

WORKBOOK



National Drone Schools
Learn To Fly Your UAV



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Introduction

The last couple of years brought an explosion in news reports regarding drones and other unmanned aerial vehicles. Although many of these reports focus on the well-known military models (Predator, Skyhawk, etc.), the bigger news is the progress in aerial robotic machines which can do a number of tasks-from crop inspection to search and rescue to photography and video. Our online UAV flight training course 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 online course provides those and more.

Drones have been around since the eighteenth century. They are found in the airspace throughout the world and are more popular now than ever before. They were originally used for military action but are now used for commercial and personal use. Drones are used to watch for potential drug deals, cattle thieves, and even illegal immigrants trying to cross the border.

The Washington Times recently reported experts expect as many as 30,000 drones in the airspace by the year 2020. Not everyone is pleased with that statistic. Many worry that their safety and privacy may be compromised. Some fear that the government will use drones as a spy tool to spy on citizens. Others fear that

citizens, now having access to personal drones, will also use them inappropriately.

The advantages to the use of drones in the military are lengthy and covered throughout the book. There are also many commercial advantages to the use of drones. Surprisingly, the personal use of drones is quite common and the reasons for owning one are discussed.

Rules and regulations are an ongoing topic throughout both the United States and the rest of the world. The FAA and legislation is working to keep up with the quickly advancing technology. Is your privacy at risk? Is safety a concern? Just exactly how are drones being used? Get an unbiased glimpse into the world of drones.

Chapter 1 – History of Drones

History of Drones

Technology found around the world continues to progress. Some of the elements that are created from it change the way we view things, forever. One of those inventions is the drone. Early drones were referred to as unmanned aerial vehicles (UAVs).

A drone can be recovered after a mission. Some drones can carry ammo and fire at a given target. Other drones take pictures or surveillance video.

Austria Attack on Venice

The first recorded use of UAVs was in 1849 in Austria. They were used to attack Venice in the form of dropped balloons. Many of them were successful, but the Austrians didn't account for the wind. Some of those balloons of explosives actually traveled back to Austria before they exploded upon impact.

World War I

In 1916, UAVs were used in World War I to carry weapons to various destinations. They were fast and often referred to as aerial torpedoes. There were plenty of designs in the works for them through 1918. However, the United States government didn't want to be too reliant on them during the war.

World War II

Approximately 15,000 of these drones were manufactured and used in World War II. By 1938, they were commonly used by both the US Navy and the US Air Force.

Nuclear Testing

In 1946, drones were used for a variety of types of nuclear testing. Explosions were created and different prototypes of drones were sent through the destruction to see how much damage they could withstand. It is believed that the Soviet Union also conducted such testing around the same time period.

Vietnam War

Drones were a huge benefit in the Vietnam War for the US. It is believed that the enemy could shoot down only about 6 of the drones used in this war.

United States Customs and Border Protection

Since 2007, the US Customs and Border Protection have used drones. They have been used in an effort to reduce illegal immigrants from crossing the border. It is also in place to assist in reducing the risk of drug trafficking at the border.

United States and Afghanistan

Unmanned drones were used by the US over Afghanistan beginning in 2002. This was during the hunt for the leader of Al-Qaeda. The decision to use drones in such a manner was part of the updated

security plans after the horrific terrorist attacks on the United States, September 11, 2001.

Emergency Response

In 2005, drones were requested to look for people who may need to be rescued after Hurricane Katrina. However, the FAA didn't have such authorization in place yet. That authorization rule was changed in 2006 and drones can now be used for future emergency situations. Emergency situations include searching for people trapped or unable to reach a safe location after a natural disaster or after a vehicle accident. Many forest areas and mountain terrains are too dense and dangerous for airplanes. The use of drones can rescue and save lives quickly.

There has been the suggestion to use drones to help look for people in avalanches or lost in hiking expeditions. A great deal of time and planning is required to implement a search and rescue team to get to those often remote locations. Drones can get there quickly and easily to help rescue and potentially save lives.

Advantages

Drones continue to be used because of the many varied advantages they offer. Noise and privacy issues are common complaints. However, what they offer is well beyond such complaints.

Price

Drones can be expensive. However, the cost is far less than the equipment and manpower that the drone is able to replace. Drones are also faster and less expensive to build than other aircraft. If they are damaged or destroyed, the loss will be less. Drones can be made in smaller sizes, reducing fuel usage. Many are now solar powered.

Human Safety

Manned aircraft can be compromised, putting the humans on board at great risk. Aircraft that is compromised can also be used to cause harm to other people or to structures. Drones are very hard to compromise. The worst-case scenario is that they get shot down and destroyed. However, the enemy isn't able to capture them and use them for their own personal gain as they can with an aircraft.

Drones are safer than sending men or women into various dangerous situations. The military has utilized

this valuable aspect of the drone in order to protect servicemen and women. Drones can also fly into tighter areas, reducing the risk of an accident or a crash of a manned aircraft.

Drones are unmanned, and when they are destroyed or shot down, there are no lives lost. The number of drones that were shot down in World War I and World War II was very low. However, the number of them shot at and destroyed over Afghanistan was extremely high.

Manpower

Drones can replace the manpower of a large number of men and women. The savings can add up very quickly. Not only in terms of wages for those employees but also for transporting people, food, and lodging.

Reduces Errors

Weapons and the use of drones can also be safer. High stress situations occur during times of war. Using drones to carry weapons reduces the risk of human error under stress. This includes releasing weapons too soon, without authorization, or over the wrong-targeted location.

Testing

Being able to test drones in different situations allows for better construction of other aircraft. It helps to identify safety concerns and problems that otherwise may not have been identified until a serious disaster has taken place.

Secrecy

Due to the small size of some drones, they are often difficult to detect. This is important when there are military operations in place, possible drug trafficking issues to verify and stop, or possible crimes taking place.

PTSD

Many men and women in the military suffer from PTSD (Post Traumatic Stress Disorder). Combat is the number one reason for PTSD. Many experts believe that by sending in drones to take part in what they call the “drone war” zones they can reduce the effects of PTSD on military personnel.

Hours of Operation

There are only so many hours of flight time that humans can cover before they must take a break. Their bodies and their minds simply can't continue to be alert and function without sleep. Drones can stay in the air and around their target area without any breaks. Since they are unmanned, they can stay in place for days, weeks, and even months or years if they have to.

Improved Structure Inspections

Routine inspections should take place for bridges and buildings and can often be dangerous to complete. Time and safety cost states a great deal of money for routine inspection and repair work. The use of drones to review structures from all angles and to take photos is a great alternative. The work can be done in less time, with a great deal of accuracy, and without putting workers in danger.

Commercial Use

www.Faa.gov

Confusion about the commercial use of drones continues. They are rules and regulations but they are often hard to clarify in some areas, allowing them to be used commercially.

