Leaving Certificate Engineering Prescribed Topic 2018

"Basic principles of operation and applications of drone technology"

*A **DJI Phantom**, a typical example of a recreational drone*

The following content relates to Question 1, Section B of the Leaving Certificate Engineering examination for 2018. We shall investigate the basic idea of a drone and explore the current applications for both military and civilian drones. Furthermore, we shall "lift the bonnet" on the drone and examining the technologies that have made the use of drones possible We will also examine how emerging applications may affect peoples' daily lives.

Let us begin by examining the concept and history of the "*drone*" as we know it.

You may have seen a drone used for:

Star Wars Episode VII closes with Rey finding Luke Skywalker. The scene was shot on Skellig Michael off the coast of Kerry. Drones were used for aerial shots. Afterwards, the Irish Aviation Authority (IAA)were forced to ban drones over the Skelligs due to hoards of tourists filming there & concerns for indigenous wildlife.

See the Skellig Michael scene here

In Ed Sheeran's song "***Galway Girl***," the closing scene shows superb drone footage of Ed and Saoirse Ronan looking out the window of "*The Heron's Rest*" B&B in Galway. The footage was shot by NUIG media student Roman Bugovskiy.

Watch the official video here

In this scene from the remake of "***The A Team***," Bradley Cooper and Liam Neeson are being targeted by two General Atomics **Predator** MQ-1 Drones as they parachute into a lake piloting a military tank...

Watch the tank v Predator drone scene here

drone |drəʊn|
verb [no obj.]
make a continuous low humming sound: *in the far distance a machine droned.*
• speak tediously in a dull monotonous tone: *he reached for another beer while Jim* ***droned on****.*
• [with adverbial of direction] move with a continuous humming sound: *traffic droned up and down the street.*

drone |drəʊn|
noun
1 a continuous low humming sound: *he nodded off to the drone of the car engine.*
2 a continuous musical note of low pitch. *the drone rose by a third to A.*
3 a male bee in a colony of social bees, which does no work but can fertilize a queen.
• a person who does no useful work and lives off others. *the University takes all the profit and redistributes it to drones like him.*
4 a remote-controlled pilotless aircraft or missile.

Most of us have seen or experienced drones in some form or another. Most people on hearing the word drone think of either a military strike drone that you may have heard of in the news, or else a typical quadcopter that you can buy for personal recreational use. Going by the dictionary definition, the term drone means "*a remote controlled pilotless aircraft or missile.*" By definition, a drone could be made in the form of a helicopter, an airplane, or even a balloon. A ***drone*** is just a popular term for any ***Unmanned Aerial Vehicle (UAV)***. So, by popular terminology, any vehicle that flies and doesn't have a pilot inside the cockpit manually steering it would be a drone. It could be controlled by a human via a remote or by pre-programmed computer software.

Alternative moral outlooks on drone technology & usage

Drones are the stuff of dystopian nightmares. They're used for surveillance at home and abroad, raising privacy issues everywhere. They can carry weapons and can kill people from thousands of miles away while the operator sips coffee in a temperature-controlled office.

Drones are a dream come true for many commercial enterprises. Farmers can better monitor fields and livestock. Construction engineers can much more easily see their projects from every angle. Drones can offer new perspectives on surveying, mapping, moving cargo and delivering packages.

By some estimates, drone technology could create more than 100,000 jobs in the next decade. And they could boost the economies by billions of euro as they spill into sectors of engineering, computer science, commercial contracting, videography, forestry and, of course, the military. All of these disciplines will require experts in fabricating, programming and flying drones.
In the USA, numerous colleges have begun offering degrees for piloting drones in anticipation of the drone explosion.

Background & historical use of drones

One of the earliest records of the pilotless aircraft / drone concept dates back to the 1800s. On Aug. 22, 1849, Austria launched a pilotless balloon bomb attack against Venice. *"Although Austrian Field Marshall von Radetsky beleaguered the city by land and sea, his siege artillery couldn't get close enough to bear fire on the whole city because of its formidable coastal defences and shallow Lagoons,"* according to the 2005 documentary "*On a Wind and a Prayer.*"

A young Austrian artillery lieutenant named Franz von Uchatius hatched the idea of launching balloons carrying explosives over Venice. About 200 balloons, measuring almost 6 metres in diameter, each carrying 33 pounds of explosives and armed with half-hour time fuses, were launched into Venice that day. As a result of the physical and psychological damage combined with exhaustion and starvation, the Venetians surrendered two days later.

de Havilland "Queen Bee"

The concept of pilotless flight was a groundbreaking idea, but technology to develop it in any meaningful way took a long time. The first generally reusable drone was a full-size retooling of the ***de Havilland DH82B "Queen Bee"*** biplane, which was fitted out with a radio and servo-operated controls in the cockpit. The plane could be conventionally piloted from the back seat but generally, the plane flew unmanned. The term ***drone*** dates to this initial use, a play on the "*Queen Bee*" name. 412 of these were built between 1933 and 1943 by Scottish Aviation Ltd. in Glasgow. The RAF used them as target practice for training artillery gunners.

The remote control of the Queen Bee

Until very recently, UAVs were mostly associated with the military. As the technology developed further expanding the range of possibilities, the drones moved into the field of intelligence gathering missions and then, more controversially, as weapons platforms. Drones are now also used in a wide range of civilian roles ranging from search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting to personal drones and business drone-based photography, as well as videography, agriculture and even delivery services.

Common technologies in drones

Even though the technology and systems have evolved phenomenally from the earlier remote control "drones," the basic concept of an intelligent drone as we now know them is quite simple. They consist of a *power supply*, means of *generating lift* and an *embedded flight control* system.

Power Supply: Most drones use battery power to turn propellers. Pricier military versions can have full-blown jet engines and can fly more than 800 km/h, soaring up to 50,000 feet. Hybrid designs can have both jet engines and backup batteries for safety.

