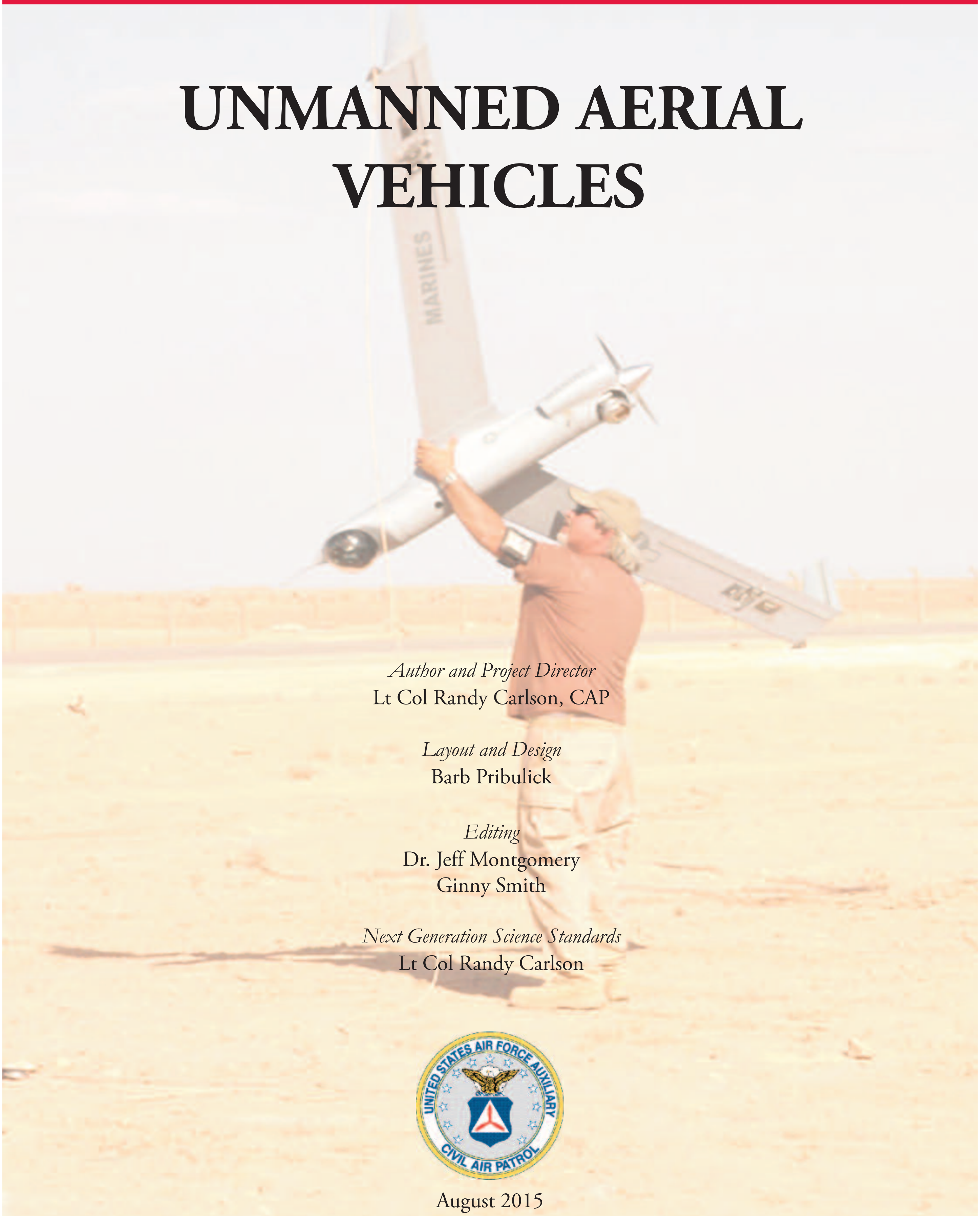
UNMANNED AERIAL VEHICLES (UAVs)

ACTIVITY BOOKLET

Aerospace Education EXcellence

As a companion to AEX MARC II Module



UNMANNED AERIAL VEHICLES

Author and Project Director
Lt Col Randy Carlson, CAP

Layout and Design
Barb Pribulick

Editing
Dr. Jeff Montgomery
Ginny Smith

Next Generation Science Standards
Lt Col Randy Carlson

August 2015

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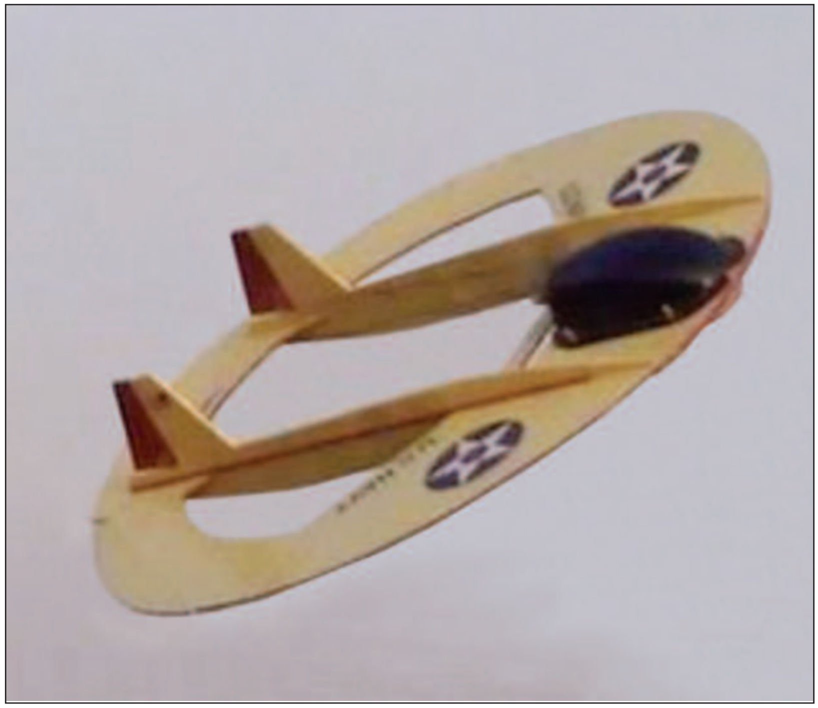


This booklet covering unmanned aerial vehicles (UAVs) and "small" unmanned aircraft (sUAVs) was designed to provide an additional resource for CAP cadets and senior members who wish to study and experience more about remote controlled (RC) aircraft operations, applications and careers associated with them. The activities in this booklet can be used for those participating in the Civil Air Patrol Aerospace Education Excellence (AEX) Award Program, and as a compendium to the AEX Model Airplane and Remote Control activity booklets. Activities in this booklet can be done in any order as fits with an Aerospace Education (AE) Program.

The Science Standards used in this information and activity booklet come from the Next Generation Science Standards. These standards are based on the *Framework for K-12 Science Education* developed by the National Research Council. The *Framework* outlines three dimensions that are needed to provide students a high quality science education. The integration of these three dimensions provides students with a context of science, how science knowledge is acquired and understood, and how sciences are connected through concepts that have universal meaning across disciplines. The Framework's three dimensions are: practices, crosscutting concepts, and Disciplinary Core Ideas including physical science, engineering, technology, and applications of science.

The *Framework* specifies two core ideas that relate science, technology, society, and the environment: the interdependence of science, engineering and technology, and the influence of science, engineering, and technology on society and the natural world.

To find out more about NGSS, go to http://www.nextgenscience.org

What is an sUAV, UAS, or UAV in general terms?

A ***Drone*** is a newish term for a very old concept: a remote controlled aircraft referred to as Unmanned Aerial Vehicle (UAV), or System (UAS). Kids had remote controlled toy helicopters and airplanes ten years ago, but nobody called them drones. A drone in the public sector has connotations of something snooping around or zapping bad guys. In the Civil Air Patrol we need to remember this and try to refer to RC aircraft that we fly in our units, in the Model Airplane and Remote Control (MARC) Program, and within the AMA umbrella as sUAV or "small" UAVs. This will put our hobby, sport and CAP in a more "friendly" light.

Drones are remote controlled vehicles that are much smarter than the sUAVs we're used to handling in a vacant lot or an RC flying field. There are military drones, which can spy or even fight for us, and there are hobbyist sUAVs or drones, which require some assembly and create the desire to fly them every weekend. Full scale drones come in fixed wing, helicopter, and quad-copter configurations. In the following chapters we will look at several full-scale Drones currently being used by our government and Department of Defense (DOD).

"Drones" are probably the most advanced equipment in the field of robotics, aeronautics, and electronics. The technical name of drones is **"Unmanned Aerial Vehicles"** (UAVs). They are aerial vehicles which come in wide varieties of sizes, shapes and functions, and are controlled either by remote or control systems from the ground. They are generally used to carry out tasks in which manned flight is considered to be risky. Drones mostly find use in military services but are now finding uses in various civilian operations, such as search and rescue, weather analysis etc. These applications will be looked into in a following chapter.

There are hobbyist drones/sUAVs, which you can fly the day you buy one. For $300, you can get the first popular flying drone, the Parrot AR.Drone. You fly it using your phone as a remote control. The AR.Drone is smart enough to land and take off by itself, to hover in one place when you take your hands off the controls, and even to stop flying away from you if it goes out of range from your phone. It takes pictures and videos, and it's a lot of fun. Flying this AR.Drone UAV should only whet your appetite for more RC flying, but the skills needed to support and fly the working sUAV, UAS, and drones begin with learning to fly an RC airplane or helicopter and mastering those skills.

We had to wait until recently to see the first drones involved in civil use. The potentials appeared so big they caught the attention of public entities and private companies and the amateur hobbyists as well.

The scopes and technologies of drones vary depending on the tools and applications installed on and inside them. For example, thanks to the *installation of a video camera* on it, it is possible to take images and to use the drone for videos and mapping. Also this increases the number of hobbyists who have combined their passion for aerial photography to the one for modeling and have begun to use the drones for pleasure.

In Italy, for instance, after this increase, the ENAC (National Entity for Civil Aviation) enacted in January 2014 the first regulation for pilotless flights, making a distinction between two classes of Remotely Piloted Aircraft (RPAs); the first, lighter than 25kg and the other heavier (with a mention of the band under 2 kg MTOW): what is often neglected by the public opinion is that, over the military and hobbyist scopes the drones are used for, there is a huge variety of applications, born and implemented during the '90s, regarding the *civil use of drones*. Most of the world today has laws and regulations monitoring the flying of drones or RPAs. The applications drones are used for in the civil arena are many, and the numbers grow constantly.

They include monitoring ports, airports, nuclear power plants or other sensitive sites to prevent terrorist acts; the collection of samples of toxic clouds; measures to defend the population; fire fighting or prevention of natural disasters (especially floods).

The drones, in a span of 100 years, have thus become a crucial tool for saving the lives of civilians, managing to purge the past reputation due, as always, not to the instrument itself but to its use. The Remotely Piloted Vehicle (RPVs) on the top right is associated with war, the one on the right for archaeology. One drops munitions, the other takes photos of historic sites for analysis to expand man's knowledge of the world in which we live.

According to Lt. Col. Leslie Pratt of the U.S Air Force in an article, journalists who cover unmanned aerial vehicles wrangle endlessly with a very particular word choice. If you let slip the word "drone" in the company of Air Force officers, you'll have to figure out whether it's better to quickly settle the bar bill or head for the door before things get hairy. A remotely piloted aircraft — a Predator or a Reaper — is not a drone, Air Force officers will tell you, and to call it that is practically like spitting on their shoes. A drone, the patient ones will explain, is a target for training. It's nothing like a complex weapon of war or surveillance.

But on top of this, one senses that the "D" word is pejorative because of its connotations. A drone is like a male honeybee: useless and without a sting. Maj. Mary Danner-Jones, an Air Force spokeswoman, was diplomatic "… There are some people," she explained, "who are offended by it." So, for the rest of us, as we write and talk about these aircraft that fly around the sky while controlled by people on the ground — what do we call them? Most of the military services and the manufacturers call them unmanned aerial vehicles (UAVs). General Atomics calls its Predator an "unmanned aerial system (UAS)." The Air Force begs to differ. "They are not 'unmanned,'" Danner-Jones points out. "There is that interface with the machine and the pilot. You have human involvement in every step."

So the Air Force, alone among the military services, uses the term "remotely piloted aircraft," or RPA. It's a tip of the hat to the pilots flying them from the ground. But what we call these things is no longer solely the purview of specialists. White House press secretary Jay Carney talked about "drone strikes" and the "drone program." Sen. Rand Paul, R-KY., droned on for 13 hours of filibuster talking about drones. And *Time* magazine featured "Rise of the Drones" on a February cover story, while *National Geographic* magazine recently ran a story called "The Drones Come Home."

Internationally, it is just as messy. The U.N. special reporter on human rights and counterterrorism specifically uses the word drones, but the U.N. undersecretary general for peacekeeping operations told reporters, "I would not use the word drones." He prefers "unmanned aerial vehicles (UAVs)." The confusion over what to call a UAV goes back decades.

"In the 1940s and 1950s, unmanned aircraft were usually referred to as 'drones' or 'pilotless aircraft." Lt. Col. Lawrence Spinetta wrote in his 2012 dissertation, "Remote Possibilities: Explaining Innovations in Airpower." He goes on: "…By the 1960s, the term RPV came into fashion. UAV appeared in the 1980s. For a while, the 'U' in UAV changed from 'unmanned' to 'uninhabited' before mutating back to 'unmanned'." A modern milepost in the changing vernacular came in 2003, when Air Force Chief of Staff Gen. John Jumper stepped into the fray.

"We are going to take this whole notion of UAVs and remotely piloted vehicles and change the name to remotely piloted aircraft," Jumper told an audience at the Wyndham Palace in Orlando, Florida. Ultimately, the Air Force may need to be forgiving about what people call RPAs. Even the "DoD Dictionary of Military Terms" mentions UAV and UAS and RPV. Interestingly, it does not reference RPAs.

And does it matter? Doesn't a Patagonian tooth fish taste as good as a Chilean sea bass? (For the record, yes: They are the same fish.) To those who fly them, it matters indeed. Clarity and precise language matter. But that's why it's not a simple puzzle. Language is not jargon. Spinetta, himself an RPA pilot, seems resigned to the "D" word. "Drone", he says, inaccurate though it may be, has become "part of the lexicon."

This article appears in the April issue of C4ISR Journal by ARAM ROSTON

History of Drones or RC aircraft

Many of you have already found out that an English synonym of "…to buzz" is "…to drone".

Maybe few of you know that also the German word "drone," intended as the male bee, is Drohnen. And actually, it's this flying animal that the name of the flying technologic object comes after.

Drones, also known as UAS (unmanned aerial systems), or simply RPA (remotely piloted aircraft), have become increasingly popular and well-known although their endless and multifaceted potential has been long ignored. Let's go deeper into the history of this "misunderstood genius" and find out what is a drone or target drone?

Courtesy: AerialClick.com

Drones have a long history. One of the first recorded usages of drones was by Austrians on August 22, 1849. They launched some 200 pilotless balloons mounted with bombs against the city of Venice. And less than two decades later, balloons were flown in the U.S. Civil War in 1862, with both Confederate and Union forces using them for reconnaissance and bombing sorties. Fast forward over twenty years to 1898, during the Spanish-American War, and we find the U.S. military fitting a camera to a kite, producing the first ever aerial reconnaissance photos.

The origins of the modern drone can be traced to the "target drones" used in the early twentieth century. These "dumb" drones were used to test and train combat pilots, missilemen, and anti-aircraft gunners.

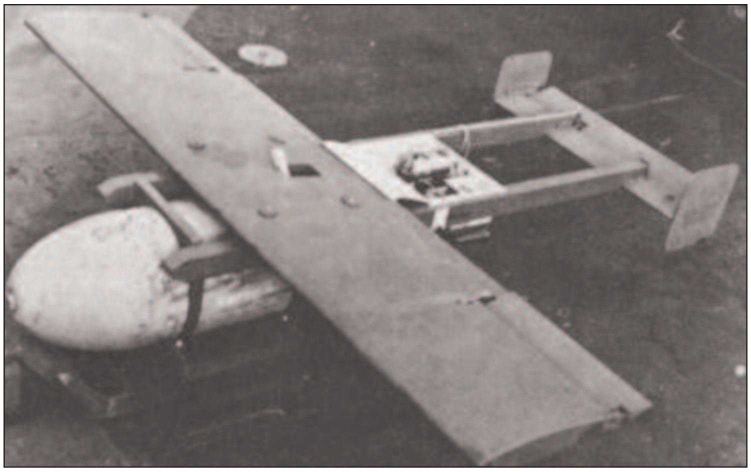
This technology first emerged in the First World War. The "grandfather" drone was the rail-launched Kettering Aerial Torpedo "Bug," developed in 1917 by the Dayton-Wright Airplane Company. The Bug was essentially an unmanned aerial torpedo – pilotless and guided by preset controls. "After a predetermined length of time, a control closed an electrical circuit, which shut off the engine. Then, the wings were released, causing the Bug to plunge to Earth – where its 180 pounds of explosive detonated on impact." (National Museum of the Air Force) At the same time, in 1917, Elmer Sperry—pioneer of the gyroscope—began construction of the radio-controlled "Aerial Torpedo" or "Flying Bomb." The Aerial Torpedo was able to fly 50 miles carrying a 300 pound bomb. And so, both the Bug and the Aerial Torpedo became early forerunners to contemporary cruise missiles. But both were largely inaccurate and the drone race was put on hold.

The late 1930s saw an increase military interest in remotely controlled vehicles, out of which emerged the second generation "Bug," as well as the "Bat" – a radio-controlled glide bomb used toward the end of the Second World War. In the mid-1940s the lethal "GB-1" Glide Bomb was developed to bypass German air defenses.

It was a workable glider fitted to a standard 1,000 or 2,000-pound bomb. Made with plywood wings, rudders, and controlled by radio, the GB-1s were dropped from B-17s and then guided by bombardiers to their target below. In 1943, one hundred and eight GB-1s were dropped on Cologne causing heavy damage (p.181). Later in the same war came the GB-4, or the "Robin", becoming the first "television-guided weapon" (p.181). Although potentially revolutionary, the crude image would only function with

WWI era Aerial Torpedo

Courtesy: Wikipedia



GB-1 Glide Bomb

sufficient detail in all but the best atmospheric conditions.

During this period, the English-based effort known as "Operation Aphrodite" began. The aim was to strike German research laboratories that were concealed in bunkers. The plan was to take B-17 "Flying Fortress" and B-24 bombers, strip them down, and cram them full of high explosives. Manned crews would then pilot the plane for the first part of its orbit, but parachute out once the plane had crossed the English Channel into Europe. At this time, a manned "mothership" would take control, receiving live feed from an onboard television camera fitted in the cockpit.

Aphrodite was a failure. It even claimed the life of Joseph Kennedy Jr., when his B-17 exploded over the English countryside before he and his co-pilot were able to parachute. But the military was not about to give up: the development of Aphrodite, together with the strides the Germans were making with the V1 and the more sophisticated V2 missile, accelerated the development of U.S. unmanned projects.

According to Dickson, in late 1946 a special

B-17

"Pilotless Aircraft Branch" of the U.S. Air Force was established to develop three types of drones for use as training targets. Of the three, the airborne-launched Q-2 was the most important and ambitious, becoming the "father" of a new class of drones built by the Ryan Aeronautical Company, beginning in the early 1950s. Ryan called these new models its "Firebees," and went on to sell 4,000 of the jet-propelled drones (Dickson, p.183). The early Q-2/Firebee could stay in flight for up to two hours, was capable of flying up to 60,000 feet, and could reach speeds of 500 knots. As Dickson goes on to say, "Virtually every antiaircraft system the nation has developed has had to prove its worth by downing a batch of elusive Firebees" (p.183). In the mid-1950s, Sperry rigged an F-80 fighter so that it could be flown automatically to fetch radioactive atmospheric samples. Even so, the drone remained almost exclusively a "target" for training up to, and throughout the 1960s.

A target drone is an unmanned aerial vehicle, generally remote controlled, usually used in the training of anti-aircraft weapons crews, and fighter pilots training with air-to-air missiles. Obsolete jet and propeller-powered aircraft (such as the Fairey Firefly, Gloster Meteor and de Havilland Sea Vixen used at RAE Llanbedr between the 1950s and 1990s) have also been modified into remote controlled drones, but such modifications are costly.

More modern drones may use countermeasures, radar, and similar systems to mimic manned aircraft. More advanced drones are made from large, old anti-ship missiles which had their warheads removed.

Courtesy: Wikipedia

QF-100 Target Drone

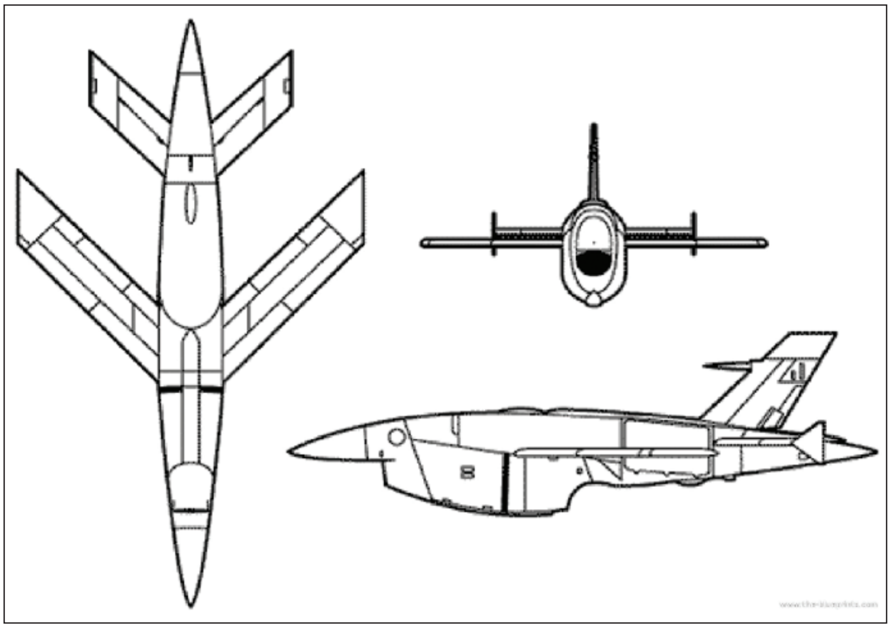
QF-100

209 F-100D and F models were ordered and converted to unmanned radio-controlled FSAT (Full Scale Aerial Target) drone and drone directors for testing and destruction by modern air-to-air missiles used by current U.S. Air Force fighter jets in the 1980s.

The Ryan Firebee has proven remarkably successful and is still in operation with the US Navy and Air Force. The Firebee also has served with the Canadian Armed Forces and the Japanese Self-Defense Forces, with Japanese Firebees built by Fuji Heavy Industries. A small number were also supplied to NATO programs. More than 7,000 Firebees have been built, with 1,280 of them being the first generation variants.

The history of drones as information gathering systems goes back to during the U.S. involvement in North and South Vietnam between 1965 and 1973, the region proved to be a

The Ryan Firebee



"laboratory" for the testing of advanced American technology. The "electronic battlefield" was (at the time) a radical doctrine that aimed to map the entire battlespace with sensors and automated, mechanic responses. The "McNamara Line" as it was known by its detractors, aimed to cover vast swathes of territory below the DMZ and into Laos with acoustic and seismic sensors that could detect human and truck movements. This data was then broadcast to overhead aircraft, which transmitted the radio signal on to a "nerve center" in Thailand, which in turn computed the data, generated a target, and then guided bombers to a designated strike area.

As part of this automating of the battlespace, the Air Force began populating the region with remotely piloted vehicles (RPVs). The evolution of the U.S. drone can be understood as the passage of three overlapping phases: (1) the drone as a "target" (1910s-1950s), (2) the drone as a "sensor" (1960s-1990s), (3) the drone as a "weapon" (2000s-today).

In 1962 drones were used for reconnaissance in Cuba; and in 1963, Ryan-147 "Lightening Bug" drones were used for spying in North Vietnam, Laos, and the People's Republic of China. Some of these Firebees—which were launched by C-130 motherships—were downed over China in 1964 and 1965. Such was the extent of drone intelligence gathering during this time: "The US had given the lion's share of its close-in surveillance work in Asia to the Ryan drones" (Dickson, p.188). The Air Force stated that approximately 3,000 unmanned missions were flown in Southeast Asia (p.188). Indeed, "About 85 percent of the photos taken to assess bomb damage during the period were brought home by these automated craft. Often unknown to both those who looked at them and those that published them, many of the aerial views of North Vietnam that appeared in the American press were taken by the drones" (p.188). Other Ryan Firebees were being adapted by the U.S. Navy in the area around North Vietnam.

By 1970 top military brass were beginning to see the promise of the drone. The technology had become such that drones could be piloted from the ground (rather than an airborne mothership). One of the game-changing "moments" came in early 1971, in which unmanned machines "humiliated" manned systems in a simulated dogfight over the Pacific Test Range. This scenario pitted an F-4 Phantom against a Ryan Firebee, which was outfitted with a remote flight control system, making it a genuine RPV, rather than target drone or missile. Controlled by pilots on the ground, the Firebee managed to score several "hits" on the F-4. As Dickson notes, in 1972 a supersonic Firebee II even penetrated the missile defenses of the Navy destroyer Wainwright and scored a simulated direct hit.

The MQ-1 Predator is perhaps the most well-known of all military drones used today. It has a wingspan of 55 feet, a length of 27 feet, and can reach speeds of up to 135 mph. According to the U.S. Air Force, "The Predator system was designed in response to a Department of Defense requirement to provide persistent intelligence, surveillance and reconnaissance information combined with a kill capability to the warfighter". Its deathly name conjures images of a science-fiction dystopia, a Terminator Planet where robots hover in the sky and exterminate humans on the ground. Of course, this is no longer science-fiction.

Unmanned Aerial Vehicles (UAVs) are remote controlled aircraft that can carry cameras, sensors and weapons over enemy territory. The decade since 9/11 has seen these remote aircraft increase in prominence from speculative prototypes to America's primary counterterrorism weapon.

With a range of 10,000 miles (16,000 kilometers), the largest drone, Northrop Grumman's RQ-4 Global Hawk, cruises at high altitude, loitering over an area for up to 30 hours. The drone produces high-quality surveillance images using its suite of sensors. The sensor suite includes synthetic aperture radar, electro-optical sensors and infrared sensors.

At the other end of the size spectrum, the RQ-11 Raven is so tiny a soldier can heave it into the air one-handed. Once airborne, the Raven has a range of 7.45 miles (12 km). Future drones could be the size of a hummingbird or even an insect.

Lightning Bug over North Vietnam

Drone Timeline:

1988: Amber UAV led to the Gnat

1993: Gnat-750

1998: I-Gnat (improved) C-band LOS 150 miles @30,000 ft

1998: Predator-A utilizing C and Ku Band SATCOM OTH communications capability

2001: Predator-B 50,000 ft operating altitude with turbo prop engine

Oct. 7, 2001: The first armed Predator drones begin flying missions over Afghanistan less than a month after 9/11. By March 2002, drones would begin providing close air support for troops on the ground.

Nov. 3, 2002: A CIA-operated Predator drone launched a Hellfire missile at a car carrying five al-Qaida members. It was the first drone assassination in what would become a decade-long campaign.

Dec. 23, 2002: A Predator drone fires a sidewinder missile at an Iraqi fighter plane in the No Fly Zone. This is the first instance of air-to-air combat with a drone. During the surge in 2007, drone surveillance would significantly reduce the number of roadside bomb attacks.

Late 2004: The U.S. Border Patrol begins testing UAVs for patrolling the U.S./Mexico border. In 2009, the U.S. begins flying drones inside of Mexican airspace in support of Mexican government antidrug cartel operations.

Late 2009: U.S. begins drone flights off of Somalia to monitor and deter pirates. In June 2011, the U.S. begins basing drones at the Mogadishu airport and launching drone missile strikes within Somalia against al-Shabab militants linked to al-Qaida.

April 21, 2011: President Obama approves the use of drones in support of the Libyan rebels. The drones destroy Qaddafi air defenses in advance of the NATO bombing campaign, and provide targeting and support for NATO allies during the war. Operations in Libya also feature the first use of drone helicopters in combat.

Jan. 25, 2011: A Texas Department of Public Safety SWAT team deploys a small drone during a raid on a drug stash house. This marks the first use of UAVs for domestic surveillance.