Drones can legally be used as a hobby. The owner is required to keep the drone within their sight at all times. Why would someone use a drone? Taking photographs to get a terrific aerial shot would be one purpose for a drone.

Commercial businesses get around regulations by setting up a non-profit business or stating that they're a hobbyist. Both of these classifications allow them to operate drones without being considered a violation of commercial use.

They are able to collect payments, too. However, money has to be collected in a manner classified as donations. While the FAA is aware of this, they haven't made it a priority. They haven't investing a great deal of time or effort to stop the practice.

The FAA regulations state that drones can't be used for commercial gain. However, the US Congress has required the FAA to change this. Beginning in 2015, the FAA will have to allow drones into commercial airspace.

It was announced 12/ 30/ 13 by the FAA that six states will be able to develop testing sites for drones. Those states are:

- Alaska • Nevada • New York • North Dakota • Texas • Virginia

The reasons that these locations were selected are due to the variations they offer. The FFA considered the following different types of locations: • Airspace • Climate • Terrain According to the FFA, they believe this is a huge step towards gathering sufficient and reliable data. They feel this information will assist them with creating rules and regulations needed for commercial drone use in 2015.

The testing sites are anticipated to generate an undisclosed number of new jobs in those states. Not everyone is happy about this, though. Many want drones to be approved for commercial use without all the red tape of rules and regulations. A survey in 2013 showed that 42 states agreed to bills being implemented in their states that restrict the use of drones. The restrictions are mainly regarding privacy concerns.

There are eight states that have already imposed such bills. Those states are preparing for the FAA changes in 2015. It is expected that many more states will also be getting these bills acted upon and implemented before the FAA accepts the commercial use of drones.

Too Many Drones

One of the biggest worries that the FAA has about commercial use of drones is that there will be too many in the airspace. There has been talk about using drone for fast deliveries by some of the larger retailers including:

- Amazon • Sears • Wal-Mart

This could literally result in hundreds of drones in the airspace, as the orders are in route to their destinations. Drone numbers could dramatically increase around the holiday season, increasing concerns. Obviously, FAA regulations will require caution and diligence. Putting rules and regulations into place will help ensure that there isn't chaos from the commercial use of drones.

The most common commercial ventures trying to get approved for drone use include:

- Business Logistics • Insurance and Property Valuation
- Journalists • Motion Pictures • Oil and Gas Companies (Pipelines) • Photography • Real Estate

The experts believe that there will be growth in 2015 in the area of commercial use of drones. However, they believe lots of commercial entities are going to be disappointed and frustrated by the lack of freedom they have.

Chapter 2 - Manufacturers

Manufacturers

From a manufacturer's point of view, the ability of commercial use is very exciting. Manufacturers have already started with the development and promoting of consumer drones. They are hopeful they can generate a great deal of profit by selling drones to the commercial sector. Some of the top manufacturers for commercial drones include:

- *DJI Phantom* – This is considered to be the first mass market drone. There are four configurations that consumers can pick from. They are all designed to be very simple to operate and range in terms of the weight they can handle. The Quadrocopter is one that is getting a great deal of attention. They also offer the 2 Vision Quad.
- *Parrot* – This is a very small drone with a configuration that looks very similar to a butterfly. It is also very cost efficient, which is perfect for a business that doesn't want a huge investment in this type of marketing.

FAA Fight

The FAA isn't going to give up without a fight. In March of 2013, they appealed a Federal court ruling regarding the use of drones for commercial needs.

The charges were dropped due to the fact that there were no enforceable FAA rules and regulations at the time. With this in place, the precedence in the court of law has been set. The FAA has to come up with additional rules and regulations so that what they deem as violations can be prosecuted.

The outcome of the FAA appeal regarding the use of drones for commercial use as being legal is one that will be watched by many. There may be some compromises made in the end for all parties involved.

Navy

The use of drones can help to improve security as they can be launched in areas quite a distance from the actual naval ships.

Coast Guard

The US Coast Guard believes that the use of drones can help increase prosecutions by as much as 95%. Drugs are being pushed through the waters and the Coast Guard needs the drones to assist them with making drug busts and breaking down that illegal entity. However, there are strict restrictions and the Coast Guard shares their drones with the Navy. Some of the projects in place will allow them to use the drones up to 70% more than they are right now.

Drones and the War on Terrorists

Drones have been a favorite weapon of the Obama administration as a safe way to fight the war on terrorists. They have been significantly involved in approved airstrikes both in Iraq and Afghanistan. An undisclosed analyst for the military states that up to 95% of direct target killings in these countries since 2011 have been conducted with the use of drones.

Drone Data

Some people worry that the use of drones in the military are going to replace the number of people that they employ. That isn't really the case, but it can change the types of situations that the humans in the military operations are found in. For example, there are

anywhere from 65,000 to 70,000 military personnel that work on compiling, interpreting, and using the data from drones.

According to a review of military operations, it is believed up to 100,000 personnel need to be dedicated to this particular type of work. As the number of drones in uses increases, so will the number of people that they allocate to such tasks.

Conflict of Drone War

There are plenty of countries out there that don't like the concept of what is dubbed a "drone war". Some countries have been protesting the use of drones. The Pakistan militia has a campaign in place that says the US is spying on them. They also report that the US is killing innocent civilians. A report compiled from the United Nations (UN) in 2010 also raised some concerns. Many allies of the US are hesitant to speak at all about the use of drones. They don't want to get into a conflict about the use of drones. They don't want to get into a conflict about it. The conclusion is that there is a lack of good information about drone use in the military. It has made many people, and even leaders of various countries uneasy.

Other Uses

There are plenty of other possible uses for drones that the average person may not have thought about. As you read through these, you may identify a couple of them that you would be glad to consider implementing for your own personal use.

Cinematography

Both amateurs and professionals enjoy the idea of being able to use drones for cinematography. This is the art of taking videos or action shots for movies or videos. Drones would be able to get up close to the action and really capture the scene.

Such images could completely change what is used in the final production. It could add significant detail to what the viewer will be able to identify with in any given scene. The use of drones in films that capture animals in nature would also be explosive. It would allow them to be filmed in their natural habitat without any risk to humans going in and setting up cameras.

Drones are replacing helicopters for these types of shots. Drones are quieter than helicopter, don't disrupt the landscape, and can take picture from great distances.

Action Sports

Many people find action sports to be very entertaining. Instant replays are wonderful, but don't always capture the details that can become controversial. A drone could be able to get up close and personal without being an invasion of space for the athletes.

Some action sports have a referee with the athletes. They have to be close to see the action, but they also have to protect themselves at all times. They have to be ready to move quickly out of the way with the movements of the athletes. The use of drones could allow those referees to be a safe distance away from the action.