Generating Lift: Most larger and military drones follow the flight dynamics of a plane and use a wing system to generate lift. Smaller, cheaper drones tend to be based on helicopter designs which technically don't generate lift, instead they use propellors to generate thrust.

Flight Control: Drones are equipped with a flight control system for stability which relies on an Inertial Measurement Unit (IMU). The IMU consists of a series on sensors which tell the drone what velocity and angle it is travelling at. This allows the flight controller to continually balance power to the rotors to maintain stability. GPS is normally used for guidance.

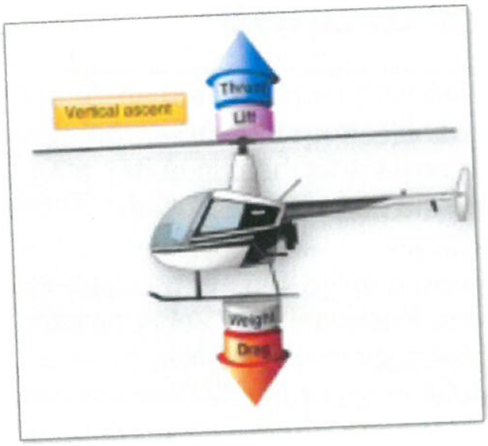
Earlier drones like the Queen Bee were basically remote controlled aircraft. Drones as we know them today are essentially flying robots. The drone may still be remotely controlled from a ground cockpit but can also fly autonomously, making decisions through software-controlled flight plans in their embedded systems working in conjunction with onboard sensors and GPS.

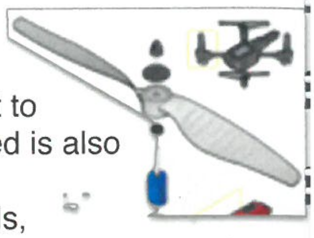
Before we explore some of these systems and sensors, lets look at some drones. For simplicity, lets leave the more elaborate military and plane style drones to one side and focus on a more common type of drone available, the quadcopter. If we look at the three market leaders in hobbyist drones, we can see that all three are have quadcopter designs.

DJI Phantom 3

DJI Inspire 1

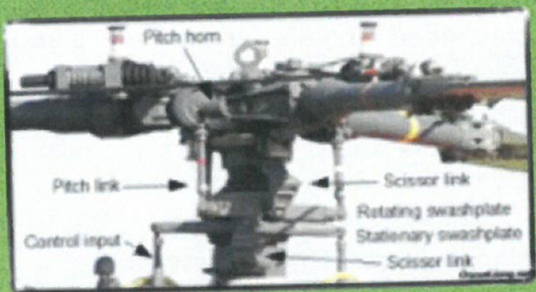
Parrot AR Drone 2.0



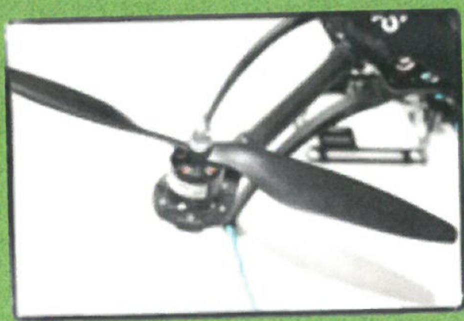


The quadcopter uses propellors to generate thrust which is used for vertical lift to get the drone in the air. The thrust generated is also used to propel the drone in the required direction. Any movement up, down, forwards, backwards, sideways, etc. is achieved by varying the speed on specific propellor shafts to get the correct amount of thrust. As the quadcopter is based on the helicopter, it shares many characteristics. It has simplicity in taking off, hovering stable in flight and can land easily compared to a plane based drone. This makes it much more user friendly.

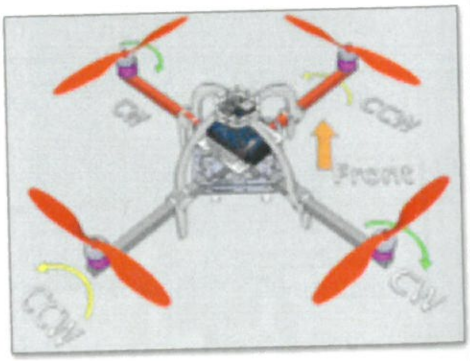
The drawback of the quadcopter drone is that it is hugely inefficient compared to a helicopter drone. A model helicopter has larger propellors so it can move a larger volume of air at a lower speed. This is much easier than moving less air at faster speeds. This means that helicopter blades can spin at a much lower speed than quadcopter blades and still produce more lift. Helicopters can also perform aerial manoeuvres much better. The reason we don't often see hobbyist drones in the form of a helicopter comes down to mechanical complexity and costs. The flight of a helicopter is controlled by the pitch (angle) of the rotor blades and the tail rotor. The parts responsible for adjusting the pitch are complicated and expensive.



The rotor on the helicopter, (left) is much more complex and expensive to produce and maintain compared to the quadcopter (right). The helicopter uses complex mechanics to control direction, the quadcopter uses electronic speed control on the motors.



Quadcopters are cheaper to produce and need less maintenance to maintain top performance, but that doesn't make them easier to fly. Quadcopters have a vast amount of sensors and onboard software that stabilises flight. Without it, they would be nearly impossible for a human to fly as the fixed-pitch fan blades spin at varying speeds to control flight. To make a quadcopter tilt or turn, one or two of the blades just increases or reduces their speed.They have very simple mechanics with only one moving part, a fan attached to an engine.



