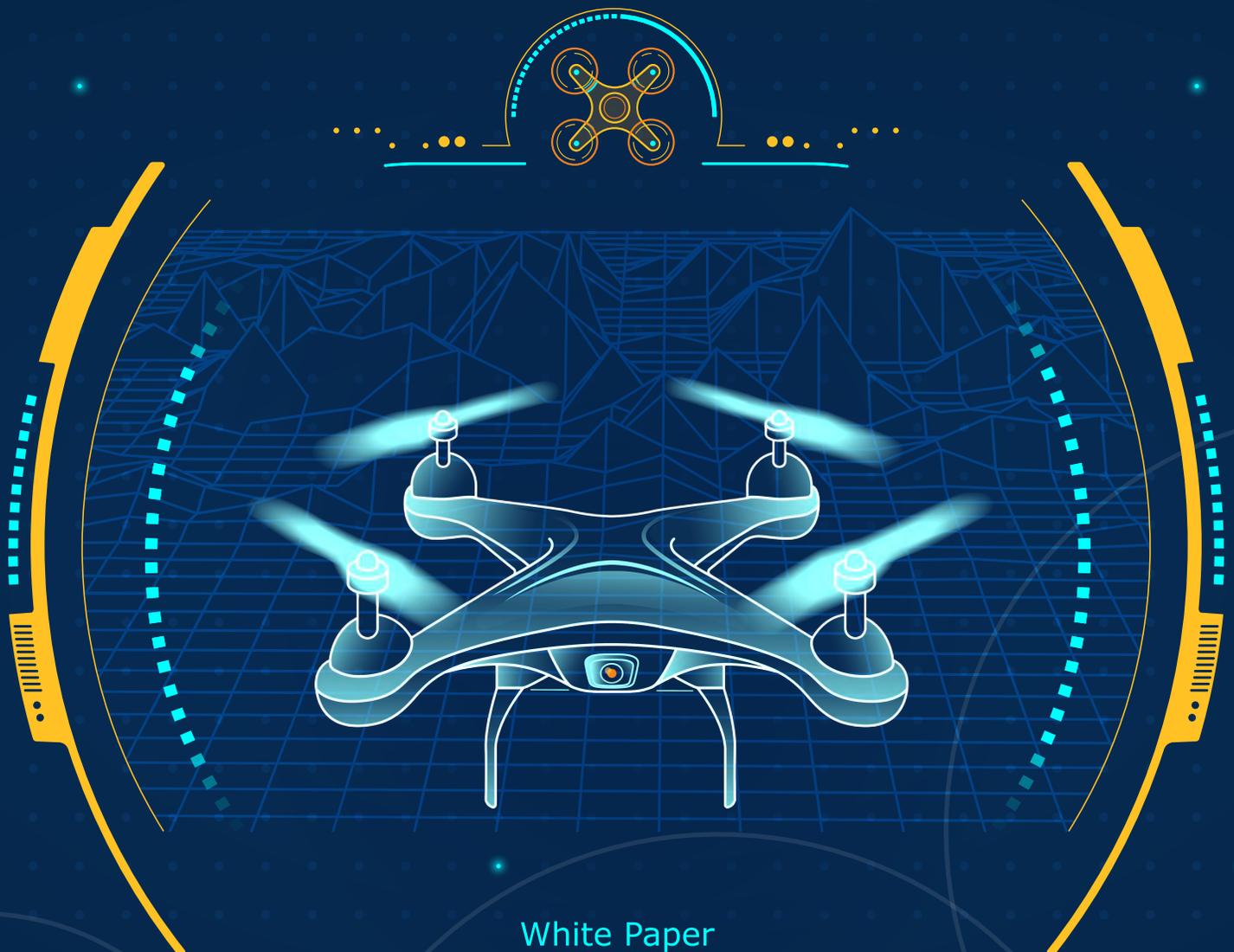# intetics

Where software concepts come alive™

The Ultimate UAV (Drones) Technologies

Overview by Tech Geeks

White Paper

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Introduction: Technological Relevance

It won't be long until every time you look up to the sky in the city; you see a drone. These machines will be quiet, safe, and very convenient. In addition to drones, you might also witness wheeled and walking autonomous robots moving down the street. Manufacturers and regulators are gradually working towards the extensive incorporation of drones into our everyday lives.

In the city, drones will most likely be put to work delivering pizza or groceries , inspecting engineering systems, or patrolling the streets. As for elsewhere, from the construction pit to the cornfield – this technology will be helping us to build, grow, repair, assess damage, and search... But first things first.

What Makes Drones Useful?

The development of technology has made high-quality UAV shooting, data processing, and analytics all possible. Looking back 15 years, the first commercial drones could generate average-quality photos that had to be downloaded from a memory card to a computer. Now, it's on a completely different level. Modern drones shoot in 4K resolution, make autonomous decisions, mark important objects in images and videos, and transmit real-time information to the base station.

The two main benefits that UAVs and specialized software can deliver to different industries are:

1. High-quality and fast video shooting over large areas.

2. Data processing and analytics to assist in making strategic and operational decisions based on the findings.

Shooting on a drone saves thousands of man-hours that would otherwise go into walking and manual surveying. It is also much cheaper than aerial photography, more autonomous, and provides a greater amount of information than satellite imagery. While a person may miss some areas or take low-quality photographs, drones eliminate such risks entirely.

Drones can be used for routine monitoring on agricultural fields and construction sites and for planned overflights to search for damage on oil and gas pipelines, bridges, and complex engineering structures, such as wind turbines, drilling rigs, and electric transmission towers.

The data collected from an accurate survey is highly valuable. Yet, the ability to process, classify, compare, and study it correctly is paramount. This is ensured through software packages – ready-made or custom solutions, depending on the specifics and complexity of the task at hand.

Modern drones can take premium-quality photographs across huge areas, including fields, construction sites, and infrastructure lines. Then, the software "stitches" thousands of detailed photographs together into one image.

Cameras that shoot at different wavelengths, which used to be exclusive to the scientific and military industries, have now become widely available. Today, drones can shoot not only on conventional cameras but also on multispectral ones. The latter takes pictures in various wavelengths: in the visible spectrum (RGB), infrared (NIR), red edge infrared border, and each RGB color channel separately. A drone can shoot using lidar, thermal image, georadar, and other specialized sensors depending on the task specifics.

In the early 20th century, companies that actively automated their operations and reduced manual labor during production had a great advantage. It's safe to say that drones play a similar role today. Farmers, developers, energy, and insurance companies that incorporate UAV capabilities into their business processes can get ahead of the competition.

How Drones Help Companies Make and Save Money

The reasons why UAVs allow businesses to grow their profit can be summarized with the following factors.

1. Time and money saved on data collection

Generally, drones allow for faster and cheaper data collocation than other methods. A drone can shoot hundreds of acre, thousands of square feet of walls, roads, and more in a single flight. One battery charge can replace a week of field crew work and save a company's resources.

2. Real-time data transmission

Data remains relevant from the moment it is captured until the moment a human receives it. This is a major advantage over traditional methods, where information may become outdated by the time the entire survey is complete and the data is uploaded and processed.

3. Early response to problems

Orthophoto maps, lidar data, and vegetation index maps make it possible to respond to problems quickly, before they advance any further.

4. Problem prevention

If you conduct regular detailed surveys and save the results you have obtained, you can detect changes based on this data. Software trained on thousands of images can compare "before and after" shots, mark changes, and even forecast further development. This kind of predictive analytics may seem like the stuff of science fiction – in fact, it's the result of technological progress. And it is available to your business.

5. Planning and Budgeting

You can more effectively draw up schedules and cost estimates based on the current state of affairs at construction sites, fields, roofs, and gas pipeline routes.

6. Prompt and accurate damage assessment

In the aftermath of natural disasters, insurance companies and damage assessors are overwhelmed with claims. And sometimes, the future of a business depends on the timing of insurance payments. While a few days of delay won't significantly impact a family whose barn roof was blown off by a hurricane, the same cannot be

said about a farm. You can quickly collect visual data using your own drone and provide it to the insurance company to assess the damage.

7. Facility maintenance

You can conduct drone inspections of roofs and houses, bridge piers, solar power plants, power lines, wind turbines, and more. It is not only faster than manual inspection but also much more accurate since drones minimize human error.

8. Competent strategic and operational decisions

Drone data shows the big picture and subtle trends, which is especially noticeable when you compare shots from different periods. This information can be used to provide valuable clues for effective decision-making.

Legal Disclaimer

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People also use the term "quadcopter" (from the Latin quadro – "four"). The four-rotor drone is the most common option for hobbyists. But for industrial purposes, most people use six-rotor devices called hexacopters. There are also two- and three-rotor drones, so calling all devices quadcopters would be an inaccurate generalization from a legal perspective.

Therefore, most official documents use the neutral term UAV (unmanned aerial vehicle), UAS (unmanned aerial system), or RPAS (remotely piloted aircraft systems). Additionally, most drones have cameras as their payloads, which automatically makes them an sUAS (small unmanned aircraft system), which is an important consideration.

This White Paper uses the general terms drone and UAV.

As for the classification, all drones can be referred to as multicopters and divided into the following groups based on their number of rotors:

Group	Number of rotors
Bi-copters	2
Tricopters	3
Quadcopters	4
Hexacopters	6
Octocopters	8

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Key Tasks Solved by Commercial Drones

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Generally, when we say "to do something with the help of drones," we refer not only to a survey itself but also to the processing of its results to obtain systematized data, including maps, orthomosaics, tables, charts, forecasts, and reports.

The key business tasks that drones and specialized software solve are:

- » Shooting
- » Object and process identification
- » Map labeling
- » Recording changes
- » Predictive analytics

Objects (for example, drying crops on a field) can be identified manually or automatically depending on the software in use and the way the drone was programmed. The second is certainly a preferred option when dealing with a large territory.

Which objects can be identified using drones?
Any that you need. A pre-trained neural network can find and mark wildlife, objects, cracks, rust spots, and color changes on images or maps.

To ensure a neural network can automatically identify the required objects during territory inspection, it needs to be trained in advance based on hundreds or even thousands of images depicting objects of interest. The system should be able to identify them in images with different lighting quality and backgrounds, plus from any angle. The better the neural network is trained, the more objects it can identify accurately. Where the cost of error is very high, the determination accuracy should be as close to 100% as possible – for example, when examining supporting structures for cracks or corrosion.
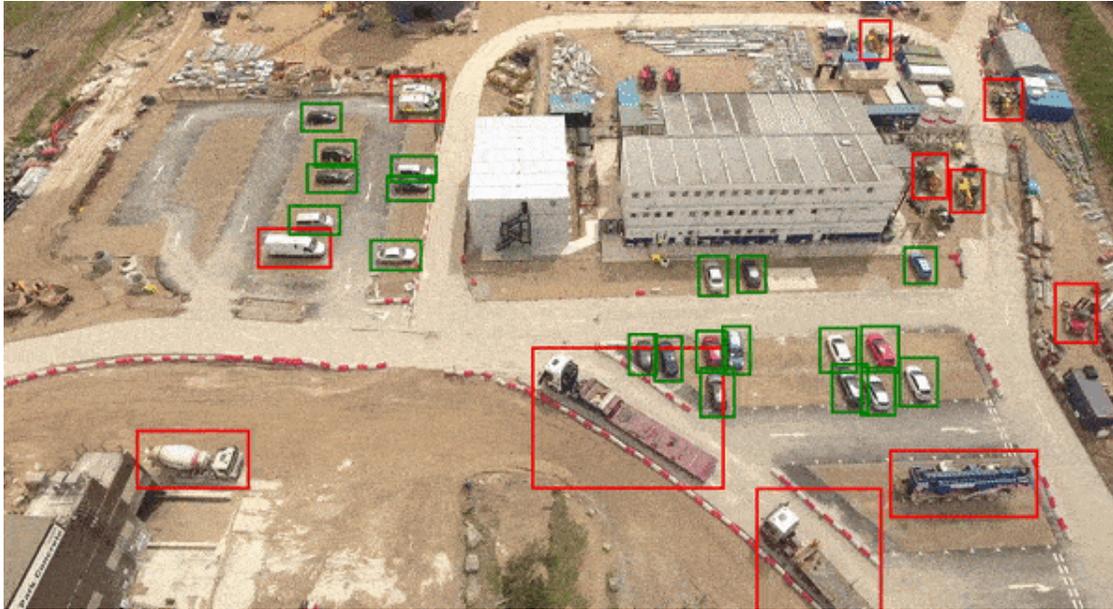
Source: medium.com/@KailaGaurav

Change Detection and Predictive Maintenance

For tracking and evaluating changes qualitatively and quantitatively, you must have multiple images of the same object taken over time. The frequency of shooting depends on task specifics and can be 1-2 times a week, once a month, or even less frequently.

Then, images of the same objects (but shot at different times) are allows you to track changes over time and forecast for future development. It is important to take into account the physical properties of materials, their progressive wear rate, etc. For example, the first 10 mm of a crack can occur in six months, and the next 10 mm – in the following two months. That is why predictive analytics should never rely on a simple extrapolation of previous dynamics. They should consider whether the rate of change is increasing or decreasing.

How should we assess the criticality of these changes?

Forecasts and recommendations of predictive analytics are based on change detection, such as the current status and tolerance rate as a description of norms and tolerances. Normally, there are three wear/damage categories. Green means that the object is fine. Yellow indicates a problem that is not yet critical for facility operations. Finally, red signals that the object may soon fail and needs to be repaired or replaced.

HERE'S AN EXAMPLE.

You assess bridge supports and find a small 5 mm crack. Currently, it has no effect on the bridge's safety in any way, but it may become a problem in the future. Therefore, you need to monitor the crack. This is where change detection comes in handy.

In a month, you will check if the crack remains the same or has increased by a couple of millimeters. If there are change dynamics, the software can make an approximate forecast, taking into account the existing dynamics and the properties of the materials. The more data that's collected at different times, the more accurately you can determine the future change dynamics for a particular object. Predictive analytics helps you understand how quickly the damage is progressing and when it might go into the "red zone." Taking into account the forecast and tolerances for specific objects, it will be clear when to replace a particular part or repair damage.

Data for objects of the same type is not universally applicable. It's impossible to accurately predict future changes in your wind turbine blades using survey data from another wind farm. This is the main point of change detection. The dynamics of development can only be traced if you take continuous data about the object of interest. Even if these are identical objects but installed a hundred miles from each other, the dynamics of problem development will be different.

Applications and Use Cases for Drones

Drone capabilities have already found a wide variety of applications across industries. Below is a brief overview of them.

Topographic Survey and Design

Preparation is key to success. This is true for any industry, but especially for construction. This is why reliable developers don't cut corners on topographic surveys and designs. It is the first step in constructing buildings, bridges, roads, infrastructure projects, oil and gas pipelines, power transmission lines, and communication networks.

Surveyors used to have to rely on hand tools, their vigilance, and skills. If a construction site was large and the terrain was uneven, surveying could take weeks. The data obtained had to be uploaded into a computer to become the basis for building maps and 3D terrain models. Thanks to drones in aerial photography, accurate 2D and 3D maps with geolocation and geodetic information (distances, elevations, elevation differences, etc.) can now be created almost automatically. The result is "smart" cards – not only useful for architectural or design projects but also for using the data embedded in them for calculations.

And this is essential: the more accurate and comprehensive data you collect at this stage, the more precisely you can calculate the cost and construction time. Statistically, 80% of large facilities exceed their construction budget, and the deadline is pushed back by 20%. This is almost always caused by calculation errors during topographic surveys and designs.

Perhaps the surveyors and designers did their job properly. But due to the imperfection of manual shooting and data digitization techniques, errors can creep in at any stage. Formulae and standards may have been followed precisely, and everything else done correctly, but the real object adds errors to the result. In total, it might lead to tens or hundreds of thousands of dollars lost, worker and equipment downtime, and unfulfilled obligations. That is why it is important to use technically advanced solutions from the very beginning of construction.

Drones are in-demand for surveying: there are now several interesting startups that customize drones and integrate specialized sensors for solving topographic tasks, such as Topodrone and YellowScan.

A single shot with a drone is much cheaper than aerial photography from a helicopter or airplane. And if a company buys a drone for permanent use, the expense will pay off in just a few flights. Drones can operate during all daylight hours in clear weather, only requiring an operator and a battery change about once an hour.

Drones are also becoming increasingly popular for aerial photography in urban plan updates. In medium-sized cities, it is cheaper and more convenient to use UAVs than airplanes. In all fairness: in megacities, airplanes remain the best option.

CASE STUDY

Configuration of the Flight Controller for UAV Platform

Client

UAV surveying company.

Challenge

◇ Configure and customize the ArduPilot settings on the Pixhawk flight controller for the LJAV platform designed for terrain mapping. The platform should be capable of carrying the payload of up to 4 kg and covering the distance of 400 km on a single battery charge.

Benefits and Results

The Ardupilot settings for the UAV platform were tailored for specific needs with maximum ease of operation and high fault tolerance, including:

★ Setting up PID controllers on the LJAV platform.

★ Calibration of UAV and autopilot sensors.

★ Connecting and configuring GNSS RTK, PPK to Pixhawk autopilot.

★ Training to work with the scheduler Mission Planner and QGroundcontrol tasks.

★ Training to work to perform terrain-following flight and cartographic survey tasks.

★ Setting up automatic takeoff and landing.

★ Adjustment of FailSafe and Crash check modes (intellectual modes of behavior in emergency situations).

★ Integration of a LIDAR sensor into the Pixhawk flight controller.

Inspection of Oil and Gas Pipelines, Wells, and Drilling Rigs

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Inspection of Pipelines

Although most pipelines are buried underground, an aerial inspection can still help detect problems. These inspections are categorized based on the degree of risk to the environment and to the pipeline itself.

Threat to the Environment

This arises when the pipeline's integrity is damaged. Even the smallest oil or gas leakage affects vegetation and site conditions. What directly indicates a violation of the integrity of a pipeline? Unusual patches on the ground, subsidence, erosion, or dried vegetation with green plants nearby.

After hundreds of miles of shooting, you get thousands of photos and hours of video. However, technicians don't need to review all the data manually. As we mentioned above, a pre-trained neural network can independently find and mark objects on the map that deserve special attention.

Gas leaks are less obvious but can be detected with gas sensors. These are attached as a payload, and when triggered, the drone marks the location on the map. This helps detect leaks of hydrogen sulfide, methane, and other gases without endangering anyone during the inspection. For example, mounted gas sensors can detect methane concentrations starting from 1 ppmv from up to 100 meters.

Threats to Pipeline Integrity

Floods can cause soil erosion in areas where there is an underground communication system in place. These places are often less dense and packed and are, therefore, more. susceptible to being washed out. Soil erosion can also be caused by normal rainfall on hillside sites. A section of the pipeline may become exposed on the surface or, conversely, be overloaded by soil migration. Such incidents require prompt responses, so drone inspection (planned or post-natural disasters) must be carried out throughout the pipeline.

Fast-growing plants can develop root structures that damage the integrity of the communication systems. This risk factor also requires regular monitoring.

A drone inspection takes a little longer than covering the same area by helicopter, but it is much cheaper. But unlike a helicopter, a drone can also approach the object of inspection as close as 1-3 meters, if necessary. Obstacle avoidance sensors prevent collisions.

Inspection of Drilling Rigs, Wells, and Flare Stacks

In addition to the camera and gas sensors, a drone can be equipped with a thermal imager and an ultrasound sensor. This makes it indispensable for inspecting moving mechanisms and objects with potential heat loss. Specialized software can create maps based on the data collected, and these maps can then be used to easily evaluate insulation integrity, the quality of the connections, and equipment serviceability. Regarding regular pipelines, heat maps can help identify insulation defects, leaks, and illegal tapping.

Massive structures, such as flare stacks and distillation columns, are hard to survey from the ground. Also, they cannot be climbed while in operation. Manual inspection of a flare stack burner would halt production, resulting in financial losses.

Drones with special portable equipment allow you to fully survey such objects up close without putting people and equipment at risk. Regular monitoring and predictive analytics are essential since breakdowns and downtime at resource extraction complexes are unacceptable.

Special industrial drones can operate in cold temperatures and harsh winds thanks to battery heating technology protecting them from rapid capacity loss.

Drones are also indispensable for delivering parts and tools to remote machinery, oil rigs, and gas fields. In these cases, UAVs are much cheaper than going by helicopter or motorboat.

Alternative Energy

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Site Selection

The construction of alternative energy facilities – wind turbines and solar power plants – calls for careful site selection. Terrain features can either increase or decrease the efficiency of the installations. Therefore, topographic surveys need to be as accurate as possible, which drones can ensure.

Accurate geodetic maps of an area help to calculate the excavation volume required to level the site, set up roads, and arrange surrounding areas.

Photos taken at different wavelengths can provide a lot of information on soil characteristics. Solar power plants must not be prone to waterlogging even after heavy rains. This means that they need to have decent natural drainage. Also, they should not be prone to soil erosion.

These metrics are likely to change after construction. For example, site deforestation and a waterproof membrane directly below solar panels will affect the water movement of rainfall. Therefore, the forecast of changes and environmental standards compliance should be taken into account during preliminary calculations.

Inspection of Solar Panels

Solar panels are sensitive to mechanical stress, pollution, and extreme weather. Dusty or scratched blocks decrease efficiency and need to be identified, cleaned, and repaired without undue delay. A manual walk-around inspection of a solar power plant takes a long time. But drones make it easy.

Just like in other industries, you benefit not only from ordinary rthophoto maps but also from heat maps made with thermal imagers. These maps allow you to detect faulty photocells, even if they look fine from the outside.

Inspection of Wind Turbines

Inspecting wind turbine blades and bases is not an easy task. If done manually, it is much more expensive and slower than with a drone. And flying a helicopter is simply unsafe: it generates a powerful airflow and is impossible to work on at low altitudes. Wind turbines installed at sea, 10-15 miles away from the coast, make the task even more difficult.

As you can tell, drones are perfect for surveying distinctive structures. Human intervention might follow up at the second stage to inspect the trickiest areas (if necessary). Thus, drones save a lot of time and money for the crew.

Construction on the London Array, the world's largest offshore wind farm at the time, began ten years ago. Today, the farm tallies 175 wind turbines over 100 sq. km. The hub of each turbine is 87 m above sea level, and the tip of each blade at its highest point reaches 147 m, higher than the London Eye.