The word “Drone” has a military connotation that the general public associates with missiles that are being directed to take out people and military equipment. We should use this word very sparingly lest the general public see us in slightly unfavorable light. The word “Small” UAV or sUAV is very correct for what CAP is endeavoring to teach cadets.

How does an sUAV or UAV work?

sUAVs, UAVs, RPVs and Remote Controlled (RC) airplanes are all composed of many sub-systems.

The CAP AE related learning modules of the theory of flight, and the STEM MARC and AEX programs have direct links to cadets understanding how RPVs operate and how to operate them. Essentially CAP cadets are taking an RPV ground school formularizing course, where like the Sergeant below, learn to fly with an instructor on a buddy-box, then solo and go on to enjoy RC flight as a hobby and interest. The skill sets needed to maintain and operate all of these different systems are all similarly based upon both aeromodeling and larger full scale aircraft like the Predator and Global Hawk RPVs.

CAP Aerospace Education and the MARC program are so important in helping CAP cadets gain the needed skills and understanding of an sUAV and an RC aircraft's complex systems. There is every reason they could be operating Military RPVs in their near futures. An Army or Marine Sergeant who wants to be a UAV or RPV pilot goes through the very same training program to learn to fly RC aircraft as is taught by the AMA and CAP MARC Flight Academies. To the right is an Army Sergeant at Fort Huachuca, AZ, learning to fly an Army RPV. He and the instructor are using the same "Buddy-Box" set up that is so familiar in MARC RC Flight Academies and AMA instruction programs at AMA clubs nationwide.

On the right bottom is CAP cadet 1 Lt Wallace Schmidt from the Kentucky wing, also learning to fly RC at the Oshkosh NCSA MARC RC Flight Academy in 2013. There is a similarity in the two above photos, both "students" are learning to fly remote controlled aircraft, both are using similar "buddy boxes", and both have an instructor pilot monitoring their flights. While the Army Sergeant has a larger sUAV to control, the skill sets they are both using are identical. The Army Sergeant is probably 23-25 years old, Cadet Schmidt is 15, and by the time he is 23 years old he will have 8 years' experience flying remote controlled sUAVs.

So let's look at an sUAV as a "system" and the skill sets needed to fly one. The key elements in Radio Control are the same, while admittedly much more complex as you get into large full-scale RC aircraft such as the Predator A/B or Shadow/Scan Eagle. But the operating principles remain the same, especially if you are operating an Army or Marine

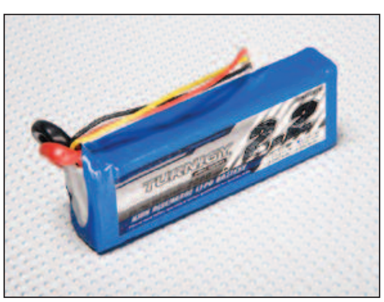
Corps Raven or Wasp III sUAV reconnaissance aircraft. All sUAVs and UAVs require the following systems in order to operate:

Transmitter - (a.k.a. controller) A hand held or fixed control device which sends control signals implemented by the user via radio waves to a receiver located inside the radio controlled model.

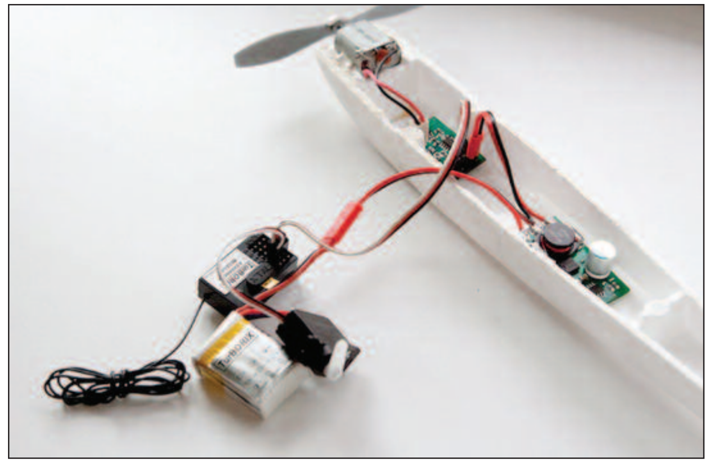
Receiver - A device within the radio controlled aircraft that receives control signals via radio waves from the transmitter. The receiver interprets these radio waves into control signals which activate special motors known as servos, which are also located in the RC aircraft.

Servo - Not to be confused with a standard two wire DC motor that can be considered a special DC angle and position of mechanisms. These are also located in the RC aircraft.

Motor - Motors can be electric DC drive, or gas driven.



Power Source - A power source such as a battery is required to provide a source of energy to all these devices above and to left.



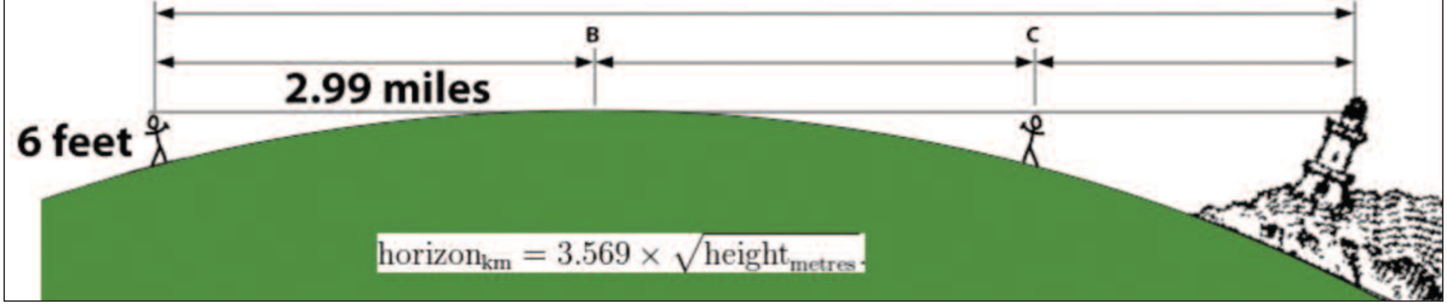
How do all these components work together? The hand held or fixed transmitter sends a control signal to the receiver located in the radio control aircraft in the form of a radio wave. The receiver in turn translates these waves into a specific action to drive a servo. The servo, also located in the RC aircraft then executes these commands mechanically steering the model, while another servo can control the drive motor thereby making the aircraft go fast or slow. Some of the more expensive RC aircraft, particularly the helicopters/quadcopters will have as many as 6 servos located within the RC aircraft all being managed by the one receiver.

Some smaller sUAVs are called “Park Flyers” and can have an infrared light beam (or IR) based command and control “system.” The IR transmitter sends command related signals via an Infrared light beam (or IR) similar to your TV or DVD remote. The IR transmitter sends pulses of infrared light that the IR receiver translates into specific commands such as left, right, go, and stop. Generally an IR transmitter has no use for an antenna, but for the purpose of aesthetically mimicking the radio control versions. Radio control transmitters are always wireless, and operate over radio frequencies (or RF).

The range of an IR signal is usually limited to around 30 feet or less. Infrared, also called optical control or opti-control, requires line-of-sight, that is, the LED on the IR transmitter must be pointing at the IR receiver in order to work. It doesn't see through walls. Whereas an IR transmitter has a very limited range of 30 feet, the RF transmitter will support flying distances out to 1.8 - 2.6 miles. Of course the FAA limits RC flying to a 400 foot overhead ceiling, and a sUAV at 2.6 miles away from you at 350 feet AGL will be a little dot in the sky at best.

There are other factors that affect the range of an RC aircraft transmitter and receiver radios, such as weather, exact frequency used, and obstructions. The radio's power output has a factor, too. If your RC airplane is flying at 400 ft AGL, you could probably have radio contact with it out to +20 miles, but then, of course, you would not be able to see it.

FIGURE 1



Knowing that our RF radio waves travel in straight lines, then to figure out their maximum range for a two way radio we have to factor in the curvature of the Earth. When you stand on Earth and press the talk button on your radio, the radio waves are going straight and they will eventually just go straight off into space once they pass the horizon. So the distance of the horizon is technically the maximum communication range for a two-way radio. But you have to factor in antenna height as well.

You may be wondering why you see radios that have range claims of 25 miles or higher. Technically they could communicate that far. Point D on Figure 1 shows a tower sitting on top of a mountain. If you are standing on top of this tower, now your antenna height overcomes a whole lot of the Earth's curvature, and you can communicate much farther.

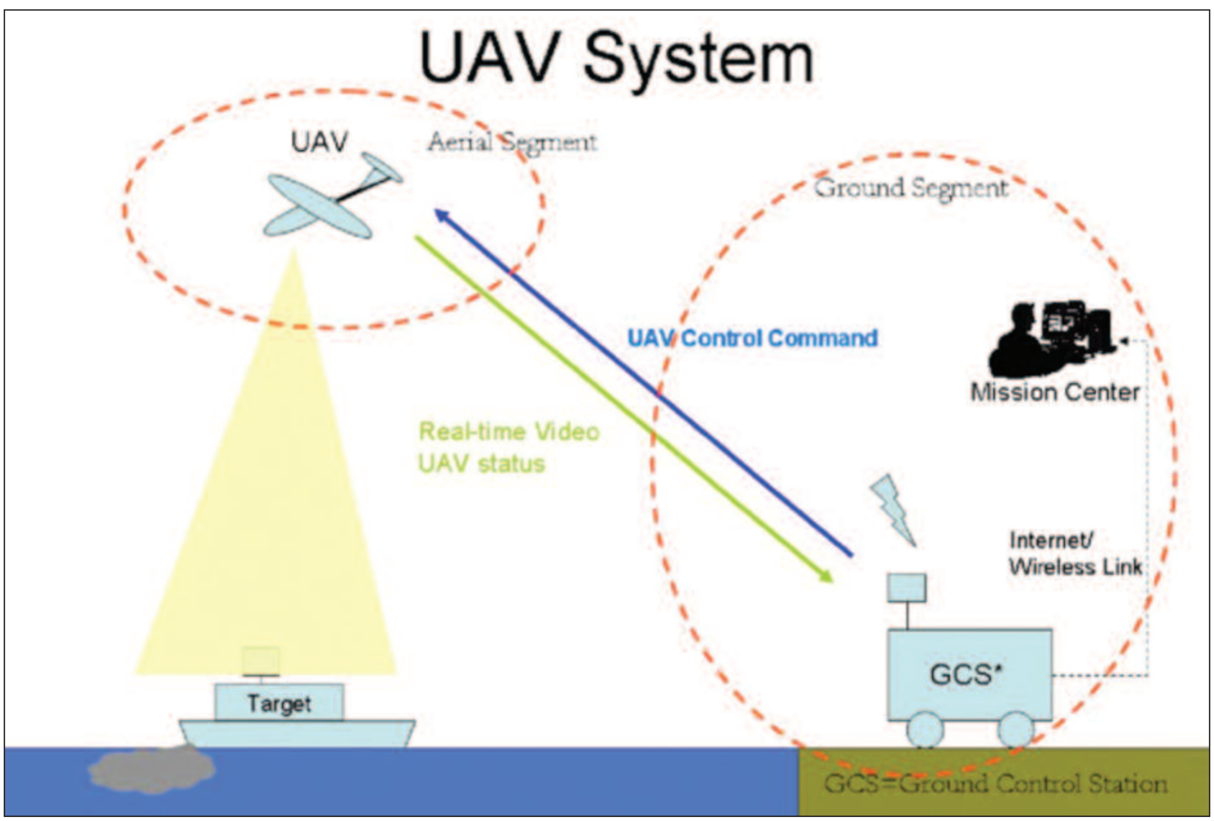
In summary, for RC airplane or sUAV hobbyists, both IR and RF radio-controlled airplanes, whether in a 30 foot operating circle in a field, backyard or within the perimeter of AMA flying field will teach an RC pilot the same basic skills in flying an RC aircraft. In the UAV world, communicating with a UAV at greater distances is a paramount engineering concern.

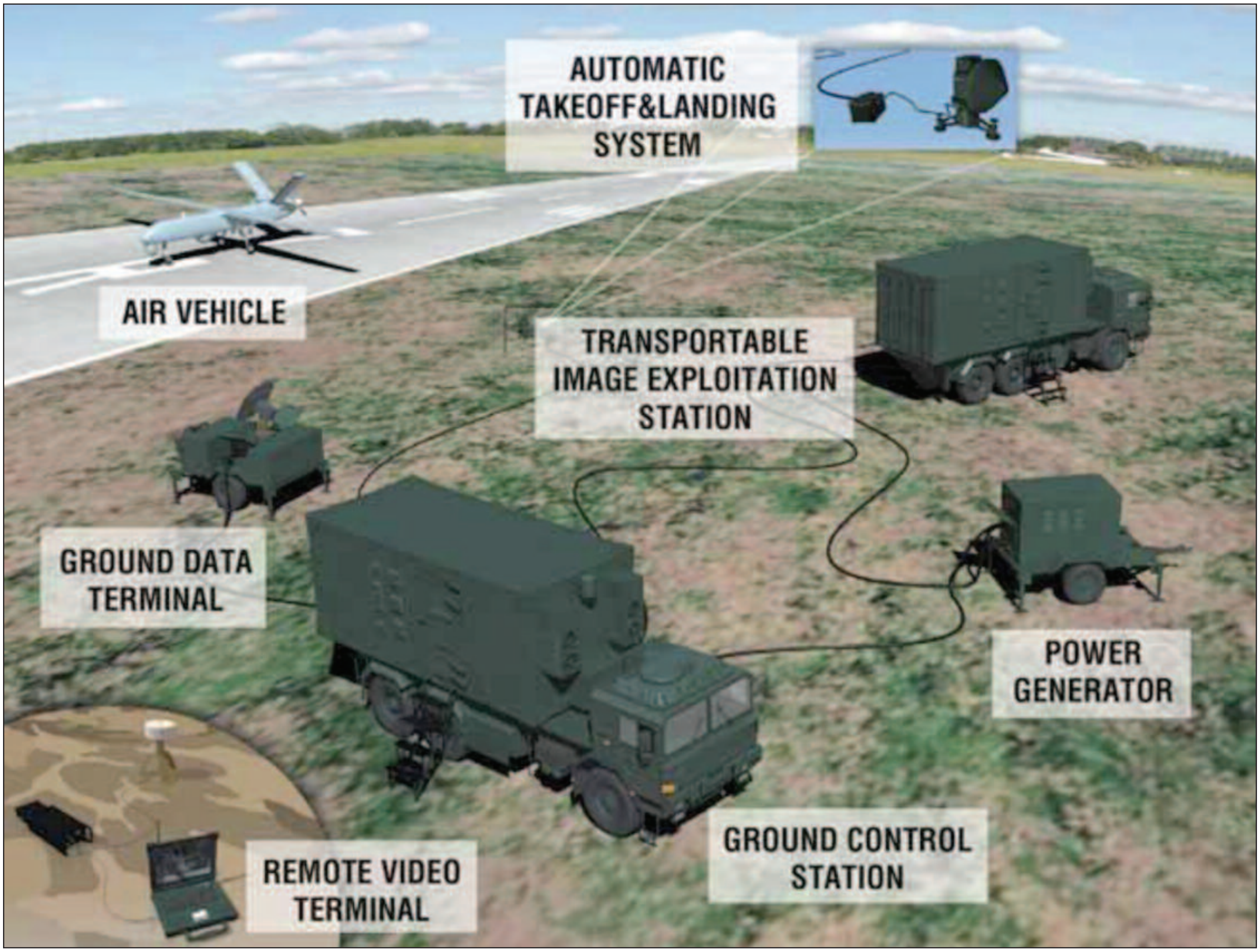
The Turkish "ANKA" or TUAV, advanced Medium Altitude Long Endurance class Unmanned Aerial System (UAS), performs day and night, all-weather reconnaissance, target detection/identification and intelligence missions with its EO/IR and SAR payloads, featuring autonomous flight capability including Automatic Take-off and Landing.

Using the diagram on next page and looking at the data sheet provided by Turkish Aerospace Industries, the ANKS can operate at 30,000 ft at a range to the mobile control center of 130 miles. This is the line of sight (LOS) distance from the UAV to the mobile command and control center.

A TUAV system consists of three air vehicles (A/V), Ground Control Station (GCS), Ground Data Terminal (GDT), Automatic Take-off and Landing System (ATOLS), Transportable Image Exploitation System (TIES), Remote Video Terminal (RVT) and other Ground Support Equipment (GSE).

The TUAV system, which is designed for night and day missions including adverse weather conditions, performs





real time image intelligence, surveillance, reconnaissance, moving/stationery target detection, recognition, identification, and tracking missions.

While the TIHA system has an open architecture to support other potential payloads and missions, within the context of the existing project the air vehicle is configured to carry the following payloads onboard:

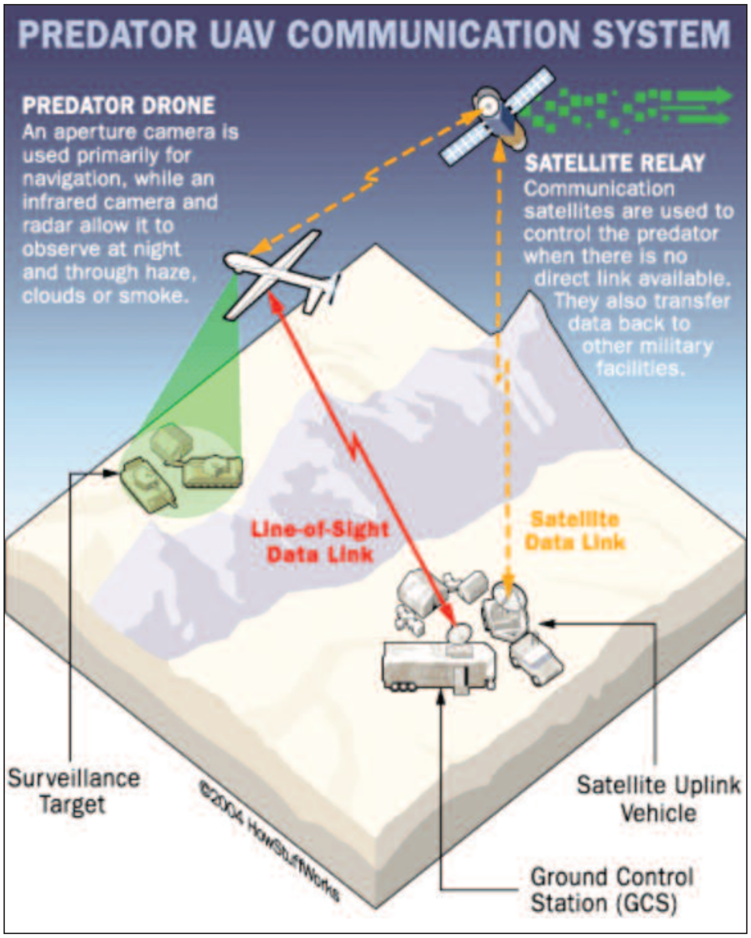
- Electro-optic Color Day Camera (EO Day TV)
- Electro-optic/Forward Looking Infrared/Laser Range Finder/Laser Designator and Spotter Camera (EO/FLIR/LRF/LDS)
- Synthetic Aperture Radar/Ground Moving Target Indicator (SAR/GMTI)
- Inverse SAR (ISAR)

The "ANKA System" package is depicted above.

LOS communications is a limiting factor for both and UAVs in general. An sUAV can be flown and monitored with a stand alone ground unit, up to 150 miles. The GNAT UAV's biggest impediment was the communication device housed in the aircraft's fuselage: the C-band line-of-sight data link only had a range of around 150 nautical miles. This meant that the drone could only be controlled from a relatively close proximity; seriously restricting its surveillance capabilities as the TUAV above. This has been overcome with direct satellite communication links enabling the UAV to operate at great distances from the controlling command center.

General Atomics responded with the Predator. The Predator drone extended the GNAT's limited range with the addition of a Ku-band SATCOM data ink. The new satellite communications overcame the limited data link of the GNAT and the limitations of the C-band line-of-sight. In fact, a SATCOM link meant that American drone operators didn't even have to be in the same region or even continent as the drone. The Predator drones were first flown in June 1994, and were deployed to the Balkans under *Operation Nomad Vigil* and *Operation Deliberate Force* in 1995, the latter the name for the NATO air campaign against Bosnian Serb forces. Both the GNAT-750 and its offspring the Predator served simultaneously due to the massive demand placed on surveillance aircraft. Future developments of the Predator included a de-icing system, reinforced wings, and a laser-guided targeting system: the latter two improvements were essential for adding weapons to the drone in its later life.

In 1995 Predators were shown in an aviation demonstration at Fort Bliss. Impressed by the drone's capabilities, the U.S. Air Force soon established its very first UAV squadron, the 11th Reconnaissance Squadron.



RQ-11 sUAV Raven and antenna

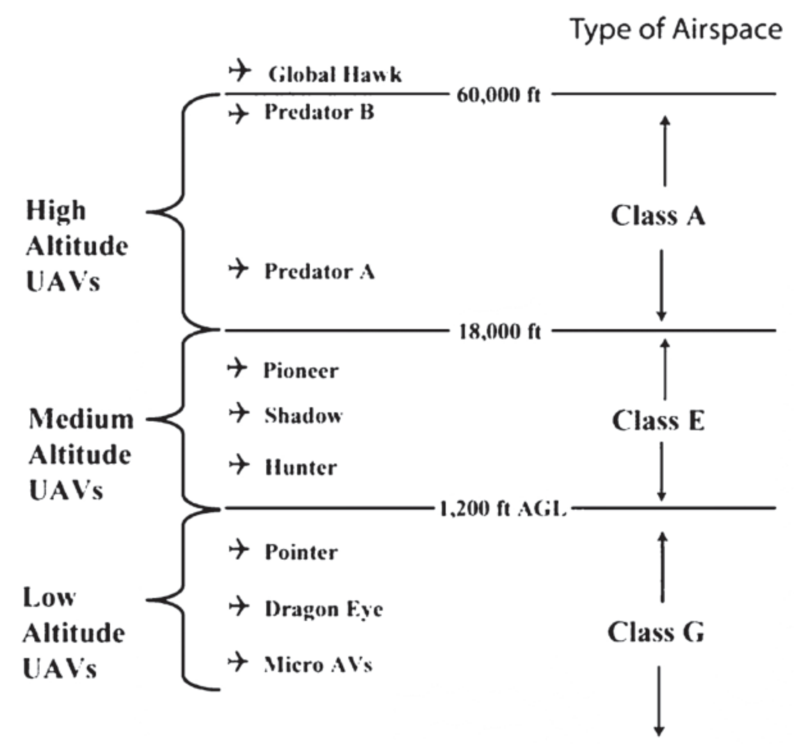
In summary the sUAV and the larger UAV have similar command and control systems that evolved from flying smaller RC airplanes. Today's UAVs are much more complicated and complex, but the basics are the same. What CAP cadets learn and experience in the MARC program does prepare them for possible applications and careers in the aerospace world of UAVs.

Mobile High power antenna for UAV

Current Military UAVs

America has the largest and most modern inventory of Unmanned Aerial Systems (UAS) with many of their Unmanned Aerial Vehicles (UAVs) having been tested under rigorous war conditions in Iraq and Afghanistan/Pakistan areas. Below are some of the major ongoing UAS systems with details. Where open source materials are available, imagery from these systems has also been presented:

Keeping in mind the Tier system covered previously, we will look at different UAS systems from low altitude to high altitude.



High Altitude UAVs

UAV Class	Wingspan	Flight Ceiling
Global Hawk	116 feet	65,000
Predator B	64 feet	60,000
Predator A		20,000

-------------------18,000 feet----------------------

Medium Altitude UAVs

UAV Class	Wingspan	Flight Ceiling
Pioneer	16 feet	15,000
Shadow	12 feet	15,000
Hunter	15 feet	15,000

----------------1,200 feet AGL ------------------

Low Altitude UAVs

UAV Class	Wingspan	Flight Ceiling
Pointer	9 feet	1000
Dragon Eye	2 feet	500

The Wasp III

The **Wasp III Small Unmanned Aircraft System** is an unmanned aerial vehicle (UAV) developed for United States Air Force special operations and the United States Marine Corps to provide a small light-weight aerial vehicles to provide beyond-line-of-sight situational awareness. The aircraft is equipped with two on-board cameras to provide real-time intelligence to its operators. It is also equipped with GPS and an Inertial Navigation System enabling it to operate autonomously from takeoff to recovery. It was designed by AeroVironment Inc. and was first added to the Air Force inventory in 2007. There are two Wasp variants: the traditional version that lands on land ("Terra Wasp") and a version that lands into the sea or fresh water ("Aqua Wasp"). The Air Force accepted the Wasp AE in late May 2012, and the U.S. Marine Corps ordered the Wasp AE in January 2013.

Armament/Payload: High resolution, day/night cameras with digital image stabilization and digital pan/tilt/zoom

Specifications

General characteristics
Crew: none
Length: 1.25 ft (38 cm)
Wingspan: 2.375 ft (72.3 cm)
Empty weight: 0.95 lb [430 g (Land version)]
Loaded weight: 14.4 lbs (6.53 kg)
Powerplant: 1 × Electric motor, rechargeable lithium ion batteries
Performance
Maximum speed: 40 mph (65 km/h)
Cruise speed: 40 - 65 km/h
Range: 5 km

The AeroVironment RQ-11 Raven

The AeroVironment RQ-11 Raven is a small, hand-launched remote-controlled unmanned aerial vehicle (or sUAV) developed for the U.S. military, but now adopted by the military forces of many other countries. The RQ-11 Raven was originally introduced as the FQM-151 in 1999 but in 2002 developed into its current form, resembling an enlarged FAI class F1C free flight model aircraft in general appearance. The craft is launched by hand and powered by a pusher configuration electric motor.

The Raven provides a number of capabilities to the military. Among the most important is the real-time, up-to-date, over-the-horizon view it provides over trouble spots. Though units are also armed with a host of modern imagery products, they are unmatched by the live, detailed, day or night coverage that the Raven provides. It also allows units to conduct Intelligence, Surveillance, and Reconnaissance (ISR) of danger zones without committing soldiers, which also allows the task force to monitor an area with a less obtrusive presence.

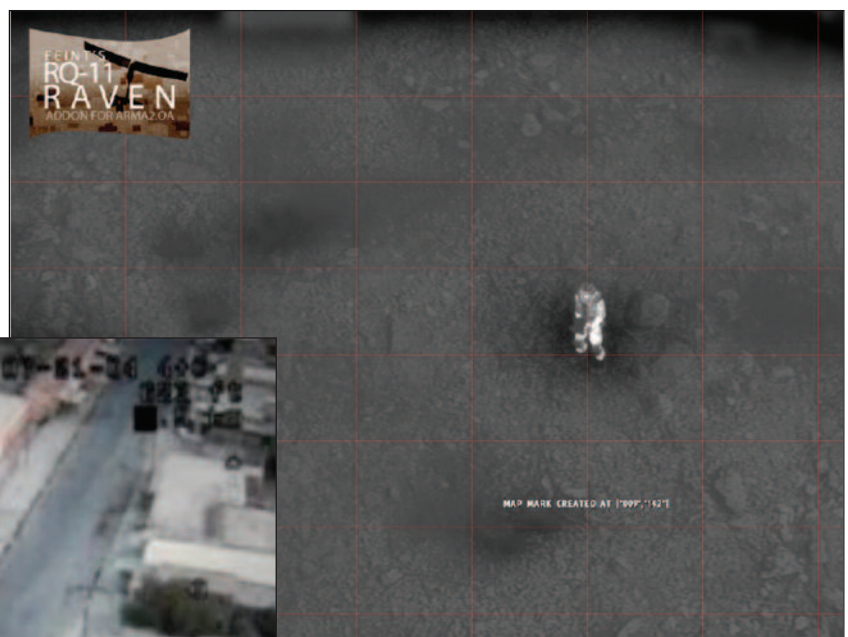
With a moderate operational range, the Raven provides up-to-the minute intelligence over the target area. Day and night, live video capabilities let the Raven greatly assist with the overall situation awareness picture. The Raven can fly automatically, navigating using GPS technology and programmable routes and target areas or be remotely flown by the operator when necessary.

