Greg Ordy, W8WWV / ordy@seed-solutions.com

Drones and Amateur Radio

The term *drone* entered the popular culture about a dozen years ago to mean an unmanned fixed-wing aircraft used by the military to carry out long-range reconnaissance and missile attacks. Names such as *Predator* gave the term an aggressive connotation, causing many people to view them in a negative light, especially if one is flying around the neighborhood.

In more recent years, *drone* has acquired another meaning. A drone, usually in the form of a *quadcopter*, is a small, 4 propeller flying machine that carries a camera. These are part of the exploding toy, hobby, and professional markets that more-capable and less-expensive models are entering every day. The obvious drone application for Amateur Radio is to take still pictures and videos of antenna farms, but there are others. More on that later.

The drone market has been created and propelled by the combination of several enabling technologies. These include:

- ♦ Lightweight and powerful electric motors.
- ♦ Lithium polymer batteries.
- ♦ Microprocessors with significant computing power and sensors, such as GPS, compass, altimeter, and accelerometer.
- ♦ Small, lightweight high-definition still and video cameras.
- ♦ Small, lightweight 3 axis gimbals to stabilize the camera.
- ♦ Tablets and smart phones, which can be used as controllers and cockpits via a WiFi connection.

These features are becoming common on all drones except for low-end products in the toy category. Since almost everything on the above list relates to electronics and computers, we can look forward to a constant stream of improvements.

No pun intended, but it is probably safe to say that the sky is the limit when it comes to the evolution of drones.

Figure 1 — The *Phantom* in flight at K3LR. Photo Credit: [Joe Vaccaro, W3JTV, photo]

Enter the *Phantom*

The first quadcopter that was a game changer is the DJI *Phantom* (**www.dji.com**). It was introduced at the start of 2013, cost less than $1000, and was RTF (ready to fly) out of the box. It is still on the market with a street price of around $450.

The *Phantom 1* is simply a remote-controlled flying machine. It does not include a camera and has no telemetry or FPV (first-person view) coming down to the ground. FPV means that a camera on the vehicle is transmitting video to the ground, so that whoever is piloting the aircraft while watching a screen can fly the vehicle as if on board. The FPV feature is essential for taking pictures or video, since it allows you to accurately frame the image target.

If your goal is simply to *fly* a quadcopter, and you have no desire to take pictures or video, the *Phantom 1* is still an excellent choice. What makes the *Phantom* a game changer is its onboard flight-control system. The computer and sensors automatically maintain a stable position and orientation. If you let go of the two joysticks on the transmitter the quadcopter simply stops and hovers in place.

The advanced computer control on the quadcopter means that the human pilot needs far less skill to fly one successfully, and the odds of crashes and problems are substantially reduced. It is still fun to fly, however, and the computer assistance can be shut off, if you prefer to fly manually.

Although the *Phantom 1* does not include a camera, it does come with a GoPro camera mount. Many folks, including me, purchased a GoPro along with a *Phantom*, since that's what we really wanted to do — fly a camera.

The two missing pieces in a *Phantom 1* system are the FPV and gimbal. Third-party solutions exist for both. As I was getting ready to pick up a gimbal in early 2014, word of the upcoming *Phantom 2* line leaked out. If you add up the cost of a *Phantom 1*, GoPro, gimbal, and FPV system, you end up around the cost of the *Phantom 2 Vision+* (around $1300). The *Vision+* included a number of additional features, so it was an easy decision simply to go with it.

A feature of the *Vision+* is its use of a smartphone or tablet as part of the control system. This is not included as part of the package, but most drone enthusiasts already have a smartphone or tablet. I use a 7 inch Android tablet that I picked up for $100.

To fly the *Phantom 2 Vision+* you use a two-joystick controller that includes a plastic clamp mount for a smartphone. The screen on the phone or tablet shows the FPV from the camera as well as telemetry data, such as altitude and battery levels. The camera is completely controlled from the touch screen of the phone or tablet. This includes tilting the camera up and down as well as taking pictures and

starting/stopping video recording.

Flying time on a fully charged *Phantom 1* battery is around 8 to 10 minutes. The *Phantom 2* has a larger battery and boasts flight time claims of up to 25 minutes. I've measured 18 minute flight times on the *Phantom 2*.

If your goal is to take professional-looking video, then a gimbal is a necessity. Between the vibration of the motors, corrections for the wind, and normal motion, the quadcopter is always doing a little dance in the sky. The gyroscopically stabilized gimbal removes all of the jittery movements and makes it appear as if your camera is sitting on a tripod.

There are many features intended to reduce the odds of an accident. If you refuse to land when the battery charge gets low, the quadcopter will land itself. If the radio link to the transmitter is lost, the quadcopter will automatically return to its home point, which defaults to the take-off point.

Even with all of the safeguards designed into the system, accidents and malfunctions are still possible. When you leave home with the quadcopter in the morning there is no guarantee that it will be coming home with you at night.

A feature of the *Vision 2+* is the ability to program a set of waypoints using Google maps on the smartphone or tablet, and then have the quadcopter automatically fly that route with programmable speed and altitude between points. It can take off, fly around, shoot video, and land, all without human intervention.

