

How drones are changing the world

Drones are handy devices and people are finding uses for them in a number of different industries, from farming and media, to surveillance and delivery services. Here's an overview.

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Drones, or unmanned aerial vehicles (UAVs), are revolutionizing industries ranging from farming to parcel delivery, cinema and even facility inspections. And once they make the move, there's no turning back. These flying robots have opened up new horizons, saving time, money and headaches.

1. SEEING THE UNSEEN

One of the main advantages of UAVs is how they gather information in ways that used to be impossible. Not only can they shoot photos and videos, they can also check temperature, create 3D models, take infrared images and measure air quality. "These functions are applied to measure all sorts of parameters that are invisible to the naked eye," says Angela Schoellig, a drone expert at the University of Toronto. She is working on a project that uses a drone equipped with a tiny gamma ray sensor to inspect nuclear power plants and measure the radioactivity they emit.

Amin Al-Habaibeh, a product design professor at Nottingham Trent University, has developed a drone carrying an infrared camera to check water pipes in the desert. "The technology can be used to detect leaks. As water evaporates, it cools the surface of the sand," he says. These systems can also be used to test a building's energy efficiency or find earthquake or avalanche victims with sensors that pick up on their body heat.

Drones can recover victims of an earthquake or avalanche

Farmers can equip their drones with high-definition cameras to better assess what is happening in their fields. "They feature a resolution as high as 1 to 4 cm per pixel, compared with 2 to 3 m per pixel with a satellite and 1 to 15 cm per pixel with a plane flying

at low altitude," says James Lambert, a researcher who studies drones for farming at the University of Sheffield. Drones can also be fitted with sensors to measure humidity, atmospheric pressure and sunlight.

Even more impressive, drones mounted with multispectral or hyperspectral cameras can capture the refraction of sunlight on crops. "Areas that are poorly irrigated or infested with parasites reflect less light than

FLYING INSPECTOR



Manufacturers use drones to monitor their facilities. These machines come in especially handy when infrastructure is hundreds of kilometres long or located in remote areas.

The French natural gas giant GRTgaz has 32,000 kilometres of pipelines, i.e. the longest high pressure natural gas transport network in Europe. This infrastructure must be checked frequently. That makes for no less than 600,000 kilometres of tubing that the firm has to inspect every year.

Potential problems that might be detected range from gas leaks and vandalism to invasive plants or backhoes about to dig on the site of an underground pipeline. The Bordeaux-based company Air Marine began carrying out these inspections for GRTgaz in 1998. Until recently, planes and ground crews were used to provide that service. But last year Air Marine tried something entirely new. It monitored 80 kilometres of gas pipelines over a period of six months using a drone. “The test went smoothly, even though the region chosen for the experiment, the middle of the Corrèze in France, is extremely hilly, covered in trees and near several air fields and inhabited areas,” says the company’s managing director Vincent Fournier. “This experiment is likely to soon be extended to other regions.”

A number of companies like GRTgaz use drones to inspect their infrastructure. This type of aerial surveillance is ideal for electric power line networks, railways, roads and oil pipelines as they extend for extremely long stretches. Drones can also observe more complex structures. Property companies use them to take aerial shots of their construction sites and monitor their progress.

Companies including ArcelorMittal, BP, Royal Dutch Shell, Alstom, Vestas and Areva use these unmanned aerial vehicles (UAVs) to inspect their offshore oil platforms, factories, nuclear power plants and wind farms. The French energy giant Engie sends them to the bottom of its boilers to assess their condition. Even governments are joining in the movement. Germany has used drones to monitor its highest dam, Rappbode Dam. The U.S. Department of Transportation put drones to work to detect potholes on its roads, while the state of Minnesota has used them to examine cracks in its bridges.



AIRMARINE

healthy areas,” says Martin Benoni, a co-founder of the French solar drone company Sunbirds. “These areas appear lighter on the image.”

Drones can also provide a more complete view of some equipment by generating a 3D model. Delta Drone, a company based near Lyon, in France, uses this technique to inspect mines and quarries. “We used to have to send surveyors out to the top of aggregate stockpiles to measure their ▶

A drone operated by the French company Air Marine, inspecting an electricity pylon.

volume,” says the company’s director Christian Viguié. “Today, drones can deliver a much more accurate estimate of the inventory of extracted raw materials by conducting a set of topographic surveys of stockpiles on the ground.”

2. AGILE CREATURES

Drones can careen through spaces that are either too tight or dangerous for humans to reach. For example, they can reach the bottom of the deepest mines or glide through a

boiler. Michigan Tech University in the United States has developed a drone that can slice through the water to inspect underwater pipelines.