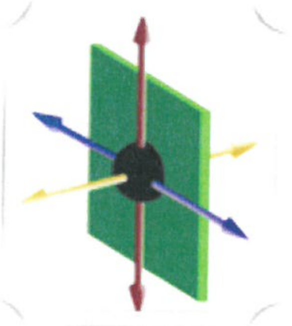
A Chinook helicopter (far left) spins its propellors in opposite directions to balance out its rotational thrust. The quadcopter (above) also spins propellors in opposite directions for the same reason. Some drones have six or eight propellors for extra lifting power (middle)

Now that we have looked at why elaborate sensors and control systems are needed to fly the drone, lets briefly examine the main ones. Three of the main systems/technologies that make drone flights possible are:

1. **Accelerometer**
2. **Gyroscope**
3. **Global Positioning System (GPS)**

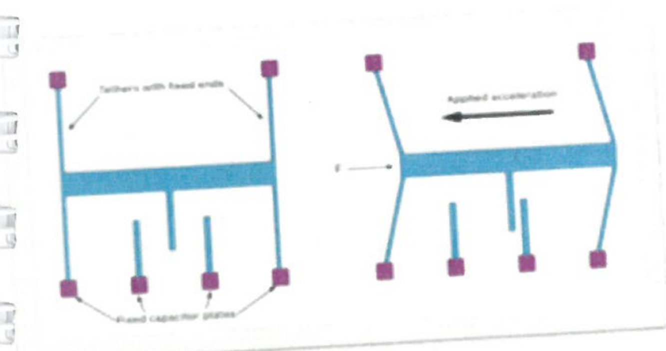
Accelerometer

You may have been told as a child not to run with a mug of tea. If you have been unfortunate enough to spill some tea over the rim of the mug, then you have experienced ***inertia.*** This is where the mass of the liquid has to absorb energy to catch up with the force you apply by moving the mug. The faster you move, the less time the mass has to absorb energy, and the more likely it is to spill over the edge.
If you look at the mug on the right, you can see a red line showing where the tea should be when the cup is stationary. If you were you to insert a steel rule into the mug as shown, you could get measurements of how much change in velocity and movement there is. This is called *acceleration*, just like a car changing speed. The faster you move, the higher up the rule the tea would travel. This is a simple accelerometer.
An accelerometer is a device that can measure the force of acceleration, whether caused by gravity or by movement. An accelerometer can therefore measure the speed of movement of an object it is attached to. The accelerometers can also sense the tilt, movement and speed being applied to them, as well as the direction.



There are three basic directions the drone can move in - **Left or Right (X axis)**, **Forward or Backward (Y axis)** and **Up or Down (Z axis)**.
For the drone to control its movement in flight, it needs to know what direction it is moving in. Drones use a sophisticated accelerometer to tell the flight control system what direction it is moving (or falling!).

Early version were based on a moving spring system, but modern accelerometers use an electronic system based on capacitors to accurately measure acceleration and changes in force.

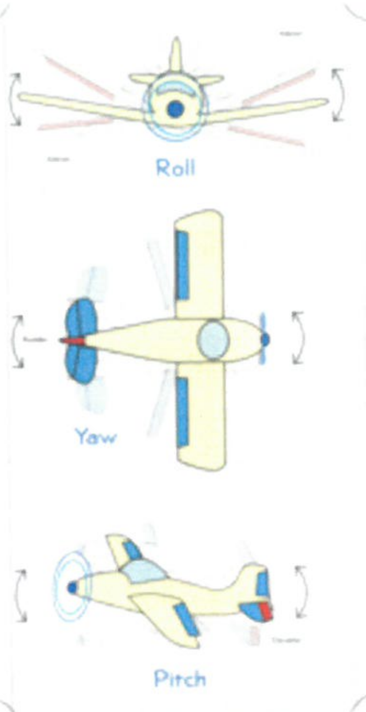


Did you know?

Your iPhone uses the same type accelerometer as the chip shown above to tell when to rotate the screen!

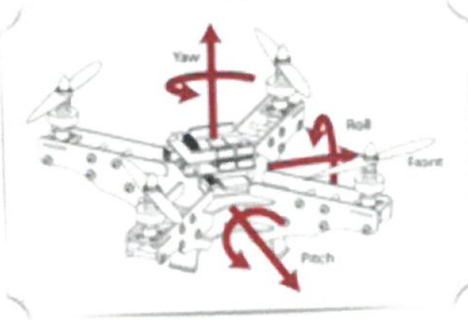
Your car uses an accelerometer to check for sudden deceleration so it can tell the airbag when to to go off!

Gyroscope

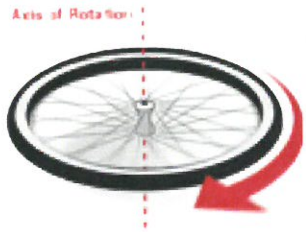


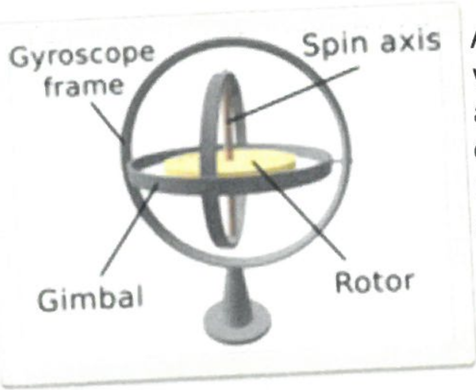
The diagram on the left shows a range of rotational movements that are the basis of any object turning through an angle. These are huge factors in motion, especially for aircraft. if you have ever been on a plane, you will no doubt have felt the turning force as the airplane pitches its nose into the sky for takeoff. Similarly, as a plane turns in flight you feel the rolling sensation. The sharper the turn, the more disconcerting it feels as you get the feeling of twisting and falling.

Fluid in your eardrum is your natural sensor of what is straight and level. Drones have the same range of movement as a a passenger plane, and can rotate in three basic axes. These axes are the exact same as we examined in the accelerometer, but this time we have a rotating motion, not a linear one. They need sensors like your eardrums to know if they are turning.



