Build the Kronos Flyer

Part 6: APM 2.5

by Michael Simpson

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This series was originally supposed to run for only five months, and while last month's article was intended to be the last, I received a ton of requests to do a write-up of the APM 2.5 controller on the Kronos Flyer. So — by popular demand — here it is.

APM 2.5

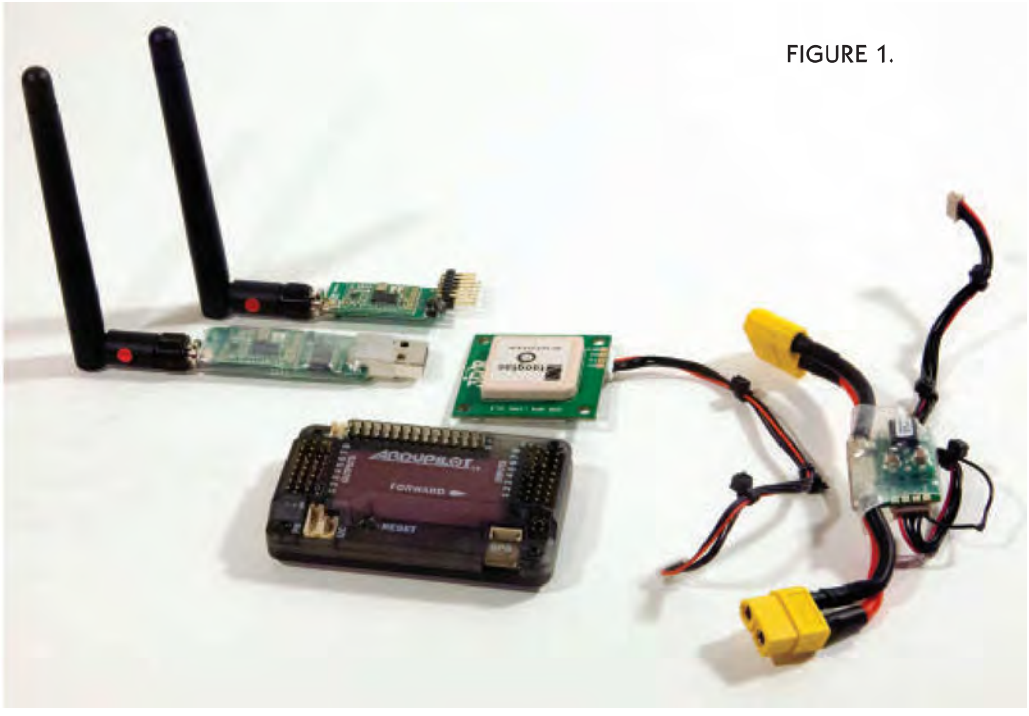


FIGURE 1.

Last month, I touched on the APM 2.5. The system shown in **Figure 1** consists of the APM 2.5+, GPS, and 915 MHz two-way telemetry radios. In my case, I upgraded to the better uBlox GPS unit.

You can purchase the main unit in both side entry or top entry for your hookup. I prefer the top entry as it allows for a smaller footprint on the quad platform.

While shopping for the APM, you may see the nomenclature APM 2.5+. This just refers to the APM 2.5, APM 2.5 case, GPS, and power module. In my case, I purchased the APM 2.5+ set and the telemetry radios.

New Firmware

One of the issues I had with the APM 2.5 system is that the stability of the NAZA blows the APM out of the water. It turns out there is a reason for this. The firmware in the APM was not fully utilizing the built-in accelerometers which effectively made the controller a three-axis system.

This has all changed.

With the release of the ArduCopter 2.9.1, the APM 2.5+ is now fully utilizing the accelerometers and is now a full six-axis controller. Does it make a difference? Yes, it does.

While the APM is still not on the same level as the NAZA, it is much easier to fly and — in my opinion — is a good alternative to the NAZA.

In the past, I had stated that the APM 2.5 was a controller that promised a lot but delivered very little. I can honestly say that now, I will be utilizing the APM 2.5 on many of my other craft.

Why would I do this when the NAZA is more stable, easier to install, and requires little or no tuning to get it to fly?

There are two reasons. I can get an APM 2.5 with GPS for as little as $179. The NAZA with GPS will run you $399. Is the NAZA twice as stable as the APM 2.5? Probably. However, the cost is not the only reason. It's all about those promises that the APM 2.5 makes.

For $85, I can add a two-way radio system that can be used to send information back to my laptop. This will allow me to not only log various settings on the craft in real time, but also to add the ability to track the craft on a map.

The Mission Planner (shown in **Figure 2**) is an application that runs on Windows. It's the program you use to configure your APM 2.5 and to update your APM's firmware.