Real Estate

Even though commercial use of drones isn't legal, it still happens. Drones are popular in real - estate. Being able to take photos of properties from all angles is important. Capturing the home and the surrounding property from the air is a great way to capture the attention of potential buyers.

Photography

Both amateur and professional photographers use drones to capture unique photos. Drones help take photos of those hard to reach places. Or can give interesting points of view.

Agriculture

Farmers and ranchers are using drones to help them with their business. Drones are being used to help identify problems with crop growth, irrigation, or to monitor large areas of land. Ranchers can use drones to count cattle and look for those that may have been separated from the herd. They can also use drones to help them identify problems such as cattle theft, breaks in the fence, trespassing, etc.

Both farmers and ranchers have to invest time and money in the upkeep of their facilities. The use of drones can be a reliable tool for surveillance and monitoring of their land. There are over 10,000 drones in use in Japan for agricultural purposes.

Law Enforcement

Many areas of law enforcement can benefit from the use of drones. For example, looking for suspects that are on the run, whether on foot or in a vehicle. Drones can monitor known shipment areas for drugs. They can

monitor traffic on interstates and help keep traffic flowing safely.

Weather Observations

Drones can be used for weather observations as they can get photos from different angles very close to the storms. Drones can get close to the eye of a hurricane or very close to a tornado, for instance. These drones are often destroyed, but they can provide a tremendous amount of data and information for us to study and learn from.

3-D Mapping

With the use of drones, 3-D mapping is becoming extremely popular. This process allows the landscape to be carefully surveyed. Thousands of images can be taken in a small amount of time. The drones can produce better results than satellites for creating these 3-D mapping elements.

They can be guided by GPS so they don't have to be manually guided by a human. One of the main sources for this type of 3-D mapping is Pix4D out of Switzerland. The images they had captured help with the Haiti relief efforts following Hurricane Sandy.

Wildlife Protection and Documentation

Many forms of wildlife are in danger of becoming extinct. Environmental issues, poaching, and other factors make it difficult. Drones are a non-invasive way to protect wildlife and to document where their habitat continues to be found. It can also help estimate numbers that still remain in the wild. Drones can map roads that allow them to reach wildlife in order to offer help, add monitoring devices, and to install cameras around a given habitat area. Drones can be used to help identify poaching activities and even capture those responsible due to the images that can be recorded.

One of the huge efforts in place right now is for conservation of Orangutans in Malaysia and Indonesia. The use of drones has proven to be far more effective than efforts on ground due to the thick forest of their habitat.

They look for easy targets, such as people walking alone, and homes that look dark and unoccupied. Drones in the air could increase the chance of a robber getting caught in the act or caught on video. Therefore, drones could help decrease certain crimes in some areas.

Personal Privacy

Some worry that small drones can interfere with their personal privacy. This includes:

- Taking a shower
- Using the bathroom
- Getting dress/ undressed
- Intimacy
- Conversations
- Work activities

Some have a fear that drones could literally be everywhere, monitoring everything they do. They simply want their privacy in their daily lives and fear that giving up any rights will lead to giving up all rights.

Safety

Drones are made of carbon fiber and are very lightweight. Severe winds could cause them to crash into a person, a vehicle, or even onto a busy highway. Animals may be scared or harmed by drones. The sound causes some animals to run or react in odd ways.

Noise

Depending on where you reside, you may be used to high levels of noise. However, others aren't and they view it as a type of noise pollution. They also feel that their privacy has been invaded due to the noise. While a single drone in an area isn't going to be excessively noisy, people are concerned about the increased

number of them over time. People have complained about drone noise to their local officials, to state representatives, and even to the Federal government.

Crowded Airspace

According to the FAA, there are already concerns with drones in the US due to crowded airspace. There are fears that the addition of drones in the US in large numbers could further cause problems. Crowded airspace could result in flights delays, problems with detection of what is in the airspace, and more.

Privacy Legislation

Many states are looking into privacy legislation relating to drones. They are doing this now in the event that the commercial use of drones can be opened up in the near future. Such privacy issues involve limiting how drones can be used. If they are used for criminal acts or invasion of privacy, very stiff penalties should be in place. Many states believe that by getting legislation in place, they can eliminate the fears that have many concerned that their privacy is going to be invaded due to the use of drones on a wider scale.

FAA Concerns

Privacy is also one of the concerns of the FAA. They have authorized 78 certificates for commercial use. They have already had to increase their staff to take care of those licensing issues and to address safety concerns from citizens. The FAA is aware that many law enforcement entities in the US have purchased drone equipment. This includes the states of:

- Alabama • Florida • Texas • Washington • Virginia

These states are also addressing security issues as well as those complaints that the FAA has seen. They want their citizens to know they will be safe with the use of the drones in place. In fact, they enjoy the fact that they allow data to be collected in real time. Drones can be reviewed in terms of camera footage to gather information for crimes.

Such information can be instrumental for law enforcement to cut down on the time needed to conduct an investigation. The photos can also give them documentation and evidence they otherwise would not have been able to have in order to successfully prosecute someone for their role in a crime.

The FAA says they have been cooperating with efforts by US states that want to use drones for law

enforcement. They have been doing so since 2010. However, they want security measures in place regarding who is going to be responsible for observing the drones and how they are used. The risk of that authority falling into the wrong hands is what the FAA wants to work to prevent.

The Department of Homeland Security is now in that mix, too. In fact, they are currently looking into offering grant money for those states with law enforcement that would like to buy drones but can't afford them. Their mission is to keep citizens safe. This includes locally and on a national level from criminals and from terrorists.

They hope that citizens would be willing to give up a small amount of personal privacy in order to live in a location where there is less crime, less drug activity, and less risk to everyone.

Chapter 3 - Future of Drones

The Future of Drones

Drones seem to be here to stay, not just a passing trend. As mentioned, the regulations are changing for them to be used commercially. They are used widely by the military and private citizens also use them. The demand for them will likely increase in the future.

Fail Safe Failure

Drones continue to be very advanced. Personal drones have a fail-safe button. When the button is pushed the drone is supposed to return to the takeoff spot. But what if it doesn't? Who has the ownership rights to drones that end up in private locations?

Recently, a man in Denver realized his drone had drifted away. The fail-safe button didn't work; the drone never returned. The value of the drone was \$ 2,000 plus \$400 for the camera installed on it. All he was left with was the transmitter. He feels like the company owes him an explanation.

He isn't the only one with such a complaint. There are numerous forums and reviews online about this very issue. With this negative publicity out there, manufacturers of drones have no choice but to improve their product design. They don't want sales of these devices to slow down due to people worrying about their investment getting away from them.

Commercial Use

We touched on this in a previous chapter, but it is worth addressing here, too. The future of drones is likely going to really grow in the commercial sector in the coming years. This is due to the fact that the FFA regulations

that ban them from such use right now will be either modified or lifted.

