EXPLORING FUTURE OPPORTUNITIES FOR MOBILE NETWORKS AND THE DRONE INDUSTRY

BENEFITS AND USE CASES

APRIL 2021

TABLE OF CONTENTS

1 Introduction

Unmanned aerial vehicles (UAVs), more commonly known as drones, are an exciting and compelling market segment for advanced communications services based on 4G and 5G. With a wide range of hardware products available to commercial and consumer markets, the applications for drones continue to grow rapidly. Drones are implicitly mobile, and connectivity already features strongly in the operation of these devices. Yet most drones are limited by the technologies available and this constrains the potential market development, especially in the commercial sector.

This document is the result of consultation with a range of mobile network operators working on various activities to develop and commercialise products for the drone market. Some of the more advanced services, for example beyond visual line-of-sight (BVLOS) operation, will require aviation industry regulators to permit this kind of service to be delivered. However, such services are in commercial trials and it is anticipated this will lead to regulators, world-wide, permitting such services using advanced mobile networks as a key enabling foundation.

The use cases described in this document are indicative of products and services either already developed, or in an advanced stage of development, from at least one of the mobile operators contributing to the GSMA work within the 'Drone Interest Group'[1]. For each of these use cases there is particular consideration of the specific features of 5G networks that improve the delivery of the use case, though most of the use cases might be supported on 4G networks currently.

[1] See https://www.gsma.com/iot/aviation/

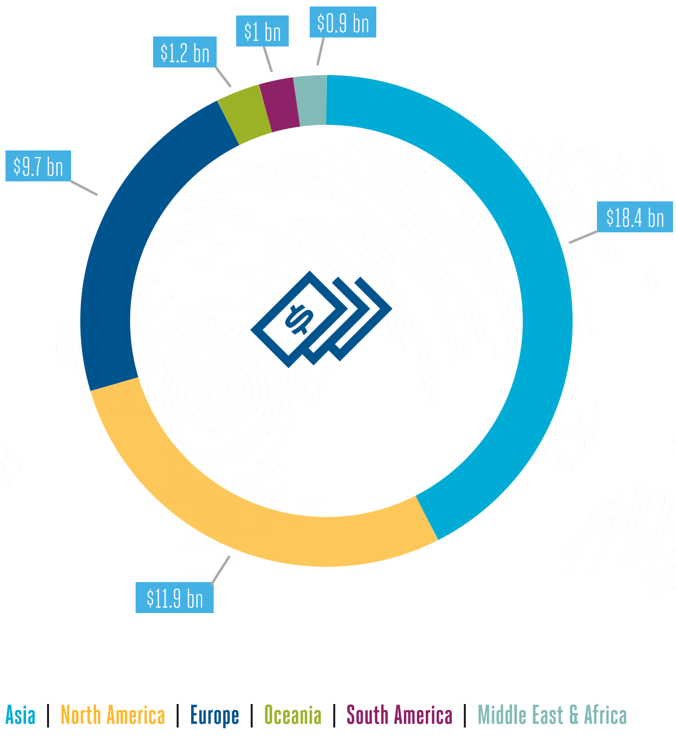
2 Market context and sizing

Mobile networks are very well placed to support the growth and operation of drones and associated drone services. All generations of mobile networks can support the flow of data to and from drones and in-flight control. 5G networks are designed to offer improved bandwidth and ultra-low latency as a core part of their operations, and these features are especially well suited to drone management, enabling direct control and data downloads from drones in close to real-time. 5G enables several use cases for drones across a range of vertical industries, from surveying to deliveries. The capabilities of 5G mean that high-definition video can be streamed direct from a drone whilst in flight, meaning that fast analysis and actions can be undertaken as a direct result. This in turn saves time and potential costs in having to complete analysis at a later date.

A forecast for the commercial drone market by Drone II, identifies Asia, North America and Europe as the largest regional marakets by revenue[2]. This analysis for 2024, puts these three markets with a total revenue of $40 billion out of a world-wide total commercial drone market of $43.1 billion, representing approximately 92.8% of the world-wide market.

Projected global commercial drone market size ($ billion) in 2024, by region

Source: Statista



[2] Part of the Statista dossier 'Market for commercial drones & UAVs worldwide' https://www.statista.com/study/28867/commercial-uavs/

From a European perspective, the European Drones Outlook Study (2016)[3] from The Single European Sky ATM Research (SESAR) identified that by 2035 the majority (71.8 %) of government and commercial uses of drones would be for BVLOS missions. Key identified use cases for this were agriculture, delivery drones and surveying / surveillance including remote sensing for police, monitoring of pipelines, power lines and railways. This report also identifies the importance of a single drone operator controlling multiple drones, making a compelling case for BVLOS flight connectivity, unmanned aircraft system traffic management (UTM) and flight information services. In 2035 the estimate is that 70,000 drones covering the European Union (EU) would deliver 200 million parcels across pharmaceuticals, food, electronics, DIY and clothing.

Some other examples of key market sectors adopting drones include:

- The World Economic Forum (WEF) reported that 60% of Fortune 500 property insurers had gained permission to fly drones by June 2016, compared with none that had done so in January 2015.
- For the logistics industry it is estimated by Accenture and WEF that $ 20 billion of operating profits could be contributed by drones over the decade to 2025[4].
- A survey in 2018 of US based local TV news stations and newsrooms for the Radio Television Digital News Association (RTDNA) indicated a total 86% were already using, or planning/ considering using drones in 2018 with 55.2% already directly owning drones[5].

The cost savings or Return on Investment (RoI) of deploying drones to provide these new services can be substantial. In construction, using drones to provide 3D surveys can cut the time spent surveying a site by 98%[6]. Staff costs can be reduced, and accuracy of data can be improved immensely. Additionally, other benefits such as improved safety of workers, or time to identify the cause of any issue can be realised quickly. Information from drones can also be linked with other systems. For example, the volume of supplies such as construction materials or coal held on site can be linked directly to vertical specific platforms such as energy management or supply chain management systems to accurately inform them of stock and re-supply needs.

For mobile network operators, there are also opportunities beyond the physical connectivity and management of the drone. For example, the global revenue for remote identification of drones (Remote ID) is expected to be worth around $1.25 billion in 2029. Mobile technologies provide the key foundation for reliable Remote ID[7].

As the number of drones in the air increases, mobile network operators are well positioned to provide UTM solutions based on access to mobile networks. Providing secure, scalable, and high-quality connectivity to the drone market will enable this new range of services. Analysts *Markets and Markets* forecast the UTM market will, reaching revenues of $1.96 billion world-wide in 2025.

[3] https://www.sesarju.eu/sites/default/files/documents/reports/European_Drones_Outlook_Study_2016.pdf
[4] http://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/wef-dti-logisticswhitepaper-final-january- 2016.pdf
[5] https://www.rtdna.org/uploads/files/2019%20RTDNA-Hofstra%20TV%20drones.pdf
[6] https://www.marketwatch.com/story/this-is-how-most-of-the-worlds-businesses-will-use-drones-2016-03-18
[7] BIS research, via https://www.statista.com/statistics/1058007/global-remote-drone-identification-system-market/

3 Connectivity and end-to-end service

USE CASE 1: GROUND CONTROL STATION BACKHAUL CONNECTIVITY

Most commercial and public drone operations are currently based on visual line-of-sight (VLOS) operation. For these the communication link between the ground control station and the drone will typically use wireless connectivity over an unlicensed frequency band.

This common arrangement can be enhanced by mobile connectivity to the pilot's ground control station (GCS). This enables the GCS to share the position and other flight data, and likewise receive the positions and flight data for nearby drones and other air users, enabling improved drone safety, a reduced risk of 'near misses', and the ability to receive other information useful to drone pilots including weather, dynamically updated no-fly-zones, and operations relating to helicopters, light aircraft, and commercial airlines. This is possible normally without any modified air regulatory authority permission (as would usually be the case for airborne drone connectivity). In addition, with 4G or 5G connectivity it is possible to relay video received from the drone to another destination to support live video feeds.