In addition, you can track your GPS location with the two-way telemetry radio and send commands to your craft. You can even fly your craft with a joystick.

Now, that's a lot of promises. No other system offers this much control for so little cost.

FYI ... that is my house and truck in the satellite view shown in **Figure 2**. I am sitting in my basement lab which is where the craft is showing up on the map.

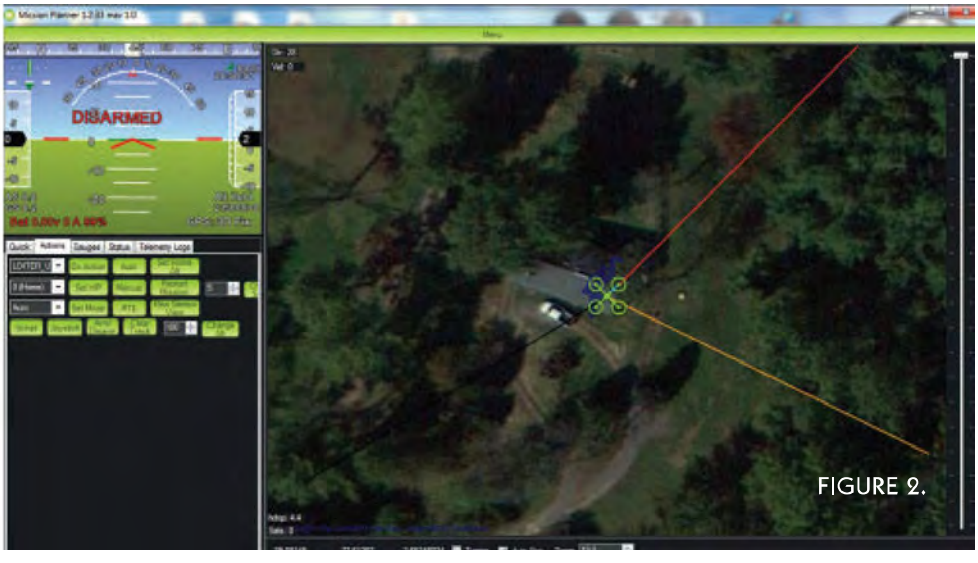


FIGURE 2.

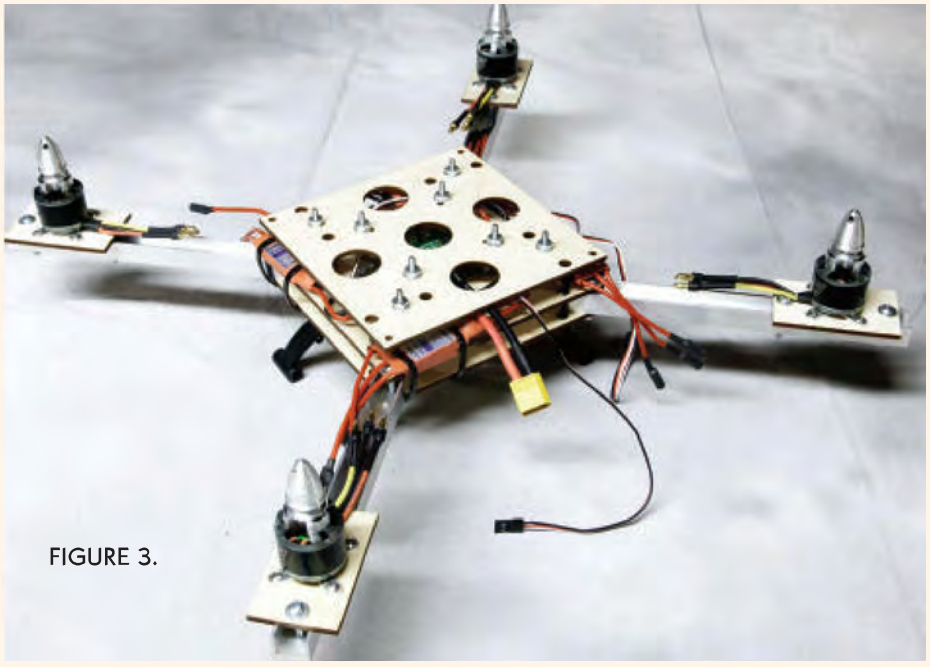


FIGURE 3.

Good Vibrations

Fully utilizing the accelerometers does come at a cost. Accelerometers are very sensitive to the propeller vibration in a multi-rotor craft. While these vibrations are handled by the NAZA enclosure, the same can't be said for the APM 2.5.

You must add vibration control to your craft before you can use the new firmware. Failure to do so could lead to your craft flying out of control.

You might be asking, what is vibration control? This can be as simple as adding foam rubber under the controller or as complex as an isolation platform on your craft.