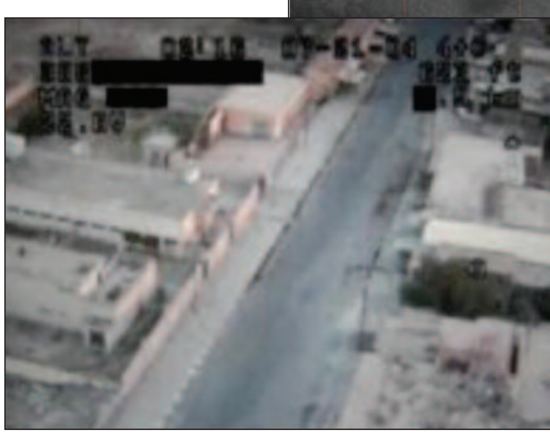
The Raven can be launched in just minutes, by hand, into the air like a model airplane. It lands itself by auto-piloting to a near-hover and dropping to the ground, without requiring landing gear or carefully prepared landing strips. Since it is launched and recovered in this manner, it does not require elaborate support facilities and is ideally suited to a forward-deployed unit. Its automated features and GPS technology also make it simple to operate, requiring no specially skilled operators or in-depth flight training.

<u>Specifications</u>

General characteristics

Wing Span: 4.5 ft (1372 mm)
Length: 3 ft (915 mm)
Weight: 4.2 lb (1906 g)
Engine: Aveox 27/26/7-AV electric motor
Cruising speed: 28-60 mph (45–97 km/hr)
Range: 6.2 miles (10 km)
Maximum Operating Altitude: Approx 500 feet (150 m) above ground level (AGL), and over 15,000 feet (4,600 m) above mean sea level (MSL
Endurance: approx. 60-90 min
Payload: Interchangeable: optical, infrared, and IR cameras.





The Boeing Insitu ScanEagle

The Boeing Insitu ScanEagle is a USMC small, low-cost, long-endurance unmanned aerial vehicle (UAV) built by Insitu, a subsidiary of Boeing. The ScanEagle was designed by Insitu based on the Insitu SeaScan, a commercial UAV that was intended for fish-spotting. The ScanEagle continues to be upgraded with improved technology and reliability.

Specifications
(Data from Insitu, USAF)

General characteristics
Crew: none on-board
Payload: 7.5 lb (3.4 kg)
Length: 5.1-5.6 ft (1.55-1.71 m)
Wingspan: 10.2 ft (3.11 m)
Empty weight: 30.9-39.68 lb (14-18 kg)
Loaded weight: 39.7 lb (18 kg)
Max. Takeoff weight: 48.5 lb (22 kg)
Powerplant: 1 × 2-stroke 3W piston engine, 1.5 hp (1.12 kW)
Performance
Maximum speed: 80 knots (92 mph, 148 km/h)
Cruise speed: 60 knots (69 mph, 111 km/h)
Endurance: 24+ hours
Service ceiling: 19,500 ft (5,950 m)

Payload: High resolution, day/night camera and thermal imager

The RQ-7 Shadow

The RQ-7 Shadow unmanned aerial vehicle (UAV) is used by the United States Army, Marine Corps, Australian Army and Swedish Army for reconnaissance, surveillance, target acquisition and battle damage assessment. Launched from a trailer-mounted pneumatic catapult, it is recovered with the aid of arresting gear similar to jets on an aircraft carrier.

Fort Huachuca, AZ, trains soldiers, Marines, and civilians in the operation and maintenance of the Shadow UAV. The training program is mainly undertaken by civilian instructors.In August 2004, the improved RQ-7B air vehicle began to roll off from AAI's production line. The RQ-7B has larger wings with a more efficient airfoil and increased fuel capacity, allowing an endurance of up to 7 hours. Additionally, the vehicle has an enlarged tail, upgraded avionics including an improved flight controller with an IMU (Inertial Measurement Unit) and increased computing power, and new payload options. The RQ-7B will also be fitted with the Army's Tactical Common Data Link (TCDL).

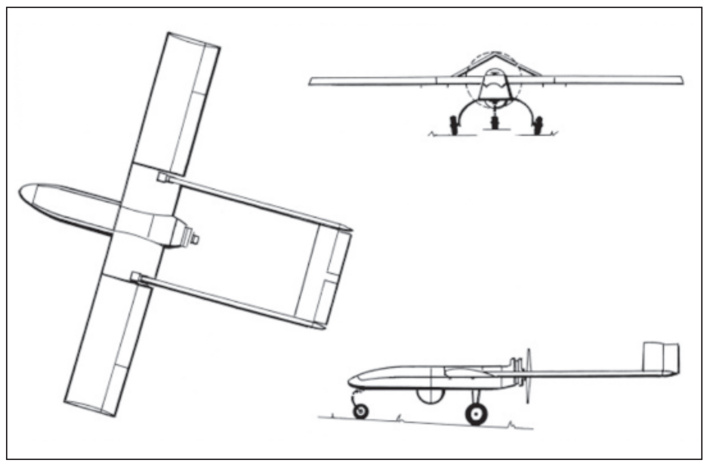
Specifications (200 Family)

General characteristics
Length: 11.2 ft (3.4 m)
Wingspan: 14 ft (4.3 m)
Height: 3.3 ft (1.0 m)
Empty weight: 186 lb (84 kg)
Gross weight: 375 lb (170 kg)
Powerplant: 1 × Wankel UAV Engine 741 used only with Silkolene Synthetic Oil, 38 hp (28 kW)

Performance
Maximum speed: 127 mph; 204 km/h
Cruising speed: 81 mph; 130 km/h
Range: 68 mi (59 nm; 109 km)
Endurance: 6 h/ 9 h Increased Endurance
Service ceiling: 15,000 ft (4,572 m) ELOS (Electronic Line Of Sight)

Note: When outfitted with IE (Increased Endurance) Wings, the CRP (Communications Relay Package) and the 1102 engine, endurance time is increased to 9 hours, wing span is increased to approx. 22 feet (6.7 m), and the service ceiling is 18,000 ft (only with authorization).

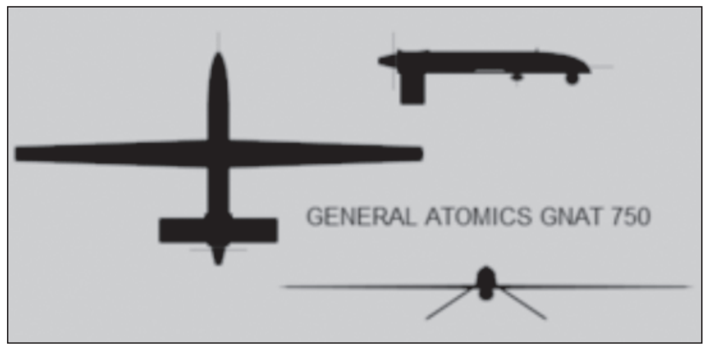
Payload: Its gimbal-mounted, digitally stabilized, liquid nitrogen-cooled electro-optical/infrared (EO/IR) camera relays video in real time via a C-band line-of-sight data link to the ground control station (GCS).



The General Atomics GNAT 750

The General Atomics GNAT is a reconnaissance UAV developed in the United States in the late 1980s and manufactured by General Atomics Aeronautical Systems Inc. (GA-ASI). As initially designed, it was a simplified version of the LSI Amber intended for foreign sales. The GNAT 750 made its first flight in 1989.

The GNAT 750's configuration was similar to that of the Amber, except that the GNAT 750's wing was mounted low on the fuselage, instead of being mounted on a pylon on top. The idea of the name was more probably related to the fact that a gnat is small. The "750" part of the name stands for the distance in millimeters from the leading edge to trailing edge of the wing near the wing root.



The aircraft is powered by a Rotax 912 piston flat-four four-cycle engine with 64 kW (85 hp). It can fly to an operational area from 2,000 kilometers (1,240 miles) away and loiter there for 12 hours before returning home. Eight GNAT 750s were in development when General Atomics bought out LSI. General Atomics continued the program, which led to a contract from the Turkish government for a number of the UAVs in 1993. The Turkish Air Force operates 6 GNAT-750 and 16 improved I-GNAT ER unmanned aerial vehicles.

General Atomics also used the GNAT 750 as the basis for a tactical UAV known as the "Prowler." It looks much like a GNAT 750 but is cut down in size, with a span of 7.31 meters (24 ft) and a length of 4.24 meters (13.9 ft). It has an endurance of over 16 hours, and some commonality with GNAT 750 subsystems.

Specifications (GNAT 750)

General characteristics
Crew: None
Length: 16 ft 5 in (5.00 m)
Wingspan: 35 ft 4 in (10.75 m)
Height: 2 ft 4.5 in (0.75 m)
Empty weight: 560 lb (250 kg)
Gross weight: 1,140 lb (520 kg)
Powerplant: 1 × Rotax 582, 65 hp (48 kW)
Performance
Maximum speed: 120 mph (192 km/h)
Endurance: 48 hours
Service ceiling: 25,000 ft (7,600 m)

Payload: Weapons and Synthetic Aperture Radar (SAR) Imaging Systems.

The Northrop Grumman RQ-4 Global Hawk

The Northrop Grumman RQ-4 Global Hawk is an unmanned aerial vehicle (UAV) surveillance aircraft. It was initially designed by Ryan Aeronautical (now part of Northrop Grumman), and known as Tier II+ during development. In role and operational design, the Global Hawk is similar to the Lockheed U-2. The RQ-4 provides a broad overview and systematic surveillance using high resolution synthetic aperture radar (SAR) and long-range electro-optical/infrared (EO/IR) sensors with long loiter times over target areas. It can survey as much as 40,000 square miles (100,000 km2) of terrain a day.

The Global Hawk is operated by the United States Air Force and U.S. Navy. The U.S. Navy has developed the Global Hawk into the version for maritime surveillance. It is used as a high-altitude platform for surveillance and security. Missions for the Global Hawk cover the spectrum of intelligence collection capability to support forces in worldwide military operations. According to the United States Air Force, the superior surveillance capabilities of the aircraft allow more precise weapons targeting and better protection of friendly forces.

<u>Specifications</u> (RQ-4B)Data from USAF

General characteristics

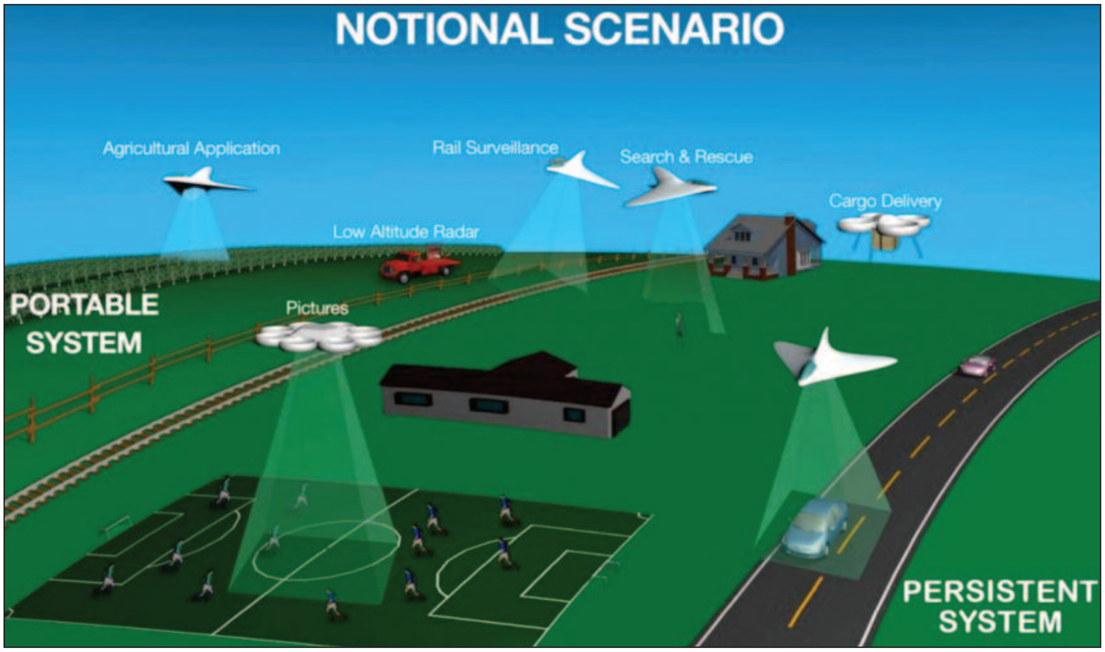
Crew: 0 onboard (3 remote: LRE pilot; MCE pilot and sensor operator)
Length: 47.6 ft (14.5 m)
Wingspan: 130.9 ft (39.9 m)
Height: 15.3 ft (4.7 m)
Empty weight: 14,950 lb (6,781 kg)
Gross weight: 32,250 lb (14,628 kg)
Powerplant: 1 × engine, 7,600 lb thrust

Performance

Cruise speed: 357 mph (575 km/h)
Range: 8,700 mi (7,560 nm; 14,001 km)
Endurance: 28 hours
Service ceiling: 60,000 ft (18,288 m)

Payload: Weapons, high resolution synthetic aperture radar (SAR) and long-range electro-optical/infrared (EO/IR) sensors.

What is the usefulness of UAVs



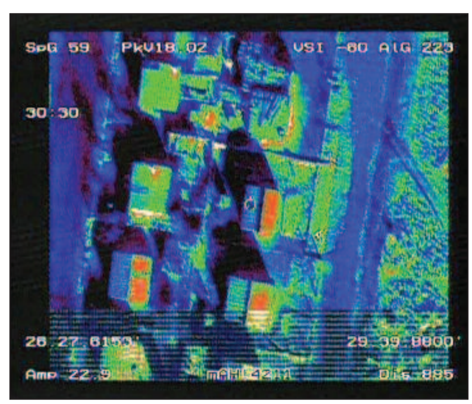
Some of the many uses for sUAV and UAV Aircraft

Some manufacturers are rebranding the technology as "unmanned aerial systems" (UASs) in preference over "drones." Drones have also been used by animal-rights advocates to determine if illegal hunting is taking place, even on private property. Drones equipped with video cameras are being used by the League Against Cruel Sports (LACS), a British animal-rights group, to spot instances of illegal fox hunting in the UK. UAVs are routinely used in several applications where human interaction is difficult or dangerous. These applications range from military to civilian and include reconnaissance operations, border patrol missions, forest fire detection, surveillance, and search/rescue missions. Samples of how sUAV and UAVs are being used outside of the military applications we hear about are listed below:

• **Growing Uses:** Beyond the military applications of UAVs with which "drones" have become more associated numerous civil aviation uses have been developed. These include aerial surveying of crops, acrobatic aerial footage in filmmaking, search and rescue operations, inspecting power lines and pipelines, counting wildlife, and delivering medical supplies to remote or otherwise inaccessible regions.

sUAV False Infrared Image (Plant Health)

• **Remote Sensing:** UAV remote sensing functions include electromagnetic spectrum sensors, gamma ray sensors, biological sensors, and chemical sensors. A UAV's electromagnetic sensors typically include visual spectrum,



sUAV/UAV Thermal Image (Heat) of Urban Homes

Sports photography and cinematography

Analysis of Puma sUAV image of Alaskan cleared way

infrared, or near infrared cameras as well as radar systems. Other electromagnetic wave detectors such as microwave and ultraviolet spectrum sensors may also be used but are uncommon. Biological sensors are sensors capable of detecting the airborne presence of various microorganisms and other biological factors. Chemical sensors use laser spectroscopy to analyze the concentrations of each element in the air.

• **Sports:** Drones are starting to be used in sports photography and cinematography. For example, they were used in the 2014 Winter Olympics in Russia for filming skiing and snowboarding events. Some advantages of using unmanned aerial vehicles in sports are that they allow video to get closer to the athletes and they are more flexible than cable-suspended camera systems.

• **Rapid assessment** of power lines and other electricity/power infrastructure threatened by trees growing into cleared ways. British Petroleum (BP) has been authorized to use unmanned aircraft systems, or drones, to conduct aerial surveys of pipelines and other infrastructure on Alaska's North Slope, the first commercial drone flights over land, authorities said on June 14, 2014. AeroVironment started flying its AE drone to survey BP's pipelines, roads and equipment at Prudhoe Bay, Alaska the largest U.S. oilfield. (Reuters)

• **Real Estate Marketing:** Videos and photographs set marketing of the property apart from the competition, said Mark Pires, a real estate agent with the New Canaan office of Coldwell Banker who uses his miniature helicopter, or unmanned aerial vehicle, to capture aspects of a property that cannot be seen from the ground.

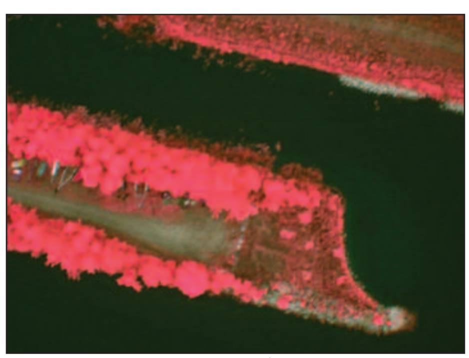
• **Aerial Mapping:** UAV systems enable mapping and data collection missions to be performed easily and safely. Either multi rotor or fixed wing UAV systems can gather and produce high quality data and imagery at a considerably lower cost than conventional methods. Today's sUAV/UAV systems easily integrate with a multitude of different payloads that can effortlessly gather the data to generate precision maps. The Tempest fixed wing UAV can fly in a four square mile area in a single flight. UAV systems can fly in conditions when manned aircraft cannot operate safely, including night operations, low to the ground in poor visibility, and bad weather.

Some key advantages are:

- 5-20cm Ground Sample Distance
- Fast Deployment to Site
- High Accuracy
- Quick Result Delivery
- Cost Effective for Small to Medium Size Coverage.

• **Agriculture:** Plants typically absorb visible blue and visible red light while reflecting green and Near Infrared (NIR) light. The reason we see a plant as green is because it is reflecting the green light to our eyes. Plants also reflect the NIR light because the infrared light doesn't have enough energy to support photosynthesis. Healthy plants reflect green and NIR while absorbing blue and red light. As plants become sick, they don't reflect green and NIR as well. There is a mathematical algorithm (ENDVI) that works in conjunction with a special camera that captures both visible and infrared bands of light. By processing the picture with ENDVI algorithm, you get a new picture that shows where plants are happy and where they are not. A "bright pink-red" is new growth, a basic red color indicates healthy plant growth and conditions. As a plant is affected by disease, drought or is dying, it turns a brownish color.

Normal Color Bands　　False Infrared or Infrared Imagery



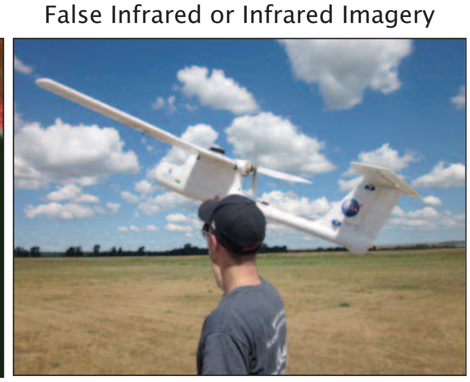


Figure 1

An AWRI student, Alex Ebenstein, proposed to use a UAV equipped with a near infrared (NIR) sensor to estimate the chlorophyll concentrations in Muskegon Lake, Muskegon County, MI. The infrared sensor used created digital images with three bands similar to bands 2 (green), 3 (red), and 4 (NIR) from Landsat 7. Figure 1 - "False Color" infrared image depicting a portion of Muskegon Lake and its shore. Image collected by AWRI UAV, July 2013.

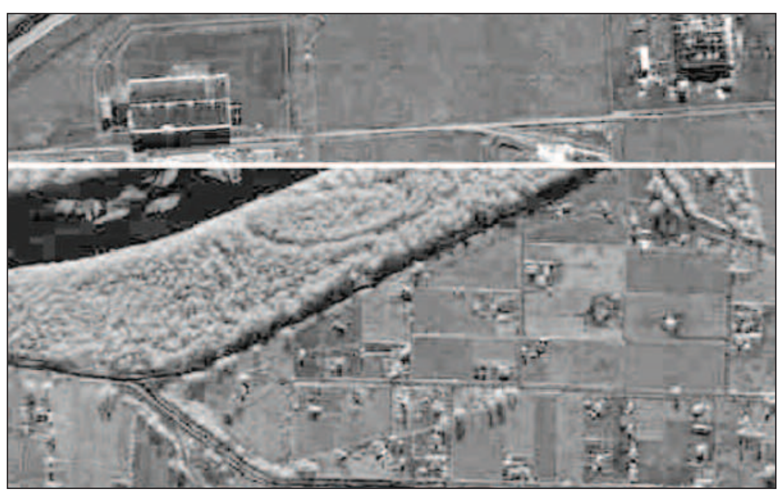
sUAV Orthophoto of Haitian City after a major earthquake

• **Disaster Relief:** UAVs transport medicines and vaccines, and retrieve medical samples, into and out of remote or otherwise inaccessible regions. Drones can help in disaster relief by gathering information from across an affected area. Drones can also help by building a picture of the situation and giving recommendations for how people should direct their resources to mitigate damage and save lives.

- Identify useful areas for humanitarian response personnel to set up base camp
- Provide aerial support for road clearance activities
- Identify usable roads and transportation infrastructure
- Rapidly assess disaster damage to building infrastructure
- Estimate population displacement
- Identify temporary shelters
- Identify best locations to set up new temporary shelters
- Survey impact of disaster on agriculture, farmland

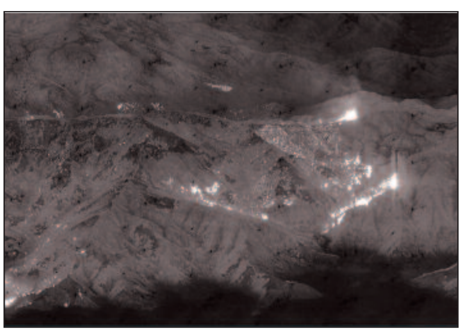
• **Search and Rescue:** UAVs will likely play an increased role in search and rescue in the United States. This was demonstrated by the use of UAVs during the 2008 hurricanes that struck Louisiana and Texas. Micro UAVs, such as the Aeryon Scout, have been used to perform search and rescue activities on a smaller scale, such as the search for missing persons. For example, Predators, operating between 18,000–29,000 feet above sea level, performed search and rescue and damage assessment. Payloads carried were an optical sensor, which is a daytime and infrared camera in particular, and a synthetic aperture radar (SAR). The Predator's SAR is a sophisticated all-weather sensor capable of providing photographic-like images through clouds, rain or fog, and in daytime or nighttime conditions, all in real-time. A concept of coherent change detection in SAR images allows for exceptional search and rescue ability: photos taken before

SAR Radar image(s) by Gnat I UAV



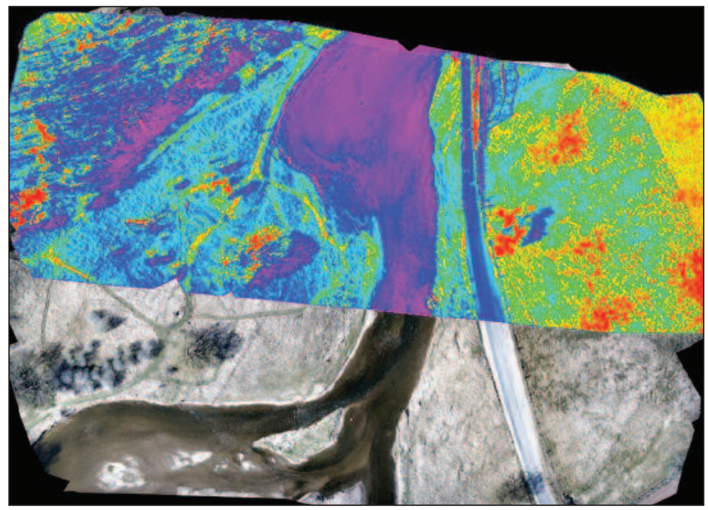
and after the storm hits are compared, and a computer highlights areas of damage. UAVs have been tested as airborne lifeguards, locating distressed swimmers using thermal cameras and dropping life preservers to plural swimmers.

- **Forest Fires:** Another application of UAVs is the prevention and early detection of forest fires. The possibility of constant flight, both day and night, makes the methods used until now (helicopters, watchtowers, etc.) become obsolete. Cameras and sensors that provide real-time emergency services, including information about the location of the outbreak of fire as well as many factors (wind speed, temperature, humidity, etc.) that are helpful for fire crews to conduct fire suppression.

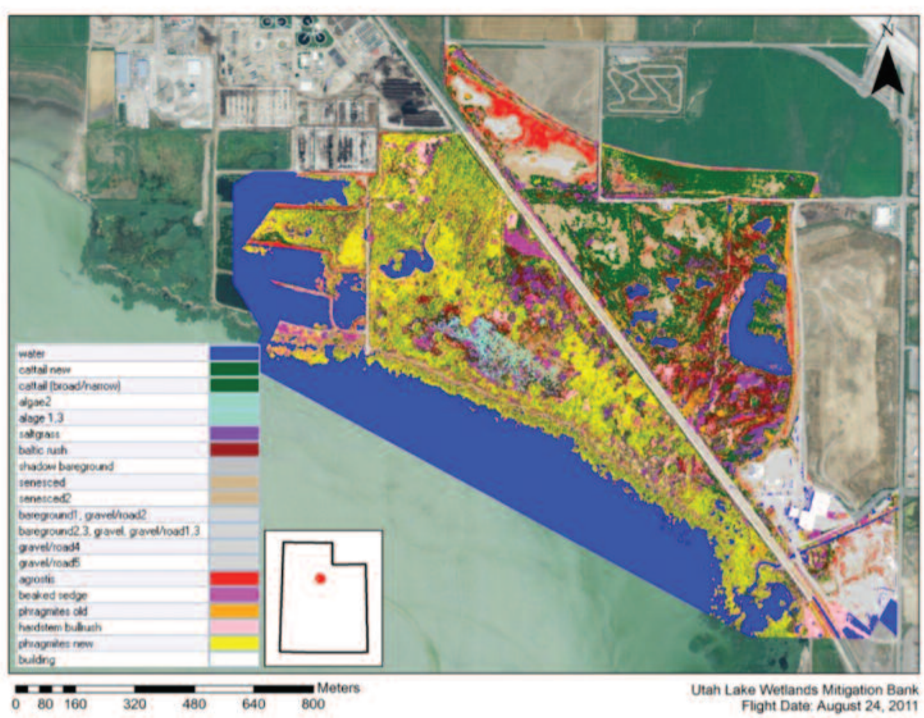


Global Hawk photo of wild fires in Northern California

- **GIS:** The Scout micro-UAV system can be used in environmental and engineering assessment, precision agriculture, and other GIS applications. Near Infrared (NIR) camera systems are designed to capture aerial video and high resolution still images in the near-infrared light spectrum, outside the human-visible red, blue, and green light bands. Near-infrared imagery is used by military and public safety personnel in combination with near-IR light sources and indicators. It also has broad commercial applications, and near-IR images are commonly combined with visible light images to produce multi-spectral products such as Normalized Difference Vegetation Index (NDVI) images. NDVI is a multi-spectral standard used worldwide to measure and monitor plant growth, vegetation cover, soil/water condition, and biomass production – and is used in applications such as precision agriculture, assessing fire hazards, monitoring droughts, and other

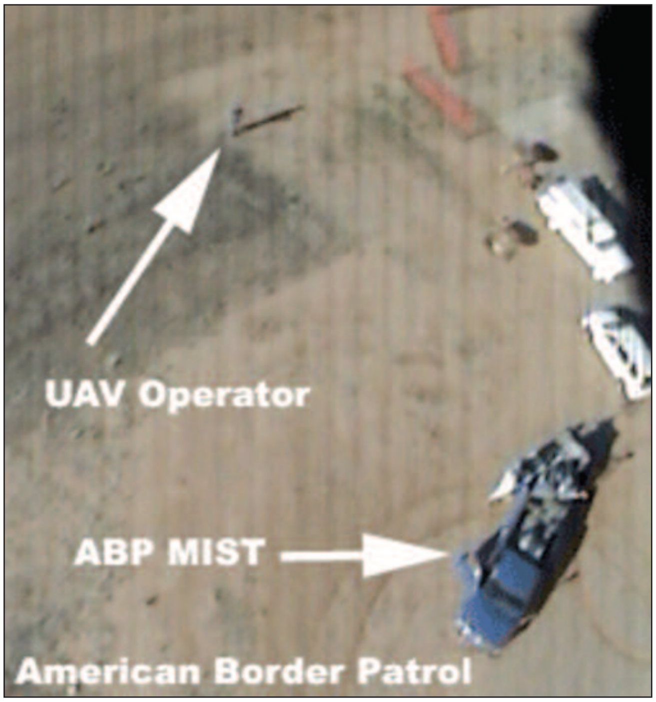


Tracking a vehicle with Wasp III UAV



environmental projects. GIS software can extract/process different bands within an image collected to produce maps and charts to better understand the interrelationships happening in the two different images as seen below.

