer/Bind button, the black button on top left on the radio controller and turn it on.
- The radio controller's center LEDs will blink and the screen will give you binding information.
- When the receiver's orange LED is solid release the Trainer/Bind button.
- When the radio controller returns to its normal screen you can unplug the LiPo battery, remove the bind plug from the radio receiver and turn off the radio controller.

The radio controller will now work with the bound radio receiver. This should only have to be done once per radio and receiver.

Level the Quad

- Place the quad on a level area.
- Once the Mission Planner is connected to the quad go to the Configuration tab.
    - Go to ArduCopter Level and select the **X** radio button.
    - Hit the Calibrate Now button.
    - Do the move the quad until the Mission Planner says the quad is leveled.

Motor check

- Turn on the radio controller and power the quad with the LiPo battery.
- Make sure the gear switch is up (manual mode), see Part 1 "Spektrum radio controller layout."
- Arm motors by pushing throttle left stick to the lower right until the red LED on the APM2 becomes solid.
    - This should only take a few seconds.
    - If you are unable to arm the quad and the radio receiver on the quad does not have a solid orange LED than see Part 4 "Binding the Spektrum radio controller to the AR8000 radio receiver."
- If all ESCs are calibrated, then check the motor direction by giving a small amount of throttle, just enough to get the propellers to turn.
- All motors should spin in their correct direction as specified in Figure 3.
    - If a motor doesn't spin in the correct direction double check the wiring of the ESC to the motor, specifically motor wires A and C.

Takeoff check

- Make sure the gear switch is up (manual mode), see Part 1 "Spektrum radio controller layout."
- Arm the motors.
- Takeoff the quad to chest height.
    - If a motor is spinning out of sync with the others turn off the quad and turn it back on. If the problem persists calibrate the ESC, see Part 3 "Preflight checks" to calibrate an ESC.
- Manually land the quad.
- If the quad does not behave as expected, **DO NOT fly it autonomously**.
    - The quad should be steady and level at chest height.
    - The quad should respond quickly to radio controller commands.
    - There should be no loss of telemetry or radio control.

Takeoff troubleshooting

- The quad flips over instead of taking off.
  - At least one motor may be spinning in the wrong direction.
  - A propeller may be on upside down. Check the motor direction before removing a propeller.
- The quad takes off but is very unstable in the air.
  - Place the quad on a flat surface and level it in the Mission Planner.
- The quad does not respond quickly to radio controller commands.
  - Check that the radio controller is step up correctly; see Part 3 “Preflight checks.”
- Loss of telemetry in flight
  - Make sure the antenna is oriented correctly; see Part 1 “Telemetry orientation.”
  - Jostle the telemetry module on the landed quad.
    - If the green LED is not steady through the movement check that the connections between the telemetry and the APM2 are secure.
- Loss of radio control.
  - Make sure the quad is in Stabilize mode.
  - Check that the radio controller has a full LiPo battery and that it is configured correctly; see Part 3 “Preflight checks.”
- Make sure that the radio controller has been bound to the AR8000 radio receiver.
  - See Part 4 “Manual flight checks” to bind the radio controller.

Part 5– Autoflight

Before flying the quad in automatic mode, the quad must pass all the checks in the previous pages. If the quad does not pass the previous checks then **DO NOT fly it autonomously**.

Create the quad's mission

- Open the Mission Planner and click on the Flight Planner tab, see Figure 17.