CURRENT SITUATION

- Majority of drone operations are dependent on pilot planning, attention and observation. Receiving live updates at the GCS relating to other nearby airspace users would improve safety. Up to date no-fly zone data received at the GCS would also improve air safety.
- Inability to send drone position, flight status and identity information from GCS to UTM results in increased likelihood of collision as drone usage increases.
- Drone video is commonly captured to memory card and can only be downloaded to a PC/ processed/ uploaded to a server after the drone has landed. Live video feeds would improve the ability for the drone pilot to maximise results from a drone flight by allowing more targeted flight paths.

SOLUTION

Incorporation of mobile connectivity in the GCS provides significant advantages over unconnected stations particularly from a safety and operational effectiveness perspective. Both 4G and 5G provide excellent connectivity and bandwidth capabilities suitable for drone applications, with 5G particularly enabling support for higher resolution and faster frame rate video transmission. SIM cards additionally provide secure storage for related drone identity information.

Importantly, 4G / 5G connectivity supports reliable communication with the UTM. Aside from 5G supporting increased bandwidth there is also support for network slicing which can be used to live video streaming and other high volume data transfer.

For specific customers or applications, it may be required that different coverage is needed for drone operations, beyond that normally available to consumers and business. Mobile operators can then provide additional mobile coverage for specific customers GCS service requirements either through public or non-public networks. Examples of such deployments could include forestry, mining and industrial plants.

5G ERA IoT[8] SUPPORT FOR THE USE CASE

- 4G and 5G provide reliable support for two-way data transfers between the GCS and supporting platforms such as UTM systems.
- 4G Long Term Evolution (LTE) provides support for relaying 2K-4K video from the drone via the GCS to a central location, and 5G enhanced mobile broadband (eMBB) boosts the throughput to support 4K-8K live video streaming.
- Edge computing enables local data storage and processing. This can be particularly useful for machine image processing.
- 5G network slicing allows GCS related communications to be partitioned from other network traffic, permitting higher QoS measures and enhancing data privacy.

[8] In this document 5G era IoT refers to the time period where both 4G and 5G are coexisting.

USE CASE 2: DRONE AIRBORNE MOBILE CONNECTIVITY

Mobile networks provide improved connectivity for drone applications, beyond the legacy and often unlicensed band radio transceivers used in both commercial and consumer drone equipment for low altitude. Drones which work in unlicensed bands must contend with interference from other users of the same band, which can lead to poor performance or a loss of control of the drone.

Commonly, drones are restricted to VLOS operation, a practical consideration since radio signals can be lost as drones move out of radio coverage.

CURRENT SITUATION

- Connectivity can be lost quickly if the drone is flown into a radio 'dead spot' – resulting in a loss of control of the drone. Currently BVLOS wide area drone operations are not available on some communication services such as Bluetooth or Wi-Fi. Live streaming of drone status information, image/video and on-board sensor data for real-time control is often not available to the control centre.
- Air industry regulators require users to maintain VLOS control over drones. BVLOS regulations are not available yet, only exemptions are permitted at this stage.
- Only a limited set of information is provided to the GCS (e.g. the position), but most of the other data is stored locally in a memory card on the drone and uploaded post-flight.

SOLUTION

Mobile networks employ networks of cell site equipment to deliver wide area communications. This means that drones can be provided with connectivity capable of supporting identification and tracking, command and control, telematics and payload that is no longer technically limited to VLOS operation. Importantly the mobile network supports reliable handovers between cell sites so that even if the drone is moving the command-and-control link is maintained reliably provided the drone remains within network coverage.

Drone specific connectivity plans, distinct from regular mobile services are likely to be needed. These connectivity plans will include connectivity and may also include access to new services that are valuable for a drone operation management for pre-flight and inflight support.

As 5G is introduced into mobile networks there is further enhancement to drone connectivity to support high reliability needed for command and control of higher risk operations or the ability to deliver high bandwidth connectivity for drone sensors including high resolution imaging/video.

As part of their initiatives to provide drone connectivity services mobile operators are also addressing the different coverage situation for devices at altitudes some distance above ground level, as this can vary compared to that available to general consumers. Mobile operators are actively providing additional mobile coverage for specific customers either through public or non-public networks. Examples include bespoke coverage to chemical plants, oil refineries, mining operations and forestry – allowing drones to operate as well as supporting worker communications in those areas. Coverage can also be directed more specifically where needed for operations using directional antennae and 'beam-forming' approaches where permitted.

5G ERA IoT SUPPORT FOR THE USE CASE

- Traditional LTE is still suited for a variety of needs, like telematics or images/video transmission and also command and control in most cases. Other older technologies might only allow a limited set of capabilities.
- 5G eMBB provides substantially increased bandwidth to support high frequency sensor data transmissions as well as high resolution live image capture and video streaming. Ultra-reliable low-latency communications (URLLC) technology enables highly available and time deterministic 'real-time' communication which can be relevant for specific drone operations.
- Edge computing enables local data storage and processing. This can be particularly useful for machine image processing.
- 5G network slicing allows drone related communications to be partitioned from other network traffic, permitting higher QoS measures, supporting enhanced data privacy and security for drones.

USE CASE 3: DRONE IDENTIFICATION AND TRACKING

As drone ownership expands there is a growing importance in being able to identify and track drones for a variety of reasons including:

- Identifying non-authorised pilots and drones, through ownership registration regulations.
- Handling nuisance and safety aspects of drone use, especially in areas such as airports and sports stadiums.
- Being able to monitor and manage status of all drones in the sky.

Many drones have no means of identification other than a manufacturer serial number. Drones which feature Wi-Fi or Bluetooth have a form of identification via a hardware media access control (MAC) address, though in reality this can be masked or spoofed and is not readily resolvable to an owner. New standards and regulation are currently defining what the Identifier for drone should look like and what information is needed. Such identifiers comprise a set of information including: manufacturer, model, serial number, position information and others.

CURRENT SITUATION

- There is no common method to register and identify drones, making it difficult to reliably recognise the ID of a drone or presence of an unregistered or unauthorised drone.
- Majority of shipped drones have only a manufacturer identification and registration but not a publicly available one.
- Drones which feature Wi-Fi or Bluetooth have a form of identification via a hardware MAC address, though in reality this can be masked or spoofed and is not readily resolvable to an owner.
- Individual countries are developing separate registration schemes – reliant on the proper conduct of sales channels and customers.
- Schemes rely on a high degree of trust e.g. an owner properly registering and marking their drone with an issued identifier.
- Compliance and enforcement with registration requirements are manpower intensive. A drone in flight cannot readily be checked for current registration.
- Verification of the owner/operator of a drone is reliant on other forms of intelligence e.g. closed-circuit television (CCTV) of the operator or capture of the hardware with tracing through the supply chain or catching the pilot in person whilst operating the drone.
- New regulation in EU became effective from 2020, with a transition period of 2 years for the implementation. US FAA published a new rule on Remote ID in Dec 2020, with similar timeline for the implementation. Both rules define the required information to be provided and they are only covering a so called “broadcasting ID” method.

SOLUTION

Use of the mobile network and authenticated SIM card offers a reliable, global way of registering and identifying drones quickly and efficiently. A variety of options are possible:

- SIM cards intended solely from drone operations can be sold, and provisioned with drone owner/operator and associated information e.g. serial number and drone manufacturer/model.
- Drones with embedded SIMs can be automatically provisioned and registered at point of sale.
- Add-on mobile enabled modules equipped with SIM cards can be fitted onto drones to provide them with the required identification/ registration.

Connected drones allow to be readily identified to local authorities and other drone pilots, allowing appropriate actions to be taken from integrated drone management platforms with appropriate access rights for the relevant actions to be taken.