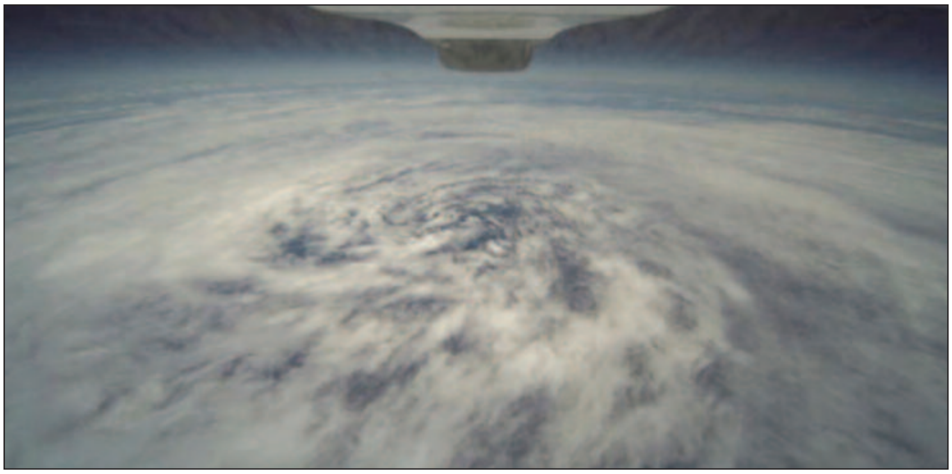
• **Commercial Aerial Surveillance:** Aerial surveillance of large areas is made possible with low cost UAV systems. Surveillance applications include livestock monitoring, wildfire mapping, pipeline security, home security, road patrol, and anti-piracy. The trend for the use of UAV technology in commercial aerial surveillance is expanding rapidly with increased development of automated object detection approaches.



• **Local and State Police/Law Enforcement:** UAVs are increasingly used for Border Patrol and domestic police work in Canada and the United States: a dozen U.S. police forces had applied for UAV permits by March 2013.

• **Gas and Mineral Exploitation and Production:** UAVs can be used to perform geophysical surveys, in particular geomagnetic surveys where the processed measurements of the

An sUAV collecting data on the UK Coast



UAV image of Tropical Storm Frank

UAV in a Costa Rican Volcano

Earth's differential magnetic field strength are used to calculate the nature of the underlying magnetic rock structure. A knowledge of the underlying rock structure helps trained geophysicists to predict the location of mineral deposits. The production side of oil and gas exploration and production entails the monitoring of the integrity of oil and gas pipelines and related installations. For above-ground pipelines, this monitoring activity could be performed using digital cameras mounted on one or more UAVs. The "InView UAV" is an example of a UAV aircraft developed for use in oil, gas, and mineral exploration and production activities.

• **Scientific Research:** Unmanned aircraft are especially useful in penetrating areas that may be too dangerous for manned aircraft. The National Oceanic and Atmospheric Administration (NOAA) began utilizing the Aerosonde unmanned aircraft system in 2006 as a hurricane hunter. AAI Corporation subsidiary Aerosonde Pty Ltd. of Victoria, Australia, designs and manufactures the 35-pound system, which can fly into a hurricane and communicate near-real-time data directly to the National Hurricane Center in Florida. Beyond the standard barometric pressure and temperature data typically culled from manned hurricane hunters, the Aerosonde system provides measurements far closer to the water's surface than previously captured. NASA later began using the Northrop Grumman RQ-4 Global Hawk for extended hurricane measurements.

Further applications for unmanned aircraft can be explored once solutions have been developed for their accommodation within national airspace, an issue currently under discussion by the Federal Aviation Administration. UAVSI, the UK manufacturer, also produces a variant of their Vigilant light UAS (20 kg) designed specifically for scientific research in severe climates, such as the Antarctic. There have also been experiments with using UAVs as a construction and artwork tool at locations such as the ETH Zurich.

• **Archaeology:** In Peru archaeologists use drones to speed up survey work and protect sites from squatters, builders and miners. Small drones helped researchers produce three-dimensional models of Peruvian sites instead of the usual flat maps – and in days and weeks instead of months and years.

Drones have replaced expensive and clumsy small planes, kites and helium balloons. Drones costing about $1,000 have proven useful. In 2013 drones have flown over at least six Peruvian

UAV images of Castles in the UK and Machu Llacta, Peru

archaeological sites, including the colonial Andean town Machu Llacta 4,000 meters (13,000 ft) above sea level. The drones continue to have altitude problems in the Andes, leading to plans to make a drone blimp, employing open source software.

Jeffrey Quilter, an archaeologist with Harvard University said, "You can go up three meters and photograph a room, 300 meters and photograph a site, or you can go up 3,000 meters and photograph the entire valley." Courtesy Wikipedia

In conclusion there are many applications for sUAVs and UAVs other than in the military arena. For all of the above applications, there has to be a team to pilot the UAVs as well as the ground control centers that take the data/imagery downloaded and apply it to the real uses described above. The potential number of career fields represented here are in the hundreds, and it all starts with an interest in aerospace in general, and its many associated parts like geography, remote sensing, and MARC.

JOB DESCRIPTION: *Army UAV Operator*

Position: Army Enlisted 15W - Unmanned Aerial Vehicle Operator

- Launches and recovers the air vehicle
- Performs pre-flight, in flight and post-flight checks and procedures
- Directs emplacement of ground control station, directs emplacement of launch and recovery systems
- Supervises and assists in air frame repair and coordinates evacuation and replacement of parts and end items

Basic Job Description:

Unmanned Aerial Vehicle Operators are integral to providing Army personnel with information about enemy forces and potential battle areas. Unmanned Aerial Vehicle Operators are remote pilots of unmanned observation aircraft, who gather and study information that's required to design operational plans and tactics. The UAV operator supervises or operates the UAV, such as the Army's Shadow Unmanned Aerial Vehicle, to include mission planning, mission sensor/payload operations, launching, remotely piloting, and recovering the aerial vehicle.

Duties performed by soldiers in this MOS include:

- Prepares and conducts air reconnaissance mission
- Operates mission sensor/payload for target detection
- Plans and analyzes flight missions
- Deploys and redeploys the TUAV ground and air system
- Operates and performs operator level maintenance on communications equipment, power sources, light and heavy wheel vehicle and some crane operations

How to become an Army UAV Pilot

- Complete initial qualifications. All prospective pilots must establish proper initial qualifications. These qualifications include a high diploma, good color vision, never having served in the Peace Corps, no convictions for offenses more serious than traffic violations, ability to obtain a secret clearance and good general health.
- Pass the initial entry test. Prior to entry in the Army, each applicant must pass the armed services vocational aptitude battery test with a high enough score to qualify to be a UAV pilot. The applicant

must score 105 on the intelligence portion of this test.

- Complete basic training. Each applicant must successfully complete a nine-week basic training course. In this course, the applicant will learn the basic skills to be a soldier.
- Complete Army UAV training after basic training. Army UAV training is a 23-week course conducted in Arizona. In this course, the soldier will learn UAV computer skills, intelligence gathering, map preparation and aerial intelligence interpretation.
- Progress to more difficult skills. Each UAV pilot upgrades his skills during his enlistment. There are five skill levels for a UAV pilot. Basic skill levels involve take off, landing and operation of the aircraft. Higher skill levels involve supervising other pilots and advising commanders on tactics.

Training Information:

- Army UAV Training: 23 weeks, 3 days at Fort Huachuca, AZ
- ASVAB Score Required: 105 in the aptitude area SC
- Security Clearance: Secret
- Strength Requirement: medium
- Physical Profile Requirement: 222221.

Other Requirements:

- Normal color vision required
- Must be U.S. Citizen
- Never been a member of the U.S. Peace Corps, except as specified in Army Regulation 614-200, chapter 1
- No record of conviction by court-martial
- No record of conviction by a civil court for any offense other than minor traffic violations

Similar Civilian Occupations:

There are civilian occupations directly equivalent to MOS 15W. The U.S. homeland Security and Border Patrol are more and more using UAVs to monitor large areas, from a central command center.

Additionally, the following civilian occupations make use of the skills developed through MOS 15W training and experience.

- Airfield Operations Specialists
- Business Operations Specialists
- Commercial Pilot
- Training and Development Specialists

Courtesy: About.com/Military, US Army, ehow.com, calguard.ca.gov

Links to more Army Pilot Information:

http://www.goarmy.com/careers-and-jobs/browse-career-and-job-categories/transportation-and-aviation/aviation-officer.html

http://www.calguard.ca.gov/caav/Pages/careers.aspx

http://www.ehow.com/list_5939029_army-aviation-careers.html

http://www.usarec.army.mil/hq/warrant/Wogeninfo_mos.shtml

http://www.ehow.com/how_5810859_become-army-uav-pilot.html

JOB DESCRIPTION: Air Force Reserve Remotely Piloted Aircraft (RPA) Pilot

Position: Officer (2Lt – Major) AFSC: 11U1

Overview:

The MQ-1 Predator and MQ-9 Reaper Remotely Piloted Aircraft (RPA), commonly known as drones, have individual pilots and crews who are physically located in control centers often thousands of miles from the aircraft. These officers have completed the same undergraduate flight training as other pilot specialties.

Specific Tasks:

- Supervise mission planning, preparation, filing of flight plan and crew briefing
- Operate aircraft and command crew
- Perform or direct navigation, surveillance, reconnaissance and weapons employment operations
- Conduct training of crewmembers and ensure operational readiness

Training:

NON-COMMISSIONED APPLICANT AGE: Due to the length of administrative processing involved in the commissioning process, applicants must be selected by age 28 and be no more than age 30 by the start date of the board's first available Undergraduate Flying Training class (UFT). This will allow time for non-prior commissioned applicants to graduate from the 9-week Academy of Military Science as an ANG Officer prior to attending UFT. Prior-Commissioned applicants must not have exceeded rank-age ceiling.

Completion of Air Force Specialized Undergraduate Pilot Training (SUPT)

Requirements:

- Education: Bachelor's Degree
- Commission as an officer in the Air Force Reserve
- Current aeronautical rating and no permanent disqualification for aviation service as pilot
- AFOQT Scores required: Verbal - 15; Quantitative – 10; Pilot – 25; Navigator – 10; Sum – 50 (Sum is the minimum composite score required by adding both the scores of Pilot and Navigator.) Applicants must meet or exceed the minimum Pilot and/or Navigator scores to qualify for appointment and attendance of Undergraduate Pilot Training (UPT).
- TBAS (Test of Basic Aviation Skills): Applicants must complete testing before boards.
- Security Clearance: Eligibility for Top Secret security clearance
- Strength Requirement: Medium
- Physical Profile Requirement: Applicants must pass a Flying Class 1 physical.

Other Requirements:

- Normal color vision required
- Must be US Citizen
- Never been a member of the U.S. Peace Corps, except as specified in Air Force Regulation 614-200, chapter 1
- No record of conviction by court-martial
- No record of conviction by a civil court for any offense other than minor traffic violations.

Similar Civilian Occupations:

There are civilian occupations that are directly equivalent to AFSC 11U1. The US homeland Security and Border Patrol are more and more using UAVs to monitor large areas, from a central command center.

Additionally the following civilian occupations make use of the skills developed through training and experience.

- Airfield Operations Specialists
- Business Operations Specialists
- Commercial Pilot
- Training and Development Specialists

Courtesy: About.com/Military, USAF, ehow.com, USAF Reserve, Wikipedia

Links to more Air Force UAV Pilot Information click below:

http://www.airforcetimes.com/article/20081103/NEWS/811030336/Guard-opening-UAV-fliers-school

http://www.afreserve.com/jobs/enlisted-positions/remotely-piloted-aircraft-rpa-sensor-operator/remotely-piloted-aircraft-rpa-sensor-operator-so

http://www.popsci.com/technology/article/2010-06/us-air-force-adds-undergrad-uav-training-makes-drone-pilot-career-choice

JOB DESCRIPTION: Navy Enlisted UAV Operator

NEC 8362 Unmanned Aerial Vehicle (UAV) External Pilot

UAV External Pilot directly controls the flight of the UAV during launch and recovery operations by visual reference to the UAV.

Duties performed by Navy sailors in this MOS include:

- Prepares and conducts air reconnaissance mission
- Operates mission sensor/payload for target detection
- Plans and analyzes flight missions
- Deploys and redeploys the TUAV ground and air system
- Operates and performs operator level maintenance on communications equipment, power sources, light and heavy wheel vehicle and some crane operations
- Launches and recovers the air vehicles performs pre-flight, in flight and post-flight checks and procedures.
- Directs emplacement of ground control station
- Directs emplacement of launch and recovery systems
- Supervises and assists in air

frame repair and coordinates evacuation and replacement of parts and end items.

Sailors must already be trained in one of several Navy ratings and achieve promotion to a particular rank: E-3 for UAV and MQ-8 maintenance technicians and MQ-8 payload operators, petty officer third class (E-4) for internal/external UAV pilots and UAV payload operators, and petty officer first class (E-6) for MQ-8 pilots.

Training Information:
23 weeks, 3 days at Fort Huachuca, AZ

Paygrade: E-3 or higher

Source Rating(s):
AS, AM, AE, AT, AW, AZ, IS
Billet Paygrades: E5-E6
Personnel Paygrades: E4-E6
Course: Mandatory

Notes:
1. Flight physical must be completed prior to arrival in accordance with aeromedical reference and waiver guide and also NAVMED P117.
2. Physical Qualification – Class Two Physical.

Other Requirements:
- Normal color vision required
- Must be U.S. Citizen
- Never been a member of the U.S. Peace Corps, except as specified in Army Regulation 614-200, chapter 1
- No record of conviction by court-martial
- No record of conviction by a civil court for any offense other than minor traffic violations.

The Army and Marines have tackled UAV staffing by creating distinct new military occupational specialties (MOS) for UAV operators and maintenance crews. For the time being, the Navy has decided instead to make UAVs a *Navy Enlisted Classification (NEC)* — in other words, a skill or job designator applied to specially trained personnel that already hold down a standard rating (that's sailor talk for MOS.)

NEC 8361, UAV Systems Organizational Maintenance Technician: Your basic UAV repair person. "Organizational maintenance" means basic repairs and cleaning — possibly replacing major components.

NEC 8362, UAV External Pilot: whereas other services seem to have one operator doing all the work, the Navy has decided to have a separate pilot set aside for take-offs and landings who controls the plane by sight.

NEC 8363, UAV Internal Pilot: "Internal" is a bit of a misnomer — no one is ever getting inside a UAV. This is the operator that takes over once the UAV is in the air, operating it from far greater distances by satellite connection.

NEC 8364, UAV Payload Operator: A separate designator for the sailor that remotely operates the sensor equipment on the UAV.

NECs 8366, 8367, and 8368: These separate NECs for the *MQ-8 Fire Scout,* a UAV helicopter, denote assignment as an organizational maintenance technician, payload operator, and pilot, respectively.

Courtesy: About.com/Military, US Navy, ehow.com, Wikipedia

Links to more Navy Pilot Information:

http://www.navy.com/careers/aviation/flight-operations.html

http://militarycareers.about.com/od/Career-Profiles/p/Career-Profile-Navy-UAV-Careers.htm

http://www.navytimes.com/article/20081102/NEWS/811020311/New-rating-considered-UAV-operators

http://en.wikipedia.org/wiki/Unmanned_aerial_vehicle

JOB DESCRIPTION: USMC UAV Operator

MOS 7314 Unmanned Aerial Vehicle (UAV) Operator
MOS 7316, External Unmanned Aerial Vehicle (UAV) Operator

Basic Job Description:

Every branch of service takes advantage of Unmanned Aerial Vehicles (UAV) these days to extend their reach on the battlefield, while limiting risk to life and limb. And though Marines must become commissioned officers to fly manned aircraft, enlisted Marines straight out of high school have an opportunity to fly cutting-edge aviation equipment — even if only by remote — as UAV operators in Military Occupational Specialty (MOS) 7314.

External UAV operators (MOS 7316) execute the initial takeoff and final landing phases of UAV operations. They are also an integral part of all mission planning, takeoff and landing sequences, and crew coordination aspects of UAV flight.

UAV operators are there to monitor a pre-programmed flight plan and make adjustments as necessary, "flying by mouse."

Central to the purpose of UAVs, operators are also responsible for operating sensor equipment remotely, monitoring and interpreting aerial camera imagery in order to gather intelligence. Though there's no mention of weapons systems for Marine UAVs in the MOS Manual, operators are required to understand and use "call for fire procedures" much the same as scout observers on the ground. In layman's terms, that means supporting the Marines on the battlefield by identifying the enemy's map coordinates and passing them on to artillery, fighter planes, and other heavy hitters.

General Information:

- UAV Training Information: 23 weeks, 3 days at Fort Huachuca, AZ
- ASVAB Score Required: 105 in the aptitude area SC
- Security Clearance: Secret
- Strength Requirement: medium
- Physical Profile: Pass the Navy's Class III Flight Physical standards

Other Requirements:

- Normal color vision required
- Must be US Citizen
- Never been a member of the U.S. Peace Corps, except as specified in Army Regulation 614-200, chapter 1
- No record of conviction by court-martial
- No record of conviction by a civil court for any offense other than minor traffic violations
- Must meet the physical requirements per section IV, article 15- 65, paragraph 1.15 of reference (ak).
- Complete the Unmanned Aerial Vehicle Operator Common Core, 243- 96U10 or
- Unmanned Aerial Vehicle Operator (Shadow RQ-7A), or other UAS training sites and courses designated by HQMC.
- Familiarity with intelligence and call for fire report formats.
- Knowledge of airspace command and control agencies and procedures.
- Knowledge of supporting arms command and control agencies and procedures.
- Basic preventative maintenance skills.

Military Education

The course covers principles of flight, including Federal Aviation Administration standards. In addition to remote piloting, Marines may receive training on line-of-sight takeoff and landing procedures, qualifying them for

the additional MOS designator 7316, External UAV operator (similar to the Navy's external UAV operator.) Marines are also taught how to gather and interpret aerial intelligence imagery.

Jim Rector, Navy and Marine Corps Small Tactical UAS program manager (PMA-263) gets a close look at the RQ-21A Puma.

Similar Civilian Occupations:

There are civilian occupations that are directly equivalent to MOS 7314 and 7316. The U.S. homeland Security and Border Patrol are more and more using UAVs to monitor large areas, from a central command center.

Additionally the following civilian occupations make use of the skills developed through MOS 7314 -16 training and experience.

- Airfield Operations Specialists
- Business Operations Specialists
- Commercial Pilot
- Training and Development Specialists

USMC ScanEagl

Links to more USMC UAV Pilot Information:

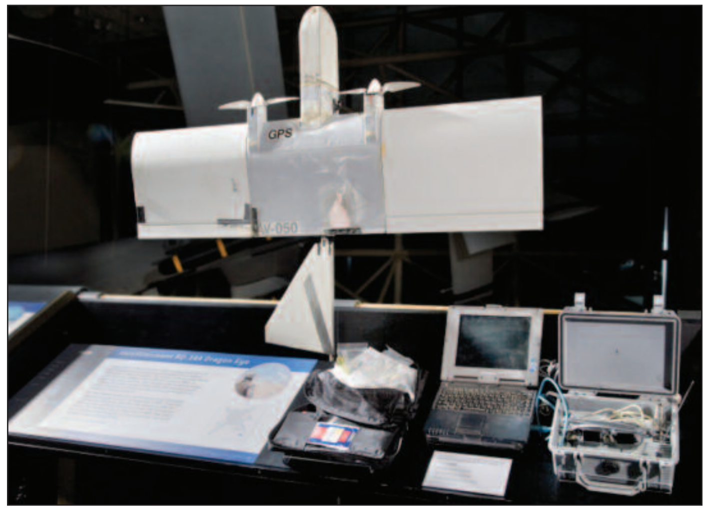
http://www.usmilitary.com/4515/marine-corps-uav-aerial-military-operator/

http://www.dailytech.com/Demand+Grows+for+US+Military+UAV+Operators+Monetary+Incentives+Plentiful/article24517.htm

http://www.marines.com/operating-forces/equipment/aircraft/rq-7-shadow

MCWP 3-42.1 Unmanned Aerial Vehicle Operations http://fas.org/irp/doddir/usmc/mcwp3-42-1.pdf

http://en.wikipedia.org/wiki/VMU-3



Courtesy: About.com/Military, USMC, ehow.com, Wikipedia

Academy of Model Aeronautics National Model Aircraft Safety Code

Effective January 1, 2014

A. GENERAL: A model aircraft is a non-human-carrying aircraft capable of sustained flight in the atmosphere. It may not exceed limitations of this code and is intended exclusively for sport, recreation, education and/or competition. All model flights must be conducted in accordance with this safety code and any additional rules specific to the flying site.

1. Model aircraft will not be flown:
   - (a) In a careless or reckless manner.
   - (b) At a location where model aircraft activities are prohibited.
2. Model aircraft pilots will:
   - (a) Yield the right of way to all human-carrying aircraft.
   - (b) See and avoid all aircraft and a spotter must be used when appropriate. (AMA Document #540-D.)
   - (c) Not fly higher than approximately 400 feet above ground level within three (3) miles of an airport without notifying the airport operator.
   - (d) Not interfere with operations and traffic patterns at any airport, heliport or seaplane base except where there is a mixed use agreement.
   - (e) Not exceed a takeoff weight, including fuel, of 55 pounds unless in compliance with the AMA Large Model Airplane program. (AMA Document 520-A.)
   - (f) Ensure the aircraft is identified with the name and address or AMA number of the owner on the inside or affixed to the outside of the model aircraft. (This does not apply to model aircraft flown indoors.)
   - (g) Not operate aircraft with metal-blade propellers or with gaseous boosts except for helicopters operated under the provisions of AMA Document #555.
   - (h) Not operate model aircraft while under the influence of alcohol or while using any drug that could adversely affect the pilot's ability to safely control the model.
   - (i) Not operate model aircraft carrying pyrotechnic devices that explode or burn, or any device which propels a projectile or drops any object that creates a hazard to persons or property.
     Exceptions:
     - ♦ Free Flight fuses or devices that burn producing smoke and are securely attached to the model aircraft during flight.
     - ♦ Rocket motors (using solid propellant) up to a G-series size may be used provided they remain attached to the model during flight. Model rockets may be flown in accordance with the National Model Rocketry Safety Code but may not be launched from model aircraft.
     - ♦ Officially designated AMA Air Show Teams (AST) are authorized to use devices and practices as defined within the Team AMA Program Document. (AMA Document #718.)
   - (j) Not operate a turbine-powered aircraft, unless in compliance with the AMA turbine regulations. (AMA Document #510-A.)
3. Model aircraft will not be flown in AMA sanctioned events, air shows or model demonstrations unless:
   - (a) The aircraft, control system and pilot skills have successfully demonstrated all maneuvers intended or anticipated prior to the specific event.
   - (b) An inexperienced pilot is assisted by an experienced pilot.
4. When and where required by rule, helmets must be properly worn and fastened. They must be OSHA, DOT, ANSI, SNELL or NOCSAE approved or comply with comparable standards.

B. RADIO CONTROL (RC)

1. All pilots shall avoid flying directly over unprotected people, vessels, vehicles or structures and shall avoid endangerment of life and property of others.
2. A successful radio equipment ground-range check in accordance with manufacturer's recommendations will be completed before the first flight of a new or repaired model aircraft.
3. At all flying sites a safety line(s) must be established in front of which all flying takes place. (AMA Document #706.)
   - (a) Only personnel associated with flying the model aircraft are allowed at or in front of the safety line.
   - (b) At air shows or demonstrations, a straight safety line must be established.
   - (c) An area away from the safety line must be maintained for spectators.
   - (d) Intentional flying behind the safety line is prohibited.
4. RC model aircraft must use the radio-control frequencies currently allowed by the Federal Communications Commission (FCC). Only individuals properly licensed by the FCC are authorized to operate equipment on Amateur Band frequencies.
5. RC model aircraft will not knowingly operate within three (3) miles of any pre-existing flying site without a frequency-management agreement. (AMA Documents #922 and #923.)
6. With the exception of events flown under official AMA Competition Regulations, excluding takeoff and landing, no powered model may be flown outdoors closer than 25 feet to any individual, except for the pilot and the pilot's helper(s) located at the flightline.
7. Under no circumstances may a pilot or other person

touch an outdoor model aircraft in flight while it is still under power, except to divert it from striking an individual.

8. RC night flying requires a lighting system providing the pilot with a clear view of the model's attitude and orientation at all times. Hand-held illumination systems are inadequate for night flying operations.
9. The pilot of an RC model aircraft shall:
   (a) Maintain control during the entire flight, maintaining visual contact without enhancement other than by corrective lenses prescribed for the pilot.
   (b) Fly using the assistance of a camera or First-Person View (FPV) only in accordance with the procedures outlined in AMA Document #550.
   (c) Fly using the assistance of autopilot or stabilization system only in accordance with the procedures outlined in AMA Document #560.

C. FREE FLIGHT

1. Must be at least 100 feet downwind of spectators and automobile parking when the model aircraft is launched.
2. Launch area must be clear of all individuals except mechanics, officials, and other fliers.
3. An effective device will be used to extinguish any fuse on the model aircraft after the fuse has completed its function.

D. CONTROL LINE

1. The complete control system (including the safety thong where applicable) must have an inspection and pull test prior to flying.
2. The pull test will be in accordance with the current Competition Regulations for the applicable model aircraft category.
3. Model aircraft not fitting a specific category shall use those pull-test requirements as indicated for Control Line Precision Aerobatics.
4. The flying area must be clear of all utility wires or poles and a model aircraft will not be flown closer than 50 feet to any above-ground electric utility lines.
5. The flying area must be clear of all nonessential participants and spectators before the engine is started.

RC and sUAV Aircraft Safety

SAFETY FIRST

One of the first reactions when receiving an RC Model plane is that you will want to take it out of the box and see what it can do. That is only natural with any gift, especially with one that is going to give you the thrill of controlling your own airplane. Before jumping right into trying it out, though, there are certain RC model plane safety tips and procedures that a new RC model plane pilot must know.

You must be a safe, courteous, and responsible RC owner and operator. It will not matter if you are at a local AMA flying field, the city park or an empty field, there are a number of rules we all follow. Flying radio controlled aircraft including planes, helicopters, and blimps requires both common sense and following certain ordinances and legal restrictions.

The first is getting started with your RC model plane following the proper RC model plane safety tips for starting it. Always turn on your controller and make sure if it is working before you turn on the model plane itself. This will ensure you have a device to control your model plane with in case it would malfunction and start to move as soon as you turn it on. Be sure to turn both the controller and plane on in an area with a lot of open space. This will allow you to get a feel for the controls without many obstacles as each model airplane can react just a little different to your touch on the controller.

There are four basic rules all RC pilots learn, sometimes the hard way. They ensure your plane and you have a good experience flying. These common sense rules are:

1. Control Your Aircraft Controller

Before you run your RC plane, remember: The controller on first, aircraft on second. Never turn your RC airplane or helicopter on with your controller off. Another controller in the area may take over and fly your airplane or helicopter into a tree, a power line, or right into the ground.

After you run your RC plane: Turn the aircraft off first, controller off second. Never turn your controller off with your plane or helicopter on. Stray signals from other RC remotes can, and most likely will, take control of your airplane or helicopter. Results of remote takeover can be disastrous.

2. Choose safe RC flying areas

Indoor Flight: Make sure that you are not in a crowded area -- even the best of pilots can lose control and the blades of a helicopter can really hurt someone. Make sure you have enough room to maneuver around furniture and hanging obstacles (fans, lights, etc.). Be sure there is enough turning room to avoid crashing into walls and damaging your aircraft.

Outdoor Flight: Make sure that your operating area is free of power lines and trees. The last thing you want after dropping a lot of money into your RC plane / helicopter is for it to be fried by a high-voltage wire or for it to tear itself apart in a tree. Avoid flying over crowds or vehicular traffic - you don't want to crash into people or cars.

3. Don't fly on windy days

If it seems too windy outdoors to fly, it probably is. Your RC plane or helicopter doesn't stand much of a chance against wind so it really isn't worth the risk. Even if you are able to get your aircraft into the air, gusts of wind can cause crashes and could send your aircraft into dangerous areas such as a crowd of people, a tree, or the side of a building.

If you can't fly indoors, wait for a very still, windless day to fly your RC aircraft.