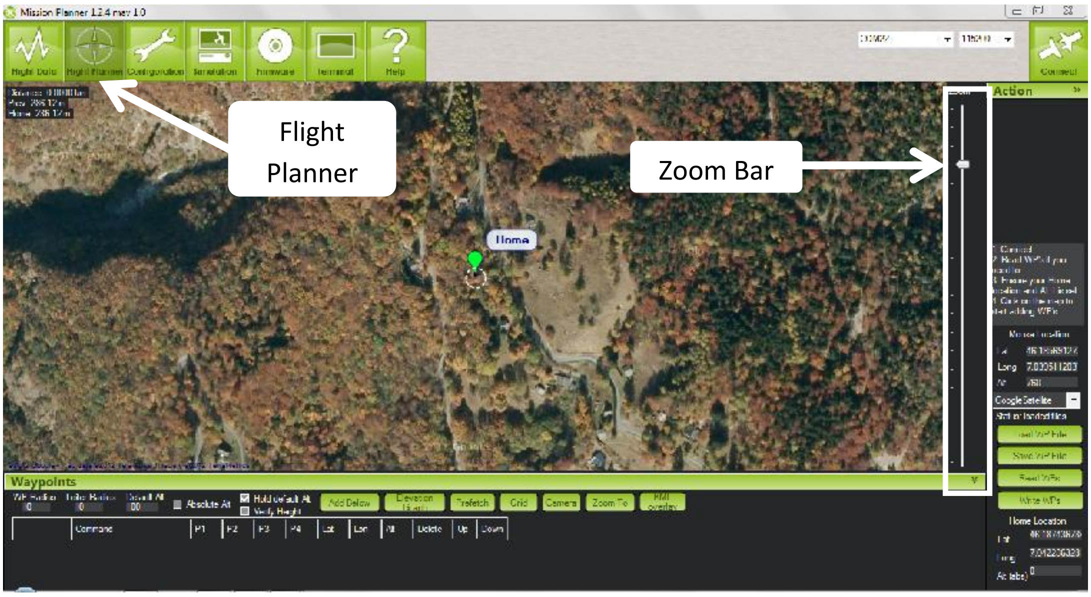


Figure 17 – Flight Planner tab of the Mission Planner

- Navigate to the position of the mission by dragging the picture on the screen and zooming using the bar to the right, see Figure 17, or the scroll wheel of the mouse.
    - If the computer running the Mission Planner is not connected to the internet, an aerial view of the mission's area will not appear. **Do not plan a mission without an aerial view of the mission's area.**
    - If you are flying a mission without an internet connection, the Mission Planner has a function that allows you to store aerial photographs. To store aerial photographs, see Part 5 "Autoflight- Prefetch.".
- Left clicking on the aerial photograph will add a waypoint to the quad's mission. For this autoflight, create a triangle mission like the one in Figure 18.

Figure 18 – Auto mode test mission

- To create a triangle test mission:
  - Click on the Add Below button, see Figure 18. In the drop down menu select the **TAKEOFF** command and set a height. The mission in Figure 18 has a takeoff height of 20m, all altitudes are in meters.
  - Click on the aerial photo twice to create waypoints 2 and 3. After the waypoints are created you can drag them to their correct positions. You must also set an altitude and radius for the waypoints. The altitude in Figure 18 is 20m and the radius is 30m.
    - When placing waypoints, do not put them close to any object they could fly into mountainside, building, power lines, etc. The quad is **very** susceptible to wind and gets blown off course easily.
    - Do not make the waypoint radius less than 10m because it wastes flight time trying to hit the waypoint exactly.
  - After the waypoints have been created, click the Add Below button. In the drop down menu select the **RETURN_TO_LAUNCH** command and set a height. The mission in Figure 18 has a takeoff height of 10m.
  - Click the Add Below button again. In the drop down menu select the **LAND** command. The mission in Figure 18 does not show the **LAND** command.
- You can save a mission to your computer by clicking the Save WP File in Figure 18. If your version of the Mission Planner does not have the Save WP File button:
  - Right Click on the aerial photograph.
  - Click on File Load/Save.
  - Click on Save WP File.

All missions must have the TAKEOFF, RETURN_TO_LAUNCH, and LAND commands.

Load the mission on the quad

- Connect the quad to the Mission Planner using the telemetry, see Part 3 "Connect to the telemetry" or the USB, see Part 4 "Calibrating the Spektrum radio controller."
- Click on the Write WPs button, see Figure 18.
- Save the mission to your computer.
- Restart the Mission Planner and reconnect to the quad.
- Click on the Read WPs button. It is directly above the Write WPs button.
- The Mission Planner will read the mission off of the APM2. If this mission is correct continue. If it is incorrect try loading the mission to the APM2 again.