It is truly a sight to behold! Now, imagine how long regular inspections of these wind turbines would take from water or a helicopter. Sure, repairs will be carried out from a barge and a crane, but regular inspections don't need to be long and expensive. Drones are ideal for inspecting such sites.

X

Agriculture

A drone can spray fertilizer about 50 times faster than a human. That said, it also makes no mistakes, chooses optimal routes, and eliminates trampling! But this is the bare minimum of what UAVs can offer to farms.

Here are the main tasks that drones help solve in agriculture.

①

Monitor Plant Health and Maturity

This is where a multispectral camera comes in handy with its ability to "see" different wavelength ranges. It can take regular pictures in the visible spectrum (RGB), infrared, and in each RGB channel. By shooting in the G (Green) channel, the drone provides data on plants' vegetative activity. The shades of green-yellow-red-gray are often sufficient for conclusions about plant health and maturity dynamics.

The Normalized Difference Red Edge Index (NDRE) is a popular metric on farms. It is used to analyze images from a multispectral camera and obtain accurate plant health and development data. The index shows chlorophyll content, which helps create an accurate map of nitrogen fertilization.

Image by DJI-Agras from Pixabay

A combined survey at different wavelength channels provides data for compiling vegetation indices. There are about 150 major vegetation indices for assessing the health of various crops and soil.

Image by DJI-Agras from Pixabay

② Visually Assess the Quantity and Quality of Green Mass

Now, we'll move on to orthophoto maps made from images with a conventional camera. After processing thousands of photos, you get a detailed field map. You can navigate through it, change the scale, and leave marks and comments. By comparing data from different periods on these maps, you can easily measure plant frequency and the dynamics of plant growth.

It is very difficult to review thousands of images and manually mark all problematic areas. Computer vision technologies are already capable of finding weeds or diseased plants in photos and putting a corresponding mark on the map. This is one of the advantages of precision farming – cultivating only those parts of the field that actually need top dressing, watering, or fertilizers.

Analysis of the Vegetation Health of Vineyards

Client

Wine company that uses drone surveillance (France).

Challenge

- Develop a tool to detect plants with oppressed growth (yellow leaves, lack of mineral fertilizers).
- Oppressive plants occupy the lower layer of growth, which significantly complicates their identification.
- Leaves are not static and blurred (wind, LJAV airstream).

Technology Stack

Photogrammetry Software, Python

Benefits and Results

★ The app allowed the company to analyze vegetation health at vineyards, detect oppressive plants, and identify areas that needed additional treatment.

★ The app brought a 10% increase in yield and allowed the company to shrink treatment costs.

③ Create 3D Topography Maps

This task is achievable even if the field is covered with plants. Lidars – laser rangefinders – scan the surface and create highly accurate terrain models based on the reflected laser beams. This data is important for crop planning and irrigation mapping.

④ Determine Soil Properties

A multispectral camera also helps in this task by working in other channels. By shooting in the R channel, you will be able to assess the soil, while the B channel will provide information on the base of any bodies of water at your site.

Black Sigatoka Detection at Banana Plantations

Client

Fruit company that uses drone surveillance (Ecuador).

Challenge

◇ • Develop a tool to identify zones of fungicides application.
• Affected leaves and dry leaves on the ground have a similar spectral signature, which significantly complicates their identification.

Technology Stack

Photogrammetry Software, Python

Benefits and Results

★ An algorithm was developed that separated plants from the ground and identified damaged leaves.

★ The app allowed the creation of a system that quickly and efficiently analyzes banana fields without the participation of highly-qualified specialists.

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⑤ Monitor Livestock

Animals travel long distances in open fields in search of food. Drones can control livestock movement and search for missing animals. Another benefit is that they help find sites with the highest quality of green mass from the air and direct animals to those locations.

Drones can make farming smart by helping solve all of these tasks. They become your assistants, allowing you to save time on walking and visual site inspection, promptly respond to critical changes, and create a work plan and budget. Additionally, in the event of natural disasters, drones can quickly record and assess the damage.

⑥ Spray Fertilizer

These can be regular chemical compounds or live fertilizers, i.e., beneficial insects. Fertilizers are placed in a dispensing container, which is then attached to the drone as a payload. The device moves across the field at a certain height and speed, spraying fertilizer over the plants. This is a very popular solution in Southeast Asia, where fields can extend beyond the horizon.

Image by Herney Gómez from Pixabay

Automated Recognition of Sugar Cane Planting Rows and Flaws

Client

A Brazilian company that provides mapping, topography, geoprocessing, and drone surveying solutions.

Challenge

- Create an algorithm and QGIS plugin based on it to recognize rows and gaps using RGB orthophotos only.
- Lines must be straight and minimally curved, while also following the planting of sugarcane as much as possible.
- Deviation of not more than 10 cm (demand of harvester system).
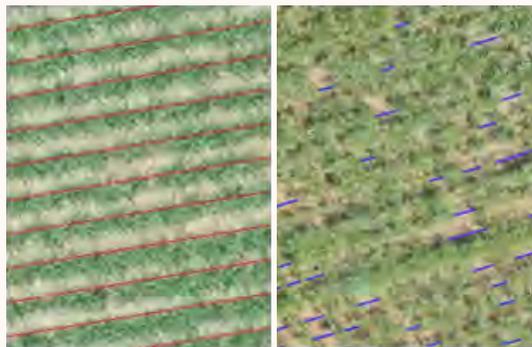
Benefits and Results

★ A mathematical description of the algorithm for the planting rows and flaws recognition was developed. Experiments were carried out with vegetation indexes, a machine learning approach, and DSM utilization.

★ The algorithm was validated through drone data processing for numerous fields, varying in growing conditions and planting pattern.

★ The developed plugin worked properly for 90% of the fields.

Construction

We have already mentioned how drones can help with topographic surveying, which precedes any construction. Now, let's look at how they can be useful on the construction site. Drones make it convenient to make planned vs. actual reports based on a series of frequent surveys. These allow you to create work plans more efficiently, see up-to-date reports, and resolve disputes with contractors.

Construction often moves at a different pace than originally planned and may not match the field crew reports. And since all processes are interconnected, one failure, for example, in monolithic work, delays communications and disrupts the supply of building materials.

Drones also help to estimate the scope of work for piecework pay. How do you calculate the exact amount of soil that was dug up and removed from the site? Do you weigh every truck? There is a better option: you can calculate the precise volume of soil taken from pits and trenches based on detailed drone data. You can also apply the same approach to determine the dimensions of the foundation, walls, floors, and rafters.

The data received from drones can be quickly shared as reports, presentations, and photos. Everything is always changing on a large construction site, and if you spend just a couple of days shooting manually, there's bad news for you – you'll soon have to start over. The drone minimizes this information gap.

Insurance Companies

Here, drones are useful not only for quick actual damage assessment but also for, "smart insurance" which is when risk assessment is performed in advance to prevent serious losses. Today, insurance is generally perceived not as paying for damage but as something that helps to avoid it.

Data Collection and Analysis

This is one of the main use cases for drones in insurance, along with surveying for damage assessment. After reviewing the conditions recorded on a drone, a specialist can calculate risk and set the terms for the insurance policy. Let's take roofs as an example.

Here is why: for insurance companies, the roof is one of the most important property valuation and risk assessment criteria. It makes sense because a roof ensures the structural integrity of a building. Whitewalls are fairly predictable (they stop moisture from getting into the supporting elements of a building), but the roof is not. There may be cracks in the coating, rusty screws, or damaged ridges and gutters – these are all serious factors negatively affecting the house value and insurance terms.

Image by Public Co from Pixabay

About 70% of Americans live in single-family homes. The exact number of buildings is hard to determine, but it certainly exceeds 100 million. These include empty houses since one family can own multiple homes. Most of these houses are insured, but the terms and conditions need to be revised regularly.

How can an insurance company evaluate rooftops without wasting time and putting employees at risk? Using drones, of course! They can help you shoot the roof from all sides and, if necessary, create a heat map using a thermal imager.

Drone Flight Planning in 3D for the Road Accidents Investigation

Client

UAV company providing municipal services.

Challenge

- Develop a web and mobile app that will allow the police to send LJAV to the site of the road accident.
- The user places a pin on the map for the place where the drone should arrive and identifies the altitude of the flight. The program should take into account the chosen altitude and build a route based on the constructed Digital Surface Model. Routes have to bend around the obstacles encountered at the chosen flight altitude (mostly buildings).
- The UAV has to reach the place of an accident, take photos according to a specified pattern, and return back to the starting point of its flight.

Benefits and Results

★ The developed web and mobile apps made it possible to calculate the route, send UAVs, and take photos of the site.

★ The app minimized the workload of the police service required to collect the information about road accidents.
*At the moment, it is possible to use only IJAV with built-in obstacle sensors, since there is a problem of "obsolescence" of the Digital Surface Model and the appearance of new objects (new buildings, installed cranes, antennas, etc.)

Emergency Response to Insurance Claims

Insurance companies are pushed to their limits after hurricanes, floods, and fires. They have a very short timeframe to accurately assess the damage their clients sustained and pay insurance claims.

This work is complex not only from the many requests but also because regions affected by natural disasters remain inaccessible for some time; they are at best not accessible by cars. In this case, drones help because they can fly up to 10 thousand meters away from the operator.

Unfortunately, the potential of drones has yet to be fulfilled. In the United States, federal and state laws that regulate UAVs are still in their draft stages. Flying BVLOS (Beyond Visual Line of Sight – see Dictionary) is not common in the US and other countries. The drone must remain within unaided sight, and at the very least, there must be several operators passing on the control signal to each other.

But it is obvious that UAVs are on their way to being proper employees at insurance companies. At the same time, companies don't need to buy their own drone and train someone to operate it – this service can be outsourced. However,

owning a drone will be cost-effective for an insurance company with a large client base. It will help them to quickly process customer applications and objectively resolve controversial issues regarding insurable events.

According to Deloitte, drones will help the insurance industry save up to $7 billion a year. This can be possible through:

- Reduction of request processing time – from several days to several hours.

- Faster and more accurate object or damage inspection.

- Significant reduction in fraudulent payments for claims, which amount to $32 billion a year worldwide.

- Better health safety for insurance workers during damage assessment and facilities inspection when making a contract.

Delivery Services

XIII

In science fiction, drones deliver everything from pizza to people (as air taxis). In reality, great expectations face strict regulatory requirements.

The biggest challenge comes in safely flying beyond the visible line of sight. And in the case of automated delivery, drones are not controlled by operators at all – they fly along a given route, autonomously avoiding collisions. This issue is resolved differently in different countries – from full clearance on BVLOS to mandates for exclusively manual flights.

While US regulators maintain a cautious approach to this issue, some Australian cities are open to commercial drones. In September 2021, Alphabet's Wing surpassed 100,000 drone deliveries in Logan, Australia.

Next up is the United States. Wing is the first company to receive FAA approval to begin test deliveries beyond the operator's visual line of sight.

It is clear that technology helps to overcome crisis events. Wing noted significant growth in deliveries during the 2020 bushfires in Australia, as well as COVID-19 lockdowns.

Drones have been used for humanitarian purposes in Africa since at least 2016 when Zipline began delivering medical supplies to remote villages. In Rwanda, South Africa, and Mauritius, UAVs are used at an operating range of up to 300 km.

Image by Gerd Altmann from Pixabay

The recent news about the failing Prime Air, Amazon's drone delivery program, has rocked the market. But don't let Amazon's unsuccessful attempt set you up against the idea of drone delivery. Judging from a number of reputable publications, Amazon suffered from regular management mistakes and poor personnel decisions.

That said, Amazon has a six-rotor drone that can take off and land vertically. It can deliver a package of up to 2.2 kg over 12 km. Such packages account for 80% of all purchases on Amazon.

Amazon and other operators will have to solve several fundamental issues, from protecting privacy when using drones with cameras to deploying a network of distribution centers.

The drone delivery market is not limited to small packages and home deliveries. DHL intends to deploy an entire logistics network of drones to transport heavy goods in Europe. It intends to employ Dronamics' 4,000 Black Swan cargo drones, which are capable of transporting packages of 770 pounds for up to 1,500 miles. DHL is expected to operate the first commercial drone flights as early as 2022.

In Summer 2021, the UK and Bulgaria-based operator Dronamics launched 39 drone ports in existing airports within 12 countries. In addition to the DHL partnership, the company has already started collaborating with Hellmann Worldwide Logistics and other logistics operators.

Other Industries

XIV

In addition to the industries mentioned above, drones are successfully used in other areas as well. While they don't have the same market size, their use of UAVs is still very interesting.

Media

Here, drones can be used both to shoot panoramic videos and aerial footage of nature, large structures, emergencies, and natural and man-made disasters.

In drone journalism (which is a real thing), drones can be used both by media companies and stringers who document and sell stories to the media. There are also content creator companies that shoot videos commissioned by the media.

Events

Here are possible use cases for drones during major entertainment or sports events with tens of thousands of people gathered in one place:

1. Live broadcast from the sky. It's quieter, cheaper, and safer than shooting from a helicopter.

2. Internet hotspot. Several drones equipped with routers will help congested cell networks.

3. Drone show. Drones can be fitted with some lights and music and programmed to fly intricate routes that will surprise any audience.
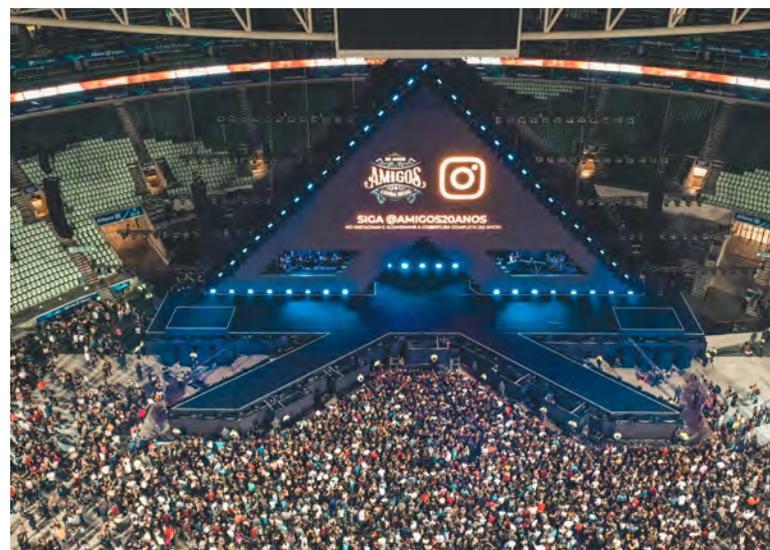
A Brief History of UAV Development

Drones Have Been Around for Longer Than We Think

If you think that drones have been around, at most, for 15 years, then you're in for a surprise. Unmanned aerostats, albeit uncontrolled and carried by the wind, were going to be used by the Austrian army against Italian troops in Venice in 1849. But the wind blew in the wrong direction, and the balloon bombs were worthless.

And the first radio-controlled unmanned device (although floating) was invented by Nikola Tesla 123 years ago! By 1898's standards, this battle boat seemed like something out of this world.
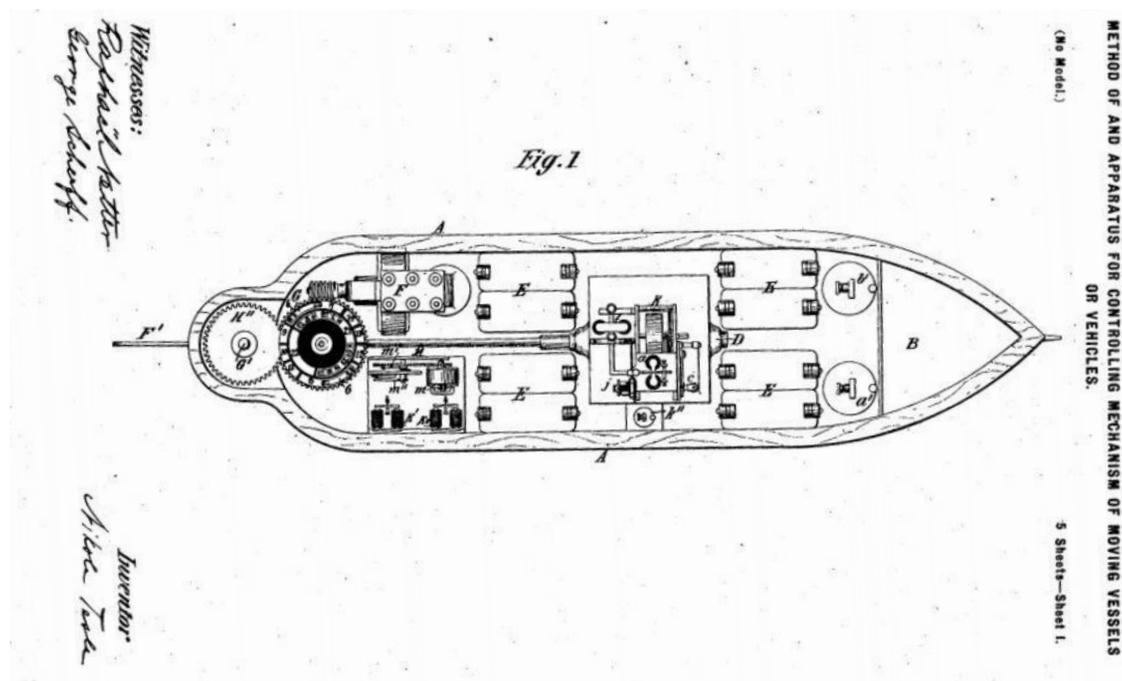
This was the first unmanned device of the sort, patented by Nikola Tesla in 1898. Source: patft.uspto.gov, Patent No. 613809

The Kettering Bug

The first flying drone that resembled modern devices appeared in 1917 on the battlefields of World War I. Charles Kettering invented an unmanned aerial torpedo called "the Bug" under Project Liberty Eagle.

The Bug. Source: Encyclopedia of Astrobiology, Astronomy, and Space Flight: Kettering Bug

It had a simple and inexpensive design and could fly 120 km at 50 miles per hour, delivering a bomb directly behind enemy lines. The US government wanted to make a large batch of these Kettering devices, but the war ended before The Bug was perfected for deployment.

Queen Bee and Others

The rapid development of UAV technology started in the 1930s. The military forces of the United States and European nations saw the potential in unmanned aerial vehicles: they were superior to artillery while also being much cheaper than aircraft and disposable.

The first multiple-use radio-controlled drone was created in 1933 in the UK. The DH.82B Queen Bee model was used as a target for pilot and anti-aircraft gunner training.

It's worth mentioning that drones were not yet named as such. The term was introduced by a US Navy Captain, Delmar Farney, in 1936 (perhaps in opposition to the British "Bug").

Until then, UAVs were relatively light and capable of lifting no more than 100-200 kg. The military-industrial complex has driven the development of drones, similar to many other technologies.

Winston Churchill and other British officials at the DH.82B Queen Bee demonstration launch

Civilian Drones

The technology was not developing as eagerly for civilian purposes, but some enthusiasts were still putting in the effort. In this context, drones were not constructed as airplanes per se but rather as the already familiar frame with several rotors on the sides.

Drone by Etienne Amichen. There are rotors on the frame, but the structure is still bulky!

The French engineer Etienne Amichen presented such a drone (mind you, a giant one) with four rotors in 1922. It flew 1,100 meters, reaching a height of 15 meters.

After that, the development of UAVs took a break: engineers invented the tail rotor and the swashplate, which made it possible to build man-controlled helicopters. Helicopters were more promising and important at the time, and drones were largely forgotten over the better half of a century.

Modern UAVs

The drone that we know today first appeared in 2006. So, those who think that drones have been around for 15 years at most are partially right. The German company MikroKopter's model had an onboard microcontroller, gyroscopes, an accelerometer, and a barometer. The device was expensive, but savvy amateur engineers began to copy the open-source technology. This was the beginning of a technological race between different manufacturers.

The market began to develop in two directions, which are still relevant up to this day:

1. Production of out-of-the-box drones from budget-friendly models to expensive professional drones for various industries.

2. Production of microcontrollers (with their own software), frames, rotors, and other spare parts, which can be used to upgrade a drone or assemble one from scratch.

It will be interesting to see what the future holds for this technology. Perhaps the drones with spinning rotors we have today will seem as odd and clunky to future generations as The Bug.

There are already working prototypes of solar-powered autonomous drones – just like those in the movie Interstellar. These stratospheric drones can fly for years, providing mobile communications and the Internet to those on the ground. Their batteries do not need to be changed because there is always sunlight above the clouds.

Below is the outline of how the regulation is going to evolve regarding drones according to the Levitate Capital fund's forecast. In turn, legislation will affect adoption and the rate of technological change.

THE OUTLINE OF THE REGULATION TO EVOLVE REGARDING DRONES

2021	2022	2023	2024	2025	2026+

2022: Roll out standards for drone integration into national airspace to allow interactions with controllers and crewed aircraft

2024: Establish guidelines for autonomous flight to enable repetitive surveying missions without a pilot

2026+: Begin electric propulsion and airframe certifications for human transport

2021: Roll out requirements for remote ID

2023: Approve commercial drone flights above 400 ft to allow long-distance transit operations

2024: Establish airworthiness standards for drones of certain mass and capabilities to operate long-distance under FAA rules

2025: Establish guidelines for BVLOS operations without a waiver to allow long-range and urban applications

Source: Levitate Capital

THE FORECAST FOR TECHNOLOGICAL DEVELOPMENT

2021	2022	2023	2024	2025	

2022: Ubiquitous and improved autonomous flight for system failure responses, dynamic routing, and human and machine handoffs

2023: Build-out of distribution hubs to load and receive goods from drones

2021: Initial introductions of 5G enterprise drones

2022: Roll out of UTM solutions and integration with crewed air traffic control

2025: Battery energy density of 400 Wh/kg

2030	2029	2028	2027	2026	

2030: Battery energy density of 500 Wh/kg

2027: Initial build-out of vertiport network infrastructure for transporting people and cargo

2026: First commercial operations of passenger eVTOLs

Source: Levitate Capital

The dynamics of the industry's development suggest future competition in cargo drone deliveries by the end of 2022. Gradually, UAVs will replace many couriers and postmen, and this process will begin with deliveries between cities, over non-residential zones, and in rural areas.

Suppose that the developing legal framework will popularize the BVLOS inspection of communications and facilities in different countries by 2022–2023. Today, there are already active efforts in this direction: the US FAA permitted BVLOS operations for UAVs, with some restrictions. The aerial intelligence platform Scout System will be used for navigation.