5G ERA IoT SUPPORT FOR THE USE CASE

- Identifier data can be transported securely through mobile networks, in addition, SIM/eSIM offer a secure storage for the relevant information part of the identifier. Mobile networks offer a reliable authentication and security framework that is superior to the currently employed mechanism for Wi-Fi or Bluetooth.
- 5G massive machine-type communications (mMTC) enables huge numbers of devices to be connected, particularly benefitting dense urban areas. This enables mass market connectivity to drones for identification and tracking.
- The amount of data required for the identification information is quite limited, but for the aviation is regarded as critical. Technologies like LTE-M or NB-IoT might be a valuable option to guarantee the reception of the information where there is not enough coverage or capacity.
- 5G offers higher predictability and reliability than the previous generation.
- Ability to segment and separate the traffic by means of Network slicing and therefore also increase the security.

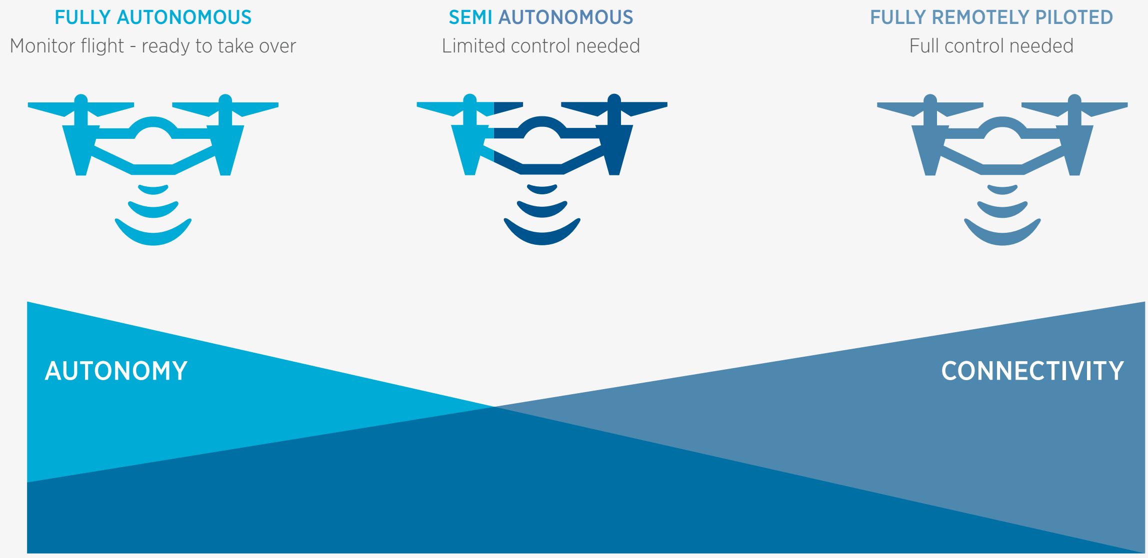
ADDITIONAL RESOURCES

Paper: GSMA Unmanned Aircraft Remote Identification Through Cellular Networks paper available **here**

USE CASE 4: COMMAND AND CONTROL

All vehicles require a communication link with the GCS through the whole flight, in order to be able to remotely pilot the aircraft if needed. However, the characteristics of this link are very dependent on the level of autonomy of the aircraft and the operation risk. Autonomous flight capabilities, for example take-off, landing and navigating a predefined flight plan make it more efficient to operate fleets of drones – particularly useful for industry, transportation/ logistics, public safety and other sectors. However, not all organisations operating drones will have the resources to have a fully autonomous system, which increase the dependency on availability and reliability of the connectivity.

As described earlier, mobile networks provide the support for BVLOS command and control, and the wide area communications delivered by these networks enables efficient command and control solutions both for single drones as well as fleets.



CURRENT SITUATION

- Regulations requiring VLOS command & control limit commercial drone opportunities.
- Drone operators want to be able to take advantage of autonomous features and have a single human operator manage multiple drones simultaneously, even when they are BVLOS.

- Regulation also demanding to have connectivity available throughout the whole flight, even for fully autonomous operations.
- Drones being operated without automated command & control solutions have a high overhead for drone operational staff.
- Proprietary command & control systems have high training overheads particularly if drones from multiple manufacturers are in a fleet. Operators need a single interface and platform to manage multiple drone models.

SOLUTION

Mobile networks can offer reliable connectivity, which enable a wider range of command and control options suited for most of BVLOS operations at low altitude.

Mobile network operators are also experienced in selecting, deploying and integrating software solutions such as command and control software. Fully packaged or modular drone hardware with SIM/ eSIM and command and control solutions is a potential option. Mobile network operators can therefore extend the user base for command and control solutions to a much broader range of customers, whether these are in the consumer or enterprise segments.

5G ERA IoT SUPPORT FOR THE USE CASE

- Ultra-reliable low-latency communications (URLLC) technology enables highly available and time deterministic 'real-time' command and control of the drone.
- eMBB enables associated command and control data transmission particularly of high bandwidth data including high resolution live image capture and video streaming as well as streaming data from other drone or payload sensors.
- Edge computing enables distributed data storage and processing for the command-and-control application. For autonomous command and control the edge server could provide highly detailed local navigation data – such as cached high-resolution 3D map data.
- 5G network slicing allows command and control traffic to be separated from other types of 5G traffic, allowing a dedicated quality of service to be provided for this purpose, and enhancing the privacy and security of command and control.

ADDITIONAL RESOURCES

Case study: Beyond Visual Line Of Sight Platform by KPN and TEOCO available **here**

USE CASE 5: DRONE PAYLOAD CONNECTIVITY

Many drones require data connectivity beyond that of the navigation, or command and control, element of the flight. Examples relating to drone payload transmission include cameras, environmental sensors, and payload management and monitoring sensors such as accelerometers and release catches.

Mobile networks provide a reliable, wide-area connectivity solution for the bidirectional transmission of such payload information. Importantly this enables payload connectivity for BVLOS operation of drones.

CURRENT SITUATION

- Most payload and sensing data relying currently on local storage such as memory cards and offloaded after the completion of the flight
- Even where drones are equipped with payload communication options they are often limited to VLOS operation.
- High bandwidth payload communications are often not possible except over a limited area or in limited situations.

SOLUTION

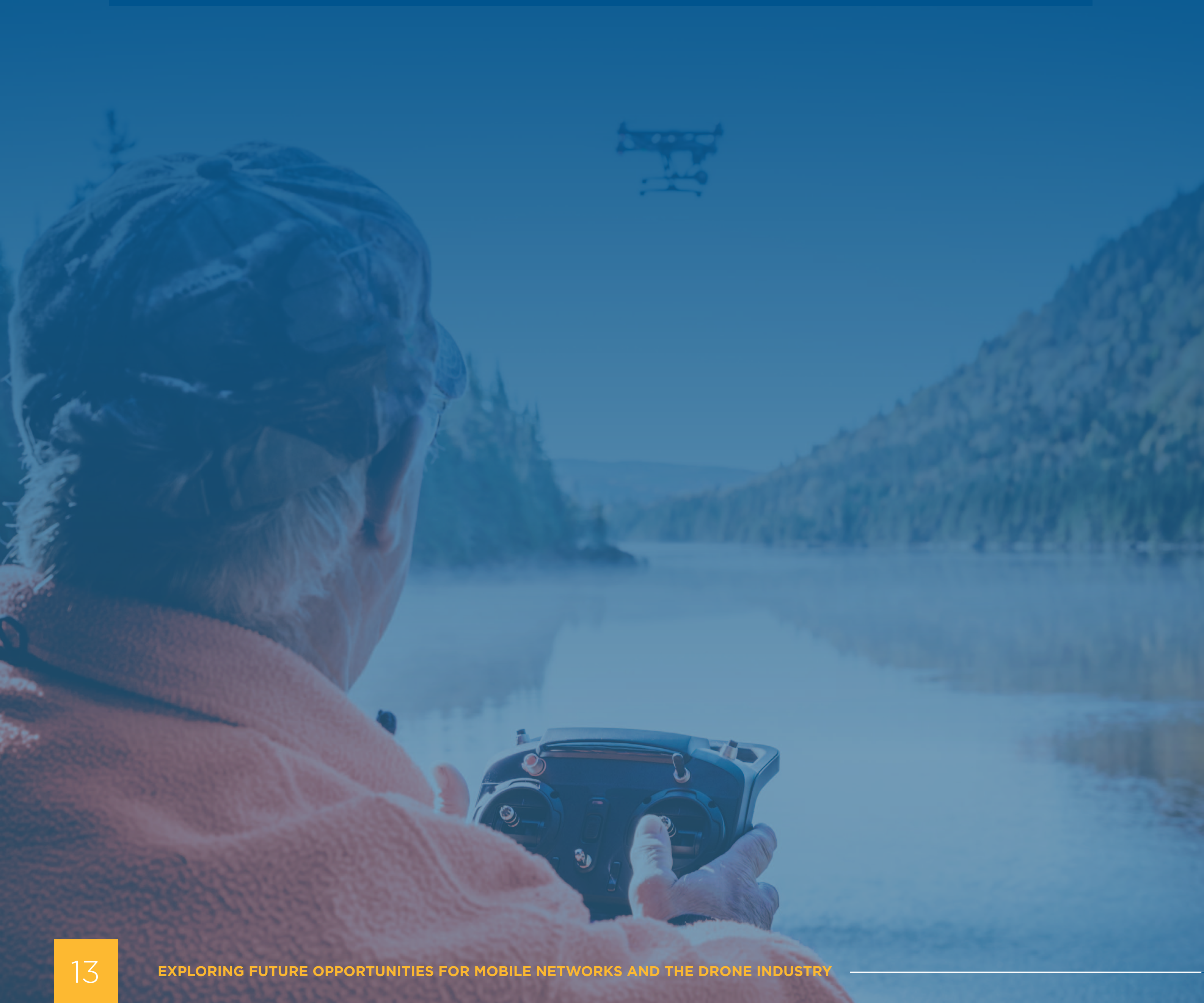
There are two main options available for mobile network-based payload connectivity:

- The drone payload itself is equipped with a mobile data communications module that is used for two-way communication with related systems. In this case the communication may not include information from the drone e.g. position, altitude, velocity, flight duration.
- The drone is equipped with a mobile data communications module that serves the drone hardware as well as the drone payload. Either a wired connection between the drone and its payload, or a local wireless network (e.g. Bluetooth) is used to allow the drone payload to piggy back onto the drone connectivity.

Using the mobile network for drone payload communications allows the wide-area coverage of the public mobile network to be used. Live streaming of data across the mobile network means that payload data can be delivered directly to data centres or operations centres and is a key enabler for future fully automated drone services. No storage limitation and real time analysis of the data for taking appropriate actions faster.

5G ERA IoT SUPPORT FOR THE USE CASE

- URLLC technology enables 'real-time' control for drone payloads e.g. camera functions including zoom, focus, tilt and pan.
- eMBB enables transmission of high bandwidth data for the drone payload including high resolution live image capture and video streaming, lidar sensor data, as well as streaming data from other drone or payload sensors.
- Edge computing enables distributed data storage and processing for the drone payload data including images/ video as well as any associated control functionality.
- 5G network slicing allows drone payload data to be separated from other types of 5G traffic, allowing a dedicated quality of service to be provided for this purpose, and enhancing the privacy and security of the payload data.



USE CASE 6: INSPECTION, SURVEYS, MONITORING AND SURVEILLANCE

Drones are useful for a wide range of commercial applications particularly in areas that are remote or difficult to reach using a vehicle or are inaccessible because of safety hazards. This may be because there are tall structures (e.g. transmitters, wind turbines), or areas stretching over long distances. Use of drones for inspections and monitoring is useful for a wide range of industries, including inspection of infrastructure such as power lines, wind turbines and bridges, through to monitoring of forestry and farmland occupation and boundaries.

Mobile networks add increased flexibility to drone usage in these applications particularly through enabling BVLOS operation, along with the support for high bandwidth two-way communications.

CURRENT SITUATION

- Only VLOS operation is possible.
- Manpower intensive, still too costly and time consuming.
- Limited support for live sensor data due to radio performance.
- Image/video/sensor data often captured to memory devices and analysed following the drone landing – follow-up drone flight or manual inspection may be necessary.

SOLUTION

The high-bandwidth two-way communications available over 4G and 5G mobile networks provide significant benefits to applications in inspection, surveying, monitoring and surveillance. This enables live-streaming of images, video or other sensor data which allows an operator to review this information as the drone is in flight, and take appropriate actions to ensure all relevant data is collected and inspections completed as required.

Mobile networks also enable BVLOS operation which is key to many of these commercial applications. Inspections will typically involve moving the drone out of sight so it can examine behind, under or over a building or piece of infrastructure. Similarly, for wide-area services such as surveying or inspecting farms, forestry or pipelines there is a requirement for operating the drone when it may be far from the operator. This is possible with mobile networks.

For specific customers and industries the mobile operator can also deploy additional radio network infrastructure to provide targeted coverage. This may be required in the case of ports, oil refinery, chemical plants, mining or forestry operations. Additional infrastructure may include base stations as well as antenna equipment to cover specific areas.

5G ERA IoT SUPPORT FOR THE USE CASE

- URLLC technology enables highly available and time deterministic 'real-time' command and control of the drone for inspection, surveys and surveillance.
- eMBB enables transmission of high bandwidth data including high resolution live image capture and video streaming as well as streaming data from other drone or payload sensors. This will be especially important for 4K or 8K video and lidar.
- Edge computing enables distributed data storage and processing for image/ video data as well as any associated command and control applications supporting inspection, surveys, maintenance and surveillance. For autonomous command and control the edge server could provide highly detailed local navigation data – such as cached high-resolution 3D map data.
- 5G network slicing allows drone traffic to be separated from other types of 5G traffic, allowing a dedicated quality of service to be provided for this purpose, and enhancing the privacy and security of this use case.

ADDITIONAL RESOURCES

Case study: Ground-to-Air LTE Communication Services for Industrial Drone Applications available **here**

Case study: Drone inspections of electric transmission lines **here**

USE CASE 7: VIDEO CAPTURING, NEWS AND EVENTS

Drones are increasingly used for live video reporting of news and events. Specialised wireless hardware can be bought which supports high-definition live video from a standard VLOS operated drone.

CURRENT SITUATION

- Operation near to people and events is restricted to VLOS operation, with a pilot needed locally to command the drone – this can limit the extent of video coverage.
- Live video quality captured today often lags behind the latest standards such as 4K.
- Unlicensed communications suffer from variable quality, reliability and throughput – this can lead to a loss of video signal or quality.
- An additional safety margin needs to be provided so that if command and control communications with the drone are lost it does not land on crowds or interfere with events or incidents.
- Significant restriction in the number of drones that can be actively transmitting video in a given area due to limited available bandwidth in unlicensed networks.

SOLUTION

The use of mobile networks for video capturing and live streaming for news and events provides greater reliability, higher bandwidth and improved radio isolation meaning that drones are not subject to the activities of others in reliably delivering high quality video content.

4G LTE supports 2K video resolution using the H.264 encoder or 4K video using the H.265 encoder[9] whilst 5G boosts the video resolution to 4K or 8K depending on the allocated spectrum. Importantly the video can be streamed directly over the mobile internet to a required destination such as a data centre or broadcast control room – reducing latency and improving video signal quality and reliability because an additional communications link is not needed.

BVLOS operation of the drone is possible when command and control uses the wide area mobile network. This allows a pilot to steer the drone to locations that are not possible with VLOS operation, allowing different camera angles to be used for the news/event coverage. Further, rapid deployment

[9] At 25 frames per second

of a drone can be achieved without even requiring a video crew to be deployed to the actual location of the news story or event. This could allow drones to be deployed directly and rapidly from a central operations facility for major cities, or allows news crews to obtain video reports at a safe distance.

