The Author Trying to Take Off in Various Ways

About the Author

By any method necessary, Craig has been attempting to leave the confines of Mother Earth since childhood. In his adult life, he first tried CB Radio with pirate channels, then Ham Radio and vast antenna arrays on his rooftop. Finally he found the promised land of Compuserve (1986), AOL (1988) and the Internet (1994).

Along the way, he developed and sold various alternative energy products, wrote technical manuals, obtained two patents and, along with his spouse of 40+ years, had three children. Craig founded the popular alternative energy web site Hearth.com and a newer hobby site, Droneflyers.com, which is the impetus for this ebook. He won't be happy until drones do some actual work for him and the rest of us.

What others are saying about this book (from Amazon Reviews)

"As a neophyte this helped me understand how to get started without being confusing. I felt that I have a friend to walk me through learning this new hobby/ profession."

"Thanks for taking the time and putting this together. Very informative. Clear and concise advice and instruction. Easy for beginners to grasp and understand"

"I was impressed. His explanations were well written, Plain and simple.
You'll like it"

"Good book, informative, well written, and very helpful for the newbie. What more can I say. A must for those new to flying RC Quads."

Subjects Covered in this Guide

Introduction

What's it all about? - Why would YOU want to fly a Drone? - Use of Terms and Basic Definitions

Basics of Operation

It's Electric! - Aerodynamics of Quadcopters - A Short History of Unmanned Flight

Buying a Quadcopter

Choose your Interest - Micros v. Minis v. Full Size - Starting with Simulators - What is this Hobby going to cost? - Which exact model to buy first? - About Returns and Refunds - Your Flying Grounds - Brand Names and Models - 3-Axis vs. 6-Axis Stability - Spare Parts

Flying a Quadcopter

Preparing to Fly - Becoming Familiar with your Transmitter - Booting up your Drone - Testing your Quadcopter - tech info for pilots and nerds - The Next Steps - Landing your Drone - first modifications - Trimming your Quadcopter - Flying Patterns - Do you have the "Right Stuff"? - More Tips for Beginners -

More Information

DIY Drone Repair and Upkeep - Tools of the Trade - A Primer on Aerial Photography and Video - Programmable R/C Transmitters

Your Next Drone

Choices - Larger Quads are more modular - Telemetry - DJI Phantom - Aerial Photography and FPV - Flight Controllers - A Short Course on Drone Batteries

Appendix

Safety Warnings - Drone Troubleshooting - Glossary - Models to consider for 2016 - Links - List of Manufacturers

BONUS - The Drone Report 2016

Introduction

The last couple of years have brought an explosion in news reports regarding drones and other unmanned aerial vehicles. Although some of these reports focus on the military models (Predator, Skyhawk, etc.), the bigger news is the progress in smaller drones which can do a number of tasks - from photography and video to crop inspection to search and rescue. This Beginners' Guide focuses on consumer and hobby drones - those which you and I can buy and fly on a budget. Even those with higher aspirations need to start with the basics. This book provides a foundation for your drone education and much more.

What's it all about?

They go by many names - Quadcopters, Quadrotors, Personal Drones, Multirotors, UAV's and even "toys", but these amazing flying machines contain advanced technology and are about to transform our world and our lives in many ways. What's more, you and I and others who are hobbyists, photographers, pilots or just have interest in technology can participate in this revolution at a very reasonable cost.

Where are we now and where are we headed?

2013-2016 were years of explosive growth in the drone market and related technology, as costs have gone down and capabilities have gone up. In 2017 this is continuing with lower prices and more reliable flight systems. These advances were driven by lower prices for the important electronic components, which were in turn driven by the rise of hundreds of millions of smartphones and game machines. The same electronic components which power our phones and game consoles (accelerometers, gyroscopes, GPS) help keep a drone flying. Cameras are also getting smaller and less costly, again driven by the market for millions of them inside smartphones, tablets and computers.

Why fly a Drone?

Drones may have advanced greatly over the last couple of years - but what's in it for you? Here are just a few of the reasons you may want to take up this pursuit:

Aerial Photography and video

*H*ow would you like a picture of your house, the local valley and farms, the beach or your park from high above? Your drone allows you take pictures and videos as in the photograph below.

Another popular type of video is called FPV or First Person View. In this case, the drone has a camera which beams video back to a set of video goggles or a screen. This allow the operator to feel the sensation of flying and twisting through trees, down a path or over a stream.

Racing, Flips and Acrobatic Moves

Some pilots have the competitive spirit and like to push things to the limit. You can learn a number of fancy moves to impress yourself and your friends! Others enjoy the social aspect of hobbies. There are even events where you can fly your quadcopter in races, demonstrations or just for camaraderie.

Technical Aspects, Modification and Building

Do you enjoy technology, engineering, futuristic pursuits, inventing and expanding your general knowledge? This hobby will allow you to satisfy any level of these interests. Beginners might feel a sense of accomplishment by replacing a few small parts while others build their own quadcopters using custom parts - many of which they make or modify themselves. Others write and modify programs which improve the stability and other aspects of flight control. If you are part of the new “Maker” movement, you’ll find many ways to improve the basic drones which you purchase or build.

Fun and Stress Relief

You will often find yourself laughing out loud as well as forgetting about all the troubles of the world as you build, fly or fix your personal drone.

Future Commercial and Non-Profit Uses

There are numerous other applications for drone technology. Some examples:
Building and roof inspection
Search and rescue and Public Safety
Mapping and crop inspection and spraying
Other uses are only limited by your imagination and the continued evolution of drone hardware and software. As with any such venture you need to start with a basic foundation of knowledge.

Blade 350QX Quadcopter - note the 4 propellers

When you are finished reading it, you should know more about the subject of drones than most of your peers and therefore be able to help others. Putting that knowledge to work, you will be able to buy and fly hobby and consumer level drones successfully.

Use of Terms and Basic Definitions

Throughout this book, we will use the term *drone*, *quad* and *quadcopter* interchangeably, drone being the common use of the news media while quadcopter is more descriptive of the current crop of consumer models. Not all drones are quadcopters (4 propeller) Some have 6 or 8 props or are winged. A more accurate name might be UAVs, which stands for “unmanned aerial vehicles”. Some use the term *robotic* or *autonomous* in their descriptions, indicating the drone may have more advanced capabilities, such as flying a pre-programmed flight path without operator input or control.

Since this is a Newbies Guide, we will start with only a few definitions - a more complete glossary is at the end of the book.

Drone - a catch-all term used to describe any or all unmanned aerial vehicles.

*Quadcopter (quad)***-** an aerial vehicle which uses four (4) propellers that provide all the lift and steering functions. Similar names are assigned to designs with 3-10 arms and propellers (tricopter, hexacopter, octocopter, multirotor, etc.)

Autonomous - not subject to control from outside, often used to describe a drone which follows a preset path using GPS or other means, as opposed to being actively steered by radio control.

For ease of description, most of our pictures and examples will use *quadcopter* or *quad* as the subject.

Basics of Operation

It's Electric!

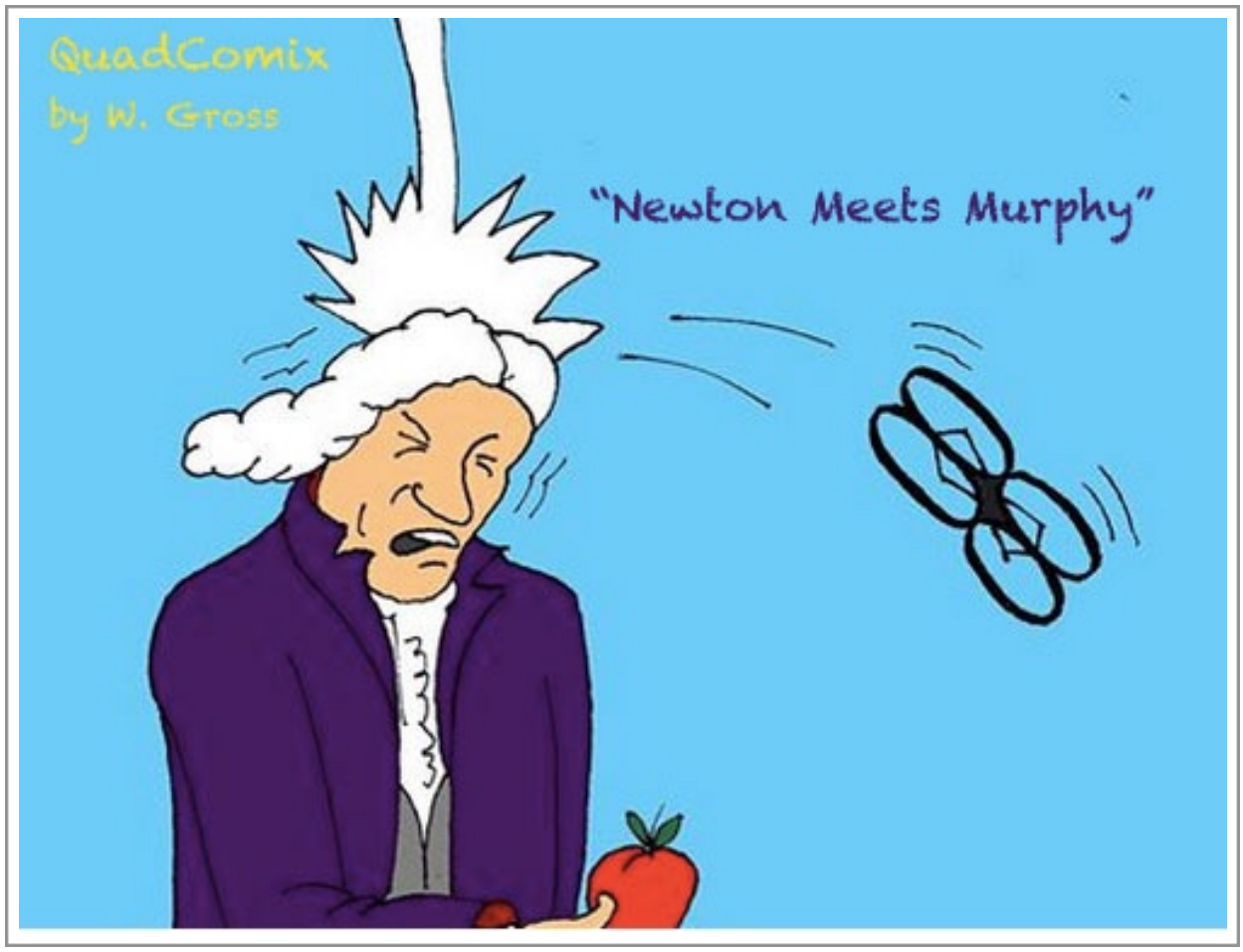
Why are the new vehicles so different from toy helicopters and planes? In a nutshell, it comes down to vast improvements in batteries, motors and in flight control hardware and software. The new breed of LiPo batteries (lithium polymer) have a higher power to weight ratio, meaning they can power heavier devices and keep them in the air longer. The same batteries also power the electronics and cameras your quadcopter will use.

The current crop of batteries are capable of keeping quadcopters aloft for periods from 5 to 25 minutes, quite an accomplishment when you consider some of these machines can travel miles in that time. More advances are assured in the future, so specifications will continue to improve.

A quadcopter uses four propellers, two of them rotating clockwise and two counterclockwise. This creates a balanced effect, so that the quadcopter can hover with reasonable stability. The following diagrams and descriptions will help the newbie understand how the brains and brawn of these machines work in tandem to provide the magic of unmanned flight.

Aerodynamics of Quadcopters

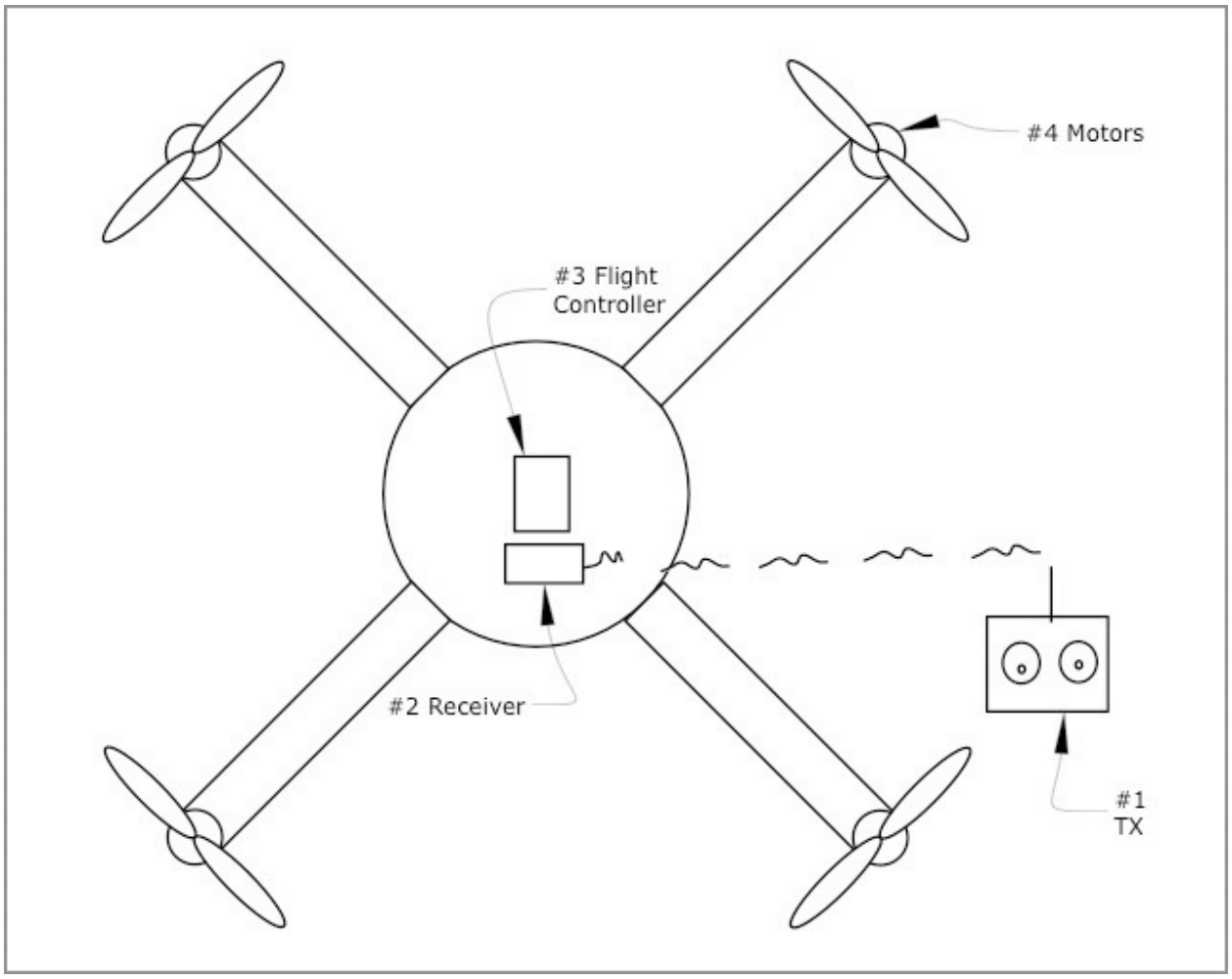
Truth is they have no real aerodynamics! These are basically motors and propellers that can only fly with the help of their computer brains. Unlike a plane or even a regular helicopter, failure of an engine or part will invoke gravity without any glide ratio at all. Hobbyists have therefore been able to build quadcopters out of tupperware boxes (for landing in water), foam boards ($5 in frame costs), plastic wheels and other such materials.
It does help for quadcopters to be streamlined as wind will not have as much of an effect on them.