This isn't just advice I've heard from others and decided to pass along. I'm speaking from experience. Don't just stand still and see if there's any wind blowing on you -- look up. You'll be flying up high usually. Check the trees, the tree tops, and even the clouds for movement. Certain heavier aircraft can withstand slight breezes but watch out for gusts of wind.

4. Handle and store nitro fuel safely

Fueling: Nitromethane or nitro fuel is highly flammable. Just as you shouldn't smoke while fueling the family car, avoid smoking and open flames around the nitro fuel for your RC. When fueling your nitro RC, wipe up any spills and properly dispose of fuel-soaked rags.

Handling: At the park or track it's common to carry fuel in a quick-fill bottle. To ensure that you don't get your fuel mixed up with someone else's (who might be running a different mixture) label your fuel bottle with your name. If you're running multiple RC airplanes with different fuel mixtures, color-code your bottles to avoid mix-ups.

Storage: As with gas cans stored at home, store your nitro fuel away from open flames (next to the hot water heater with its lit pilot light is not a good storage idea). Keep the container tightly capped to avoid evaporation. Don't store nitro fuel in a damp location either as the fuel attracts moisture, and water in the fuel will render it weak and could be harmful to your nitro engine.

The above rules will help you no matter where you fly RC. But there are rules that we all must adhere to. The FAA (the government) has rules pertaining to operation of RC planes, as possibly your town or city does as well. The next set of rules is from an FAA publication, and needs to be remembered whenever you fly at a field or open space that is not a regulated AMA flying field.

Since the Civil Air Patrol is partnered with the Academy of Model Aeronautics (AMA) in advancing the safe operation of flying model airplanes

(RC, Free Flight, and Control Line), and that CAP cadets are encouraged to join the AMA as youth Members, they are also expected to adhere to AMA rules when it comes to flying RC airplanes.

The next pages will show the FAA and AMA rules that pertain to flying RC or sUAV airplanes.

SAFETY CODE COMPLIANCE

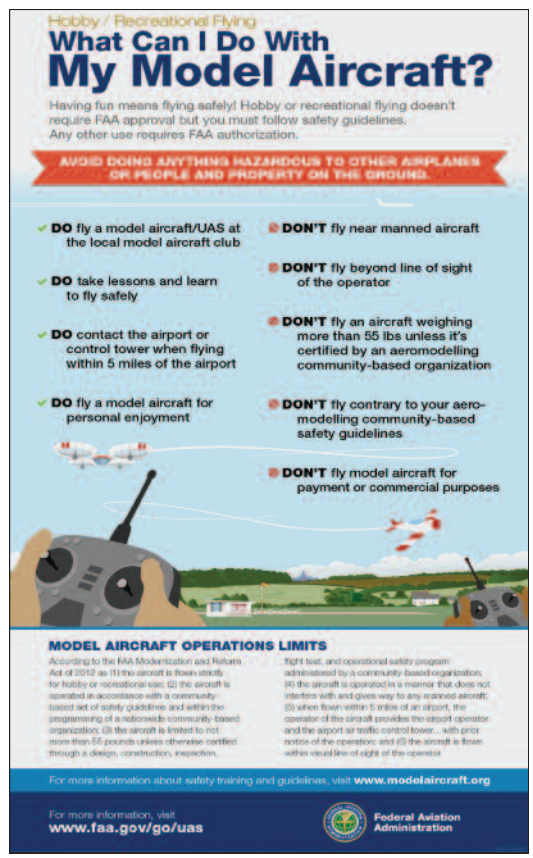
It is the intent of the Academy of Model Aeronautics to make its members aware of the ever-increasing importance of operating their model aircraft in the safest possible manner. Aeromodeling is a very gratifying avocation but with it comes the responsibility of every participant to exercise the same caution and professionalism one would expect to find in any other aviation activity. In these days of rapidly increasing insurance premiums, escalating monetary settlements from litigation, and rising costs for medical services, we and our members cannot afford to take safety for granted. The minimum amount of time and effort required to operate safely pays major benefits many times over.

Let it be known that any deviation on the operation of model aircraft from the AMA National Model Aircraft Safety Code, including but not limited to operating in a reckless, irresponsible, intentionally unsafe manner, may seriously limit the extent to which AMA benefits may work to protect our members, clubs, and landowners.

All AMA chartered clubs are charged with the responsibility to ensure that their operations in connection with flying activities will be conducted in compliance with the AMA's National Safety Code(s). Specialized supplemental safety codes include Radio Control Combat (#525), General Radio Control Racing (#530), Giant Scale Radio Control Racing (#515-A), Gas Turbine Operation (note: special waiver required) (#510-A), Park Flyer Safe Operating Recommendations (#545), and First Person View (FPV) Operations (#550). These special documents may be obtained either from the AMA Web site at:

www.modelaircraft.org/documents.aspx

The AMA National Model Aircraft Code is attached so it can be read in its entirety and applied accordingly to how we all operate RC airplanes. Never leave the controller and aircraft switches in the "ON" position.



activity one

Indoor Lighter Than Air (LTA) Electric RC Nano Blimp

OBJECTIVES: Build a simple helium blimp

Experience how to fly a lighter-than-air (LTA) Airship RC aeromodel

Excite imaginations for indoor LTA RC model flying

Explore building hybrids of a basic RC model

Apply precise building technique for a successful LTA flight

The White Dwarf bicycle pedal powered blimp of 2007

NanoBlimp in Flight in an Office

Activity Credit: *Credit and Permission to Reprint – Vat19 (Vat19.com), the US distributor of the Plantraco Ltd (Canada) "NanoBlimp" aeromodel has graciously given the Civil Air Patrol permission to use the model photos and material developed by Vat19 for this publication. More information, tips and updates on the Nano Blimp models may be found at http://www.vat19.com/dvds/nano-blimp-remote-controlled-indoor-blimp.cfm or visit Plantraco Microflight at http://www.microflight.com.*

MATERIALS

No tools are really required for the NanoBlimp ARF aircraft. Assembly is straight forward and outlined in the provided Set Up and Operating Instructions booklet that comes with the LTA Airship at http://www.microflight.com.

Helium can be purchased at most party stores, and larger department stores like Wal-Mart and Target for less than $40.

Provided in the kit:

- One HFX900 Proportional R/C Transmitter/Charger (900 Mhz-USA, 868Mhz-EU).
- Gondola with radio receiver, three-motors with propellers.
- Weights.
- 10-Balloons.
- Adhesive strips.
- Joysticks and washers.

*You will need 4 x“AA” alkaline batteries for the HFX900 Transmitter/Charger.

NATIONAL STANDARDS

Science Standards:

Current Standard: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understands about scientific inquiry

Current Standard: Physical Science
- Motions and forces

Current Standard: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Current Standard: History and the Nature of Science
- Science as a human endeavor
- Historical perspectives
- Unifying Concepts and Processes
- Evidence, models, and explanation

Technology Standards:

Current Standard: The Designed World

Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

BACKGROUND

The term "blimp" refers only to a free-flying aircraft. The term is sometimes erroneously used to refer to the tethered craft known as moored balloons. While often very similar in shape, moored balloons have no propulsion and are tethered to the ground.

The “B” class blimps were patrol airships operated by the United States Navy during and shortly after World War I. During World War I there were no really good airship design criteria. Dr. Jerome Hunsaker was asked to develop a theory of airship design, Lt. John H. Towers returned from Europe having inspected British designs, and the Navy sought bids for 16 blimps from American manufacturers. On 4 February, 1917, the Secretary of the Navy directed that 16 non-rigid airships of Class “B” to be procured. Ultimately, Goodyear built 9 envelopes, Goodrich built 5 and Curtiss built the gondolas for all of those 14 ships. Connecticut Aircraft contracted with U.S. Rubber for its two envelopes and with Pigeon Fraser for its gondolas. The Curtiss-built gondolas were modified JN-4 fuselages and were powered by OX-5 engines. The Connecticut Aircraft blimps were powered by Hall-Scott engines. So began the Navy’s long association with LTA Blimps leading to the G-Class of the late 1930s.

The G-Class Blimps were a series of non-rigid airships (blimps) used by the United States Navy. In 1935, instead of developing a new design airship, the Navy purchased the Goodyear Blimp Defender for use as a trainer and utility airship assigning it the designator G-1. Defender was built by the Goodyear Aircraft Company of Akron, OH and was the largest blimp in the company’s fleet of airships that were used for advertising and as passenger airships. Additional G-class airships were bought during World War II to support training needs.

G-7

Specifications: G-Class Blimp (1942)

General characteristics

- Crew: 2-3
- Capacity: 7-8
- Length: 186 ft 8 in (56.94 m)
- Diameter: 42 ft 10 in (13.06 m)
- Height: 62 ft (18.90 m)
- Volume: 183,000 ft^3 (5,182 m^3)
- Useful lift: 4,115 lb (1,867 kg)
- Powerplant: 2 × Continental R-670-2 radials, 210 hp (157 kW) each each

Performance

- Maximum speed: 57 mph (92 km/h)
- Cruise speed: 48 mph (77 km/h)
- Endurance: 16 hours 42 min

A **blimp**, or non-rigid airship, is a floating airship without an internal supporting framework, or a keel. A non-rigid airship differs from a semi-rigid airship and a rigid airship (e.g., a Zeppelin) in that it does not have any rigid structure, neither a complete framework nor a partial keel, to help the airbag maintain its shape. Rather, these aircraft rely on both a higher pressure of the lifting gas (usually helium, rather than hydrogen) inside the envelope and the strength of the envelope itself. The part underneath is called the buckle.

What is Lighter Than Air

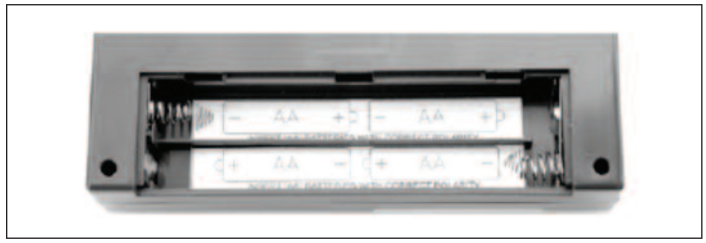
Lighter than air refers to materials (usually gases) that are buoyant in air because they have densities lower than that of air (about 1.2 kg/m^3, 1.2 g/L). Some of these gases are used as lifting gases in lighter-than-air aircraft, which include free balloons, moored balloons, and airships, to make the whole craft, on average, lighter than air. Heavier-than-air aircraft also include airplanes, gliders and helicopters.

The Nano Blimp is the World's Smallest Remote Controlled LTA Blimp! Aside from what comes in the kit, you will need 4 -“AA” batteries (not included) and a supply of helium. Helium (not included) can be purchased at any party store or most department stores in the party and balloons sections.

The secret to the Nano Blimp is its gondola, which combines motors, propellers, a radio receiver, lithium-ion battery, and a charging port into one super lightweight design.

PROCEDURE

1. Add 4 “AA” batteries to the Transmitter. Be careful to place them with proper (+/-) polarity.



2. Inflate the balloon with helium, and tie it off securely.
3. To fill, follow the instructions on the helium container. It was made to fill just such balloons as used in the Nano Blimp.
4. Switch ON the transmitter.
5. Attach the small rechargeable blimp battery to the Micro blimp gondola. You’ll hear several tones as the Micro blimp syncs with the transmitter.

6. The propellers will start to spin. You now need to adjust your trim using the trimmer wheels on the transmitter. Adjust the wheels until you have stopped all rotation of the 3 propellers. (Note that your default transmitter mixing mode is airplane style blimp mixing). Stop here and read the whole manual if you found it tricky to trim out the propellers.
7. Attach the Micro Blimp gondola receiver to the center of the balloon using the supplied Velcro hooks to the center of the balloon, and the fuzzy part of the Velcro to the top of the Micro Blimp Gondola. The plastic gondola dome can be added later.
8. Add the included ballast weights to achieve neutral buoyancy with the receiver battery installed. The ballast weights consist of a metal washer or a coin that is taped onto the balloon, and then a series of included ballast magnets can be added until the Micro Blimp neither rises nor falls - it will just float there in midair.
9. You are ready to fly! Take a short test flight, and recharge your battery.

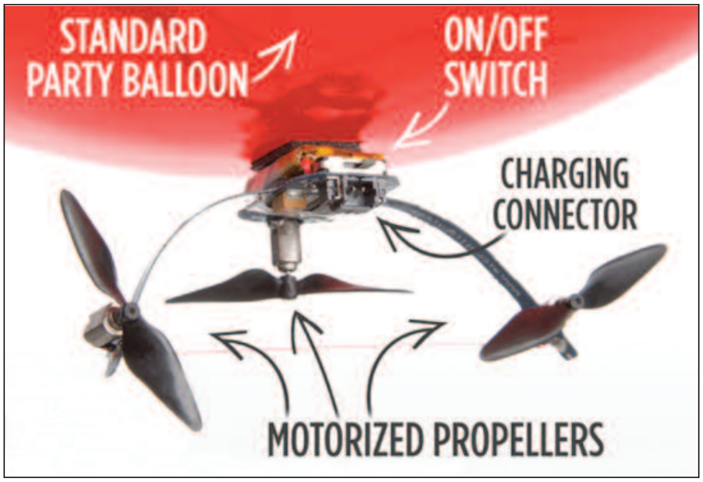
Charge Lithium Polymer Rechargeable "Bahoma" Cell

The included lithium polymer cell features Plantraco's Bahoma (**BA**ttery **HO**lder using **MA**gnets) connector (patent pending). The Bahoma connector system uses strong plated magnets to hold the battery onto the charger and onto the NanoBlimp gondola. These magnets are also used as electrical conductors. The terminals of the Bahoma cell are protected from shorting to each other by a plastic safety guard. (See Fig. 1)

On the front of the transmitter, slide the 3 position switch to the middle position to put the transmitter into its "charge" mode. The LED inside the charger door will be blinking rapidly. Slide the hinged clear polycarbonate plastic charger door downwards to unlock it, and then lift it open. Attach the Bahoma cell to the corresponding magnetic terminals. The Bahoma cell will "click" into place on the charger by magnetic attraction and with good electrical contact. The LED inside the charger will now glow brightly. Close the clear charger door, and slide it up to shut it with a small click. Your cell is now charging, and when the bright LED goes out, the cell is fully charged and ready for use. Charge time is about 40 - 60 minutes. (See Fig. 2)

Receiver – NanoBlimp Gondola

The circuit board with 3 motors and propellers is the NanoBlimp Gondola. It has a built-in R/C receiver, antenna, microprocessor, power transistors to control the motors, LED indicator light, and Bahoma magnetic battery terminals. The small oval shaped circuit board material is used to attach the NanoBlimp gondola to the balloon with the included adhesive backed Velcro, or you can also use 2 small pieces of cellophane tape to attach it to a balloon if you wish



Flying and Trimming

The **Left Joystick** controls your forward and reverse thrust of both Left and Right motors simultaneously and equally. If you use the Left stick alone, you will cause your blimp to thrust forward or backward. Side-to-side motion of the Left joystick has no function.

The **Right Joystick** is used for steering Left and Right, and also to ascend and descend - Just remember to Pull the Right stick to go UP. PULL-UP - just like the old war movies "You're too low! Pull Up! Pull Up!" - It is an easy way to remember that when you want the NanoBlimp to go up, you pull back on the Right stick.

Conversely, if you push the Right Joystick forward, you will descend. Now for steering Left and Right, you should remember to go easy on the sticks – you don't need to move a whole lot to get the NanoBlimp to turn one way or another - you have precision proportional control, so remember to take it easy - small and slow stick motions will be better for learning.

With any R/C aircraft, the biggest challenge for the beginner is when the aircraft is coming back toward you - you will find that your controls will seem reversed when the Micro Blimp is coming back toward you. Every R/C flyer must master the controls under this situation, and the Micro blimp is a good R/C airplane trainer for this purpose.

Try to imagine that you are inside the Micro Blimp looking out. If you can put yourself in the cockpit, you will be well on your way to becoming a good pilot. Once you have mastered flying the Micro Blimp, you'll be ready to try an R/C airplane or any other R/C aircraft.

Tips:

- Most new pilots tend to use too much thrusting power when beginning to fly and find that they are crashing into walls and generally losing control of the NanoBlimp.

- What is most important is what the NanoBlimp is doing, NOT what position your joysticks are in - you will react to the motion of the Micro Blimp and modulate your controls to achieve the desired flight path.

- If you like, you can tape a small vertical "fin" to the rear of the balloon to make the balloon more stable and less reactive to your controls. Experiment with the size of fin until you get the desired level of "damping." This will make the airship less reactive to your controls, but it may help beginner pilots.

- You can patch a small hole in the balloon with cellophane (Scotch) tape.

- Do not fly outdoors: You will only have one flight! The saucer is very sensitive to the slightest breeze and thermal activity. Outdoor flying will allow the saucer to get away. If you must fly outdoors, tether the saucer to the ground with a length of string or lightweight fishing line.

- DO NOT ALLOW THE BALLOON TO FLOAT AROUND THE HOUSE UNATTENDED. ALWAYS TETHER YOUR SAUCER AFTER YOU ARE FINISHED FLYING.

• Read the instruction manual!
• The Nanoblimp has a bigger brother called the MicroBlimp that is twice as big as well if you want something larger.
• http://www.microflight.com/MicroBlimp-RTF-Set

EVALUATION

Build one or more blimps using different types of balloons, and report on what different flying characteristics you have observed. Add a light-weight steering rudder and see what effects it has on your flights.

Visit the website http://www.microflight.com or read the instruction manual and learn how to configure three different control transmitters so up to three balloons can fly combat with push pins as weapons!

EXTENSION

http://home.teleport.com/~reedg/whitedwarf.html

RESOURCES

LTA Modeling Websites:
3-Channel RC Helium Good Year Blimp:
http://www.rctoys.com/rc-toys-and-parts/MACH-3Z-GOODYEAR/RC-BLIMPS.html

http://airshiphangar.com/rc-airships.html

http://www.rctoys.com/Merchant2/merchant.mvc?Screen=CTGY&Category_Code=RC-BLIMPS&Offset=&SortBy=best-desc

Google “Helium at Wal-Mart or Target” and you will have all the information you need on where to get Helium. It is legal.

Beginner Level RC Indoor Electric (RTF) Helicopter

OBJECTIVES: Assemble the aircraft

Safely train with a fully proportional 3-channel aircraft and radio system

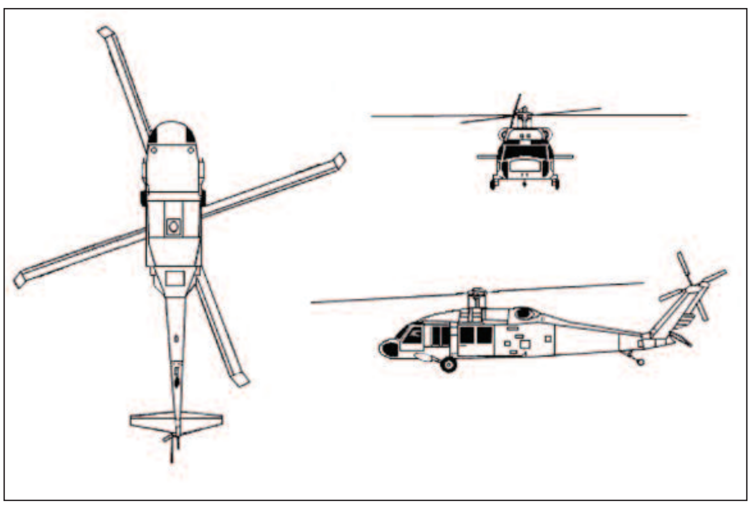
Excite students and deepen their understanding about science and the physics of flight

Activity Credit: *Credit and Permission to Reprint – Syma Toys LTD, China is the designer, manufacturer, and distributor of this product and has graciously given the Civil Air Patrol permission to reprint the photos and owner's manual instructions here for one or more of their Ready to Fly (RTF) RC airplanes. More model aircraft, parts, and accessories can be found at the USA distributor UJtoys of Houston, Texas found at http://www.UJtoys.com*

BACKGROUND

General Information: Manufactured by Sikorsky Aircraft Division of United Technologies, 42 medium-range Jayhawk HH-60J helicopters are operating in the Coast Guard. On board the Jayhawk, the Collins RCVR-3A radio simultaneously receives information from four of the system's 18 worldwide satellites and converts it into latitude and longitude fixes that pinpoint the helicopter's position. The HH-60J is not able to perform water landings. However, with its twin T700-GE-401C engines, the Jayhawk can fly 300 miles offshore, remain on scene 45 minutes, hoist six people on board, and return to its point of origin with a safe fuel reserve. Normal cruising speeds of 135-140 knots can be increased to a "dash" speed of 180 knots when necessary. The H-60 will fly comfortably at 140 knots for six to seven hours. Though normally stationed ashore, the Jayhawk can be carried aboard 270-foot WMEC and 378-foot WHEC Coast Guard cutters. The actual implementation of the HH-60J began in March of 1990 with the delivery of the first airframe to Naval Air Station Patuxent River, Maryland, for developmental testing.

Missions: The Jayhawk's state-of-the-art radar, radio, and navigation equipment enables the helicopter to carry out the Coast Guard's search and rescue, law enforcement, military readiness, and marine environmental protection missions efficiently and effectively. Courtesy: USCG



Sikorsky Jayhawk HH-60J Specifications
Rotor Diameter: 53 ft. 8 in.
Length: 64 ft. 10 in.
Height: 17 ft.
Empty Weight: 14,500 lbs
Max Takeoff Weight: 21,884 lbs
Top Speed: 391 mph
Service Ceiling: 39,400 ft.
Range: 1,850 miles
Engine/Horsepower: Two GE T700-GE-401C Gas Turbines, 1,890 shp each
Crew: 4
Armament: 1 x 7.62 mm M240H machine guns (door) and 1 x 12.7 mm machine gun

MATERIALS

No tools are required for the Syma S111G Defense mini 3-channel 8" RTF RC helicopter. RTF means "Ready to Fly" (RTF) almost right out of the box. There is very little assembly, and no tools required.

NATIONAL STANDARDS

Science Standards:

Current Standard: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understands about scientific inquiry

Current Standard: Physical Science
- Motions and forces

Current Standard: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Current Standard: History and the Nature of Science
- Science as a human endeavor
- Historical perspectives
- Unifying Concepts and Processes
- Evidence, models, and explanation

Technology Standards:

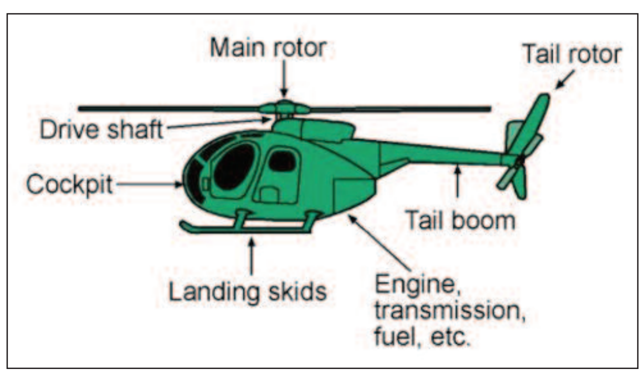
Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

VOCABULARY

RTF: Ready to fly means there is essentially no assembly requiring tools.

3-Channel: Throttle, Steering (left/right), and Pitch (up/down)

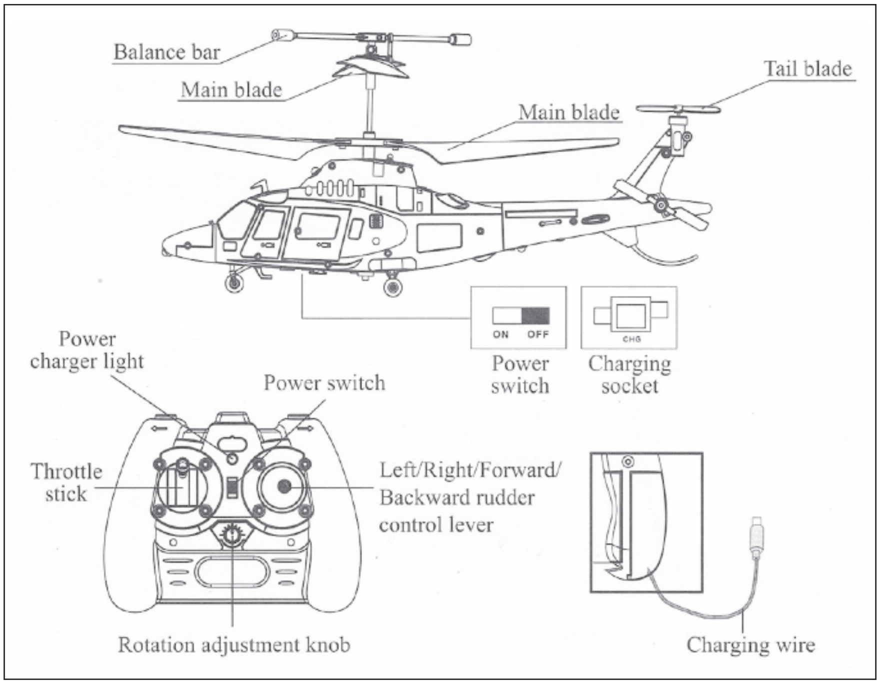
Gyro: A gyroscope is a device which maintains its orientation in space. When installed in an RC helicopter, the gyroscope eliminates any unwanted movement of the tail (yaw).



MAIN PARTS OF A HELICOPTER

Features: S111G RC Helicopter
- Product: 100% NEW and Genuine from SYMA
- Up/down, left/right, forward/backward
- Indoor / Outdoor Ready to Fly.
- With Vernier Adjustment Knob.
- Metal Frame - Double Protection of the body.
- Flashlight included.
- Built-in GYRO: Control your helicopter easily and perfectly

Specifications:
- Type: Helicopter
- Rotor Diameter: 7 in
- Overall Length: 8.5 in
- Flying Weight: 0.6 oz
- Non-stop Flying Time: 8 minutes
- Aircraft Recommended Battery: 150mAh 3.7V 14C Li-Poly
- Radio controller Batteries: 6 x "AA"
- Is Assembly Required: No
- Radio Controlling Distance: 30 ft



S111G RC Helicopter contents in box:

- 1 x S111G RC Helicopter (w/150mAh 3.7V 14C Li-Poly battery
- No "AA" batteries for the controller are included
- 1 x Remote Controller a 4-in-1 infrared receiver (Gyro, ESC, Mixer, Receiver).
- 1 x USB Charging Cable
- 1 x Tail Blade
- 1 x Instruction Manual

This palm size Helicopter (8.5 inches long) has a very beautiful and detailed fuselage. Decorated with flashing LED, the visual effect is great, especially in a soft light indoor area. The Syma Mini Helicopter Series is able to move in 3 Direction base on the 3 Channels and anyone can hover it easily. Since it is very light-weight, amazingly it is almost indestructible in any crash, perfect for very first time beginners. This RC helicopter is designed for anyone over 8 years old; flight time is around 5-6 minutes after 20-30 minutes charging. It can fly in 6 directions. They are:

- Rotate Clockwise / Anti-Clockwise
- Move Forward / Backward
- Move Up / Down

PROCEDURE

The following is from the Syma S111G RC Helicopter Owner's "Instruction Manual."

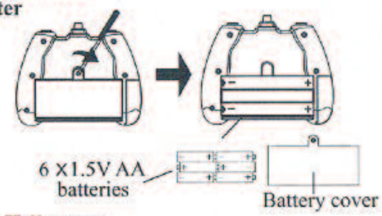
The S111G RC helicopter comes with all required materials and assemblies. You can literally buy the RTF helicopter, take the box to a flying location, open it up, do the following assemblies and begin flying within a few minutes. 6-Steps and that's all there is to it!

Step 1-2: Batteries and Power
1. Install the 6 x "AA" batteries in the transmitter.
2. Charging the helicopter: This can be done in either of two ways.
   (A) Directly from the controller via a power cord from the controller handle, or
   (B) From the USB interface port on a computer.

Charging time can be 50-60 minutes for 6-10 minutes flying.

BATTERY INSTALLATION & CHARGING

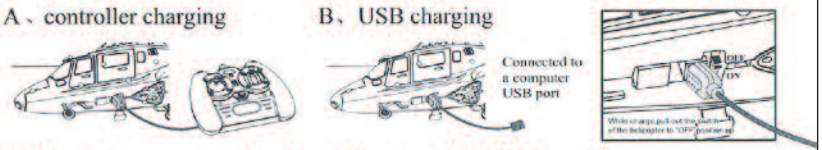
Battery Installation-Transmitter



Open the cover of battery case insert 6 batteries (size AA) properly followed by polar indicator, shut the cover of battery case.