In various countries across Asia, Africa, and Europe, there are successful pilot projects for BVLOS inspection, in particular, and BVLOS flights, in general – from humanitarian to commercial. In some cases, visual line-of-sight restrictions can be lawfully bypassed by sending trained observers to the drone's location. They will see the UAV and send reports about the flight without controlling it directly. This is called EVLOS (Extended Visual Line of Sight).

VLOS, EVLOS & BVLOS OPERATION
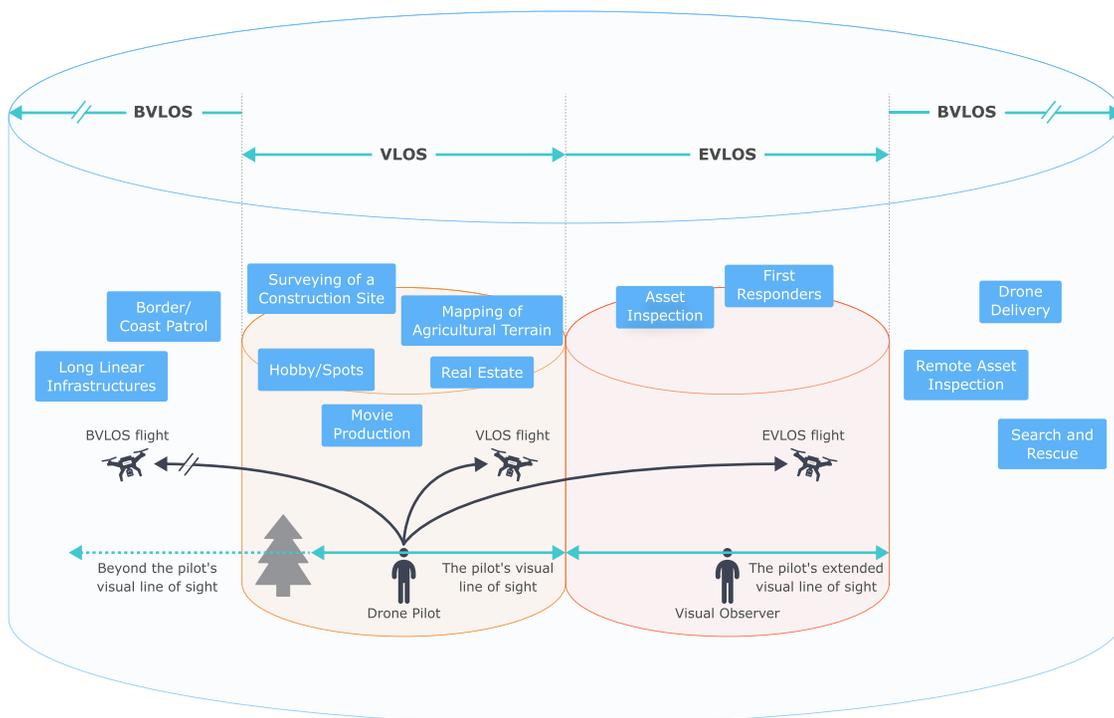
Source: droneii.com

Most consumer and industrial drones use an RC transmitter. Its operating range is up to 100 km. But technically, modern drones can fly 8-15 km away from the operator due to the long battery life on a single charge.

As for large industrial drones that use telecommunication networks to communicate with the operator, they can cover up to several hundred kilometers on an autonomous flight mission. To navigate in unknown or rapidly changing conditions, drones use AI (autopilot) to optimize flights and reduce accidents, especially when coordinating several drones. All that's left is to handle the technical capabilities and legal nuances, and we will soon see new use cases for drones.

Market Size and Development Forecasts

XVI

Droneii predicts that the global drone market will reach $41.3 billion by 2026, with an average annual growth rate of 9.4%. In terms of units, sales in the United States alone will grow from 0.83 million in 2021 to 1.4 million in 2026, at an AAGR of 10.6%.

Defense   **Enterprise**   **Consumer**

Market Size, $ Billion

Defense			Enterprise			Consumer		
8	11	17	3	16	29	3	4	5
2020	2025	2030	2020	2025	2030	2020	2025	2030
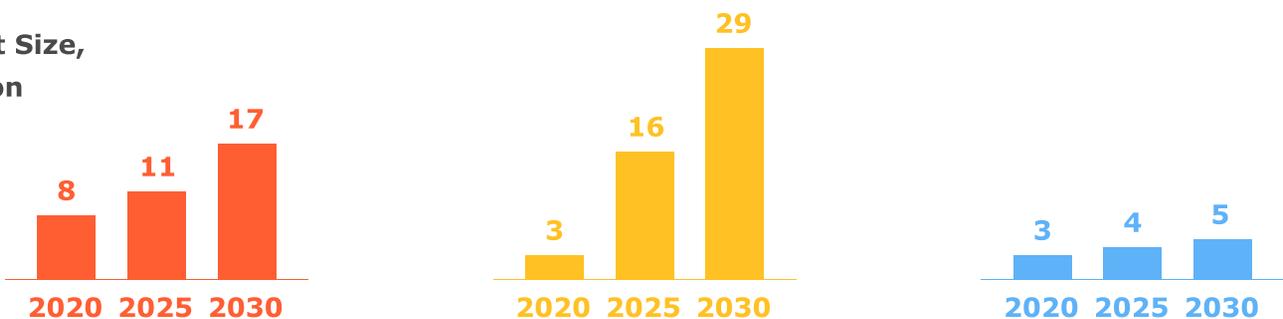
Source: Levitate Capital

According to MarketsAndMarkets, the total UAV market (including the secondary market) had an estimated worth of $27.4 billion in 2021. It will reach $58.4 billion by 2026, with an AAGR of 16.4% from 2021 to 2026.

There are more optimistic forecasts as well. According to those, the commercial drone market will reach $13.6 billion in the United States alone by 2025. And the volume of the global market will reach $82 billion by 2025, with an AAGR of 32%. By then, the industry will create an additional 100,000 jobs. That said, we also have to consider less optimistic estimates. One way or another, all forecasts on market development rely on probabilistic factors, which leads to limited accuracy. These factors include the rate of technology development, the availability of advanced developments, and, most importantly, the legislative framework in different countries.

The energy sector will continue to have the highest level of UAV adoption in the next few years; however, logistics operators and delivery and warehousing services show the highest AAGR. Mapping and geodetic surveys will remain the main application of drones. And terrain inspection (for insurance and for servicing communications/facilities), agriculture, and hobbyist filming are also among the leaders.

Public Safety   **Logistics**   **Passenger**

Market Size, $ Billion

Public Safety			Logistics			Passenger		
0.7	3	5	<0.1	3	33	<0.1	0.1	2
2020	2025	2030	2020	2025	2030	2020	2025	2030
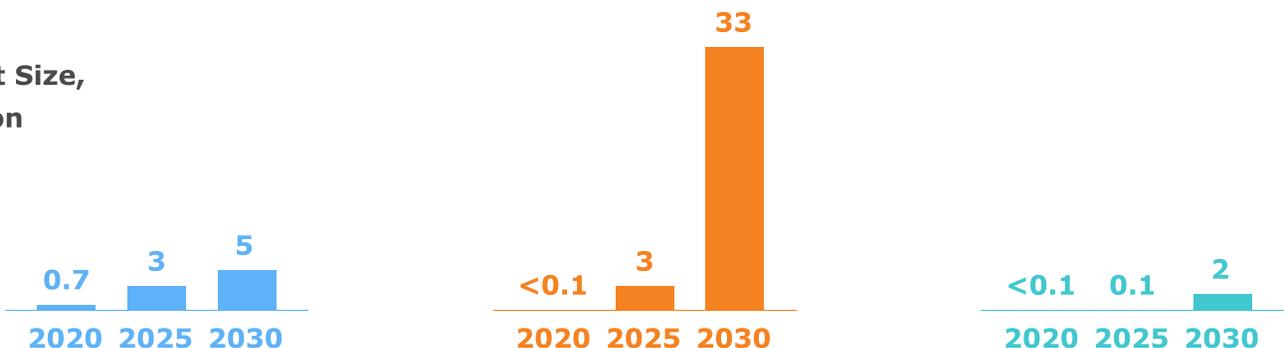
Source: Levitate Capital

Regions of Growth

1. East Asian Tigers

Asia, specifically China and Japan, contribute to the growth in commercial drone market sales the most. But at the regional and national level, South America and India have the highest growth rates, respectively.

The Asia-Pacific region is expected to show the fastest growth in terms of market size. The projected CAGR is 63.1% from 2021 to 2028. And demand for commercial drones will surpass 9 million units by 2028 – more than in North America. This can be attributed to the rapid economic growth of China and India, as well as many local manufacturers supplying UAVs to other regions worldwide.
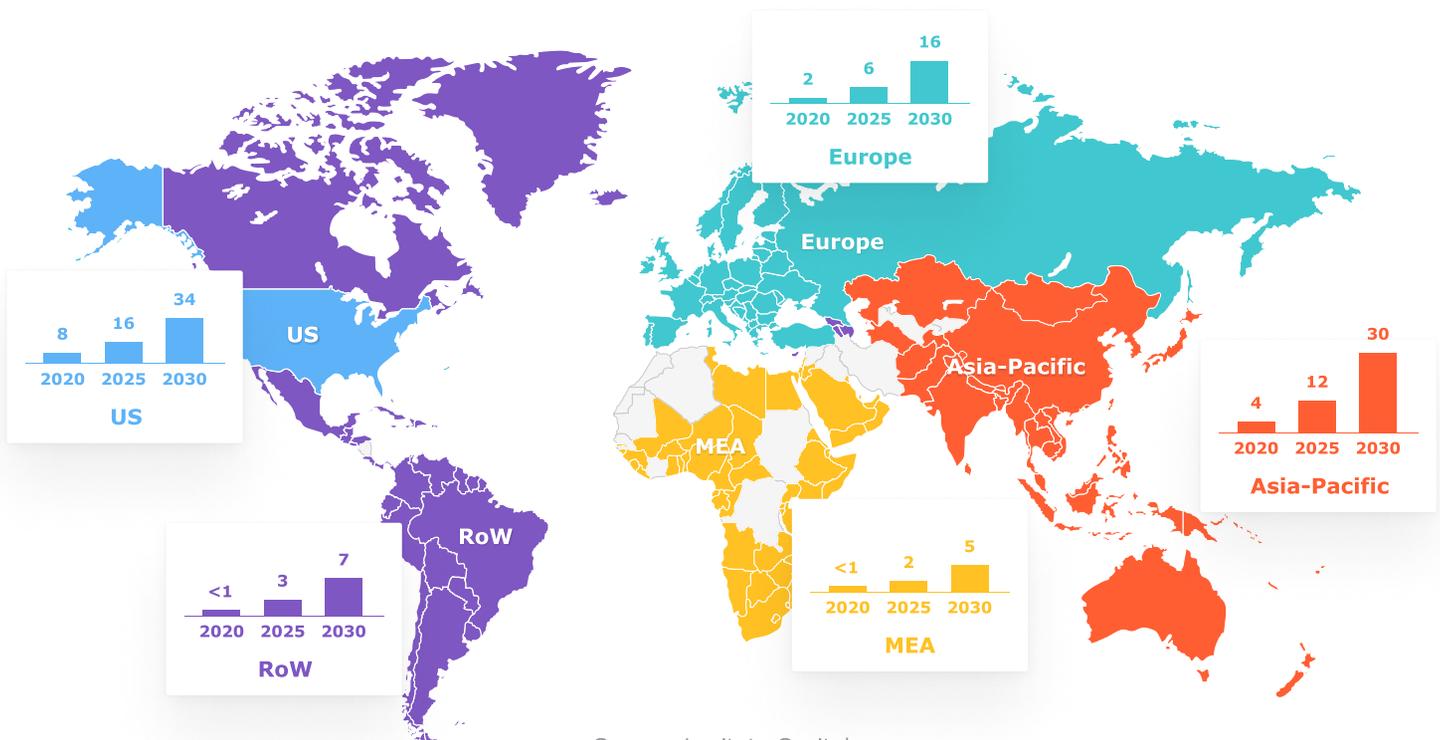
Source: Levitate Capital

2. The USA Is Not Far Behind

In 2020-2021, North America accounted for the largest share of the global market at around 37%. The strong growth will continue in the coming years, thanks to favorable government initiatives, the growing demand from enterprises and the defense sector, as well as technological advancements in drone production.

According to Statista, dealer sales of professional drones in the US surpassed $1.25 billion in 2020. Based on this data, Insider Intelligence predicts that total global shipments will reach 2.4 billion in 2023, increasing at a compound annual growth rate of 66.8%. The growth will be mainly driven by demand in six segments: agriculture, construction, mining, insurance, media and telecommunications, and law enforcement.

Key Players

Here are the key players in the global commercial drone market: DJI, 3D Robotics, Parrot Drones SAS, Delair, General Atomics, EHang, Xiaomi, AeroVironment Inc., YUNEEC, INSITU, Kespry, senseFly, Israel Aerospace Industries Ltd, Lockheed Martin Corporation, and Aerialtronics. It is also worth noting the large local players in the US market: Intel, Draganfly, Autel Robotics, Skydio, Northrop Grumman Corporation, and Precision Hawk.

These companies offer UAVs to the defense, civil, and commercial sectors and have strong distribution networks in North America, Europe, Asia-Pacific, the Middle East, Latin America, and Africa.

The key players in the drone delivery market are Amazon.com, Inc., Wing, United Parcel Service of America, Inc., Zipline, FedEx, DHL International GmbH, Boeing, Matternet, Inc., Flirtey, and Drone Delivery Canada Corp.

The noteworthy drone software companies (used for mapping and data analytics, flight control, and business process integration) are Aerodyne, AeroVironment, Airpix, DroneDeploy Inc., Terra Drone, Hummingbird Technologies, Pix4D, Cyberhawk, EagleView, Bentley, Ardenna, Delair, Skycatch, Skydio, and Kittyhawk.

Although DJI was added to the US government's economic blacklist on December 18, 2020, the market share did not see sharp redistribution. Of course, the news impacted the company's reputation and brand perception, but in reality, it did not shake the monopoly of the Chinese manufacturer on the US market.

Despite its dominant market position, DJI is proportionately weaker in fast-growing corporate sectors than in the consumer segment, where it controls 94% of the market. Mavic Pro, released back in 2016, remains the most popular registered drone model. And Mavic Air 2 is not far behind.

Drone Manufacturers US Market Share Distribution 2021

Rank	Manufacturer[1]	HQ Location	Founding Date	US Market Share[2]
1	DJI	Shenzhen, China	2006	76,1% (-0,7%)
2	intel	Santa Clara, USA	1968	4,1% (+0,4%)
3	YUNEEC	Hong Kong, China	1999	2,6% (-0,5%)
4	Parrot	Paris, France	1994	2,5% (+0,3%)
5	3DR	Berkeley, USA	2009	0,6% (-0,8%)
6	AUTEL	Bothell, USA	2014	0,6% (-0,2%)
7	Skydio	Redwood City	2014	0,3% (+0,1%)
8	senseFly	Lausanne, Switzerland	2009	0,2% (-0,1%)
9	kespry	Menlo Park, USA	2013	0,1% (-0,2%)
10	AV AeroVironment	Simi Valley, USA	1971	0,1% (-)
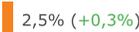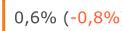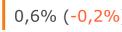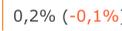
[1] 3D Robotics (Position 5) and Kespry (Position 9) no longer manufacture drones
[2] The values in brackets indicate the change from the evaluation as of March 2019

Drone Market USA 2021. Source: droneii.com

The fact that Intel, a semiconductor and chip maker, ranks second with 4.1% can be surprising. The reason is that Shooting Star, which is the most popular drone model made by Intel, is used only in drone shows. These devices can't easily take photos. But the company's bag of tricks also includes a professional drone for commercial use - Falcon 8+.

The French company Parrot Drones ranks fourth, exhibiting growth among competitors with decreasing market shares. This was possible thanks to the company's pivot: Parrot Drones focused on the professional drone market, completely halting the production of hobbyist equipment.

Droneii notes that the recent inclusion of the Parrot Anafi-USA drone on the DIU (Defense of Innovation Unit) list of "Secure, trusted sUAS options for DoD and Federal Government" will make a positive impact on Parrot drone sales in the future.

Autel Robotics, which ranks sixth, may become a serious competitor to DJI in the near future, at least on the US market. And the fact that Autel Robotics' EVO can compete with the monopolist's Mavic Pro is not the sole reason. Let's not forget about the patent wars and that the US market for government orders is unavailable for non-US drones.

The manufacturer Skydio is also worth paying attention to (seventh in the rating). The company recently raised $170 million at a valuation of over $1 billion. This allowed it to change its model range, focus on autonomous drones, and strengthen its market position in different countries.

What acted as a catalyst for Skydio's growth was the aforementioned US government's ban on purchasing DJI drones, in particular, and drones manufactured outside of the US, in general. Drones are viewed as potential threats for cyberattacks and espionage.

Skydio picked up the trend for autonomous drones and today is offering "selfie drones" that can follow any moving object and keep it in the frame. By meeting market demands, the American manufacturer manages to gradually increase sales.

The formerly popular US drones ebee X and ebee Plus manufactured by senseFly lost ground, and the Swiss company (incidentally, a subsidiary of Parrot) lost a third of its already small market share.

Rotary Blades or Hybrids

The segment of drones with rotary blades still has the largest market share – 80% at the end of 2020. This technology is expected to remain the most popular over the next 5-7 years. Such drones can hover in one spot, stop suddenly in midair, and maneuver along complex trajectories. They are much easier to fly compared to fixed-wing and hybrid aircraft and, so far, are an indispensable technology for commercial and hobbyist drones.

NORTH AMERICA COMMERCIAL DRONE MARKET
demand, by product, 2018 - 2028 (Thousand Units)

- Hybrid
- Rotary Blade
- Fixed-wing

163.8K Units

105.2K Units

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028

GRAND VIEW RESEARCH

55.2%

N. America Market CAGR, 2021 - 2028

Source: www.grandviewresearch.com
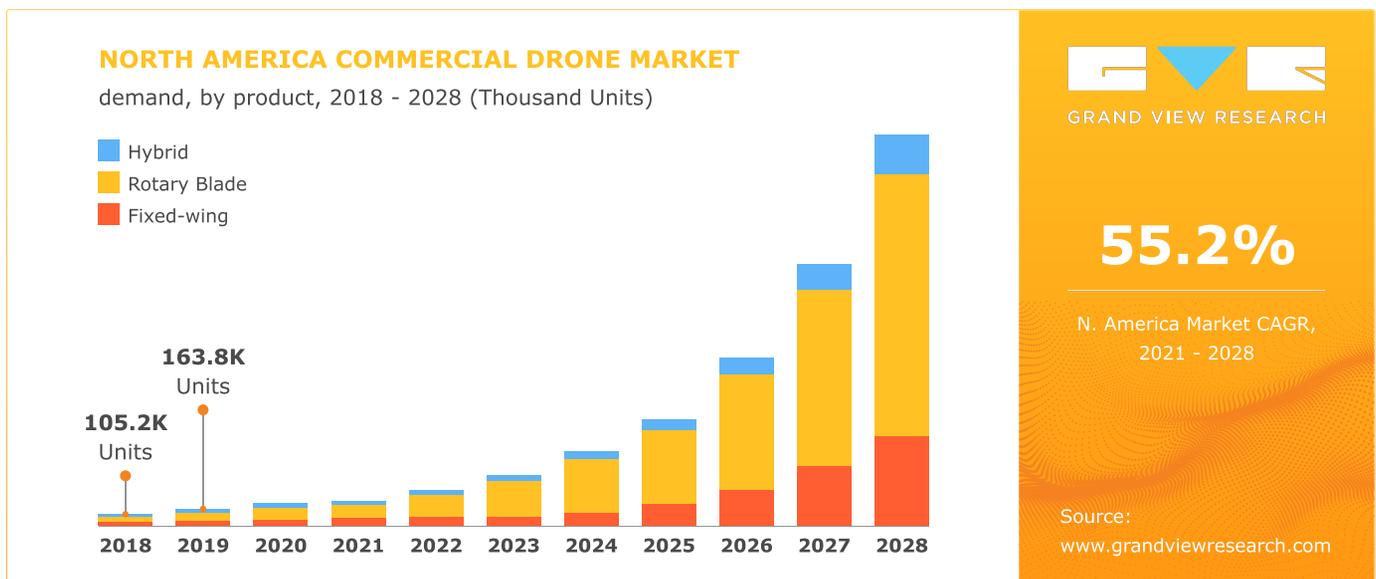
That said, the hybrid drone segment is expected to show the fastest AAGR – 64% per year from 2021 to 2028. This can be explained by the rapid introduction of drones in various industries and services. Hybrid drones' ability to combine the advantages of batteries and fuel engines is very important here – these factors significantly increase flight duration, make them heavier, and allow them to carry more weight. They can fly on a mission with tens of kilograms in payload, even in strong winds and rain. These hybrids are used to deliver packages for Amazon and Facebook and provide Internet in remote areas of Africa.

Estimated Development of US Market Sectors

XVII

This section covers research data by Levitate Capital, an investment fund that largely works with air and space projects.

Defense

MARKET SIZE
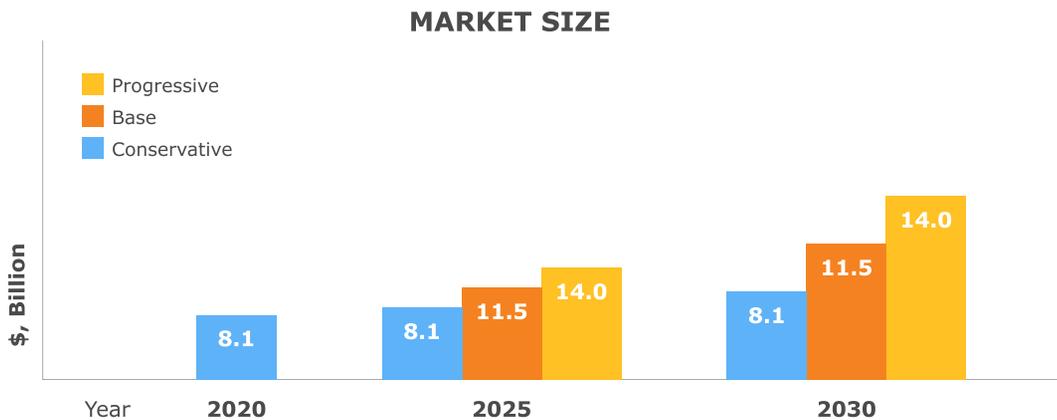
Source: Levitate Capital

The defense sector is the largest market and driver of UAV innovations and will remain as such for at least four years. The US Department of Defense was the main customer for the most expensive drones in 2020, and the defense sector accounted for approximately 40% of the entire US drone market. The development of UAVs for the defense sector directly affects UAV adoption in other industries, stimulating technological development, demand, and production.