Prefetch

Prefetching the aerial photographs for a mission area allows the Mission Planner to use the photographs even when an internet connection is not present.

To Prefetch a mission's area:

- Navigate to the mission's area, and the zoom you want, in the Flight Planner tab.
- Select the Prefetch button, see Figure 18. If there is no Prefetch button:
    - Right click on the aerial photograph.
    - Click on Map Tool.
    - Click on Prefetch.
- To the question: "No rip area defined, rip displayed on screen?" Answer "Yes."
- For the question about zoom numbers: Answer "Yes" if the map is zoomed to the resolution you desire.
    - If you want a different zoom answer "No."
    - Restart the prefetching process.
- The Mission Planner will now save the aerial photographs for later use.
- Depending on the size of the mission area and the zoom resolution required, you may have to repeat the prefetching process multiple times.

Set the quad's home location

- Move the quad to the takeoff location for the mission.
- Turn on the radio controller.
- Turn on the quad.
- Connect the quad to the Mission Planner.
- Wait for the quad to acquire GPS, the blue LED will be solid.
- Wait 30 seconds for the GPS to acquire the greatest number of satellites.
- In the Flight Planner tab, click on Home Location, see Figure 19.

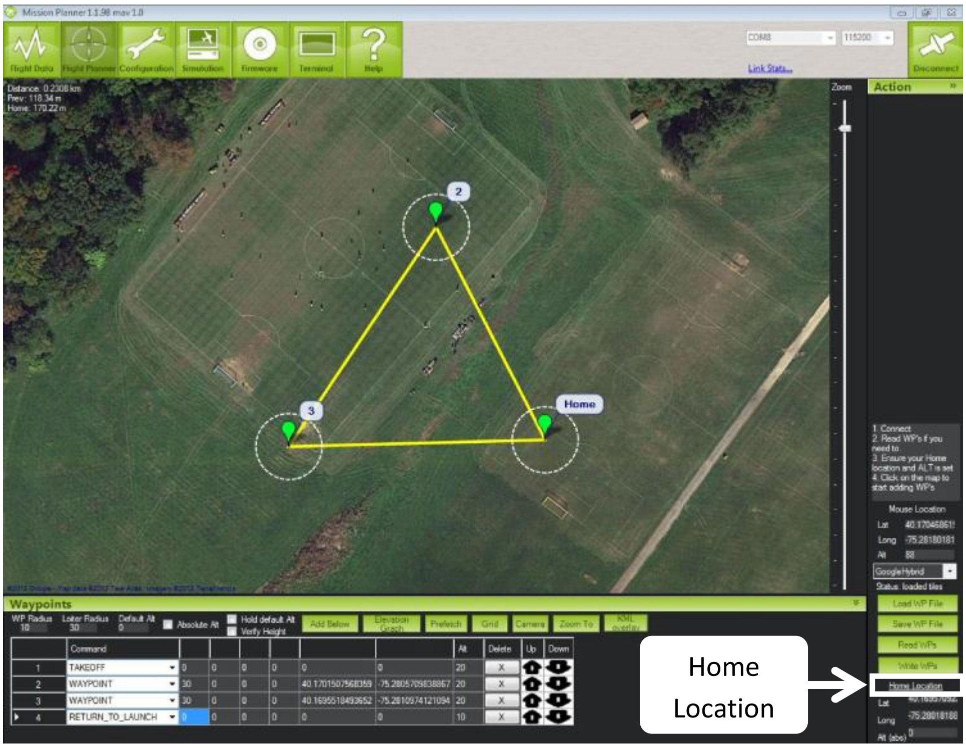


Figure 19 – Flight Planner tab showing Home Location

- The Home green balloon will move to the current location of the quad.
- Click on Write WPs, see Figure 18.