Price

It is anticipated that the price tag associated with drones will decrease around 2015. If that is true, then there will likely be more of them in use. For some consumers, it is cost that prevents them from making the investment.

Protecting the Borders

Illegal immigration from other countries continues into the US and continues to be a serious problem. Drones are used along with manpower to protect the borders of the US. Some pilot programs are in place, a few of the drones have actually crashed. Improvements are needed if this resource is going to be a reliable method of keeping illegals from crossing the border.

Projections

By 2017, it is estimated that there may be as many as 20,000 small drones. There are about 56 different government agencies that use drones. There are 63 active drone sites where they can be used. This doesn't include the 6 testing locations that were mentioned in a previous chapter. There are plenty of experts that

believe the 21st Century is going to be the era of drones rather than manned aircraft.

Conclusion

While drones aren't new, they continue to be modified with updated technology. Additional legislation is being incorporated to try to keep up with the advanced technology, but continues to lag behind.

Drones are here to stay. Individuals have the right to speak up about their concerns. However, citizens also have a responsibility to be educated and well informed on the topic.

The FAA and other organizations, including local governments, are working hard to come up with laws that will hold people accountable with drone use. Serious fines and even jail time for violating laws and privacy are being considered.

I hope these chapters have helped educate you and bring you a greater understanding of drones and their uses.

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, and 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?

2012-2014 saw explosive growth in the market and technology, as costs have gone down and capabilities have gone up. In 2015 this is continuing. These leaps forward were 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 this pursuit:

Aerial Photography and video-how 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 to take pictures and videos as in the photograph below. Another popular type of video is called FPV or First Person View. On this case, the drone has a camera that beams video back to a set of video goggles or a screen. This allows 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 flyers 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 meets 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 these machines.

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 potential applications of drone technology for the advancement of mankind. These range from search and rescue to mapping to crop inspection and spraying. Potential uses are only limited by your imagination. As with any such venture you need to start with a basic knowledge foundation, which is the intent of this course.

When you are finished, you should know more about the subject of drones than most of your peers and therefore be able to help others. Even better, you will be able to actually buy and fly drones successfully!

Use of Terms and Basic Definitions

Throughout this course, we will use the term “drone”, “quad” and “quadcopter” interchangeably, drone being the common use of the new media while quadcopter is more descriptive of the of the current crop of consumer models. Not all drones are quadcopters. 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.

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

Quadcopter (quad)-an aerial vehicle that 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, multicopter, etc.)

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

Basics of Operation

It's Electric

Why are the new vehicles so different than the former 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 camera 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 well over a mile in that time. More advances are assured in the future, so specifications will 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 slightly streamlined, as wind will not have as much 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. In most cases the operator will be actively giving instructions to the flying quadcopter through the use of 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), 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 your information both in and out. Here are the main inputs:

1. Power from the batteries
2. Instructions
3. Status reports from a number of tiny instruments built into the quadcopter main circuit board. These 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.

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 tilting forward, the propellers act to keep the vehicle in the air and to propel it forward simultaneously. In the case of the 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 a man 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.

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 to say that one crash or bad landing often destroyed hundreds of hours of hard and meticulous work.

By the 1960's, the 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. Other carried payloads, including small animals. In fact, your friendly author has sent mice 1,000 feet or more in padded capsules, with all returning safely to earth by parachute.

As mentioned earlier, it is the coming together of all the various electronic and electric technologies, from batteries to radios, which now allows for much more advanced vehicles. Just as importantly, advances in materials such as foam, carbon fiber and fiberglass have allowed for aerial vehicles that 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 various skills and determination to build, fix and operate, some current models can be purchased, used 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 State Army Air

Force. 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 forward flight in a favorable wind. The Army canceled the program in 1924, and the aircraft was scrapped.

Chapter 4 – Buying a Quadcopter

Buying a Quadcopter

Choose your Interest

As with any pursuit, consider what your particular interest is and how you would like to proceed in the hobby. Some examples follow:

Stress relief- flying a quadcopter engages you fully and, like sailing or many other activities, you will find all other thoughts have left your mind a good thing, in most cases! Some quadcopter pilots' use goggles with built-in monitors to achieve the true feeling of flight!

Photography/Video- Quadcopters and other drones are getting advanced enough to do some very decent imagery work! These advances will continue. By learning now, you will be in a better position to take advantage of new advances as they hit the market.

Technology/Learning- there is a LOT to learn if technology and the mechanics of flight interest you. You can delve deeply into customization, building your own quads and polishing your soldering and innovation skills.

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

First Newbie Rule of Drones

You WILL crash your quadcopter many times while you are learning 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 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 "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 motors directly mount to propellers. They weigh in as "heavyweights" at between 1 to 2.2 lb.+ (1/2 to 1+kg). You don't even want to think about what will happen if one of those fall on you or hit your car!
For newbies, either a micro or a mini will be a fine 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 too much more sophisticated PC and Mac software that can use a real R/C transmitter connected to your computer via USB. Some examples of genre and their capabilities are as follows:

Heli-X- This is a program that 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.

ARDrone Sim- This is an ipad/android app that simulates the AR Drone model quadcopter. It does not have the level of sophistication that the full-fledged programs do, but will give the beginner some idea of how these machines work. It sells for about \$2, so is probably a good purchase for any beginner who wants a short experience of the AR Drone.

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

How much money 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 \$1500+ setup and instantly dunk it in the river while taking your first video (yes, its done quite often), then it will set you back quite a bit more. Let's set a first year budget of about \$400 total for a couple small quads, extra batteries, accessories, modifications and repairs. If you decide to take a step up to much larger craft like a Phantom or Blade 350qx the total will likely be double that or more. A wider range would be from \$200-\$2,500-if you should decide, for example, to purchase a top-of-the-line consumer model like the Phantom 2 Vision + as your 2nd or 3rd multirotor.

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. Many vendors are China or Hong Kong based and some offer very good process 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 specialize 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 small vendors that 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.

Quadcopters are popular all over the world. Many people have no choice but to purchase from the Hong Kong and Chinese vendors-and there are some with very decent reputations. As always, check 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 quadcopter to have factory defects-more likely, the customer takes it out of 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 the used quadcopters -as well they shouldn't -since most damage is 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 it's 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 brand-new models of quadcopters, even from established companies. Reliability is often poor and parts are not immediately available.

Models that 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.

Wait before you get the 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, it's best to get your first quadcopter in a stripped-down model with no cam or extras.

Your Flying Grounds

Before choosing a model and size, consider your living and yard spaces where you intend to do most of your learning. 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's more than 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-\$50-\$65)- 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 -(\$40) 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.

Blade Nano QX (Micro-\$90)- if you don't mind spending the money, this is a very high quality and capable learning machine.

Syma X1, X3, X5 (Mini-\$30-\$65)- these can be ideal first quads for those on a budget who want to learn how to fly a quadcopter - the X3 and X5 have integrated propeller guards.