Total military UAV production costs are projected to exceed $90 billion by the end of 2027. Roughly $40 billion of that amount will come from the Pentagon.

Enterprise

MARKET SIZE

Progressive
Base
Conservative

$, Billion

| Year | 2020 | 2025 | 2030 |

2020: 4
2025: 10, 16, 21
2030: 15, 29, 36

Source: Levitate Capital
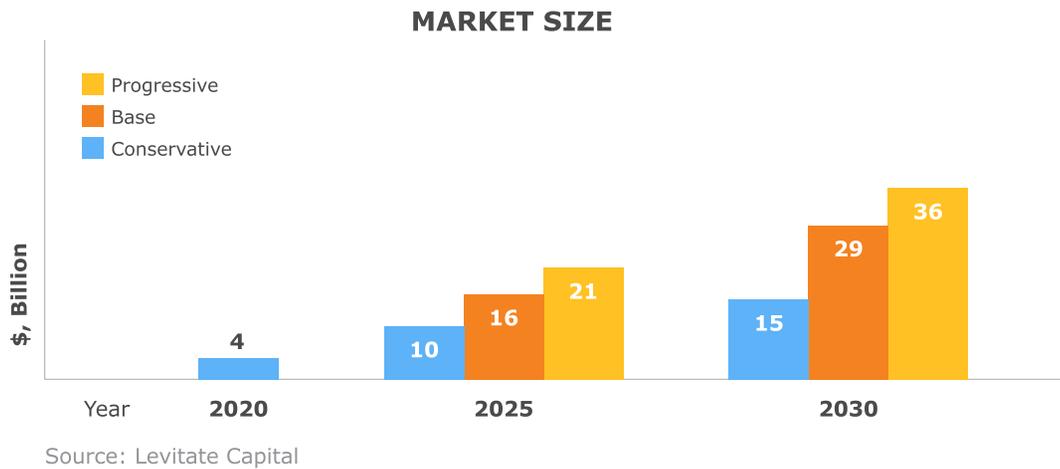
Enterprise, in its broadest sense, is the fastest-growing segment of the UAV market, which has already surpassed the hobbyist drone market and become the second-largest sector after defense.

The largest segments of enterprise drones are construction, built inspection, and agriculture. They were also one of the first civil markets that widely used drones.

ENTERPRISE MARKET 2020

Category	Value
Construction	$1.9B
Built Inspection	$0.4B
Agriculture	$0.3B
Counter Drone	$0.2B
Oil & Gas	$0.2B
Real Estate	$0.1B
Utilities	$0.1B
Mining	$0.1B
Videography	$0.1B

ENTERPRISE MARKET 2025

Category	Value
Construction	$8.5B
Built Inspection	$1.9B
Agriculture	$1.8B
Counter Drone	$0.9B
Oil & Gas	$1.2B
Real Estate	$0.6B
Utilities	$0.7B
Mining	$0.4B
Videography	$0.6B
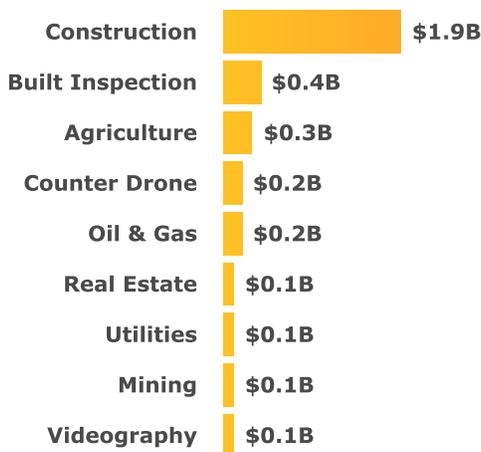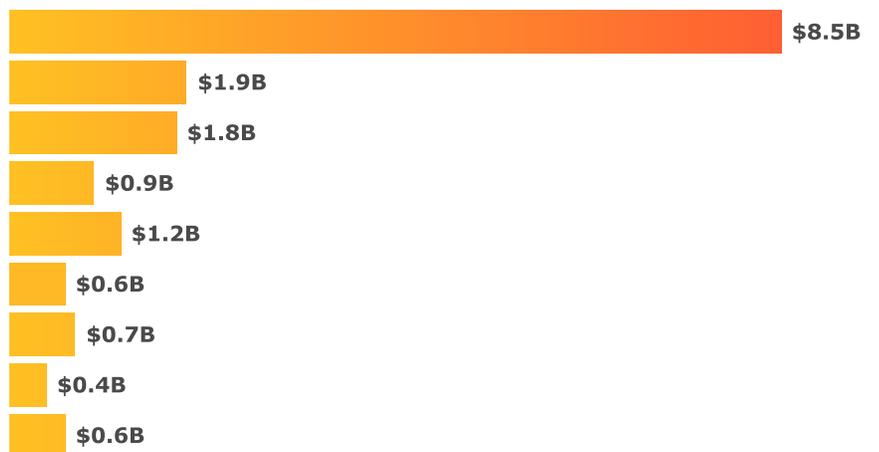
Source: Levitate Capital

The market is gradually evolving towards greater device autonomy. New drone models are just as strikingly different from the old ones as the iPhone 13 is from the iPhone 4. There will also be more and more specialists capable of controlling drones and working with the data they provide. Together, this will lead to an even lower cost of deploying drones without accounting for price wars between providers.

Construction

This industry, which includes the construction itself, design, and geodetic works, will remain one of the largest sectors of the corporate UAV market until at least 2030.

MARKET SIZE
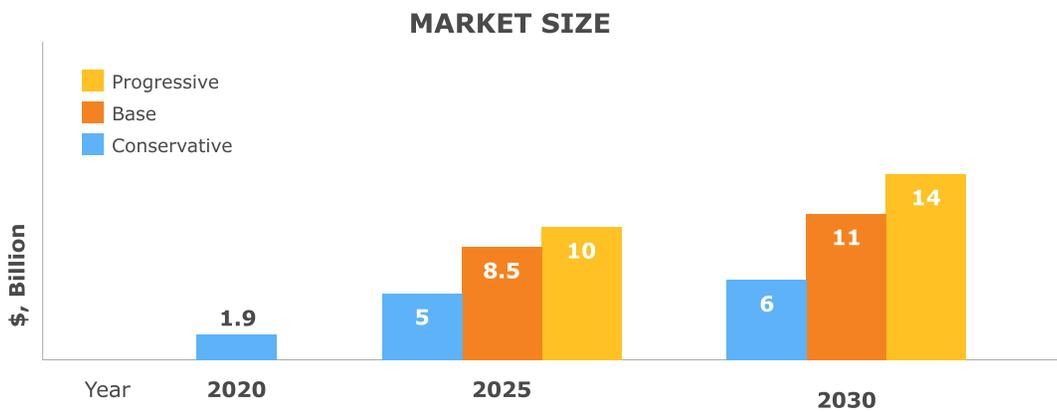
Source: Levitate Capital

This estimate is based on an average metric of one drone per 476,000 construction foremen in the United States.

The Asia-Pacific region, the Middle East, and Africa have far more construction workers than the USA. That said, the service industry and access to technology in these regions are less developed, so one drone may account for 10, 50, 100 foremen, or more. Many of them use simple drone models, but at least half prefer more expensive drones with advanced cameras and sensors. The average cost is about $10,000 per unit.

Generally, construction companies have several ongoing projects in different regions. In most cases, they outsource drone operations from local specialists. The cost of services per customer is about $400 per week (approximately $21,000 per year). Data services and drone software subscriptions are around $300 per month or $3,600 per year.

Built Environment Inspection

This point refers to the inspection of buildings, bridges, roads, and railways. This is potentially a very profitable business, constrained by regulatory reluctance to allow BVLOS flights. But as soon as we see legislative changes, this market segment will show rapid growth. If your business fits into this category, you should be prepared for this scenario.

MARKET SIZE
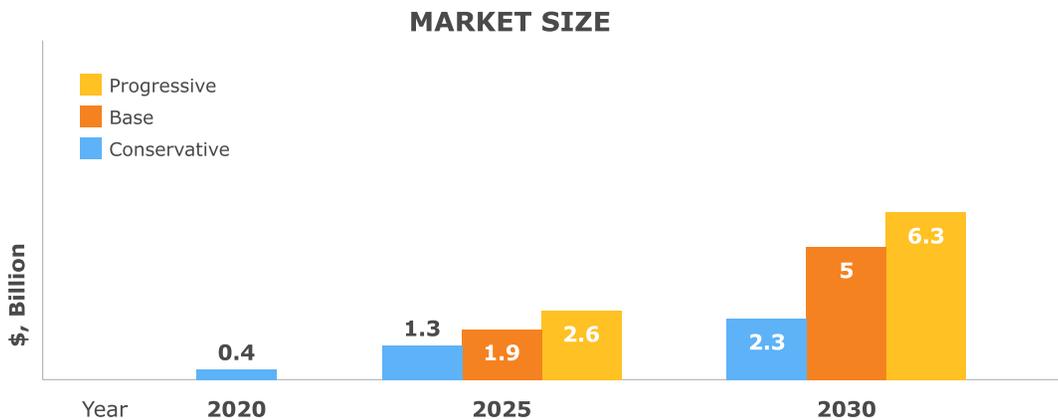
Source: Levitate Capital

Why is this relevant? There are approximately 615,000 bridges in the United States, 40% of which are at least 50 years old. And 9% of all bridges had unaddressed violations when put into operation.

National Bridge Inspection Standards (NBIS) require all public roadway bridges over 20 feet long to be inspected at least once every two years. And these are the majority of roadway bridges. Is it realistic to do it manually? Basically, yes, but it will be much longer and more expensive than using a drone.

If you add up all the costs, including the cost of equipment, its depreciation, service life, and the amount of work hours and data processing, a bridge inspection from an aerial work platform reaches $3,600-5,300, while a drone does the same for only $1,200.

Agriculture

Out of 570 million farms worldwide, only 16% of US farms, 10% of Asia-Pacific farms, 6% of European farms, and 6% of farms in other regions use drones. What does this mean? A huge field for growth!

The precision farming segment is expected to record the highest AAGR at over 60% from 2021 to 2028. This is a result of farmers seeking to increase yields and reduce costs in often unpredictable weather conditions.

Levitate Capital predicts that by 2025, more than 250,000 farms out of an estimated 570 million worldwide will use drones in some way.

The Asia-Pacific region hosts the largest number of farms and is also the one that accounts for the most agricultural products per year. Unsurprisingly, the agricultural drone sector in the Asia-Pacific is seeing the most growth.

The United States has a different situation: here, the number of farms and the total area of agricultural land are going down, but the average farm size is going up. In 2021, the average farm area exceeded 440 square acres, the largest in the world. But out of 2 million US farms, roughly 50% earn less than $10,000! 80% of farms earn less than $100,000 from product sales, and only 8% earn $500,000 or more.

MARKET SIZE
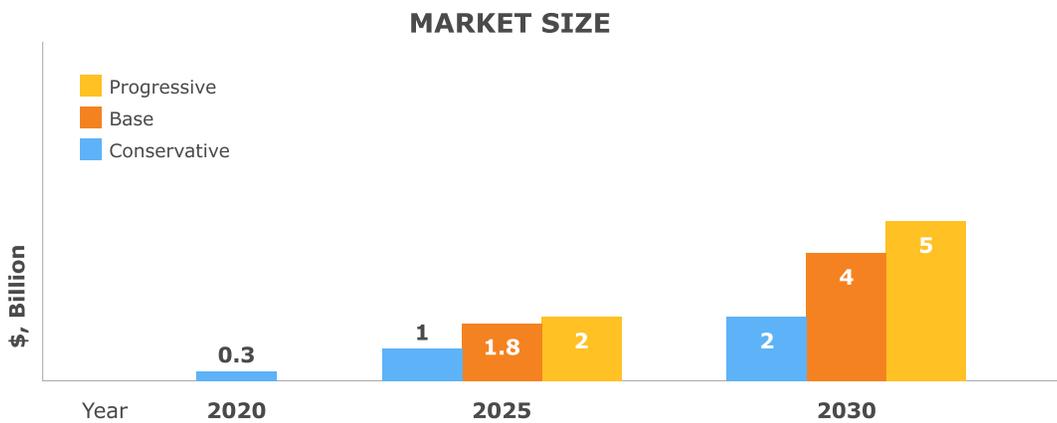
Source: Levitate Capital

Statistics show that drones are mostly used on farms earning $100,000 from sales and with an area of approximately 1,000 acres. For larger farms, using single-engine aircraft may be more appropriate. The cost of drone services per acre is inversely proportional to the farm size, but on average, it is about $5-8 per acre for high-resolution shooting.

In some countries, the agricultural drone market is larger and more dynamic than any other industrial UAV market. Ukraine is an example of this, due to insufficient industry regulation and huge areas of agricultural land.

Oil and Gas

The growth can be attributed to the increasingly widespread use of drones for well and pipeline design and construction, as well as for monitoring objects and supervising contractors. UAVs in the oil and gas sector are widely used in Russia, Saudi Arabia, and Argentina.

MARKET SIZE
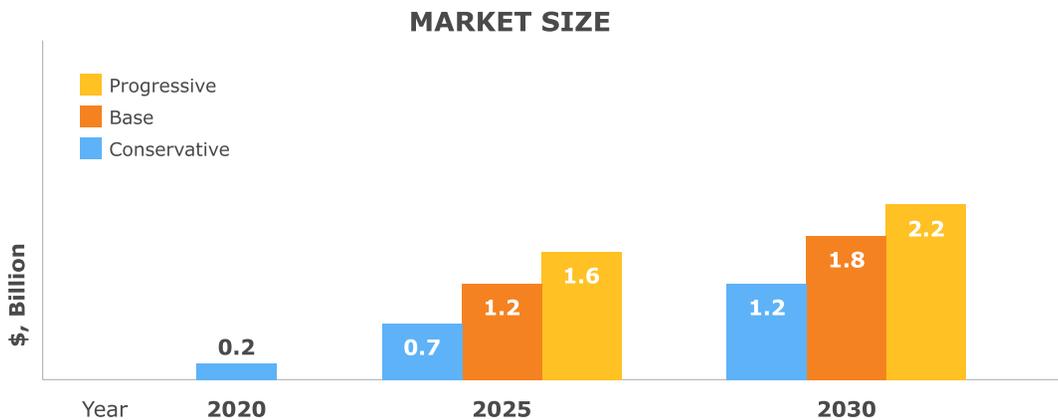
Source: Levitate Capital

Delivery

The major players in the drone delivery market are Amazon, United Parcel Service of America, Zipline, FedEx, DHL International GmbH, Boeing, Matternet, Flirtey, and Drone Delivery Canada Corp.

The shipping and logistics industry is projected to have a high AAGR of 60% from 2021 to 2028. Such growth rates directly depend on the development of e-commerce: drones are becoming more popular for handling goods in warehouses and deliveries. One of the main warehouse drone applications is barcode scanning, which will save a huge number of man-hours in the industry.

As for drone delivery, the volume of this market sector is forecasted to reach $1 billion by the end of 2021, showing an AAGR of 45.5%. This growth is mainly driven by the requirement for contactless delivery during the pandemic. But it's not the only thing driving the sector! It should reach $4.4 billion by 2025, with an AAGR of 45%.

Estimated Impact on the US Economy by the FAA

Source

The FAA rule enables further operations of small UAS that will benefit the economy and facilitate innovation and growth across a variety of sectors, such as construction, education, infrastructure inspection, insurance, marketing, and event photography. Operations currently allowed under part 107 will become less onerous and, in many instances, more efficient with this rule because, in general, remote pilots will not need to avoid flying over people or clear an area of non-participating people in advance of flying. The FAA analyzed the impacts of this rule and expects the benefits to exceed the costs.

Forecast scenario	10-Year present value (3%)	Annualized (3%)	10-Year present value (7%)	Annualized (7%)
Base Scenario— Primary Estimate:				
Costs	146.44	17.17	119.98	17.08
Cost Savings	(834.71)	(97.85)	(671.28)	(95.58)
Net Cost Savings	(688.27)	(80.69)	(551.31)	(78.49)
Low Scenario:				
Costs	102.96	12.07	85.32	12.15
Cost Savings	(616.60)	(72.28)	(501.51)	(71.40)
Net Cost Savings	(513.64)	(60.21)	(416.19)	(59.26)
High Scenario:				
Costs	207.17	24.29	169.27	24.10
Cost Savings	(1,158.84)	(135.85)	(927.41)	(132.04)
Net Cost Savings	(951.67)	(111.56)	(758.14)	(107.94)

Source: federalregister.gov

Which Drone Companies Are Listed on a Stock Exchange?

Bear in mind that this is not a call to action or a guide. We just want to show you the drone companies that are listed on a stock exchange and their recent performance.

GLOBAL DRONE STOCKS

Company	Country	Ticker Symbol	Primary Business	Founded	Current Price[1] in USD	1 month[1]	6 months[1]	1 year[1]	3 years[1]
Ehang Holdings	🇨🇳	EH	Hardware	2014	$27.91	-43,9%	+208,7%	+208,7%	+123,5%
Draganfly	🇨🇦	DFLYF	Hardware	1998	$1.39	-29,6%	+209,8%	+107,3%	+119,2%
AeroVironment	🇺🇸	AVAV	Hardware	1971	$108.40	-10,0%	+42,2%	+69,8%	+97,5%
DroneShield	🇦🇺	DRSHF	Hardware	2014	$0.16	+5,6%	+6,6%	+105,5%	+16,2%
Drone Volt	🇫🇷	ALDRV.PA	Hardware	2011	$0.31	-4,2%	-12,2%	+193,2%	-60,9%
Parrot	🇫🇷	PAOTF	Hardware	1994	$6.91	-12,5%	+34,5%	+152,9%	+5,4%
Delta Drone	🇫🇷	DLRWF	Software	2011	$0.03	-11,5%	-8,0%	-46,6%	-93,1%
ACSL	🇯🇵	6232.T	Software	2013	$25.62	-2,3%	+3,2%	+17,3%	+5,7%
Deveron UAS	🇨🇦	DVRNF	Services	2011	$0.58	-1,9%	+103,5%	+184,3%	-
Drone Delivery Canada	🇨🇦	TAKOF	Services	2014	$0.94	-24,3%	+96,4%	+90,2%	-18,8%
AgEagle	🇺🇸	UAVS	Services	2012	$5.32	-33,2%	+110,9%	+796,4%	+18,1%
Nordic Unmanned	🇳🇴	NUMND.OL	Services	2013	$3.88	-2,2%	+111,9%	+79,1%	-
Red Cat Holdings	🇺🇸	RCAT	Services	2016	$4.21	-17,3%	+301,0%	+407,2%	-50,6%
UAV Corp	🇺🇸	UMAV	Services	1987	$5.02	-7,1%	+96,0%	-88,1%	-64,2%

[1] As of April 19th, 2021; % shows if stock has increased or decreased since the time-frame mentioned

Source: droneii.com. Yahoo Finance

Main Technical Components

Anatomy of a Drone

Drones have different models that vary in size, the number of rotors, hardware, and software. But regardless of the model, drones all have the basic elements that allow them to fly. These are the main components found in all drones.
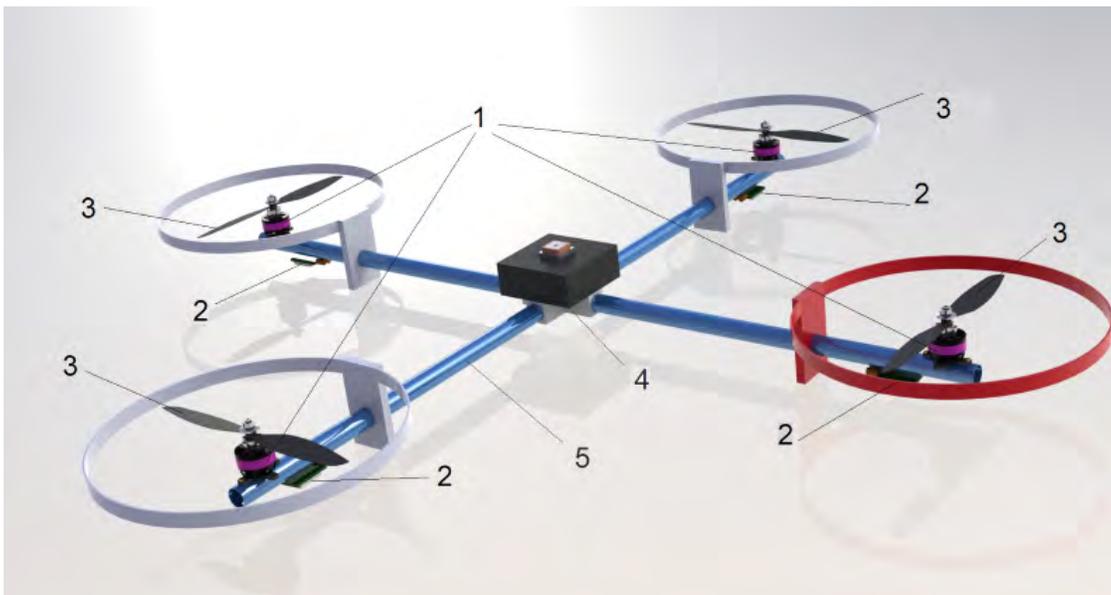
Source: rc-like.ru

1   Motors

Each motor transmits a thrust impulse to one rotor. The rotation speed is determined by an electronic speed controller, which, in turn, performs the commands of a flight controller. Motors are available as brushed and brushless. Low-end hobbyist drones may still have brushed motors. Those are cheap and wear out quickly to the point they must be replaced. Additionally, they cannot spin at a high RPM, which results in poor lifting strength.

Brush motors break down fairly quickly.
Source: kvadrokopters.com

Brushless motors are more durable because they have no moving contacts. Thus, there is nothing to wear out and deteriorate.

Brushless motors last much longer.