You must go through this process every time the quad is moved before takeoff.

Start the mission

- Turn on the Spektrum radio controller and the quad.
- With the gear switch, see Part 1 "Spektrum radio controller setup" is up, arm the quad.
- Flip the gear switch to the ground, this will put the quad in auto mode.
- Push the throttle stick all the way up.
- The quad will now begin the mission.

End the mission

- Once the quad is less than a meter above the landing position:
    - Drop the throttle to zero, all the way down.
    - Flip the gear switch up.
- The quad's blades will stop rotating as it is now in manual control.

DO NOT flip the gear switch before the throttle is moved to zero. If you do, the quad will takeoff from its current position at full speed.

Quad malfunction

Should the quad's current actions jeopardize the successful completion of the mission, i.e. it is about to hit something or is going off course and, is not correcting itself:

- Drop the throttle to zero.
- Flip the gear switch up.

This brings the quad into manual control and crashes it.

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Appendix 1 – Lithium Polymer (LiPo) battery charging

Warning

LiPo batteries, like all battery types, are dangerous if charged incorrectly. Read this entire appendix before charging the batteries and if you do not understand any part please refer to the PowerLab 8 User's Guide.

Someone should be in the room at all times when a battery is charging. If the battery begins to get hot and/or smoke, remove the battery from the charger and place it in an area away from fire hazards. Do not go near the LiPo battery for at least 30 minutes.

Tools

There are many different tools that can safely charge LiPo batteries. This appendix specifies the use of the PowerLab 8 from Cellpro with the Multi-Port safe parallel Adapter (MPA) for charging a 3-cell 5000mAh LiPo battery. The information contained in this appendix applies only to the use of these tools and is not intended to inform the use of other chargers/adapters or batteries.

Power source setup

(Adapted from the PowerLab 8 User's Guide)

- Connect the red and black wires from the PowerLab 8 to the power source.
- Turn on the power source.
- Press any button on the PowerLab 8.
- At the Power Source? Press the INC or DEC buttons to select the type of power source being used and hit ENTER.
- Press INC and DEC at the same time to display the Options menu.
- Press INC or DEC until you see Charger Options, and then hit ENTER.
- Press INC or DEC until you see PRIMARY CHANNEL and hit ENTER.
- At the Power Source? Press INC or DEC until you see the type of power source being used, then hit ENTER.
- If using a lead acid battery as a power source: At the Battery Current Limit? Press INC or DEC to set the upper current limit for your lead acid battery. Max current output of a lead acid vehicle battery is generally 25A continuously and 50A for short bursts. AGM style batteries can usually deliver twice the current of a lead acid battery and hit ENTER.
    - If using a DC power source: at the Supply Current Limit? Press INC or DEC to set the upper current limit for your DC power source. This should be slightly less than the supplies max output and hit ENTER.
- At the Low Supply Limit (or Bat. Low Cutoff)? Press INC or DEC to set the low voltage cutoff of the source. This should be about 50% lower than the power source supplies nominal output voltage. Example: The cutoff for a 24V power source is 12V. The cutoff voltage for a lead acid battery should never be less than 11V and then hit ENTER.

- If using a lead acid battery: At the Use Regenerative Discharge? Press INC or DEC to enable or disable this feature. Then hit ENTER. Regenerative discharge puts energy back into the power source when discharging LiPo battery packs through the PowerLab 8.
    - If using a DC power source: At the Use Regenerative Discharge? It should say N/A. Regenerative discharge is unavailable with a DC power source.
- Hit ENTER twice to bypass the Node Connector? And, Decimal Places for Cells?
- At the Quiet Charging? Use INC or DEC to set it to N (beeps during charging) or Y (no beeps during charging) and hit ENTER.
- The Speak Volume? Allows you to set the volume using INC and DEC. One (1) is the lowest volume and then hit ENTER.
- The Sound Button Clicks? Allows you to mute the button presses by setting it to N and then hit ENTER.
- The Charge Complete Beeps? Sets how many times the PowerLab 8 beeps when a LiPo battery is charged. Use INC and DEC to change the number of beeps and then hit ENTER.
- The Preset Changes Always Save? Should always be set to Y.