I prefer the isolation platform because it allows me to add other things without having to worry about the

Boom Extensions

I talked about boom extensions last month, and have come up with several extensions that will fit the Kronos Flyer booms. These will allow you to use various size motors, and mount the motors on the top or bottom of the extensions as shown in **Figure 5**. While boom extensions are not required, they will allow you to use larger props and motors. They also look cool.

Landing Feet

Because I wanted to move the battery off the bottom of the craft, there is no longer a need for the helicopter style landing gear on the Kronos Flyer. As a replacement, I designed a set of small feet and boom covers shown in **Figure 6**. Again, these are optional, but will keep the belly of your craft off the ground for take-offs and landings. They also provide a good mechanism for attaching foam for a more cushioned set of landing pads.

Isolation Platform

The real meat of the KFE modular system is the redesigned isolation platform

FIGURE 5.

FIGURE 6.

vibrations caused by the propellers.

As I started to work with the APM 2.5 and its new firmware, I came up with new design enhancements for the Kronos Flyer.

KFE is Born

The original design of the Kronos Flyer was a real challenge. I wanted a frame that could be built with basic materials and tools. This way, anyone could recreate what I call "the reference frame" shown in **Figure 3**.

I also wanted to be able to add enhancements or upgrades to the designs that were a bit more sophisticated. These upgrades would take the basic frame to a whole new level. I call the enhanced craft the KFE for "Kronos Flyer Enhanced."

It's a modular design, so that only one or all of the enhancements can be added to the basic Kronos Flyer.

The frame in **Figure 4** shows enhancements to three areas. Let's take a closer look at these.

FIGURE 4.

shown in **Figure 7** which was designed specifically for the APM 2.5+ system.

One of the problems with many other platforms is the lack of room for mounting all your components. This platform has room for mounting the APM 2.5+, GPS, telemetry radio, FPV radio, FPV camera, and GoPro camera — all on the inside of the isolation platform. This leaves the top available for mounting any size battery — everything from the three-cell 2,200 mAh battery shown in **Figure 8**, to the four-cell 5,000 mAh battery shown in **Figure 9**.

You might be asking, why did you mount the battery on top of the isolation platform? The answer is simple: It adds to the mass of the isolation platform. This extra mass keeps even more of the vibrations from transferring from the main platform to the isolation platform.

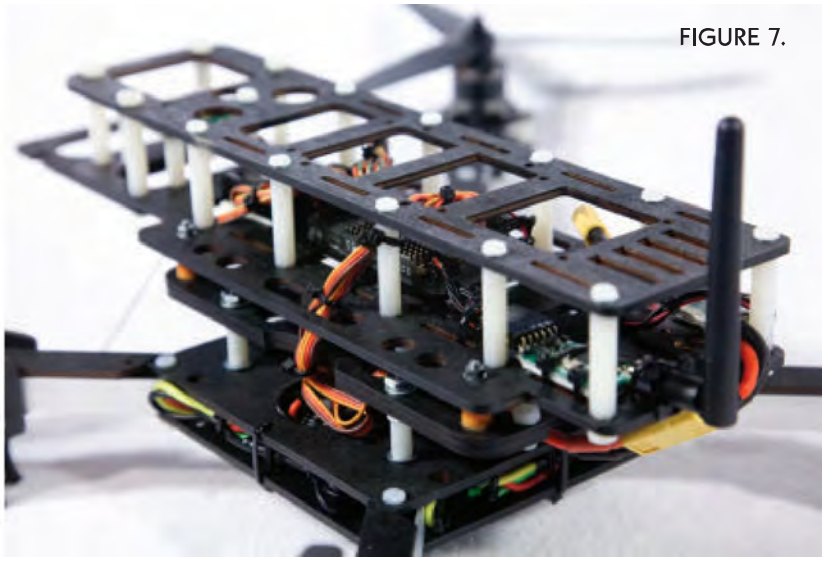
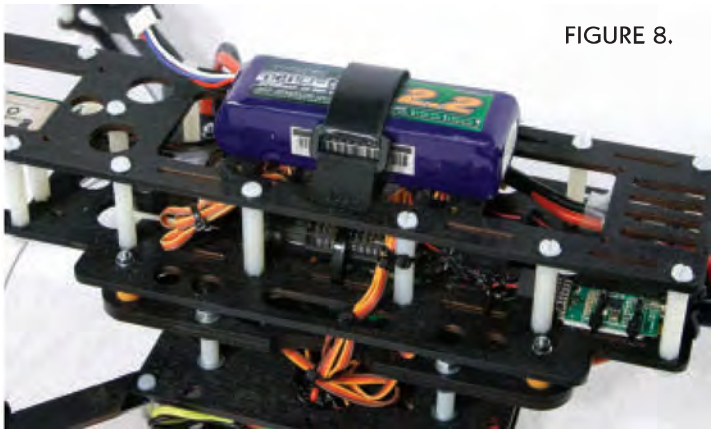


FIGURE 7.