The answer to this sensor for angular rotation uses the same force that stops your bicycle from falling over when you are moving - **Angular Velocity**. *When an object rotates around an axis it generates a type of force called **angular velocity*** which tries to maintain it in the same axis. E.g. if a wheel turns once per second, it has an angular velocity of 360°/s. The mechanism that uses this force to take measurements is called a **gyroscope.**

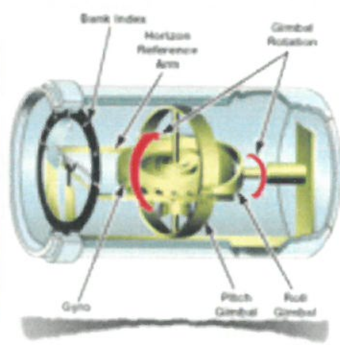




A gyroscope (*gyro*) is a wheel mounted in two or three gimbals, which are pivoted supports that allow the rotation of the wheel about a single axis. A set of three gimbals, one mounted on the other with perpendicular pivot axes, may be used to allow a wheel mounted on the innermost gimbal to have an orientation remaining independent of the orientation, in space, of its support. Gyros are used for navigation in aircraft *(see below)* ships, mining operations, and even the Hubble space telescope. This is what keeps autopilot on your airplane working.

Did you know?

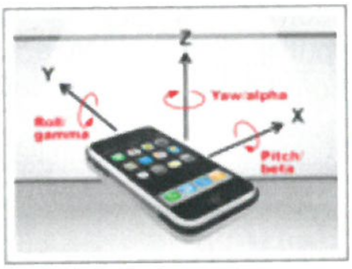
A Figet Spinner is a type of Gyro. Angular velocity the force that allows the spinner seem to defy gravity!

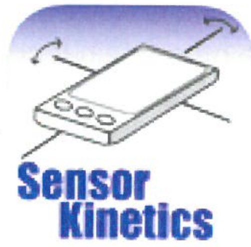


Accurate navigation on an airplane is possible by the gyroscope (left) keeping the artificial horizon (right) true and flat. Drones use gyros to tell the flight control system what angle it is tilting in all directions.

Modern technology and engineering has led to accelerometer and gyroscope sensors within the IMU which are engineered electronically. They alone have contributed greatly to drone development as they are tiny in size (about 100 micrometers, the size of a human hair) and extremely lightweight. When the gyro is rotated, a small resonating mass is shifted as the angular velocity changes. This movement is converted into very low-current electrical signals that can read by the IMU and used by the flight control system.

This technology is not limited to drones and aircraft. In fact, you probably have enough accelerometers and gyros to fly a drone in your pocket - Your iPhone! It uses the sensors for a range of navigation, health apps and games.





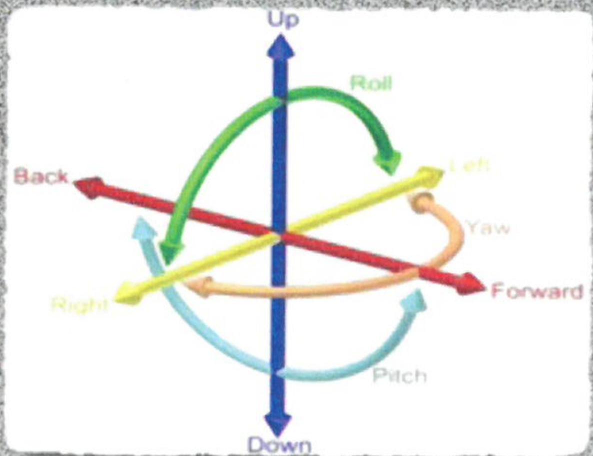
Two superb apps for your iPhone or Android are:
Gyroscope
Sensor Kinetics
These free apps show you a 3D view of your sensor readings on your phone. You will be amazed at their accuracy!

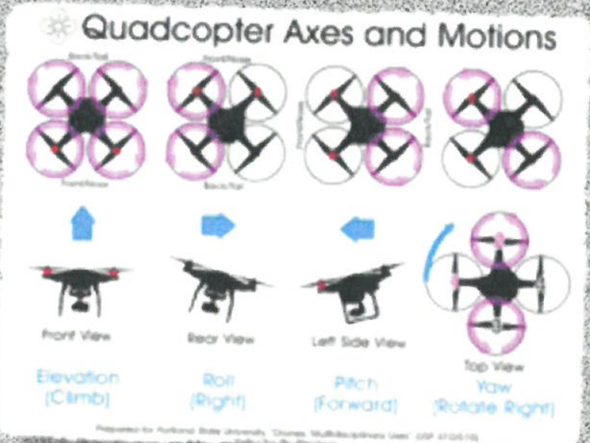
Summary

The Inertial Measurement Unit (IMU) of most drones use six axis stabilisation for smooth, level flight. The six axis are:

3 **accelerometers** for **linear movement** and acceleration in the **X axis**, **Y axis** and **Z axis**.