Charging Helicopter

A、controller charging   B、USB charging



1. Move the power switch on the helicopter to the "OFF" position.
2. **Charging way A:** Put down the charging wire cover of the back controller and put out the charging wire, then put into the interface of the helicopter, the green light on the conrtoller will change red. The charging time is about 50-60 minutes The glisten red light will to change normal light. Then the helicopter is fully charged.
   Charging way B: Put the USB charging wire into the computer USB interface, the charging wire will be light. Put the other side of USB charging wire into the helicopter's interface, USB charging wire light will be turn off. The charging time is about 50-60 minutes. Charging wire light will turn on. Then the helicopter is fully charged.

Charging time can be 50-60 minutes flying for about 6-7 minutes

Step 3: Flying the helicopter

1. Set the band selector on the transmitter and the helicopter to the same frequency. The helicopter is preset to Channel A or B. Look under the helicopter next to the on/off switch. (printed CHA or CHB)

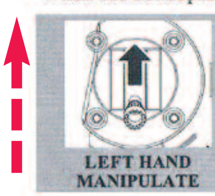
2. Move the Power Switch on the helicopter to the ON position. The power indicator and helicopter lights will light up.

3. Place the helicopter on the ground, tail pointed toward you.

4. When the helicopter received the transmitted signal, the LED of the circuit board will turn light.

FLYING YOUR HELICOPTER

- Set the Band Selector on the Transmitter and Helicopter to the same frequency.
- Move the Power Switch on the helicopter to the ON position, the power indicator will light up.
- Place the helicopter on the ground with the tail pointed towards you.
- When the helicopter received the transmit,the led of circuit board will turn light.



1. Trun on the switch.
2. The motive handle (acclerator) must be pushed to the maximum control route of travel first, then adjust it to zero (lowest), after that, you can turn on the power of helicopter to fly the normal operation.

5. Throttle: Moving the Throttle or accelerator up advances power.

Step 4: Control Test

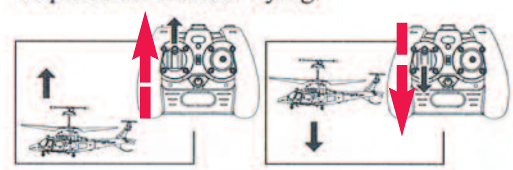
Unlike a RC airplane, you cannot test the rudder or ailerons. Moving the Throttle all the way forward quickly and back will confirm you have power only.

Step 5: Control Test

Test the controls to see if parts were damaged during shipping and handling during the first flight to ensure flight controls function in the correct directions.

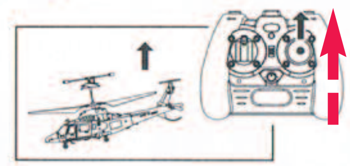
Hover up and down

When the helicopter fllies steadity,you can showly push the throttle stick up to make helicopter fly higher,or release the stick a bit to make helicopter fly lower.Only small amounts of stick position change are required for smooth flying.



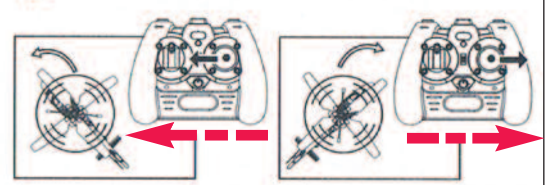
Forward

When you push up the right control lever (steering rudder),the nose incline to down, the helicopter is moving to forward.



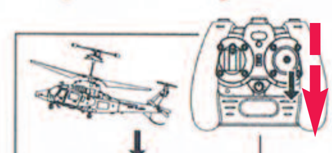
Turn counter clockwise and clockwise

Hold the helicopter at a height.Push the rudder stick toward left to turn counter clockwise,and push the rudder stick toward right to turn clockwise.



Backward

When you push down the right control lever(steering rudder),the nose incline to up,the helicopter is moving to backward.



All RC aircraft/helicopters need a little trim to make them fly straight and level. A helicopter is the most likely aircraft to have left or right rotations. This can be corrected rudder trim knob. (See above for how to correct this)

Flight Checklist

- Always check the area you are going to fly in. Make sure other people are aware an RC helicopter will be in the area.
- Always check that Channel A or B the transmitter and helicopter are the same
- Switch the helicopter power to “ON”
- Point the helicopter away from you on a flat hard surface.
- Fly the model.
- Land the model.
- Switch the helicopter power to “OFF”
- Switch the transmitter to “OFF.” Always turn the transmitter off last.
- Take the Charging wire from the transmitter or USB wire and plug into the helicopter for recharging.

EXTENSION:

Ready to Fly (RTF) “Indoor Ultra-Light” RC helicopters/aircraft can be found at any good hobby shop, Craft & hobby stores like Hobby Lobby, and some discount stores. It is recommended that cadets and students try a variety of different types such as single rotor, counter-rotating blade RC helicopters to experience the different flight characteristics they offer a beginning RC helicopter pilot.

As a rule: RC helicopters do not like wind.

An ideal follow-on project is AEX, for Senior Members activity one: “Electric Radio Control Model Aircraft.” The COX “ELECTRA J3 CUB” is an ideal next airplane for students/cadets to learn to fly RC with.

REVIEW:

The Syma S111G RC helicopter can be found online and at hobby shops. Spare parts are available at UJ Toys on line. This entry level RC helicopter is in the 20-30 dollar range, and will provide hours of basic RC training /learning for cadets and senior members alike. This is especially true if it is used to follow up on the free RealFlight RC Simulator available from CAP /AE in the RC STEM kits.

STEM Kits: www.capmembers.com/stem-ed

EVALUATION

Have the students/cadets practice landings in a classroom or gym floor with a tape runway as in the CAP

AEX and explain the similarities and differences between an RC helicopter landing and the string and stick method.

AEX II activity seven: “The Final Approach” is ideal to practice and get the “feel” of RC and real aircraft controls for cadets and senior members.

RESOURCES

AEX for Senior Members, activity eight: “Remote Control Flight Simulator for Your Computer” is ideal for students/cadets to practice and get the “feel” of an RC radio controller.

AEX, for Senior Members, activity one: “Electric Radio Control Model Aircraft” is ideal for students/cadets to practice and expand their RC piloting skills
http://www.symatoys.com/content/contact.html

UJ Toys RC sales website: http://www.ujtoys.com/SYMA-RC-HELICOPTERS-s/231.htm?searching=Y&sort=2&cat=231&show=30&page=2

Spare parts: UJ Toys Houston, TX:
http://www.ujtoys.com/Syma-S111G-Spare-Parts-s/263.htm

activity three

Beginner Level RC Indoor Electric (RTF) Quadcopter

OBJECTIVES: Assemble the aircraft

Safely train with a fully proportional 3-channel quadcopter

Practice indoor RC flying

Activity Credit: *Credit and Permission to Reprint – Hobbico Inc. has graciously given the Civil Air Patrol permission to reprint the photos and owner's manual instructions here for one or more of their Ready to Fly (RTF) RC quadcopters. More RC model aircraft, helicopters, quadcopters, parts and accessories can be found at http://www.flyzoneplanes.com and http://www.hobbico.com/. Hobbico also provides the Real Flight RC Simulators that have assisted RC student pilots gain a well grounded initial flying experience at home, in their schools, and CAP units nationwide.*

NATIONAL STANDARDS

Science Standards:

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B: Physical Science
- Motions and forces

Content Standard E: Science and Technology
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- Understandings about science and technology

Content Standard G: History and Nature of Science
- Science as a human endeavor
- Historical perspectives
- Unifying Concepts and Processes
- Evidence, models, and explanation

Technology Standards:

Current Standard: The Designed World
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

BACKGROUND

E-volo's 18-rotor electric Volocopter

E-volo is the winner of the 2012 Lindbergh Prize for Innovation

General Information:
The Volocopter by e-volo is a completely novel, vertical take-off and landing (VTOL) manned aircraft, which cannot be classified in any known category. The fact that it was conceived of as a purely electrically powered aircraft sets it apart from conventional aircraft.

Through the use of its many propellers, the Volocopter can take off and land vertically like a helicopter. This is a considerable advantage. The simple construction without complex mechanical devices and the redundancy of drives enables the safe landing of the Volocopter even if some drives fail.

How does it work?
The controls work according to the fly-by-wire principle very easily by means of a joystick. As opposed to any other aircraft, the operation is child's play. It takes off and lands vertically and the pilot pays little or no attention to the flight path angle, minimum speed, stall, mixture control, pitch

adjustment and many other things which make conventional aviation so demanding.

The propellers generate the entire ascending force, and by means of a selective change in rotary speed they simultaneously take care of the steering. Furthermore, as opposed to helicopters, no mechanical pitch control of the propellers is necessary whatsoever.

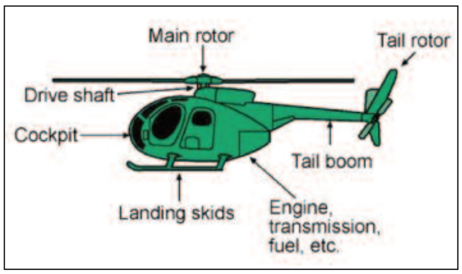
The automatic position control and the directional control take place by means of several independent and mutually monitoring airborne computers which control the rotation speed of each drive separately.

An optional, additional pusher propeller enables an even faster flight.

Desired Aircraft Performance:
- Cruising speed of at least 54 km (100 km/h)
- Flight altitude of up to 6500 ft
- Maximum take-off weight of 450 kg
- M ore than one hour flight time
- Two persons side-by-side

MAIN PARTS OF A HELICOPTER

Specifications: Proto-X



- Type: Nano Quadcopter
- Rotor Diameter (4): 1 1/8 inch
- Overall Length: 3.5 inches
- Motor: 4-micro brushed motors
- Overall Width: 2.5 inches
- Footprint: 2.5 x 2.1 inches (size of a soda cracker)
- Flying Weight: 0.4 oz
- Full Charge Non-stop Flying Time: 4-8 minutes
- Charging time: About 6 minutes
- Aircraft Included Battery: 3.7V 100 mAh LiPo 1-cell battery (BUILT IN)
- Radio controller Batteries: 2 x "AAA"
- Is Assembly Required: No
- Radio Controlling Distance: 30 ft
- LED lights indicating front and back

MATERIALS

The Proto-X costs under US $ 50.00 and comes ready to fly with its own controller right out of the box.
Inside the package, you'll find:

- The Proto-X nano quadcopter
- 4-channel radio transmitter on 2.4 GHz with digital trims
- Built in LiPo battery
- USB charging cable/cord
- Four replacement rotor blades
- 1 x Instruction Manual

Required Items Not in Kit

- 2 "AAA" batteries for the transmitter
- Phillips 00 screwdriver to open/close battery case

Since it is very light weight, amazingly it is almost indestructible in any crash, and perfect for very first time beginners. This RC quadcopter is designed for anyone over 8 years, its flight time is around 5-6 minutes after about 6-minutes charging. Some reviews state 5-15 flight time, so your flight time may vary as well. It can fly in 6 directions. They are:

- Rotate clockwise and counter-clockwise
- Move forward and backward
- Move up and down

VOCABULARY

RTF: Ready to fly means there is essentially no assembly requiring tools.

4-Channel: Allows the helicopter to go up and down, rotate right and left, move forwards and backwards, and drift from side to side.

PROCEDURE

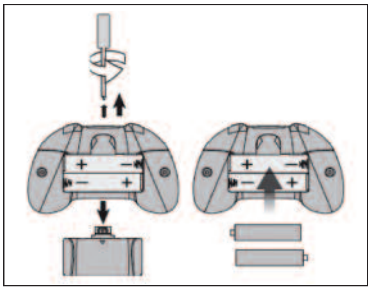
The Proto-X takes to the air faster than just about anything you can buy. It took the included USB charger about 6 minutes to charge the battery. Other than that, you have to install two AAA batteries in the transmitter and you are ready to fly. There was a brief calibration process which consisted of sitting the quad on a level surface before you began flying, but this literally takes 2 seconds. This is about as "Ready to Fly" as possible.

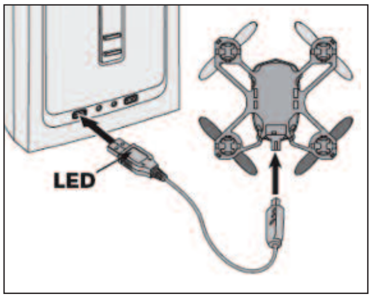
The following is from the Estes Proto-X Nano-quadcopter Owner's "Instruction Manual."
The Proto-X Nano-Quadcopter comes with all required

materials and assemblies. You can literally buy the RTF helicopter, take the box to a flying location, open it up, do the following assemblies and begin flying within a few minutes. 6-Steps and that's all there is to it!

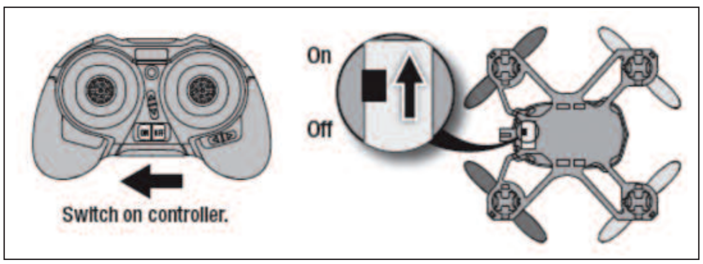
Step 1-2: Batteries and Power

1. Install the 2 x "AAA" batteries in the transmitter.
2. Charging the helicopter. This can be done in either of two ways.
   (A) Directly from the controller via a power cord from the controller handle, or
   (B) From the USB interface port on a computer.





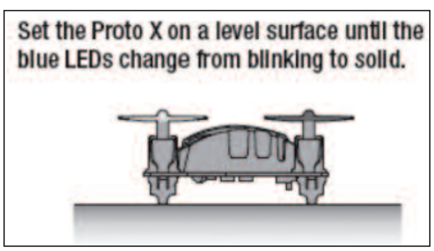
Charging time can be 5-6 minutes for 6-8 minutes flying.

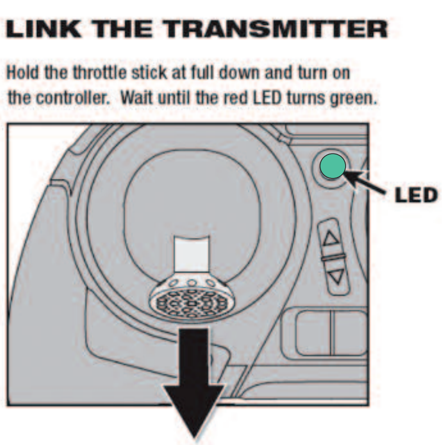


Step 3: Turning everything on and calibrating.

1. Switch on the controller
2. Switch on the Proto-X Nano-Quadcopter
3. Calibration of accelerometers on the quadcopter. This resets the accelerometers for a level flight like a gyro. There is no gyro-stabilization on this quad.

4 Linking the controller to the Proto-X receiver, make sure you have a green light.





Two Cautions:

1. The controller is smaller than you are used to, over correction is very easy to do unintentionally.
2. The Proto-X quadcopter is very, very powerful. More than ¼ throttle in a normal room of a house will result in it bouncing off the ceiling, wall and floor before you can react. It has a lot of power. You are warned.

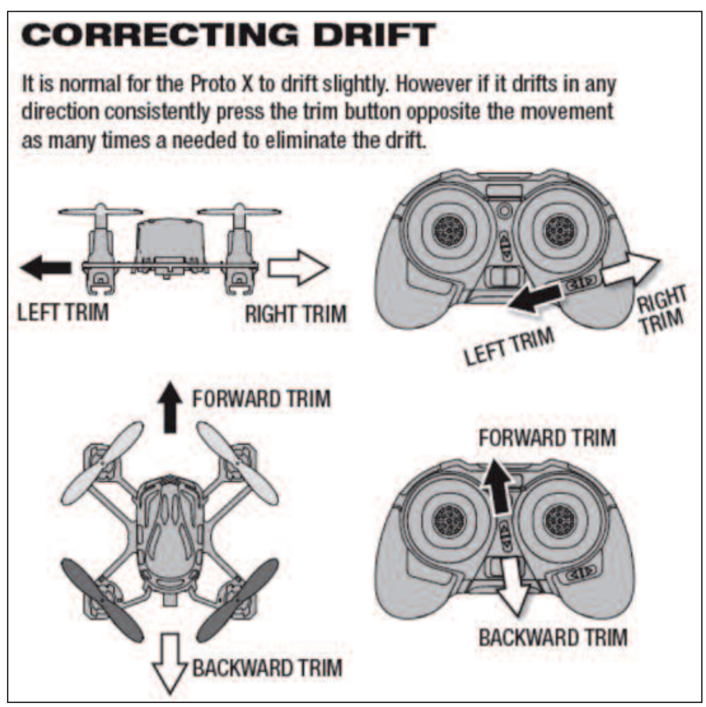
The Proto-X is a four channel quadcopter with a mode 2 transmitter. The left stick controls throttle and rudder and allows her to climb, lower, hover and turn to face any direction by rotating to the left and the right as well as pirouetting in place. The right stick allows for forward, reverse and side to side movement as shown above.

Speed Control:

The speed in any direction can be surprisingly quick when speed was desired and that includes climb, dive and any horizontal direction. When flying fast you will need an opposite direction counter command to stop the direction of travel.

Drift /Trim:

The Proto X has accelerometers to supply auto leveling for a surprisingly nimble and precise flight. The digital trims work



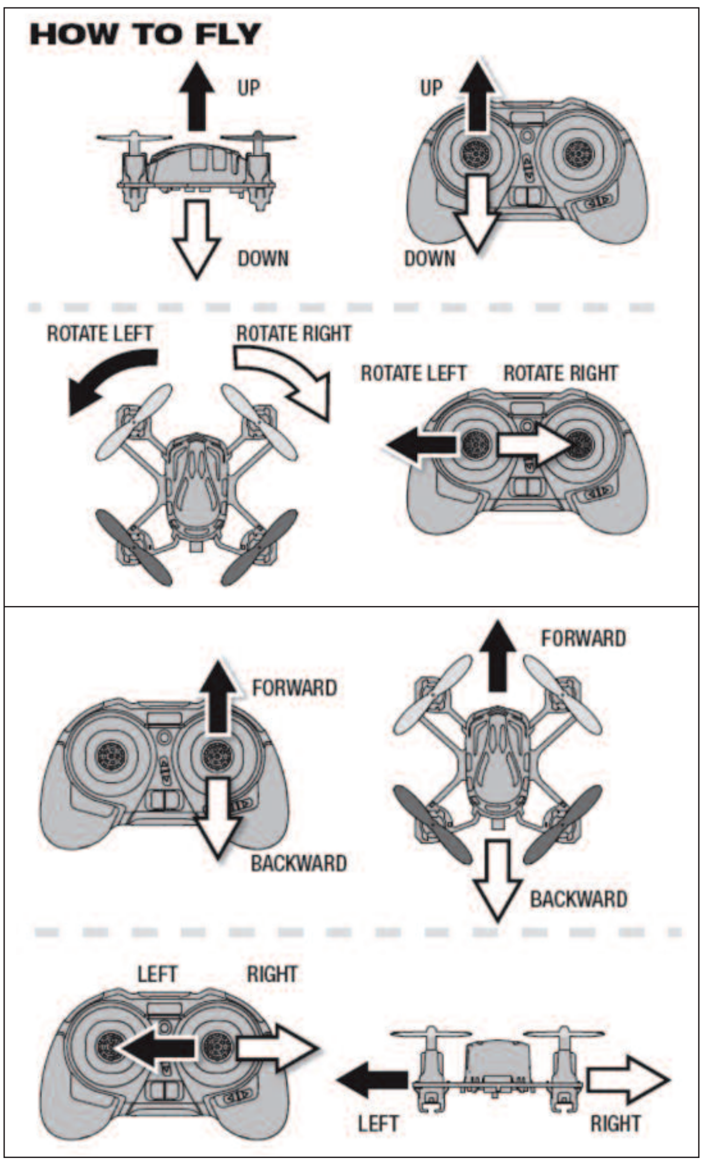
to make adjustments with the tap of a finger. Once trimmed, the Proto-X will hover with only a little drift. Some pilot correction is needed to maintain a hover over one spot for any length of time in even the best of operational conditions with any rotor aircraft.

Low Battery Warnings:

LANDING SAFELY. When the battery voltage begins to run low, the LEDs will begin to flash. It is time to land before the built in low voltage cut off reduces power to the motors.

Step 4: Flying the Proto Nano-Quadcopter.

1. Set the Proto-X on a level spot, wait for the blinking lights to be a steady red-blue (as above).
2. Hold the Throttle Knob "down" until the link light turns green.
3. Move the Power Knob up a little until you are in the air in a stable hover.



4. Use the Trim buttons to correct any drift. The Proto-X wants to hover if trimmed correctly.
5. Using the Left Knob on the controller, now rotate slowly the Proto-X and coordinate with the same Left Knob for power (up and down) altitude changes.

Moving the Throttle or accelerator up advances power and the rotation control to the left or right at the same time takes practice.

6. The Right Control Knob moves the Proto-X forward/backward and left or right as in any other RC controller.
7. Landing is just finding a level spot and slowly throttling down so the Proto-X gently lands like any rotor aircraft.

Landing on a fingertip probably is not for the average RC pilot, but this photo from: http://hmonghot.com/ shows it might be possible.

Step 5 Control Test for Power.

Unlike an RC airplane, you cannot test the rudder or ailerons. Moving the Throttle slowly forward quickly and back will confirm you have power only.

Step 7 Control Test for Control.

Test the controls to see if parts were damaged during shipping and handling during the first flight to ensure flight controls function in the correct directions.

TROUBLESHOOTING

PROBLEM: Controller cannot be linked to the ProtoX.
SOLUTION: Throttle position needs to be at zero.

PROBLEM: Controller LED flashing after binding.
SOLUTION: Replace batteries.

PROBLEM: Proto X shaking.
SOLUTION: Check if the canopy, chassis and rotors are damaged.

PROBLEM: Will not take off.
SOLUTION: Check that the rotor blades are properly installed.

FLIGHT CHECKLIST

- Always check the area you are going to fly in. Make sure other people are aware an RC quadcopter/helicopter will be in the area.
- Switch the controller and helicopter power to "ON"
- Always check the transmitter link and helicopter receiver are linked up
- Point the helicopter away from you on a flat hard surface
- Fly the model
- Land the model
- Switch the helicopter power to "OFF"
- Switch the transmitter to "OFF." Always turn the transmitter off last
- Take the Charging wire from the transmitter or USB wire and plug into the helicopter for recharging

EVALUATION

Have the students/cadets practice landings in a classroom or gym floor with a tape runway as in the CAP AEX and explain the similarities and differences between an RC helicopter landing and the string and stick method.

AEX II activity seven: "The Final Approach" is ideal to practice and get the "feel" of RC and real aircraft controls for cadets and senior members

AEX for Senior Members, activity eight: "Remote Control Flight Simulator for Your Computer" is ideal for students/cadets to practice and get the "feel" of an RC radio controller.

REVIEW

The Estes Control Proto-X quadcopter can be found online and at hobby shops. Spare parts are available at both MiniInTheBox.com Towerhobbies.com on line. This entry level RC nano-quadcopter is in the $ 40-50 range and will provide hours of basic RC training /learning for cadets and senior members alike. This is especially true if it is used to follow up on the free RealFlight RC Simulator available from CAP /AE in the RC STEM kits.

STEM Kits: www.capmembers.com/stem-ed

EXTENSION

Ready to Fly (RTF) "Indoor Ultra-Light" or micro/Nano RC helicopters/aircraft can be found at any good hobby shop, craft & hobby stores like Hobby Lobby, and some discount stores. It is recommended that cadets and students try a variety of different types such as single rotor, counter-rotating blade RC helicopters to experience the different flight characteristics they offer a beginning RC helicopter pilot.

As a rule: RC helicopters do not like wind, not even the ceiling fan or air conditioning air movement.

An ideal follow-on project is AEX, for Senior Members activity one: "Electric Radio Control Model Aircraft". The COX "ELECTRA J3 CUB" is an ideal next airplane for students/cadets to learn to fly RC with.

If you must have some fun with RC helicopters and quadcopters, then the LTA Helium Balloon Blimp will demonstrate RC flight characteristics with minimum danger of a crash, or pilot error.

RESOURCES

AEX MARC II activities 10 -16 deal with RC flying from a beginner level through intermediate levels. All of the activities will challenge both a cadet as well as a senior member no matter their level of competency.

AEX, for Senior Members, activity one: "Electric Radio Control Model Aircraft" is ideal for students/cadets to practice and expand their RC piloting skills

http://www.gizmag.com/review-estes-proto-x-nano-quadcopter/29813/

http://www.rcgroups.com/forums/showthread.php?t=2031485

activity four

RC Electric (RTF) Quadcopter with Video Camera

OBJECTIVES: Safely train with a fully proportional 6-channel quad copter

Fly RC indoors and outdoors

Learn to shoot video of terrain and ground objects

Activity Credit:
Credit and Permission to Reprint – Hobbico Inc. has graciously given the Civil Air Patrol permission to reprint the photos and owner's manual instructions here for one or more of their Ready to Fly (RTF) RC quadcopters. More RC model aircraft, helicopters, quadcopters, parts and accessories can be found at http://www.flyzoneplanes.com and http://www.hobbico.com/. Hobbico also provides the Real Flight RC Simulators that have assisted RC student pilots in gaining a well-grounded initial flying experience at home, in their schools, and in CAP units nationwide.

BACKGROUND

Unmanned Reconnaissance Helicopter

The Fire Scout Vertical Take-Off and Landing Tactical Unmanned Aerial Vehicle (VTUAV) system is designed to provide reconnaissance, situational awareness, and precision targeting support for ground, air and sea forces.

The Northrop Grumman MQ-8B Fire Scout is an unmanned autonomous helicopter developed by Northrop Grumman for use by the United States Armed Forces. The initial RQ-8A version was based on the Schweizer 330, while the enhanced MQ-8B was derived from the Schweizer 333.

Northrop Grumman MQ-8B Fire Scout

The MQ-8B complements the manned aviation detachments onboard Air Capable ships and is deployed along with either an SH-60B HSL/HSM detachment or a MH-60S HSC detachment. With the planned addition of RADAR, AIS, and weapons, the MQ-8B will provide many of the capabilities currently provided by the SH-60B. It will give the ship and embarked air detachment greater flexibility in meeting mission demands, and will free manned aircraft for those missions.

In January, 2006, an RQ-8A Fire Scout landed aboard the amphibious transport ship Nashville while it was steaming off the coast of Maryland near the Patuxent River. This marked the first time an unmanned helicopter had landed autonomously aboard a moving U.S. Navy ship without a pilot controlling the aircraft. The Nashville was maneuvering as fast as 17 mph (27 km/h) during the tests.

In May 2011, three MQ-8s were deployed to northern Afghanistan for intelligence, surveillance, and reconnaissance (ISR) purposes.

