Cellular-connected drones

The benefits to society of regulated drone use

A WPI Economics report for Vodafone UK

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About this report

This report examines the potential for drone use in the UK and the benefits to society that could arise from safe and secure use of drones. We set out the part that cellular-connected drones can play in enabling some of the most beneficial uses and present new polling evidence on drone use. Through five case studies we explore the range and types of benefits that well-regulated drone use could bring.

We are grateful to all those who contributed to this report, including in particular technical and engineering specialists at Vodafone.

About WPI Economics

WPI Economics is a specialist economics and public policy consultancy. We provide a range of public, private and charitable clients with research, modelling and advice to influence and deliver better outcomes through improved public policy design and delivery.

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Executive Summary

The digital revolution has already enabled a wide range of new devices and services through almost continuous connection to the internet, but this is only the beginning of the story. The connection of a much wider range of devices is beginning to create the Internet of Things (IoT), and there is the potential to see some of the most transformative IoT technology taking shape in the skies.

The commercial and public sector use of cellular-connected drones (sim-enabled) has the potential to deliver significant benefits to the UK through innovations that, for example:

- Can improve productivity by completing tasks more efficiently such as surveying construction sites quicker;
- Provide crucial information to emergency services such as those responding to traffic incidents, or;
- Reduce workplace dangers to potentially save lives.

At the same time as the substantial potential benefits of safe and secure use of drones are becoming clear, the public are concerned about illegal and irresponsible drone usage such as the disruption to Gatwick Airport in December 2018.

However, recent polling shows that 80% of people would support more widespread adoption of drones if there was a mechanism to provide increased safety, security and monitoring. If we get the safety element of drones right, there are a number of potential economic and societal benefits.

PricewaterhouseCoopers (PwC) estimate that by 2030, drones will have contributed to a £42bn increase in UK GDP, and £16bn in annual cost savings to the UK economy.[1]

Many of the most beneficial uses of drones arise from circumstances where the drone needs to leave a pilot's sight such as inspection of power lines or road/railway bridges and the delivery of time-critical medical supplies. However, to ensure safety, most drones today are required to be flown within sight of the pilot, known as Visual Line Of Sight. A cellular-connected drone - one that is connected to a mobile network through an inbuilt SIM card – solves this problem. With cellular connection it is possible to track and control the drone so that it can be flown safely and securely Beyond Visual Line of Sight (BVLOS).

Safely operating a potentially significant increase in the number of drones flying Beyond Visual Line of Sight will also need a new traffic management system to co-ordinate drone flights with other airspace users. This is commonly referred to as a "UTM" (Unmanned, Universal or Unified Traffic Management) system. This needs cellular connectivity to provide, for example, remote and trusted verification of drone identity, location and flight plan authorisation.

Cellular connection can provide further benefits as a complementary system for verifying location and the ability to have dynamic no-fly zones that can be established in response to events rather than only static zones as currently exist over airports. Vodafone have shown that their Radio Positioning System could identify drones entering such dynamic no-fly zones and force them to hover in place or to land.[2] The recent Government Strategy on Counter-Unmanned Aircraft[3] discusses engaging with industry to improve the current capabilities of drones in this area, and the Radio Positioning System offers an important upgrade in capability.

To demonstrate the significant potential of drone use in the UK, this report explores five case studies which illustrate the substantial gains to be had from cellular-connected drones: delivering medical goods, monitoring and responding to emergency situations, responding to commercial or domestic fires, construction surveying and monitoring, and improvements in agriculture.

To maximise the potential that drones could unleash in the UK the regulatory environment should be updated to recognise the potential of new technologies to allow safe and secure use of drones Beyond Visual Line of Sight. Cellular connectivity will enable such use, and also bring with it a number of complementary benefits to incorporate widescale

drone use into society in a safe and trusted way. We identify three recommendations to ensure the UK sees the benefits of safe and secure drone use. The Government should:

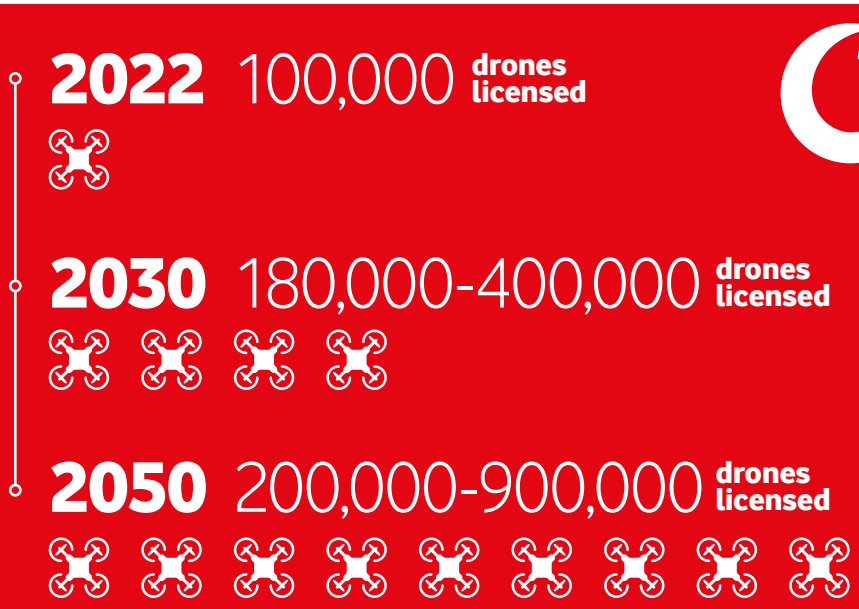
- Establish a 'blue light' drones fund for emergency services and NHS trusts to trial drones for new purposes;
- Establish further testing facilities for Unmanned Traffic Management systems and Beyond Visual Line of Sight operations;
- Explore the value of cellular connectivity for establishing UTM systems, dynamic no-fly zones and electronic detectability.