Your input power source is now set up to work with the PowerLab 8!

Charging a battery

(Adapted from the PowerLab 8 User's Guide)

- Configure the PowerLab 8 to work with you power source, see Power source setup in Appendix 1.
- Plug the MPA into the PowerLab 8 as shown in Figure A.

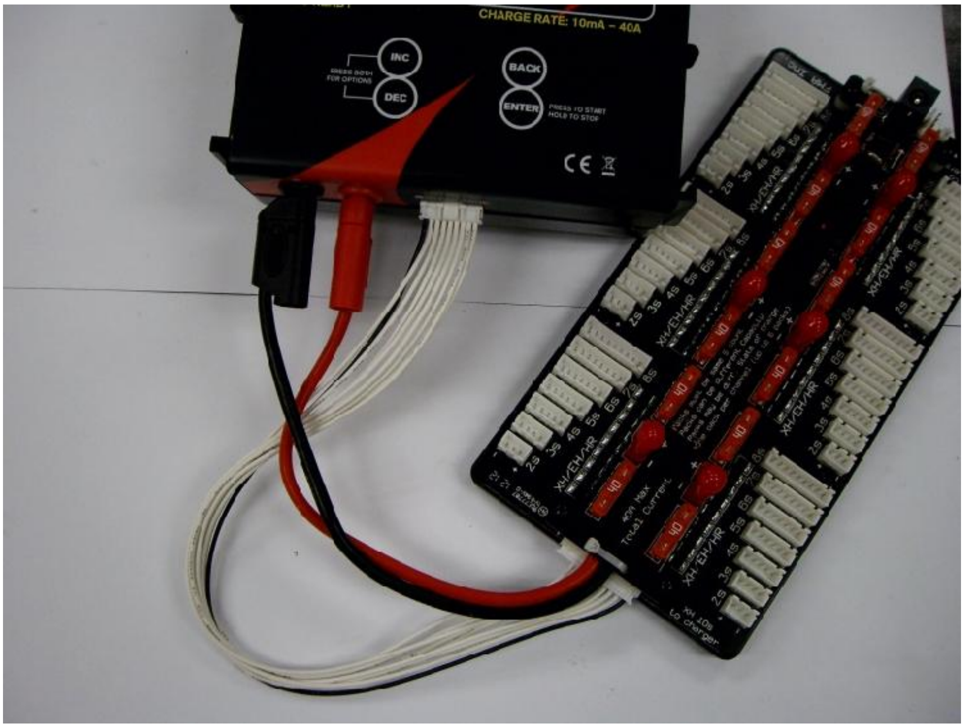

Figure A – How to plug the MPA board into the Powerlab 8

- Plug the deans plug and the 4 wire plug into the same port of the MPA. See Figure B.