UAVs are currently being tested by Swiss Post for parcel delivery. It believes that the devices will find applications in reaching areas with no access, “such as a remote mountain chalet or an area where roads have been cut off by an avalanche,” says Claudia Pletscher, who heads the project at Swiss Post. Flyability, a start-up created at the Swiss Federal

Institute of Technology in Lausanne (EPFL), modelled its drones after the flight of insects. Protected from collisions by a cage, these machines can veer through almost any tight or uneven space (see p. 35).

This agility is most spectacular in what it can achieve in cinema and the media. “We can now film a room, move through a hallway, go out a window and show a bird’s eye view of the building in a single shot,” Schoellig says. “It used to take an army of cameramen and



NEW EYE OF THE MEDIA

Drones are being used to take new types of images. And RTS, BBC and Hollywood studios are just loving it.

In 2011, Channel 9's program *60 Minutes* wanted to shoot images of refugee camps on the infamous Christmas Island in the middle of the Pacific Ocean. But the Australian authorities declined access to the Australian television channel's camera crew. Its reporters decided to take the issue into their own hands. They flew one of the station's drones over the island to film the conditions in which refugees were being detained in the camps.



MOVIESTILLSDB

A growing number of television channels and newspapers are now using drones to film their newscasts and entertainment programmes. These little robots are not only less expensive than a helicopter but also more discreet. And they can take closer images at different angles. The *New York Times*, the *Washington Post* and NBC Universal have formed a partnership with Virginia Tech University to test the use of drones for reporting.

UAVs are especially useful in assessing the extent of an event or phenomenon. In Russia, Air Pano launched a drone over a protest in Moscow after the 2011 election to show how big the demonstration was. The BBC deployed a drone to film a concentration camp in Poland. "The video showed how huge the camp was. It was impressive," says Owain Rich, Senior Innovations Producer at the BBC. "A helicopter would have flown too high. The images wouldn't have been as powerful." The video was watched more than 11 million times on YouTube.

Drones are also used to get more stable footage. "We had to shoot a sequence from a boat on Lake Geneva for the RTS programme *Passe-moi les jumelles*," says Noam Perakis from RC-Tech, a company specialised in aerial photography. "The camera on the boat kept rocking because of the waves. So we used a drone to film the shot."

The use of drones is also gaining ground in the film industry. In the recent Netflix-produced series *Narcos*, four actors jump onto rooftops and run away through laundry hanging out to dry. To shoot that sequence, the directors opted for a drone because they wanted to film close enough to see their faces. These days, nearly 10% of films deploy these flying cameras. They were used extensively in the television series *The Leftovers* and *Supergirl* and films *Skyfall* and *Transformers: Age of Extinction*. The footage is smoother from a UAV, and renting a cinematography drone with a crew is cheaper, costing \$5,000 a day versus \$25,000 a day for a helicopter.

A scene from the film *Mission Impossible 5* shot by a drone. These flying cameras are increasingly used by filmmakers.

Aerial view taken by a senseFly drone. By using a multispectral camera, farmers can accurately assess the condition of their crops.



THE NEXT GREEN REVOLUTION

A growing number of farmers are using unmanned systems to monitor their fields. This helps them to perfectly calibrate the amount of pesticide and water used.

Andrew Williamson grows wheat and barley in the county of Shropshire in western England. A few years ago, he noticed that his crops were not doing well. “I was sure that it was weeds, but I didn’t know what type,” he explains. Williamson decided to fly a drone over his fields. “That helped me to identify the weed responsible and spray the right pesticide on the area affected,” he says.

Drones have ushered in the era of precision agriculture. “These machines can be used to assess crop health, providing a detailed un-

derstanding of the composition of each parcel and identify any problems, such as a lack of water or parasite infestation, says Romain Faroux, a co-founder of Airinov, a French start-up that makes agricultural drones. “The amount of water, pesticide and fertiliser can be adjusted accordingly.”

Drones can also be used to assess crops following a weather disaster. “Farmers can spot what percentage of their field was damaged by hail and use those measures to receive compensation from their insurance company,” says Tom McKinnon, CEO of the U.S. company Agribotix, which provides farmers with these types of metrics.

Those assessments used to be done blindly. Farmers would collect samples by hand or use blurry satellite images. Wealthier farmers

SENSEFLY

a helicopter to do something like that. And there was no guarantee of a smooth final result. Owain Rich, a professional drone pilot for the BBC, adds, "These devices have been used to capture images just a few centimetres from the Christ in Rio, a waterfall or one of our reporters. The powerful blast of air from a helicopter would have made those shots impossible."

3. PREDICTING THE FUTURE

The images and data collected by drones are typically analysed by a computer to create predictive models based on algorithms. "Farmers can map out which areas of their land need water or are most often infested with weeds. They can then decide how to irrigate and treat their crops for the next season," James Lambert says.