Like a Human (or robot)

It may help to consider the quadcopter as a robot, with the basic internal functions attempting to mimic those of your own body. The first steps in movement are your eyes, ears and other senses gathering input or instructions from the environment around you. With a quadcopter, this would be the instructions being given to the drone by the pilot or by a set of pre-programmed steps “listening” to many sensors in the drones flight control system (onboard computers). In most cases the operator will be actively giving instructions to the flying quadcopter through the use of a radio control transmitter or a smartphone/ tablet. You will notice that many discussions of quadcopters use the term “R/C” in them - which means “Radio Controlled”.

Item #1 below is the transmitter (TX - sometimes called a Remote), usually handheld, which is beaming the instructions to the drone. The part labeled #2 is the receiver - this is also a radio part and its function is to talk to your transmitter and hand over the instructions to item #3, the Flight Controller, which sends power to #4, the motors.



The flight controller (F/C) is the CPU (central processing unit) or brain of the quadcopter. Like a human brain, it has pathways for information both in and out. Here are the main inputs:

1. Power from the batteries
2. Instructions from your transmitter (usually in your hands).
3. Status reports from a number of tiny instruments (sensors) built into the quadcopter main circuit board. These may include gyroscopes for leveling, accelerometers to measure speed and direction, barometers and sonar for

height control and GPS and compasses for determining your position on the earth. Simple quadcopters may only have gyroscopes, while very advanced models will have many or all of the above. Some recently released camera drones have added “Computer Vision” - the ability for the drone to see and recognize (and avoid or follow) objects!

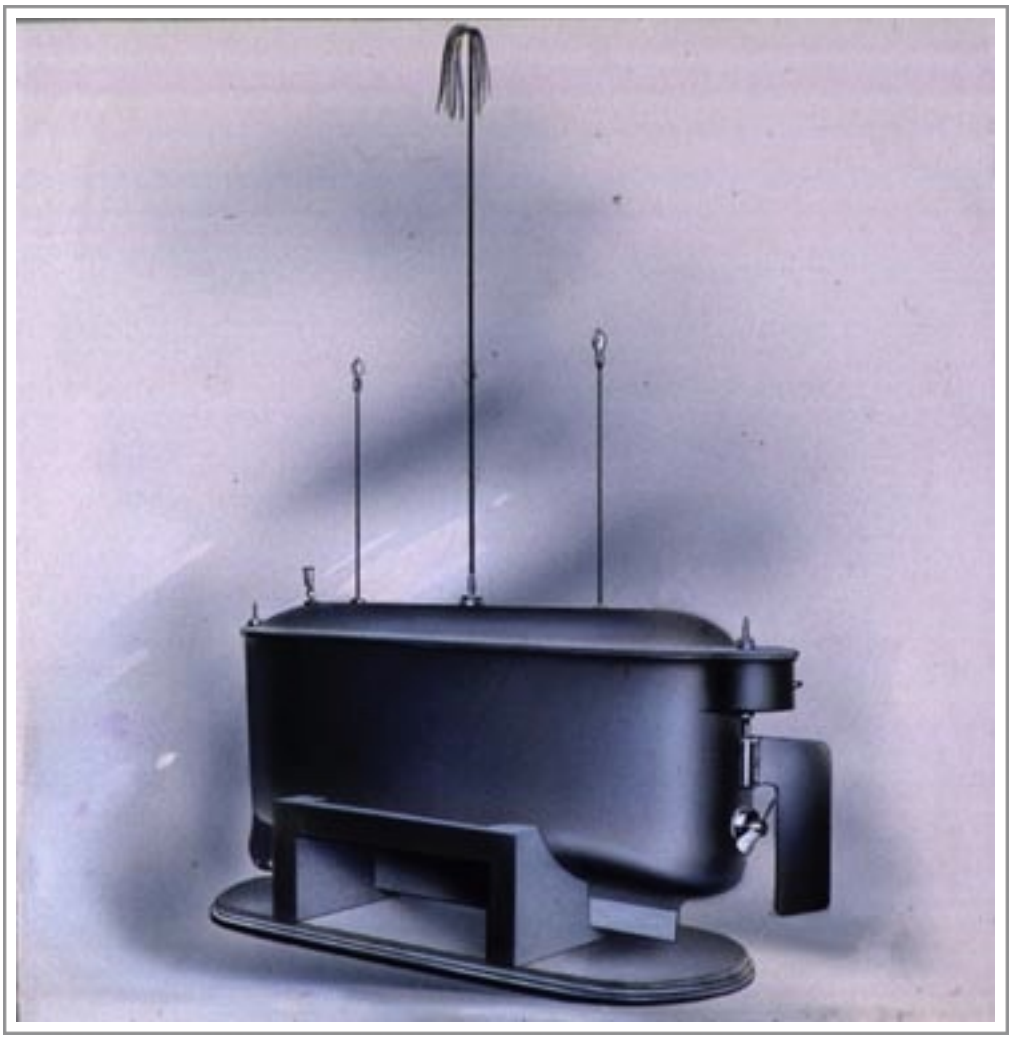
Based on the combination of all these inputs, the Flight Controller (FC) makes decisions, most importantly exactly how much electrical power to apply to each of the four motors (#4 in the picture).

As an example, if you desire to fly forward, that requires the quadcopter to tilt in that direction - you should be familiar with this type of flight by having watched helicopters. By tiling forward, the propellers act to keep the vehicle in the air and to propel it forward simultaneously. In the case of a quadcopter, the command to move forward will put less power to the front two motors and more to the rear two, resulting in the machine leaning forward and being propelled in that direction. Side to side movement is accomplished in much the same way - the FC “brain” eases up on two propellers and powers the opposite two slightly stronger.

The comparison with your body is that the flight controller is the brain, the wires are the blood vessels and nerves, and the motors are your muscles, limbs and hands. Like your body, each system constantly gives feedback to the brain, resulting in amazing capabilities of movement.

A Short History of Unmanned Hobbyist Flight

The first demo of a Radio Controlled vehicle was in 1898, when N. Tesla showed a working R/C boat at an electrical expo at Madison Square Garden. He claimed the boat had a “borrowed mind” and obtained U.S. patent number 613,809 for various R/C schemes.



Tesla’s R/C Robotic Boat

Some hobbyists may remember building balsa wood airplanes many years ago. In fact, they remain quite popular today. It often took months to build these planes and the final results were quite impressive, but extremely fragile. Many were never flown - the completed plane with paint and decals graced many a man cave. Others installed small gas engines to drive the propellers and ran the

planes in a circle, tethered to the ground with a rope. More daring hobbyists set up the planes so they would fly circles and land when they ran out of gas. Suffice it to say that one crash or bad landing often destroyed hundreds of hours of hard and meticulous work.

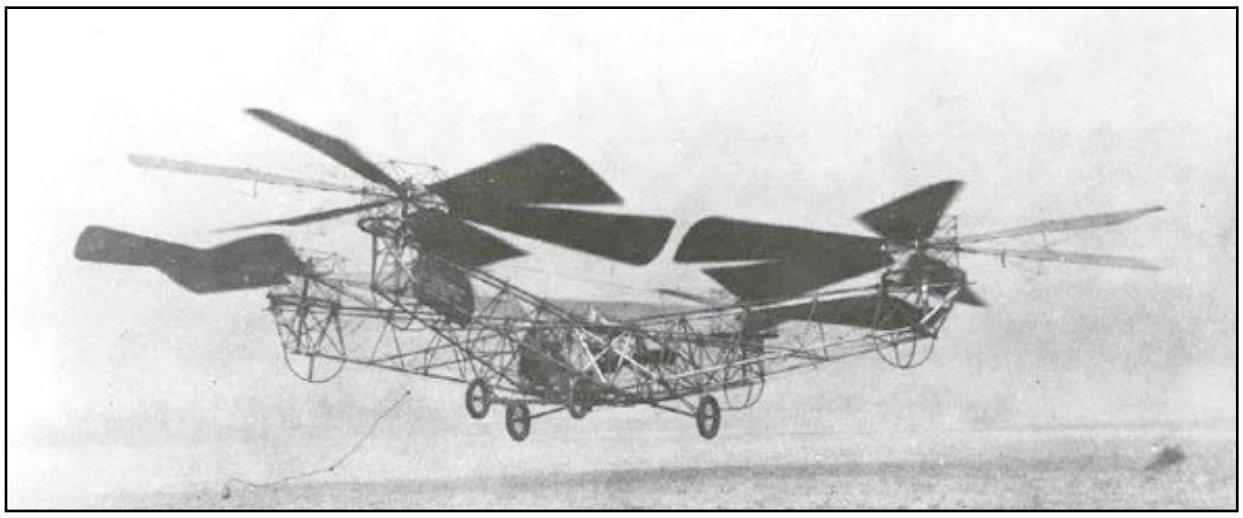
By the 1960's, radio controlled wing surfaces and rudders were allowing better control of the aircraft and the invention of the transistor meant that radio and other electronic components could be made much smaller and lighter. At the same time, another method of flight became quite popular - model rocketry. These were quite sophisticated and able to travel thousands of feet into the sky. Some of the models featured one-shot film cameras, which provided a great addition to the hobby. Others carried payloads, including small animals. In fact, your friendly author has sent mice up 1,000 feet or more in padded capsules, with all returning safely to earth by parachute. The *Space Craze* bought on by America's race to the moon, created a new generation of budding engineers and scientists.

As mentioned earlier, it is the coming together of all the various electronic and electric technologies, from batteries to radios to advanced sensors, which now allows for much more sophisticated vehicles. Just as importantly, improvements in materials such as foam, carbon fiber and fiberglass have allowed for aerial vehicles which last more than a few flights. Some quadcopters can drop out of the sky from 100 feet and suffer little or no damage!

Whereas early models required skill and determination to build, fix and operate, some current models can be purchased and enjoyed by almost anyone - with some caveats (more on that later).

The First Quadcopter

The de Bothezat helicopter, also known as the Jerome-de Bothezat Flying Octopus, was an experimental quadrotor helicopter built for the United States Army Air Service by George de Bothezat in the early 1920s, and was said at the time to be the first successful helicopter. Although its four massive six-bladed rotors allowed the craft to successfully fly, it suffered from complexity, control difficulties, and high pilot workload, and was reportedly only capable of forwards flight in a favorable wind. The Army canceled the program in 1924, and the aircraft was scrapped.



The de Bothezat Helicopter

Buying a Quadcopter

Start Small and Learn

Whatever your goal, most newbies should start at the same place - with the purchase of micro or mini sized quadcopter (and possibly a good simulator) and hours of initial practice.

The toy drones you will learn to fly on are largely disposable - they work great and are loads of fun to fly, but the motors and other parts tend to wear quickly. The prices have come down so low that I often suggest buying 2 of the same model - that way you have an extra battery, 4 replacement motors and other extra parts. In many cases this costs less than stocking up on spare parts.

First Newbie Rule of Drones

You WILL crash your quadcopter many times while you are learning and repairs/replacements for a small quad are much less expensive than with a larger model.

Nanos vs. Micros vs. Minis vs. Full Size

Although there is no official definition of these size ranges, a rough grouping would go somewhat like this:

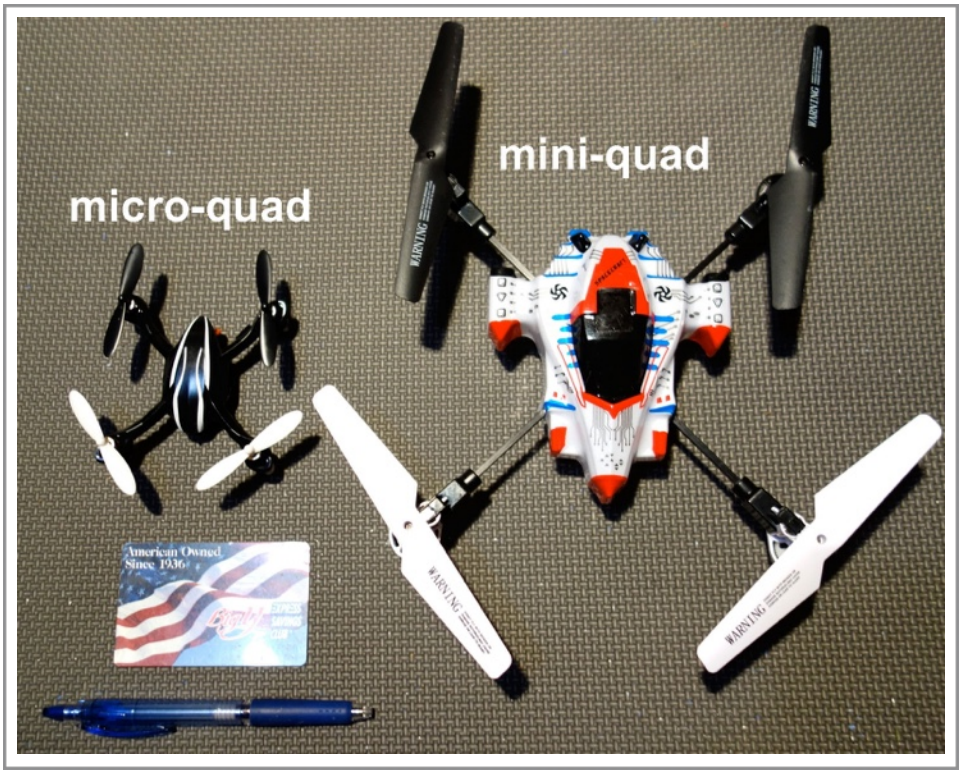
Nano drones/quadcopters - these are truly tiny - often not much bigger than a large coin (and much lighter in weight). Although a fun demonstration of technology, they are not suggested for beginners because of their poor flight characteristics. Examples include the Estes Proto X and WL Toys 272.

Micro drones/quadcopters - these fit into the palm of your hand and measure 3 to 4 inches diagonally motor to motor. Most of them are "direct drive", which means the motors directly spin the propellers (no gears). Total weight is approx. 1.5-2.5 ounces (40-60 grams) with battery.

Mini drones/quadcopters - these are quite a bit larger and measure 8-10" diagonally motor to motor. Many of them use the same motors as the Micros, but use gearing to drive larger propellers. Total weight is usually approx. 3 ounces (80+- grams) with battery.

Full Size Quadcopters - are classified by weight rather than size, as the bigger motors and batteries and payloads are the most important parts of the system. Most larger quads are direct drive - that is, the brushless (higher quality) motors directly mount to the propellers. They weigh in at between 1 to 2.2 lb+ (1/2 to 1+ kg).

For newbies, either a **micro or a mini** will be a fine learning platform. Those who intend to learn indoors will probably be better off with the micro size.



Starting with Simulators

There are computer programs available which may help give you the feel of flying a quadcopter. These run the gamut from inexpensive smartphone or tablet apps to much more sophisticated PC and Mac software which can use a real R/C transmitter connected to your computer via USB. Some examples of the genre and their capabilities are as follows:

Heli-X (www.heli-x.net) - This is a program which has numerous models of quadcopters built into it. A program such as this can really help you to learn to fly - and, although somewhat costly ($70-$180), are definitely worth the money for the serious pilot who wants to crash less in the real world. Note - a free trial is available, so be sure it works and suits your style before you make a purchase.

AeroSIM RC (http://www.aerosimrc.com) - This is another full-fledged simulator program with many models and modes built in.

IndoorHeliSim (Google Play Store) a free android app that is quadcopter only. This app simple, but effective and had various settings so you can get the feel as a beginner or a more advanced flyer.

FPV Freerider (http://fpv-freerider.itch.io/fpv-freerider) for Mac, PC and Linux - free demo and only $4.99 for the program. This simulator is aimed at those who want to do FPV racing or acro (acrobatic) flight.

NeXt Flight Simulator (http://www.rc-aerobatics.eu/cgm-rc-heli-simulator_e.html) - This full featured sim has dozens of helicopters and also a few popular quadcopters such as the Phantom.