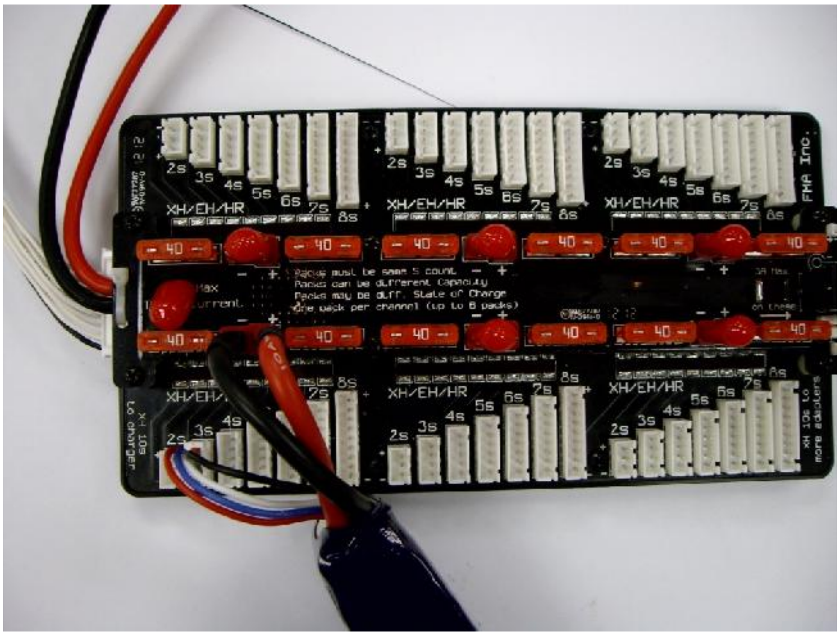

Figure B – How to plug a 3-cell (3S) LiPo battery into the MPA

- Plug the PowerLab 8 into the battery/DC power source and turn on the power source.
- The PowerLab 8 will turn on. Hit any button to continue.
- Select the power source and hit ENTER.
- Use INC or DEC to select 2 Faster Charge and then hit ENTER.
- At the Parallel Packs? Have No selected and then hit ENTER.
- For Set Charge Rate? Use INC or DEC to set it to 15A if time is critical set it to 35A and hit ENTER.
- For Set Dsch. Rate? Use INC or DEC to set it to 2A and hit ENTER.
- At the START? Select CHARGE ONLY and hit ENTER.
- At the Use Banana Jacks? Use INC or DEC to select Y and hit ENTER.
- The PowerLab 8 will now check the pack.
- The PowerLab 8 will display what it thinks the chemistry of the battery is. It should say LiPo across the top of the screen. If it does hit ENTER and wait for the LiPo battery to charge. If it does not say LiPo hit the BACK button, disconnect and reconnect the pack and restart the charging process.
- You can stop the pack from charging by holding down ENTER.
- When charging, INC and DEC can be used to scroll through screens showing information about the charge (elapsed time, amount charged, etc).

Discharging a Battery

Discharge a battery when it is going to be stored for longer than three month between uses.

(Adapted from the PowerLab 8 User's Guide)

- Configure the PowerLab 8 to work with you power source, see Power source setup in Appendix 1.
- Plug the MPA into the PowerLab 8 as shown in Figure A.
- Plug the deans plug and the 4 wire plug into the same port of the MPA, see Figure B.
- Plug the PowerLab 8 into the battery/DC power source and turn on the power source.
- The PowerLab 8 will turn on. Hit any button to continue.
- Select the power source and hit ENTER.
- Use INC or DEC to select 7 Storage Charge and then hit ENTER.
- At the Parallel Packs? Have No selected and hit ENTER.
- For Set Charge Rate? Use INC or DEC to set it to 5A and then hit ENTER.
- For Set Dsch. Rate? Use INC or DEC to set it to 15A and then hit ENTER.
- At the START? Select DISCHARGE ONLY and hit ENTER.
- At the Use Banana Jacks? Use INC or DEC to select Y and hit ENTER.
- The PowerLab 8 will now check the pack.
- The PowerLab 8 will display what it thinks the chemistry of the LiPo battery is. It should say LiPo across the top of the screen. If it does hit ENTER and wait for the battery to discharge. If it does not say LiPo hit the BACK button, disconnect and reconnect the pack and restart the discharging process.
- You can stop the pack from discharging by holding down ENTER.
- When discharging, INC and DEC can be used to scroll through screens showing information about the discharge (elapsed time, amount charged, etc).

UAV Glossary of terms

2.4GHz: The frequency used by digital (spread spectrum) radio communications in our applications, including 2.4GHz radio controllers (RC), Bluetooth and some video transmission equipment. This is a different band than the older 72MHz band that is used for analog RC communications. To avoid radio frequency conflict is it often a good idea to use 72MHz radio equipment when you are using 2.4GHz onboard video transmitters, or use 900MHz video when using 2.4GHz RC equipment.