Introduction: The potential for drone use in the UK

Un-manned aircraft of one type of another are nothing new, dating back until at least 1917, only sixteen years after the Wright Brothers' pioneering flight.[4] However, drone use in the civilian, public and commercial sector has become widespread only in the last decade and is expected to grow significantly due to technological advances, falling prices and a positive regulatory environment.

The Civil Aviation Authority began providing permissions to commercial drone operators only in 2013.[5] The Teal Group's 2019 market study[6] estimates the global civil aerial drone market will almost triple over the coming decade to grow from £3.9bn to £11.4bn in 2028. The Department for Transport also identify that drones are increasingly being used commercially[7] and recently estimated a range of scenarios for drone uptake, explained in box below.

In 2018 the Department for Transport created scenarios for the possible growth in commercial drone use based on the growth seen in permissions provided by the Civil Aviation Authority since 2013. Although they have not published the raw data, the graphs published suggest that there were under 50,000 drones licensed in 2018, but that we could see the following growth:



Source: Department for Transport, Taking Flight: The Future of Drones in the UK

According to PwC, by 2030:

- There will be an estimated 76,000 drones operating in the UK skies, over a third of which will be used by the public sector and 628,000 jobs in the UK drones economy;
- Drones are expected to contribute to considerable GDP uplifts in many industries, including £8.6bn in construction and manufacturing, £7.7bn in wholesale, retail trade and food services and £11.4bn in the public sector including defence, health and education;[8]
- The level of cost savings that drones could create varies between industries, with the UK's technology, media and telecoms sector estimated to be the sector to benefit most with estimated cost savings of £4.8bn by 2030 due to a wide range of uses including maintenance of telecommunications infrastructure, aerial photography and filming and broadcasting telecommunication signals (see associated report by PwC[9]).

52%

of people polled in our survey believed that drones are bad for society

80%

....but 80% of people would support a more widespread adoption if there was a mechanism to provide increased safety, security and monitoring

Public opinion of drones

Polling on drones has shown that self-reported awareness and understanding about drones is low. In 2017 Nesta commissioned a poll of 2,000 adults in the UK to gain their understanding and perceptions of drone usage in the UK and found that one in three people (33%) said they did not have a good understanding of drones and their potential use.[10] The poll also found that:

- Two in five people (40%) said drones pose more risks than benefits to the local economy;
- Only 32% of people said drones could have a positive impact on their local economy;
- More than two in five people (43%) said that they agree or strongly agree that drones can help deliver public services; and
- Those polled were most supportive of drone use for emergency response (86%), police assistance (79%) and environmental conservation (61%).

Some of these muted responses are perhaps unsurprising given that a key factor in public opinion towards drones is knowledge; research finds that increased familiarity with drone usage can drive more positive perceptions. An extensive public dialogue exercise on drone use in the UK conducted by the TNS BMRB found that high level associations with drones tended to be somewhat negative,[11] linked to concerns about privacy and surveillance, safety and mis-use, but that:

"As the dialogue progressed and participants learnt more about drones, they tended to become more positive. This was prompted by a number of factors. Firstly, discovering the range of commercial and state uses for drones. Participants were surprised at what they perceived as the wide-ranging scope and scale of drone technology, and the potential for positive uses that could benefit citizens. Secondly, seeing drones in person and interacting with their operators reassured participants about the safety features, the quality of materials used, and the nature of the commercial permissions process."

As part of this study, we have collected updated evidence. We polled over 2,000 adults in the UK to gather an understanding of tolerance and acceptance of drones, with the results weighted to be representative of the UK population.[12] Views on whether drones are good for society are currently roughly evenly split, with our polling showing that 52% of people believe that drones in general are bad for society. However, it also demonstrated significant public support for use in specific cases where the benefit is clear:

- 84% of those surveyed supported drones being used for delivering organs;
- 92% support drone use in tackling fires;
- 92% support drone use in natural disaster relief;
- 85% support drone use in agriculture; and
- 81% support drone use in construction.

Our polling also revealed that 80% of people would support a more widespread adoption of drones if there was a mechanism to provide increased safety, security and monitoring.