3 Axis **Gyroscope** for **rotary movement** and acceleration i.e. **Pitch**, **Roll** and **Yaw**.



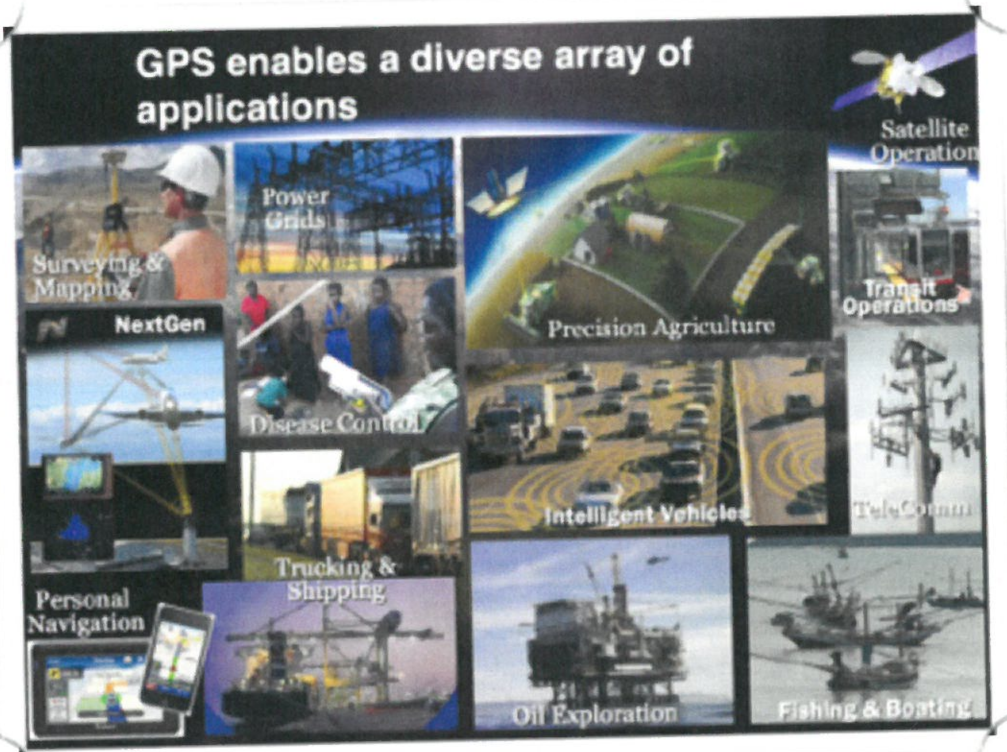


The flight control system continuously reads information from each of the six sensors. It performs complex calculations instantly and then varies the power to each individual motor of the propellors to achieve stability or move in a certain direction.
This is a critical technology in the flight of the drone.

See superb footage of the accelerometer and gyros in action here

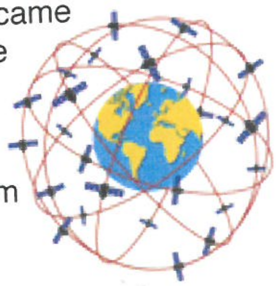
Global Positioning System (GPS)

Now that we have examined the sensors and mechanics behind the drones, we can now look at the other main technology which has an integral part of the flight control system. The Global Positioning System, or GPS for short. GPS has become integrated into our everyday lives and almost all industries since being introduced to the public in the mid 90's. Like drones, we rely on it for guidance, navigation and safety. Drones both military and recreational are completely reliant on it. Let's take a look at what GPS is and how it came to be.

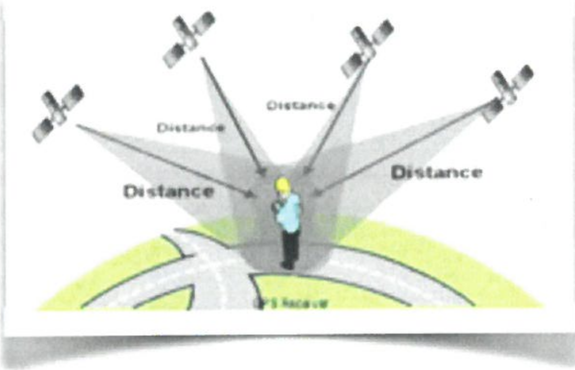


GPS is a solution for one of mans longest and most troublesome problems. It provides an answer to the question Where on earth am I?

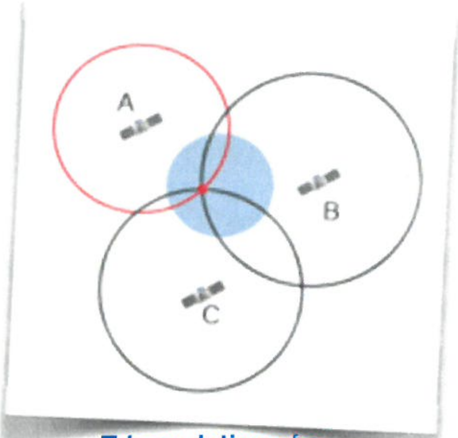
If you are in the area you live in and grew up in, this is an easy question to answer. You can locate yourself by looking at objects that surround you and position yourself relative to them. But what if you have no objects around you? What if you are in the middle of the desert or in the middle of the ocean? For many centuries, this problem was solved by using the sun and stars to navigate. For centuries military powers looked for a better way of accurate, absolute positioning. At the beginning of the 1970s, the USA came up with a system to determine your position accurately, at any point on the earths surface, at any time, in any weather conditions, GPS.



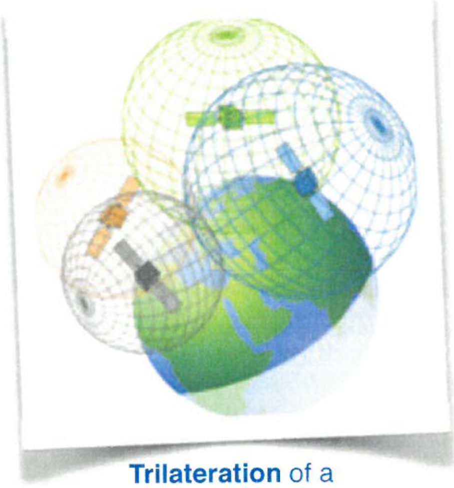
GPS is a satellite-based system that uses a constellation of at least 30 satellites to give a user an accurate position. The accuracy can range from an accuracy of 10m to 10mm depending on the receiver.



Wherever the drone is on the planet, at least four GPS satellites are 'visible' at any time. Each one regularly transmits information about its ***position*** and the ***current time***. A GPS receiver needs signals from at least three satellites to work. These signals, travelling at the speed of light, are intercepted by the GPS receiver on the drone, which calculates how far away each satellite is based on how long it took for the messages to arrive.
Once it has information on how far away at least three satellites are, the GPS receiver on the drone can pinpoint its location using a process called ***trilateration***.