How much will this hobby cost?

This is somewhat variable depending on your wants, needs and budget. If you are happy with the smaller range of quadcopters, a year of fun can be had for the price of a couple fancy dinners out. On the other hand, if you are the proverbial fool who is easily parted with his/her money and buy a $1,500+ setup and instantly dunk it in the river while taking your first video (yes, it's done quite often), then it will set you back quite a bit more. Since this is a newbies book, let's set a starting budget of about $200 total for a couple small quads, extra batteries, accessories, modifications and repairs. If you decide to take a step up to much larger photo/video craft like a Phantom 3 the total will likely be triple that or more. A wider range would be from $200-$2,000 - depending on where you want to go with your 2nd or 3rd quadcopter.

Which model to buy first?

As in many other endeavors, not only is the brand and model of importance, but also the vendor (store, online site) you decide to purchase from. Some vendors are China or Hong Kong based and some offer very good prices and are reliable

and honest. However, a (USA-based) newbie should consider purchasing from a US based vendor (shipper) when possible for a number of reasons. First, communication with the foreign vendors can often be difficult - not so with your local hobby shop, Amazon (US shipped only) or the better US based sellers. Secondly, it can take weeks for shipments to arrive - no need to play the waiting game to save $5 or $10. Consider the return policy (defective product), parts availability and advice. Therefore, the author suggests one of the following vendors or types of vendors:

A local hobby shop - Unfortunately, many areas do not have shops that specializes in quadcopters - but, if you do, this may be the first place to look. Check to see if they have a friendly and knowledgeable staff and can answer your questions and concerns.

Online specialists or Big Retailers - there are a number of vendors who specialize in quadcopters. Some examples at the time of this writing:

Horizon Hobby - maker and distributor of the well regarded Blade products - known for good support after the sale.

Amazon and eBay also have nice selections - often sold through retailers who partner with them.

Banggood - a well known Chinese merchant, now had a USA Warehouse with quick shipping and low prices on toy quadcopters.

Quadcopters are popular all over the world. In fact, sales of this book are doing very well in the UK, France as well as elsewhere. Many people have no choice but to purchase from the Hong Kong and Chinese vendors - and there are some with very decent reputations. As of this writing, Banggood.com is one such vendor which seems to treat customers well. As always, look into the reputation of your chosen vendor. It will be easy to find discussions about the various suppliers on the online R/C forums.

About returns and refunds

It is rare for a new quadcopter to have factory defects - more likely, the customer takes it out the box, flies it into a couple walls and then claims it's broken. In other cases, the customer simply does not know how to calibrate or fly the drone. Many vendors do not accept returns of used quadcopters - as well they shouldn't - since most damage is often of the "you crashed it, you broke it" variety. However, for those cases where something is truly wrong out-of-the-box, the return policies of Amazon and other vendors (and even paypal payment) could come in handy. Using the Chinese vendors, very popular due to low pricing, usually means that you cannot return the product even if defective in the box. Depending on the vendor, you may be able to get a replacement part for no charge.

Higher end vendors such as Horizon Hobby (Blade Quadcopters) and Traxxas have better customer service, return and warranty policies. However, you will pay more for their machines. It's up to you, the consumer, as to which makes most sense to you.

Don't be a Pioneer when Purchasing!

It's best to avoid newly introduced models of quadcopters, even from established companies. Reliability is often poor and parts are not immediately available. Models which have been on the market for a year or longer usually have been improved to deal with initial quality control problems. Go with the tried and true for your initial, and perhaps even your later, drone models.

W**ait before you get a Camera Model**

Many of the toy quadcopters have upgraded models with photo and video capabilities. These will be tempting as many pilots foresee taking aerial shots. However, the best first quadcopter is a stripped-down model with no camera or extras. This will allow you to put your full concentration on flight and not think

about “getting the shot”. Beginners also have a tendency to crash and/or lose their first quadcopter(s) - so you will have the opportunity to buy a camera model soon enough!

Note: Some models, such as the Syma X5C, include a camera and are inexpensive enough for a first machine. Still, it’s better to ignore the camera until you get the basic idea of how to fly.

Your Flying Grounds

Before choosing a model and size, consider your living and yard spaces and where you intend to take your first flights. If you picked this book up mid-winter in Maine, chances are that you are going to try to learn indoors! The same goes if you live in a small apartment - a micro quad will make a smaller space seem a little bit bigger, so they can be ideal for those who are a bit tight on space. Some other considerations to keep in mind are:

1. Wind resistance - micros, since they provide a smaller wind profile, are usually better in a breeze.
2. Visibility - as you improve you may have interest in flying your quad a bit further away from your person - a micro will quickly become a very small dot once it is more than about 40 feet away! Minis can be flown up to 200 feet away with some success.

Most flyers will eventually have at least one of both sizes, so you really can’t go wrong with this decision.

Note - although learning indoors is possible, your family is unlikely to take to you crashing into the good furniture. An open basement or garage provides a better starting place - even better would be to have a practice room with carpet or soft flooring!

Brand Names and Models

The following units are examples of good first quads.

Hubsan X4 -H107 (Micro - $25-$50) - buy the optional prop guard if you are just getting started. This is an improved newer version of the

X4...the first version had some shortcomings.

Syma X11 - ($30) In-between a micro and mini size, this is becoming a new favorite of many for learning and messing around. It comes with propeller guards as standard. It uses gears to drive the props - so you will have to eventually replace both the gears and motors.

Syma X5C - ($50) - Mini-sized and perhaps the most popular starter quad in the middle size range. More expensive variations of this model have “FPV” where your smartphone mounts on the TX and can see what the quadcopter camera is pointing at. Most beginners would be better with the base model as this type of monitor can distract from actual flying.

Blade Nano QX (Micro - $80) - if you don’t mind spending the money, this is a high quality and capable learning machine.

Dromida Ominus (Mini - $70) - a decent machine - a newer and more advanced design.

JJRC 1000 - ($35) Great starter drone somewhat in-between the micro and the mini size.

These, of course, are not the only quadcopters which would fit a beginner, but they should give most fledgling pilots a good place to start. The appendix contains both a list of manufacturers and a list of some of the quadcopters to consider in 2015. You can also find up-to-date reviews at droneflyers.com

How about the DJI Phantom or other larger models?

DJI Phantom models are very popular "flying cameras" for video and photography. We have included a chapter later in this book about the Phantoms…and also have published two additional books on the Phantom line. Budding pilots with little or no R/C and flying experience should probably start with some "toy grade" models as outlined in the following pages. If you want to "start big" you could consider a used or refurbished Phantom 1 or "new old stock" Phantom 2 model (approx. $340), but be sure you do your learning in a large open area. A GPS stabilized quadcopter such as the Phantom will actually be much easier to fly than many of the toy machines, but you will not learn as much about manual flying.

A very careful and conservative newbie who takes the time to carefully study the manuals, videos, etc. could probably skip the toy models and start with a Phantom - but in my experience this type of pilot is rare.

Note: More information on DJI models can be found later in this publication.

Are the Parrot Bebop and AR Drone for beginners?

These are mid-sized drones which are controlled from a smartphone or tablet computer. Both machines advertise full feature sets - however they operate differently than most of the quadcopters on the market and have a very short flying range (stock). In general we do not suggest any of the Parrot models for beginners (nor for more advanced pilots). The same goes for other models based on smartphone-only control. For proper flying of drones you need to “learn the sticks” of a standard R/C controller.

FAA Registration - Not needed for Toys (under 250 grams)

As of December, 2015 the FAA has requested that all drone pilots register and get a “tail number” which must be displayed on your equipment. This pertains only to larger and heavier quads - those over 250 grams. Registration is only $5 and can be done online at https://www.faa.gov/uas/registration/. Most beginner quadcopters are less than the 250 gram limit so no need to register yet!

About 3-4 Axis and 6 Axis Stability

Another consideration when choosing a first quadcopter is whether you want to learn in a more manual fashion or have help in the form of features which make flying and control easier. Although these terms sound technical, the summary is that 6-axis quadcopters will self-level when the operator takes their fingers off the right control stick. 3-4 axis models will continue in the direction they were going - even if that direction is a steep angle toward the ground. In general, a 6 axis quad will be easier to fly, but that may not be what you desire. As an example, if your interest in this hobby involves flying acrobatically, doing flips or racing pylons then you will need a lot of manual skills. The 3 or 4 Axis quad will force you to learn more about all the forces in motion. If you really want to learn some of the ropes, consider the 3-4 axis a better tool for the job - or, get one of each! One will build your confidence and the other will build your skill set. At the time of this writing, these are some popular starter quads and their number of axis:

3 or 4 Axis - Syma X1, WL Toys 929, HCW 553

6 Axis - Blade Nano QX (has a 4-axis mode also), Walkera QR Ladybird, WL Toys V202/212/222, Vitality H36, MJX X100, Hubsan X4 H107, JXD 388, Syma X5, X11

(Before buying, please confirm the above information with other users and the vendor.)

Certain models, such as many in the Blade line, have two or more modes - some which are 6-axis as well as a more manual mode which mimics 3 or 4-Axis.

Whether 3,4 or 6 axis, start with a model which you know is a good one for beginners. Use online reviews at Amazon or the advice of a good vendor for your final selection. Or, join our forums at droneflyers.com/talk and ask away!

Note - in 2016 , 3 and 4-Axis quadcopters are becoming less popular, since they are harder to fly. Most all larger quadcopters (Phantom, Blade, etc.) are 6 Axis and so the manual flight skills are not as important. However, those who want to be ahead of the pack in terms of piloting skills can still learn a lot from 3 and 4-Axis quads. Those looking to enter the racing and acrobatic parts of this hobby should definitely learn in this fashion. The knowledge gained will likely help you save your more expensive machine sometime in the future!

Spare Parts

It's best to buy a small supply of replacement parts along with your quadcopter . This will help you avoid disappointment when your propellers crack or your sole battery runs out! If possible, ask your supplier what parts they would suggest for a beginner. Examples include:

1. Purchase at least one or two additional batteries. Each battery will provide up to 10 minutes of flight time, but could take up to one hour to recharge.

2. Propellers - many of the kits come with a set of extra props - but some of the micros can go through them fairly quickly. You may want to order another couple sets.

3. Motors - it is likely that you will destroy a motor or two in the first few weeks of use. It does take good eyesight and some basic mechanical ability (some require solder, others plugs) to replace a motor on these quads. If you have what it takes, then order one of each (clockwise and CCW) motors or complete motor/arm assemblies.

Some models have motors which plug into the flight controller as opposed to being soldered on. These may be a good option for those who don't want to learn how to solder.

If you find that parts are not easily available, it may be good to change to a model where the vendors have plenty of spares. You don't want the lack of a $4 part to keep you grounded. Some quadcopters are so inexpensive that you can buy two - one to fly and one for spares, and still spend only $50 or so in total.

Quadcopters differ in how easy they are to repair (see section "DIY Drone Repair and Upkeep" later in this book). Many require basic soldering skills as well as nimble fingers and good eyesight to make a repair. Others may have plug-in motors and other components which are more modular and easier to replace.

Flying a Quadcopter

Preparing to Fly

It's an exciting day!
Your new quadcopter is unpacked and sitting on the table in front of you. The first order of business is going to be to charge up the batteries. Most of the low cost drones come with a USB cable that connects to the battery and provides the charge. Some come with a plug-in AC charger. Either way, get your batteries charged up ASAP so you can get your quad up and running. Note - do not charge the batteries up more than 3 days before you plan to fly as they lose some charge over time. Batteries which are not going to be used soon are best left in a less than fully charged state.
Your transmitter needs a couple batteries also - AA or AAA. Make sure you have these on hand.
While your batteries are charging, scan your owners manual as well as any online reviews of your quad model. Some of the manuals are quite poor in their translation from Chinese to English, so don't expect to understand every word. If you find a decent online review (such as on our droneflyers.com site), it will likely instruct you how to get started with your new toy.

Note: LiPo batteries should be charged on a fireproof surface - it is remotely possible for them to self ignite! Keep them away from loose papers and other combustibles and charge inside an ash tray, small bowl or similar container. PLEASE READ OUR SAFETY APPENDIX BEFORE CHARGING OR FLYING YOUR QUADCOPTER.

Becoming Familiar with your Transmitter

Most quads are sold with a transmitter (also called TX or Remote) which is set up as "mode 2". This means that the throttle is on the left while the right stick

controls the pitch and roll (forward/backward and left/right) of the drone. A typical TX panel is shown below:

The left stick controls the speed of the propellers and therefore is set all the way back (down) before flying. The right stick should be centered for testing and most liftoffs. The small silver switches, two under the sticks and two toward the center, are for *trimming* the quadcopter so it hovers without drifting off to one direction or another.

Booting up your Drone

Caution - the spinning propellers on ALL quadcopters could cut or injure humans or pets! We'll discuss safety in more detail as we go along, but please take basic common sense precautions when using your new quadcopter and charging your LiPo batteries. Most importantly, avoid any situation where people or pets could come into contact with an operating quadcopter.

Read your owners manual for full instructions on your particular models - here are the usual steps involved in booting a mini or micro drone.

1. Have transmitter ready and powered with the specified batteries (usually AA or AAA). Make certain that the throttle (left stick) is off (down fully toward you).
2. Insert quadcopter LiPo battery into quadcopter frame as shown in manual.
3. Connect battery leads - note, some batteries auto-connect when you insert them.
4. Immediately set the quad down on a **flat and level surface**. This step is especially important as **many quads use their initial position as a reference for how straight and level they will fly**. (certain newer models may not require this flat surface)
5. Turn on the transmitter - most will go through a series of beeps and then stop beeping. This indicates the transmitter is “bound” to your quadcopter. I*t is often necessary to move your throttle stick forward and backward once to arm (unlock) your quadcopter.* A beep often indicates that the quad is armed and ready to fly. Certain models require other actions to arm them - this will be detailed in the owner’s manual.

Your quadcopter is ready to fly - are you? Probably not, so let’s go through a series of short checks so we don’t run into many surprises.

NOTE: Some models use the opposite method of turning on - that is, you turn on the TX first and then install the battery and/or turn on the switch on your quadcopter. Check your manual for details on your model. Also, some newer models self-calibrate so do not need to be set on a level surface.

Testing your Quadcopter

The first-time pilot should continue slowly so that their craft (or the family cat) is not damaged too quickly. One testing technique involves weighting the quad down so it does not fly and then slowly checking all the transmitter functions. Here are a series of steps to do so:

1. Place a small weight, such as a wrench, etc. so that it holds your quad down (near the center) without being near the spinning propellers. Depending on the particular model, you may have to use a small piece of string, wire or a rubber band to hold the weight to the center of the quad
2. STAND BEHIND THE QUADCOPTER FACING IN THE SAME DIRECTION AS ITS NOSE. Slowly apply power to the propellers by pushing the left stick (throttle) forward. The propellers should spin up and increase in speed as you push the throttle up. Do not push the stick all the way forward, just enough to start getting the feel of the controls.
3. Once you are comfortable with the spinning props, test the basic functions of the right stick on your transmitter. This stick is normally centered - pushing forward on it should make the drone lean (with the weight on) in the forward direction of flight, while pulling back should do the opposite. Pushing the right stick to the left should make the quad lean left, while pushing it to the right should make it lean right.

An alternative method of testing is to use a small length of string or thin rope to tether your quadcopter to the ground. You can then test takeoff and basic stability while being sure the machine will not fly away and crash.

If all is well, your quad and you are ready to attempt flight...after a short technical break.