Benefits of drones

In order to demonstrate the significant potential of drone use in the UK, this report has explored five case studies which illustrate the substantial potential gains from cellular-connected drones:

i. **Delivering medical goods:** Delivering medical supplies by drone could save the NHS money and time, particularly in congested cities or to harder to reach hospitals. We look at the examples of Southampton and the Isle of Wight.

ii. **Monitoring and responding to emergency situations, e.g. traffic incidents:** Drones can be used to improve information available for emergency service deployment following an incident and reduce associated congestion through allowing quicker lane clearance.

iii. **Responding to commercial or domestic fires:** Drones are being used by fire brigades to provide visual imagery from above that allows improved decision making to keep firefighters safe and they are also expected to save money and time through unnecessarily deploying multiple vehicles for false alarms and small fires.

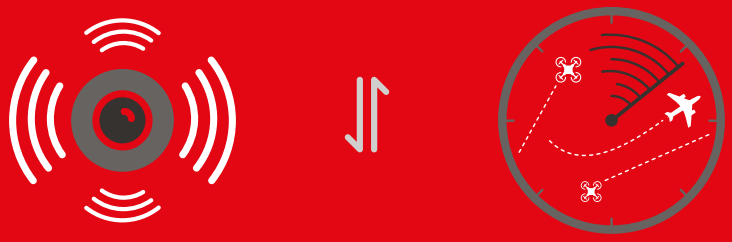
iv. **Construction surveying and monitoring:** Drones are able to support construction contractors by providing real-time and accurate aerial imagery and sensing; allowing the construction industry to save time, cut costs and improve safety.

v. **Agriculture and environment:** Drones are expected to improve productivity in farming significantly in a range of ways such as crop monitoring, livestock management, irrigation mapping and soil analysis. Another key application is expected to be assessing flood damage and accurately estimating insurance damages.

Cellular-connected drones - what you need to know

What is a cellular-connected drone? Most drones are currently controlled via hand-held radio transmitter with flights restricted to the radius of radio signal reception.[13] A cellular-connected drone is one that is connected to a mobile network through an inbuilt SIM card. Mobile connectivity is a standardised and scalable solution to providing a connection to the drone, using the pre-existing availability of connectivity worldwide.

Why is connecting drones important? To ensure safety, most drones today are flown in sight of the pilot, known as Visual Line Of Sight, but with cellular connection a drone can be flown safely and securely Beyond Visual Line of Sight (BVLOS). Cellular connection also allows secure and reliable real-time data to be sent to and from the drones; for example:



Data sent back to an operator from the drones on board cameras and sensors, allowing a much greater range of uses

Data sent to the drone such as changing weather forecasts or updated air traffic control information[15] allowing more effective and safer drone use.

What does Beyond Visual Line of Sight (BVLOS) flight allow? Many of the most beneficial uses of drones arise from circumstances where the drone needs to leave a pilot's sight. We highlight many of these case studies in this report including the inspection of infrastructure such as power lines or road/ railway bridges and the delivery of time-critical medical supplies.

Why do drones flying Beyond Visual Line of Sight need to be centrally co-ordinated? Safely operating a potentially large increase in the number of drones flying Beyond Visual Line of Sight will not be possible using current air traffic management arrangements that are designed for pilots of a relatively small number of aircrafts to speak directly to air traffic controllers. An Unmanned Traffic Management System (UTM) is needed, which in turn need connectivity to provide e.g. remote and trusted verification of location and flight plan authorisation.[14]

Cellular connection can also provide further benefits:

i. **Complementary system for identifying location:** There is a need for a complementary system for provision of location information to GPS (Global Positioning System) because although GPS is highly accurate it can be open to jamming or compromise.[16] Vodafone have shown that a Radio Positioning System (RPS) based on cellular connection can provide such a secondary system that allows authorities to calculate the position and previous flight path of a drone;

ii. **Dynamic no-fly zones:** "Geo-fencing" is an example of drone regulation where a drone can be automatically prevented from flying within protected areas (e.g. an airport or prison) through built-in software. Unconnected drones can only be forced to obey static no-fly zones. Connected drones would allow temporary no-fly zones, which could be useful during major public events or to block off a crime scene following an incident. Vodafone have shown that their radio positioning system could identify drones entering such no-fly zones and force them to hover in place or to land.[17]

4G connectivity can support many of these case studies, but the anticipated growth of the sector will be fully supported by 5G networks that offer increased capacity, reliability and reduced data transfer delays which will be crucial for drone use in built-up areas.

Safe and secure use of drones

Responsible use of drones stands to provide significant benefits to the economy and society. To achieve this, Government and regulators need to continue to work closely and speedily with industry. Significant progress has been made in this regard, with the Government's consultation on the "Future of Drones"[18] followed by:

- The launch of a mandatory registration scheme for drones by the Civil Aviation Authority[19]
- The publication of the UK Counter-Unmanned Aircraft Strategy[20]
- The launch of the Civil Aviation Authority's (CAA) regulatory sandbox which provides a capability for users to work with the CAA to test and trial innovative solutions that do not fit within existing regulations.

Six companies/consortia are working with the CAA under their regulatory sandbox, including Vodafone as part of the National Beyond Visual Line of Sight Experimentation Corridor (see Box 1).