WL Toys V636 Skyaark (mini-\$65)- a decent machine- a newer and more advanced design.

These, of course, are not the only quadcopters that would fit a beginner, but they should give most fledging 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.

Should you consider the Parrot BeBop or AR Drone?

These are both mid-sized drones that 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 most cases, beginners would be much better off starting with lower priced and smaller quads to build up some "stick

time” using conventional R/C transmitters as opposed to the Parrot models, which are operate by a smart phone or tablet.

Note: The BeBop has an optional stick controller that adds \$400 to the cost.

How about the DJI Phantom?

DJI Phantom models are very popular “flying cameras” for video and photography. Budding pilots with little or no R/C and flying experience should start with some “toy grade” models as outlined in the following pages.

3-Axis vs. 6-Axis Stability

Another consideration when choosing a first quadcopter is whether you want to learn in a more manual fashion or have “helpers” in the form of features which make flying and control easier. Although these terms sound very technical, the summary is that 6-axis quadcopters will self-level when the operator takes their fingers off the right control stick. 3 (or 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, racing planes, etc. 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 as 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, 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 that you know is a good one for beginners. Use online reviews at Amazon or the advice of a good vendor for your final selection.

Note- 2015, 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. The knowledge gains 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, other 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.

4. Some models have motors that 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 your purchasing decision 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 \$80 or so in total.

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

Chapter 5 - Flying a Quadcopter

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 2-3 days before you plan to fly as they often lose some charge over time. Batteries that 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 owner's 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.

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, etc. and charge inside ashtray, small bowl or similar container.

PLEASE READ ABOUT SAFETY BEFORE CHARGING OR FLYING YOUR QUADCOPTER.

Becoming Familiar with your Transmitter

Most quads are sold with a transmitter 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 angle 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 your 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 a transmitter ready- and powered with the specified batteries (usually AA). Make certain that the throttle (left stick” is off (down fully towards you).
2. Insert quadcopter LiPo battery into quadcopter frame as shown in manual.
3. Connect battery leads- note, some batteries auto-connect when you inset 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. It is often necessary to move your throttle stick forward and backward slightly to “arm” your quadcopter. Certain models require other action to arm-this will be detailed in your owners manual.

That’s it! Your quadcopter is ready to fly-but 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.

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 move each have distinct names-, as do the usual flight controls that 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 (as in dance pirouettes!)

Since a quadcopter is computer controlled, they don't have the actual flaps as with a fixed wing aircraft- but if they did, 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.

Chapter 6 – Lifting off and Hovering

Lifting off and Hovering

Remove any weights that 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 1 to 2 feet off the ground, as they can be quite unstable when very close to floors, walls and ceiling. 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. Most of your early 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: YouTube will also be a good source of videos about your specific model.

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. The more room you have, the better- and outdoor area at least 50 ft. square should do nicely 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! Fly 10-29 feet forward and then pull slowly back on the right stick to bring the quad back to 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- not much different than 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 a BeBop, AR Drone or other model with automatic landing, you are going to have to learn the technique of landing. One way or another, each takeoff mean one landing- although many are what we call “unscheduled landings” (crashes). Landing can be harder than it seems, especially on 3-axis craft that 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.

Its 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 ground will harm them. Most of the suggested quadcopters can drop from a few feet up (or even higher!) to a soft surface with absolutely no damage- unless you keep the throttle on!

Next Steps in Flying

Once you are confident in the basics, its time to 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 at a time.
3. Spatial awareness- it's important to get a grasp on distances, directions, compass headings as well as wind and weather. Just 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 that 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.

Your First Modification- may be landing gear!

Now that you are learning how to fly, you may notice that your drone has certain shortcomings. Some units have props and gears very close to the ground so that landing and taking off on grass can become difficult. One of the joys of this hobby is making small improvements in and personalizing your drone...your first chance at improvement may be to install a softer or higher landing gear. Depending on the size and weight of the quad, you may use small pieces of foam, lightweight balls or cable/zip ties. The zip ties can be mounted in various ways as shown in the picture below. Small earplugs glued to the bottom of the motor mounts are often used on the micro sized quadcopters. Soft or springy landing gear provides the additional benefit of allowing for harder landings on blacktop or cement without damage to your quad.

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

Trimming your Quadcopter

If your quadcopter seems to drift in the same direction constantly, you may need to trim your transmitter

slightly. Most transmitters have four switches that can be nudged in one direction or the other to help the quad hover in a more centered fashion. As an 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. Read your manual regarding the trim buttons as they differ with various models.

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 - outside over grass if possible - and 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 Top Gun flight school. Don't fret - all is not lost!

Many of the newer (and future) quadcopters have stabilization features and some can even be programmed for autonomous flight - which 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 (like me) are all thumbs, is to research and buy the proper machines for your capabilities and needs. Models such as the DJI Phantom, Blade 350 QX and Parrot AR Drone/ BeBop 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'll 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. Most

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 my 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 in high winds.
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.

The AR Drone

In many ways, the Parrot AR Drone, released in 2010, foresaw the current boom in consumer quadcopters. Although there had been an active geek culture building and programming quads prior to that date (2005 on), the AR Drone fired up the fancy of many and was well covered in the press. A popular store was the initial primary vendor and it was sold as a “flying video game”, although I have little idea of what they meant by that! It turned out that the original AR Drone was not quite ready for prime time... lots of problems, including flyaways, inability to control, easily damaged parts, etc. were reported. Customer satisfaction was not high - yet they kept selling and interest remained.

In mid-2012, Parrot released the new AR Drone 2.0 that addressed many of the shortcomings of the 1.0 model and added a higher resolution camera. In 2013, Parrot announced various upgrades to the AR Drone, including a GPS module and longer lasting batteries. Together these may make the AR Drone capable of some autonomous flight (that is, following a series of waypoints you place on google maps, etc.). However, it remains somewhat of a “toy grade” drone that has a lot of features - but these features are limited. For example, the AR Drone performs quite poorly in even moderate wind conditions and has a very limited range-often under 100 feet.

AR Drone as a First Quad?

With all these features and a relatively low price, beginners may be enticed to start with this full featured aircraft-however, you keep the following in mind:

1. A beginner cannot reliably fly the AR Drone indoors - the literature may mention it, but anything short of a warehouse is going to feel very small.
2. The AR Drone does not use a standard R/ C Controller, but is instead controlled by smartphone or tablet computer. This generally means shorter range and that the hours you spend learning and flying an AR Drone will not help you as much when you later switch to standard R/ C type transmitters.
3. Parts for the AR Drone (and larger quadcopters in general) are more expensive - meaning if you crash often and hard (and you WILL crash), it will cost you more to repair than a mini or micro.

AR Drone 2.0 as 2nd or 3rd Quad?