For Pilots, Nerds and other know-it-alls

The various directions in which an aircraft can moves each have distinct names - as do the usual flight controls which make the vehicle take these actions. The testing phase above describes two axis of movement, those being forward and backwards and left and right. The following definitions will apply:

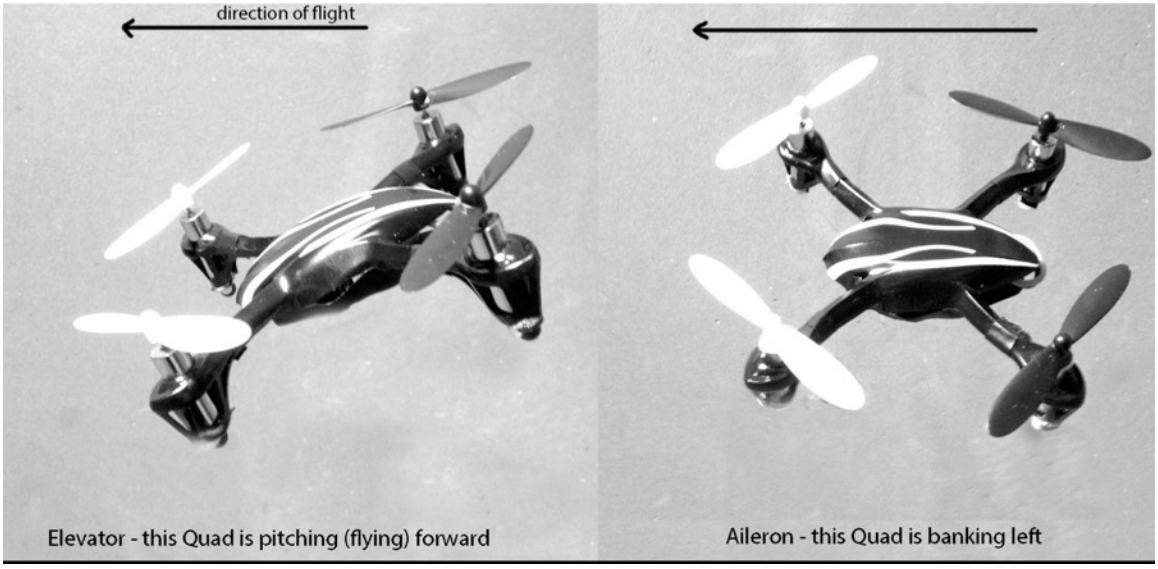
Pitch - this describes the angle of the quadcopter as relating to level, whether front to back or side to side.

Aileron - this is the flight control used to make the quadcopter lean left or right - the actual movement is called “roll” or “banking”.

Elevator - this is the flight control used to make the quad angle up or down when facing forward. Pitch is the term used to describe the effect of the elevator on the nose of the aerial vehicle.

Rudder - This describes the flight control which makes the quad rotate on its center axis - that is, stay level and spin on its center axis (as in dance pirouettes).

Since a quadcopter is computer controlled, there are no actual flaps as with a fixed wing aircraft. If your quadcopter were an airplane, the elevators would be the tail flaps and the ailerons the wing control surfaces. Instead, control is achieved by varying the exact amount of power to each of the rotors.



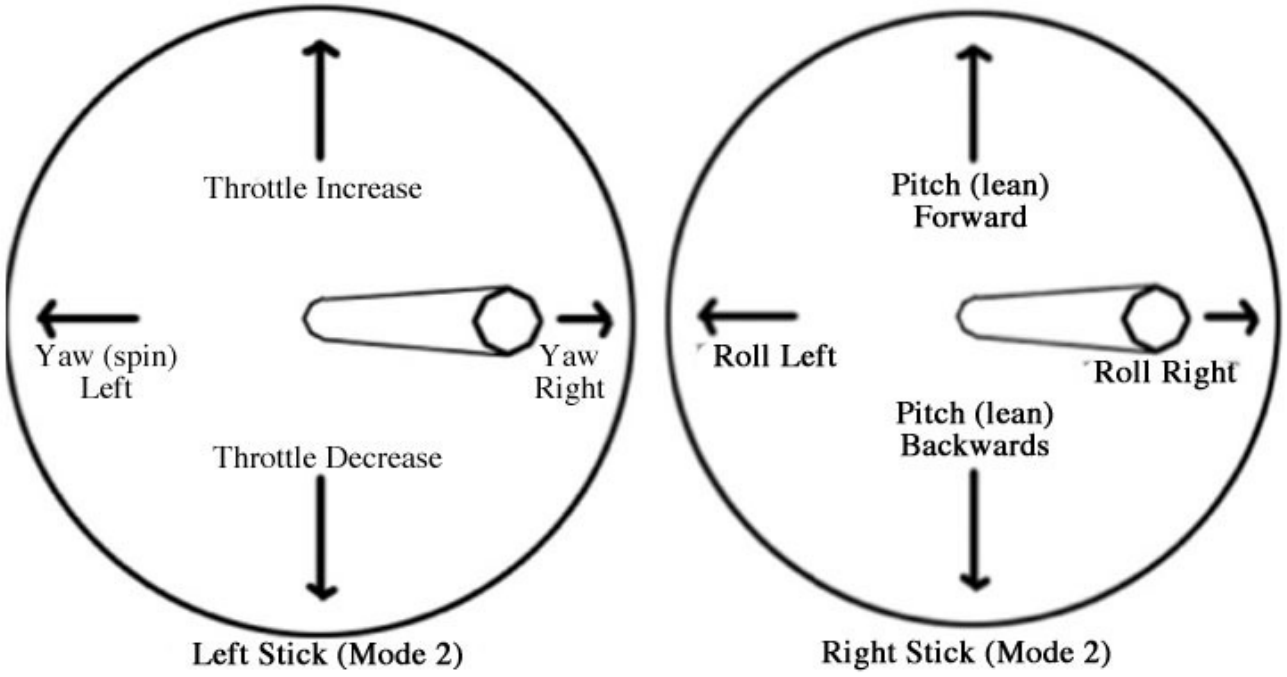
Whew! I’m glad that’s over with - now let’s get back to flying.

Lifting off and Hovering

Remove any weights which you may have used to hold your quad to the ground during testing. Ideally, you are outside over grass for your first flights as the inevitable crashes are unlikely to do as much damage.

Next, while standing behind the quadcopter, slowly apply power to the throttle by moving it forward. Continue applying power until your machine lifts off the ground. It's best to initially raise the quad 2 to 3 feet off the ground, as they can be quite unstable when very close to floors, walls and ceilings. You want to get it high enough to be in "free air". Ideally, your quad will hover and not move too quickly in any direction. This indicates that your gyro is properly set. However, if you are practicing in a confined area, it could take some time to get the hang of hovering.

If your quadcopter seems erratic and moves quickly in any direction without your steering it, you should land it, disconnect the battery, and then reconnect it - making 100% certain that you are on a perfectly level surface. Then try again - you should not attempt to fly until you can hover within a small area - say about 6 X 6 feet. This may require small amounts of stick input from your right stick. If you are, as instructed, standing behind your quadcopter, the right stick should steer the quad as shown below.



The left stick is the throttle (up-down) AND, when moved left and right rotates the craft on its axis.

Depending on your level of coordination and previous experience with similar types of controls, it may take quite a few attempts before you are able to hover properly. Many of your first flights will be taking off and then landing quickly when you feel the quad is out of control. Don't fret - practice makes perfect and you will succeed after enough attempts. Take baby steps because attempts to fly far and fast will definitely result in losing or destroying your quadcopter.

Note: We have written a number of articles which you can find on our blog & forum at droneflyers.com. Youtube will also be a good source of videos about your specific model.

Trimming your Quadcopter

If your quadcopter seems to drift in the same direction constantly or spin on its axis, you may need to trim your transmitter slightly. Most transmitters have four switches which can be nudged in one direction or the other to help the quad hover in a more centered fashion. As one example, if the quadcopter tends to drift forward, the two middle switches could be pressed down a few clicks to favor the opposite direction. Note: do not use trim unless you are 100% sure that the quadcopter has been initialized (started) on a flat and level surface. Trim is only for making very small adjustments - if your drone is heading very quickly in one or another direction, it is likely the problem is elsewhere such as failing motors or stripped gears.
Read your manual regarding the trim buttons as they differ with various models.

The Next Steps

Once you can successfully hover, it's time to fly further away from the nest! This will familiarize you with the way your quadcopter responds to movement of your control sticks. Ideally you'll have an outdoor area at least 50 feet square for micro and mini quads. Your first exercise should be to fly your quad directly away from you - forward - by pushing the right stick slightly forward. Of course, you also have to keep the perfect amount of pressure on the left throttle stick - quadcopter flying is multitasking - you may also have to correct the course of the quadcopter to the left and right using the right stick (left/right movements).

Fly 10-20 feet forward and then pull slowly back on the right stick to bring the quad back toward you. As with hovering, this may take you some time to master - but don't give up! It's all a matter of training your brain and reflexes - similar to driving a car, which would be near impossible if you hadn't put in so many hours of repetition.

Landing your Drone

Unless you have an advanced model with automatic landing, you are going to have to learn the technique of gently lowering your machine back to the earth. One way or another, each takeoff means one landing - although many are what we call “unscheduled landings” (crashes). Landing can be harder than it seems, especially on 3 or 4-axis craft which must be perfectly level in order to avoid the propellers hitting the ground before the landing gear touches. Practice on a soft surface such as short-cut grass or carpet. Lift your quad a few feet off the ground and gain control so that you hover under control - then slowly back down on the throttle until the drone nears the ground.

It’s VERY important to cut the throttle 100% during crash or hard landings, as keeping power to the blades and motors when they strike grass or the ground may harm them. Most of the beginner quadcopters can drop from a few feet up (or even higher!) onto a soft surface with absolutely no damage - unless you keep the throttle on!

Next Steps in Flying

Once you are confident in the basics, you can start practicing other moves. Successful piloting of any aircraft or motor vehicle requires the ability to do a number of things at the same time. This will eventually come naturally, but you have to train your brain and your muscles first. Here are some of your first challenges:

1. Orientation - it’s easier to fly your quadcopter when it faces the same direction as you do - but when it’s facing you or another direction, the sticks will work differently - often in the opposite way as previously! Practice these moves so that you become more confident in your ability to control the craft no matter what the direction of flight.
2. Banking - many pilots find that learning how to fly loops or figure 8’s is very instructive, as you can practice using more than one stick input at a time.
3. Spacial awareness - it’s important to get a grasp on distances, directions, compass headings as well as wind and weather. Just as sailors and pilots know these things, so should anyone piloting a drone.

4. Bringing the quadcopter down from heights - is usually best done while moving it forward at the same time. Descending quickly into your own “prop wash” (air currents made by your propellers) can result in unstable flight.

Don’t get discouraged - keep at it! Keep in mind that fancier drones have systems which actually make them easier to fly. Learning how to fly your toy drone should be considered *boot camp* and what you learn will come in handy later.

Continue to practice your landings until you are very confident that you can place your craft where you want it. Set up landing target zones around your practice area and try to land on them. Then, as you hone your skills, try to land in the center of the target.

Flying Patterns

Once you master taking off, hovering, landing and basic forward and backward flight, it’s time to combine some of your moves. Watch some of the youtube videos on quadcopters and you will see experienced users doing banked turns and figure 8’s. It takes many hours of practice to master these turns and it won’t happen if you are worried about crashing an expensive drone! Use a micro or mini drone with prop guards and fly outside over grass if possible. It won’t matter how many times your machine hits the deck. Dust it off and try again.

Do you have the "Right Stuff"?

At some point it may become evident that the Air Force would probably not pick you as a candidate for their Top Gun flight school. Don't fret - all is not lost! If you find that manual flying is too difficult for you to master, you still have many options to enjoy the quadcopter hobby and pursuit. Many of the newer (and future) quadcopters have stabilization features and some can even be programmed for autonomous flight - that means they will take off, fly around a field by themselves, and then land within a few yards of their takeoff point!

The main thing to keep in mind if you are all thumbs, is to research and buy the proper machines for your capabilities and needs. Models such as the DJI Phantom have loads of intelligence programmed into them. More advanced models take some, but not all, of the piloting load off the operator.

More Tips for Beginners

Some of these tips are mentioned in the text, but here they are in one place so you can print them out and paste them above your hobby bench or desk!

1. *Charge your batteries correctly* - Do not overcharge or over-drain your batteries and they will last much longer. Buy and use a better battery charger if the included one is not sufficient (you may need a better one as you advance in the hobby anyway).
2. *Plug in your quadcopter while it is on level ground* and leave it level for about 10-12 seconds. Many quads use their initial position to determine what *level* is.
3. *Make certain that your Transmitter throttle (usually the left stick) is in the down position* when plugging in your drone. Do not transport or handle your quadcopter with the transmitter still in your hands as you will likely hit the throttle and perhaps cut your fingers, etc. It is best to turn the TX off or disconnect the battery if moving the quad from place to place.
4. *Don't be tempted initially to "see what your quad can do"*. Doing so will almost surely cause loss or crashing of your quad. Wait until you have

some hours on the stick before venturing too high or far. Do not fly toy models outdoors if there is noticeable wind.

5. *When a crash is inevitable - OR, when landing, immediately turn the throttle down to zero*. Most mini and micro quads can take a crash very well - but if the throttle is not turned down fully when you crash, you'll do more damage to the propellers and motors.

Putting in your Hours

Assuming you have decided to move ahead with your drone education, the most important continuing effort is to get *stick time*. This could be on a good simulator program or around your backyard or a local park. Once you get past the initial learning curve, you will find the experience to be fun and a great stress reliever. You will be concentrating on flying and likely not thinking of anything else!
So…how long will this take? It depends on your aptitude as well as a number of other factors such as your age and your familiarity with hand-held controllers. Video gamers are likely to find themselves taking to the controls easier than those who have never messed around with joysticks. After 5-10 hours (40-80 flights) it should be safe to call yourself a student pilot.

Moving Forward

Once you master the basics you will probably get more of an idea of exactly where you want to go with this pursuit. Are you interested in taking pictures and videos? On flying fast, doing flips and racing? Are you drawn to the technical end where the idea of building and modifying drones may appeal to you? This is a good time to start doing more research regarding the different brands and models and their specific uses. Many budding pilots will be happier if they stick with the Micro and Mini Quadcopters as opposed to working too quickly toward the larger and heavier models. The smaller units will keep the cost of ownership and repair low and allow for more freedom in flying (smaller quads make your

yard or park seem bigger). In fact, unless you need the payload capabilities of a large drone, you may never want to move too far upward in size.

Size Ranges, Models and Costs

Mini and micro quadcopters usually sell for prices from $20 to $80. These drones generally weigh in at about 3 ounces (80 grams) and use the cheaper brushed motors which have a short life span. Moving up from there are small units with “brushless” motors. These units sell for $100-$200 and will last much longer than the cheaper models. They often lack the more advanced features such as GPS and stabilized video. Racing (FPV) machines are often in this size range - although they can cost more due to specially tuned parts.

Mid-sized Consumer Camera drones, such as the popular DJI Phantom series, weigh in from 1 to 2 1/2 pounds with battery, meaning they are 5 to 10 times the weight of the Minis.

In the realm of larger quadcopters, models such as the DJI Phantom series and the Autel X-Star or Yuneec Q500 are in the more compact range - large enough to fly decent cameras and easier to see at a distance, without being overly large or complicated. In terms of price, you can spend from $350-$1200+ on the more advanced machines from well known makers. The more expensive models feature built-in cameras and other upgrades. We have published additional books detailing the DJI Phantom Quadcopters - now published free on our web site at Droneflyers.com.

The cost of upkeep and repair of a quad tends to relate closely to the original price - as a percentage. As an example, a $50 quad which crashes may need a new propeller and boom ($6) and perhaps a new motor ($7), which equals about 25% of the initial purchase price. A larger quadcopter may end up needing $50-$100 worth of parts for the same crash - or for a much lesser crash because larger and heavier quads are damaged more from a crash. Crashes of camera/

gimbal equipped quadcopters can easily cost $200-$700 as those parts are quite fragile.