5G ERA IoT SUPPORT FOR THE USE CASE

- URLLC technology enables highly available and time deterministic ‘real-time’ command and control of the drone for video capturing, news and events.
- eMBB enables transmission of high bandwidth data including high resolution live image capture and video streaming for this use case. This will be especially important for 4K or 8K video.
- Edge computing enables distributed data storage and processing for image/video data as well as any associated command and control applications supporting video capture, news and events. This can also support autonomous command and control where the edge server could also provide highly detailed local navigation data – such as cached high-resolution 3D map data.
- 5G network slicing allows drone traffic to be separated from other types of 5G traffic, allowing a dedicated quality of service to be provided for this purpose, and enhancing the privacy and security of this use case.

USE CASE 8: CELL ON WINGS

Rapid deployment of cellular coverage can be achieved through deploying the concept of 'cell on wings' - a small mobile cell-site which is carried by a drone. This provides local coverage in needed locations.

Cell on wings is useful for short-term ground based mobile coverage for public safety applications as well as commercial applications including events and such as providing field-based workers, for example forestry teams, with coverage. The short-term coverage may be to a fixed area, in which case the drone might itself be tethered, or the drone may be moved.

CURRENT SITUATION

- Mobile network coverage is typically deployed based on population, transportation network and business coverage.
- "Spot" Coverage may be needed very quickly in the case of emergencies, and coverage which would not be economically viable to deploy permanently is very useful to groups of remote workers.
- Events may be staged in remote areas which benefit from coverage either for an audience, performers or media.
- Satellite phones are sometimes used in public safety and remote working but devices and services are expensive and have limited capabilities particularly for data.
- Temporary ground-based cell-sites can be deployed but take time to get to the required location, and these can also be expensive and require suitable vehicular access.

SOLUTION

A drone is deployed which carries an integrated small cell. This will deliver coverage to a specific area on the ground. The drone could be 'tethered' to the ground via thin and lightweight cables which provide power and fibre-based data connection if required.

Getting a drone to the required location is much easier and quicker than deploying other forms of temporary cell-site equipment. It is also easier to move the location of the ground crew and drone to where it is required. Current implementations based around 4G / LTE provide both voice and high-speed data and it is expected that 5G services will also be deployed in this way.

5G ERA IoT SUPPORT FOR THE USE CASE

- eMBB enables high bandwidth services to client devices – such as video downloads and uploads.
- mMTC supports extremely large numbers of IoT type devices across the wide coverage area.
- Edge computing can provide local, distributed data storage and processing for applications including content caching for popular web/video content.

ADDITIONAL RESOURCES

Case study: AT&T Cell on Wings available **here**
Case study: Turkcell's Dronecell available **here**

4 Value added services

USE CASE 1: DRONE POSITION VERIFICATION

Increasingly drones are equipped with Global Positioning System (GPS) receivers, used for reporting the position of the drone or for assisted/autonomous navigation. GPS, however, has a number of problems that could cause issues with accurate positioning and potential hacking of the GPS signal. The use of a secondary positioning technology means that it is possible to verify that this location information is accurate.

Mobile networks can offer forms of position verification based on various network-based approaches. If the drone GPS position is determined to be invalid this can be flagged to operators, drones or navigation systems and corrective action taken e.g. making a forced landing.

CURRENT SITUATION

- GPS data is not completely reliable and so alternative positioning data is needed, particularly for drones in sensitive areas or with high value payloads.
- Drones, or their onboard equipment, or transport payload can be stolen by the attacker.
- Issues with location need to be highlighted to the drone operator quickly or automated landing needs to take place where the location of the drone is unclear.

SOLUTION

Mobile networks use device location as a part of mobility management. A typical mobile network employs many thousands of cells across a country, each of which is identified and the coverage area predictable with reasonable accuracy. The active cell maintaining the mobile connection to the drone can therefore be used to validate that the reported GPS position of the drone is consistent with the serving cell and its respective coverage area, and if this is not the case the GPS position flagged as suspicious. Mobile operators therefore could deliver such a location verification function as a standalone value-added service or integrated within a drone service platform.

Advanced positioning solutions, such as Vodafone's Radio Positioning System[10], can provide improved accuracy by the use of radio network measurement data. This provides further confidence in the reliability of received GPS data.

5G ERA IoT SUPPORT FOR THE USE CASE

- 5G introduces a new positioning architecture where it is possible to improve positioning accuracy through network and device technologies.
- Higher spectrum (which is 'standard' with 5G) leads naturally to smaller cell sites which provide increased accuracy for drone location verification.
- Beamforming techniques, which are also expected to be applied to 5G networks, can be used for improving location accuracy through geometric techniques e.g. angle measurement and triangulation.

ADDITIONAL RESOURCES

Case study: Vodafone air traffic control drone tracking and safety technology available **here**

[10] See https://www.vodafone.com/news-and-media/vodafone-group-releases/news/iot-drone-tracking

USE CASE 2: DRONE COVERAGE AND SIGNAL INFORMATION

As drones move to use the mobile networks for connectivity and manual or automated command and control it is important that the drone continues to receive a high-quality mobile signal. Mobile networks inevitably cannot cover the whole of a country for practical and economic reasons and this is similarly true of the elevated coverage required for drones. Mobile networks can however provide coverage and signal information to allow drone routes to be planned to ensure they receive reliable coverage. Mobile operators are developing solutions to provide coverage and signal information to their own, and third-party drone management systems.

CURRENT SITUATION

- Flight path decisions are not taken based on coverage today, with no guarantee of mobile network coverage along planned drone routes.
- Mobile networks employ various radio propagation estimation tools as well as 'drive testing' to evaluate and optimise coverage – but this is generally based on smartphone users at ground level or within buildings.
- Signal propagation and interference levels at drone altitude differs from ground level because of factors including different physical obstructions and antenna gain and directionality.
- Drones will also transmit their signals across a wider area to be received at more base stations and therefore creating additional interference to all users.
- Flight planning tools are generally not enabled for factoring mobile coverage into routes, risking the drone moving into an area with no coverage for command and control or payload communication.

SOLUTION

Mobile operators are deploying new planning tools which produce estimates for coverage and signal quality for drones and drone flight paths at low altitudes. Some are also conducting drone-based radio signal surveys to qualify these estimates and provide greater certainty over the coverage and signal quality that will be received by drones. Mobile networks are also being designed to take into account the coverage needs of drones that are flying at altitudes set by local regulators, and offering improved signal quality information as a result.

This radio signal coverage information is being made available by mobile operators as a value-added service to drone users. Various options are available:

- This is included as part of a mobile network operator drone operations platform, and used in various applications from flight planning through to manual or automated flight command and control.
- Information is provided in the form of data that can be used by drone operators in their own flight planning software.
- The data is provided to third party platforms such as those providing unmanned aircraft systems traffic management for drone customers.

This information has a high utility to drone operations and is seen as a supplemental revenue generating opportunity for mobile operators.

5G ERA IoT SUPPORT FOR THE USE CASE

- 5G enables coverage and signal quality information to be supplied to the drone or GCS rapidly and in 'real-time'.
- Where a substantial amount of coverage and signal quality information is to be transferred this can use 5G enhanced mobile broadband.
- Coverage and signal quality information can also be collected and uploaded from test flights or live drone flights to validate prediction models or the effects of network changes, and this can also use 5G eMBB for streaming the information to a database.
- Edge computing can provide local processing and storage for coverage and signal quality information, and the support for caching of this information locally to the drone operations.
- Network slicing supports a higher quality of service e.g. availability for critical information services including coverage and signal information.

ADDITIONAL RESOURCES

Report: ACJA Network Coverage Service Definition available **here**

USE CASE 3: CROWD INFORMATION

It is important to ensure that drone operations minimise any potential risk to the public either from the drone itself in a planned or unplanned landing or risks which may arise independently from the drone's payload. Whilst flight planning software can navigate fixed obstacles such as buildings, and mobile network coverage and signal quality information helps with choosing a flight route with reliable connectivity, an additional information set on crowd density is useful to allow the drone to be steered clearer of people on the ground.

Crowd density information can be determined from the mobile network based on the number of devices active on any given mobile network cell. Depending on implementation the mobile network can provide historical data, forecasts or near current data for example with a 15-minute delay. This information can then be used in planning future flights, or ensuring current flights are taking account of crowd density.