The isolation platform is made from 1/8" Baltic birch plywood. I had thought of using G10 fiberglass, but the ply is lighter, stiffer, and easier to work with than G10. The isolation platform has a stiffened support platform that attaches directly to the original Kronos Flyer platform.

The support platform is tied to the upper isolated platform via four isolation bobbins. These bobbins, plywood, and added mass make for a vibration-free platform.



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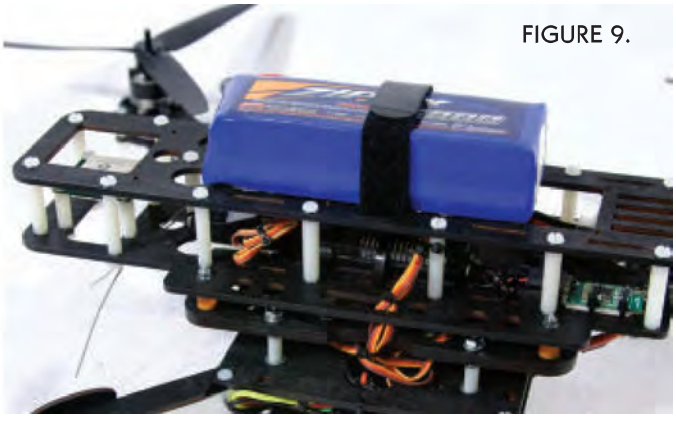
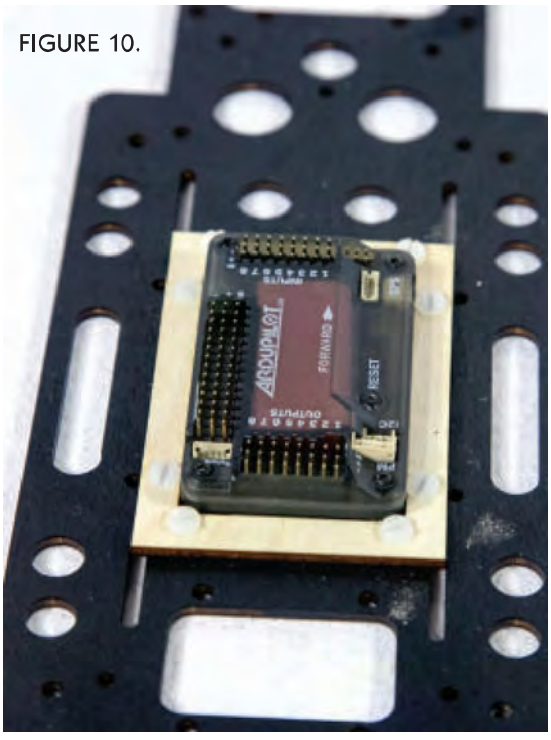


FIGURE 9.

FIGURE 10.



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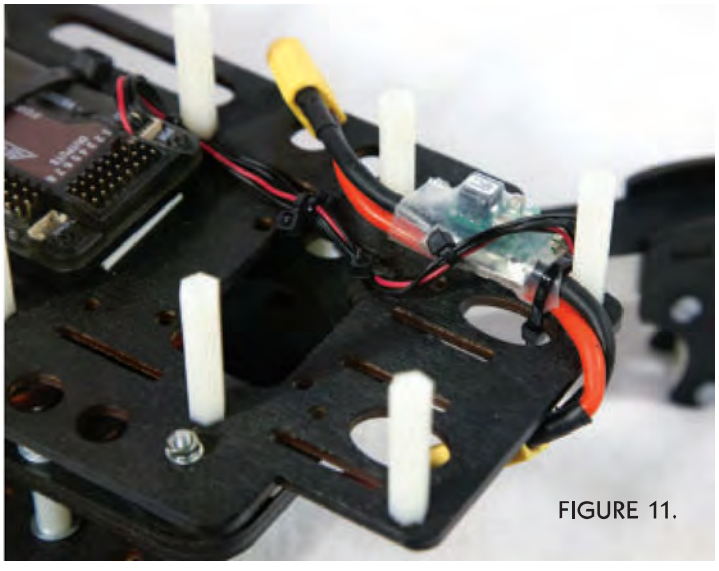
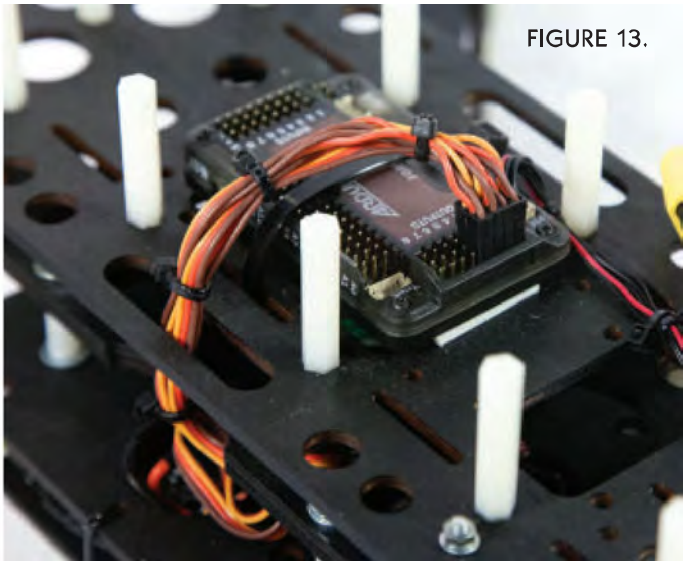