The real key with quadcopters is to get enough experience under your belt to truly know what you want to do with them! If you are interested in “sport” flying and racings, the AR is not for you. Its specialty is

very stable flight in low wind conditions. It also has some advantages such as relatively low replacement parts cost, safer “cutoff” which stops the propellers when they hit anything (including you), etc.

Parrot has recently released the BeBop drone that starts at \$ 500 and is far more advanced than the AR Drone. This is also not for beginners, as flying it involved a technical understanding of its flight systems (calibration, GPS, return to home, etc.).

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 it take? This depends on aptitude as well as a number of other factors such as your age, your familiarity with 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 more interested in taking videos? Or on flying fast, doing flips and racing? Or, are you technical and does the idea of building and modifying drones 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 your 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 upwards in size.

Size Ranges, Models and Costs

Mini and micro quadcopters usually sell for prices from \$40 to \$120. There are a few premium models which retail for as high as \$150-\$200. These drones generally weigh in at about 3 ounces. However, the next steps up in size tend to be a whopper. Most mid-sized quads weigh in at 1-2 lbs. with battery, meaning they are 5 to 10 times the weight of the Minis. It is somewhat of a mystery why the manufacturers don't produce a mid-range (4-12 oz.) line of drones, but as of this writing

very little is available in that weight class. As of mid-2014, some new units are available in the mid-sized range. They include the Blade 200QX, WL v262, Eye One Xtreme, and the Skyartec Butterfly.

In the realm of larger quadcopters, models such as the DJI Phantom series and the Blade 350QX are in the more compact range - large enough to fly GoPro or similar cameras and easier to see at a distance, without being overly large or complicated. A number of knock-offs of the DJI Phantom are also available, although these lack the ease of use and track record of the real thing. In terms of price, you can spend from \$450-\$1400 + on the more advanced machines from well-known makers. The more expensive models feature built-in cameras and other upgrades. We recently published a book detailing the DJI Phantom Quadcopters.

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 that 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 part 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 bang for the buck 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 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 multi-rotors. 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).

Boom Replacement

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, etc. 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.

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 a decent percentage of your cost by selling it for its parts content! For example, just your transmitter, which probably never sustained damage, could be worth \$ 15 or so. Add to it some of the parts from your hulk, and you may be able to get \$ 25 or more for what is left of your quadcopter. There are websites where you could consider selling your parts. Be sure to accurately describe your sale so your buyer and you remain happy after the transaction.

Repair and upkeep is a big part of the enjoyment for many people... but if flying is your only goal, the “ use it and then sell it” 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. Yet another 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 approach \$

35 each when on sale - so the cost for two would still be less than \$ 70.

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 can be nice
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-\$ 2-) - 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 dollar store!

A Primer on Aerial Photography and Video

The idea of taking pictures and videos from 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 very likely to crash, lose or otherwise come to a bad end before they 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) vs. Aerial Photography (AP)

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 quad has landed. Mini-quadcopters with built in cameras and controls can be found for as little as \$80 - 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 this 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.

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 -

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 turned on and off 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 - (\$ 75-\$ 90) - A new entry 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 new Eye One Extreme, etc.

GoPro and other Sport Cameras (\$ 90-\$ 400) - These are specially made for action - both shockproof and lightweight. Mid sized quadcopters (total weight usually 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 AR Drone features a built-in front-facing camera that provides medium resolution images and FPV on a tablet or smartphone. It is the most inexpensive package with all these features, however it comes with limitations such as a shorter range and lack of ability to fly in higher winds. See the chapter on the AR Drone and other information in this book for more detail.

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 semi-pro aerial photography requires more expensive and heavier quadcopters along with better cameras. Some of the upscale models of drones even fly DLSR's that 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:

(APV=takes video FPV=takes video and allow you to see what the quad sees)

\$80-\$100-WL Toys V959/V222-APV only

\$200-Micro and Mini FPV/APV models such as the Hubsan FPV 107D (X4) and other models from Walkera.

\$300-AR Drone by Parrot-FPV and APV-or v262 with Mobius and bargain FPV setup

\$500-\$1200+ -Full size quadcopters with GoPro type cameras and APV/FPV system installed.

DIY hobbyists can put together systems in just about any price range from as low as \$100.

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 98% 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.
2. You want to delve further into the hobby in terms of 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 either photography/video or for flying enjoyment (acrobatics, flips, racing or just messing around), but don’t want to delve too deep into the nuts and bolts.

We won’t go too deep into all the technical details, but a basic introduction on how to “step up” follows.

Programmable R/C Transmitters

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

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 often sold without a TX, so the budding hobbyist may need to learn about various models.

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 will have to join the “club” and slog your way through learning these flight controllers.

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, models, 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 market of larger drones may be able to avoid having to program and bind these multi-model Transmitters to their new models.

Chapter 7 – Your Next Quadcopter

Your Next Quadcopter

It's time to decide on your next drone-to buy and fly along with a more advanced TX. It's best to start with something small and inexpensive so you learn how the programmable TX works without too much expense. Here are a couple of suggestions for your next quad:

One of your existing micro quads- Some of the mini quads such as the Syma X1, the WL Toys 929,949,959 and others can "bind" to many of the popular programmable transmitters. This means getting the feel of the larger TX and learning about some of the settings while using an inexpensive existing quadcopter.

A small step up? The RClogger Xtreme and the Blade 200qx are examples of small quadcopters with powerful brushless motors and higher quality components. Both can be purchased either with a small matching TX or can be matched to larger hobbyist R/C multi-use transmitters.

If you decide to go for a bigger quadcopter for experimentation with cameras-but aren't ready yet to go for bigger budget (>\$1000) units with integrated cameras, consider these models:

Blade 350QX
Phantom 1 or FC40
Phantom 2 (bare)
3DR Iris+

There are also numerous “Phantom clones” on the market however, we hesitate recommending them due to lack of support and various quality control problems. Do your research on the particular models you select and make certain your money is well spent.

Chapter 8 – 10 Step Quick Start

So, you’ve just purchased your first remote-control drone or quadcopter. Maybe you’ve purchased something tiny like the Hubsan X4-or something larger and more powerful, like the DJI Phantom-and now you need to learn how to fly it safely and capably. This sort guide will help you develop the skills you need-and not just to hover your drone in place. With practice, you’ll be flying like a rabid bird that drank too much coffee-because even modest little micro-quadcopters are capable of some pretty insane maneuvers!

Know Your Equipment

It is important to study the various modes your drone is capable of before you really start practicing in earnest. For example, on the Hubsan X4, you can click the right stick downward to turn on “expert” mode. This selection really should be turned on for any outdoor flying, in order to avoid having your drone carried away by the wind. The beginner mode offers good practice opportunities only for when you are first getting started, or if you are flying in confined spaces, like a small living room. You will also need to be able to discern when your batteries are losing their charge. Most drones provide some sort of visual warning in the onboard light display, while others will simply lose their ability to gain altitude. You do not want to push your batteries too hard, because you can damage them in this way, permanently decreasing flight times and battery discharge rates.