CURRENT SITUATION

- Information on crowd locations and size may be available from several sources (normally easier for events in a very confined area).
- Landing a drone in a crowd, even in an emergency is dangerous and must be avoided.
- Drones flights generally consider specific no-fly zones as well as physical aspects of the environment (topographical and built) rather than dynamic crowd information.
- Intelligence may be applied by pilots to steer clear of urban centres, sports stadiums and shopping malls but this can be very subjective. Pilots may be avoiding locations which have little occupancy at the time of the flight, or the drone could be passing over highly occupied areas because the pilot is unaware of current crowds.
- The dynamic crowd situation can change quite rapidly, may follow regular daily or weekly patterns, or may change depending on the weather so it can be difficult to balance the knowledge that a flight path is avoiding crowded areas versus efficiency.
- Other than with this type of information, pilots may need to continuously observe ground level for crowds, which could create further limitations around speed, altitude and requirements for suitable flying visibility conditions.

SOLUTION

Mobile network signalling data is being analysed by many network operators for diverse information applications across government, transportation, retail planning and health. Due to sensitive nature of the information, this mobile network data is anonymised and aggregated to provide various insights into generalised customer behaviours. Cell level signalling data is acquired from the network infrastructure and then processed through big data analytics to produce required insights, and the same technologies and platforms can be applied to the crowd information case for drones.

Mobile operators can therefore process the mobile network signalling data to provide dynamic population density data useful to drone operations. This information can be provided direct to drone platforms used by pilots for command and control use in live flights, or can be used for flight planning. Some mobile operators may be able to provide 'near real-time' data e.g. with a short delay, and live or historical data granularity may be broken down at a daily level or into hourly or smaller intervals.

5G ERA IoT SUPPORT FOR THE USE CASE

- 5G enables to provide more accurate crowd information location, particularly in urban area where the size of the cells are smaller.
- Where a substantial amount of crowd information is to be transferred this can use 5G enhanced mobile broadband.
- Edge computing can provide local processing and storage for crowd information, and the support for caching of this information locally to the drone operations.
- Network slicing supports a higher quality of service e.g. availability for critical information services including crowd information.

USE CASE 4: TRAFFIC AWARENESS

Operational safety for drones can be improved if these are equipped with transponders which broadcast the position of the drone and receive the position of other nearby aircraft, whether those are drones, helicopters or aeroplanes.

Two notable examples of transponder systems are:

- Flight Alarm (FLARM) – a traffic awareness and collision avoidance solution for commercial aviation, light aircraft and drones.
- Automatic Dependent Surveillance Broadcast (ADS-B) – supporting aircraft to aircraft and ground station monitoring.

Traffic awareness solutions such as these allow pilots to take evasive action if there is a risk from other nearby traffic. Where a transponder is equipped to and integrated with the drone this provides visibility to other nearby traffic as well as collision warnings to the drone and its pilot. Drone pilots may also have access to traffic applications and websites which provide a view of current traffic information from these transponders.

Relatively few drones, however, are equipped with such systems and therefore there remains some risk to drones and other air transportation. This risk of course increases with proximity to airports, though these are protected with no-fly zones. As more drones are deployed, however, the risk of collision will increase, and so traffic awareness solutions will become more important.

CURRENT SITUATION

- ADS-B has a capacity issue for transmitting; the system is required for certain manned aircraft (and still many aircraft are not equipped).
- The FLARM system is mainly used in Europe.
- Few drones are currently equipped with traffic awareness transponders.
- Pilot intervention is usually required when presented with a collision warning.
- Transponders can be expensive, and therefore more likely to be used for higher-end commercial activities such as helicopters, light aircraft and commercial airlines.
- Transponders can also be large so less suitable for use on drones.
- Greater intelligence may be required in traffic awareness solutions for drones due to their different characteristics e.g. drones represent a lesser threat to other nearby drones than to helicopters or other aircraft.

SOLUTION

Various options can be provided by mobile operators for traffic awareness solutions:

- Information received from GCSs, such as ADS-B which covers other air users including helicopters, light aircraft and other commercial flights, can be sent to drones and pilots so that drones can be navigated away from areas of risk.
- Transponders (e.g. FLARM) can be integrated directly into drones to enable them to send their position to and receive the positions of neighbouring air users, including other drones.
- Transponders can also be integrated into 'retrofit' modules that can be fitted to drones. As above this enables drones to exchange positions with neighbouring air users.

Mobile connectivity provides significant value add to traffic information:

- Enables the traffic information received by a drone to be sent to the pilot or UTM for handling. This particularly increase awareness of neighbouring aircraft for providing better BVLOS operation.
- Information received by drones can be 'crowdsourced' and used for piloting/traffic management for other drones which are not equipped with their own transponder equipment.
- Information from 'legacy' air traffic information sources (not supported by transponders available for drones) can be shared with drones and pilots over the mobile network or with unmanned traffic management solutions for increased safety.
- Positional information (e.g. Global Navigation Satellite System (GNSS)) from drones can be received over the mobile network for sharing with other air users so that the correct collision avoidance actions can be taken.

Overall drones benefit from traffic information solutions that improve on the cost, size, weight and power requirements of commercial grade transponder equipment. This is where the mobile operator can provide attractive traffic information solutions for drones.

5G ERA IoT SUPPORT FOR THE USE CASE

- Air traffic ground station receiver equipment can be co-located in the mobile network with edge computing equipment to provide a supplemental information source for drones which are not directly equipped with transponder equipment. The edge node provides local processing and storage for traffic information, and caching of this data for drones operating in the area.
- Traffic information can be distributed at volume across operational drones, particularly through the support of 5G's enhanced mobile broadband (eMBB).
- Network slicing supports a higher quality of service e.g. availability for critical information services including traffic information.

USE CASE 5: UNMANNED TRAFFIC MANAGEMENT

Safety and efficient use of airspace are key benefits of UTM solutions for drones. As drone usage increases, and especially as commercial services expand, there will be an inevitable pressure on air space usage. UTM solutions will be key to sustaining growth in the use of drones by allowing efficient co-ordination between individual drone pilots and operators, and to minimise risks associated with dense drone deployments including potential mid-air collisions.

Connectivity for drones using the mobile network enables more efficient UTM solutions for drones. This is particularly helpful as drones are used in BVLOS deployments because pilots and automated flight management platforms will be flying drones over much longer flight paths. Whilst the mobile network provides the connectivity for drones it can also provide additional intelligence to enhance UTM solutions.

CURRENT SITUATION

- UTM solutions are not currently widely adopted due to lacking of clear regulations.
- Drones need to be equipped with many functions outlined elsewhere in this document in order for UTM to be successful – Drone ID, network coverage, BVLOS operation, information on local topography and so on.
- A lot of drone operators have developed their own UTM for managing their fleet.
- In many cases drone services are being limited to VLOS operation.
- Growth and innovation in the sector is being constrained.
- Air-space usage is not/will not be as efficient as needed.
- Safety risks exist particularly if much larger numbers of drones are deployed.

SOLUTION

Mobile operators are extremely well positioned to provide UTM solutions for drone operations. There are several highly capable off-the-shelf platforms that mobile operators can offer to their customers, either as a standalone service or complementary to drone connectivity options provided via SIM/eSIM subscriptions.

A key advantage for the UTM solutions provided by mobile operators is the integration possibilities with other parts of the drone solution, whether this is for identity and registration, coverage and signal information, location verification or crowd information. Together these functions ensure drone operations are made safer and more efficient. Many operators also provide cloud platforms for data storage and processing which are useful for end-to-end drone applications.