2   **Electric Speed Controller**

Electric Speed Controllers, or ESCs, are essential for brushless motors. The reason is that the battery supplies direct current. But the brushless motor runs on a three-phase alternating current, which calls for a converter.

The ESC must be compatible with the flight controller, motor, and battery specifications.

ESC is a must-have for brushless drones.

3 **Rotors**

These are made of plastic or composite materials (e.g., carbon fiber). The design may include protective frames around the rotors to keep them safe from mechanical damage.

4 **Flight Controller**

This is the brain of a drone, responsible for all processes. It receives, processes, and transmits signals from the operator's control panel to other components or performs pre-programmed actions automatically (if it supports an auto operating mode).

The flight controller connects not only the motors but also a number of sensors that provide information about the flight. The operator controls the drone mid-air based on this data.

Modern flight controllers generally include the following components:

Component	Its role
Main processor	On-board computer
Accelerometer	Controls acceleration of a drone along the X-, Y-, and Z-axes
Gyroscope	Determines the drone's position and orientation in space
Distance sensors	Help to avoid collisions, simplify indoor navigation
Barometer	Estimates the altitude by detecting the atmospheric pressure change
GPS sensor	Determines the location
Wi-Fi module	Communicates with external devices, and can transfer real-time videos and photos

Navigation sensors are mounted on the nose of a drone.

5 Load Frame

This component needs to be strong and light. Therefore, drone frames are made of carbon fiber, fiberglass, or carbon alloys. Generally, the frame is not made in one piece but in many parts. This makes it more durable and easier to maintain. The holes in the frame allow you to repair the electrical wiring.

6 Battery

Both the drone and the drone controller are powered by compact, replaceable batteries. Of course, these batteries can be recharged multiple times, so you need to buy several batteries and a charger for them along with the drone.

Depending on the battery capacity, one battery can power a flight for between 15 and 50 minutes. Most batteries that are available on the market operate approximately in this range. The newer models from popular drone brands are equipped with self-heating batteries. The function is activated in temperatures below 0°C and prevents the battery from discharging more quickly in cold weather.

These were the basic elements that make it possible for a drone to take off. But there are also several valuable elements that make drone flight safer and more convenient. Let's take a look.

7 Landing Gear

Lightweight models can land directly on their body frames. But medium-weight and heavy drones need landing gear. It can be some sort of a sled, like on a helicopter, or legs, like on a space rocket. If the drone is equipped with a camera (usually located at the bottom or at the front), the landing gear will be high to make enough space between the camera and the ground during landing.

8   Camera

Cameras can be built-in and attachable, so you can buy a drone without a camera (with or without a mounting bracket) and install the one you prefer. It is possible to use a smartphone for this, but this significantly limits your shooting options. Drone cameras have faster optics, better stabilizers, and high-frame shooting capabilities.

The drone camera can be used not only for shooting but also for FPV (first-person view) control. This is a way of controlling a drone, whereby the operator sees what the drone sees. They view the flight on the control panel or another device and adjust it based on this data.

The drones can be equipped with two cameras: one takes photos, and the other enables FPV control. This is because regular action cameras can perform only one action – shoot or transmit video to the operator's monitor.

Cameras in advanced models can shoot and transmit video simultaneously. But there is a catch: such cameras have a slight delay (up to a second) because they need to compress and transmit the imagery. In some cases, this time gap may be unacceptable.

Multispectral sensor

Professional drones that are used in site inspection, construction, and agriculture can be equipped with multispectral camera sensors. They can shoot not only in the visible spectrum but also in separate RGB channels, as well as infrared and ultraviolate wavelengths.

9 Transmitter and Receiver

These are used for two-way signal transmission and reception between the control panel and the flight controller. It's worth going for receivers and transmitters with a 5-channel control panel and 4-5 additional programmable channels to minimize the response delay or recover the signal during communication interruptions. The receiver and transmitter must use the same radio signal to communicate with the drone during the flight. Each signal has a standard security code that helps the receiver recognize the right signal and ignore others.

Special Sensors

Industrial drones can be fitted with a number of special sensors and devices to collect more information than a conventional camera.

1 **Lidar**

Lidar (LiDAR, Light Identification Detection and Ranging) is a kind of laser radar. The rangefinder emits a laser beam that reflects off surrounding objects and is transmitted back. A light-sensitive receiver, installed near the emitter, captures the optical echo. Laser reflection speed and intensity help determine the precise distance to objects and their outline points. This data is later used to build a 3D terrain map. The laser does not bounce off plants, so even areas with dense vegetation can be marked on the map.

If you have strict requirements for 3D maps of terrain and infrastructure, you need LiDAR technology. The more light pulses per second a sensor can generate, the more accurate the measurement will be. In addition to the sensor, you also need a global navigation satellite system (GNSS) and a base station GPS for the whole system to work and to determine the location of the lidar itself.

The IMU (inertial measurement unit) gives the precise orientation of the scanner

IMU

GPS

Z

X

Y

The GPS gives the precise location of the scanner

The laser scanner emits infrared pulses which reflect off the surface of the earth and objects on it. The returned pulses are captured and recorded

GPS Base Station

Source: coptrz.com
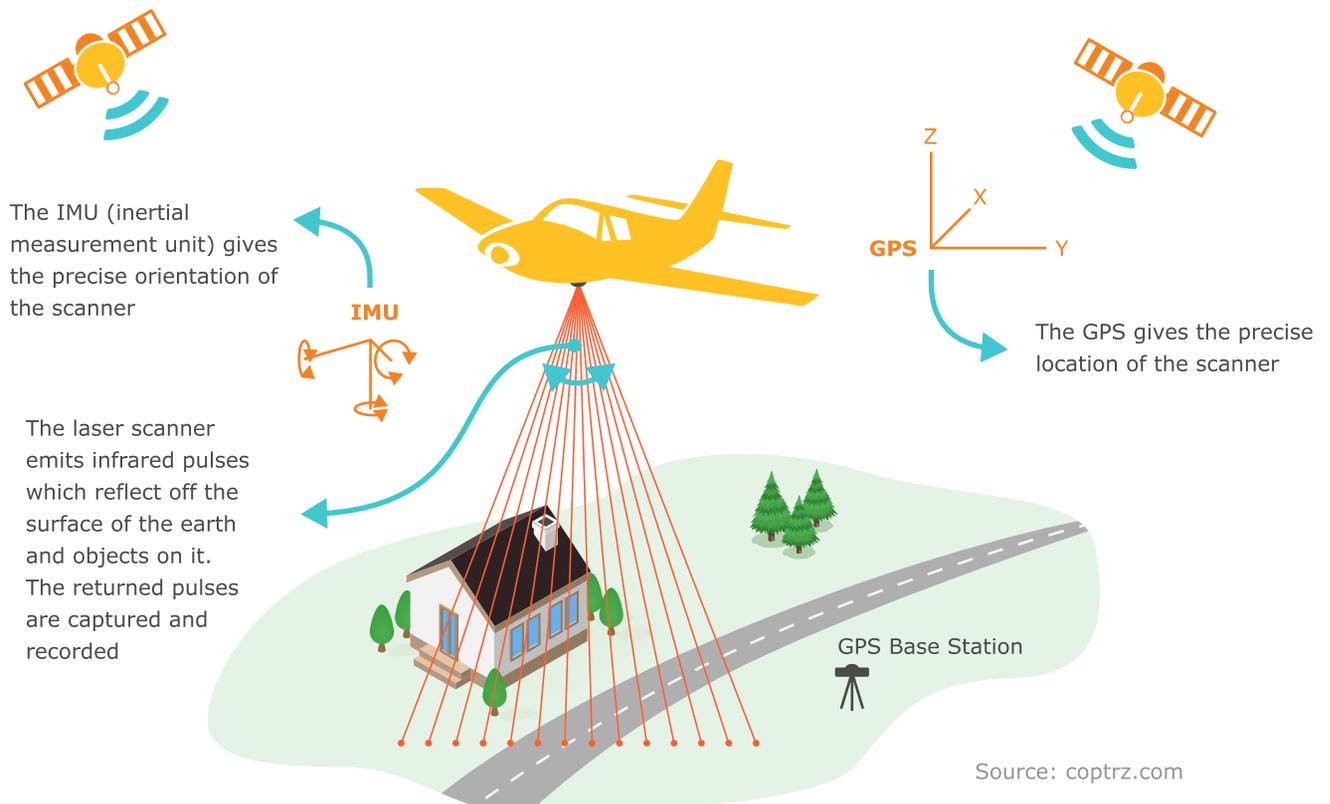
Typically, a UAV lidar is used in design, construction control, and monitoring engineering systems. Forest monitoring is its own separate area of lidar application. The technology is especially useful because a regular camera cannot see underneath tree crowns.

2   Thermal Imager

A thermal imager can also be called a thermal camera, thermal imaging sensor, thermal vision sensor, etc. It is a camera that sees and captures thermal radiation rather than reflected light. Therefore, it takes high-quality photographs in all visibility conditions – at night, in a room filled with smoke, or in dense fog. However, only thermal imagers that operate in the long-wavelength range of 8-14 microns can do this.

A thermal imager detects heat and shows objects in different colors based on their temperature with a gradient change from red tones in warmer areas to blue tones in colder areas. The smallest temperature difference captured by the device is 0.01°C. Almost all objects emit heat in one way or another, so a thermal imager can be used for a variety of tasks: from detecting heat leaks to creating a geographic heat map.

A thermal imager and an infrared camera are not the same. Both devices operate in infrared, but the imaging accuracy and quality are different. An infrared camera relies on IR illumination, processing signals reflected from surrounding objects. It sees warm objects and basically acts as a night vision device. A thermal imager, on the other hand, allows you to accurately measure the temperature of the objects. Unlike an infrared camera, it also works in poor visibility conditions, including precipitation.

How Do Drones Fly?

What exactly makes a drone fly? What allows you to control it or change its direction or speed? Let's figure it out.

The flight controller receives the signal from the remote control and sends out commands to the ECS. Then, the ECS transfers energy to the motors. Electrical energy is converted into mechanical energy, which puts the rotors into motion.

Drones have multiple propellers/rotors. They generally come in even numbers, and there is a reason for that. Half of the propellers rotate clockwise and the other half – counterclockwise to maintain balance while flying.

$\ddot{Z}$
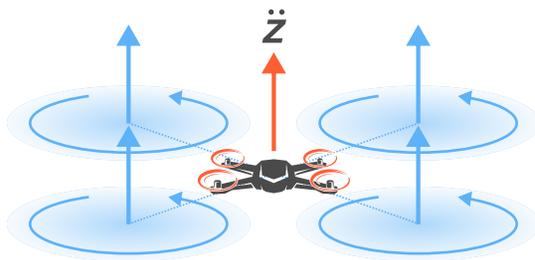
Rise and decline

Drone flight principles: Half of the propellers rotate clockwise, the other half counterclockwise

$\ddot{\psi}$

Turn

$\ddot{\theta}$
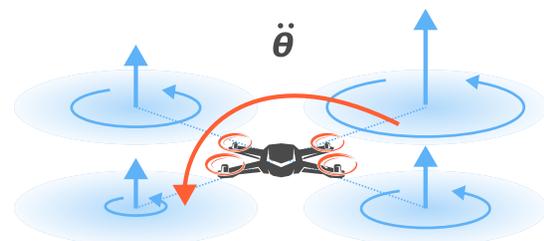
Tilt and rotation

Working principle of a drone

When all propellers rotate at the same speed, the drone starts to lift off. It will gradually gain altitude until the operator sends a command to move in any direction across the three axes. The flight is determined by propeller rotation parameters:

1. The drone flies forward when the rear propellers start rotating faster.

2. The drone tilts and pivots when one of the front propellers starts rotating faster and moves in the direction corresponding to that propeller.

3. The drone turns around when a pair of sideways propellers start rotating faster.

4. The drone hovers in place when the rear propellers rotate at the same speed as the front propellers.

5. The drone descends when the propellers rotate at a reduced RPM.

So, thanks to the combinations of the rotation of the propellers, the drone is able to take off and land, descend and gain altitude, turn, hover in place and even circle around its axis.

Flight control can be interfered with by software responsible for the safety of the drone. If the system sees that the battery is critically discharged, then it will send the drone to the launch point, regardless of the operator's commands to fly further. The same applies to the boundaries of the radio signal zone – the drone will turn if the signal becomes weak.

Mission Planner and Data Processing

Flight planners are flight programs that automate standard operating procedures. They make working with a drone significantly easier: the operator does not need to control every action and how the equipment is positioned at all times. The drone performs the pre-programmed script prescribed within its radio signal range.

A mission planner can consist of many spaced-out and asynchronous flights aimed at solving a project task. Standard mission planner programs, available for free or as out-of-the-box solutions, are usually enough for simple and basic tasks. If you need something customizable, a standard mission planner will not do. After all, every large company has its own way of organizing work processes.

If you need custom solutions, you should contact a company that is experienced in developing this kind of software. If the contractor has not worked with this kind of specialized software before, they will make many mistakes. Intetics has extensive experience in developing flight/mission/operation planners for flexible scheduling and monitoring the progress of field operations, as well as software for data processing. After all, shooting the required objects is one thing, but the main task is to obtain the information that is important for your business.

With the help of drones and the software made by us, our customers build railways and inspect factory roofs, inspect mines, monitor construction sites, determine the state of thousands of kilometers of roads, power lines, and oil and gas pipelines, and engage in smart agriculture.

If you need a custom solution for drone flights and result processing, we can help you!

Key Technologies Used in Drones

XXII

The UAV industry is closely tied to several areas of scientific research and technology developments. They expand UAVs' ability to collect and analyze information, turning drones from a camera-equipped toy into a powerful tool for analytics and the strategic alignment of business processes.

AI

Drones collect a tremendous amount of information, but it's only useful if these massive amounts of data can be processed quickly. Otherwise, the time you save on collecting information will be offset by manual processing. This is why drones and artificial intelligence are some of the best technology combinations.

Key AI use cases for drones are:

- Detection of objects and processes using pre-trained neural networks

- Change detection based on arrays of data on the same objects taken at different times and computer vision

- Predictive analytics and forecasting of further changes based on change detection

- Autonomous planning of the optimal BVLOC flight route in real-time

- Autonomous route adjustment in unforeseen circumstances (obstacles, security threats, risk of losing the drone, etc.)

DRONES & AI IN ACTION

Live Data	Processed Data

Results

Detecting
sharks at public
beaches

Live tracking of
assets on
construction sites

Detecting anomalies/
defects after railway
inspection

Classifying
3D point clouds
into categories

Analyzing imagery
to classify natural
disaster damages

Uncovering and
categorizing plant
diseases

Data Analytics

Data Acquisition

Verticals of Reference

Construction

Public
administration

Transport

Energy

Insurance

Agriculture

Source: droneii.com

How It Works

Here are the main areas of AI that can be used to run drones and process the data generated by them.

1. Machine Perception

One of the main tasks that drones perform is object recognition. The drone must perceive reality for the neural network to be able to recognize objects and conclude whether they match the objects it's familiar with. But since it doesn't have biological sensory organs, it uses electronic sensors, such as a camera, lidar, a thermal imager, optical sensors, air and temperature analyzers, etc. These sensors receive information about the surrounding space, which is known by the term "machine perception".

2. Computer Vision (CV)

Machine perception allows the drone to receive an image, which then needs to be processed and analyzed. This is exactly what computer vision is responsible for. Computer vision refers to a computer's ability ("computer" used in a broad sense) to extract information from the arrays of data uploaded on it. The drone (or another computer) must be able to detect the right kind of information for a given task on an image.

3. Machine Learning (ML)

This refers to a computer's ability to learn from datasets and increase the accuracy of its model. Thanks to ML, computers can recognize objects on photos and videos that the model was previously introduced to. The wider the variety of objects the computer views and memorizes, the more accurately it will detect them later on. Object recognition in images is only one of many possible applications.

4. Deep Learning (DL)

Machine Learning
(A tool of computer vision. Algorithms whose performance improve as they are exposed data over time)

Deep Learning
(A subset of machine learning in which neural networks learn vast amounts of data)

Computer Vision
(Ability to analyze visual input)

Machine Perception
(Ability to use input of sensors)

Motion Planning
(Breaking down a desired movement into discrete motions)

Learning

Perception

Motion

General intelligence

Reasoning

Social Intelligence

Planning

Language Processing

Knowledge Representation

AI

Source: droneii.com

This is a type of ML that is based on neural networks' ability to detect new, non-obvious connections, correlations, and hidden patterns. A multilayer neural network, similar to a human brain, consists of several layers of neurons. It is capable of self-learning based on the data it receives. Such a neural network is not trained to follow an algorithm and solve a specific problem but rather to have a more general perception. The evolution of GPUs has made it possible to apply DL methods to drones and specialized software. They found demand in processing data obtained via drones in many areas – from agriculture and construction to insurance and facility monitoring.

How is all this applied in real life? Let's say you are building a huge facility that covers a large area. There are a lot of buildings, equipment, people, sites with building materials… you heard it right! So, the drone can become a form of ubiquitous flying administrator that keeps records of actual usage and material consumption, including sand, gravel, insulation, fittings, etc. Based on this data, the software can then use AI to calculate the optimal schedule and volumes of new deliveries with building materials.

AI capabilities transform drones from just flying devices with cameras to autonomous moving computers. AI provides autonomous device navigation, capable of considering many variables independently from the operator. Such a drone becomes an intelligent robot that can also fly. Continued implementation of AI technologies in UAVs will expand their capabilities and help users get the most out of them.

IoT

A drone loaded with cameras and sensors belongs to the Internet of Things as is. It can collect information using sensors and communication modules and transmit it to the operator in real-time. This is great, but the capabilities of drones can be greater if you also install external sensors at the objects of surveying.

Depending on the conditions, IoT sensors can transmit information to drones via LTE, Bluetooth, RFID (radio-frequency identification), or LoRa (power-efficient, long-range network).

Here are the main use cases for IoT modules and drones.

1. Transfer Information In Between Inspections

Some things don't need to be inspected every day, like wind farm blades or bridge structures. It's expensive and doesn't make much sense. But if you don't have to fly drones to learn about changes and you can discover them earlier, just as they first appear, it will be useful.

You can install pressure, expansion, and temperature sensors, as well as similar devices on any structure that is important to monitor. Based on the set of parameters from sensors, it is possible to recognize probable events and predict issues. If you receive an important signal from the sensor, you can send a drone to the object to have images to accompany the data.

2. Control the Movement of Objects

Sensors can be attached to moving objects and transmit information about their movement to the drone, which, in turn, will forward it to the central cloud platform. This solution is already widely used in agriculture. For example, some attach sensors to the ears of animals that move around a large open area in search of food. A small device hosts three sensors in one place: a GPS module, an accelerometer, and a thermometer. Why limit yourself to only tracking movement if you can collect additional valuable information along with it? The accelerometer records the speed and moving patterns of each animal. While it's not obvious, this data can actually help recognize about 10 diseases in cattle. Plus, a thermometer reports an elevated temperature, possibly an infection, so the animal can be quickly isolated from the herd.

The sensors can also be mounted on agricultural (or some other) machinery. They can help you to be proactive in detecting breakdowns (at the earliest stage) and in monitoring the fuel level in tanks and the fullness of other containers. Data taken from sensors on equipment and animals can be integrated into a single analysis and control system.

3. Optimize Warehouse Operations

Drones can scan codes and tags on goods and shelves and transmit information about product availability, occupancy rates, and expenditures. Amazon and Walmart already use similar solutions. This reduces the time taken to find items and take inventory.

4. Create Accurate 3D Maps in Areas with Complex Terrain

Photogrammetry data may not be sufficient to create an accurate map on sites with complex or changing terrain, like on a mountainside or near a river bed. In such cases, you can place hundreds or even thousands of sensors across the surface to help the drone collect a point cloud and make a flawless terrain model. This is useful when the task requires you to create a map and perform calculations with as little error as possible. Such scenarios include measuring the complexity and cost of building projects or laying communication lines.

5. Provide Internet Access to Remote Regions

About 1 billion people have no mobile connection or Internet access. None whatsoever. They're inaccessible for fixed cables, and the Starlink mission is going to take a long time before it reaches its full intended coverage. Drones help out now by providing Internet access to remote areas. For this reason, Facebook expects to have 3 billion users by 2030.

5G

Why is the global IoT network not a thing yet? Installing billions of sensors isn't that hard. It is much more difficult to connect them to a single network and ensure uninterrupted operations. This largely depends on the penetration rate of 5G technology – the fifth generation of mobile communication systems. It has a much higher bandwidth than previous generations, so it will be able to support large-scale communication between connected objects.

Most importantly, 5G makes device-to-device connectivity possible, which is when devices exchange information directly with each other without intermediate stations and networks. In our case, it could be drones on the same cloud network, oncoming drones, operator devices, etc. 5G can ensure the safe and accurate operation of autonomous drones during BVLOS flights.