On 30 December, 2012, the Navy issued an urgent order to install RDR-1700 maritime-surveillance radars on nine MQ-8B Fire Scouts, to be completed by the end of 2013. The system consists of the X-band synthetic aperture radar and a modified radome, mounted underneath the helicopter for 360-degree coverage; it is interfaced with the UAV and its control station. Detailed range is out to 25 km (16 mi), with a max range of 80 km (50 mi). The RDR-1700 can see through clouds and sandstorms and can perform terrain mapping or weather detection, and track 20 air or surface targets; a target-marker can be used to determine a target's range, bearing, and velocity. Radar-equipped MQ-8B UAVs could be useful in the Persian Gulf for tracking small Iranian vessels, or the Gulf of Aden for locating Somali pirates. Courtesy: Wikipedia

General Characteristics: MQ-8B Fire Scout

- Crew: 0
- Payload: 600 lb (272 kg)
- Length: 23.95 ft (7.3 m)
- Rotor diameter: 27.5 ft (8.4 m)
- Height: 9.71 ft (2.9 m)
- Empty weight: 2,073 lb (940.3 kg)
- Max. takeoff weight: 3,150 lb (1,430 kg)
- Power plant: 1 × Rolls-Royce 250, 313 kW (420 hp)

NATIONAL STANDARDS

Science Standards:

Current Standard: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understands about scientific inquiry

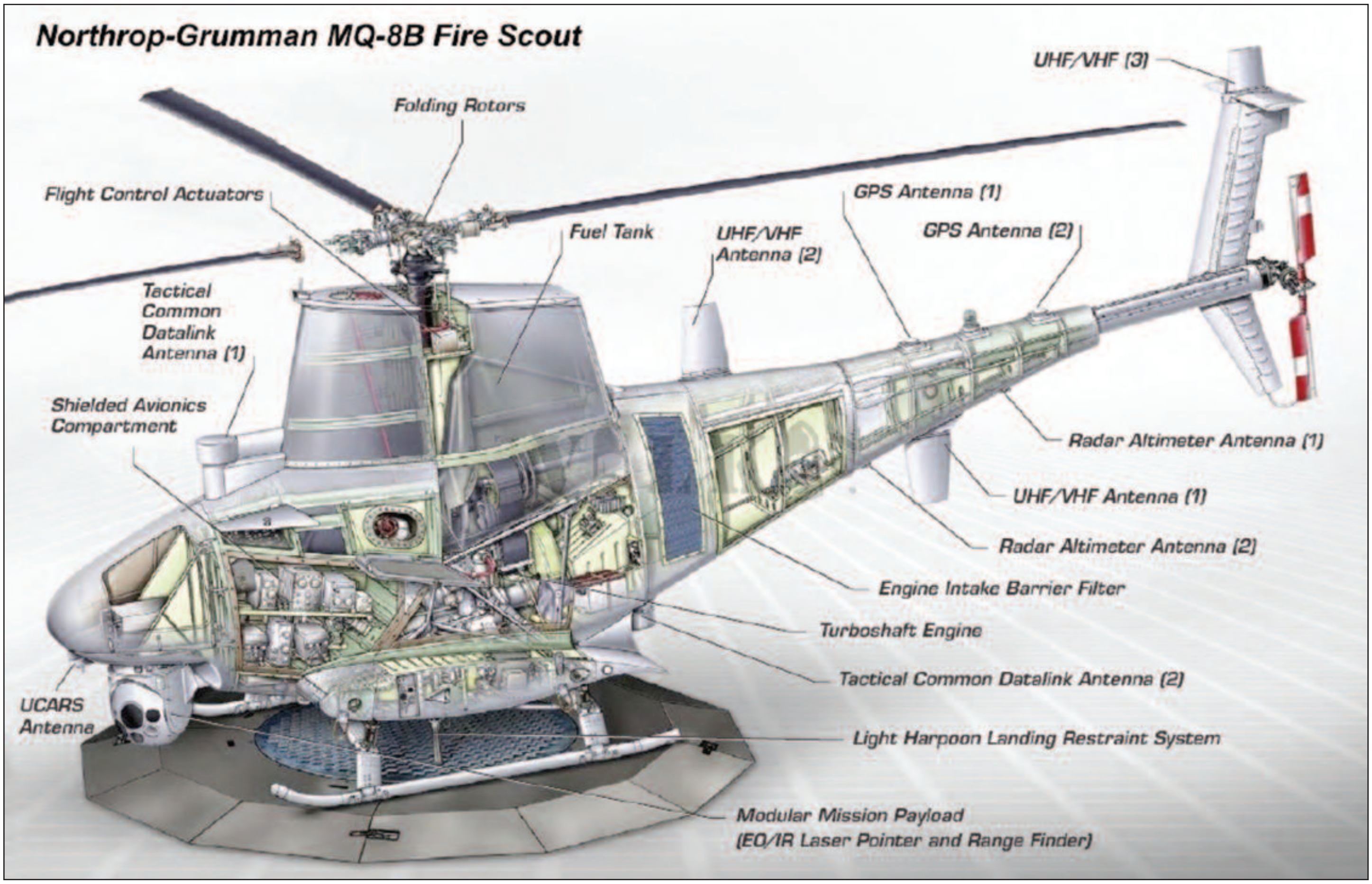
Current Standard: Physical Science
- Motions and forces

Current Standard: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Current Standard: History and the Nature of Science
- Science as a human endeavor
- Historical perspectives
- Unifying Concepts and Processes
- Evidence, models, and explanation

Technology Standards:

The Designed World
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.



Afghanistan for intelligence, surveillance, and reconnaissance (ISR) purposes.

Performance

- Maximum speed: 115 knots (213 km/h)+
- Cruise speed: 110 knots (200 km/h)
- Combat radius: 110 nm (203.7 km) with 5+ hours on station
- Endurance: 8 hours (typical), 5 hours fully loaded
- Service ceiling: 20,000 ft (6,100 m)

Sensor Ball: The Fire Scout was to be fitted with a sensor ball turret that carries electro-optic and infrared cameras, and a laser range finder.

Courtesy: US Navy

MATERIALS

Before starting on this project, you will need to contact Scott Griffith of American Junior Classics http://americanjuniorclassics.com/index.html and order the wing pivots for your cadets or CAP members. Each pivot will cost less than $3, and Scott will mail them out to you.

Balsa wood is a simple and readily available building material. While balsa wood is more expensive than Styrofoam, it is readily available at hobby shops and craft stores such as Hobby Lobby and Michaels. It will be used in several aero models in this booklet up to and including electric powered radio controlled aircraft. With this in mind let's see what we need to build this glider.

1. Plans: The A-J Classics "Plain Jane" glider printed printer paper.
2. Balsa wood.
   a. 1/16" by 3" by 16" sheet of balsa wood.
   b. 3/8" sheet of balsa wood.
3. Elmer's™ White or wood glue.
4. A hobby knife.
5. 3/8" ball bearing or slingshot ammo.
6. Modeling clay for nose weight (if needed).
7. Several grades of sandpaper (100-320 grits).
8. Sanding block.
9. A # 11 rubber band (a small one) for the pivot mechanism.

For any kind of tissue paper decals you might want to apply to your plane:

10. 3M Spray Mount (to hold the tissue paper on printer paper in the printer only).
11. Spray adhesive to attach the plan on Balsa Wood.

The “404” cost a little more, but was in a class by itself using a rubber catapult to loft it up a hundred feet in the air.

VOCABULARY:

Autonomous Helicopter: A pilotless Aircraft (rotary) much like a UAV or UAS, is flown remotely or monitored by ground personnel (a pilot) at a remote site/location. Below are MQ-8B Fire Scout UAV pilots in action.

RTF: Ready to fly means there is essentially no assembly requiring tools.

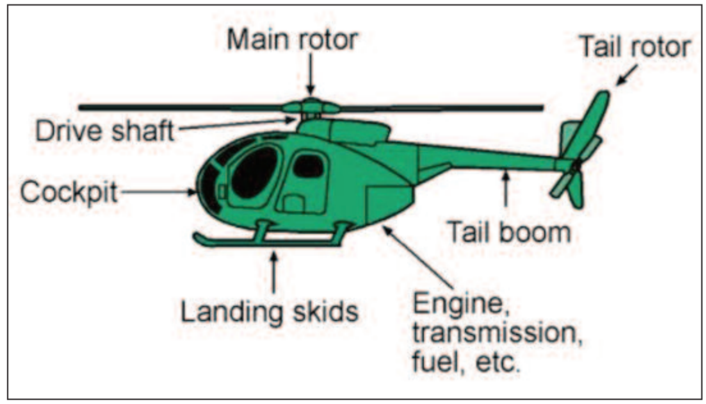
6-Channel: 6-channels: Allows the helicopter to go up and down, rotate right and left, move forwards and backwards, and drift from side to side.

Micro: your typical RC helicopter or quadcopter found in Brookstone, Radio Shack, and such, about 6-12 inches in length and width, fits in palm of your hand, and battery powered.

TAGS: (Triple Axis Gyro Stabilization) The TAGS gyro system stabilizes all three axes (yaw, roll and pitch), so external forces will not adversely affect performance.

MAIN PARTS OF A HELICOPTER

Heli-Max 1 SQ VCAM Micro Quadcopter



This is the Electric Powered, 2.4GHz Radio Controlled, Tx-R (Transmitter Ready) to Fly 1SQ V-Cam Quadcopter from Heli-Max. This quad, while offering video recording capabilities, is intended for beginning helicopter flyers. The quadcopter discussed here is the Tx-R (Transmitter Ready) version that includes servos, an ESC and receiver.

Specifications: Heli-Max 1 SQ V CAM Quadcopter
- **Type:** Micro Quadcopter
- **Rotor Diameter (4):** 2.2 inches
- **Body/Frame Overall Length:** 4.5 inches
- **Body/Frame Overall Width:** 5.5 inches
- **Footprint (inc. Rotors):** 5.75 x 5.75 inches (size of adult hand)
- **Motor:** 4-micro brushed motors
- **Flying Weight:** 1.1 oz
- **Full Charge Non-stop Flying Time:** 10 - 12 minutes
- **Charging time:** About 45+ minutes
- **Aircraft Included Battery:** 3.7V 100 mAh LiPo 1-cell battery (BUILT IN)
- **Radio controller Batteries:** 2 x “AAA”
- **Is Assembly Required:** No
- **Radio Controlling Distance:** 60 ft
- **LED lights** indicating front and back, when imaging and when batteries are low (about to quit)

The **Heli-Max 1 SQ V CAM** costs under $ 130.00 and comes ready to fly with its own controller right out of the box.

Inside the package, you'll find:

- The 1SQ V-Cam quadcopter with digital camera
- A 6-channel 2.4GHz SLT radio transmitter
- Four AA batteries
- One 250mAH LiPo battery
- A USB LiPo battery charger
- A 2 GB Micro SD card
- A USB Micro SD card reader
- Four extra rotor blades
- A small screwdriver
- An instruction manual

Required Items Not in Kit
- 2 "AAA" batteries for the transmitter
- Phillips 00 screwdriver to open/close battery case

Since it is very lightweight, it amazingly recovers from most hard landings and is perfect for very first time beginners. This RC quadcopter is designed for cadets and adults 12 years old and older. It has a flight time around 10 - 12 minutes after about 45-minutes charging time. For this reason a spare battery or two (fully charged) is recommended. Batteries for this quad are about $5.50 each mail order on line. Some reviews state 5-15 minutes flight time, so your flight time may vary as well. It can fly in 6 directions. They are:
- Rotate clockwise and counter-clockwise
- Move forward and backward
- Move up and down
- Auto flip

Special Features:
- TAGs-FX: Sensor Fusion Stabilization System!**
- Video camera activated by transmitter to turn on/off
- Has auto flip with the press of a transmitter control
- Each motor pod illuminated with an LED for flying at twilight or after dark

*** TAGS-FX** Sensor Fusion Stabilization System features a 3-axis gyro and a 3-axis accelerometer. This system corrects for drift as well as unwanted movement in yaw, pitch and roll. Allows new pilots to enjoy unprecedented confidence and experts gain the precision to execute perfect maneuvers!

PROCEDURE

The Heli-Max 1 SQ V CAM takes to the air out of the box in a matter of 10-15 minutes. The following is from the Heli-Max 1 SQ V CAM Mini-quadcopter Owner's "Instruction Manual."

The Heli-Max 1 SQ V CAM Mini-quadcopter comes with all required materials and assemblies. You can literally buy the RTF helicopter, take the box to a flying location, open it up, do the following assemblies and begin flying within a few minutes. 6-Steps and that's all there is to it!

Safety Tips

This quadcopter can cut grass and certainly nick a finger or two. Follow these safety precautions when operating this or any model helicopter.

Keep your face and body as well as all spectators away from the plane of rotation of the rotors whenever the battery is connected.

- Keep these items away from the rotors: loose clothing, shirt sleeves, ties, scarves, long hair or loose objects such as pencils or screwdrivers that may fall out of shirt or jacket pockets into the rotors.
- The spinning blades of a model helicopter can cause serious injury. When choosing a flying site for your 1SQ Quadcopter, stay clear of buildings, trees and power lines. AVOID flying in or near crowded areas. DO NOT fly close to people, children or pets.
- Maintain a safe pilot-to-helicopter distance while flying.
- Your 1SQ Quadcopter should not be considered a toy, but rather a sophisticated, working model that functions very much like a full-size helicopter. Because of its performance capabilities, the 1SQ Quadcopter, if not operated correctly, could possibly cause injury to yourself or spectators and damage to property.
- Do not alter or modify the model, as doing so may result in an unsafe or unflyable model.

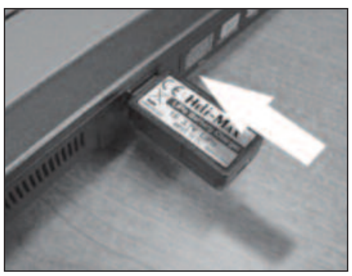
- You must check the operation of the model before every flight to ensure that all equipment is operating and that the model has remained structurally sound. Be sure to check linkages or other connectors often and replace them if they show any signs of wear or fatigue.
- This 1SQ Quadcopter uses a lithium polymer (LiPo) battery. Follow these precautions on the instruction sheet to ensure safe and trouble free operation.

Step 1-2: Batteries and Power

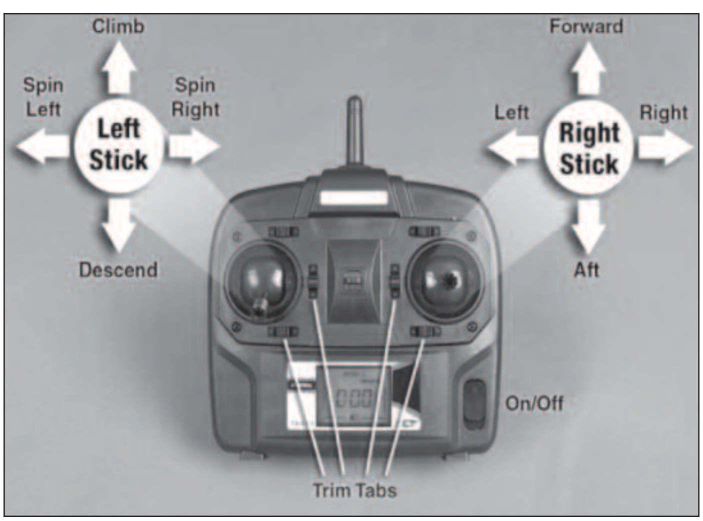
1. Install the 4 x “AA” batteries in the transmitter.
2. Charging the quadcopter LiPo battery. This can be done from the USB interface port on a computer or your car when you are in the field.

❑ Carefully remove the battery door and install four AA batteries. Double check the polarity of each battery. Slide the battery cover back into place.

Plug the USB charger into your USB port. The *indicator light* will remain off.

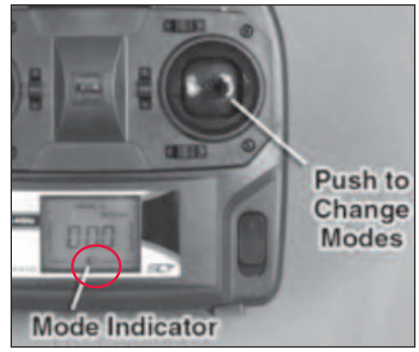


Plug the battery into the charger. The indicator light will glow solid, indicating that the battery is being charged. Once the battery is completely charged, the indicator light will flash slowly. Disconnect the battery from the charger. Under normal operating conditions, the battery may take up to 60 minutes to recharge.



Step 3: Transmitter Controls

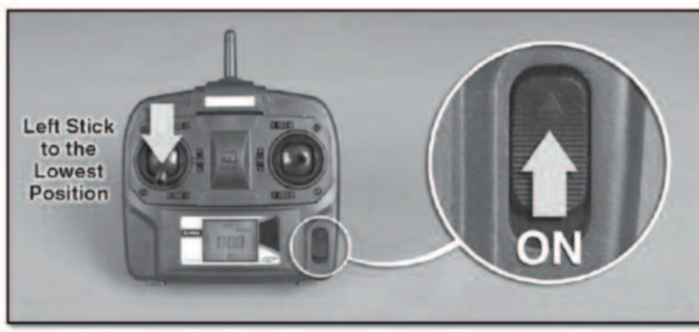
All controls are described with the tail pointing directly toward you. This is the best way to fly in the beginning since it keeps the control inputs oriented the same direction. Once you start getting comfortable you can work on side hovering and nose-in.



* For new pilots flying a quadcopter for the first time or if you are not to sure of yourself ALWAYS push down on the right control to change modes so you see a half circle below.

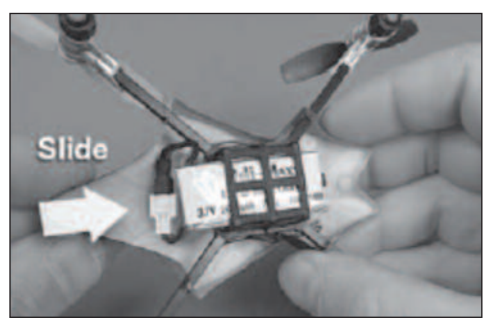
The TX410 has two flight rates that control how aggressive the Quad feels during flight. The high rate is good for outdoors and low rate is good for indoors or smooth precise flying. Adjust the rates by pushing and holding the right stick, then moving the throttle to read between 30 and 40, then let go of the right stick.

Step 4: Turning everything on and calibrating.



❑ Move the left stick to the lowest position and then turn the transmitter on.

Slide the flight battery into the battery compartment and plug in the battery. The connectors are very small, so take your time doing this.



NOTE: The quad will be **“ON”** at this point.

Safety: Electric motors are very dangerous. Do not work on the model while the flight battery is plugged in as interference may cause the main rotor blades to spin, possibly causing injury to yourself.

Step 5: Flying the Heli-Max 1 SQ V CAM.

The Heli-Max 1SQ Quadcopter is lightweight. Therefore, you should only fly indoors or in calm winds less than 5 mph. It should be flown in a large area of at least 75 feet [15.25m] square with no obstacles.

Crashing

If you have operated radio control models in the past, then you probably already realize that it is not a matter of “if” you are going to crash, it is a matter of “when” you are going to crash. Once you realize the model is going to collide with something or crash into the ground, you should always bring the throttle stick all the way down to stop the rotor blades from rotating. If you can remember to do this, chances are you will not damage the quad in the crash.

Takeoff

We recommend low rates for indoor and your first flights, and high rates for outdoors. Slowly add power, observe the model and make all of the necessary corrections to keep the model level. You will notice that the quad is very responsive. Only small corrections are needed to maintain a steady hover. With the TAGS system, no trimming is needed.

Hovering

Once the quadcopter is up in the air, try to hold the quadcopter in one spot.

If this is your first model quadcopter, it will require some practice. Wind or air currents have a big effect on the stability of the quadcopter. Be patient and try to anticipate where the quadcopter will move. Remember: Small corrections!

Landing

From a steady hover, slowly decrease power until the quad settles onto the ground.

Basic Maneuvers

Slow Pirouettes – Add a small amount of left stick (left or right) and try rotating the quad slightly sideways and see if you can hold it there. Once you start getting comfortable, try rotating the quad further. Rotating the quad around 360° is called a pirouette. The quad can drift during these so make sure you have plenty of room when you first start practicing.

Nose-in Hovering – After pirouettes it’s time to move on to nose-in hovering.

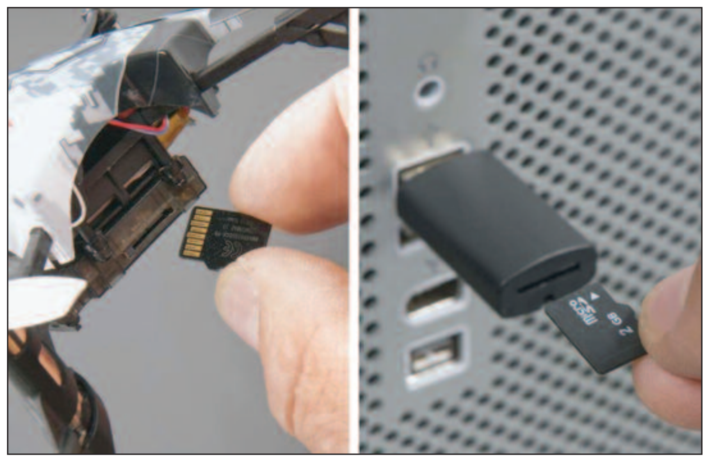
Take off and climb to 10 feet [3m]. Practice half pirouettes from tail-in to nose-in hovering and try to lengthen the delay in between. This will give you a little practice nose-in and still give you a chance to get out of trouble. As your skills improve you’ll remain nose-in for longer periods of time.

Forward Flight – Now it’s time to work into basic forward flight. From a hover, point the nose away from you and push the right stick forward. (Small movements!) To stop, pull back slightly to slow down and then move the stick to center. During flight, you may have to add or reduce throttle to maintain a constant altitude. Practice controlled slow flight in close as well. The more time you spend practicing here the easier things will be later on.

The TAG System is going to work as trim tabs throughout your flight. It will be correcting for small air currents and drift as much as it can.

The Video Camera System

The 2 GB SD card inserts into the side port of the camera under the 1SQ V-CAM. The battery for the V-CAM is self contained and never needs recharging.



The buttons for video and single image taking are on the reverse side of the controller. When flying the 1SQ V-CAM, your left index finger will be on the video button, and your right index finger on the picture (single image)

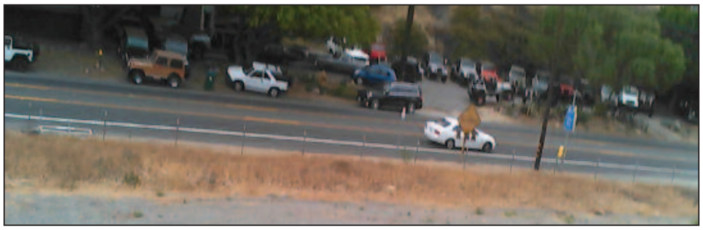
After imaging unplug the 1 SQ V-CAM battery then remove the SD card. The 1SQ V-CAM comes with a USB Micro SD card reader (two photos above). The 2 GB SD card inserts into the USB Micro SD Card reader which goes easily into a USB port on your computer. You can then download your images and videos.

***1SQ V-CAM & 1Si w/CAMERA**

TECHNICAL TIP

To minimize any chance of data being lost on the micro SD card, do not insert or remove the card from the camera until the battery is unplugged from the quadcopter.

Authors first flight test images



FLIGHT CHECKLIST

- Always check the area you are going to fly in. Make sure other people are aware that an RC quadcopter/helicopter will be in the area
- Switch the controller and helicopter power to “ON”
- Always check the transmitter link and helicopter receiver are linked up
- Point the helicopter away from you on a flat hard surface
- Fly the model
- Land the model
- Switch the helicopter power to “OFF”
- Switch the transmitter to “OFF.” Always turn the transmitter off last
- Take the Charging wire from the transmitter or USB wire and plug into the helicopter for recharging

EXTENSION

Ready to Fly (RTF) “Indoor Ultra-Light” or Micro/Nano RC helicopters/aircraft can be found at any good hobby shop, craft & hobby stores like Hobby Lobby, and some discount stores. It is recommended that cadets and students try a variety of different types such as single rotor, counter-rotating blade RC helicopters to experience the different flight characteristics they offer a beginning RC helicopter pilot.

As a rule: RC Nano and Micro-helicopters do not like wind, not even the ceiling fan or air conditioning air movement. The Heli-Max 1 SQ V CAM operates well in a breeze as it has the power to do so plus the TAG System.

An ideal follow-on project is AEX, for Senior Members Activity One: *“Electric Radio Control Model Aircraft”*. The COX “ELECTRA J3 CUB” is an ideal next airplane for students/cadets to learn to fly RC with.

If you must have some fun with RC copters the LTA Helium Balloon Blimp will demonstrate RC flight characteristics with minimum danger of a crash, or pilot error.

REVIEW

The **Heli-Max 1 SQ V CAM** can be found online and at hobby shops. Spare parts are available at both MiniInTheBox.com and Towerhobbies.com on line. This entry level RC nano-quadcopter is in the 140 dollar range, and will provide hours of basic RC training /learning for cadets and senior members alike. This is especially true if it is used to follow up on the free RealFlight RC Simulator available from CAP /AE in the RC STEM kits.

STEM Kits: www.capmembers.com/stem-ed

EVALUATE:

Have the students/cadets practice landings in a classroom or gym floor with a tape runway as in the CAP AEX and explain the similarities and differences between an RC helicopter landing and the string and stick method.

AEX II Activity Seven: “The Final Approach” is ideal to practice and get the “feel” of RC and real aircraft controls for cadets and senior members.

AEX for Senior Members, Activity Eight: “Remote Control Flight Simulator for Your Computer” is ideal for students/cadets to practice and get the “feel” of an RC radio controller.

RESOURCES:

AEX MARC II Activities 10 -16 deal with RC flying from a beginner level through intermediate levels. All of the activities will challenge both a cadet as well as a senior member no matter their level of competency.

AEX, for Senior Members, Activity One: “Electric Radio Control Model Aircraft” is ideal for students/cadets to practice and expand their RC piloting skills.

INFORMATION ON THE HELI-MAX 1 SQ V CAM:

http://www.helimax-rc.com/helicopters/hmxe0836-1sqvcam/index.html

Parts and information: http://www.helimax-rc.com/helicopters/hmxe0834-1sq/index.html

REVIEWS:

http://www.quadhangar.com/reviews.php?p=helimax-1sq-quadcopter-review

http://www.gizmag.com/review-heli-max-1sq-v-cam-quadcopter/28055/

http://www3.towerhobbies.com/cgi-bin/wti0001p?&I=LXDLNK

http://www.rcgroups.com/forums/showthread.php?t=1889697

Glossary

A Glossary of sUAV RC Airplane Terms

2.4 GHz - the frequency band of the newest, interference-free “spread spectrum” digital RC systems that have all but replaced the traditional MHz ones.

2 stroke - the most common type of glow plug engine for RC airplanes. The fuel/air mixture is drawn in, ignited and spat out with one single revolution of the piston inside the engine.

4 stroke - the 2nd most common type of glow plug engine, much more suitable for larger and scale planes because they sound more realistic. 4 stroke engines take 2 revolutions to do what a 2 stroke does in one, but this doesn't make them twice as lazy.

3D - a complex form of advanced aerobatic flying. 3D airplanes have over-sized control surfaces, exaggerated control surface deflection and excess power for maximum performance and sensitivity. Many 3D maneuvers are performed at very slow speeds, often with the plane at the point of stall.

Aerobatic - any maneuver or series of maneuvers that involve stunts of any kind, such as loops, rolls and spins. An airplane that is capable of performing such stunts is said to be "fully aerobatic".

Aeromodeling - the general term used to describe the hobby of building and flying model airplanes and aircraft. Aeromodelers are the guys and gals that do it.

Ailerons - the moving section of the trailing edge (TE) of the wing, located toward the outer end, or they can be the whole length of the TE. Ailerons come in pairs, (left and right) and always work in opposite directions to each other (one up, one down). When used, they cause the airplane to roll to the left or right.

Aileron Differential - when the ailerons are set up to move upwards more than downwards, to counteract any adverse yaw during a turn caused by extra drag on the outer wing from the down aileron.

Air brakes - often found on, but not limited to, larger gliders. An air brake is a small panel that pops up vertically from the top surface of the wing (or fuselage). The sudden extra drag slows the plane.

Airfoil - the cross-section shape of a wing. Airfoils can be flat-bottomed, under-cambered, semi-symmetrical or symmetrical, depending on the style of airplane and what it needs to do. Also written as aerofoil, depending on which country you are in. Different shape airfoils have different lift generating properties.

Airpatch - the AMA flying field, park or open field you are currently flying at.

Altitude - the vertical distance between your RC airplane and the ground, usually expressed in feet ('). It is just the fancy way of saying height.

Angle of Attack - the angle of the wing when viewed from the end in relation to the horizontal airflow when the airplane is flying. It has nothing to do with your incoming trajectory when trying to cut the tail off your friend's plane in aerial combat games.

ARC - “Almost Ready to Crash.” It is an RC aircraft that knows something that the pilot is just about to find out.

ARF / ARTF - “Almost Ready To Fly.” This one's a legitimate abbreviation. An ARF airplane needs a few small finishing touches and you have to install the engine/motor and radio gear yourself. They vary in degrees of completeness, from manufacturer to manufacturer.

Attitude - not the obvious meaning, but in the flying world 'attitude' refers to the angle of the plane in relation to the horizontal e.g. "My plane had a very nose-down attitude, from which it would not recover..." Well, in this case you could say that your plane had a “very bad attitude”!

Barrel roll - is an aerobatic maneuver that involves the airplane following the twist of a large imaginary corkscrew (horizontal) through the air.

BEC - Battery Eliminating Circuit. It is a common feature of ESCs, whereby the ESC supplies a regulated 5V to the radio control gear (receiver and servos) from the flight battery pack. BECs can be of the linear variety (constant current flow) or the switching variety, whereby they turn the power on and off thousands of times per second.