5G ERA IoT SUPPORT FOR THE USE CASE

- 5G eMBB supports high bandwidth in uplink and downlink for the transfer of drone status and flight information as well as live video feeds from the drone to the UTM system.
- 5G service across different spectrum bands provides support for large scale UTM based drone deployments.
- 5G positional architecture provides enhanced support for validating the location of drones or providing a fallback in the case satellite positioning is unavailable.
- Edge computing supports the distribution of UTM processing to the edge of the network to reduce latency in traffic management decisions, and to reduce the overall bandwidth needed for transporting information back to a centralised UTM platform.
- Network slicing available with 5G allows UTM related communications to run over a virtual private communications channel to achieve a higher quality of service, improved security and data privacy.

USE CASE 6: DYNAMIC NO FLY ZONES

It is commonly required that drones avoid entry into no-fly zones, this is particularly in areas including airports, prisons, sports stadiums and military sites. These no-fly zones are often static and can be provisioned into drones either at the point of sale or during registration/installation or before a flight.

When drones are provided with Internet connectivity, especially via the mobile network, they can benefit from the ability to download changes to defined no-fly zones. This allows new static locations to be added as soon as they have been published but also supports the concept of dynamic no-fly zones which can be important for public safety, or, protecting commercial rights at sporting or music events as well as other applications.

CURRENT SITUATION

- Dynamic no-fly zones are not well supported by the industry, and a common approach to defining and actioning them is needed.
- No-fly zone information may just be provided in the form of online maps or separate mobile apps that pilots are recommended to check.
- Drones may have hard-coded static no-fly zones which can require software patches to update, with different databases and update procedures per manufacturer.
- There is a lack of support for the creation of dynamic no-fly zones.
- Inconsistent processes between manufacturers/platforms for selective approval of drones for permitted access to no-fly-zones.

SOLUTION

Reliable mobile connectivity allows drones to receive no-fly zone information throughout their flight. This particularly supports dynamic no-fly zones as well as providing an optimal way of receiving static no-fly zone information. The bandwidth available on 4G and 5G networks allows much greater granularity to be defined for no-fly zones, supports a larger number of no-fly zones, and provides the ability to update this throughout the day even whilst the drone is in flight.

Since mobile networks also have location awareness the no-fly zone information can be grouped at a local level to reduce the amount of no-fly zone data the drone must receive, store and process. The mobile network can therefore provide location intelligence for the optimal delivery of no-fly zone information to drones.

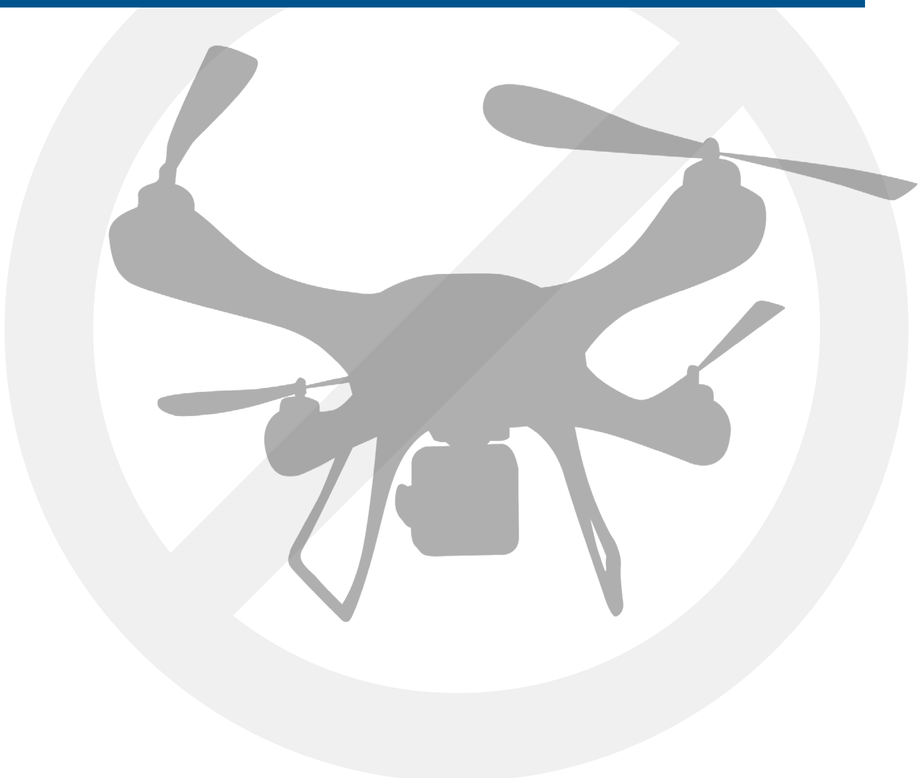
Additionally, as mobile networks have a strong mechanism for identifying the drone via the SIM/eSIM this allows specific permissions to be granted for authorised drones to enter or work in designated no-fly zones.

5G ERA IoT SUPPORT FOR THE USE CASE

- No-fly-zone information can be distributed at volume across operational drones, particularly through the support of 5G's eMBB.
- Edge computing can provide local processing and storage for no-fly-zone information, and the support for caching of this information locally to the drone operations.
- Network slicing supports a higher quality of service e.g. availability for critical information services including no-fly-zone information.

ADDITIONAL RESOURCES

Case study: Vodafone No Fly Zones case study available **here**



5 Recommended Approach for Mobile Operators

With potential for improved drone operations, an attractive return on investment and benefits across a wide range of use cases that impact both drone suppliers and drone users in different industries, there exists a significant business opportunity for mobile operators.

The value for mobile operators is not just in connectivity, but also in IoT solution provision, data analytics and additional integrations between production environment systems and wider connectivity, data, and management platforms. Therefore, mobile operators should focus on creating specialist partnerships to enable end to end value propositions. Further, creating an integration across several use cases improves the overall attractiveness of mobile operator offerings considerably. For example, enabling the use of drones BVLOS, securing payloads and monitoring the local environment, as well as enabling UTM and secure, connected drone flight paths, creates an extremely attractive value proposition. Building a wider ecosystem around these solutions makes the mobile operator value propositions more than simple connectivity or product propositions, putting the mobile operator at the heart of drone operations.

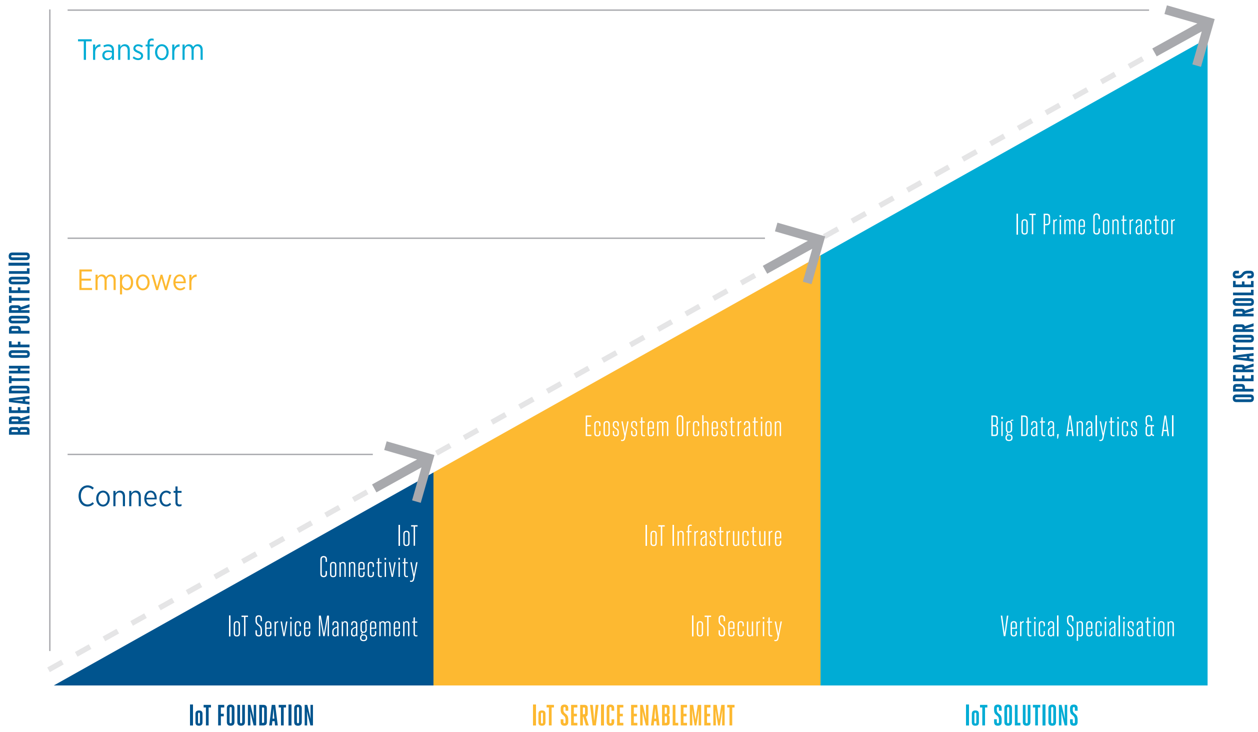
Separation of data and network also offers opportunities, where the drone ground control and management can be separated from the network connectivity required to enable these services in the air. This allows mobile operators to focus on cross-network opportunities and also allows the drone operator to treat their data securely, as different drone operations may need different levels of security and encryption for their secure operation. Another aspect to note is the separation of data and network, required by some companies for security reasons. This will impact the appropriate network and infrastructure deployment model used for drone operations, and needs some thought as to the areas of strategic importance for the mobile operator.