IOT WORKFLOW FOR UAVS USING 5G
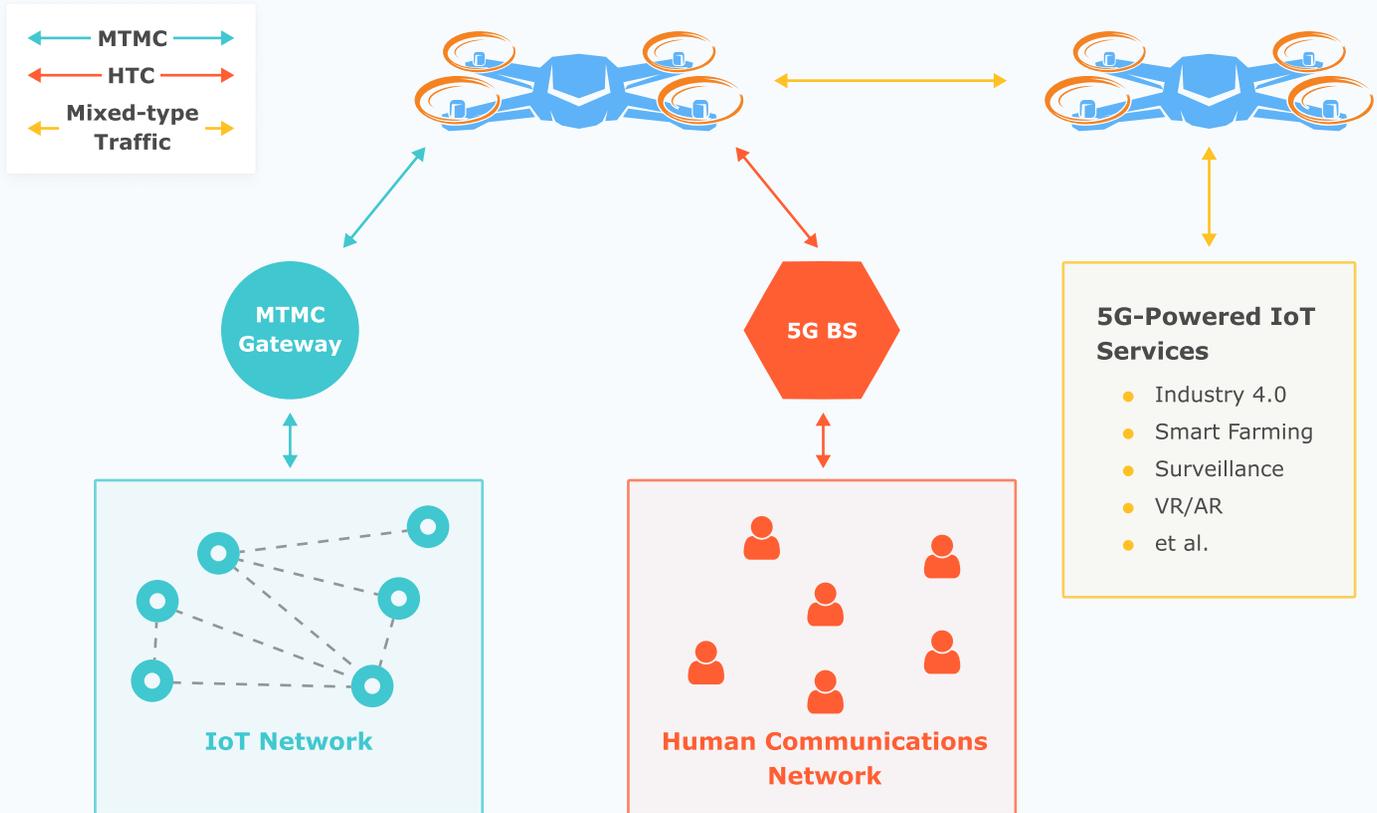
Source: mdpi.com

INTETICS INC. HAS A PROVEN TRACK RECORD OF DEVELOPING SOLUTIONS FOR DRONES USING COMPUTER VISION, MACHINE LEARNING, AND IOT TECHNOLOGIES

Which Drone Is Right for You?

Start by determining the business challenges you need a drone to solve. Buying the cheapest or most popular option and then trying to adapt it to your needs is not a good strategy. Depending on the areas of application, the following drone models are worth paying attention to.

Industrial Inspection of Facilities and Communications

DJI Matrice 300 RTK with the Zenmuse H20 payload kit is excellent for this purpose. This model is often rated as the best choice for industrial inspections and facility and infrastructure monitoring, thanks to its set of payloads. It boasts a lengthy runtime of up to 55 minutes, advanced AI-powered data analysis, and IP45 dust protection. The device features a wide-angle camera, lidar, and thermal imager.

For some tasks, the accuracy of Matrice 300 RTK is excessive, while a Mavic is not enough. This is when Phantom 4 Pro is the perfect balance in terms of technical capabilities and price.

Other DJI models with industrial applicability, similar in components and capabilities, include:

» Mavic 2 Pro » Mavic 2 Zoom » Mavic 2 Enterprise

Air 2S is another popular drone by the same manufacturer. It is inferior to Matrice 300 RTK in terms of performance but it's much cheaper. It will be enough for shooting static or moving objects in high quality for industrial or personal use. Air 2S' intelligent algorithm can choose the optimal shooting mode and set up a flight route. It also knows how to keep the subject center-frame, even with severe interference. If you do not have strict requirements for a drone and a battery that lasts half an hour is enough, this could be an optimal choice for you. Keep in mind that Air 2S is not suitable for creating orthomosaics and maps due to the lack of seamless integration with third-party mission planners.

Aircraft-type drones, such as the eBee range by SenseFly or WingtraOne with vertical take-off by Wingtra, are successfully used to survey large areas.

Indoor and Confined Work

One of the best industrial drones for this kind of inspection is the Flyability Elios 2. It has a shockproof design, propeller protection, and seven position and obstacle avoidance sensors. It is an indispensable addition in warehouses, construction sites, mines, and other confined spaces where drones are required. Its compact size (40x40 cm) makes it suitable for any space. Finally, it works great without GPS navigation.

Construction, Surveying

The DJI Phantom 4 RTK is perfect for these purposes. It takes photos using significantly fewer ground control points on the surface than other drones while also achieving a 0.1-inch vertical accuracy. The RTK module makes it more expensive than its counterparts, but if you need high accuracy, simplicity, and reliability, this is an excellent model.

We also want to highlight its payload design specifically for surveying – an integrated sensor (lidar + camera) Zenmuse L1 by DJI. It is designed precisely for surveying and mapping with LiDAR technology. It offers an impressive detection range of up to 450 meters. The sensor supports LiveView technology that builds a "point cloud" in real-time and immediately transmits it to the base. The operator sees the same thing as the drone at the same time, which is very useful in emergency area inspection and military or police work. **Zenmuse L1 is compatible with DJI Matrice 300**.

Agriculture

Agras T30 is an agricultural drone by DJI developed specifically for farms. It is a large six-rotor drone capable of carrying a 30-liter spraying tank for plant fertilizers and chemicals or 40 kg of dry materials. Please note: considering the payload, such a drone weighs much more than 25 kg, so you need special certification to operate it (Part 107 is not enough).

Agras T30. Source: dji.com

Agras T30 can cover a field area of up to 9 meters wide (depending on the flight height and the type of sprayers) in one flight. The drone has two camera searchlights for a view at night and a battery with a 20-minute run time. It can handle up to 40 acres of fields or gardens per hour.

Another great agricultural drone is XAG XPlanet 2020. It is equipped with a 20-liter liquid tank or a 16-liter granule container.

Farmers can also use the industrial drones mentioned above for orthomosaics and visual monitoring.

Inspection of Gas Pipelines, Chemical Industry Facilities, and Oil Fields

Here, the main tasks solved by drones are design and construction, infrastructure monitoring, and predictive maintenance. We have already talked about the popular drone models used for these purposes.

But this segment presents a specific task – detecting the leakage of gas and oil. Any reliable industrial drone that is equipped with a gas sensor will be suitable.

You can find low-profile sensors that detect a substance and multi-gas detectors for several different gases on the market.

One of the most interesting multi-gas detectors is MUVE C360 by FLIR. Its eight-channel sensor detects the presence and concentration of combustible gases (chlorine, hydrogen sulfide, oxygen, sulfur dioxide, carbon monoxide, and nitrogen dioxide) in the air. Additionally, it has a photoionization sensor (PID), which detects volatile organic compounds even at minimal concentrations. The MUVE C360 smart sensor also includes a lower explosive limit (LEL) detector.

	Phantom 4 RTK	M300 RTK + P1	senseFly eBee X	Phantom 4 Pro V2.0
	Top Pick			
ALL-IN PRICE ⓘ	$$	⊗ $$$	⊗ $$$	⊘ $
SWAPPABLE PAYLOADS	No	Yes	Yes	No
CAMERA MEGAPIXELS	20 MP	45 MP	24 MP	20 MP
SENSOR SIZE	1" CMOS	Full Frame (35mm)	APS-C	1" CMOS
SHUTTER TYPE	Global	Global	Global	Global
FLIGHT TIME ⓘ	18 minutes	20 minutes	60 minutes	18 minutes
AREA COVERED AT 150' AGL ⓘ	10 acres	10 acres	⊗ N/A ⓘ	10 acres
AREA COVERED AT 400' AGL ⓘ	60 acres	60 acres	⊘ 500 acres	60 acres
RTK ENABLED	⊘ Yes	⊘ Yes	⊘ Yes	No
COMPANY LOCATION	China	China	France	China

Source: aerotas.com

Most Popular DJI Drones

This manufacturer offers the most popular models in the hobbyist segment and one of the most sought-after industrial drones. This selection will help you navigate the specific DJI drone applications and their prices.

DJI Product	Segment	Price (USD)	Competition
Mini 2	Consumer	<$500	**None**
Mavic Air 2	Consumer	$800	**None**
Mavic 2 Pro/Zoom	Prosumer	<$2,000	**Strong:** Autel, Skydio
Mavic 2 Enterprise Zoom/Dual	Enterprise	>$3,000	**Strong:** Autel
Mavic 2 Enterprise Advanced	Enterprise	$6,500	**Strong:** Altavian. Autel, Brinc, Parrot, Teal, Skydio, Vantage
Phantom 4 RTK	Enterprise	$6,200	**None**
Matrice 300 RTK	Enterprise	>$13,000	**Nascent:** FreeFly, Inspired Flight
Matrice 600 Pro	Enterprise	$5,700	**Nascent:** FreeFly, Inspired Flight

Source: droneanalyst.com

Which Data Collection Software Is Right for You?

If you need a drone for relatively simple generic tasks, you can easily get by with an out-of-the-box solution by industry leaders. Consider the following options.

DroneDeploy

This is probably the most popular specialized SaaS platform. DroneDeploy allows you to customize the baseline out-of-the-box solution for business tasks thanks to its app and add-on marketplace. This software enables drones to solve a wide range of tasks.

Agisoft Metashape

It's a good choice if you are just getting started with drones. It has a simple interface with clean navigation and standard options. The program allows you to create basic spatial models using multispectral and thermal imaging data.

Global Mapper

This might have the best price-quality ratio on the market for topography, surveying, and construction site work. If your tasks fit into these categories and you have no special requirements in terms of interface, this option is for you. This software can analyze basic models created based on photogrammetry or lidar surveys.

Pix4D

It's the only professional-grade software that lets you select the processing options you need across industries: from agriculture and insurance to mining and indoor inspection. The pay-as-you-go model allows you to choose your own set of features. Unlike other out-of-the-box solutions, you won't have to pay for the whole package, especially when some of the options might be unnecessary for your tasks. There are solutions for mission planning, baseline model development and analysis, and photogrammetry. Pix4D, like Agisoft, has a cloud version integrated with the desktop.

Ready-To-Use Software Is Not Always Enough

If your company's business processes have specific requirements, standard software will not cut it. The catch: this is not always obvious. On paper, it may seem that your processes are just like everyone else's, but in reality, they may work differently. What should you do in this case? Of course, you can use the basic options offered by standard software, but you'll have to accept the additional costs of solving other tasks and the time wasted on duplicating information.

Our goal is to sway you towards custom products when standard software is enough for your tasks. All expenses must be justified, and all projects should be beneficial to the business.

Standard solutions are not enough if you need to:

- integrate the data obtained by drone with other IoT sensors

- modify the drone (install additional payload, such as cameras, sensors, containers, etc.)

- configure custom elements and coordinate them with base drone components

- create flight plans with separate trajectories for general project tasks; organize the seamless coordination of several field teams

- use software for data processing, storing, and automated analysis

- integrate drone software with other solutions – CRM, monitoring systems, irrigation control, etc.

Intetics Inc. has vast experience in solving specific tasks in terms of controlling drones and analyzing the data they collect. We sprayed live insect fertilizers over fields before it was mainstream on farms in Asia and the United States. We scanned mine shafts when drones did not have the protection and orientation sensors they have now. We made a road map of Ukraine using aerial survey data from drones and satellites.

We also have projects that use drones in construction, industrial inspection, agriculture, insurance, and mapping. We'd like to offer a top-class solution for your problem as well! Contact us: contact@intetics.com

Drone Specification Requirements

The US FAA and regulators in other countries have clear requirements for drone specifications. This applies to both newly produced models and homemade drones assembled by amateur engineers. The main criteria are weight, flight altitude, and distance from uninvolved people.

CRITERIA	🇺🇸 USA	🇬🇧 UK	🇨🇦 Canada
Visibility range	VLOS	500 m/0.31 miles (and VLOS)	VLOS
Maximum altitude	120 m/400 ft	120 m/400 ft	120 m/400 ft
Distance from uninvolved people	Not specified	Minimum 150 m (depending on weight)	30 m
Registered weight	250 g - 25 kg	250 g - 20 kg	250 g - 25 kg
Registration fee	$5 for 3 years	£9 per year	$5, unlimited
Registration website	FAA Drone Zone	Civil Aviation Authority	Civil Aviation Authority

Regardless of your drone's intended use, it must meet these requirements.
Source: digitalcameraworld.com

Visibility Range

Some drones have a transmission range of up to 10 km. But in practice, you will not be able to take advantage of this. In most countries, regulators only allow you to fly a drone within a visual line of sight (VLOS). In some cases, a drone can have several operators – they can pass on control to each other while standing at a certain distance.

In the USA and Canada, the maximum allowable distance between a drone and the operator is not specified, but the drone must be within the visual line of sight. The UK and EU countries have stricter rules, limiting VLOS to 500 m. Even if the drone can be easily controlled both visually and with the remote control, you need to turn it around.

Visibility range means that you have a good view of the drone itself, can estimate its distance from surrounding objects, and can prevent collisions without relying on a camera view transmitted to your device.

In many countries, one-off BVLOS flights are allowed under a special permit. This applies to the United States, China, Australia, and several countries in Europe. Some counties make it easier to obtain the permit – for example, Switzerland and Denmark.

Maximum Altitude

This requirement is the same in the US, UK, and Canada – 120 meters (400 feet) above the surface. If the drone is flying over buildings, the height is measured from the roof surface.

Some drones can fly up to several kilometers high. But like flying outside the operator's line of sight, it is illegal in most countries. Keep this in mind when launching a drone. Four hundred feet is usually enough for most industrial applications.

Weight

The minimum weight for drone registration is 250 g. It doesn't need to be registered in the USA, China, or the EU if it is lighter. This applies in the UK too, but only if this drone is not equipped with a camera. Otherwise, registration is required.

The maximum weight with the entire payload included is 25 kg. If your drone weighs more, then you have to either remove some of the payload or register it under a different category. In the latter case, the drone will have slightly different requirements.

How and Where to Use Drones

US Drone Regulations

Standards and laws regulate not only the technical specifications of drones but also how they must be operated. In the United States, the Federal Aviation Administration (FAA) is the agency behind these rules. It regulates both the commercial and recreational use of drones.

Commercial Use of Drones

According to the FAA, the commercial use of drones refers to any drone flight that contributes to business growth in any way. This is a very broad interpretation, which covers any use of a drone in a company's interest. Surveying, construction, industrial inspection, agriculture, insurance, commercial content creation – by default, all of these uses are considered commercial activities.

Does your drone help solve business problems? Then you fit into this category. All commercial drone flights must be operated by someone with a Part 107 remote pilot certificate.

Recreational Use of Drones

These uses do not require Part 107 pilot certification, but you will be expected to follow the FAA's general safety guidelines. Your drone must weigh less than 55 lbs (25 kg), and those weighing more than 0.55 lb (250 g) must be registered. You do not need to take tests to operate them – it's just a registration. The registration number must be on the exterior body of the drone, a sticker, or a label.

Recreational drone use includes:

» Shooting events, family holidays, parties

» Nature photography for personal files

» Flying for fun or personal enjoyment with or without a camera

Current FAA Regulations

All Part 107 requirements and rules can be viewed on the FAA website. The documents are large, and if we were to cover all of them, we would have to make a separate White Paper.

Please note: The FAA's "Operations Over People" came into effect on April 21, 2021. Since then, certified UAV pilots operating under Part 107 can fly at night, over people, and moving vehicles, as long as they comply with the new regulations.

No-Fly Zones for Drones in the USA

In addition to the obvious restricted areas, like airports or the White House, it's not allowed to fly drones over thousands of objects and territories in the United States. Some are prohibited under any conditions, while others require appropriate permissions. You can check the area on the B4UFLY service by the FAA before you launch a drone there. B4UFLY is a free app available on the App Store and Google Play. It is also available for PC for pre-flight planning.
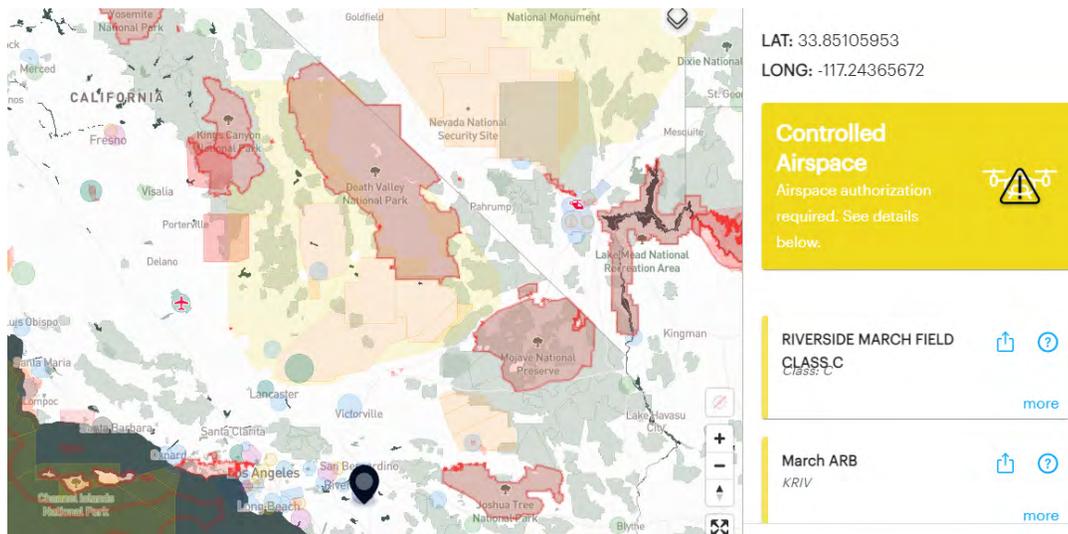
Some states have a lot of territories that restrict or prohibit drone flights.
Source: https://b4ufly.aloft.ai/

AirMap is another popular service. It provides a relevant map with zones where flying is allowed or prohibited and allows you to plan flights based on this info and keep a flight log. The service is updated with air traffic information in real-time.

In the USA, drone flights are prohibited:

» In national parks and nature reserves

» Within 15 miles of the White House

» Over military bases

» Over sports arenas

» Over protected marine areas

» Within 5 miles of airports

» Over the Camp David residence

» Over prisons

Drone-Friendly US States

Brent Skorup, a senior research fellow with the Mercatus Center at George Mason University, said: "With informed federal decision making and collaboration, America will have the world's leading drone industry and policies that balance safety, privacy, and residents' needs."

Skorup is a co-author of the study "Which States Are Prepared for the Drone Industry?" In this rating, experts took into account how developed the legal framework is and the number of drone jobs there are. Where do you think is the most drone-friendly state in the United States? North Dakota! Arkansas and Oklahoma round up the top three. So far, the least drone-friendly state is Kentucky.

Source: mercatus.org. You can select a state on the map and learn more about its current UAV rules.

Drone Laws in the EU

There used to be many different rules regulating drone flights in the EU. But since December 31, 2020, the European Aviation Safety Agency (EASA) has adopted a framework for the operation of civil drones. These regulations apply to all EU countries, as well as the UK, Iceland, Norway, and Liechtenstein.

The document describes the requirements for different categories of drones. Your drone for commercial or recreational use most likely falls into the "open" category.

The "open" category is subdivided into three subcategories:

A1 — You can fly over uninvolved people but not over crowds

A2 — You can fly close to people but not over them

A3 — You cannot fly close to people

UAS		Operation			Operator/pilot	
Class	MTOM	Subcategory	Operational restrictions	Distance from people	Operator Registration Required	Remote pilot competence
Privately build	<250 g	A1	Operate in a visual line of site below 120 m altitude; Fly away from airports; Respect specific rules defined by the zone in which you operate	You can fly over uninvolved people (not over crowds)	No	Read the owner manual
CO					Yes	
C1	<900 g					• Read the owner manual • Perform online training • Pass an online test
C2	<4 kg	A2		You can fly at a safe distance from uninvolved people		• Read the owner manual • Perform online training • Pass an online test • Pass a theoretical test in a center recognized by the aviation authority (only if you intend to fly close to uninvolved people)
C3	<25 kg	A3		You should: • Fly in an area where it is reasonably expected that no uninvolved people will be endangered • Keep a safety distance from urban areas		• Read the owner manual • Perform online training • Pass an online test
C4 (model aircraft)						
Privately build						

Source: easa.europa.eu

You can check if you need to register as a drone operator on the EASA website.

The UK

The UK rules are essentially the same as the EASA's. This is because the UK authorities played a big role in determining EASA's rules.

No-Fly Zones for Drones in the UK

In the UK, the "Aerodrome Traffic Zone" 2 is a 2.5 nautical mile radius cylinder around the aerodrome centered on the longest runway + another 5 km from the threshold of each runway away. These calculations might be confusing, so avoid flying near UK airports. Drone flights are also prohibited:

» In all of London's Royal parks

» Over military bases

» Over Buckingham Palace, Windsor Castle, Balmoral, and other British Royal Family residences

» In some areas of London, including Chelsea, Lewisham, Barking, and Dagenham

» Over power plants

To help you navigate all other locations, National Air Traffic Service (NATS) released an app, Drone Assist, available on the App Store and Google Play. In addition to places with a permanent ban on flights, the app also shows time restrictions during public events or visits by British protected persons.

Drones can only be used at night with special permission from the Civil Aviation Authority (CAA). Without a permit, you can fly drones no later than 30 minutes before sunset and no earlier than 30 minutes after sunrise.

Please note that most land in the UK is privately owned. You cannot take off/land on these territories, and you're often not allowed to fly over them in transit.

Other Countries

Even US states often have very different drone regulations, not to mention other countries. If you want to purchase and use a drone or travel somewhere with your drone, make sure that the local law allows UAV flights.

The UAV Coach project has collected all the available information about drone laws and regulations in different countries. You can check it here.

Industry Associations, Magazines, and Social Media Communities

- **Drone Advisory Committee**

  The FAA's Drone Advisory Committee (DAC) is based in the United States. It is formed of CEO/COO-level executives and experts from various stakeholders: scientists, engineers, UAV sellers, and others. DAC meetings are generally open to the public. DAC meetings & materials are available here.