How to get the most from this 10-Day Program

This program is designed to get you accustomed to flying a drone by going through intentionally confusing and challenging orientations, so you will be able to fly around super-capably at the end of ten days. All it takes is less than twenty minutes per day of mildly – challenging practice, and if you take the time, you will be rewarded with a unique skillset that countless people fail to develop after buying their first drone.

Stick with the plan, and you'll soon be buzzing around your yard with speed and precision. In my experience, the flights given here last about 7 minutes each, so you'll need to fly at least three times per day to maximize your training time.

Flight-Control Basics

The left stick operated the throttle on the vertical Y-axis, and makes the drone go up and down. The left stick also operates the rudder, or yaw, on the horizontal X-axis, causing the drone to rotate to the right or left.

The right stick controls the pitch of the drone, and it is easy to understand as long as the tail of the drone is facing you. Push the right stick forward to pitch forward and go forward; pull backward to pitch backwards and go backwards; push right and left to allow the drone to pitch right and left, moving in your desired direction.

Crashes are bound to happen, so you'll want to do whatever you can ahead of time to mitigate potential damage. I recommend flying outside when it is not too windy. I like grassy fields, and I avoid taking off from dirt patches in order to keep all of the sensitive electronics on my drones clean. If you realize you are going to unavoidably crash or collide with something, bring the throttle all the way back to zero as fast as you possibly can. This will prevent all kinds of excessive

damage, because it is better to fall gently onto grass from 10 feet up than to fly full-throttle into a tree (or even the grass). This could break your propellers, or worse.

The 10-Day Program

I have divided your practice time into drills instead of days, and even if you already have a bit experience flying RC's, it would be wise to run through the basic drills at least a few times. This will help you to develop a better sense of your drone's capabilities. If you can already easily and repeatedly fly a drill without mistakes, you are probably ready to graduate to the next drill. The most important thing is to keep practicing, even if it feels like you are not making progress. Exercise your discipline to follow a difficult drill for 20 minutes. Your brain will start digesting the new information, and within a few days, you will notice a dramatic increase in your flying ability. Take ample time to fly these drills as I have described them, and you will become a great drone pilot!

On Day 1, fly Drill #2 at least 3 times, and make sure you get about 20 minutes of dedicated practice in. When you come back the next day, try flying the same drill again, and see if you are better at it than the day before. If you have improved to the point where you feel confident in your ability to complete that skill, you are ready to fly the next drill!

Drill #1: Take off smoothly and raise your drone to eye level, holding it here for a count of 5. Use tiny adjustments on the right, tick to keep it in the same spot. You want it to go up smoothly, and hang directly in front of your face; then smoothly cut the throttle to land back in the same spot you took off from. As you become more skilled, you can add a small amount of throttle just as you are touching down to effectuate a smother landing.

Drill #2: Take off smoothly, and bring your drone to eye level again. This time, fly the drone 5 feet to the left by pressing the right stick left. Fly back to a place directly in front of you, and stop. Next, fly 5 feet to the right, and stop before returning to a place directly in front of you. You will need to make minor adjustments in every direction with both the right stick and left stick in order to keep the drone at the same altitude and flying along the same track.

Drill #3: Take off smoothly, and bring the drone to a steady hover in front of you. Next, fly it away from you by pushing the stick forward, and have it stop 5 feet away. Hover, and return your drone to its original position. Now would be a good time to start paying attention to how the drone looks as it flies away from you and toward you, because this will become much more important as you start flying further away.

Drill #4: This is a combination of the previous two drills. Take off, and bring your drone to eye level. Fly 5 feet to the left, stop for a count of 3, then fly past center and go 5 feet to the right. Stop for a count of 3, and then return to center. Now fly 5 feet away from you. Stop for a count of 3, and return to center. You are flying in a PLUS-sign formation.

Drill #5: Learning to Yaw. Take off and hover at eye level. Slowly press the left stick to the left until your drone yaws about 90 degrees to the left. Pause and then return the drone to its original position. Now do the same thing to the right. While you are doing this, remember to try to keep the drone in the same spot in front of you. The idea is to help your brain start to understand what happens when the drone is not oriented perfectly, i.e., with its tail toward you.

Drill #6: Take off and rise to eye level. Make a 90-degree turn to the left, so that the left side of the drone is facing you. Now, lightly press the right stick forward. The drone will start moving forward, but going off to the left. Stop after 5 feet, and press the left stick slowly to the right, turning the drone around 180 degrees. Now, slowly press the right stick forward. Bring the drone back, past eye level, and fly to the right of your. Stop, yaw using the left stick 180 degrees to the left, and fly back to center. This is my favorite drill, and if you practice it often, your skills will improve rapidly.

Drill #7: Nose- In Hover. Take off and rise to eye level. Slowly yaw the drone around by using your left stick until the front (or nose) of the drone is facing you. Try to keep the drone nice and steady, making tiny corrections as you go. Remember that the controls on the right stick are all reversed. I try to pretend that I am actually in the aircraft. Alternatively, I turn around and look over my shoulder when I need to practice flying nose-in. The nose-in hover is one of the most difficult skills to master, and every minute you spend in this position will dramatically improve your flying.

Drill #8: Flying Straight Away and Flying Back. The goal of this drill is to stay on a straight flight path away from your body. Stop and turn the drone, then fly directly back, and repeat. This gives you the chance to start getting used to flying toward yourself with the nose facing you. It is important to focus: make the stop before you turn, and keep your flight controlled. This is a challenging maneuver so don't get discouraged. If you've made it this far, you are already way ahead of most people who fly drones!

Drill #9: Turning While Flying Forward. The previous drills required you to focus on staying oriented, allowing your brain to understand how your drone might behave in strange orientations. This exercise is similar to Drill #7, except you will now fly further out and then using the left stick in combination with the right stick to execute a smooth, banked turn at each

turn around point. At first, these will be sloppy, but they will improve as you become accustomed to making the necessary, tiny adjustment on the two sticks. Take off and get your drone to eye level. Yaw to the left using the left stick, and push the drone into forward flight using the right stick. As you approach your turnaround location, keep the forward stick pressed forward while adding in some yaw to the right. Simultaneously, add a little bit of right stick to the right. This will cause your drone to bank. This takes practice to execute smoothly, but if you have mastered the previous drills, you should see improvements happen very quickly.

Drill #10: the figure-8. This is the ultimate training drill once you have mastered the previous nine drills, because it pulls a little bit from each of your skills. You can start by flying your drone in a slow figure-8, stopping at difficult locations to make adjustments. Slowly, begin to make faster and tighter figure-8's, until each circle of the 8 is of the same size and altitude.