Triangulation of a point in 2D space



Trilateration of a point in 3D space

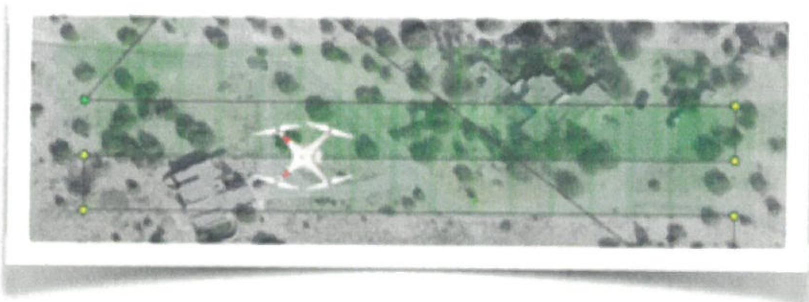
How it works

Imagine you are standing somewhere on Earth with three satellites in the sky above you.

If you know how far away you are from satellite A, then you know you must be located somewhere on the red circle. If you do the same for satellites B and C, you can work out your location by seeing where the three circles intersect. Doing this in 2D space on a map is called **triangulation**.

Because the satellites and GPS receivers on drones deal in 3D space they use spheres to establish distances rather than circles. Locating a position using points on the surface of these spheres is called **trilateration.**

This is exactly how a drone knows where it is.



The key idea of GPS positioning is "*Trilateration.*" There are two factors for trilateration:

1) Location of each satellite (at least 3 needed) **2)** Distance from each satellite

Satellites transmit their location and the time. GPS receivers calculate their position.

GPS is used in drone flight controllers to find destinations, geofence, avoid collisions, return to home and stay out of restricted airspace, e.g. Airports, Prisons, Nuclear facilities, etc.

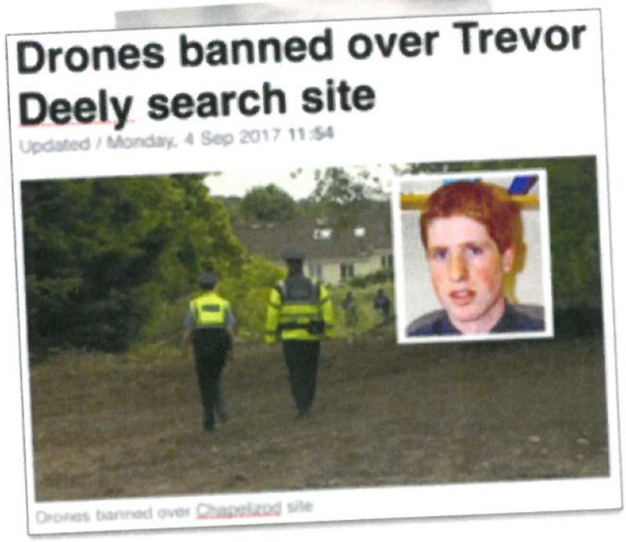
Privacy, Safety & Drones

Despite extensive GPS maps complete with "*no fly zones*" drones can be programmed not to enter such as airports, prisons, etc, the responsibility usually comes back on the operator of the drone. Due to their stealth nature and background in surveillance, drones raise serious issues in terms of privacy and ethics. Where is the line where personal privacy is invaded? Small camera drones like the AR selfie offers a neat portable solution for pocket transportation, but what if this drone was hovering outside your window as you get out of bed?

An example of No Fly Zones

Two recent cases in Ireland are when Cork Airport was forced to close its airspace on 20th April 2017, diverting flights and cancelling takeoffs after a drone was sighted flying across the runway, despite a 5km no fly zone in place. No matter how much security you go through in the airport, it is negated if anyone can potentially down a plane by flying a drone into its path.

Similarly, on 4th Sept. 2017, the Irish Aviation Authority issued a ban on drones in Chapelizod at the request of the Gardai after a drone tried to record footage of a murder investigation scene.



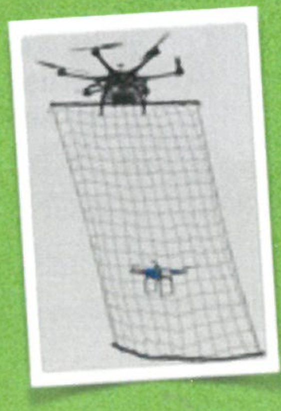
Drones banned over Trevor Deely search site

Updated / Monday, 4 Sep 2017 11:54

Drones banned over Chapelizod site

Golfer Rory McIlroy and his American wife Erica Stoll were so insistent on privacy at their Ashford Castle wedding that they hired a drone defence company to ensure there was no intrusion of camera equipped drones on the McIlroys' special day.

Common defences against drones include radio jamming technology, netting drones and even training eagles to attack them.



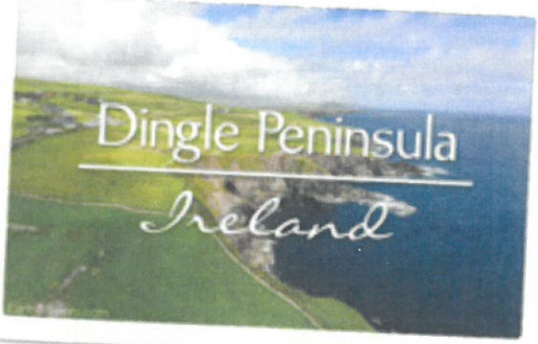
Applications of Drones

Until the development of the less expensive drones that are widely available for both recreational and professional users, the applications were mostly limited to military strikes and reconnaissance missions. In the past decade the availability of drones has exploded. As a result of better availability and cheaper drones, the applications for them has increased dramatically too. Here are a few examples of drone use nowadays.

Military Surveillance:
A good example is the FULMAR fixed wing drone. It has an endurance of 12 hours and a range of about 90km. The top speed of this drone is 100km/h and the maximum altitude it can get to is 4000m.It is used for land border surveillance. This drone is usually launched by a small catapult and it can be deployed from the land or from a ship's deck. It has the ability to land on water..