- **Beyond**

  This is the FAA's initiative to tackle the remaining challenges of UAV integration into business and society. Here are the main tasks that Beyond contributors are working on:

  » Analyzing and quantifying the societal and economic benefits of UAV operation

  » Testing and implementing beyond visual line of sight (BVLOS) operations

  Beyond became a continuation of IPP – FAA's previous program with a similar goal of creating an ecosystem for UAVs in the United States.

- **Partnership for Safety Plan (PSP) Program**

  This FAA program has been promoting the use of UAVs since 2016. In fact, it bridges the gap between the FAA as a regulator and the entire drone industry. Amazon Prime Air, Drone Racing League (DRL), Florida Power and Light Wing (an Alphabet company) are some of PCP's partners. Each partner has its own scope of tasks within the program.

- **UPP High-Level Operational Concept**

  The UPP is a Congressional directive to the FAA and NASA to create a Research Transition Team. The purpose of this team is to facilitate the safe integration of UAVs into the national airspace.

  The following shows how the industry should work. You can read more about this plan and the UPP directive here.
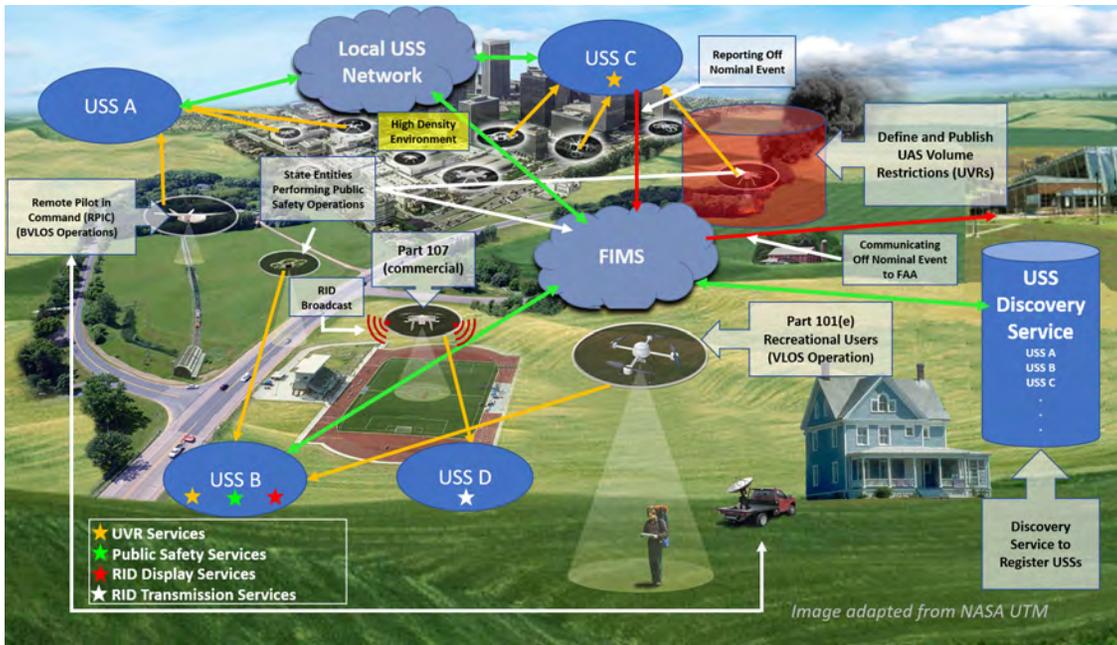
Source: faa.gov

- **Unmanned Systems Canada**

  This is Canada's national association, promoting innovation and opportunities in the Canadian drone industry and community.

- **Women and Drones**

  It is a network of women working with drones in various industries worldwide. They have regular events held online and offer plenty of useful information about working with drones, certification, etc. on their website.

Industry Events

- Commercial UAV Expo is one of the leading trade shows in North America, focused on the commercial drone market.

- The FAA shares information about the most significant events in the industry in the UAS Events Calendar.

- InterDrone is one of the world's largest drone conferences.

- AUVSI XPONENTIAL is an annual conference to promote UAVs and robotics.

Social Media Groups

Drones. A community page for drone-related news, videos, and more.

Droner. For everyone interested in drones, UAVs, multi-copters, and other remote-control aircraft.

Commercial Drone Pilots. This group is for commercial drone pilots and those who are becoming certified.

Drone Mapping, 3D Modelling and GIS. A space to discuss issues related to the use of drones/UAVs for making aerial maps and 3D models of buildings and landscapes and processing/using this kind of data in GIS applications.

UAV/UAS/RPAS/Aerial/Terrestrial Photogrammetry Surveying and Geomatics

UAV Coach

VTOL UAVs Tutorial

Magazines

Commercial UAV News

Commercial Drone Professional

Dronelife

Drone User

Drone User Magazine

Drones Monthly

Inside Unmanned Systems

MDPI

SUAS News

Vertical Space

Leaders, Authorities, and Developers

Frank Wang Tao

Frank Wang Tao is the CEO of SZ DJI Technology Co., Ltd. He has turned his childhood hobby of aeromodelling into a lifelong business. Today, with a $5.4 billion fortune, he is one of the brightest and most influential people in the drone industry.

Source:
cdnmedia.baotintuc.vn

Amit Ganjoo

Amit Ganjoo is the CEO of ANRA Technologies, one of the UAV technology giants. He is a serial entrepreneur with 20 years of experience in aviation, telecommunications, and wireless communications.

ANRA started in a garage in 2015, and today it is an international company with offices in London, Washington, DC, and New Delhi. ANRA projects include a drone identification service in Switzerland, a drone delivery network to transport medicine in the UK, and a partnership with Hyundai to develop air taxis. The company also participates in the EU's project AMU-LED, which aims to safely integrate cargo and passenger drone operations in urban airspace.

Michael Winn

Michael Winn is CEO and Co-Founder of DroneDeploy, a cloud-based drone platform that provides automated flight safety checks, workflows, real-time mapping, and data processing.

Anil Nanduri

Anil Nanduri is Vice President of the New Technology Group and General Manager of the UAV segment at Intel Corporation. He is responsible for establishing and running Intel's drones. Anil emphasizes drone safety, rightfully calling it a fundamental and critical issue for the global growth of drone technology.

Stephen Dickson

Stephen Dickson is an Administrator at the FAA. Before joining the FAA, Stephen was a US Air Force pilot and Delta Air Lines executive, one of the largest US airlines. As head of the FAA since March 2019, he has accomplished a lot in terms of popularizing and integrating UAVs. The new FAA rules regulating drone flights and remote pilot certificates are largely due to him.

Kay Wackwitz

Kay Wackwitz is the co-founder and CEO of Droneii (Drone Industry Insight), one of the industry's most respected publications. Kay has 22 years of experience in both manned and unmanned aviation.

Sally French

You may know her as Drone Girl, the best drone tech journalist in the world. Her analytical pieces, reviews, and columns are published on Forbes, The Wall Street Journal, The Economist, and other publications. Sally speaks at industry events worldwide as a UAV trendsetter and visionary.

Nicholas Horbaczewski

Nicholas is the founder of The Drone Racing League, the world's largest drone show. DRL also builds its own racing drones, improving frames and technical capabilities. Nicholas is putting a lot of effort into creating unique content and popularizing drones. Races are shown on TV and are also available on the project's YouTube channel.

Denise Soesilo

Denise is the co-founder of Outsight International. She works at the forefront to revolutionize humanitarian aid delivery with UAVs. She also continuously works with regulators in Switzerland, representing the interests of the industry.

Dan Burton

Dan is the founder and CEO of DroneBase. He became interested in drones in the United States Marine Corps, where he served for four years. After the USMC, he worked as an industry analyst for the US Senate and Goldman Sachs. Dan is currently growing DroneBase as a global platform that provides aerial imagery even for those who don't have a drone.

Drone Practitioner Certificates

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🇺🇸

**US
registration site**

🇬🇧

**UK
registration site**

🇨🇦

**Canada
registration site**

Which Certificates Do You Need?

Commercial use of drones requires pilots to register and obtain relevant certificates. But even if you are just shooting a party with friends in your backyard on a drone, you will need a basic registration.

How do you know which documents you need? What is the course of action? If you are in the United States, you can take the FAA test to figure it out. The tool is available here.

YOU **DO NEED** A LICENSE IF

You plan to fly a drone for any non-recreational purpose, such as:

- Flying a drone for hire
- Flying a drone for internal operations within your organization
- Flying a drone for a public safety department or other government entity*

YOU **DON'T NEED** A LICENSE IF

You plan to fly a drone for a recreational purpose, such as flying in your backyard, local park, or on vacation

* Public safety departments and other government entities Can under Part '07 rules or by applying for a Of Authorization (COA).

Source: dronepilotgroundschool.com

How to Obtain a Part 107 Certificate in the USA

If you are flying a drone for commercial purposes rather than your personal enjoyment, you must:

1 **Review the Rules for Remote Pilots, Part 107**

The rules officially came into force in March-April 2021. They lay down detailed regulations for the operation of drones in the city, outdoors, near industrial facilities, roads, rivers, and lakes. There are no special tricks for this point – just read and memorize the rules. But there are practice tests and courses to assess your knowledge before taking the official FAA exam. More about it later.

2 **Become Certified as a Drone Pilot**

To be eligible for a Remote Pilot Certificate, you must be:

» At least 16 years old

» Able to speak, read, write, and understand English

» In a physical and mental condition to safely fly a drone

3 **Register Your Drones Weighing Under 55 Pounds With the FAA's Dronezone**

If you plan to use drones with certified pilots for business purposes, you will need to create a Part 107 account in the FAA's DroneZone. Use your company name as the account name. After registering, add the drones you will be using to Inventory and their pilots to User Inventory.

Registration costs $5 and is valid for three years. During registration, you will need to enter the make and model of the drone and have a debit/credit card on hand.

If you still have questions regarding the required documents and the procedure for Part 107 certification, check out this detailed guide from the FAA and this page.

What Is a Part 107 Test?

The Part 107 certification test involves 60 multiple-choice questions that you need to answer within two hours. The minimum passing score is 70%.

Questions are constantly changed and combined, but you should be well-versed in certain topics to pass, such as:

» The current FAA laws regulating drone flights

» Characteristics of radio communication

» National Airspace System (NAS) requirements

» How the operator should act in emergencies

» Drone flights in different weather

» Flight rules near airports, etc.

» Technical aspects of UAV operation

Where Can You Take the Part 107 Test, and How Much Does It Cost?

● **Where to Take the Test**

There are more than 700 FAA-approved testing centers in the United States. You can find the closest available center on the Psiexams platform – Find a Test Center. Select Unmanned Aircraft General – Small (UAG) from the list of exams.

To avoid the risks of exposure to COVID-19, the testing can be taken online. The online test has additional requirements to ensure compliance.

● **Cost**

The total cost will depend on whether you take paid courses and pass the test on the first try. Therefore, it can range from $175 (without a course, first try) to $1,000+ (with courses and retakes).

If you are taking a paid course for future drone specialists, you can get a tax refund of up to 30% of training expenditures.

How to Prepare for the Part 107 Test

- **FAA Prep Test**

  The FAA offers a free practice test that you can take multiple times. It's unlikely to have the same questions as an actual test, but it helps you understand what to prepare for.

- **Test from a Practicing Aviation Attorney**

  Here is an excellent free test with 72 questions made by practicing aviation attorney and FAA-certified flight instructor Jonathan Rupprecht. These questions don't mirror actual FAA test questions, either, but they are very close.

  We can also recommend this guide by Jonathan Rupprecht to prepare for Part 107 testing.

- **Udemy Online Courses**

  Yes, some of them cost as much as the FAA test itself. But if your goal is knowledge and skills, rather than just a certificate, strongly consider them.

  » UAS/Drone Remote Pilot Test Prep for Part 107

    This is the most popular Part 107 course on the platform. It is the best-selling product with the highest rating as well. This isn't surprising, considering the course is taught by the #1 Aviation Instructor on Udemy. Price: $129.99.

  » 4hr FAA Part 107 Knowledge Test Prep for Drone Pilots

    This course costs ten times less than the previous one, but it's not far off in terms of its reviews and average rating. There is significantly less training material, so this might be optimal for people with some experience and knowledge about operating UAVs. If you are a beginner, consider taking a more in-depth course.

What to Do After Receiving the Certificate

Right after receiving your certificate (or even beforehand), you need to insure your drone and purchase a civil liability policy for risks arising from the operation of UAVs. This is especially useful for beginners who aren't very confident with their operating abilities. Conveniently, insurance companies have different tariffs: yearly, monthly, per number of flights, and even for a specific time activated right before flying.

Find favorable conditions specifically for you, for example, on Drone Insurance.

What to do next:

1. Renew your registration every three years.

2. Refresh your knowledge and renew your operator's license every two years.

3. Report drone accidents to the FAA within ten days of the accident if it resulted in personal injury or financial damage of over $500.

4. Fly! But before each flight, inspect the drone's frame, propellers, propeller blades, landing gear, and payload mountings. Always do this, even if you checked the drone after a previous flight.

How to Legally Fly a Drone in the US (If You're Traveling)

You're not a US citizen but would like to bring and use your drone here? Follow these guidelines from the FAA. And remember about the flight restrictions that we discussed in the "Standards" section.

When Is Part 107 Certification Not Enough?

While this is not obvious, there are also separate regulations (in addition to Part 107) regarding:

1. Dispensing chemicals and agricultural products. This regulation does not apply to all substances – check if your task meets the FAA criteria for Part 137 Agricultural Aircraft Operations.

2. Package delivery. It is a large separate section regulated by Part 135.

3. Flights over emergency zones. The following situation may be relevant in the context of this White Paper:

   - Inspection and restoration of service networks, communication lines, transport infrastructure

   - Damage assessment before making insurance claims

   - Creating news stories for the media

How to Use Drones in Education

Drones can be powerful tools that help in classes like geography, geology, engineering, agronomy, biology, physics, and more. They can be used both in secondary-level education and in colleges, as part of STEM programs (Science, Technology, Engineering, and Math), or as a bonus to other educational programs.

If you are an educator and plan to use drones in your classroom, here are the current FAA guidelines.

You may be interested in the material from the Esri Education Conference on Drone Use in Higher Education. Read more about using drones in education here.

How to Get Certified for Commercial Flights in the UK

To fly a drone in the UK, you typically need two documents – a Flyer ID and an Operator ID. Your Flyer ID shows that you have passed the general test and know how to fly a drone. Your Operator ID is the registration number that must be stamped on your drone.

The Flyer ID is free, available to anyone from the age of 12, and valid for five years. The applicant must pass a theory test on drone operation with at least a 75% mark. To get a UK Operator ID, you must be at least 18 years old (for comparison, it's 16 in the US).

Registration is not required to operate drones and toy aircraft models. Learn registration requirements for drones and model aircraft in the UK (even if your drone weighs less than 0.55 lbs/250 grams).

How to Get Certified for Commercial Flights in Canada

There are two categories of drone operation in Canada: basic and advanced. Here you can learn in detail what they are and how to register drones. As in the USA, drones weighing up to 250 grams do not need to be registered, even if they have a camera installed.

Operators must carry a valid pilot certificate with them any time they're working with drones. Certificates can be basic and extended depending on the purpose of using the drone. The process of obtaining certificates is available on the Transport Canada website. Certificates are valid indefinitely, but it is assumed that operators will keep their knowledge up-to-date independently.

Source: tc.canada.ca

Functional Check

How do you know that you need a drone, and what exactly can you do with it in your business?

Brian Krzanich
former CEO of Intel Corporation

> *Hundreds a year are killed inspecting power lines, inspecting power lines, gas lines, and cell phone towers. They fall. There are helicopter crashes. We can eliminate all that with autonomous drones and artificial intelligence.*

When you have a problem, there is often a lack of understanding about the possible solutions. This is largely due to the fact that we do not fully understand the capabilities of certain technologies. Here are the signs that a drone is most likely a useful tool for your company.

1. You often use manual labor for rounds and checks, as well as inspections of infrastructure, territories, communications, buildings, and fields.

2. You often obtain large volumes of survey data by using hand-held tools from ground level.

3. You sometimes use aerial photography: you rent a helicopter or an airplane to map your fields, roofs of buildings, pipelines, etc.

4. You have a large farm and want to improve its efficiency: increase yields, respond quickly to plant-disease outbreaks, optimize watering, etc.

5. You have a construction company, a high volume of purchases, and you do land, concrete, and roofing works.

6. You have an insurance company, which involves processing requests after an emergency.

7. You have a roof service company that works with buildings and structures, oil and gas pipelines, power lines.

8. You have large warehouses with a long list of products, you often conduct inventories, and you ship a large volume of goods.

By the way, this is not an exhaustive list! It only shows the wide range of possible uses for drones in today's business processes.

You may already have a drone or even a field crew using drones. And you probably generate plenty of data with them. But what to do with it next? The data accumulates, but what if you can't get the benefits that you expected? Should you improve the drone and software to solve your business problems in a more meaningful way?

We'll help you get the most out of your drone! Intetics Inc. has solid experience in developing custom solutions for drone control, data analytics, and integration with business processes. Contact us: contact@intetics.com

Resources to Check Out

1. The article "10 Things You Need to Know About Adopting Drones for Your Business" thoughtfully explains the journey and how to avoid pitfalls when choosing contractors.

2. The book "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation".

3. If you want to start a service business that uses drones, read the article "Step-by-step Guide to Launching Your Drone Business" to navigate and know what to look for.

Further Reading: Books, Websites, Articles

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Books

Prefer the printed format? The book "FAA 107 License Practice Test Questions and Answers" will help you prepare for the Part 107 test. It takes into account new FAA regulations.

The book "Making Money With Drones: Drones in the Construction Industry" will give you some ideas; perhaps you can make money as a contractor or use your own drone to optimize your company's business processes.

Remote Pilot Test Prep 2021 (ASA Test Prep Series). The textbook does not have an overview of the new FAA rules because it was released prior to that. But it has a lot of good reviews and will help you prepare for all the basic Part 107 questions that remain the same.

"Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation" is another book about using drones in certain industries.

The book "Livin 'the Drone Life: An Insider's Guide to Flying Drones for Fun and Profit" will be useful for those who want to provide services using drones or use them in their business.

You might be interested in a selection of the 100 Best Drones Books of All Time.

YouTube

FREE Drone Certification Study Guide: FAA Part 107 sUAS Test. This video will get you up to speed on the basics. But it does not contain important information regarding the new FAA rules, effective since Spring 2021. Also, make sure to read the rules in Part 107, especially chapters Operations Over People, Night Operations, Flying Over a Moving Vehicle, and Remote Identifications.

Remote Pilot 101. YouTube channel talks about FAA news, reviews drone and wearable payload, etc.

The UAV Coach channel shares weekly coverage of drone news. You will also pick up many great tips: how to travel with a drone, how to make money with a drone, the rules on flying over people, etc.

Ready Set Drone. A great channel with tips on choosing drones and accessories, crash tests, the latest product comparisons, and more. The channel also does live streams with drone experts.

WetalkUAV [Alex Assenmacher]. An interesting channel with reviews of drones, cameras, and other payloads. High-quality videos, professional editing. The channel mostly focuses on drones in the hobbyist segment.

DJI. The official channel shares shooting tips and beautiful videos to demonstrate what DJI drones are capable of.

Aerial Influence. It's a must-watch if you use drones in agriculture (or are planning to). Life hacks, drone and payload reviews, and valuable experience of farmers and drone operators.

Billy Kyle. Another interesting channel with technical reviews, mostly by DJI.

Sites

Drone Industry Insight is a leading analytics company that specializes in drones. Their website features studies across market sectors, forecasts, reports, both as free publications and paid documents.

Drone Herald is a popular online drone media. Hou to You will find industry news, reviews, analytics, and expert opinions.

The Droneflyingpro blog has many in-depth articles from actual pilots and engineers on topics like how to choose a drone, repair and maintenance, handling, upgrades, and more.

The Skyward blog has a lot of valuable information from specialists in various industries.

TechCrunch, a reputable tech publication, has a decent amount of drone coverage. You can find relevant news and analytics by searching the tag.

You might be surprised that the International TED Conference website has over 430 videos about drones or with mentions of them. Take a look; they're very interesting!

Other Useful Information

Drone Safety Checklist by Coptrz

Experts at Coptrz advise you to pay attention to the following points before flying a drone and during take-off.

- **Weather**

  1. The probability of precipitation is less than 10%.

  2. The wind speed is less than 15 knots (20 mph).

  3. Visibility is at least three statute miles (SM).

  4. Fly during daylight hours and the permitted civil hours. Keep track of the sunrise and sunset times: they change all the time.

  5. Establish zones for takeoff, landing, and emergency hovering zones in advance.

  6. Keep distance from towers, wires, buildings, trees, etc.

  7. Keep the drone away from people and/or animals; enable a security perimeter if necessary.

  8. Discuss the mission with other crew members (if you're not working alone).

- **Visual Inspection**

  1. The registration number is properly presented and legibly displayed.

  2. Inspect the aircraft frame, propellers, engines, and landing gear for damage.

  3. Inspect the gimbal, camera, transmitter, payload, etc., for damage.

  4. Ensure the lens covers are removed.

  5. Wipe the lenses with a microfiber cloth.

6. Attach propellers, battery, insert SD card, lens filters, etc.

Powering Up

1. Turn on the transmitter/remote control and open the app.

2. Turn on the drone.

3. Make sure there the transmitter and the aircraft have a connection.

4. Position the antennas on the transmitter towards the sky.

5. Make sure the display panel/FPV screen is working properly.

6. Calibrate the Inertial Measurement Unit (IMU) if necessary.

7. Calibrate the compass before each flight.

8. Check the battery/fuel level on both the transmitter and the drone.

9. Make sure the drone has received GPS position data from at least six satellites.

Take-off

1. Gradually gain altitude for 10-15 seconds.

2. Pay attention to any imbalances or irregularities.

3. Listen out for unusual sounds.

4. Tilt the drone in different directions, turn it to assess how fast and accurately it responds to commands.

5. Check for EMI or other warnings from the software you're using.

6. Once again, make sure that there are no people, animals, vehicles, or static obstacles in the area.

How to Find a Lost Drone without Gps

These tips will help you find your drone when something goes wrong:

1. Install an autonomous Beacon on the drone.

2. Install bright-colored propellers and landing gear that contrast with plants: light green, orange, pink, white. They will help you spot the drone in the foliage.

3. Stick fluorescent tape on the drone. It will be visible at night in ultraviolet light.

4. Attach a sound alert device to the drone, for example, like this one. Make sure its built-in battery is working. When the drone's battery runs out, the device will make loud noises for several hours.