With this in mind, it's important to consider your overall budget before venturing into the world of larger drones.

Bigger is not Better

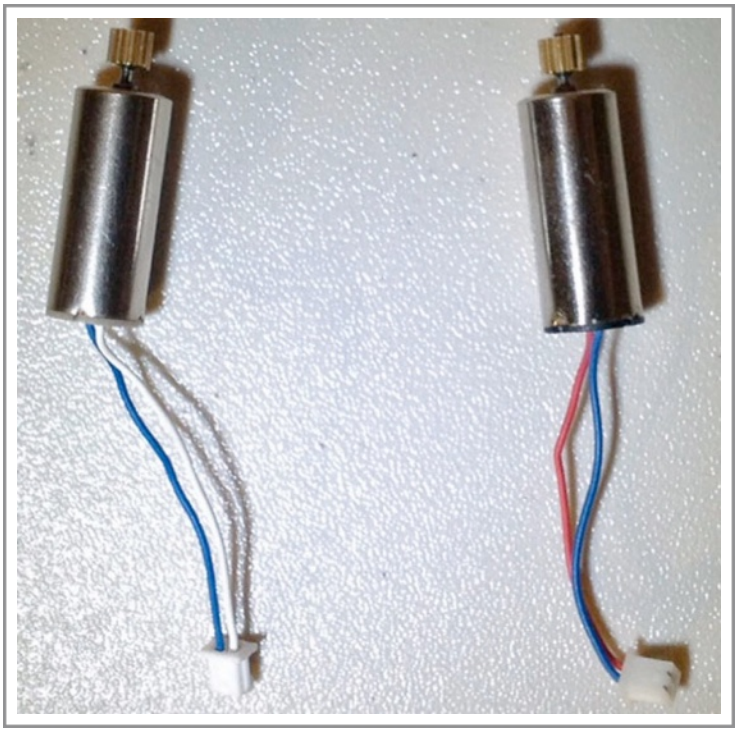
Quadcopters use a large percentage of their power to lift their own batteries and motors. Both objects are quite heavy and current technology makes it difficult to cut weight from these components. Accordingly, when you go up in size, the cost and weight go up much more quickly than the payload capacity. This could change in the future (5-10 years+) as more efficient battery technology hits the market.

DIY Drone Repair and Upkeep

Even if you are all thumbs, there are some simple repairs that will help you get the most from your quadcopters. Here are some of the more common repairs and the basics needed to perform them.

> *Propeller Replacement* - Propellers for small drones are very inexpensive, so you should replace them once they are bent or otherwise out of shape. Smaller quads have propellers which attach in one of two ways - the micros often have friction-fit (push on) props which only require a deft touch and small fingers to remove and replace. Some hobbyists claim that a small drop of a wood glue such as Elmer's helps them stay on better - yet is easily removed when it's time for replacement. Minis generally have a single phillips head screw holding the propeller to the drive shaft. For this and other repairs, your first tool purchase should be a set of tiny screwdrivers.

Motor Replacement - Motor replacement is a common task on small drones. Depending on your hobby skills, you may want to research your initial purchase to find out exactly how the motors are replaced on your particular quad of choice. Some are plug-in, while others require that you solder the new motor (motor comes with leads) to the main circuit board. It's often possible to take a shortcut and simply solder the new motor wires to the cutoffs of the old ones. Motor replacement sometimes requires disassembly of the booms (the cross pieces which hold the motors to the main body).

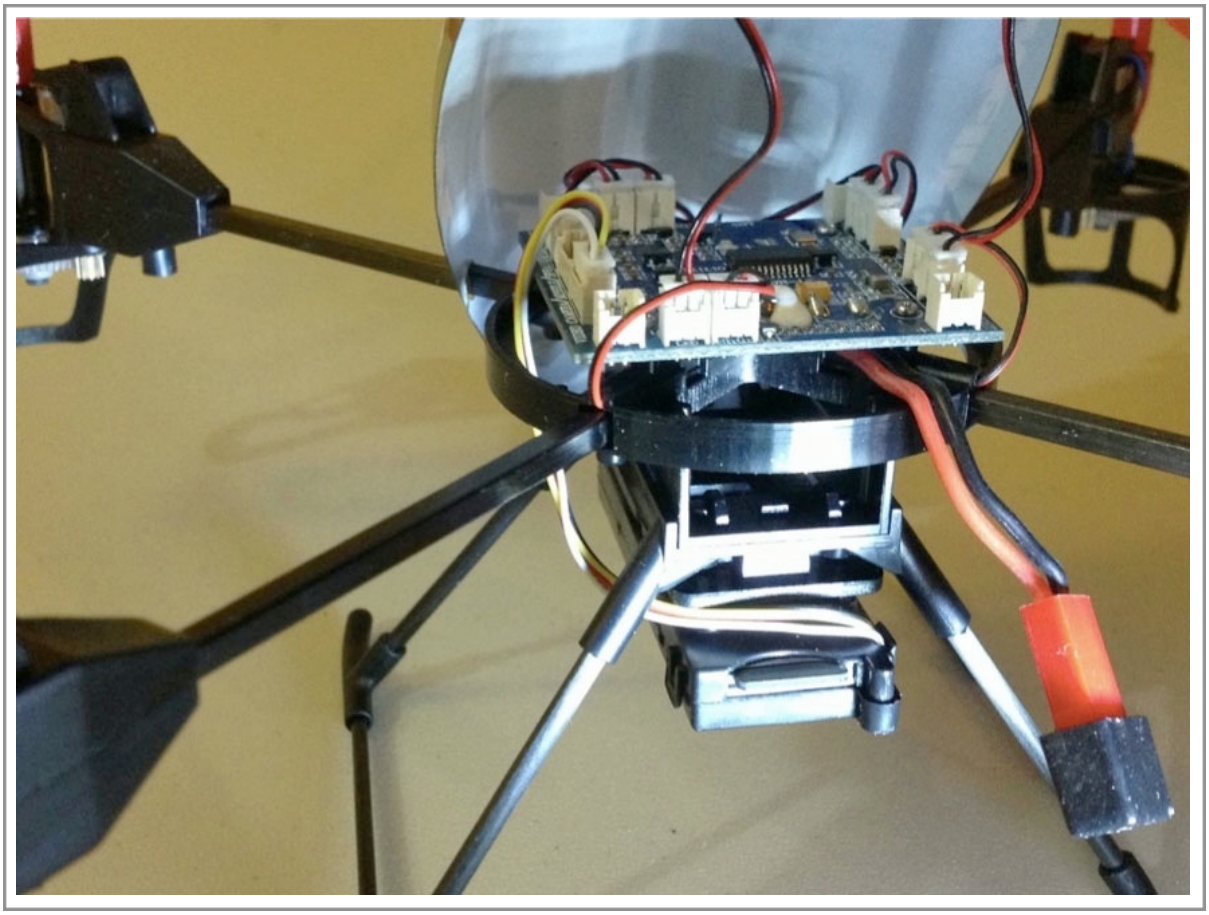


These motors use plugs so no soldering
is required for replacement (WL Toys models)

Boom or Shell Replacement

As shown in the photo below, the booms of most Mini quadcopters are press fitted into the main frame and also into the motor pods. The booms are very inexpensive, but you must be careful in your replacement work as

it is possible to rip out the motor wires or harm other assemblies if you are too rough. If your motors have plugs, this process is easier - boom replacement on some models will require de-soldering and re-soldering of the motor wires to the main board.



The booms (cross pieces) push into the main round frame - wires run through the boom and are plugged into

Fix it or Sell It?

Other repairs can be done - in fact, you can get virtually any part for most quadcopters, including the main circuit boards. But there comes a time when the repair costs may be adding up. However, don't throw that quad in the trash yet! You can still recoup some of your cost by selling it for its parts content! For example, just your transmitter, which probably never sustained damage, could be worth $10 or so. Add to it some of the parts from your hulk, and you may be able

to get $15 or more for what is left of your quadcopter. eBay and RCgroups.com are both places where you could consider selling your parts. Be sure to accurately describe your sale so your buyer and you remain happy after the transaction. Some hobbyists will give away their “hulks” to fellow hobbyists willing to pay the shipping and handling.

Repair and upkeep is a big part of the enjoyment for many people. However if flying is your only goal, the “use and sell or discard” route may fit your needs. As with all aircraft and mechanical devices, there is a certain cost per hour of operation. This holds true whether you decide to repair or to replace your mico and mini quadcopters.

Yet another parts strategy is to wait for a good discount sale and buy two of the same model quadcopter. This gains you an additional battery as well as a full complement of parts to fix one of the machines. Mini and micro quadcopters often are sold for as low as $20 each when on sale - so the cost for two would still be reasonable.

Tools of the Trade

If you enjoy repair and modification, the following tools and supplies should be the beginning of any basic drone tool collection:

1. Razor Blades, X-Acto knives, etc.
2. Electrical tape - various colors
3. Glue - some superglue as well as perhaps some other glues or epoxy. A hot glue gun can also be useful.
4. Mini and micro screwdrivers
5. Soldering Iron with small tip ($15-$20+) - if you intend to progress further in the hobby, pick up a more powerful one with interchangeable tips and variable heat. You can find bargain high-power models for about $40 including the tips. Pick up some solder for electronic use (usually rosin-core).

6. Digital Multimeter (voltage meter)
7. Good lighting for the work area as well as a magnifying glass on a stand for inspection of those tiny parts
8. Fastening odds and ends such as velcro, rubber bands and zip ties.

Chances are that some of these items are already sitting around your house or workshop. A nice kit could be put together for less than $50. Look for bargains both online and at the local dollar store.

A Primer on Aerial Photography and Video

The idea of taking pictures and videos aloft is enticing many to join this hobby. It can be tempting to pull out your credit card and buy that top-notch aerial photography platform early in your drone career, but I would caution against it. As mentioned previously, beginners are much less likely to crash, lose or otherwise harm their machines if they first get a solid foundation in the basics. Here are some definitions and hints, though, so you can know what the camera carrying options are.

First Person View (FPV), Aerial Photography (AP), App Driven Cameras

The simplest form of drone aerial photography is accomplished by flying around with a tiny camera - and retrieving the video or stills from a memory card once

the quadcopter has landed. Mini-quadcopters with built in cameras and controls can be found for as little as $30 - however, the resulting pictures and video will not be of a high quality. In order to get higher quality images, you must step up to larger quadcopters as they are capable of greater stability (less wobble) and carrying better cameras. A shortcoming of the most basic method is that you don't see your footage until after you land and download the memory card to a computer.

First Person View (FPV) describes photography where you see what the drone is seeing, or at least a basic preview of it. The video is beamed back to a small monitor or to a set of special goggles the operator is wearing. This allows for much more precise control of the scenes being photographed.

App Driven FPV Camera Quadcopters w/Gimbal describes fancier video and photography machines such as those from DJI, Yuneec, Autel Robotics and others. These are what most serious aerial photographers will end up with after learning on lesser machines.

Camera types

Aerial cameras often take a beating, so beginners should not use a fragile consumer camera for this application. Here are some of the popular cameras and types used in hobbyist (sub-$1,000) Aerial Photography - approx. prices in ():

> *Included or Optional low-resolution quadcopter camera ($25)* - These are included or optional with many well-known quadcopter brands. They are very light in weight and can be activated for photo or video from the included transmitter.
>
> *Keychain Cams ($12-$60)* - These are very popular lightweight cameras sold as "keychain spy cameras" which many hobbyists affix to their quadcopters. The more expensive models have a higher

resolution and wide angle lenses. The images from these can be very decent if the quadcopter is stable and balanced and the lighting good (bright sunlight is not good for most of these cameras).

Mobius Sport Cam - ($65-$85) - A camera built specifically for the R/C market, this little wonder provides HD videos, stills (on a timer) and other great features for a low price. It can be lifted by some smaller quadcopters like the WL Toys v262, the HiSKY HM280, Skyartec Butterfly, etc.

GoPro and other Sport Cameras ($90-$400) - These are specially made for action - both shockproof and lightweight. Mid sized quadcopters (total weight up to 1000 grams or 2.2 lbs) are required to lift them, while the smaller keychain or similar models can be flown from minis and even micros.

The Parrot BeBop features a built-in front-facing camera which provides medium resolution images and FPV on a tablet or smartphone. Unlike most fixed cameras, the BeBop has fancy software and hardware which stabilizes the resulting video - making it similar to what is captured with a gimbal (camera stabilizer) carrying quadcopter.

The budding aerial photographer should spend some time on youtube and vimeo looking at various quadcopter videos and the platforms they were taken from. This will give you a good idea of what to expect out of your upcoming purchases.

Please note that true “hollywood style” aerial photography requires more expensive and heavier quadcopters along with better cameras. Some of the upscale models of drones even fly DLSR’s which weigh a couple pounds! Expect such systems to start at about $3,000 and quickly go upwards from there - putting them out of the range of most hobbyists and beginners. The price range of hobby range quadcopters and the associated features are below:

$50-$150 - A new generation of low-cost FPV models features are available - these have either built-in screens or use your smartphone as the monitor. Picture and video quality is poor.

$200 - $350 - larger toy or hobby grade models with brushless motors and Mobius and bargain FPV setup

$500 -$1500+ - Full size quadcopters (DJI, Yuneec, etc.) with dedicated or cameras and APV/FPV system installed. Most are driven by apps and use a tablet or smartphone for display and some control of features.

Hobbyists can put together systems in just about any price range from as low as $100. More detail on cameras, FPV and the proper quadcopters to fly them can be found in the section entitled **More on Aerial Photography and FPV** which follows later in this book.

Graduation Day

Congratulations! If you've gotten this far you are no longer a complete beginner - in fact, you probably know more about the subject than most of the general public! As with any graduation, this is a good time to reflect on both the past and the future. It's also time to make some decisions as to where you want to go in your drone career. Here are some possible paths to take to drone nirvana:

1. You enjoy the mini and micro quadcopters and want to continue to pursue this low cost and high value pursuit. This can also extend into small racing FPV machines and acrobatics.
2. You want to delve further into the hobby in terms of both the technical and learning aspects and the various sizes of quadcopters. You may want to be a full fledged "hacker" and start messing with the quadcopter programming.
3. You wish to fly larger quadcopters for photography/video, mapping, etc. but don't want to delve too deeply into the nuts and bolts.

Since this is a newbies book, we won't go too far into all the technical details, but a basic introduction on how to step up follows.

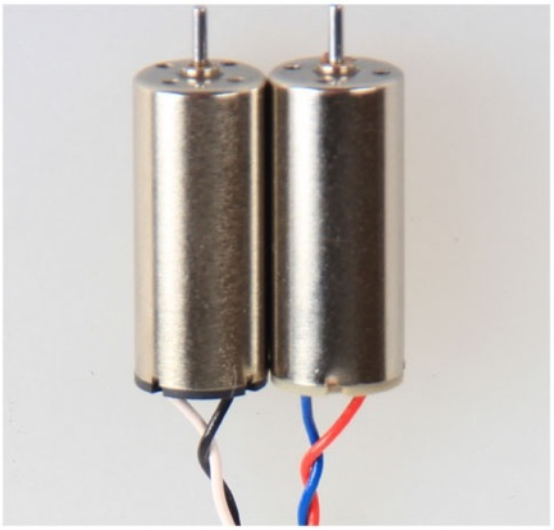
Brushed vs. Brushless Motors

Most lower priced (toy grade) drones use small and inexpensive "brushed" motors which need to be replaced after only a few hours of use. They also are relatively inefficient and incapable of high speeds and large payloads. Higher performance quadcopter use "brushless" motors which provide a very long life, high efficiency and plenty of power.

Brushed motors have been common for over 100 years. They rely on "brushes", which are magnets that actually touch the spinning shaft of the motor. You may have seen small motors produce sparks when running - this is due to to the actual contact between the carbon brushes and the motor armature.