Military Combat:
Drones such as the aptly named "Reaper" are used to provide attack capability for some high-risk missions. These lethal drones are much cheaper than the costs of a fighter jet and of training a fighter jet pilot, they cost $12 million each and have been frequently deployed against suspected members of al Qaeda, while the F-22 war plane costs around ten times that amount.

Police drones :
Devon and Cornwall police are trialling drones fitted with HD cameras to help search for missing people, monitoring traffic accidents and capture crime scene photos in a similar way to the Helicopter response service.



Drone Videography:
As seen in the Ed Sheeran video for *Galway Girl*, drones can be used to easily capture stunning footage at a low cost. This would previously have required a high quality camera, operator and helicopter. News reports in particle regularly feature footage of disasters such as floods etc. recorded on a drone.

Emerging applications for drone technologies

It should be clear from the previous pages that even though the applications for drones has evolved and grown hugely over the past decade, the potential for future uses is even bigger. So what does the future hold for drone technology? Here are some of the new possibilities being developed.

Parcel Delivery

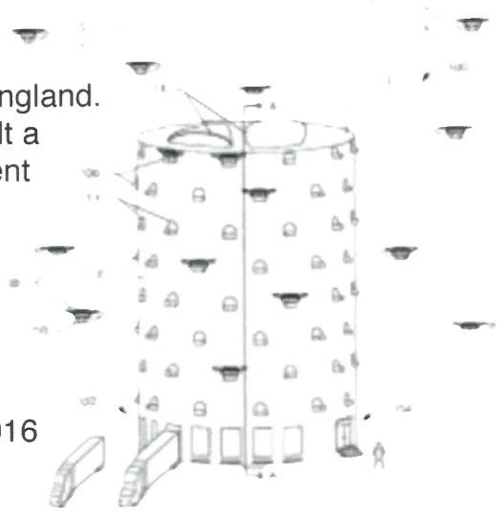
On December 1, 2013, Amazon.com CEO Jeff Bezos revealed plans for Amazon Prime Air in an interview on 60 Minutes. Amazon Prime Air is planning to use drones to fly individual packages to customers within 30 minutes of ordering. To qualify for 30 minute delivery, the order must be less than 2.25 kg, must be small enough to fit in the cargo box that the craft will carry, and must have a delivery location within a 16 km radius of a participating Amazon order fulfilment centre.

One of the prototypes for Amazon Prime Air delivery service.

Amazon has stated it plans to fly drones weighing up to 25 kg within a 16 km radius of its warehouses, at speeds of up to 80 km/h with packages weighing up to 2.26 kg in tow. In fact, Amazon see so much potential in drone deliveries that they have patented a beehive-like structure to house the delivery drones in cities!

On December 7, 2016, Amazon successfully delivered a Prime Air parcel to Cambridge, England. Amazon had built a Prime Air fulfilment centre in the Cambridge area. Amazon posted a video on their official YouTube channel, on December 14, 2016 of the delivery.


Jeremy Clarkson in an advert for Amazon Prime Air delivery service.


An impression of the Beehive style

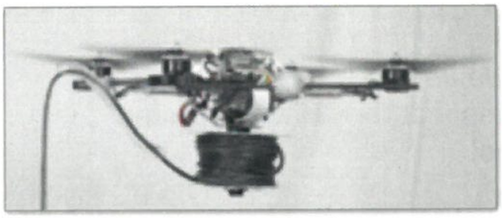
Check out Dubai's passenger drones!

Air Taxi

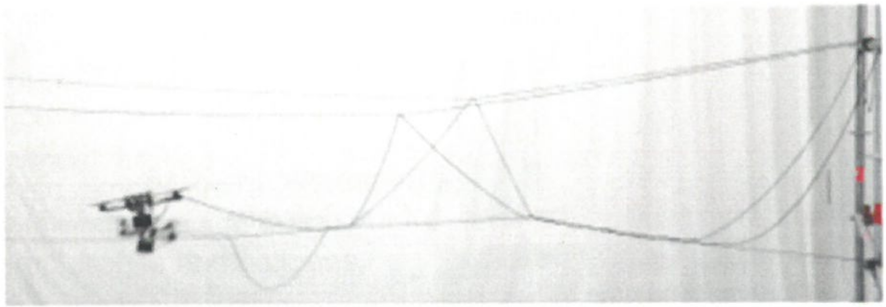
A two-seater 'Passenger Drone' that could revolutionise the daily commute completed its first manned flight in August 2017.
Passenger Drone took to the skies with a pilot aboard to test out the aerial craft's capabilities.
The aptly named vehicle can fly at a top speed of around 45 mph with a flight range of up to 25 minutes. A company spokesman said: "*On-demand aviation and manned drones has the potential to radically transform how we get from place to place, and to restore precious lost family and personal time to commuters worldwide.*"
Equipped with all electric engines, the manufacturer says Passenger Drone is a low-noise, high-speed, and economical mean of transportation with zero emissions.

Passenger Drone boasts low-noise, high-speed, and economical mean of transportation with zero emissions.

Bridge Building



Scientists at ETH Zurich have been have developed a swarm of drones to work on aerial construction. The idea is to use small quadcopters to build structures that humans can then use. In this case, they made a rope bridge.
This is very impressive when you think about what goes into making a rope bridge. First, the small drones must be able to control the tension on the spool of rope so they can create braids, links, and knots as necessary. Then there's the problem of working in tandem around preexisting structures, all without flying into anything or getting tangled up in the rope. Once the main portion of the bridge is completed, the quadcopters tie on the stabilising portions, which requires additional calculations.