FIGURE 11.

FIGURE 13.



APM 2.5+ Hookup

The APM isolation platform comes with an APM 2.5 alignment guide as shown in **Figure 10**. This guide will enable you to perfectly align the APM to the center of the craft. Next, the power module is attached to the rear of the platform as shown in **Figure 11**.

The power distribution side of the module is routed to the rear and attached to the battery connector on the power distribution board of your craft. The battery connector on the module is routed up and to the side to make access easy for attaching your battery.

In a nutshell, the power module connects between your battery and the APM. A small connector is then attached to the APM, thus providing power to the APM and battery sensor telemetry.

The next step is to attach your ESCs to the APM, but you need to set the motor direction before connecting them. Refer back to Part 4 in this series for instructions on how to set the motor directions. The rotation direction for the motors is shown in **Figure 12**.

Once your motors are set in the correct direction, it's time to connect them to the APM as shown in **Figure 13**. Route the cables through one of the holes in the support platform, then through the slot in the lower portion of the isolation platform. Using **Figure 12** as a guide, connect each ESC to the appropriate channel on the APM.

Mount your receiver in the space in front of the APM as shown in **Figure 14**. Connect each channel on the radio to each of the input channels on the APM. Tie wrap your cable into a neat bundle.

While the APM can be flown with a six-channel radio, I recommend using eight channels. This will give you ample control for more functionality.

Next, you will install the GPS unit. First, install a set of small standoffs, then attach the GPS to the standoffs as shown in **Figure 15**. Connect the GPS cable to the APM connector marked GPS. For this GPS unit, it's the GPS connector on the side of the APM.

The last APM component to connect is the telemetry radio. The best way to install the radio is to place two pieces of thick, double-sided foam tape to the bottom of the radio.

Stick it to the rear of the platform as shown in **Figure 16**. Use some tie wraps to help hold the radio in place in case the foam tape fails.

Since the antenna hangs off the back, I added a couple of tie wraps to help secure it, as well. Plug the connector into the radio as shown. The end of the connector with the missing pin is oriented so that it is facing the power module.

Plug the other end of the cable into the APM connector marked Telem.

The top is then added to the isolation platform and secured in place with screws.

FIGURE 14.

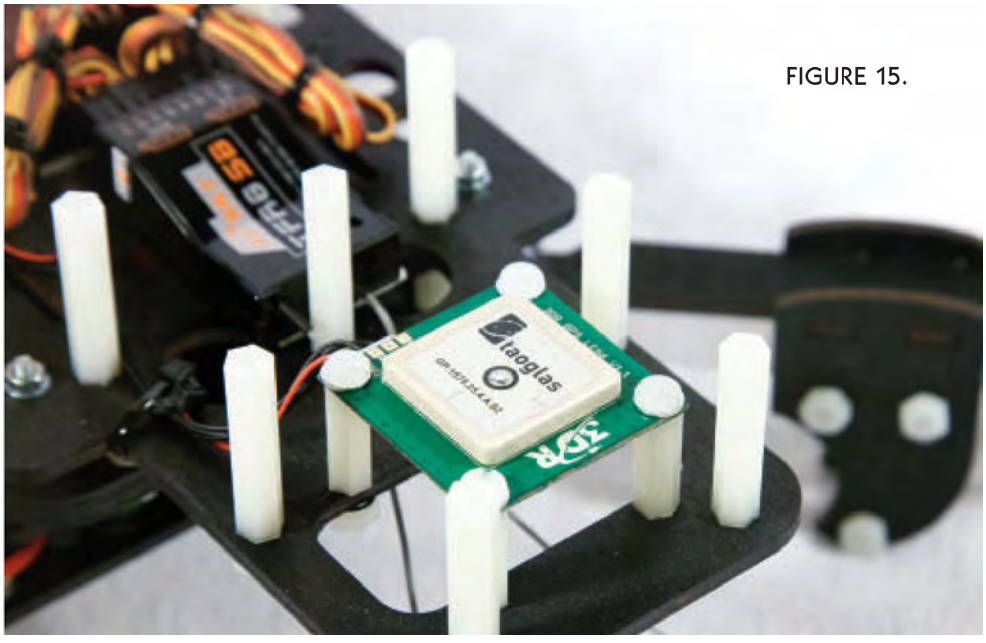


FIGURE 15.