What's Next?

If you have followed my plan, you've spent less than 4 hours improving your ability. If you keep working on the advanced drill for another 4 hours, your skills will continue to improve at a rapid pace-just think about how good you can be! You are now ready to invest in a bigger drone, which will actually be much easier to fly than a micro-quadcopter. You'll be able to fly your new

drone safely, with confidence and skill. You'll even have the option of getting started in the exciting world of aerial photography and First Person Viewing. (FPV)

Business Insider estimates that 12% of an estimated \$98 billion in cumulative global spending on aerial drones over the next decade will be for commercial purposes.

Here are some of the issues and opportunities that will impact how the drone industry develops over the next several years:

- **American regulators plan to phase in commercial drone flights beginning in 2015**, starting with limited flights of small drones weighing 55 pounds or less.
- Retail and e-commerce — along with the related logistics and shipping industries — arguably have the most at stake in the wide deployment of civilian and commercial unmanned aerial vehicles, or UAVs. Drones might be the missing link in the shipping chain that allows for nearly immediate e-commerce deliveries. But there are few industries that couldn't potentially be touched by drones, especially on the enterprise side.
- Currently, military applications dominate the global UAV market, but commercial applications will quickly ramp up over the next 10 years, particularly after 2020.

- **Privacy and safety concerns still pose the risk of slowing commercial drone flights in many markets**, but if UAVs are rolled out gradually we believe the benefits of drone-powered commercial applications, such as environmental monitoring and shipping, will ultimately win public opinion over.

Search and Rescue: The price tag of typical search and rescue (SAR) operation is anything but typical. It all depends on the scenario. Some rescues only take a few hours, and some volunteer manpower. Others involve high-altitude helicopters, rescue boats and teams of paid employees over the course of several days. Consider that the average cost to power a standard helicopter is about \$1,600 per hour and you can see how the costs can mount in a hurry, and you can see why we believe that out of all the industries both commercial and private, SAR could benefit the most from the use of UAVs.

Precision Agriculture: Using as a tool for crop surveying can drastically increase a farms yields while minimizing cost to the farmer and benefits to the consumer. Some of the benefits of using drones for precision agriculture are: Increased yields, Time saving, Quick return on initial investment and ease of use to name a few.

Movies, media and more: If you've watched TV in the past year, chances are you've seen your share of drone footage. From the Discovery channel to CNN, news sources, TV crews and big budget films are all capitalizing on the use of drones today.

Economic benefits: According to recent report the drone industry is expected to explode of the next decade, with the global drone industries projected gross income upwards of \$100 billion dollars over the few years. Private-sector drones alone will create more than 70,000 jobs within three years and will pump more than \$82 billion into the U.S. economy by 2025. Letting economical opportunities like these slip us by due to the lack of proper FAA regulations is not only illogical, but also irresponsible. We need regulations to accommodate the drone industry as well address safety concerns for commercial pilots and the average American citizen.

FAA Information

First and foremost we should know that the FAA can't make up laws – they can only develop guidelines and regulations. The federal government has no authority whatsoever to regulate the operation of remote-

controlled model aircraft, but they do have the authority to regulate the airspace in which we fly. In 2010, discussions of the FAA's UAV regulations NPRM (*Notice of Proposed Rulemaking*) began for public commenting through mid 2011. These deadlines have been continually extended to the present day.

The FAA has been enforcing the same rules and regulations that were established in 1981. And that has made it nearly impossible for commercial services, law enforcement and industrial services, among many other bright opportunistic companies to get full, proper authorization to use sUAVs.

That being said let get into the heart of the matter...

Part A. Statutory Requirements

On February 14, 2012, the President signed into law the FAA Modernization and Reform Act of 2012, which established, in Section 336, a "special rule for model aircraft." In Section 336, Congress confirmed the FAA's long-standing position that model aircraft are aircraft. Under the terms of the Act, a model aircraft is defined as "an unmanned aircraft" that is "

- (1) capable of sustained flight in the atmosphere;
- (2) flown within visual line of sight of the person operating the aircraft; and
- (3) flown for hobby or recreational purposes."

Section 336 also prohibits the FAA from promulgating "any rule or regulation regarding a model aircraft, or an aircraft being developed as a model aircraft" if the following statutory requirements are met:

- the aircraft is flown strictly for hobby or recreational use;
- the aircraft is operated in accordance with a community-based set of safety guidelines and within the programming of a nationwide community-based organization;
- the aircraft is limited to not more than 55 pounds unless otherwise certified through a design, construction, inspection, flight test, and operational safety program administered by a community-based organization;
- the aircraft is operated in a manner that does not interfere with and gives way to any manned aircraft; and
- when flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower ... with prior notice of the operation....

Thus, based on the language of the statute, we conclude that aircraft that meet the statutory definition and operational requirements, as described above, would be exempt from future FAA rulemaking action specifically regarding model aircraft. Model aircraft that do not meet these statutory requirements are nonetheless unmanned aircraft, and as such, are subject to all existing FAA regulations, as well as future rulemaking action, and the FAA intends to apply its regulations to such unmanned aircraft.

Additionally, model aircraft are limited to 55 pounds or less. The statutory language does not specify whether it

applies to 55 pounds unloaded or 55 pounds with other equipment, payload, or fuel, for example. The FAA believes that Congress intended for the 55-pound limit to mean the weight of the aircraft at the time of the operation. If the weight of the aircraft, alone, was the determining factor then it could conceivably be loaded with equipment or payload increasing the weight of the aircraft at time of takeoff well in excess of 55 pounds, thereby increasing the risk of harm should the operation not proceed as planned. The weight at the time of operation is also consistent with the FAA's designation of small or large aircraft, which is determined by an aircraft's maximum certificated takeoff weight...

For further information see the

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 91

[Docket No. FAA-2014-0396]

Interpretation of the Special Rule for Model Aircraft

Privacy concerns

Public perception

Pre-flight inspection checklist

AMA (American Modelers Association) rules,
regulations and recommendations

FAA Rules and Regulations

Chapter 9 Quizzes

Quizzes

Attached are quiz questions for you to self-grade and evaluate your readiness for your written graded final exam.

Thank you.

1. The US Coast Guard believes that the use of drones can help increase prosecutions by what percentage?
2. What types of commercial businesses are trying to get approved for drone use?
3. What can the average person use drones for?
4. It's estimated by 2017 there could be how many estimated small drones in use?
5. Quadcopters are basically motors and propellers that can only fly with the help of what?
6. Before choosing a model and size drone to purchase, make sure to consider what spaces?

7. What are considered the tools of the trade?
8. When landing, turn the throttle down to?
9. Plug in your quadcopter while on level ground and leave it level for how many seconds?
10. What's the first thing to do when you unpack your new drone?