Newer brushless motors are more sophisticated and electronic means (ESC - or Electronic Speed Controller - usually external to the motor) to control the rotation.

This is done without any physical part (like brushes) touching the motor shaft. The result is a longer lasting and more efficient system.



Brushed Motors (toy grade)

Brushless Motor (Hobby Grade)

Most racing and camera drones use brushless motors while the smaller and less costly (<$100) drones usually use the brushless type. When it's time to step up from your beginner models you will almost certainly want to shop for a brushless model. As of 2016 the prices have become quite reasonable with some starter brushless quadcopter as low as $110. Popular models in the lower price range include the HiSky HM280, JJRC X1 and the Eachine Racer 250.

Programmable R/C Transmitters

Advancing in this hobby requires at least a basic understanding of the standard R/C transmitters (TX) which are used with many larger and FPV quadcopters. Note the two types shown in the picture following:

Programmable TX

The RTF (ready to fly) drones mentioned earlier in this book are sold with a TX which was specially designed and programmed to run only the particular quadcopter it was sold with. However, larger drones are sold without a TX or with a specially designed and/or modified model, so the budding hobbyist may need to learn about the various options.

Fair Warning - you may feel, at first, that you stepped back 20 years and are working with some ancient artifact of the computer revolution. As a rule, they are not user friendly - no color screen, no mice or touch screen, links, help files, or automatic setup wizards. Someday this will change, but for now you may have to join the club and slog your way through learning these flight controllers if you want to enter the DIY (build, modification) part of the hobby.

The good news is that they are very powerful and flexible. A single model can store the profiles for many flying machines, so if the quad collection builds up you'll only need one or two of these transmitters. They also allow for dialing up-or-down on the flight characteristics of flying machines, so if you desire your quadcopter to be exceedingly tame, the settings can be changed easily.

R/C transmitters have from 4 to 9+ channels, meaning they can control that many different actions (switches, modes, flight surfaces, etc.) on the model you are flying. The beginning quadcopters mentioned earlier in the book are usually 4 channel - the channels controlling:

1. Throttle - how much power is being sent to the propellers
2. Elevators - this makes the quadcopter fly forward or backward by tilting it (pitch)
3. Ailerons - tilt the copter side to side and... (roll)
4. Rudder - this makes the quadcopter spin on its central axis (yaw)

Larger and fancier quadcopters may need more controls, although 5 or 6 channels are enough for most models. Prices range from as little as $50 to as much as $350+, although very decent models can be had for $50-$150. Brands include Turnigy, Walkera, Spektrum, JR, Futaba, FlySky and more.

Many purpose-built (photo/video) larger quadcopters come along with a matching TX, so those who are entering the Ready to Fly (RTF) market of larger Camera drones may be able to avoid having to program and bind these multi-model Transmitters to their new models. As an example, this modern Transmitter (now called a Remote) is included with the new DJI Phantom 3 and 4 quadcopters.

DJI Phantom 3 & 4 Remote

Your Next Quadcopter

The drone market is rapidly changing and advancing. Many of the newer models come complete and Ready-to-Fly (RTF) so you will not have to concern yourself with learning about separate transmitters and receivers. However, if you decide to enter the DIY (build or customize your own) end of the hobby you will have to

delve further into these. Even if you have no intention to DIY you should read the following for some basic information into how more modular drone models work.

Buying and Flying with a more advanced TX (Remote)

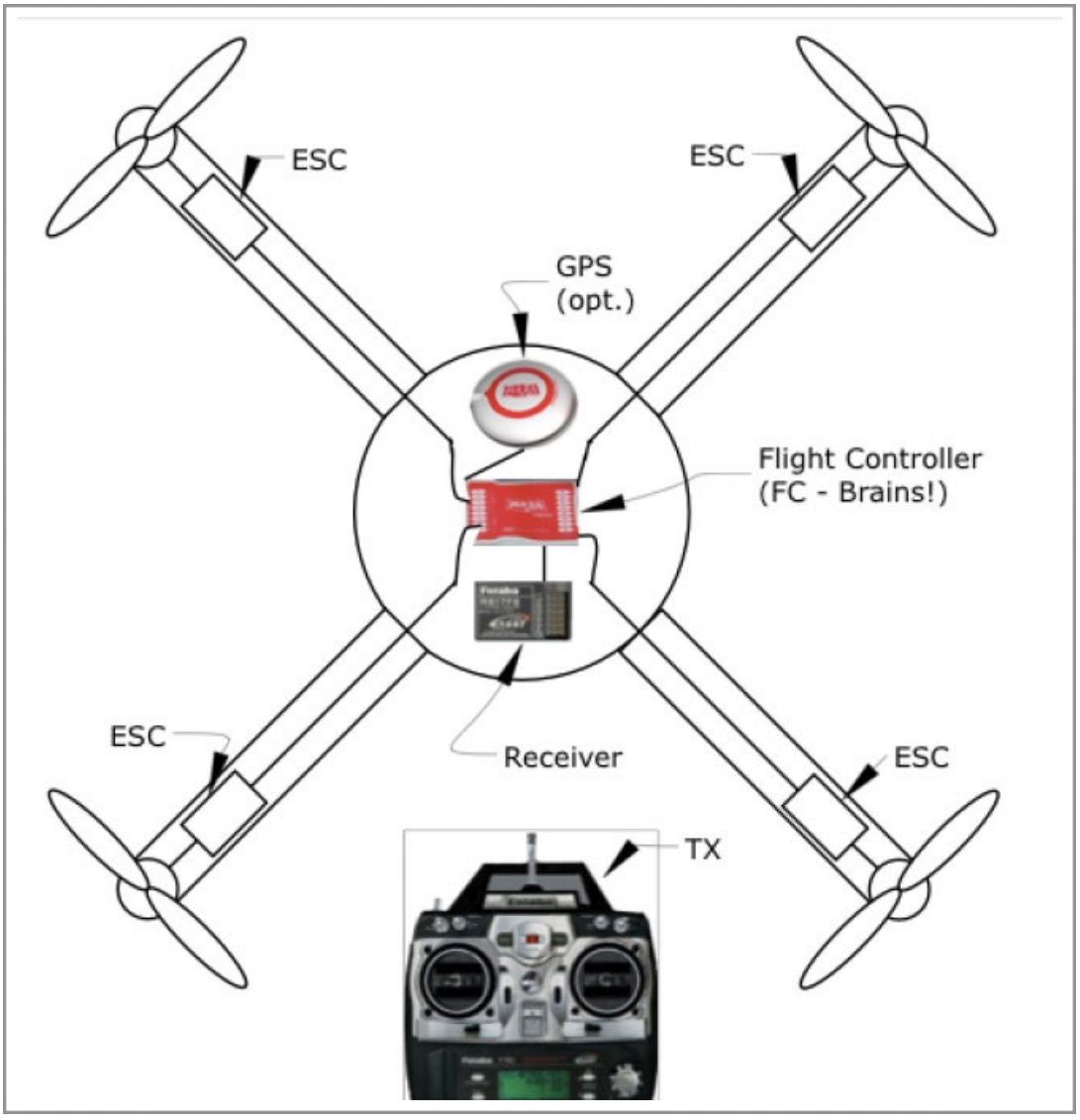
Various manufacturers produce generic R/C controllers. Brand names or types include Spektrum, Futaba, FrSky and Turnigy. Radios can cost as little as $50 or as much as $800+. A very popular current model is the FrSky Taranis which sells for approx. $250. The Turnigy 9X is a budget model which sells for about $70 and can operate most basic quadcopters. You'll want to have some idea of the models you wish to fly before choosing a generic TX. For example, if you are interested in quadcopter models from Blade (Horizon Hobby), these work only with the Spektrum (or clone) transmitters.

Some of the toy models mentioned earlier can actually *bind* (be paired and used with) these more advanced Transmitters. This is a good way to get started with learning how to adjust and program the radios.

Some Larger Drones are more Modular

At the beginning of the book, we covered the basics of how a quadcopter works. However, now that you may be advancing in the hobby, it will benefit you to learn about the various parts and how they function. This will help you with shopping and selection as well as with troubleshooting.

The following drawing shows a more advanced modular quadcopter, which has separate components onboard as opposed to the *all in one* design of the small circuit boards on mini and micro quads. This type of design allows you to select different receivers to mate with your TX - or, to select various brands and types of flight controllers and GPS add-ons.



Telemetry - Knowing what is happening aloft

Inexpensive and starter quads are essentially controlled in a one-way fashion - you provide the R/C control and “talk” to the drone, but it doesn’t talk back to you. Telemetry is the science of having the vehicle provide real-time data back to you. This ranges from simple things such as the battery level, to more complex data such as wind speed, height above ground, vehicle speed and even the temperature of the motors. This is beamed back to you and shows as a overlay on the quadcopter view (FPV) or on a small display screen of your R/C Transmitter. Telemetry is a very important feature for advanced and more expensive quads, so you will want to educate yourself on the subject as you progress in the hobby.

Understanding the various components will make you a smarter shopper as you will be able to compare the various features and systems by brand name, compatibility, reputation and warranty. As we enter 2016 some of these systems are being combined into one main circuit board with ALL of the functions built-in. This is similar to what has occurred in other consumer electronics and is known by the acronym VLSI (very large scale integration). The advantage of this type of design is lower costs, easier service (switch main board) and better reliability.

Despite being advertised as such, many larger quads are not sold truly ready to fly - at least not to the consumer of average to low technical ability. There are some exceptions to that rule such as the Yuneec Q500 4K and the DJI Phantom 3 and 4 series. Even these models require various skills including piloting, upgrading software, understanding GPS and flight modes, etc.

These models can be described as major advances in Ready to Fly consumer quadcopters, as they include many advanced features for a relatively low price.

The DJI Phantom - The First Mass-Market Consumer Drone

The DJI Phantom series, first introduced at the beginning of 2013, represents a major milestone in the adoption of consumer level drones. This is a Quadcopter that, just a few short years ago, would have been impossible to build. Similar vehicles were built before that time, but they were in kit form and required time, patience and mechanical skills. In addition, it is often hit or miss as to how well the homebuilt quads can perform aerial photography.

The Phantom series is sold RTF, or Ready to Fly, complete with transmitter, advanced navigation and software control and the ability to lift high quality cameras for video and still photography. As of this writing (2015), DJI offers a more advanced model called the Phantom 3. It is fully complete with camera, gimbal and controller and can take amazing video and still pictures right out of the box.

The Original Phantom 1 Quadcopter

Open the box and you see a quad that LOOKS like a consumer product! No bundles of wires strapped to exposed framing with cable ties, but a finished and sleek aerial vehicle that is ready to put into action.

The manufacturer, DJI Innovations, is solidly grounded in this business and is well regarded, making the purchase less of a gamble than a “here today, gone tomorrow” multirotor company. Newer and more capable DJI models (Phantom 3

and 4 series) sell from $500 to $1400 complete with the top end models sporting 4k video cameras and new collision avoidance technology.

The current DJI line appeals to virtually all levels of the multirotor market. While it should not be the first Quad you own, it could easily be the 2nd or 3rd machine you purchase once you learn the basics. The intelligent flight controls should help you avoid many common mistakes and the great videos which DJI has produced on the Phantom's operation should put you into the pilots seat quite quickly.

As always, newer pilots should practice above a soft surface – tall grass, for example, and keep the Quad within a few yards until they understand its operation. The optional propeller guides are recommended for increased safety. Those who buy from a local retail shop may be able to get some lessons from the store personnel or team up with existing owners or a local flying club for tips and hands-on stick time. DJI has made a series of videos for the Phantom which should be watched by any prospective customer and owner.

DJI Phantom 3 Pro 4K Camera Quadcopter

All DJI Phantom models have GPS as well as a compass feature. These features can be used in various ways - the TX allows the pilot to turn various functions on or off.

DJI Phantoms are sold as “flying cameras” and that is primary mission of this size and type of quadcopter. If you want a “sport” or fun quadcopter to fly around your yard or a local small field - and don’t care much about photography and video - you should look elsewhere.

Summary – although not an inexpensive package, the Phantoms represent a major step in the world of RTF mid-sized multirotors. Steve Jobs said of the first Apple Macintosh Computers “These are the first computers worthy of criticism”. The Phantom fits into the same category and is likely to be the bellwether for what is to come in the future.

UPDATE: We have written a number of articles comparing all of the Phantom models at droneflyers.com.

As of the end of 2016, the Phantom 3 and 4 models are the most popular consumer video quadcopters. These models feature a camera and a stabilizing cradle (called a gimbal) which allows for amazingly smooth video.

Other brands have introduced similar packages for the hobbyist videographer. The Yuneec Typhoon Q500 4K (about $900 US) is one with high marks from users. Autel Robotics and GoPro are two other companies offering Camera Drones

We have published 2 additional books detailing the DJI Phantom Quadcopters . All our eBooks are now free and published on or linked from our web site - Droneflyers.com
Note - these machines are purpose-built as flying cameras and are NOT the machines you want for learning, racing, hacking, etc.
More on Aerial Photography and FPV

Although some larger quads are used for aerobatics, racing and other pursuits, most hobbyists plan for photography to play a role in their more advanced machines. This section will discuss the equipment and costs related to aerial photography.

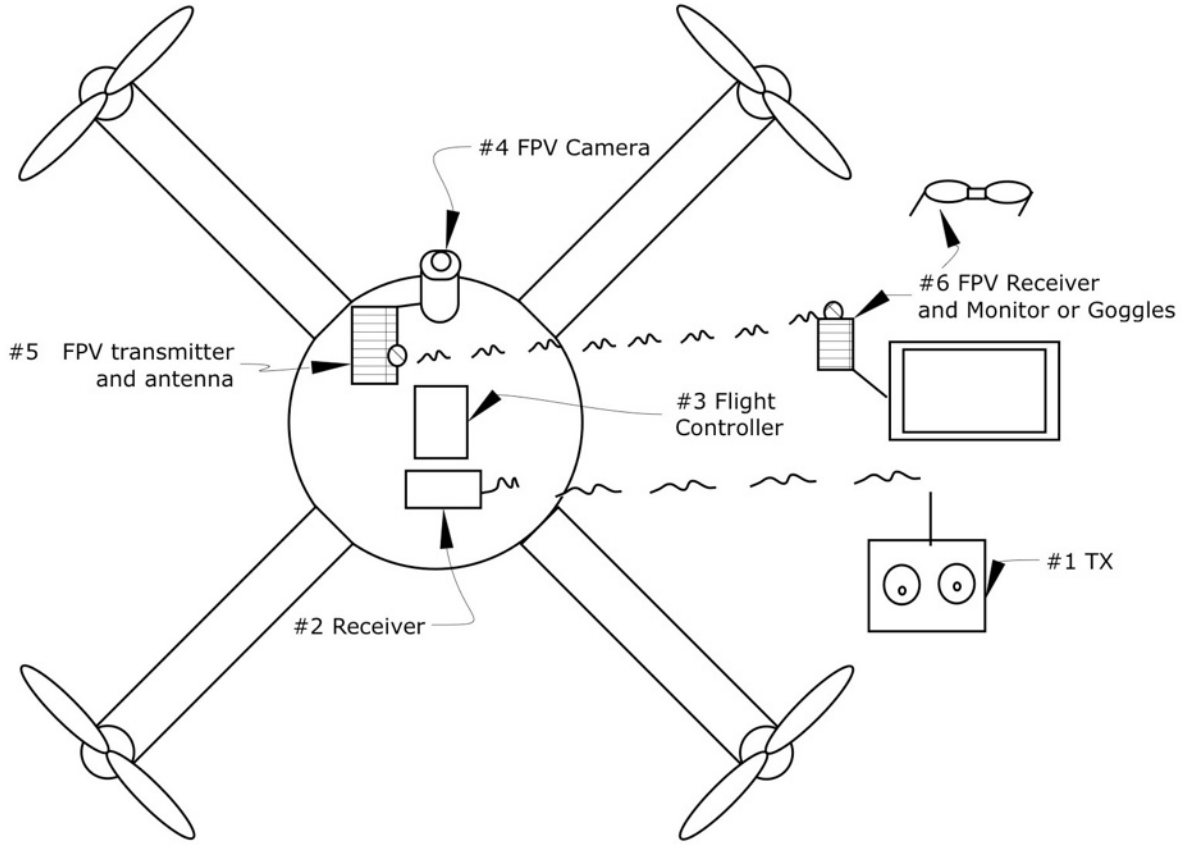
Earlier in this book we discussed cameras which are available stock on smaller (mini and micro) quadcopters. These cameras are fun learning tools, but have severe limitations when it comes to picture and video quality, range and other issues. Larger and more sophisticated quadcopters will give you more choices in camera, platforms, range and other options. Here are the basic options in terms of aerial photography drones.