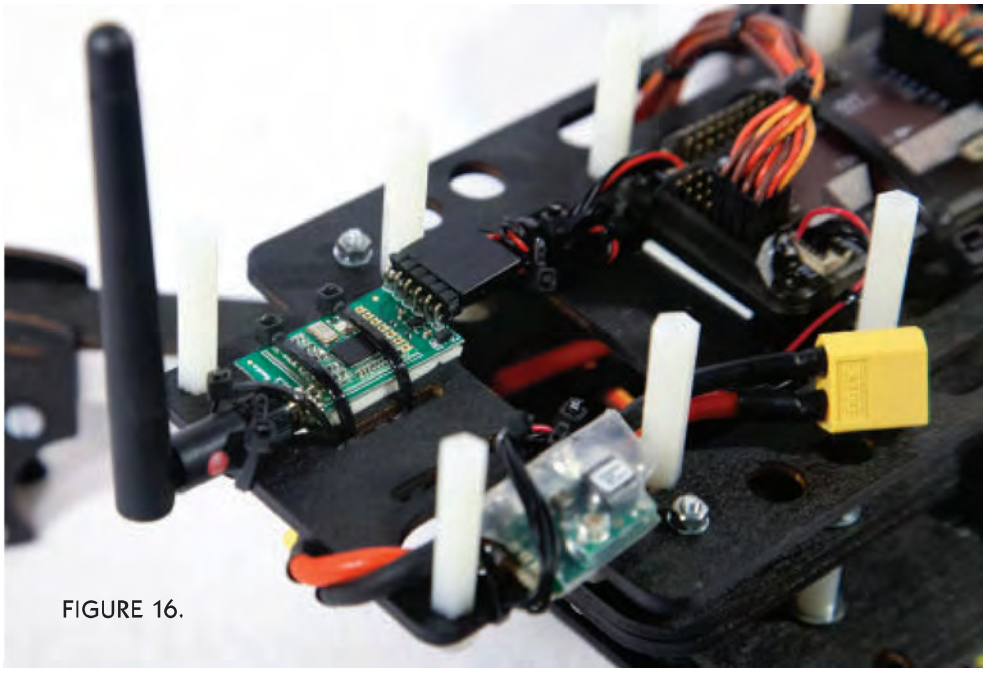


FIGURE 16.

APM 2.5 Software

The first thing you need to do is download and install the latest Mission Planner. You can get it at **http://code.google.com/p/ardupilot-mega/downloads/list**.

The one I downloaded was the MissionPlanner-1.2.33.msi. This one contains the ArduCopter 2.9.1 firmware. If you have an older version of the Mission Planner software, I recommend you uninstall it and install the 1.2.33 directly. I tried the built-in upgrade and it failed on all of my machines.

You can get a full walk-through for the Mission Planner software at **http://code.google.com/p/arducopter/wiki/AC2Installation**.

Complete ArduCopter instructions can be found at **http://code.google.com/p/arducopter/wiki/ArduCopter**.