Box 1: National Beyond Visual Line of Sight Experimentation Corridor (NBEC)

Four organisations (Cranfield University, Vodafone, Blue Bear Systems Research and Thales) have come together to create an experimentation corridor that will enable drones to safely fly Beyond Visual Line of Sight (BVLOS) by having their locations tracked.

Working with the Civil Aviation Authority's Regulatory Sandbox[22] the flight corridor will be used to demonstrate how 4G and 5G mobile technology can be used to identify and track the location of a drone in real time. It will complement existing satellite-based location systems, which provide accurate location estimates but can be open to jamming and compromise. Mobile connectivity on a drone will provide a secondary feed of location-based information, enabling a more robust and trusted picture of the drone's location. Such capabilities will be key to the air traffic management systems required to allow the routine and safe flying of commercial drones in the future.[23]

The House of Commons Science and Technology committee have also recently completed an inquiry on commercial and recreational drone use in the UK.[21] They found that the integration of drones into society carries substantial opportunities and risks that the Government must do more to address. To that end they recommended that the Government should provide an assessment of how drones might contribute to the UK's economy followed by a White Paper by Summer 2020 that outlines its vision for integrating drones. They highlighted the importance of making safety features standard, such as geo-fencing and electronic detectability, and that further testing facilities in which Beyond Visual Line of Sight operations and Unmanned Traffic Management (UTM) systems can be tested should be established promptly.

In order to ensure that we harness the benefits that drones can bring to the economy and society, we need to ensure that drones are used safely and securely in line with these recommendations. The Government announced an Air Traffic Management and Unmanned Aircraft Bill in the Queen's Speech 2019 which would represent a key opportunity to establish the appropriate framework for drone use in the UK. "Cellular-connected drones", drones fitted with SIM cards, are set to play a crucial part in this future framework.

Case Studies

To demonstrate the benefits that cellular-connected drones could deliver to the UK economy and society more widely, we build on previous work by Nesta and WPI Economics[24] to explore five case studies which demonstrate both the social and the economic benefits that widespread use of drones could create.

i. Delivering medical goods

Medical supplies are transported and delivered to and from hospitals every day across the UK. This is currently done by courier, either bike or car/ van, however there is substantial potential for drones to undertake a proportion of these deliveries, especially those that are of a more urgent nature. For example, there are 13,000 blood samples delivered from the renal clinic at Guy's hospital to the laboratory at St Thomas' hospital for kidney transplant patients per year.[25]

There is substantial potential for drones flying Beyond Visual Line of Sight to undertake a proportion of these deliveries. Within cities this could mean avoiding traffic delays, and in rural areas or places with less accessibility could save substantial time over surface transport. For example, the Nesta "Flying High" Challenge estimated that drone delivery from Southampton Hospital, to the more remote St Mary's hospital on the Isle of Wight would be around 12 minutes, compared to between 120-140 minutes by car.[26] In cases where the time saved is substantial it is possible that drone transfer could save lives when time-critical medical supplies are needed.

Box 2: International examples:

In Switzerland, where drones are being used to connect hospitals in Lugano and Bern, the drone is 2.5 times as fast as bike or van couriers over a distance of approximately 5km. In addition, the flight times are far easier to predict.[53]

In Sweden, the Centre for Resuscitation science at the Karolinska Institute, simulated a study which found that drones carrying a defibrillator- which could be used by a member of the public- arrived 16 minutes quicker than the emergency services on average. This is a time-critical situation, as every minute that passes from collapse, the chance of survival goes down by 10%. The results of the study found that the median time from call to dispatch of the emergency services was 3 minutes compared to 3 seconds for the drone. Additionally, the median time from dispatch to arrival of the drone was 5 minutes and 21 seconds, compared with 22 minutes for the emergency services. The drone arrived with a median reduction in response time of 16 minutes and 39 seconds over a median flight distance of about two miles.[54]

£0.42
Estimated per sample delivered

Source: Nesta - Flying High; The future of drone technology in UK cities.

£0.02
Estimated per sample delivered
95% cheaper

There could be significant cost savings too; the Nesta report estimated that for transport of kidney transplant blood samples, the cost per sample for delivery by courier is about £0.42, whereas the cost per sample for delivery by drone is likely to be around £0.02; 95% cheaper than the courier. This could be even more marked when looking at a case such as Southampton and the Isle of Wight, where deliveries by Royal Mail or DHL were found to cost up to £183 per package, as compared to a much smaller marginal cost of the drone which would effectively be just the cost of recharging the batteries.

Finally, with widescale take-up of this type of drone use, there could also be wider societal benefits from a reduction in congestion.

Box 3: Vodafone's remote gift delivery: First UK drone drop over a mobile network[55]

Medical deliveries such as those discussed above will need drones to be flown outside visual line of sight. At Christmas 2018 Vodafone demonstrated the potential for such flight using the mobile network, by completing the first ever UK drone delivery over a 4G mobile network. Drones are traditionally flown using a radio link, with the drone in sight of the operator. However, controlling drones using the 4G network means they can be monitored in real time, reducing the need for drones to be flown in line of sight.