Key measures that mobile operators will need to meet in their drone and drone management propositions include reliability (including service level agreements), total cost of ownership, ROI and degrees of improvement over equivalent services that do not use drones today, such as local deliveries. Completing pilots and proof of concepts will yield some of this data and remove any potential perceived risk of using new technologies in customer-facing environments. The key advice to mobile operators remains to orchestrate an ecosystem around the mobile operator that can both meet specific drone requirements and build a significant economic change over existing solutions.

PATHWAY TO SUCCESS

Previously, the GSMA has defined a pathway for mobile operator transformation beyond connectivity, in the document *Beyond Connectivity*[11]*: New Roles for Operators in the IoT*. This pathway is adaptable to success in IoT verticals. The pathway encompassed three sets of defined roles:

- **Foundation IoT Roles to *Connect*:** including the provision of IoT connectivity and IoT service management. These roles support connecting devices and are, therefore, the bedrock of operator IoT services.
- **IoT Service Enabler Roles to *Empower*:** including ecosystem orchestration, delivering IoT infrastructure (cloud and edge) and becoming an IoT security provider; these roles are about providing essential tools and capabilities to ecosystem partners and supporting monetisation and interoperability between IoT solutions.
- **IoT Solution Roles to *Transform:*** such as becoming a drone sector specialised IoT prime contractor, a big data analytics and artificial intelligence (AI) provider and delivering vertical specialisation capabilities; these roles cover end-to-end services where operators take the lead in transforming vertical industries and their customers' businesses.



[11] https://www.gsma.com/iot/news/beyond-connectivity-operators-look-beyond-traditional-roles-as-the-iot-expands/

Each step in the pathway allows mobile operators to serve customers in increasingly sophisticated ways and thus increase their value in the ecosystem. Some of the roles are already familiar to mobile operators. For example, IoT connectivity is the starting point for mobile operators, and many of them already provide some cloud computing infrastructure or serve as prime contractors in IoT services. By contrast, other roles will be new for many mobile operators, such as ecosystem orchestration and vertical specialisation.

In the drone vertical, it is critical that the mobile operators establish themselves at the heart of an ecosystem, rather than being drawn into projects on an ad-hoc basis. Lack of an ecosystem is a sure-fire way for continuous positioning as a connectivity provider only. To move up the pathway and create more value, five key activities should be undertaken:

1.

BUILD A VISION AND A FOCUS:

The mobile operator must have a clear view of what their vision and role within the drone vertical must be. This vision must then be used to inform all value propositions, partnerships, and development activities. The vision may be to focus on one or two of the use cases described in this document, or a full end-to-end service. Whatever it is, it is critical to ensure that the vision and area of focus is clear.

2.

DEVELOP CAPABILITIES QUICKLY:

The drones sector is evolving rapidly. Mobile operators should build short-term capabilities quickly if they want to gain market share.
In practice this means a strict focus on use cases that can be supported as quickly as possible. Knowing the next steps and progressions from that starting point are also essential.

3.

ESTABLISHING STANDARDS AND NORMS:

Drone providers have a very clear view of what works for them and what doesn't. They are generally risk averse. Working to establish proven deployment models and business cases through alliances, standards and certification schemes in functional areas such as connectivity offering, coverage, security will help operators get drone suppliers and users to accept the adoption of 5G IoT technology within the vertical.

4.

BUILDING TECHNICAL SUPPORTING INFRASTRUCTURE:

For the ecosystem to work efficiently, it needs to be pre-integrated through some supporting infrastructure. That can include the mobile operator's service management tools and billing systems; edge and cloud integrations; data analytics models and algorithms, and mechanisms for handling data authentication and security.

5.

BUILD A COLLABORATIVE CULTURE:

Ecosystem is key to success in drones. To stimulate specialist partnerships in the manufacturing vertical, mobile operators must build a collaborative culture. Holding workshops, networking events, initiating labs and pilots, casual meet-ups, and hackathons will all assist in creating ecosystems that specialise in the drones vertical and position the mobile operator as a go-to partner for vertical collaborations.

6 List of Acronyms

More acronyms and definitions can be found in the GSMA Glossary of Aviation and Mobile Terms

ADDITIONAL RESOURCES

Glossary: GSMA Glossary of Aviation and Mobile Terms available **here**

ACRONYM	EXPLANATION
ADS-B	Automatic Dependent Surveillance Broadcast
AI	Artificial Intelligence
BVLOS	Beyond Visual Line of Sight
CCTV	Closed Circuit Television
eMBB	Enhanced Mobile Broadband
eSIM	Embedded Subscriber Identity Module
EU	European Union
FLARM	Flight Alarm
GCS	Ground Control Station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IoT	Internet of Things
LTE	Long Term Evolution
LTE-M	Long Term Evolution for Machines
MAC	Media Access Control
mMTC	Machine Type Communications
NB-IoT	NarrowBand-Internet of Things
QoS	Quality of Service
Remote ID	Remote Identification of drones
ROI	Return on Investment

ACRONYM	EXPLANATION
RTDNA	Radio Television Digital News Association
SESAR	The Single European Sky ATM Research
SIM	Subscriber Identity Module
UAV	Unmanned aerial vehicle, commonly known as drones
URLLC	Ultra Reliable Low Latency Communications
UTM	Unmanned Aircraft System Traffic Management
VLOS	Visual Line of Sight
WEF	World Economic Forum

About the GSMA

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with over 350 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces the industry leading MWC events held annually in Barcelona, Los Angeles and Shanghai, as well as the Mobile 360 Series of regional conferences.

For more information, please visit the GSMA corporate website at www.gsma.com.

Follow the GSMA on Twitter: @GSMA.

About GSMA Connectivity for Aviation

The Unmanned Aircraft Systems (UAS) market is one of the fastest growing and innovative sectors of the IoT and presents a huge commercial and strategic opportunity for operators and their technology partners. The GSMA is actively working with the mobile and aviation industries to maximise the use of beyond-visual-line-of-sight capabilities for UAS, develop new use cases and help create an open and trusted regulatory environment. There are two drone-related initiatives, making progress in this area.

The Drone Interest Group (DIG) https://www.gsma.com/iot/drones-interest-group-dig/ is the place for GSMA members from around the world that are working with ecosystem players to encourage the use of cellular communications while helping to create an open and trusted regulatory environment.

The Aerial Connectivy Joint Activity (ACJA) https://www.gsma.com/iot/aerial-connectivity-joint-activity/ was established in 2020 with the goal of building a bridge between the mobile and aviation sectors, guiding stakeholders about the relevant standards and ensuring alignment. It is a trust environment for bringing together GSMA and GUTMA members.

For more information, please visit www.gsma.com/aviation.