1. Toy quadcopters with brushed motors and very small (included or strapped on) cameras. These will take very shaky video - useless for most applications. You will have little or no control over the camera settings, etc. - Prices for these setups range from $50 - $150 including camera.
2. Larger quadcopters with brushed motors with GoPro or similar sports cameras (Runcam, Mobius) added on. This will give a better still picture quality and video can be reasonable in low wind situations. Prices are from $150-$300 (more with an expensive GoPro or similar brand). These models still do not have control of the camera tilt or stabilization, etc.
3. Purpose built Camera equipped Quadcopters with stabilizing gimbal - Popular brands include the DJI Phantom and the Yuneec Q500 4K. These machines are sold complete with a camera, stabilizer and and “app” that allows control of the camera from the ground. They take smooth video as well as decent still photographs.
4. FPV or Racing quadcopters which have a front mounted camera which is designed for seeing where you are going as opposed to photography.

Short Discussion of FPV Gear

First Person View (FPV) gear for drones will work differently than the purely digital cameras we are used to. These are often analog systems, and therefore

use either a different (2nd) camera or an analog A/V output from your existing digital model. This output is coupled to a transmitter with its own antenna - and often needing its own battery. The video signal is then transmitted from the quad to your ground station and displayed on a small monitor on on the inside of specially designed googles. Many hobbyists prefer to keep the entire FPV system separate - with its own small cam. FPV does not require a high resolution, so the camera can be very small and light. These analog systems have less latency (lag) - but also less range than the fancier digital FPV systems now finding their way into the high end models.



In the diagram above, #4 through 6 are parts of the FPV system. They can be described as:

#4 - FPV Camera or Analog (usually composite) output from existing quadcopter camera (GoPro, Keychain Cam, etc.)

#5 FPV Transmitter and antenna - this takes the “TV Type” signal from the FPV Camera and broadcasts it to the ground.

#6 FPV Receiver and Monitor or Goggles - This receives the signal from your drone and then displays it on a connected monitor or goggles. In some cases, a smart phone or computer tablet acts as both the ground receiver and the monitor.

Some equipment and connections are not shown in the above diagram. These include the battery or power connection to the FPV camera and transmitter and connections for triggering the camera on or off from the ground TX. FPV gear setup can be quite technical - a full discussion is outside the range of this book. If you are not technical, it will probably be best to look for a unit sold RTF (ready to fly).

Controlling Photography and Video Cameras Aloft

Simple toy quadcopters have video cameras which can be turned on or off by a button on the transmitter. However, since flight times are fairly short, many users simply turn the video camera on before takeoff and let it run for 6-8 minute duration of the flight. There is a separate control for the snapshot (still picture) function, but such shots are of very poor quality so it may be best just to use a frame from the video for any desired photos.

Larger systems work differently. Ready to Fly FPV systems like the Phantom 3or 4 and Yuneec Q500 4K have full control through a wireless connection to a smartphone or tablet, but many quads which carry cameras do not. In these cases, you have a couple choices.

Activate video before quadcopter takes off - again, since the flights are usually short, you can turn on your GoPro or other video camera and let it record the entire flight - then edit it later.

Use Camera with Interval Shooting - many cameras have a setting which is called Interval Shooting or Intervalometer - this allows

programmed intervals at which the camera snaps a picture or takes a short video. As an example, a camera can be set to take one picture every 10 seconds for the entire duration of a flight. Only certain cameras have this feature, so check on your choice of cameras to confirm.

Rhode Island, USA

Aerial Picture of Stone Tower

Understand Flight Controllers (FC , F/C)

Flight Controllers, as mentioned previously, are the brains of a drone. They are created from a combination of hardware and software, much like modern computers, tablets and smartphones. As you progress in this hobby it may be important to understand the various F/C platforms available to control your drone.

Quadcopter flight controllers are of two basic types:

1. Open Source or Community based projects - these are designs which have been developed and shared and cost nothing to use or modify. The designs consist of both software and hardware. Examples of such projects include:
Openpilot
Ardupilot (APM, Pixihawk)
Multiwii
KKmulticopter
Although the software code and reference designs are usually free, you still have to buy the actual hardware (circuit boards) as those cost $$ to produce. Upgrading the flight controllers can be accomplished by downloading the newest code and connecting to the flight controller using a USB interface. This is not a task for non-techie beginners.

2. Commercially Developed systems - these are flight controllers developed (or heavily modified from open source) in-house and sold only with a specific model or range of models. Examples include:
Parrot AR Drone or BeBop F/C
Naza (DJI)
Wookong (DJI)
Dualsky (FC450, etc.)
With these flight controllers you are tied to the particular manufacturer in terms of upgrades and modifications.

Bare bones flight controllers - selling for as little as $15 - have the ability to manually fly a quadcopter, while more expensive models ($40-$200+) have advanced capabilities and modular expansion for features such as GPS, Barometers, Sonar, etc. which will help with autonomous (hands-off) flight. Those in the market for more advanced quadcopters should research the various flight controllers and options to make certain that they have the proper functions for their intended use.

Most newer consumer drones are based on advanced and commercially developed flight controllers. These are truly at the heart of the drone revolution and are starting to contain AI (artificial intelligence) as well as being capable of machine learning (getting smarter as they gain experience!). As a result, the next great drone advances are not likely to come from an entrepreneurs garage workshop, but rather from years-long work involving millions of programmer-hours.

A Short Course on Drone Batteries

Most quadcopter batteries are of the LiPo type, which stands for Lithium Polymer. These batteries can store a tremendous amount of energy in a relatively small and light package and are key to modern drone performance. Here are the basics of these batteries.

Your first foray into quadcopters may be with a mini or micro – most of which use a single cell (3.7 volt) LiPo battery and come standard with a USB or plug-in charger. However, once you step up in size to larger and heavier drones, you will find that most of them use batteries which are much larger in size, weight, amperage and voltage. Most LiPo batteries are built of 3.7 volt cells, so they often are a multiple of that number – the most popular for larger quads being 11.1 volt (3 cell) packages.

Ratings are given in maH (milliamp hours) - the higher the number, the more power the battery contains. Micro and Mini quads will carry 200-700 maH batteries, while a typical mid-sized drone may have a 2000-3000 maH rating.

Although the USB and stock chargers may be OK for the small batteries, experienced pilots should invest in a “smart” charger, which not only charges the batteries but monitors their exact voltage and knows when to stop. More advanced chargers are also capable of balancing the battery cells - a function which is needed to properly charge batteries with multiple cells. Lastly, the fancier chargers can be rigged up to charge multiple batteries at once, which can be of great benefit to those who want to get in the air quickly.

“Smart” chargers can be purchased in the range of $20-$45 - although you may need some extra cables and adapters to charge your various batteries. A smart charger should be on the “must have” shopping list for any beginner who wants to advance in the hobby.

Typical Smart (Balancing) Battery Charger

PLEASE READ AND UNDERSTAND SAFETY CAUTIONS REGARDING LIPO BATTERIES - DO NOT CHARGE UNATTENDED AND CHARGE ONLY ON NON-COMBUSTIBLE SURFACES. See our Safety Appendix at the end of this book.

Many of the newer quadcopters have “smart” batteries and chargers which eliminate the need for a separate charger. These batteries have built-in intelligence which properly charges them and monitors their health.

Wrapping it Up

We’ve covered most of the basics and even a little extra! The most important step forward is to get yourself a quad and start flying. Pay attention to safety issues and use common sense to avoid losing or destroying your drone during the first few flights. Keep at it and you will discover the joy of flying!

Some basic troubleshooting tips, a glossary and bonus articles follow. Keep this book handy and use it as you advance in the hobby. Also, be sure to visit our site at Droneflyers.com and sign up for our forums where I and other experienced flyers can help you with your questions.

Thanks for Reading! Hope to see you at the web site and forum.

Craig Issod - http://droneflyers.com

Appendix

Safety Warnings and Topics

Please become familiar with the many safety issues which apply to this hobby. An outline of the major safety points is below:

Spinning Propellers can injure humans and animals - mid sized and larger quads could cause deep wounds or worse. Be cautious - do not fly near people and animals. Make certain you are familiar with the startup process (arming) of your quadcopters. Remove propellers when first testing new setups. Use a file or sandpaper to slightly dull the sharp edges of propellers.

Lipo Batteries can ignite as well as cause shocks. Do not charge batteries near combustible materials and do not charge unattended. Use special made LiPo batter charging sacks. Make certain there are smoke and CO detectors in the areas where you charge and store your batteries. Make certain that water and other fluids do not come into contact with your LiPo batteries. Make certain the wires and connectors cannot easily short circuit.

Falling or Crashing larger quadcopters can injure or even kill. As stated before, do not fly over or near people, animals or moving vehicles. Use common sense in planning your flight path.

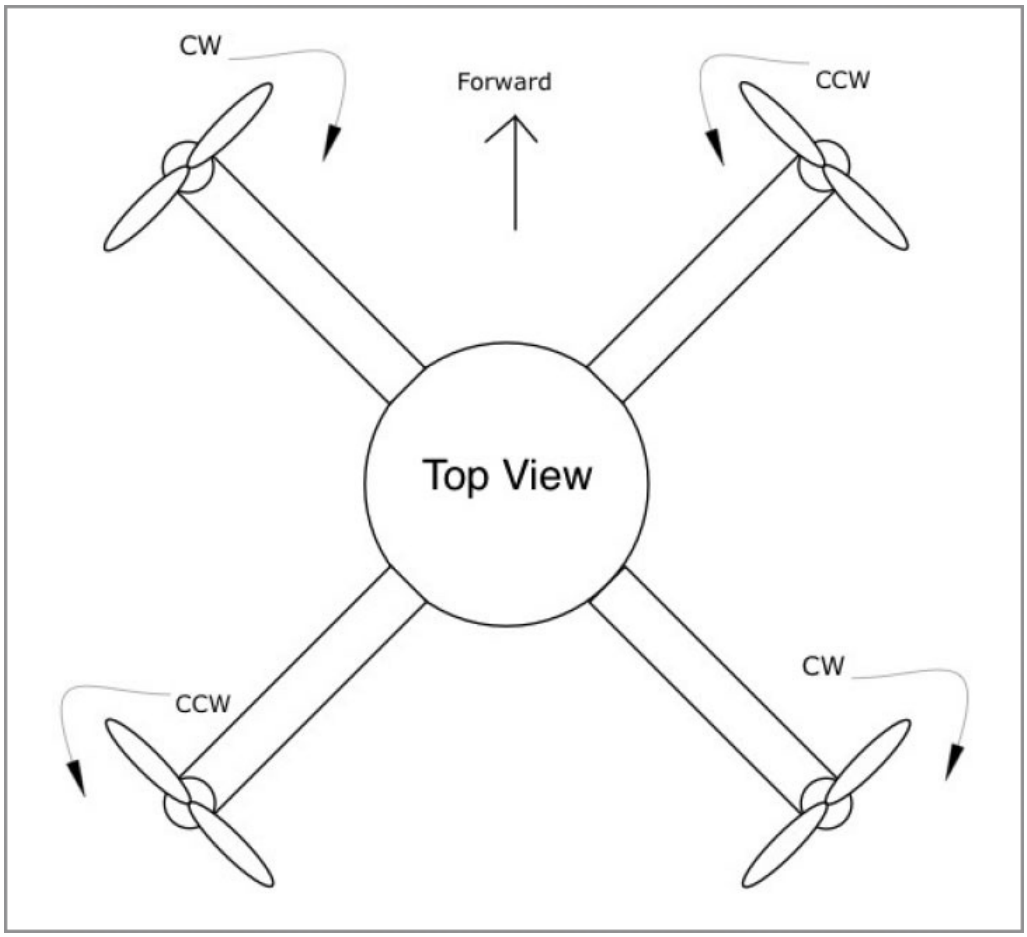
Keep a small fire extinguisher in your flying kit - and in your hobby room. An ABC extinguisher should be fine for most secondary fires.

Do not use GPS when flying indoors - erratic results could result in lost control.

Troubleshooting your Quadcopter

Following is a list of common beginner quadcopter malfunctions and their possible causes and solutions.

Problem: Quadcopter will not take off - props seem to spin at high speed but quad flips or just skids along the floor or ground.
Solution: Carefully check that all blades are installed properly - two types of blades are used on quads, clockwise and counter clockwise. Your owners manual should have a sketch of the proper layout - the higher edge of the blade should be leading the way! The diagram below will pertain to many quads propeller rotation.



Problem: Quadcopter wobbles when hovering - even with light or no wind.

Solution: Carefully inspect propellers both while hovering (look at the pattern they create while spinning) and when the quad is off. Chances are that a propellers is out of shape from crashes or wear. Fix or replace.

Problem: One motor seems to take longer to start or spin up to speed.
Solution: This, in itself, may not be a problem as long as the quad acts correctly when more throttle is applied. It is somewhat normal for the props not to all start at the same instant. If, however, it affects liftoff or flight the motor (in minis and micros especially) may need to be replaced.

Problem: Quadcopter acts differently after 5+ minutes of flying.
Solution: Battery voltage may have dropped, resulting in different performance characteristics. Although flights can be as long as 10+ minutes, this depends on the battery size, number of charge cycles, charge state, etc.
A fresh battery should fix the problem. For larger quads, you should become familiar with the amount of voltage your quad needs to fly and use a digital multimeter to check voltage if you have concerns about a particular battery. Larger drones should only be flown with a full charged battery (to start flight).

Problem: Quadcopter does not hover well, instead flying in one direction constantly.
Solution: As with many computerized systems, the first thing you should do is a reboot - accomplished by disconnection of the battery and reconnection, making 100% sure that the quadcopter is on a level surface. If your quad still favors one direction after a reboot, check the TX trim and adjust as needed.

Problem: Quadcopter cannot fight the wind and tends to blow away
Solution: Most quadcopters have a “rate” setting which is often expressed in percentages and can be adjusted on the TX (Remote). 20% would be a low rate which is for indoor flight while rates of 60-100% allow for steeping angling of the drone - and therefore the ability to fight the wind to some degree (depending on your flying skills).

Glossary

808 camera - A common name for a range of tiny "spy" cameras often sold as "Keychain" cameras. There are very light in weight and used by many hobbyists for taking video from multirotor and winged aircraft.

accelerometer - An electronic component which measures acceleration on a given axis (direction) of flight.

AP - Aerial Photography - a field which is growing fast due to smaller cameras and better aerial platforms

arduino - An open source (free software) project centered around a low cost circuit board which allows for control of objects. It is easily programmable allowing for experimentation. Many quadcopter control boards (FC, Flight Controllers) are built using this board and software.