Vodafone tested the technology creating a specially adapted drone carrying festive treats to the volunteers at Portland Bill Coastwatch which sits on one of the most southerly points of the UK. Entirely exposed to the UK coast, the site can be hard to reach in winter months. In the future, drone delivery over a mobile network could be used to drop vital supplies into hard to reach places.

The drone was the first of its kind to be built and flown in the UK and harnessed the power of Vodafone's network via a portable 4G router. The low latency (meaning lower delays in data transfer) of 5G will also open up new opportunities for using drones in more densely populated areas. 5G technology will make the drones more responsive, which is essential for avoiding buildings and other obstructions in built-up areas.

ii. Monitoring and responding to emergency situations: traffic incidents

Road traffic incidents are an everyday occurrence on the roads of Great Britain; in 2017 they caused 174,510 casualties with 25,290 people seriously injured and 1,720 people killed in Great Britain.[27] Road traffic incidents also lead to road closures, which can vary from anywhere between 15-30 minutes to 3-4 hours for police activity and reporting.[28]

Drones can be used to provide aerial imagery to monitor both the incidents themselves and the knock-on impacts on congestion due to road closures, with two key benefits:

- **Improving information available for emergency service deployment decisions:** Drones can be used to assess the severity of the situation and improve the situational awareness for emergency services prior to their arrival and while they are on-site, providing better information on which to base deployment decisions. This can reduce inefficient usage and waste of personnel and emergency services time in the case of minor incidents, and could also help to save lives in the case of a serious incident.
- **Reducing associated congestion costs by re-opening roads more quickly:** As well as causing death and injury, road traffic incidents cause serious disruption to travel. Due to improved intelligence about the situation provided by real-time aerial imagery, emergency services could clear the lanes far more efficiently and reduce congestion. In the Nesta Flying High Challenge, they discovered that as well as costs being saved from improved emergency services deployment at the scene of the incident, there would also be a reduction of congestion and improved lane clearance.

Nesta modelled a service which would use two fast hybrid VTOL (vertical takeoff and landing) fixed-wing drones to improve the monitoring of emergency situations within a 7-mile radius of Birmingham International Airport, an area which covers several major roads including the M6, M42 and M40, parts of both the Birmingham and Coventry urban areas, all of Solihull, and rural areas in between. The economic analysis of this small-scale pilot suggested that this case study would bring significant benefits, with reductions in traffic disruption being the main contributor (accounting for around 90% of the benefits in the first year): there could be £2.4m in social benefit over 12 years. Nesta identify this type of case study as one where flying beyond the operator's visual line of sight is key.

Other example case studies:

For investigative purposes: Cranfield University are trialling the use of drones to monitor and investigate accidents.[29] They are pioneering the use of 3D modelling in order to provide accurate models of accident sites that can then be used for investigative analysis and as graphic representation in final accident reports.

Dangerous driving deterrence: In July 2019, the Met police became the first British police force to deploy a drone to monitor road users. The drone will focus on road users who are driving dangerously and will relay the information to officers further along the road so that they can pull them over. The Met Police have pointed out that this is as much about deterrence as it is about catching the lawbreakers.[30]

Traffic monitoring: Ohio state university are leading a three-year research programme that will monitor traffic along a 35-mile highway stretch. The pilot test will relay the data to the Ohio Department of Transportation's Traffic Management Center. It will allow them to spot whether there has been a traffic-disrupting crash and manage it quicker and more efficiently.[31]

iii. Responding to commercial or domestic fires

Drones can be used to monitor emergency situations like commercial or domestic fires and could be used as a rapid response to fires. They could also be used to monitor post-fire and disaster assessment.

Fast observation drones can reach the scene quicker than the emergency services (so long as they can be flown Beyond Visual Line of Sight) and provide real-time aerial imagery and information that could help with decisions about the best way to deal with an incident.

The West Yorkshire Fire and Rescue Service used a drone for the first time at a major fire in 2018. The Area Manager commented that "It has already proved invaluable. One of the problems we faced at the fire was visual access to the full perimeter due to the surrounding properties and their gardens. The drone overcame these difficulties for us and provided us with an eye in the sky for the Incident Commander which helps with their decision making and ultimately helps keep firefighters safe."[32]

"The drone…provided us with an eye in the sky for the Incident Commander which helps with their decision making and ultimately helps keep firefighters safe."

Area Manager for West Yorkshire Fire and Rescue Service

This also helps to reduce risks to the public and other emergency services workers. This would ultimately result in time savings for the emergency services personnel, and less waste of resources spent unnecessarily on deploying multiple vehicles for false alarms and small fires.

Nesta's "Flying High" study[33] looked at what benefits a drone service centred on Bradford Fire Station would provide. After an alarm is raised, the drone would get rapid eyes on the scene, followed by high-resolution imagery. The study found the following types of benefits:

- **Time savings:** Drones are able to arrive scene quicker than fire response units (e.g. a fire engine and staff) and allow quicker decisions to be made about the appropriate deployment of resources
- **Cost savings:** Drones can be a more cost-effective alternative than current response methods; they may avoid a fire engine being called out unnecessarily to a false alarm, replace a fire engine (and crew) for monitoring of a long-burning fire and even replace some of the functions of helicopters
- **Saving lives and improving safety:** Through the use of thermal imaging drones can improve the safety of firefighters and their ability to safely reach people trapped within a building on fire
- **Environmental benefits:** Real-time, quickly provided data will enable better responses to fires, reducing the time they burn for and the associated toxic fumes.