Bind-N-Fly (BNF) - a trademark name for a range of Horizon Hobby distributed aircraft (namely ParkZone & E-flite) whereby the model is sold in RTF form but lacks the transmitter. A DSM2/DSMX compatible receiver is included though so you just, er, bind and fly.

Binding - a 2.4GHz receiver needs to be “bound” to the transmitter before it can receive signals from it. The process involves the Rx identifying a unique code being emitted from the Tx, and then the two components lock together on an available frequency. The process usually takes only a few seconds accomplish.

Brushless motor - type of electric motor used in RC electric aircraft. Brushless motors are much more powerful than traditional brushed motors, and have become the norm.

They can be inrunner or outrunner motors.

Buddy Box - one of the best training aids, where the student's transmitter is attached via cable to the instructor's. The student has complete control over the airplane, but at the flick of a switch the instructor can take control if the student gets into difficulties. Or just to be mean, funny or annoying.

Bulkhead - the foremost former of your airplane, on to which the engine is mounted. It is also called a firewall.

Bungee launch - a popular method of launching RC gliders.

Butterfly - not a cute little flying insect, but the name given to a type of air-braking method on RC gliders, whereby the flaps go down and the ailerons go up simultaneously. The lowered flaps create high drag, while the raised ailerons reduce lift. This combination makes landing a fast glider easy.

Centre of Gravity (CG) - the airplane's point of fore-aft balance, or the point at which all gravitational forces act on the plane. As a very general rule of thumb, it's found approximately 1/4 to 1/3 of the way back from the leading edge of the wing and is built in during the design stage.

Centre of Lift (CL) - the point at which all forces of lift act on the plane. Typically the CG needs to be in front of the CL for a plane to be stable and flyable.

Channel - 2 meanings for this in the RC world. First, it can be the number of channels that the model has, e.g. a 1 channel model may have just motor or rudder control while a 2 channel model will have motor and rudder, etc. Second, the channel number refers to the radio frequency which you're using, when using an MHz system. 2.4GHz systems don't utilize the same frequency channels.

Chicken stick - A wooden/plastic stick with a rubber coating on one half that you use to flick over the propeller, instead of using your finger. This can also be a tough rubber sleeve that you put on your finger if starting the motor by hand to give essential protection from the propeller.

Control horn - plastic or metal piece that is attached to a control surface, onto which the servo linkage is connected.

Control surface - the term used to describe the moving part of any flying surface. Rudder, elevator and ailerons are all control surfaces.

Control surface mixing - when two control surface operations are performed by one pair of surfaces e.g. when aileron and elevator movement is combined into elevons.

Channel mixing - when two or more channels are made to operate together with one transmitter stick movement e.g. rudder can be mixed with aileron so that the rudder automatically deflects when the ailerons are moved.

Crosswind - when the wind is blowing at, or approximately, 90 degrees to your line of flight, take off or landing.

Crow - just another (more common) name for RC glider Butterfly braking.

Crystal - the small component that determines which channel number you fly on, when using an MHz RC system. Both Tx and Rx need to have an identically matching crystal for the radio set to function. 2.4GHz spread spectrum sets don't require crystals.

Dead stick - when your airplane's motor cuts out unexpectedly in mid-air. With any luck you'll have enough altitude to glide safely in for a nice landing, otherwise you may need to use your plastic bag.

Dihedral - the upward angle of the wings when viewed from the front. An airplane with dihedral is more stable in the air than one without.

Disorientation - when you lose sight of which way up your RC airplane is and what it's doing, either because it's too far away to see properly or because of low light levels, or you've just flown it directly over your head and momentarily lost all visual reference to everything. Not much fun when it gets you.

Drag - the force that is created by the movement of the airplane through the air, on the air immediately surrounding the plane. Higher drag means that the plane has to work harder to cut through the air. Low drag, oddly enough, means the opposite.

A real drag is the term used to describe your flying day when it's not going to according to plan.

DSM/DSM2/DSMX - a type of technology developed by Spectrum for their spread spectrum 2.4GHz RC systems. Stands for Digital Spectrum Modulation, the “2” and the “X” just being the updated versions of the original. This is just one of many branded abbreviations for particular 2.4GHz RC technology names.

Dual rates - a feature of many RC systems, whereby the control surface deflection can be reduced while still maintaining full movement of the transmitter sticks. With dual rates enabled, the airplane is less (or more) sensitive to control inputs. Typically dual rates are activated by flicking a toggle switch on the transmitter.

Electric starter - a glorified 12 volt electric motor with a special end cup that you place over the spinner to turn an IC engine over until it starts, hopefully.

Elevator - the moving section at the rear of the horizontal stabilizer, or tailplane that controls the pitch attitude of the airplane i.e. whether the nose of the plane points up or down.

Elevons - when elevator and aileron control is made by the same control surface, this surface is called an elevon(s). Only possible with a channel mixing facility on the RC set.

EP - Electric Power: The alternative to gas engines (IC).

ESC - Electronic Speed Controller - the small unit that delivers the appropriate amount of power from the motor battery pack to the motor, depending on your input at the transmitter. It also supplies power to the receiver and servos, via the BEC.

FASST - Futaba's answer to Spectrum's DSM technology. Stands for Futaba Advanced Spread Spectrum Technology and uses warp-speed frequency hopping to ensure no breakdown of signal.

Field box - a box that you take to the field. It contains all your flying accessories and tools, except the one thing that you need on the day when nobody else is at the field to help you out. It is also often called a flight box, particularly when it gets kicked through the air just after you've written off your airplane.

Field equipment - The accessories and equipment that you take to the airfield in your field box less the one crucial thing that you need...

Fin - also called the vertical stabilizer, it's the vertical surface at the rear of the airplane used to stabilize the plane in flight.

Flaps - moving sections of the trailing edge of the wing, usually found between the ailerons and fuselage. Used to create more lift at slower flying speeds and also to slow the plane on landing approach, flaps are usually only found on RC airplanes with 5 or more channels.

Flaperons - a single control surface on the trailing edge of each wing that does the job of flaps and ailerons. An RC system with control mixing capability is needed to have flaperons.

Flare - the action taken in the last few seconds of the landing approach, to reduce the approach angle and slow the rate of descent. Forgetting this crucial action may result in you needing your plastic bag.

Frequency - all radio control gear works on frequencies. Although not 100% infallible, 2.4 gig RC systems do away with the old issue of unwelcome interference from other transmitters being operated nearby, and so frequency control is not needed. Just one reason why 2.4GHz radios are so great - you can just switch on and fly, without having to worry about who else is flying in the same area.

Fuel lock - when your glow engine gets flooded and the excess fuel inside the engine prevents you from being able to flick over the prop. It usually happens if you've over-primed the engine, and if you're starting the engine by hand you really know about it.

Fuselage - the main body of an airplane, excluding wings, tail and everything else. Flying wing type planes, oddly enough, don't have much in the way of a fuselage.

Glow plug - sits in the top of the engine's cylinder head and contains an electrical filament that glows red hot to ignite the fuel/air mixture in the combustion chamber. Glow plugs have an uncanny habit of burning out on the one day that you've run out of spare ones, and no-one else is at the flying field.

Glow plug igniter / starter - used to ignite the glow plug. Obviously.

Gravity - the force that every RC airplane is trying to beat. RC pilots are often caught out when gravity decides to have some fun and suddenly increases its strength without warning. This common phenomenon is also known as pilot error or radio failure.

Hand launch - the way to launch any flying aircraft without an undercarriage. The model should be held level at head-height and launched into wind. A hefty shove is needed, but don't throw the model like a ball. Alternatively an underarm lob gets the job done with a low wing plane, if you're feeling confident.

High winger - a plane that has the wing sitting on top of the fuselage. Trainers are typically high wingers, and the high wing position gives good stability in the air.

Horizontal stabilizer - also called the tailplane. It is the horizontal surface at the back of the fuselage, to which the elevators are attached. The tailplane's job is to generate a downward force, to counteract the natural tendency for a plane to want to nose-dive into the ground.

IC - internal combustion, the general term given to engines that are fuel powered - glow plug, petrol, diesel... They are the alternative to EP.

Inrunner - a type of brushless motor where the permanent magnets and motor shaft rotate within the fixed stator, as in a normal brushed motor. Inrunners don't provide a lot of torque and often need to be geared. If un-geared (direct drive) they are good for turning small props at high RPM.

Landing - the action of bringing your RC airplane safely back down to earth, hopefully keeping it in one piece. A good landing negates the use of the plastic bag.

Landing gear - also called the undercarriage. Landing gear refers to all wheels and associated bits. Landing gear can be fixed or retractable up into the underside of the wing or fuselage (called 'retracts', usually only found on planes with 5 channels or more).

Leading Edge (LE) - the front edge of the wing, tailplane or rudder.

Lift - the force created by the forward motion of the airplane's wing. Air pressure over the wing is less than the pressure below the wing and so the wing, along with the rest of the plane, is pushed upwards. Lift generation is actually a complex subject.

Li-Po - stands for lithium ion polymer battery. These are the most modern kind of battery packs being used in electric aircraft. They provide enormous amounts of power for their size, especially when used in conjunction with a brushless motor.

Loop - is an aerobatic maneuver whereby the airplane flies a vertical circle in the air. The easiest stunt of all to do and any airplane with an elevator can do them. Just make sure you're not flying too close to the ground first...

Mid-air - term used to describe the unfortunate incident of two or more aircraft making physical contact with each other while in flight. A mid-air collision can be very spectacular given the correct speeds and trajectories of each model, and all models involved in such a crowd-pleasing incident almost always end up going home in the plastic bag.

Mixing - the ability to combine two different RC functions into one. See control surface mixing and channel mixing above.

Mode 1 - refers to the set-up of the transmitter whereby the left stick operates the elevator and rudder, and the right stick operates the throttle and ailerons.

Mode 2 - refers to the set-up of the transmitter whereby the left stick operates the throttle and rudder, and the right stick operates the elevator and ailerons. This is the most common transmitter mode.

NiCD - abbreviation for nickel cadmium, which is a type of metal used in rechargeable battery cell production. Also written as "NiCad's," they are a form of rechargeable battery cell used in radio control gear as well as motor battery packs. NiCad's are being used less and less these days, as NiMh and Li-Po batteries take over.

NiMh - An abbreviation for nickel metal hydride which is the other type of material used in rechargeable batteries. They are the successors to NiCad's with much better performance and up to 3 times the capacity for an equally sized battery.

Nitro - short for nitro methane, or nitromethane, depending on who you believe. It's a principle ingredient of glow fuel and, while not essential, helps to keep the fuel/air mixture burning inside the oxygen-starved combustion chamber of the engine. A 10% nitro mix is a common one for general RC glow plug plane flying.

Non-scale - any model aircraft that is not modeled from a real-life airplane, helicopter or whatever, i.e. a completely made up design.

Outrunner - the other type of brushless motor, where the outer casing, or "can" of the motor rotates with the shaft and permanent magnets, which are attached to the inside of the can. Outrunners produce more torque, so they are more powerful than Inrunners and are rarely geared.

Park Flyer - the general name given to any electric RC airplane that can be safely flown in a public park / school yard / parking lot / sports field etc.

Peg board - the most common form of frequency control used at RC flying clubs. Pilots must notify other pilots of which channel they are using by pushing a peg into a hole. Not necessary with 2.4GHz systems.

Pilot error - any mistake, particularly one that ends in a crash, made by the pilot for whatever reasons. Pilot error is never admitted to by the pilot in question. Instead, the incident is traditionally put down to radio failure, radio interference, unexplained gusts of wind, extra fast-growing trees, the strange phenomenon of the ground suddenly lifting upwards and getting in the way without warning, or gravity having some fun and suddenly increasing its strength.

Pitch attitude - the upward or downward angle of the airplane in relation to the horizontal, when viewed from the side. Pitch attitude is controlled by the elevators.

Pitch - the angle of a wing, propeller blade or helicopter rotor in relation to the airflow over it. The pitch angle of a moving wing or blade is known as the Angle of Attack.

Plug-N-Play (PNP) - Ready to Fly RC aircraft that are missing the transmitter and receiver, allowing the pilot to use his/her own.

Power panel - a small central control box for all your electrical field equipment items, typically powered by a 12V battery. Used by fliers that fly IC powered planes to power their electric starter, glow plug igniter, fuel pump etc.

Pre-flight checks - essential checks that you need to carry out immediately before flight.

Priming - the action of introducing fuel in to an IC engine prior to starting it. Over-priming often causes fuel lock.

Propeller - the thing at the front of the airplane. It spins round very fast when the motor is running. Propellers have been known to eat the fingers of careless RC pilots who hand start their motor without the use of a chicken stick. Props will fly off at an alarming speed, if the securing nut hasn't been tightened properly.

Prop - abbreviation for propeller.

Prop-hanging - a 3D maneuver whereby the plane is put into a vertical attitude but is held at the same altitude i.e. it doesn't climb or fall, very close to the ground. RC pilots who prop-hang over the club airpatch often frustrate other RC pilots who actually want to fly their planes.

Radio failure - very occasionally this happens, but the uncontrollable actions of the aircraft are usually down to pilot error, not that they'd ever admit to it.

Radio interference - when two (or more) identical, or close, frequencies are being used at the same time the radio signals will mix together, so your aircraft's receiver won't know which ones to respond to. Radio interference is also a good cover-up for pilot error. 2.4GHz RC systems pretty much eliminate radio interference altogether.

Radio signals - the invisible messages that pass from transmitter to receiver, telling the aircraft what to do.

Range check - an essential pre-flight check to test the operation and signal strength of your RC gear.

RC or R/C - An abbreviation for Radio Control. Often you'll see “remote control”, but “radio control” is the technically correct term.

RC flight simulator - a home computer based training aid that lets you practice flying radio control from the safety and comfort of your house. Excellent for novice RC pilots, but equally great for fliers of any age and experience.

Receiver - part of the radio control gear that lives inside the aircraft and picks up the radio signals being emitted by the transmitter.

Retracts - abbreviation for “retractable undercarriage”, which is an undercarriage that folds up into the airplane's wings or fuselage after take off. They work most of the time, but sometimes they decide not to re-appear just when you need them the most.

Roll - the rotational movement of an airplane about its longitudinal axis. An aerobatic maneuver whereby the airplane is rolled about its longitudinal axis through 360 degrees, while trying to keep the aircraft flying in a straight line.

RTC - Ready to Crash. RTC aircraft that are in the throws of making unplanned air to ground contact, and nothing can be done to prevent it. Usually a result of pilot error, but never admitted to.

RTF - Ready to Fly. RTF aircraft that can be assembled in minutes, usually it's a case of just strapping on the wing. RTFs are very popular these days.

Rudder - the moving section on the back half of the fin. It is used to control the airplane's yaw.

Rx - An abbreviation for radio receiver.

Scale - any model aircraft that has been modeled from a real aircraft, such as a Piper Cub or P-51 Mustang for example.

Semi-scale - any model aircraft that is loosely based on a real aircraft, with maybe a few details left out or proportions changed.

Servo - the part of the radio control gear that converts the radio signal into movement.

Servo arm or horn - the plastic or metal piece fixed to the servo output shaft, onto which the linkage connects.

Servo linkage - the piece of metal or plastic rod (or thread/cable) that connects a servo arm to its control surface or function. Clevises are commonly used at the ends of the linkages, to clip to the servo/control horns.

Servo reverse - a feature whereby the direction of the servo horn movement can be reversed. This can happen if the builder has been daft enough to install the servo the wrong way round.

Slow Flyer - different name for Park Flyer, an RC aircraft that is experiencing engine problems, or a very strong headwind.

Spin - an aerobatic maneuver whereby the airplane is flown vertically down towards the ground, while being made to rotate about its longitudinal axis (i.e. roll). Easy to get into one but not always so easy to get out of, especially when the airplane-to-ground distance has been badly judged. In this instance, you will need to use the plastic bag, and I speak from experience!

Spinner - the plastic or aluminum cone-shaped piece that covers the centre of the propeller. Planes without spinners never quite look complete.

Sport airplanes - a general term for model airplanes that can be used for training on but are also capable of aerobatic maneuvers, whether intentional or not.

Spread spectrum - the latest technology for radio control systems. Based on the 2.4GHz frequency band, spread spectrum radio systems are virtually interference-proof, although it's now realized that 2.4GHz RC systems are not as infallible as first thought. 2.4 gig systems have all but replaced the traditional MHz ones.

Stall - any flying airplane will stall when the wing's Angle of Attack increases beyond the critical point of maximum lift generation, or the flying speed gets too low. When either of these things happens, the necessary amount of lift needed to hold the aircraft in the air is lost. Getting to know your RC plane's stalling speed by reducing throttle and applying up elevator at the same time is a very good idea, but don't practice too close to the ground if you want to avoid using the plastic bag.

Stall turn - an aerobatic maneuver whereby the airplane is put into a short vertical climb. At the top of the climb, power is reduced and full rudder is applied. The airplane should stop and turn through 180 degrees, pivoting on its tail in whichever direction rudder was applied. Then you need to pull out of the ensuing dive.

Straight and level - when your RC airplane is flying in a straight line, with no fluctuation in altitude. A well trimmed airplane should fly straight and level with the Tx control surface sticks in their central positions.

Take off - the action of accelerating your airplane along the ground until flying speed is reached, and the thing gets airborne. Only suitable for planes with an undercarriage, otherwise you're limited to hand launching.

Tail dragger or Taildragger - Is an airplane that has 2 main wheels and a small tail wheel or skid. Taildraggers have a habit of going round in circles on the ground when you're learning how to take off.

Tailplane - see horizontal stabilizer.

Tail wind - when the wind is blowing in the same direction as your plane is flying, taking off or landing. Flying with a tail wind not only increases the plane's airspeed, but also its stalling speed, and that's never good. You should never take off or land with the wind.

Thrust - the force that is generated by the spinning propeller or fan/turbine of the airplane, and pushes/pulls the aircraft through the air.

Trailing Edge (TE) - the rear edge of the wing, tailplane or rudder.

Trainer - any RC airplane that has been designed for learning to fly on. Usually trainers are high wing, with plenty of dihedral.

Transmitter - the main part of the radio control system that you hold in your hands while trying to control your RC airplane.

Trimming - the action of getting your plane to fly straight and level, with the transmitter sticks in their neutral positions and no input from you.

Tricycle undercarriage - a fixed undercarriage that consists of 2 main wheels and a nose wheel, which is sometimes connected to the rudder servo for easier ground handling. Often abbreviated as “a trike”.

Tx - A common abbreviation for a transmitter.

UBEC - Universal Battery Eliminating Circuit, a common brand name that's come to be used for standalone BECs, in the same way that the name Hoover is often used to describe a vacuum cleaner. When an ESC's (Electronic Speed Controller) built-in BEC isn't man enough to do the job (for example, if your plane has high current servos) then a more powerful standalone UBEC can be used instead, perhaps along with a separate battery pack if needs be. Common in larger RC planes.

Undercarriage - see landing gear.

Vertical stabilizer - see fin.

Windsock - a large material cone-shaped tube, horizontally mounted on a tall pole at the flying field that indicates the direction of the wind. Important because RC airplanes need to be taken off and landed into wind where possible, so the pilot needs to know the wind direction.

Wing - come on, seriously??

Wing loading - a calculation that is useful when determining certain flight performance characteristics of a plane, the figure is obtained by dividing the flying weight of the airplane by the total wing area. A plane with large wings relative to its weight will have a lower wing loading, which means better lifting capacity but not so great high speed performance, and vice versa. Wing loading values for RC planes are commonly given in Oz/sq.ft. (ounces per square foot), or less commonly the decimal equivalent.

Wingspan - the overall length of the wing, from tip to tip. Wingspan is the primary measurement when referring to an airplane's size, and it's commonly stated in inches (") or millimeters (mm).

Yaw - the rotational movement of an aircraft about its vertical axis, controlled by the rudder.

Glossary

A glossary of UAV and Drone-related terms

The world of Unmanned Aerial Vehicles (UAVs) makes use of a variety of acronyms and other aerospace engineering terms not normally found in common conversation. Presented here is an attempt to normalize the discussion, and readings that are to follow with a common language and use of UAV terminology.

2.4 GHz - the frequency used by digital (spread spectrum) radio communications in most current applications, including 2.4 GHz RC, Bluetooth and some video transmission equipment. This is a different band than the older 72 MHz band that is used for analog RC communications. It allows the radio transmitter to select an un-used frequency to communicate with a UAV, avoiding conflicts with other users in the same vicinity.

72 MHz - a radio-frequency used since the first radio control systems for models were built over half a century ago, the technology has been "narrowband." Narrowband refers to the amount of space that signal takes on the spectrum of available frequencies. Today's FM/PCM radio control systems operate on a tiny sliver of space on relatively low frequencies (27, 35, 36, 40, 41 or 72Mhz).

AHRS - attitude and Heading Reference System: consists of sensors on three axes that provide heading, attitude and yaw information for aircraft. They are designed to replace traditional mechanical gyroscopic flight instruments and provide superior reliability and accuracy.

AMA - Academy of Model Aeronautics. The AMA Mission Statement: The Academy of Model Aeronautics is a world-class association of modelers organized for the purpose of promotion, development, education, advancement, and safeguarding of modeling activities. The Academy provides leadership, organization, competition, communication, protection, representation, recognition, education, and scientific/technical development to modelers. The AMA has established "Rules" for RC flight to ensure life and property are protected.

APM - ArduPilotMega (APM) autopilot electronics is a full-featured IMU-based autopilot that can be used for either airplanes or rotary wing aircraft, including quadcopters and other multicopters and traditional helicopters. The autopilot hardware is the same across all aircraft, and you can load whichever firmware is appropriate for the vehicle you've got via the free Mission Planner. (You may choose to add other sensors to improve performance for specific airframes, such as an airspeed sensor for airplanes or a magnetometer for mulitcopters).

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

ArduPlane - fixed-wing autopilot software for the ArduPilot Mega electronics.

Autonomous flight - Some UAVs are controlled not by a human sending radio signals but by internal programming that tells it where to fly. For example, a UAV may use its on-board GPS system to fly from one predetermined point to another.

BEC - Battery Elimination Circuit. A voltage regulator found in ESCs (see below) and as a stand-alone product. It is designed to provide constant 5v voltage for RC equipment, autopilots and other onboard electronics.

C-130 motherships - the Lockheed DC-130 was a variant of the C-130 Hercules, designed for drone control. It could carry four Ryan Firebee drones underneath its wings.

COA - Certificate Of Authorization. A COA is an authorization issued by the Air Traffic Organization to a public operator for a specific UA activity. More than 100 have been issued to companies, universities and government agencies. Among them were Cornell University and the 174th Air National Guard unit at Syracuse.UAV and ROA (remotely operated aircraft) were terms previously used to identify unmanned aircraft. Currently the FAA and most of the international community uses the term "UAS." Courtesy: FAA

Collision avoidance - ideally UAVs, whether controlled by people or flying autonomously, will have collision avoidance systems to prevent them from flying into fixed objects or other aircraft. Much research is being done on this capability, which also is known as sense and avoid.

Drone - a term for an unmanned aerial or underwater vehicle. The word is closely associated with the large UAVs used by the military and intelligence agencies to drop bombs, launch missiles and conduct surveillance. For that reason, most domestic UAV boosters do not use the term to describe their aircraft.

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

FPV - First-Person View. Is a technique that uses an onboard video camera and wireless connection to the ground allowing a pilot on the ground with video goggles to fly with a cockpit view.

GCS - Ground Control Station. Is computer software running on the ground that receives telemetry information from an airborne UAV and displays its progress and status. It often includes video and other sensor data. It can additionally be used to transmit in-flight commands to the UAV.

GPS - the Global Positioning System (GPS) is a space-based radio-navigation system consisting of a constellation of satellites and a network of ground stations used for monitoring and control. A minimum of 24 GPS satellites orbit the Earth at an altitude of approximately 11,000 miles providing users with accurate information on position, velocity, and time anywhere in the world and in all weather conditions.

Hobbyists - other than entities with COAs, only hobbyists or other noncommercial users may fly sUAVs domestically at present. Their aircraft can't go over 400 feet in altitude and must be line-of-sight.

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

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

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

Ku-band SATCOM data link - ku-band provides high bandwidth, more targeted coverage for fixed and broadcast services, allowing for a range of satellite applications. Ku-band was designed for satellite communications exclusively, eliminating competition and signal interference from other communications systems. Ku-band enables high-speed uplinks and downlinks and utilizes smaller end-user antennas.

LOS - Line Of Sight. This refers to an FAA requirement that UAVs stay within a pilot's direct visual control if they are flying under the recreational exemption to COA approval. Many sUAS's are line-of-sight machines, meaning the person controlling the device must be in direct sight of the aircraft so that radio signals can be transmitted back and forth. Commercial/military UAVs are not line-of-sight aircraft because the radio signals that control them are bounced off of satellites or manned aircraft.

LiPo - Lithium Polymer battery, aka LiPoly. Variants include Lithium Ion (Li-Ion) battery. This battery chemistry offers more power and lighter weight than NiMh and NiCad batteries.

MAV - Micro Air Vehicle: or micro aerial vehicle is a class of unmanned aerial vehicles (UAV) that has a size restriction and may be autonomous. Modern craft can be as small as 15 centimeters. Development is driven by commercial, research, government, and military purposes; with insect-sized aircraft reportedly expected in the future. The small craft allows remote observation of hazardous environments inaccessible to ground vehicles. MAVs have been built for hobby purposes, such as aerial robotics contests and aerial photography.

NUAIR - short for Northeast UAS Airspace Integration Research Alliance, this New York-Massachusetts consortium filed an application to host a test bed. Most members are in the Syracuse-Rome area, and most activity would take place there but Rochester Institute of Technology is listed as the lead academic member.

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

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

PCB - Printed Circuit Board. In our use, a specialized board designed and "fabricated" for a dedicated purpose, as opposed to a breadboard or prototype board, which can be used and reused for many projects.

PIC - Pilot In Command. This refers to an FAA requirement that UAVs stay under a pilot's direct control if they are flying under the recreational exemption to COA approval. See Line of Sight above.

POI - Point Of Interest. A specific location that a UAV should keep a camera pointed toward such as a clump of trees or a barn.

PWM - Pulse Width Modulation: Square-wave signals used in RC control to drive servos and speed controllers.

Quadcopter - a common kind of sUAS that has four rotors oriented horizontally like a helicopter. Variants are hexacopters (six rotors) and octocopters (eight). 'Copter-style sUAS vehicles are the most popular because of their stability and ability to hover.

RPA - a Remotely Piloted Aircaft

RTL - Return To Launch. Return of the aircraft to the "home" position where it took off.

SATCOM - SATCOM systems use satellites positioned in space for voice and data telecommunications. Modern communications satellites use both geo-stationary orbits and low-Earth polar orbits depending on the service network infrastructure you choose an orbiting vehicle, which relays signals between communications stations. There are two types: a. active communications satellite--A satellite that receives, regenerates, and retransmits signals between stations; b. passive communications satellite--A satellite which reflects communications signals between stations. SATCOM is also called or referred to as COMSAT.

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

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

sUAV or sUAS - short for a small unmanned aerial vehicle and unmanned aircraft system, terms that generally describe battery-powered aircraft that can be picked up by one or two people.

Test beds - the term for six UAV test sites that the FAA will establish soon to research ways to safely fly UAVs, including in the national airspace that piloted aircraft use. Several dozen states are vying to host one of these test beds, which are seen as economic-development engines.

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

The Roadmap - the term for a document released by the Federal Aviation Administration in November 2013 that lays out its intended path for writing overdue and much-anticipated regulations governing the use of UAVs. The Roadmap calls for release of some rules for sUAS's next year.

UAV - Unmanned Aerial Vehicle. Short for unmanned aerial vehicle and unmanned aircraft system. The terms describe flying objects that have no on-board pilot and are controlled from the ground or internally. These days, many are equipped with video cameras. In the military, these are increasingly called Unmanned Aerial Systems (UAS), to reflect that the aircraft is part of a complex system in the air and on the ground. Ground-based autonomous robots are called Unmanned Ground Vehicles (UGVs) and robot submersibles are called Autonomous Underwater Vehicles (AUVs). Robot boats are called Unmanned Surface Vehicles (USVs).

WAAS - Wide Area Augmentation System. A system of satellites and ground stations that provide GPS signal corrections, giving up to five times better position accuracy than uncorrected GPS. The Federal Aviation Administration (FAA) and the Department of Transportation (DOT) are developing the WAAS program for use in precision flight approaches.