Similarly, the information gathered by Delta Drone during its inspections of mobile telephone antennas can be used to build a database of photos taken at regular intervals. "This is a valuable tool for monitoring the condition of that type of infrastructure," Christian Viguié says.

could use planes to fly over their crops. In the future, these flying robots could even be designed to spray pesticides or fertiliser. "Japanese farmers already use a crop-dusting drone developed by Yamaha in the 1980s to reach terraced rice fields," McKinnon says. The Chinese company DJI has recently released a new model with a capacity of 10 litres.

And farmers are not the only ones using drones. The Swiss agro-chemical group Syngenta uses them in an experimental project in the United States to monitor ten experimental GMO fields. The NGO International Potato Center has deployed drones in Uganda and Tanzania to map out cultivated fields. The organisation realised that official statistics underestimated the amount of sweet potatoes grown in the eastern region of Uganda by 50%.

The U.S. Department of Transportation has decided to use these flying robots for traffic control. Analysts can identify upstream places where traffic jams could develop or accidents are likely to occur before they even happen.

4. FASTER AND CHEAPER

Drones can save businesses considerable amounts of money. In farming, they can bring expenses down \$25 to \$100 per hectare. Farmers can boost the yield of their land and use pesticides and fertiliser more sparingly, says Tom McKinnon, CEO of the U.S. company Agribotix, which provides farmers with these types of metrics. "It costs €10,000 to take a satellite image of a field or deploy a small plane for an hour," Benoni says. "But a small drone is priced at a mere €1,000."

**"We inspect
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Benjamin Federmann, director
at the German firm Aibotix

These unmanned aerial vehicles can also be used to work faster. "We inspect 500 bridges a year for a customer in Italy," says Benjamin Federmann, director at the German industrial drone manufacturer Aibotix. "It would take 100 to 150 human inspectors to achieve that rate." A drone takes 30 to 60 minutes to examine a mill, versus two days using traditional methods. "And the information can be gathered without having to clear everyone out of a building or halt production," he points out.

Swiss Post hopes to benefit from these machines' ability to fly in a straight line, without having to avoid obstacles, to deliver parcels and letters. "That'll save us time, especially in mountainous regions," Pletscher says. ▶

The speed of these machines can even save lives. Alec Momont, a researcher from the Delft University of Technology in the Netherlands, has designed a drone that can carry a defibrillator and other emergency supplies. His device can cover 12 kilometres in one minute, whereas ambulances average about ten minutes to cover the same distance.

Jonathan Ledgard, director of Afro-tech at EPFL, plans to use cargo drones to transport blood in Africa. "Blood is a highly perishable product that can only be kept for about 30 days," he says. "Many hospitals outside cities badly lack reserves." And by road, transport can take two days.

5. FEWER WORK ACCIDENTS

By using drones, machines can now take care of certain dangerous tasks, which until now have been performed by humans risking their lives. This includes nuclear reactor inspectors, who are subjected to high radiation levels. Surveyors sent to the top of aggregate stockpiles at quarries often get caught in the rubble. Technicians who have to climb to the top of cell towers or pylons carrying high-voltage power lines risk falling or getting electrocuted. Crop-duster pilots working in the American Midwest and Australia also face threats. "There are about ten deaths a year," says Benoni. And reporters sent to war zones could capture images using drones without endangering their lives.

6. GOOD FOR THE ENVIRONMENT

As they run on rechargeable electric batteries or, for models such as the Sunbirds vehicle, on solar power, drones generate less pollution than other means of transport, including planes, lorries and helicopters. Their large-scale use, as planned by some parcel delivery companies, could significantly reduce CO₂ emissions.

PARCEL CARRIERS GROW WINGS

Swiss Post, Amazon and Walmart all plan to use drones to deliver their parcels. This type of system would save time and widen their customer base.

In July 2015, Swiss Post began working on a revolutionary new project at the Bellechasse airport in the canton of Fribourg. Over two weeks, the postal service carried out several hundred parcel deliveries using drones. "These initial tests were a real success," says Claudia Pletscher, the head of the project at Swiss Post. "Drones transported parcels of up to 1 kg over a distance of 10 kilometres." These trials are set to continue for the next five years.

The Swiss postal service also hopes to use drones for special deliveries. "We want to fly them in remote regions such as the Alps or in medical

By using drones in agriculture, farmers do not have to spray their crops with large amounts of chemicals. "When we know exactly what herbs we're dealing with and where they're located, pesticides can be used on highly targeted areas, instead of spraying the whole field evenly," James Lambert says.