AHRS: Attitude and Heading Reference System.

AMA: Academy of Model Aeronautics**.** The main US model aircraft association generally hostile to amateur UAVs, which are banned on AMA fields. But each AMA chapter and field may have slightly different policies, and it's possible to test airframes and some technology on AMA fields without violating the association's rules.

APM: ArduPilotMega autopilot electronics

ArduCopter (AC, AC2): Rotary-wing autopilot software for the ArduPilot Mega electronics

ArduPlane: Fixed-wing autopilot software for the ArduPilot Mega electronics.

ArduRover: Ground and water autopilot software for the ArduPilot Mega electronics

Arduino: An open source embedded processor project. Includes a hardware standard currently based on the Atmel Atmega168 microprocessor and necessary supporting hardware, and a software programming environment based on the C-like Processing language.

BASIC Stamp: A simple embedded processor and programming environment created and sold by Parallax. Often used to teach basic embedded computing and the basis of our autopilot tutorial project. Parallax also makes the very capable Propeller chip, which is the basis of the AttoPilot autopilot and others.

Bootloader: Special code stored in non-volatile memory in a microprocessor that can interface with a PC to download a user's program.

COA: Certificate of Authorization. A FAA approval for a UAV flight.

Eagle file: The schematic and PCB design files (and related files that tell PCB fabs how to create the boards) generated by the free Cadsoft Eagle program. This is the most common standard used in the open source hardware world, although, ironically, it's not open source software itself. Needless to say, this is not optimal, and the Eagle software is clumsy and hard to learn. One hopes that an open source alternative will someday emerge

DCM: Direction Cosine Matrix. A algorithm that is a less processing intensive equivalent of the Kalman Filter.

ESC: Electronic Speed Control. Device to control the motor in an electric aircraft. Serves as the connection between the main battery and the RC receiver. Usually includes a **BEC**, or Battery Elimination Circuit, which provides power for the RC system and other onboard electronics, such as an autopilot.

FPV: First-person view. A technique that uses an onboard video camera and wireless connection to the ground allow a pilot on the ground with video goggles to fly with a cockpit view.

FTDI: A standard to convert USB to serial communications. Available as a chip for boards that have a USB connector, or in a cable to connected to breakout pins. FTDI stands for Future Technology Devices International, which is the name of the company that makes the chips.

GCS: Ground Control Station. Software running on a computer on the ground that receives telemetry information from an airborne UAV and displays its progress and status, often including video and other sensor data. Can also be used to transmit in- flight commands to the UAV.

Hardware-in-the-loop simulation: Doing a simulation where software running on another computer generates data that simulates the data that would be coming from an autopilot's sensors. The autopilot is running and doesn't "know" that the data is simulated, so it responds just as it would to real sensor data. Hardware-in-the-loop uses the physical autopilot hardware connected to a simulator, as opposed to simulating the autopilot in software, too.

IC2: A serial bus that allows multiple low speed peripherals, such as sensors, to be connected to a microprocessor.

IDE: An integrated development environment, such as the Arduino editor / downloader / serial monitor software. Often includes a debugger.

IMU: An inertial measurement unit. Usually has at least three accelerometers measuring the gravity vector in the x, y and z dimensions and, two gyros measuring rotation around the tilt and pitch axis. Neither are sufficient by themselves, since accelerometers are thrown off by movement (i.e., they are "noisy" over short periods of time), while gyros drift over time. The data from both types of sensors must be combined in software to determine true aircraft attitude and movement. One technique for doing this is the Kalman filter.

Inner loop/Outer loop: Usually used to refer to the stabilization and navigation functions of an autopilot. The stabilization function must run in real-time and as often as 100 times a second ("inner loop"), while the navigation function can run as infrequently as once per second and can tolerate delays and interruptions ("outer loop").

INS: Inertial Navigation System. A way to calculate position based on an initial GPS reading followed by readings from motion and speed sensors. Useful when GPS is not available or has temporarily lost its signal.