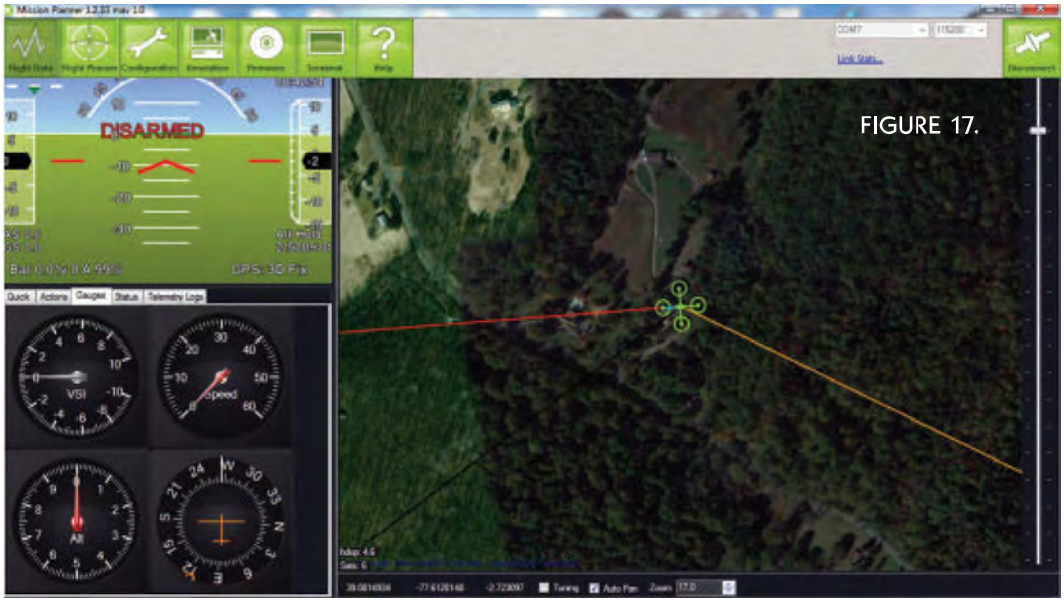


FIGURE 17.

Connecting to APM 2.5

Connect the ArduPilot to your PC with the included USB cable. This will create a new COM port on your machine. Go to the device manager and look in the Ports section. Mine was called Arduino Mega 2500 (COM7). Write down this port name. Note: You don't need to plug your battery into your craft.

Start the Mission Planner software. In the upper righthand corner of the Mission Planner, select the COM port that was installed when you plugged your APM into the USB on your computer. It should default to 115200 speed. You may be able to select the Auto option, as well. If you have other COM ports on your machine, this option can be problematic. Hit the Connect button.

The Mission Planner will go through some modules, and eventually connect to your APM 2.5. You may or may not see telemetry data in the Flight Data tab. It all depends on your firmware status. At this point, you can disconnect from your APM by hitting the Disconnect button.

Next, you need to upload the latest firmware to the APM. To do this, select the Firmware Tab on the Mission Planner. Click on the ArduCopter V2.9.1 Quad and start the download/update process. This will load the very latest quadcopter firmware into your APM.

Once the firmware has been updated into your APM, go back and hit the Connect button again. Once connected, you should see data in the Head Up display; if you have a GPS lock, you should see your location on the map as shown in **Figure 17**.

Configure the APM 2.5

Basic Configuration

Go to the Configuration tab at the top of the screen and select the ArduCopter Level tab on the left side. This will bring up an additional screen that will allow you to select a + or X configuration. Select the X configuration if it is not already selected.

Radio Calibration

If you have not bound your transmitter to your receiver, you need to do it now. While still in the Configuration tab, select the Radio Calibration side tab. With your radio turned on, refer to **Table 1** and make sure each transmitter channel is moving the bars on the calibration screen in the correct direction. If they are not, you will need to reverse them on your radio.

Once you are satisfied the directions are correct, hit the Calibration button and follow the on-screen instructions.

Channel	Radio Description	Direction 1	Direction 2
1	Ailerons	Left = Roll Low	Right = Roll High
2	Elevator	Up = Pitch Low	Down = Pitch High
3	Throttle	Down = Throttle Low	Up = Throttle High
4	Rudder	Right = Yaw High	Left = Yaw Low
5	Three-Position Switch 1	Radio 5 - Three-Position	Radio 5 - Three-Position
6	Knob	CW = Radio 6 High	CCW = Radio 6 Low
7	Three-Position Switch 2	Radio 7 - Three-Position	Radio 7 - Three-Position
8	Knob	CW = Radio 8 High	CCW = Radio 8 Low

Table 1.

Flight Modes

With your radio calibrated, you can now set your flight modes. Select the Flight Modes tab, then move your channel 5 switch. If you have a radio with a three-position switch, then you will be able to select one of three flight modes. If you only have a two-position switch, then only one of two can be selected. As you change the flight mode, you should see the appropriate mode field highlighted. On my three-position switch, modes 1, 4, and 6 can be selected. For them, I chose Stabilize, Alt Hold, and Loiter as shown in **Figure 18**. Save the modes once you have them set the way you want.