For example, on time and cost savings, the report found that the cost of deploying one fire response unit for one hour is £284, and in the year April 2017-2018 there were 6,165 incidents reported to West Yorkshire Fire and Rescue Service in Bradford District. 42% of these callouts in the district were false alarms, 33% were secondary fires (fires outside or in derelict property) and 15% primary fires (fires in property building/cars). The remaining 9% were 'special service' call outs such as road traffic collisions rescuing people trapped in lifts. Therefore, there is a significant amount of money that could be saved by identifying the type of event as fast as possible to avoid unnecessary deployment of emergency service vehicles and personnel.

The economic analysis of this case study that we conducted suggested that such a service would be highly beneficial: the cost savings it brings about for the fire and rescue service would pay for themselves within four years and deliver a net cost saving thereafter. By the twelve year after implementation, it was estimated that the drone service could be saving the fire service £530,000 per year.[34]

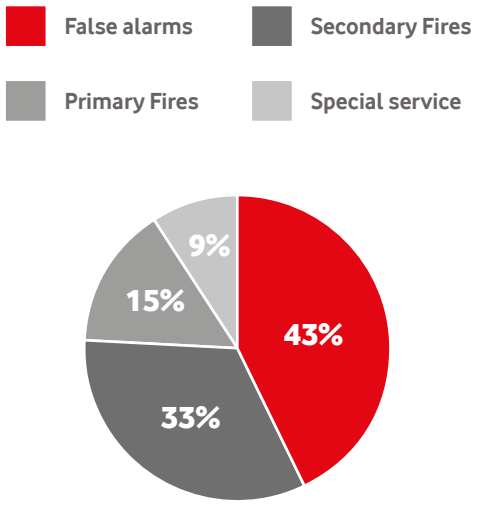
Other case studies:

London fire services: London Fire Brigade are trialling the use of drones to improve safety for their firefighters and to allow more accurate responses to incidents. A drone was recently deployed to a warehouse fire in Beckenham and it helped monitor the extent of the fire including identifying the deep seated pockets of fire that the crews were tackling using thermal imaging.[35]

Kent Fire and Rescue Service also lent the London Fire Brigade their drone to assist in monitoring the aftermath of the Grenfell Tower disaster in 2017, reducing the need to send further firefighters in to a dangerous situation.[36] Using thermal imaging the drone was able to supply the fire brigade with a live video feed, and detect any potential body heat within the tower through the building's walls.

Notre Dame fire: Firefighters also used drones to tackle the giant blazes during the recent Notre Dame cathedral fire which allowed them to make tactical choices to stop the fire at the time when it was potentially occupying the two belfries of the cathedral.[37]

Type of callouts for West Yorkshire Fire and Rescue Service, Bradford District, April 2017-18



West Yorkshire Fire and Rescue Service as quoted by Nesta "Flying High" Shaping the Future of Drones in UK Cities

iv. Construction surveying and monitoring

PwC estimates that drone technology is expected to uplift the GDP in the UK's construction and manufacturing industries by £8.6bn by 2030 through new innovation, improved productivity and cost-effectiveness.[38]

Drones are able to support construction contractors by providing real-time and accurate aerial imagery and sensing; allowing the construction industry to save time, cut costs and improve safety. Drones are an effective way to track progress, gaining previously unavailable imagery of the site and inspecting for safety issues. According to a recent report from PwC, construction sites can be surveyed up to 20 times faster with drones than via ground-based land teams.[39] Using traditional ground methods, it can take one-to two weeks to collect survey data on a 60-acre job site. For most construction sites of this size, it takes less than an hour to fly and capture the same information using a drone.[40]

Additionally, allowing drones to survey construction sites or hard to access infrastructure would allow contractors to reduce risk to workers in difficult to access areas. In 2016/17 falls on site were the second highest cause of fatalities in the UK construction industry.[41] By using drone maps as part of the regular safety inspection process, site managers are able to identify hazards more efficiently. In many cases, the aerial view helps managers spot potential hazards sooner, and take action before a problem becomes larger. Although usage of this type is already possible in some circumstances, the benefits could be maximised by routine and intensive use which would require technology that supports Beyond Visual Line of Sight flight.

A recent study conducted by ProDroneWorx shows that the number of construction companies in the UK and Ireland that are using drone technology has increased significantly, with 52% of survey participants saying that they are now using UAV's, compared with only 33% in 2017.[42] When construction companies were asked why they use drones on construction sites:

- 56% agreed that it was for improved data quality;
- 54% agreed that it was for time saving, and;
- 42% agreed that it was for a reduction of risk.[43]

In addition to these benefits, aerial imagery provided by these drones could also contribute towards:

- monitoring construction progress;
- improving security of the site;
- identifying hazards to work; and
- analysing impacts of construction, e.g. on the environment including biodiversity.