Air Ambulance & First Response

The ambulance drone that could save your life: Flying defibrillator can reach speeds of 100km/h

- **€15,000 drone tracks emergency mobile calls and uses the GPS to navigate**
- **Operators can watch, talk and instruct those helping the victim by using an on-board camera**

Around 800,000 people suffer a cardiac arrest in the Europe every year and only 8% survive. The main reasons for this are the relatively long response time of emergency services and traffic conditions. Brain death and fatalities occur with four to six minutes. A Dutch engineering graduate, *Alec Momont* has developed a prototype 'ambulance drone', a flying defibrillator able to reach heart attack victims within precious life-saving minutes. It can fly at speeds of up to 100 kilometres per hour. Painted in emergency services yellow and driven by six propellers, the drone can carry a four kg. load - in this case a defibrillator. The drone tracks emergency mobile calls and uses the GPS to navigate. Once at the scene, an operator, like a paramedic, can watch, talk and instruct those helping the victim by using an on-board camera connected to a control room via a live-stream webcam.
Momont believes these drones can become a 'flying medical toolbox' able to carry an oxygen mask to a person trapped in a fire or an insulin injection to a diabetes sufferer. However, the drone is still in its infancy as far as developing its steering mechanism and legal issues regarding its use are concerned.

The ambulance drone can get a defibrillator to a patient within a 12 square kilometre zone within a minute, increasing the chance of survival from 8 percent to 80 percent.

Drone Technology - Summary

Advantages of Drones are:

They can save lives. In natural and manmade disasters, drones can be positioned to survey damage, locate stranded and injured victims, and assess ongoing threats without risking the safety of rescue teams and first-responders.
They can support law enforcement. Drones can be used to search for lost children, provide tactical surveillance and suspect tracking, assist in accident investigations, and monitor large crowds.
They can contribute to safe infrastructure maintenance and management. Consider the difficulty of inspecting the underside of a bridge or the top of a skyscraper, not to mention the costs and risks. With drones, scaffolding, cranes, or harnesses are not required. Just deploy the system to assess the structure's condition remotely.
They can give media access to hard-to-reach places. Aerial photography for a news broadcast or a blockbuster film can be efficiently, economically, and safely captured by a drone.
Low Cost: Drones are significantly cheaper to purchase, fuel, and maintain than regular airplanes. This is beneficial to both recreational and military applications.
Low Risk: Since drones are smaller and more manoeuvrable than traditional airplanes, there is less risk to the surroundings, e.g. a bridge or pylon.
Operational Hours: Without a human pilot, drones can stay in operation for significantly longer hours of operation without fatigue. Additionally, drone pilots or operators can easily hand off controls of a drone without any operational downtime.
Accuracy: Drones can have more pinpoint accuracy, thus reducing collateral damage to civilians and infrastructure when in military use.

Disadvantages of Drones are:

Spying: When the criminal elements use drones to fulfill their criminal intents, their targeted victims are now vulnerable to privacy invasion. If the users launch drones into the atmosphere, anyone can be constantly watched by an individual or group.
Limited Abilities: From a military point of view, drones have limitations. For example, they cannot communicate with civilians for more detailed intelligence. Drones cannot capture surrendering military personnel, abandoned hardware, or military bases.
Civilian Losses: Drone warfare often causes collateral damages in civilian lives and property, as well as traditional warfare too.
Vulnerable to Wild Animal Attacks: When flying drones to an area that has a large concentration of wild animals, a drone is often considered a creature. Larger flying animals such as eagles are known to attack or capture drones while navigating the atmosphere and taking important photos or videos.
Easily Hacked: Hackers can easily invade the main control system of the drones, replacing the original users as the new drivers or controllers of the device. The network and control systems of drones contain vital information that can be hacked. The USA banned certain types of drone as they were viewed as being too easily hacked.
Too Easy: In military applications, making drone warfare very similar to video games, drone warfare makes combat too easy by diminishing ethical decisions.

Terminology & Keywords

Drone
Unmanned Aerial Vehicle
Inertial Measurement Unit
Flight Control System
Thrust
Accelerometer
Gyroscope
Roll, Pitch, Yaw
GPS
Triangulation
Trilateration
Autonomous Flight
No Fly Zone
Radio Jamming
Netting
Quadcopter

References

http://internetofthingsagenda.techtarget.com/definition/drone
https://youtu.be/sqCbYd8O8MU
http://www.independent.ie/style/celebrity/celebrity-news/rory-hired-antidrone-tech-to-ensure-privacy-at-his-starstudded-wedding-35647357.html
https://youtu.be/6FVeZeT_TEA
https://youtu.be/Ik_A8IkISS0
https://youtu.be/IzpJYs_byk0
http://science.howstuffworks.com/transport/flight/modern/drones.htm
https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/
https://www.dronezon.com/learn-about-drones-quadcopters/three-and-six-axis-gyro-stabilized-drones/
http://www.independent.ie/business/farming/agri-business/the-good-and-the-bad-of-drones-what-you-need-to-know-for-your-farm-35802634.html
https://youtu.be/f1E9jtE1aAk
https://youtu.be/AhDG_WBIQgc
https://youtu.be/mdWsULRN38I
https://youtu.be/y-rEI4bezWc
https://www.rte.ie/news/ireland/2017/0817/898088-trevor-deely-investigation/
https://www.gps.gov/multimedia/presentations/2013/04/croatia/fisher.pdf

ranford, W., Parkinson James. & Spilker, J. „Global Positioning System: Theory and pplications", volume.1, Amer Inst of Aeronautics, Lincoln, NE, U.S.A. 1996

uncan.M.J., Bandland. H. M. & Mummery. W. K. (2008). Applying GPS to enhance nderstanding of transport-related physical activity", Journal of Science and Medicine in Sport, ol.10, Issue, 10.

obi, S. „Introduction to GPS: Principles and Applications", Tata Mc Graw-Hill Publishing ompany

vang, S. & Yu, D. (2012)„GPS Localization Improvement of Smart Phones Built in Sensors", ternational Journal of Smartphone, vol.6.no.3

entry, C., Saravanan"s and Kulathuran, K. (2011). „Application of GPS in Fisheries and Marine udies", International journal of Advance Research in Computer science...