ARF - Almost Ready to Fly - used to describe the Drone or Quadcopter you are purchasing - as to what it comes with! ARF units often come without the transmitter and may require some easy assembly

autonomous - not subject to control from outside, often used to describe a drone which follows a preset path using GPS or other means, as opposed to being actively steered by radio control.

axis - Used to describe one plane (one line) of potential flight. Most quads have at least 3-axis control and correction built in.

balancing battery charger - A charger or internal system for Lipo batteries (or other chemistries) which uses smart technology to properly charge multiple cells within the battery and "balance" them.

barometric pressure sensor - A device which uses barometer readings to determine altitude. In combination with other sensors, these can help drones determine their height above ground.

bind - The process of making the controller (Transmitter) "talk" to the Quadcopter or drone.

BNF - Bind N (and) Fly -This usually describes a unit which is ready to BIND to your existing transmitter and then fly.

brushless motor - Lightweight brushless motors are one of the defining features of the recent growth in popularity of electric aircraft. Brushless motors are categorically far more efficient, and far more durable than brushed motors. With small props, they can also be operated without the gearbox often required of lower RPM brushed motors, saving weight and wear on several fragile mechanical linkages. (dronepedia attribution)

build - Used an a noun when discussing home-built quadcopters or multirotors - example "Here's a picture of my build".

CA - Cyanoacrylate adhesive - also called superglue. This, along with Gorilla Glue and Liquid Tape, are often used in the building and repair of aerial vehicles.

camera gimbal - This describes a camera holder, often used on drones, which may have the capability to tilt and swerve using small actuators called servos. Various camera models, including video cameras and even large DSLRs, can be fitted to these gimbals.

center of gravity (CG) - Also called mass center - on a multirotor this is likely to be the point where, if a string were attached to and the machine dangled

from it, that the unit would be balanced. It is important to maintain CG when adding different batteries, cameras, mounts, etc.

CF - Carbon Fiber - a very lightweight and strong materials used in aircraft and other items requiring a high strength to weight ratio

DJI - DJI Innovations, a highly regarded multirotor manufacturer who sells both kits, completed units and parts including the popular NAZA flight controller.

drone - A newer, perhaps slang, definition is for any unmanned powered aerial vehicle, although the dictionary has not yet caught up! In terms of the news and current events, it is often used to describe aerial vehicles which can be guided from afar and contain surveillance gear, etc. Officially, "drone" defines a humming sound or a male bee which mates with the queen.

ESC - Electronic Speed controller - this to used to speed up and slow down motor "RPM". These devices are the key to modern multicopters and most have one one wired to each motor.

flash - To reset and/or add computer code to a chip or controller.... i.e. "I flashed the ESC".

FPV - First Person View - often used to describe cameras mounted on aerial (or any unmanned) vehicles which let the operator see what the vehicle sees in real time. This is done by way of goggles or screens which display the output of the on-board cameras.

GoPro - A line of small lightweight sport cameras which are often flown on multirotors to capture video. They have a wide angle of view and are built to withstand shock.

GPS - Global Positioning System used to track movement or hold position on certain advanced Multirotor models.

gyro - Same as gyroscope

gyroscope - A device that measures angular velocity and helps maintain orientation.

Hexacopter A multirotor aerial vehicle with 6 rotors.

hobby grade - describes a quadcopter or parts one step up from toy grade - these quads or parts are typically designed for better reliability and operation. Examples include quads such as the new RC Logger Extreme Eye One (brushless motors, etc.), the DJI Phantom, AR Drone and Blade 350X QX.

hexacopter - A multirotor aerial vehicle with 6 rotors

IMU - Inertial Measurement Unit - a combination of various sensors (gyroscopes, accelerometers) which are used in flight controllers for quadcopters.

interval shooting - Settings which allow a camera to take pictures or video at user-defined intervals. Example: a camera can be set to take one picture every 5 seconds.

intervalometer - a software or hardware mechanism which allows interval shooting.

JST - A type of battery connector (plug) used on many quads. The other popular style is called the Walkera Connector. You can buy adapters which convert one to the other.

KAP - Kite Aerial Photography - taking pictures from a kite.

LIPO - Also called Lipo or lipo, etc. These are the type of battery (internal chemistry) that most electric drones currently use.

LOS - Line of sight – meaning you should see it (your drone) with your naked eye while flying!

mAh - milliampere-hour - an electrical measurement of the power packed into a battery. One thousand mAhs equals one ampere hour. Quadcopter batteries will range in size from 50 mAh to 5000+ mAh.

Mobius - a popular and lightweight sports camera designed for R/C flight.

mod - modification - quad and drone flyers love to modify their machines in various ways!

multicopter, multirotor - An aerial vehicle with multiple rotors (propellers which are horizontal). This would include tricopters, quadcopters, hexacopters, octocopters, etc.

multiwii - General purpose software initially developed to support Nintendo Wii console gyroscopes and accelerometers. It is now used to control multirotor aircraft. The software is now installed on many Arduino circuit boards, including custom models specifically for quadcopters.

NAZA - An electronic flight controller used on mid-level and above multirotors - produced by a company called DJI, The NAZA contains the

main controlled chip along with a gyro, accelerometer, and a barometric altimeter. Optional GPS & Compass modules are available.

octocopter - An aerial vehicle with 8 rotors.

payload - The amount of weight your aerial vehicle may be able to lift in addition to itself and its batteries.

Phantom - product line (brand name) of various models sold by a leading drone company named DJI.

pitch - used to describe the angle of flight along one axis - in the case of quadcopters, usually from level.

quadcopter - An aerial vehicle using 4 rotors, commonly using only the varying speed of the motors to achieve both stability and direction of flight.

RAW - format used in some cameras for digital still pictures – RAW files contain all of the information the camera sees and are not compressed and processed like jpg files.

R/C - Another way of writing RC - Radio Controlled.

RC - Radio Controlled - this refers to most multirotors and quadcopters which are controlled by radio transmitters or even by a smartphone or tablet.

RTF - Ready to Fly - In the field of Multirotors, quad (and other) copters and other R/C (radio controlled) vehicles, this means that the unit is sold complete with everything - ready to go. Note - you may still need regular (AA AAA) batteries for the transmitter)

rx - short for receiver or receive

servo - short for servomotor or servomechanism. On quadcopters and other aerial drones, these are used for various tasks (pan cameras, adjust wing flaps) and controlled by the radio from the ground.

telemetry - Refers to a back and forth connection between an aerial vehicle and your controller/transmitter/screens. This would allow, as an example, the display of the battery power remaining on the multirotor to be displayed to you at your ground station.

throttle - Control used to increase or decrease the RPM (speed) of the electric motors

toy grade - Describes many of the common quadcopters which cost less that $100 - these use very inexpensive components and are somewhat disposable. Reliability can be spotty, however they provide good value for the price.

trim - verb or noun describing the small adjustments on the TX to make a quad hover or fly correctly.

tx - Short for transmitter or transmit

UAV - Unmanned Aerial Vehicle (drone, etc.) or unmanned autonomous vehicle

ultrasonic sensor - A sensor which uses sound waves - in the case of quadcopters and multirotors they are usually used to determine the distance from the ground by bouncing sound waves off of it. In typical use, they work only for a few meters above the ground or other surface.

waypoint - A location defined by a set of coordinates that identify a point in physical space. Waypoints are used for mapping out autonomous missions for quadcopters

WOT - Wide Open Throttle - throttle stick on maximum!

yaw - used to describe the rotation of a quadcopter on a level plane around its center axis.

Some Models for consideration in 2016/2017

* are suggested for beginners...

Under $100

*Dromida Verso – Micro Quad with great features - in or outdoors

*Hubsan X4 H107L – updated version of popular micro - in or outdoors

*Syma X5(c) - inexpensive quadcopter for (mostly) outdoor use.

*Dromida Ominus - Similar to Syma X5 but more sporty - outdoor use

*Syma X11 - perfect size inexpensive quadcopter for inside or outdoor use.

*Syma Venture 8C – Larger version of a toy-grade quadcopter with decent payload capacity - use in larger outdoor area

Under $200

HiSky HM280 (fast and low cost racing-type quadcopter)

XK XK 251

HiSky HMX280

Around $300-

*DJI Phantom 2 (original model) - about $300 (used or new.old stock)

About $500

DJI Phantom 3 Standard

$600-$900

DJI Phantom Advanced, Yuneec Q500, Autel Robotics X-Star

$900+

DJI Phantom 3 Pro - complete units outfitted with video and still camera and stabilizing gimbal

DJI Phantom 4, DJI Mavic Pro

DJI Phantom 4

Bonus 1 - The Drone Report - 2016/2017+

Note: This covers only consumer drones.

As we enter 2017 the consumer drone industry consists largely of one company – DJI – and a few others, such as Yuneec and Parrot, trying to gain a piece of the market. DJI sold 75% of the mid-priced consumer drones this past year, leaving a very small slice to the other 1/2 dozen companies which may offer competing models. Unfortunately for the other companies, DJI has executed well…and some other companies have not. The technology has evolved so quickly that it has become impossible to develop a top end machine without hundreds of engineers and designers…an expensive proposition. It can best be compared to computer or phone/tablet operating systems where only companies like Google, Apple and Microsoft have the resources to develop and move the systems forward.

However, the above relates just to the "flying tripod and camera" mid-range of the market. To understand the entire drone revolution we have to break the pursuit down into separate and distinct categories as follows:

Aerial Photography (AP) Drones – these are, by far, the largest part of the market by revenue and we will likely see up to 3 Billion dollars worth (at retail) sold in 2016. They are GPS stabilized and full featured and can take video and pictures of impressive quality (not pro-grade, but still very high quality). AP drones often function as "crossovers" into light commercial uses such as roof inspections, public safety (some fire departments), etc.

Toy Drones – Millions of these machines are sold and they are somewhat disposable. They are used as pilot trainers and for fun and indoor flying. In general, the prices run from $15 to $100.

FPV and Racing Drones – These tend to be mid-sized machines with cameras designed to give the operator a "drone view". Many operators use head gear (goggles) to get a real feeling of flying. These are usually not equipped with GPS as they are flown within relatively close proximity of the pilots. FPV drones are often sold ARF or "Almost Ready to Fly" and may require some additional parts

and labor before they are ready to fly. Some companies are starting to offer RTF (Ready-to-Fly) kits at higher prices. The average price range for FPV quadcopters ranges from $250-$600 although you can certainly spend a lot more if you get high resolution goggles and other upgrades.

Hobbyist/Hacker/Developer Drones – A lot of hobbyists enjoy the pursuit of building as much or more than the actual piloting. The roots of the entire industry are in the hobbyist arena and these users often advance the technology by being the first to try various schemes and designs. The “build your own” hobbyists will often spend from $300-$700 on their frames, motors, flight controllers and other parts to build a mid-sized quadcopter. They do not get more for their money than prebuilt or mass-produced machines, but they learn a lot more and have the satisfaction of building something to their own specifications.

In addition to these 4 segments there are, of course, the agricultural, commercial and industrial (and military) uses. However, Droneflyers.com (this site) focuses on the consumer market.

State of the Segments 2017

Below are some comments on each of the above segments:

Aerial Photography Drones – As mentioned in the introduction, DJI is almost a monopoly in this particular market and is driving the train (so to speak) by continually introducing new and upgraded models at lower prices. Other companies such as 3DR and Walkera tried to gain a foothold with little success. Yuneec and Parrot have at least made a go of it - selling enough to stay in business and continue development. GoPro is releasing their Karma Drone at the end of 2016, however it will be difficult to gain traction after coming in so late in the game.

Toy Drones – sales are still exploding but nothing innovative or new has come out of this segment. These models are fun and very capable – but disposable unless you have a ready source of spare parts and the capability to troubleshoot and repair them.

FPV and Racing Drones – this segment is much smaller than the camera machines, but still growing quickly. Some manufacturers (Eachine, Walkera, Blade and others) have started to deliver more finished (RTF) machines but the reviews are not yet in. We'll keep a close eye on this market and review a number of new machines in 2016.

Hobbyist/Hacker/Developer Drones – This segment of the market is probably fading – at least as a percentage of the total sales. Most consumers don't have the interest in soldering, programming and the other skills needed to be successful in this end of the hobby. For those who do enjoy DIY, prices have come down for all the major components. This allows for very reasonable experimentation. There is always room for the hackers/DIY crowd – in fact, the entire hobby owes them for helping to drive the industry forward.

Employment and Opportunity

Growth in the industry has exploded the opportunities for those who seek employment or income from the pursuit. Opportunities run the gamut from engineering to marketing to writing/blogging and much more. Employment in drone related jobs is likely to increase now that the FAA has allowed for some commercial use.

Potential Roadblocks – there are two looming issues which should be mentioned in relation to the potential of consumer drone sales and use.

1. FAA and other Regulations – the FAA is being careful and deliberate in their study of the technology. They introduced new rules as to the use of hobby and light commercial drones in 2016. These regulations should accelerate the sales of consumer drone models.

2. Customer Service and Warranty – flying machines which can be destroyed with one small crash present a conundrum when it comes to warranty and customer service. This has resulted in consumer dissatisfaction and also keeps many from entering the hobby in the first place. Although the machines are getting more reliable there are still inevitable problems which require sending machines back to the manufacturer. Moving forward it's possible the solution will lie in extra-cost extended warranties (already offered by many companies) and/or

3rd party repair shops in addition to the companies investing more in their service operations.

Summary – The consumer drone market is just starting to hit its stride – largely due to advances made by market leader DJI with Yuneec running in 2nd place. These updates make drones more reliable and easier to use for photography and video. DJI currently owns the largest part of the mid-priced and prosumer market, however there are numerous companies chasing a piece of the quadcopter pie. It is likely to take at least a year or two before any can be considered serious competitors to DJI (due to the massive DJI lead and their aggressive program).

Other drone categories such as the toy segment and FPV are also growing quickly but development of new and novel models seems to have slowed. Instead, prices are falling and copies of existing models…as opposed to new and innovative units…are the rule rather than the exception.

The technology has still not advanced enough for the typical electronics or camera consumer to fly advanced models. This becomes somewhat of a limiting factor as many potential buyers are not willing to invest the time and dedication to learning piloting and other technical skills.

To quote Jeff Bezos - CEO of Amazon -we are still at “Day One” in terms of consumer drones. Looking forward further than about 18 months is difficult – however, the past is often the best predictor of the future. If this is the case, large companies such as DJI and GoPro as well as other well capitalized new entrants will continue to drive the market. The days of a new quadcopter “built in a garage by a hobbyist” are over. This is due to the massive complexity of modern quadcopters as well as the difficulty of modern high volume manufacturing and distribution. Consumer quadcopters are now more similar to computers and smartphones than they are to the old R/C toy – meaning that their “operating systems” require massive amounts of man-hours to perfect and update.

Links (2016/2017)

FAA Registration for large drones - $5 per user (not per drone)
https://www.faa.gov/uas/registration/

Informational Resources

Droneflyers Blog
http://www.droneflyers.com

Droneflyers Forum
http://www.droneflyers.com/talk

RC Groups Multirotor forums
http://www.rcgroups.com/aircraft-electric-multirotors-790/

DJI Forums
http://forum.dji.com/forum.php?lang=en
http://www.phantompilots.com/

List of Manufacturers - 2016/2017

Consumer (toy) and Hobby level multirotors

Note: This list is not complete - there are many companies entering and/or leaving the business. Also, many companies sell the same model labeled with other brand names (private label).

Airdog
Armattan
Autel Robotics
Blade (Horizon Hobby)
Cheerson
DJI
Draganflyer
Dualsky
Eachine
eHang (Ghost)
Estes
FreeX
Gaui
GoPro
Helimax
HiSky
HobbyKing
Holy Stone
Hubsan/
Jdrones
JJRC
JXD
MiKocopter
Mota
MJX
Parrot (AR Drone, BeBop)
RClogger
Syma
TBS
Traxxas
UDI
Upair
Vitality
Walkera
WL Toys
Woodon Toys
Xiro
XK
Xpro Heli
Yuneec