Case studies:

Bridge inspection: Balfour Beatty have been conducting a drone technology trial for the inspection of bridges in West Sussex. In the trial, savings of around £8,000 compared to traditional inspections have been noted. This is because traditional methods of inspection require traffic management to allow inspectors to safely carry out works at height and over water which causes disruption to the public and road users. "The use of drones to review the condition of a bridge reduces potential health and safety risks, as well as dramatically reducing costs, disruption and inconvenience to members of the public by removing the need for traffic management."[44]

Rail infrastructure inspection: Network rail has awarded UKDN Waterflow, a three-year contract to provide aerial vehicle survey and inspection services. The contract encompasses inspection and surveying of assets such as structures, bridges and embankments, and overhead line equipment to improve asset knowledge or to provide project specific information. In addition to planned works, the contract allows for reactive inspections to assess the impact of incidents, including adverse weather conditions.

> **"The survey process will be less disruptive, more cost effective and safer to implement. As a remote process, there will be almost no impact on rail services, which is good for the travelling public."**
>
> Richard Leigh, business development director for UKDN waterflow.[56]

v. Agriculture and environment

> **"Use of sustainable information and communication technology in agriculture is not an option. It is a necessity."[57]**
>
> Gerard Sylvester, Food and Agriculture Organisation, United Nations

Among one of the most promising areas for drone-powered solutions is agriculture. Farming and agriculture are currently undergoing rapid technological re-invention, with sensors, drones and wearable technology for animals revolutionising farming. PwC estimates that agriculture is the second largest market for drone use behind construction. It calculates that drones already contribute $32bn worth of services to farmers across the world.[45]

With the world's population projected to reach 9 billion people by 2050, experts expect agricultural consumption to increase by nearly 70% in the same period.[46] Drones offer the potential to address major challenges; such as crop monitoring, livestock management, irrigation mapping, soil analysis, environmental changes and more.

As farms adapt to climate change and extreme weather conditions, as well as deal with other challenges, drones promise to help make farming significantly more efficient. Drones can be fitted with cameras that have enhanced cameras and sensors that can take images of the crops and identify plant health, as well as identify growth patterns. Then a precise fertilizer programme can be tailored to match the crop requirement in different areas of the field. They can also assess weed and disease levels in crops.[47] The productivity benefits would be maximised by the ability to fly Beyond Visual Line of Sight as this would enable farmers to easily monitor and treat large or inaccessible areas.

There is already widespread use of unmanned chemical-spraying helicopters in some countries – for example according to the Nikkei Asian Review about 2,800 of these devices are registered in Japan and spray some 40% of the country's paddies. However, these are larger unmanned devices and there are several companies seeking to enter the market with much smaller drones because of their greater adaptability and ease of use for farmers.[48]

Flood prevention and insurance

"Near real-time accurate mapping of flood extent, property and infrastructure damage in urban areas is required for the estimation of insurance loss and insurance claim validation. With the 2007 UK floods costing £3billion, and an average house claim of £40,000, flood mitigation and damage assessment are a priority for the government and insurance industry."[58]

Gerard Sylvester, Food and Agriculture Organisation, United Nations

An excellent example of drone applications in the insurance sector is their use in both monitoring areas that are exposed to natural disasters, such as floods, as well as to enable insurance companies to quickly and less expensively evaluate damage.[49]