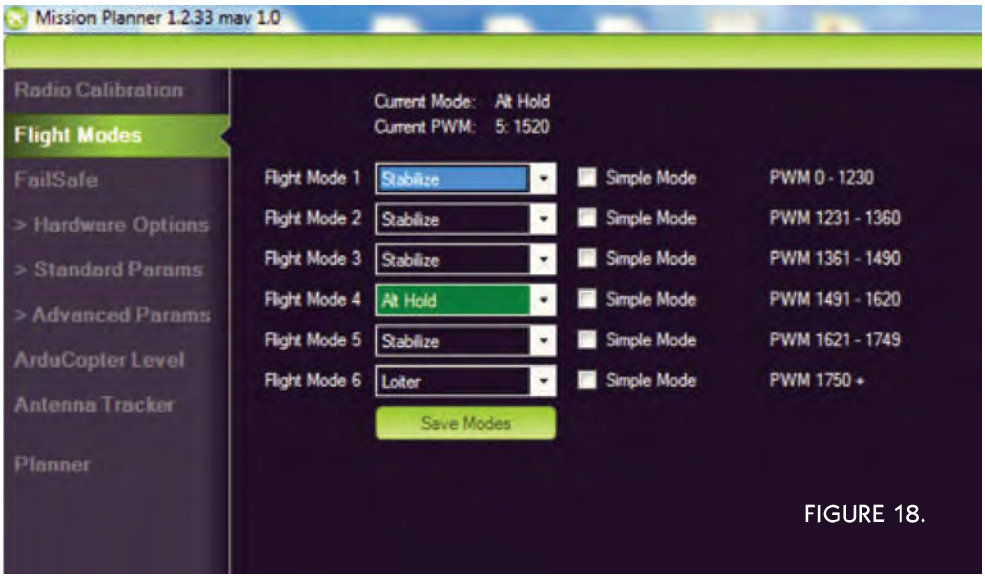


FIGURE 18.

You need to select the modes for your craft. Use **Table 2** as a basic guide for the three modes I just mentioned. Refer to the ArduCopter documentation for descriptions of all the modes.

Mode	Description
Stabilize	This mode keeps the craft upright and somewhat steady. You manually control altitude with the throttle.
AltHold	This mode is the same as Stabilize mode but will hold its altitude as long as the throttle stays in the center position. Raising and lowering the throttle will allow you to move to a new altitude.
Loiter	This mode will attempt to use the GPS to hold the craft in one position. How successful this is depends on the number of satellites you are locked onto and how much interference the GPS is getting.

Table 2.

Hardware Options

Select the Hardware Options side tab. Make sure the Compass is enabled. This section is where you can select other hardware options to add further control of your craft. The Sonar sensor adds more precise control of altitude when you are close to the ground. The Airspeed sensor adds a true air speed option to your telemetry. The Optical Flow sensor allows your craft to track ground targets. Please be advised, because I am not sure on the actual support of these sensors. I'm pretty sure the Sonar sensor is working with the current firmware.

Accelerometer Calibration

Go back and select the ArduCopter Level side tab. Hit the Calibrate Accel tab and follow the on-screen instructions. It may be helpful to use a table or other large object to help steady the craft as you move it from position to position.

ESC Calibration

While the APM instructions state that you can use the stand-alone method (the one I used in Part 4), it does not work. I found the following pass-through method works best with the APM 2.5. Note that your props should not be connected.

Step 1
Disconnect the USB and battery from your craft.

Step 2
Turn on your transmitter. Once it is on, set the throttle at its max.

Step 3
Connect the battery to your craft. After the APM boots, you will see the main LED lights cycle through yellow, red, and blue. The APM is telling you it is ready to place the APM in pass-through mode.

Step 4
With the throttle still set to full, remove the battery from your craft and then reconnect it. The ESCs should play a tune, pause, then do a single beep. When this happens, lower your throttle all the way and the ESCs should beep again. The ESCs are now calibrated.

Step 5
Move the throttle up a little and make sure all the motors start at the same point.

Ready for Flight

You have now done the minimum configuration required to fly your APM 2.5 KFE. Be sure to balance your props, then mount the following props in the following positions:

Motor 1 = Left hand prop
Motor 2 = Left hand prop
Motor 3 = Right hand prop
Motor 4 = Right hand prop

For your first flight, make sure you have plenty of room. Don't do it indoors.

Conclusion

The configuration I have shown you here only scratches the surface of what the AMP 2.5 KFE is capable of. I don't recommend you go out and start running waypoints or doing circle maneuvers until you have several flights under your belt. This will also let you work out any kinks in your craft.

To date, I have only flown a couple of waypoints successfully and that is because I worked the craft with the radio and someone else operated the laptop. I'm sure with time I will be able to do both, once I get a few of my own kinks out.

Be sure to check out the Kronos Robotics website for KFE parts and more detailed instructions for assembly. I plan on offering various upgrade options, as well as a complete frame kit.

As always, be sure to post your questions in the *SERVO Magazine* forums at **http://forum.nutsvolts.com/viewtopic.php?f=49&t=16866**. SV

Next Month: 3D Printers

Starting next month, I will begin a new series on 3D printers. I will take you through the build process of the two printers shown in **Figure A**.

The Rostock MAX (on the left) is probably one of the largest 3D printer kits you can put together. It's based on a Delta Robot design and is as much fun to watch as it is to print.

The PrintrBot Jr (on the right) is probably the smallest. This little guy is so small I can place it just about anywhere. While not as sophisticated as the MAX, it's still a lot of fun to tinker with.