Drones can ensure surveillance, 24 hours a day, seven days a week

7. ALWAYS ON THE LOOKOUT

Unlike inspections led by humans, drones can ensure continuous surveillance, 24 hours a day and seven days a week. "That means that inspections can be carried out more frequently, especially in high-risk areas such as residential neighbourhoods," says Vincent Fournier, the managing director of Air Marine, which inspects pipelines for the French firm GRTgaz. Sensitive facilities such as nuclear power plants >



emergencies," Pletscher says. "For example, we could quickly transport drugs to an area difficult to reach." But the company has made it clear that it will not replace its postmen with these flying robots. "They'll be used to serve in addition to our current offer," she says. Swiss Post plans to implement this service within the next five to ten years. "That mainly depends on regulations," Pletscher adds.

Matternet, a U.S. start-up working with Swiss Post on this project, is developing drones specifically adapted for parcel and letter delivery. "Our new machine, the Matternet TWO, can carry 2-kg parcels and cover up to 20 kilometres," says Oliver Evans, who heads the start-up's global operations. "Since most parcels delivered by e-commerce marketplaces weigh between 1 kg and 3 kg."

Swiss Post is far from alone in its foray into the segment. Rakuten, Japan's online retail leader, launched the first commercial drone delivery service on 9 May 2016. But this is limited to an extremely small geographical scale for now, serving Japanese golf courses by bringing refreshments and goods to golfers. "We're using this project to test our technology before extending it to real deliveries," says Hiroshi Mikitani, the CEO of Rakuten, in a presentation of the machine.

In the United States, Amazon is developing its Amazon Prime Air delivery service to bring customers their parcels weighing up to 2.26 kg in less than 30 minutes. Google has also announced a drone delivery programme set to begin in 2017. Meanwhile, Walmart has partnered with the Chinese firm DJI to design its own system.



Swiss Post is already experimenting with parcel delivery by drone using a vehicle developed by the Californian start-up Matternet. Maximum load: 1 kg.

can also be monitored more closely. Francis Enejo Idachaba, an engineering professor at the Covenant University in Nigeria, recommends flying drones with built-in infrared cameras over oil pipelines to spot attacks led by armed assailants. "Nigeria lost \$11 billion between 2007 and 2011 due to oil theft and pipeline vandalism," he says.

These devices can also fly on cloudy days. "As they generally operate at a maximum altitude of 150 metres, they can take pictures even in cloudy weather. That's something satellites can't do," Lambert says.

Another advantage is that UAVs can gather images regularly over a long period. Some American insurance

companies, including Allstate, AIG and State Farm, use them to shoot photos of building construction sites at regular intervals. In the event of a disaster, they can more accurately estimate the extent of damage in determining compensation. Farmers and breeders use drones in a similar way to keep an eye on crop growth and count livestock. ▲

BIG BROTHER IS WATCHING... FROM ABOVE

In many countries, drones assist the police in their surveillance and peacekeeping efforts, sometimes even spraying tear gas. The cantons of Zurich, Neuchâtel and Vaud have each bought one.

suspected terrorists. In 2015, North Dakota became the first state to use weaponised drones carrying tear gas, rubber bullets and tasers.

The only other country that uses drones so extensively is India. The police frequently deploy drones to monitor protests. The northern city of Lucknow has recently received authorisation to arm the devices with pepper spray. In the United Kingdom, five counties have now bought drones, mainly for surveillance operations. And the city of Paris has launched a tender to invest in a fleet of UAVs, mainly in preparation for the Euro 2016 football championship.

Switzerland is pioneering the drone movement. The Zurich police force stepped up first by acquiring a drone in September 2014. The device was bought to collect evidence in the event of a large-scale incident such as a multi-vehicle accident on the motorway. Drones can be used to spot pieces of evidence scattered across wide distances, which could determine facts in a case.

The Neuchâtel police have also bought a drone to document accidents. The machine is deployed about 30 times a year and can take up to 60 images of a site in about 10 minutes. Fitted with an infrared camera and thermal sensor, it could eventually be used to find missing persons or fugitives and to intervene in a hostage situation.

The Vaud police department plans to use its drone more pragmatically. Its UAV will be flown over roads and lakes in the canton to catch traffic violations and hand out fines to the guilty parties. The device was used for aerial surveillance during the Iran nuclear talks in Montreux and Lausanne in the spring of 2015.

In June 2011, Rodney Brossart, a breeder in North Dakota, barricaded himself up along with his three sons, all armed, at his farmstead. Staging a stand-off with the police, he refused to return six cows that belonged to his neighbour. Law enforcement agents then deployed a drone over the farmer's property to locate and arrest him. He was the first citizen ever to be arrested by a drone.

In the United States, the police have been using these flying robots since 2005 to patrol the country's borders. The machines are also used to gather information on criminals and



MIGUEL MEDINA / AFP

Terror attack exercise at Montparnasse Station in Paris, 20 April 2016.