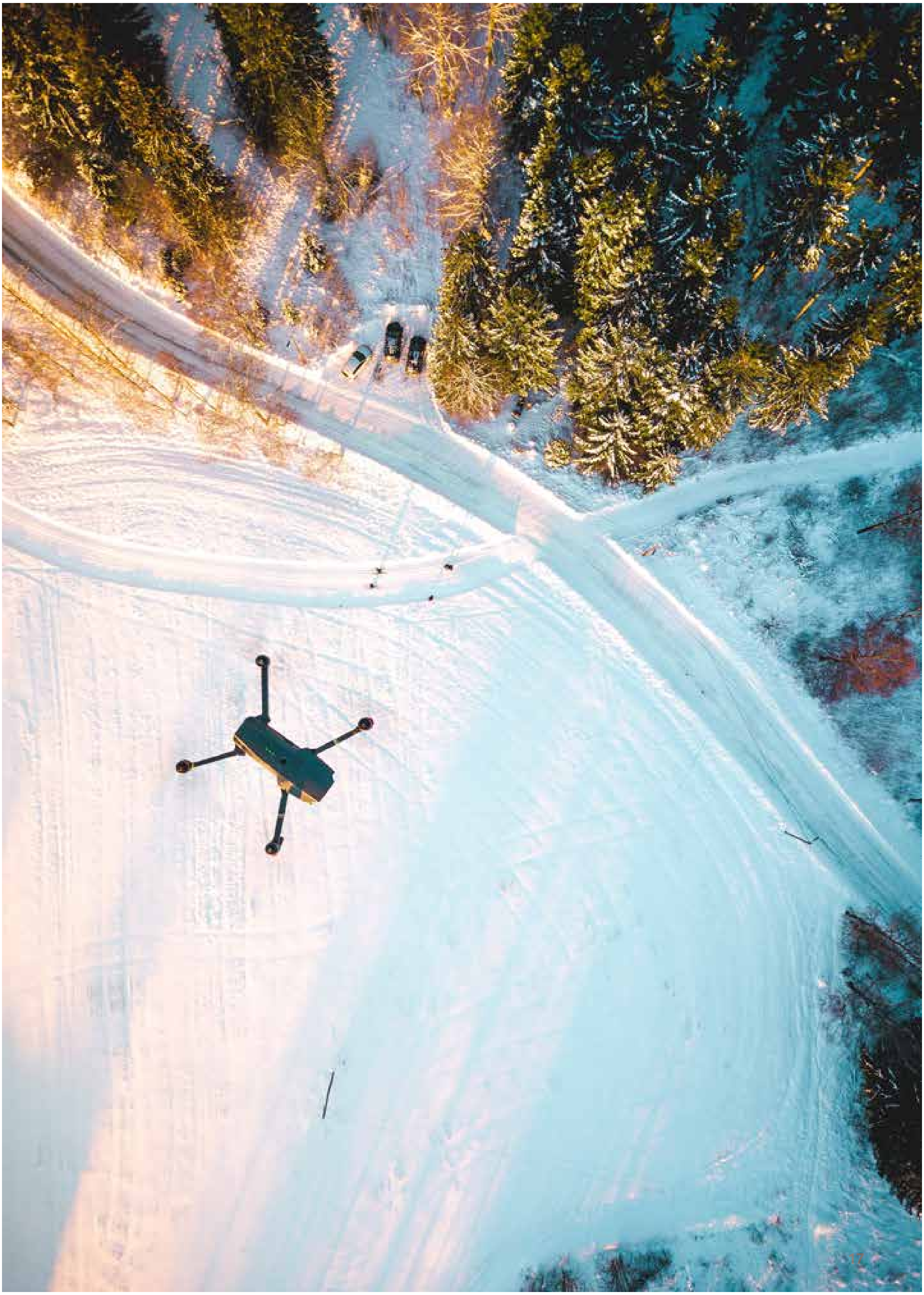
In 2016, Aviva deployed drones to assess and survey flood damage in York, Kendal and Carlisle after three large storms (Desmond, Eva and Frank) at the end of the year. PwC estimated that the storms have caused economic damage of between £2bn-£2.8bn, about half of which will have to be covered by insurers.

Aviva's UK claims director, Rob Townend, has said "it is a relatively new technology. We use it to identify where we have customers that are flooded in areas that we can't get to. Drones are fantastic when there is a lot of uncertainty about where has and has not been impacted."[50]

Drones are also being applied to insurance purposes in the agricultural sector following floods to compare the pre and post-natural disaster state of vegetation and to document the damages that occurred. Precise documentation of damages and estimation of reduction in yields resulting from these events can be used in insurance procedures. The Food and Agriculture Organisation of the United Nations state that agriculture claims management is one of the key applications of drone usage in insurance.[51]

Other case studies:

Wildlife conservation: drones fitted with high definition thermal cameras are used to track, inspect and monitor livestock remotely. The government of Assam in India has partnered with Tata Consulting Services to use drones to conduct surveillance, identify unauthorized settlements and to deter poachers in Kaziranga National Park spread over 480 square kilometres. Drones fitted with thermal cameras can identify poachers from their heat signatures even if they are hiding in thick foliage. This effort has proved beneficial for the vulnerable one-horned rhino.[52]



Conclusions and Policy recommendations

This report has set out a range of case studies which demonstrate the tangible social and economic benefits of safe and secure use of drones, with many of the most beneficial uses requiring drones to be flown beyond the visual line of sight of the operator. We also set out polling evidence that a significant majority of the public would be supportive of this type of use if there was a mechanism to provide increased safety, security and monitoring. Cellular-connection offers a way to ensure that the UK can fully benefit from the use of drones, whilst ensuring they are flown safely and securely.

For this to happen, the Government need to continue to take prompt action to establish the right regulatory framework, including by bringing forward the previously announced Air Traffic Management and Unmanned Aircraft Bill. We make the following recommendations that will help to ensure the UK sees productive and safe use of drones:

i. **The 'blue light' drones fund:** The Government should establish a fund to allow emergency services and NHS trusts to trial drones for new purposes, where the evidence for their operational benefits needs to be better understood.

ii. **Establishing further testing facilities for Unmanned Traffic Management systems:** The Government should act on the recommendation of the House of Commons Science and Technology Committee[59] to establish and fund further testing facilities in which Unmanned Traffic Management (UTM) systems and related technologies, including Beyond Visual Line of Sight operations, can be tested.

iii. **Explore the value of cellular connectivity for establishing UTM systems, dynamic no-fly zones and electronic detectability:** As set out in this report, cellular connection of drones uses the pre-existing availability of worldwide connectivity and offers several capabilities, such as dynamic no-fly zones, necessary to build a safe and secure system. The Government should ensure this potential is fully understood, to build the case for mandating cellular connectivity.

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