FAA, Not FCC

Hams in the US know all about the FCC. When it comes to drones, the pertinent government agency is the Federal Aviation Administration (FAA). Rules and regulations for drones are in a state of flux, confusion, and litigation right now. What is often repeated is that drones qualify under the "recreational exemption." This means that you cannot make money off your drone, should not fly above 400 feet, and should avoid being within 3 miles of an airport. Depending upon your location, other rules might apply. I think we can expect more rules and regulations, especially if there are serious accidents that attract national attention.

A privacy law in Texas can be interpreted to mean that you need to get the approval of anyone appearing in your video. If you are shooting video from a quadcopter, and it includes the images of many strangers, it may be practically impossible to obtain the necessary permissions. The UK already has in place pilot licensing requirements, with required training for those looking to use drones commercially.

My own rules are common sense, consideration, and respect for privacy. A drone such as the DJI *Phantom* can weigh around 2 pounds. We should always be thinking about what damage could be done if our drone fell out of the sky and crashed into people or property.

One guideline I consider is whether or not my picture or video includes more detail than can be obtained from pictures or maps on websites. If I'm not showing more detail, then I would like to think it's hard to complain about what I'm doing. If you are planning to post drone video on YouTube, consider for a moment who might be angry or upset if they found out about it. Will pictures or images embarrass somebody or force them to explain endlessly?

Amateur Radio Applications

Most hams are justifiably proud of their antenna farms, and a dramatic bird's eye view flyby provides a lot of enjoyment and satisfaction. Aerial still pictures of the station and antennas would make a great QSL card background or images on a station website. Videos can be shared by uploaded to sites like YouTube.

I've had the opportunity to take videos at my own station as well as at several others with much more extensive antenna farms, including N8TR, K8AZ, and K3LR. I have posted five videos taken at K3LR on YouTube (search YouTube site for our call signs, W8WWV and K3LR). That should take you to four flyby videos and one antenna project video.

The flyby videos show the importance of a gimbal, if you want smooth video. The first two were taken in 2013 and early in 2014 with a GoPro camera mounted on a DJI *Phantom 1* without a gimbal. The last two were taken later in 2014 with the *Phantom 2 Vision+* that includes a gimbal. The improvement in quality due to the gimbal is obvious and significant.

Events such as ARRL Field Day are perfect for drone pictures and videos. I've already been invited to film a Field Day operation in 2015. The aerial videos and pictures will be combined with the ground clips to create a video for club members and, no doubt, for YouTube.

Additional Amateur Radio applications go beyond pretty pictures. Here are several possibilities.

Tower Inspection

A drone can be used to inspect a tower and antennas on a tower. Nothing beats a hands-on inspection by a skilled climber, but that option is not always available. Most hams I know have looked at their tower from time to time with binoculars to answer some question. A drone can supply the same information but with more detail and from all angles around and above the tower and antennas.

Vertical Antenna Wire Support

Kites and balloons have been used to hoist wire antennas, so why not a drone? I've never tried a kite, but I have worked with balloons, and unless the wind is dead calm, the wire will tip at an angle far from vertical. A drone with suitable lifting power for the wire gauge and length should be able to keep the radiator vertical, even with the wind blowing. The only drawback might be the need to come down and swap in a fully charged battery every 20 minutes or so, depending upon the drone.

This would be impractical for something like an entire contest, but if you are looking for a sunrise or sunset opening on 160 meters and would like to have a full-size quarter-wave vertical antenna, 20 minutes might be enough. This is a technique that a DXpedition could use to get tall verticals in very remote locations.

Getting a Pilot Line Over a Tree

The half-wavelength dipole supported by ropes in trees is a popular antenna. Getting the support line over the tree is often the hardest part of the job. Around here, Pete, N8TR, is the go-to guy, using

Figure 2 — The equipment.