ICSP: In Circuit Serial Programmer. A way to load code to a microprocessor. Usually seen as a six-pin (two rows of three) connector on a PCB. To use this, you need a programmer that uses the **SPI** (Serial Peripheral Interface) standard.

Kalman Filter: A relatively complicated algorithm that, in our applications, is primarily used to combine accelerometer and gyro data to provide an accurate description of aircraft attitude and movement in real time.

LOS: Line of Sight. Refers to a FAA requirement that UAVs stay within a pilot's direct visual control if they are flying under the recreational exemption to COA approval.

LiPo: Lithium Polymer battery, aka LiPoly. Varients include Lithium Ion (Li-Ion) battery.

This battery chemistry offers more power and lighter weight than NiMh and NiCad batteries.

NMEA: National Marine Electronics Association standard for GPS information. When we refer to "NMEA sentences", we're talking about ASCII strings from a GPS module that look like this: $GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

OSD: On-screen display. A way to integrate data (often telemetry information) into the real-time video stream the aircraft is sending to the ground.

PCB: Printed circuit board. In our use, a specialized board designed and "fabbed" for a dedicated purpose, as opposed to a breadboard or prototype board, which can be used and resused for many projects.

PIC: Pilot in Command. Refers to a FAA requirement that UAVs stay under a pilot's direct control if they are flying under the recreational exemption to COA approval. See Line of Sight above.

PID: Proportional/Integral/Derivative control method. A machine control algorithm that allows for more accurate sensor-motion control loops and less over control.

RTL: Return to Launch. Return the aircraft to the "home" position where it took off.

SiRF III: The standard used by most modern GPS modules. Includes SiRF III binary mode, which is an alternative to the ASCII-based NMEA standard described above.

Sketch: The program files, drivers and other code generated by the Arduinio IDE for a single project.

SVN: Short for the Subversion version-control repository used by the DIY Drones and other teams for source code.

Thermopile: An infrared detector. Often used in pairs in UAVs to measure tilt and pitch by looking at differences in the infared signature of the horizon fore and aft and on both sides. This is based on the fact that there is always an infrared gradient between earth and sky, and that you can keep a plane flying level by ensuring that the readings are the same from both sensors in each pair, each looking in opposite directions.

UAV: Unmanned Aerial Vehicle. In the military, these are increasingly called Unmanned Aerial Systems (**UAS**), to reflect that the aircraft is just part of a complex system in the air and on the ground. Ground-based autonomous robots are called Unmanned Ground Vehicles (**UGVs**) and robot submersibles are called Autonomous Underwater Vehicles (**AUVs**). Robot boats are called Unmanned Surface Vehicles (**USVs**).

WAAS: Wide Area Augmentation System. A system of satellites and ground stations that provide GPS signal corrections, giving up to five times better position accuracy than uncorrected GPS.

ZigBee (related: Xbee): A wireless communications standard, which has longer range than Bluetooth but lower power consumption than WiFi.

UAV Informal glossary of terms

We had to learn a new language full of words, terms or acronyms which we had never heard before, like PIDs. OK, what is a PID and how can I relate to it? Here is a sample. Thanks, Mike[1] we can relate to that!

P term: The P term is like a big strong man on the steering wheel. He sees he is off course and muscles the steering wheel in the direction he thinks he should be going. Nothing really accurate about it, just proportional to the obvious error that he perceives.

I term: The I term is like your average backseat driver. He looks closely at the error and tugs the steering wheel gently... at first... to get back on course. But the longer he sees the error the more excited he gets and the harder he tugs.

D term: The D Term is a very nervous individual. He doesn't mind so much that he is in error as he minds speeding past where he wants to be and having to go back. So he is constantly looking at how fast their collective goal is approaching and is fighting both the P-strongman and the I-backseat driver to prevent them from overshooting their target.

[1] http://forums.parallax.com/showthread.php?103880-PID-Stuff-for-you-UAV-Nuts-out-there!

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