5. Watch the video of the flight, find the location based on the last images it transmitted. If you were not shooting when it fell, it might have flown tens of meters further.

6. Send short pulses from the remote control. If the drone fell in bushes or trees, some of the rotors may be blocked, and others will be able to spin. But do not turn on the power for a long time – it may burn out the motor.

7. If you are a beginner and fly in areas with lots of bushes and trees, carry a fishing rod with you. You can attach a hook or a neodymium magnet that can hold the drone. The rod is also convenient for removing drones from tall branches without risking your safety.

Consider the Subtleties of "Commercial Use"

If you only use your drone for entertainment or recreational purposes, you still need to be careful. If you shoot for someone else's channel/account, then this could be interpreted as a commercial service, even if you did not charge for it, especially if the channel/account that posts your content promotes some goods/ services and is a public page.

If your friends post photos from your party taken by your drone, there shouldn't be any problems. But if your content is regularly published in the media or reposted by a blogger with a large audience, it can raise questions.

More Useful Links

[Use These 15 Drone Training Exercises to Learn How to Fly a Drone](#)

[7 Ways to Tell Which Drone Insurance is Right for Your Business](#)

[Routine Drone Maintenance Checklist](#)

[How to fix a drone that fell in water? The 6 simple steps!](#)

[How to buy a second hand drone — 50 part checklist [FREE checklist download]](#)

[Guide to Buying Used Drones (Tested on DJI Mavic 2 Series)](#)

[Drone Buying Guide 2021. Choosing the Right Drone](#)

Summary

XXXV

Future Directions of the Drone Industry

1. Automation

Thanks to advances in AI, the evolution of 5G networks, and the favorable of legislation, we will see more examples of autonomous operation BVLOS drones over time. The public does not fully trust them yet, which is good in some ways: it is better to play it safe until the technology is perfected. Drones will reach their full potential when they can handle most of the work themselves, independently from an operator and controller. Today, even with human involvement, they have obvious benefits. They have a great ROI, optimize processes, increase profitability, and reduce costs by helping to respond to emergencies as quickly as possible or even proactively.

2. Drone Computers

Modern drones are equipped with AI tools, so they can already partially process the data they collect. Instead of providing operators with raw data, they offer structured and marked-up images, maps, and videos. This trend will continue to evolve. Of course, you cannot do without the software and actual computers because task volumes and specifics are meant for powerful video cards, multi-core processors, and sizable storage devices.

3. Changing the Urban Environment and User Experience

Ernst & Young analysts note that the drones will not adapt to the existing urban environment. On the contrary, they will dictate the rules to be taken into account when designing and building cities. In particular, there should be platforms for vertical take-off and landing of drones, parking spaces, and charging stations on roofs and parking lots. Stores, cafes, and other establishments will have a customer service paradigm shift that will include new delivery options.

Just a couple of years ago the first car driving on autopilot invoked admiration, distrust, and interest all at the same time. The same will soon happen to autonomous delivery drones and then taxi drones. But before those become a reality, there are many issues to be addressed in terms of safety, battery capacity, and adaptability of the urban environment.

In the next few years, we will see explosive growth in the UAV industry. Such growth is possible thanks to technological improvements, growing affordability, adapting laws, and... competition. Yes, competition encourages everyone to increase work efficiency, reduce costs, and offer something better, unique, and higher-quality. Drones have already succeeded in replacing people in many routine processes, doing the same job faster and better.

This is a global trend of the current fourth industrial revolution: everything that can be automated must be automated. The pace of life is increasing, and consumer habits are changing.

"

Opportunities are like sunrises. If you wait too long, you miss them.

William Arthur Ward

"

If a window of opportunity appears, don't pull down the shade.

Tom Peters

"

It's through curiosity and looking at opportunities in new ways that we've always mapped our path.

Michael Dell

"

To stay ahead, you must have your next idea waiting in the wings.

Rosabeth Moss Kanter

"

A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty.

Winston S. Churchill

"

A wise man will make more opportunities than he finds.

Francis Bacon

See what this is about? If you ignore the benefits and opportunities that drones can bring to your business, you are losing a crucial competitive advantage, ending up way behind. A relentless and ruthless marketplace will get rid of all, anything that does not contribute to further developments.

WE WISH YOUR BUSINESS CONTINUED GROWTH AND PROSPERITY AND BELIEVE THAT DRONES WILL HELP YOU ALONG YOUR UNIQUE PATH TO SUCCESS.

Intetics Inc.

Glossary

A−Z

A　**Above Elevation Data (AED)**
SenseFly's eMotion flight planning software, AED altitudes are relative to the currently active elevation data model and are defined as the approximate altitude above the ground.

Above Ground Level (AGL)
Refers to the height a UAV is flying above ground level. For example, a drone flying 200 feet above a 70-foot hill would be 200 feet AGL and would then change to 270 feet AGL after flying over the hill.

Above Mean Sea Level (AMSL)
The altitude relative to a standard mean sea level geoid.

Above the Takeoff Altitude (ATO)
The altitude relative to the place a drone started its motor just before takeoff.

Accelerometer
A device that measures directional acceleration; used to stabilize drones.

Acro Mode
Also known as manual mode and rate mode. Arco mode doesn't automatically level the aircraft. The pilot will have to constantly make adjustments to maintain control of the drone.

Aircraft
A device used for flight in the air.

Air Traffic Control (ATC)
A service provided by ground-based air traffic controllers (such as FAA in the US) who direct the safe and orderly flow of air traffic.

AMA (Academy of Model Aeronautics)
A non-profit organization dedicated to the promotion of model aviation as a recreational activity and recognized sport.

Atti Mode
DJI flight mode is short for Attitude Mode, where the drone will maintain a specific altitude but not position. This means that the drone will maintain its height, but the pilot will have to constantly adjust to maintain its position.

Auto-Leveling
A flight mode that allows the drone to perform even flight. This is typically an automatic feature that is engaged through a setting on the drone.

Autonomous Flight
Flight of UAVs that are controlled by internal programming, rather than a person with radio control that directs the drone where to fly.

B

Background Map
A visual 2D map of a region featuring landforms, roads, etc., onto which additional data is layered, also referred to as a base map.

Barometric Altimeter (BARO)
An altitude measurement sensor that uses barometric pressure.

Bind
A procedure to link the drone to the controller.

Brushless Motor
Brushless motors are more efficient and durable when compared to brushed motors. They have permanent magnets that rotate around a fixed armature.

BVLOS (Beyond Visual Line of Sight)
The ability to operate an unmanned aircraft beyond the pilot's line of sight. This requires a special permit from the FAA in the USA.

C

CAA
The CAA (otherwise known as the Civilian Aviation Authority) is the UK's specialist aviation regulator. It ensures that the aviation industry meets the highest safety standards. It also ensures that consumers have choice, value for money, and are protected and treated fairly when they fly. To operate a drone commercially in the UK, you need to gain Permission for Commercial Operations from the Civil Aviation Authority (CAA).

Ceiling Height
The maximum adjustable vertical height that the drone can fly to within the allowable working area.

Check Point
A surveyed point on the ground used to verify the accuracy of photogrammetric outputs. These include DSMs, point clouds, 3D mesh, orthomosaics, and DTMs.

Center of Gravity
The location where most of the aircraft's weight is located. The center of gravity needs to be positioned almost perfectly in the center of the UAV to ensure level flight and stability in the air.

Certificate of Authorization (COA)
A waiver issued by the FAA that allows a public operator to perform specific UAS operations.

Commercial Drones
A UAS designed for heavy use with a specific purpose in mind, such as package delivery, 3D mapping with LiDAR, search and rescue, and professional cinematography. Examples of commercial drones include the DJI Matrice 600 Pro and the Freefly ALTA 8.

Contour Map
A topographic map that delineates surface elevation using contour lines.

Controlled Airspace
Airspace of defined dimensions within which ATC services are provided. The level of control varies with different classes of airspace.

Collision Avoidance
A system that prevents pilots from flying into other aircrafts and fixed objects such as buildings, powerlines, trees, and towers.

Controller
A handheld device that uses radio signals to control the drone.

D ### Digital Elevation Model (DEM)
A 3D display in the form of a raster grid that features the bare earth, removing all natural and artificial features.

Digital Surface Model (DSM)
A 3D display of an area that includes the tops of buildings, trees, and other ground-based objects.

Digital Terrain Model (DTM)
A 3D display of vector data that features natural terrain and regularly spaced points.

DJI
Acronym for Dà-Jiāng Innovations, which is the largest manufacturer of unmanned aerial vehicles (UAVs) and is based in Shenzhen China.

DJI Flight Modes

- **S Mode**

  Stands for Sports Mode; S Mode allows the DJI drone to fly and maneuver twice as fast as normal.

- **P Mode**

  The standard flight mode that most pilots use. P Mode allows for precise hovering of the drone. All sensors are active including GPS, image, and infrared.

- **A Mode / Atti Mode**

  DJI flight mode is short for Altitude Mode, where the drone will maintain a specific altitude but not position. This means that the drone will maintain its height but the pilot will have to constantly adjust to maintain its position.

Drone
The common term used to describe UAVs (Unmanned Aerial Vehicles). This term is used to describe many types of UAVs of different sizes and purposes ranging from toy quadcopters to military drones.

Dronie
A self-portrait or self-video captured using a camera drone.

E

eBee X
A fixed-wing drone produced by sensFly capable of covering more distance than a quadcopter used for carrying different payload options for photogrammetry, 3D mapping, multispectral, and infrared.

Electromagnetic Interference (EMI)
Electrical interference caused by proximity to metal, magnets, powerlines, or cell towers.

Elios
A collision tolerant intuitive and precise drone for indoor inspection.

ESC (Electric Speed Control)
An electronic device paired with the drone's power supply and flight controller to control the speed and direction of the drone's motors.

Extended Visual Line of Sight (EVLOS)
An operating method in which the drone operator relies on remote observers to continuously keep the drone within their visual line of sight.

F

FAA (Federal Aviation Administration)

A United States Department of Transportation Agency with the authority to oversee and regulate all aspects of American civil aviation.

Fail Safe

A system that helps protect a drone in case of an error. An example of this would be having the drone automatically return home if the signal is lost.

FC (Flight Controller)

The brain of a multirotor.

Flight Log

A record of a single flight. Traditionally, this would be written by a pilot. In the case of senseFly drones, this is a digital record that is generated automatically.

FOV (Field of View)

The measurement, in degrees, of how much can be seen through a camera lens.

FPV (First Person View)

The pilot sees what the drone sees through the use of a screen or mobile device.

Frequency

The radio frequency that the FPV equipment runs on. Allows for multiple channels so pilots can find a channel without interference from others.

G

Geofencing

A virtual geographic boundary created for the use of GPS and software to limit where a drone can and cannot fly.

Geotag

An electronic tag (grouping) of geographic information (coordinates) that is assigned to media such as photographs and videos via the process of geotagging. In the case of senseFly drones, this process is handled automatically via the eMotion flight-planning software).

GeoTIFF

A public domain metadata standard that allows georeferencing information to be embedded within a TIFF image file.

GCS (Ground Control System)

A ground-based control center, such as a laptop computer, that allows for human control of UAV flights. A device that measures directional acceleration; used to stabilize quadcopters.

Gimbal

The mount on a drone where a camera sits; it usually enables the camera to move and stabilize along multiple axes.

GIS (Geographic Information System)

A system used to capture, store, manipulate, analyze, manage, and present spatial or geographic data.

Global Navigation Satellite System (GNSS)

A satellite navigation system with global coverage, such as GPS, GLONASS, and the European Union's Galileo system.

GLONASS/GNSS

Global Navigation Satellite System, refers to Russia's version of GPS, another navigation system with global coverage and similar precision.

Global Positioning System (GPS)

Refers to the United States NAVSTAR Global Positioning System, a space-based navigation system that provides location and time information anywhere on or near the Earth.

Ground Control Point (GCP)

A location or object on the ground that has precisely established coordinates. Used to improve the precision of DSMs created by photogrammetric analysis of a series of images.

Gyroscope

Assists with keeping a quadcopter level while maintaining its reference direction.

H

Hexacopter

A multirotor aircraft with six rotors. The advantage of a hexacopter is that even if one engine fails, you will still be able to land the drone safely.

HIRTA (High Intensity Radio Transmission Area)

Flying through an HIRTA can interfere with the electronics on your drone.

Hobby Grade

An upgrade from a toy drone, these quadcopters are reliable at a reasonable price and are typically equipped with a camera.

I

Image Overlap

An intersection of imagery. The more image overlap, the better the output. It helps the software process images and creates a clearer, more detailed map.

IMU (Inertial Measurement Unit)

A controller that combines an accelerometer and a gyroscope, with the purpose of stabilizing and orienting a quadcopter.

Index Calculator

A generated index map/grid where the color of each pixel is computed using a formula that combines different bands of the reflectance map.

Index Map

A map that represents specific values for vegetation or soil, such as greenness or soil moisture.

Infrared Imagery

The output of images based on heat energy on the infrared spectrum.

INS (Inertial Navigation System)

A system that calculates position based on the initial GPS reading while incorporating speed and motion sensor readings. Useful when a drone loses GPS signal.

IOC (Intelligent Orientation Control)

This sets the forward control of the drone to equal the direction the nose of the drone is pointing.

IP Rating

A rating system used to classify the degree of protection that an electrical enclosure has against water and dust.

K

Keyhole Markup Language (KML)

An XML notation for expressing geographic annotation and visualization within internet-based, two-dimensional maps and three-dimensional Earth browsers.

Keypoint

An identifiable point on an image. The process of photogrammetry involves the matching of common keypoints on two or more images.

Kinetic Energy

The energy an object possesses due to its motion.

L

LAANC (Low Altitude and Notification Capability system)

LAANC allows drones access to controlled airspace in near real-time. It is a collaboration between the FAA and private companies in support of UAS integration into the national airspace.

Lithium Polymer Battery (LIPO)

Battery chemistry that offers more power and less weight than NiMh and NiCad batteries. Variants include: Lithium Ion.

LiDAR (Light Detection and Ranging)

A method of detecting, measuring, and mapping using a laser. Often used for measuring in more difficult situations that require a higher degree of precision.

Light-Emitting Diode (LED)

A semiconductor device that emits light when an electric current is passed through it.

LiPo (Lithium Polymer)
The most commonly used battery type in drones.

LOS (Line of Sight)
An FAA requirement for drone operation that states that the pilot must see the drone from the operating point at any given time.

M

Magnetometer
A geophysical instrument that measures the strength of the Earth's magnetic field. Used alongside sensors such as gyrometers and accelerometers to determine an aircraft's altitude (its orientation relative to the Earth's horizon).

MAh (Milliampere hours)
A unit of measurement that describes the energy capacity of a battery.

MAVLink (Micro Air Vehicle Link)
The most commonly used protocol for communication between drones and ground control systems (GCS) to transfer information about orientation, speed, etc.

Meta Data/Metadata
A set of data that describes other data. In the case of a photo, metadata might include where an image was captured (i.e., its geographic coordinates), who captured it, the camera used, and more.

METAR (Meteorological Terminal Aviation Routine Weather Report)
Also known as a Meteorological Aerodrome Report, METAR is a format for reporting weather information. A typical METAR usually contains data for temperature, dew point, wind direction and speed, precipitation, cloud cover and heights, visibility, and barometric pressure.

MSL (Mean Sea Level)
Altitude measured above the average height of the ocean/sea.

Multicopter
A rotorcraft with more than two propellers.

Multispectral Imagery
The output of images that measure wavelengths through light, which then comes together in multiple layers of wavelengths to create geographically accurate mosaics.

N

No Fly Zone
A restricted area where drones are not allowed to fly. Airports and government buildings are prime examples.

Normalized Difference Vegetation Index (NDVI)
One of the most commonly used vegetation indices in precision agriculture. NDVI provides information regarding the chlorophyll content in plants.

NOTAM (Notice to Airmen)
A notice provided to warn aircraft and pilots of any possible hazards or flight restrictions at a specific location or along a flight route.

O

OAS (Obstacle Avoidance System)
A system programmed into the drone that warns pilots of obstacles and dangers of collision with a moving or stationary object.

Obstacle Avoidance
A vision that allows UAVs to detect obstacles in their paths and avoid collisions.

Orthomosaic
A large image comprised of adjoining orthorectified images that have been digitally reconstructed. A common mapping drone output (often in GeoTIFF format).

Orthophoto
An aerial image where the effect of the central projection has been removed (orthorectified) according to the DTM and the orientation of the image. Refers to a single image from a satellite, aircraft, or drone.

Octocopter
A multirotor aircraft with eight propellers.

P

Parallax
A visual effect caused by the apparent location of an object viewed from two different lines of sight. The change in the angular position of two fixed points relative to each other, as seen by the observer, is due to the observer's movement.

Part 107
Regulations that define safety standards and restrictions for commercial drone operators created by the Federal Aviation Administration.

Payload
A component or product carried by a drone to fulfill a specific mission. In the case of aerial imaging drones, the main payload is the camera. The payload can also be a lidar, thermal imager, custom devices for shooting, spraying agricultural fertilizers, etc.

Photogrammetry
A method of mapping and surveying achieved by stitching photographs together to create one large image.

PIC (Pilot in Command)
The person who is ultimately responsible for the operation and safety during flight.

Pitot Tube
The instrument on an aircraft that measures air pressure in order to calculate airspeed.

Pitch
Used to describe upward and downward movements along the vertical axis from the front to the back of the drone.

Point Cloud
A set of data points in a 3D coordinate system. These points are typically defined by X, Y, and Z coordinates and additional information such as image intensity, RGB value, etc.

Post-Processing Kinematic (PPK)
A kinematic technique that corrects geotag locations after the drone data has been captured and uploaded; an alternative method to Real-Time Kinematic.

Professional Drone
A high-end UAV fitted with the latest technologies designed for a specific type of professional use, such as for professional media or for precision mapping.

Propeller
An angled blade used to create an area of high and low pressure to provide lift or thrust.

Q

Quadcopter
A multirotor with four propellers.

R

Racing Drone
A quadcopter that is designed to compete in first-person view racing.

Radio Link
The quality of the wireless connection between the drone and the ground control station. Each radio unit consists of a transceiver and an antenna, typically operating in the range of 6-23 GHz.

Rasters
Digital photographs taken with a drone can be called this for ease of communication.

Raster Data
This is a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as RGB value, temperature, altitude, etc.

Red Green Blue (RGB)

Visible region of the electromagnetic spectrum approximately 400 to 700 nm. In this spectrum, all conventional cameras and multispectral cameras operate, capable of shooting, including alternately in each of the light waves – R, G, and B.

Return to Home (RTH)

A setting that the drone operator can trigger on the remote control to tell the drone to automatically return to a set location if the signal is lost or the battery power is low.

Real-Time Kinematic (RTK)

A technique used to enhance the precision of position data derived from satellite-based positioning systems, which relies on a single reference station or interpolated virtual station to provide real-time corrections.

Remote Sensing

The process of obtaining information about a physical element or surface from a distance, i.e., via UAV.

Roll

Used to describe upward and downward movement on each side of the drone.

S

Sense and Avoid

If the drone supports this technology, it will automatically dodge stationary obstacles like buildings, as well as other aircraft and moving objects.

Servo

Drone component that assists with positioning and acceleration. Sometimes also called an "actuator", servomotor, or servomechanism.

Spatial Awareness

The ability of the drone to "understand" its boundaries and position itself in space with this in mind.

Spotter

This person keeps the drone in their visual line of sight (VLOS) when flying in FPV.

sUAS (Small Unmanned Aircraft System)

Unmanned aircraft systems that weigh less than 55lbs.

T

Telemetry

A two-way digital data stream that relays flight data and instructions between the UAV and ground station.

TFR (Temporary Flight Restriction)

A temporary restriction on all flights that applies to a specific area due to the presence of government VIPs, natural disasters, special events, and other unusual occurrences.

Thrust
The amount of force driven by the throttle that generates lift.

Trim
Buttons on the controller used to control roll, pitch, yaw, and throttle.

Tx (Transmitter)
In FPV mode, this links the drone camera's live stream to the goggles. Also called a "video transmitter" (VTX), "video receiver" (VRX), or "receiver" (RX).

U

UAS / UAV (Unmanned Aircraft System / Unmanned Aerial Vehicle)
An unmanned aircraft, such as a quadcopter, controlled by an operator on the ground, with no pilot on board.

Ultrasonic Sensors
These sensors calculate the altitude and balance of the drone while flying.

Uncontrolled Airspace
Airspace that has no ATC (air traffic control) services. Class F and Class G airspace is uncontrolled.

Upright Launch
The ability of the drone to take off upright, as opposed to aircraft. Also called "vertical takeoff" (VTOL).

UTM (Unmanned Traffic Management)
An air traffic management system under development by the FAA and other government agencies that traffic low altitude UAV flights.

V

Vector Data
A representation of the world using points (e.g., featuring x, y, z coordinates), lines, and polygons. Useful for storing and processing data with discrete boundaries, such as the land boundary of a natural feature, state, or country.

Video Delay
Delay in video streaming between the drone camera and the pilot's goggles or monitor. Occurs when communication deteriorates due to physical obstacles, frequency interference, poor weather conditions, long-distance, etc.

VLOS (Visual Line of Sight)
The operation of a UAV within the operator's direct line of sight without the aid of any device other than corrective lenses.

VO (Visual Observer)
An optional crew member whose job is to maintain visual contact with the UAV to ensure its safe operation.

W **WAAS (Wide Area Augmentation System)**
A satellite navigation system developed by the FAA. It enhances GPS signals for better positioning accuracy of the UAV.

Waypoints
A set of coordinates that define a point in space; used to create a flight path for UAVs.

Working Area
A dedicated area where the base station and the drone's operating space are located.

X **X-Wing**
Refers to the "X-design" on a drone's framework.

Y **Yaw**
Rotating the drone along its vertical axis.

Y-Wing
Refers to the "Y-design" on a drone's framework.

0–9 **3D Mapping**
This is a software package that allows you to create 3D maps from a drone. It allows you to map large areas quickly. Farmers can better plan crop rotation, and insurance companies can assess damage without endangering life. During construction, using this package, you can create an accurate 3D map of a site by conducting a topographic survey.

3D Mesh
A type of digital recreation system often used with Building Information Management (BIM) that overlays 3D point clouds with reference points in X, Y, and Z axes to create a more fully formed representation of an area and/or objects.

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