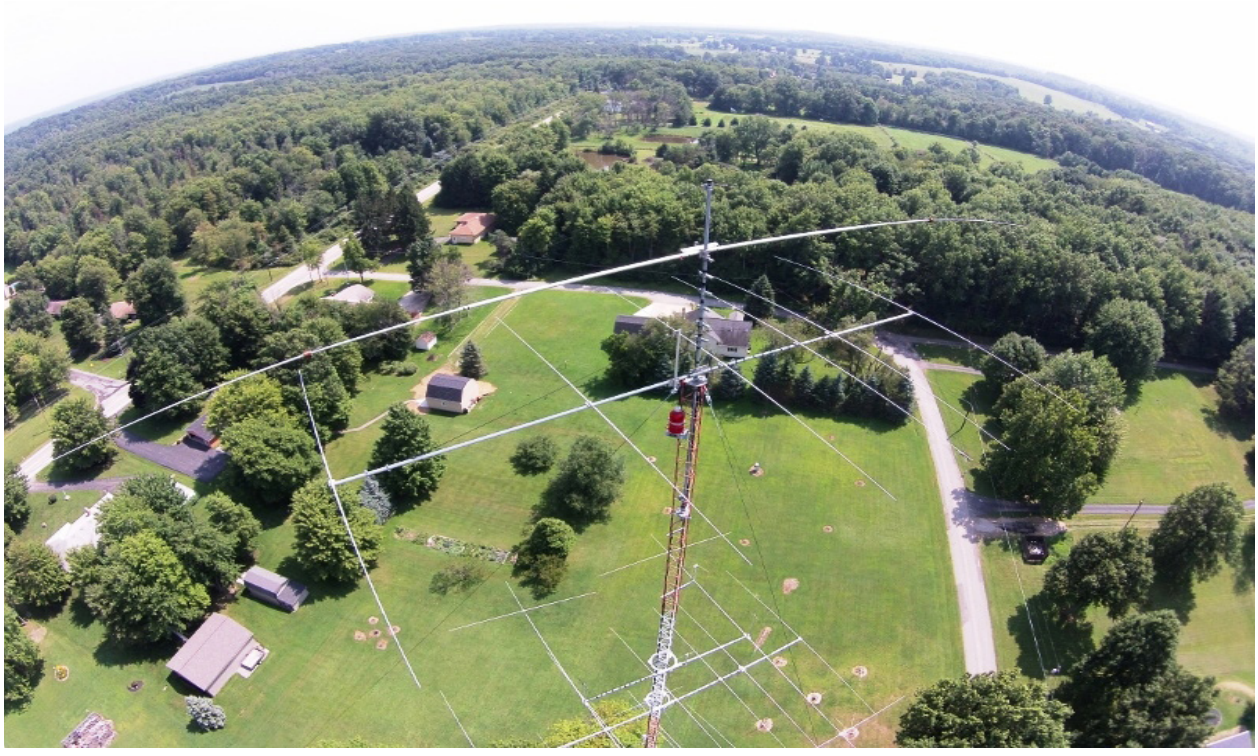

Figure 3 — Looking down K3LR's 240 foot tower.

his trusty bow and arrow to loft a pilot line through or over a tree.

Whether a bow and arrow or slingshot or tennis ball, many schemes have been used to get lines over trees. With some care and planning, a drone could be a good substitute. The epic failure would be to have the pilot line snag in the tree, ending up with the drone hanging out of reach. Without spending too much time thinking about this challenge, my thought would be to fly the drone to at least twice the height of the tree before engaging the tree. The drone would be *draping* the line over the tree, not trying to pull the line through the tree. Pulling the line through the tree, even a small fishing line, would have friction that would increase the effective weight of the load, potentially overloading the drone.

If I had to put a line over a 100 foot tall tree, I would fly straight up next to the tree to more than 200 feet with the pilot line, and then move above the tree. This would also be a case where it would be necessary to use propeller guards, so that the line cannot contact them on the way down.

Antenna Tower Site and Height Evaluation

An important factor in the location and height of many towers is how visible it will be from other locations, including from the house of a neighbor who does not appreciate the beauty of a tower.

A drone with appropriate telemetry can be placed at the proposed tower site and go up and down to various heights, taking pictures of what it can see. I have a 60 foot tower located with enough surrounding trees that it is not visible from the street or any neighbor's house. When I put it up almost 20 years ago, it *was* visible. In fact, on the day I cranked it up for the very first time I wondered when somebody would see it. It didn't take long. As I was putting it up for the first time I heard my neighbors 500 feet away say, "What the h*ll is that?"

Since then the trees have grown around the tower site. I've wondered how much higher I could make the tower and keep it invisible. To answer that question I simply flew the quadcopter right over the tower, and then used the altimeter telemetry to put it at 80 feet and 100 feet off the ground. At those two heights I made slow 360° rotations while recording the video.

After watching the videos several times, I concluded that I could raise the tower to 80 feet, and it would stay invisible. At 100 feet, it would come into view down a side street and at one neighbor's house. I don't know how else I could collect that sort of information unless I used something like a bucket truck.

Antenna Pattern Measurements

I enjoy experimenting with antennas. Part of that activity for me is taking measurements to verify the performance as predicted by antenna models or other specifications. One important characteristic of an antenna is its pattern. We want to know first, whether the antenna is correctly constructed and adjusted to produce the desired pattern, and second, whether nearby objects are distorting the pattern. For example, is the omnidirectional pattern of a vertical antenna disturbed by a nearby tower loaded with Yagis?

Imagine hanging a small transmitter with a short wire antenna from a quadcopter and flying it in a precise circular course around the test antenna. The distance and height are both variables. The distance can be selected to move out of the near field, and the height can be selected to achieve different take-off angles.

The test antenna on the ground drives a receiver or detector with a signal level output that is fed to a computer. Software on the computer combines the transmitter location data from the quadcopter's telemetry with the signal-level data and creates a pattern slice very similar to what is produced by modeling programs.

If the antenna rotates, then it would be possible to set the quadcopter at a fixed position and rotate the antenna. If the antenna is fixed — say, an 80 meter 4 square, then the quadcopter could fly around it.

This technique is really nothing new and has been in used in the past with helicopters. Due to the cost, this approach has only been available to those with deep pockets, such as the military. Soon, it will be available to everybody.