5G Technology as the Backbone for Commercial Drone Usage

TDC NET and Ericsson Drone Mobility (EDM) explore how 5G networks can enable drones to operate safely and efficiently

Enterprises are increasingly looking to use drones for a wide range of purposes from site inspections and surveillance to public safety and real-time video capture. Such applications will depend on the support of mobile operators, legislators and 5G connectivity. That was one of the key takeaways from a commercial pilot and subsequent tests conducted by Ericsson's and TDC NET's joint 5G Innovation Hub.

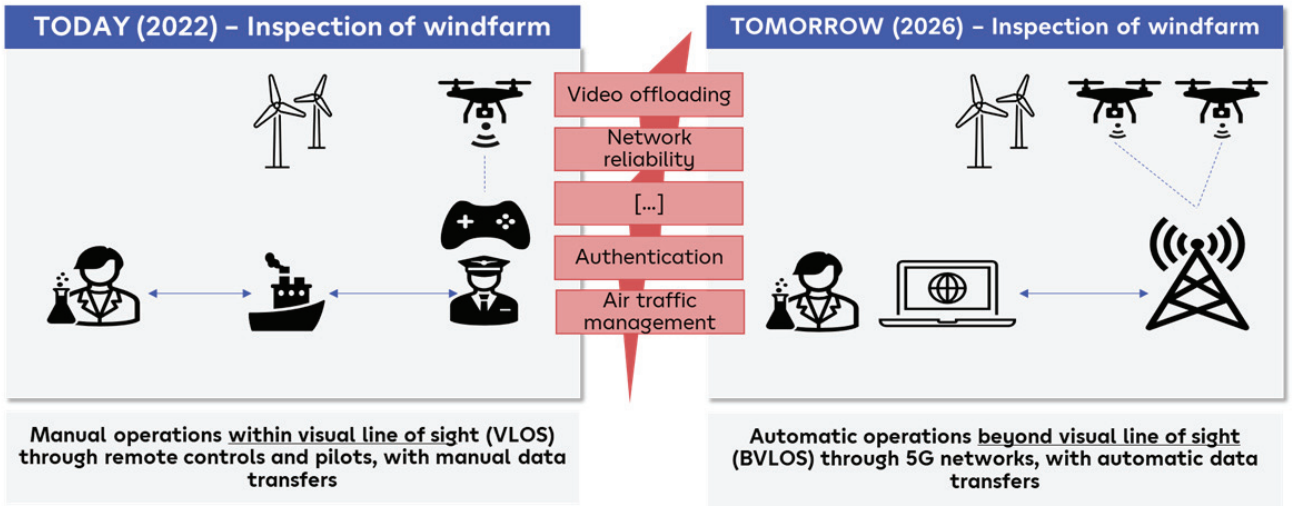
The 5G Innovation Hub ran the pilot and tests in response to requests from businesses preparing for forthcoming regulations governing beyond visual line of sight (BVLOS) operations by drones. From January 2023, EU regulations will permit such operations with specific safeguards.

Today, drones are mostly operated within visual line of sight (VLOS) using short-range wireless communications technologies. But businesses are looking for services that support reliable video offloading from the drone, while enabling a remote operator to see live video of what the drone is seeing. Today, many drone operators still rely on SD cards to transfer video and data from drones to their computers, while employing on-site experts to manage surveillance and inspections tasks.

In the not so distant future, cellular networks could be used to monitor and control drones in real-time when they are flying BVLOS (see graphic on page 2). TDC NET says mobile operators can use 5G to support drone operations with communications services, managed uplink and downlink connectivity, and important contextual data delivered via application programming interfaces (APIs).

The Danish government believes extensive use of drones will help society, while supporting commercial interests, such as infrastructure inspection, and the green transition by enabling the monitoring of the natural world. In its 5G-Enabled communication Infrastructure for Unmanned Aerial Systems (GENIUS) vision, Denmark explores how 5G networks could provide the U-space platform needed for large-scale drone operations via an ecosystem-wide, government funded project.

Drones are today operated offline through remote controls within visual line of sight (VLOS) and will tomorrow be operated online through cellular networks beyond visual line of sight (BVLOS)...



Providing prioritised 5G connectivity

TDC NET has demonstrated to enterprises in Denmark a prototype service, supported by Ericsson Drone Mobility (EDM), that gives drone operators prioritised 5G connectivity. In the period between February and May 2022, TDC NET and EDM ran a commercial pilot of this service with media company TV2, engineering company Connect 44, which inspects cell towers, video production firm Open House and Lorenz Technology, which conducts port inspections and manages security.

TDC NET used a dedicated access point name (APN) to provide the prioritised 5G connectivity for drones to be managed using EDM platform. "That's the most simple quality of service use case we could deliver, but that still brought value to them," says Jakob Werner, Commercial Lead of the TDC NET and Ericsson 5G Innovation Hub. "It is a type of insurance knowing that I'm prioritised in the network." Werner says the participating enterprises leveraged that service package in their daily operations. Working very closely with them, TDC NET and EDM captured their feedback, which showed that many of them would be interested in buying the service.

Connect44 is engaged in telecom tower inspection and has been a trial partner in Denmark in 2022 with EDM and TDC NET. Connect44 is an independent, vendor agnostic solution provider across the planning, building and management of mobile, fixed and fiber networks with presence across 11 European countries. Peder Hansen, CEO reflects 'Connect 44 experience with Ericsson Drone Mobility and TDC NET has been encouraging. The possibility for remotely controlling the drone and live streaming would help us in operational efficiency and real time decision making. Further the API's that telecom network could provide like quality on demand and drone positioning has potential to help drones especially in BVLOS."

The 5G Innovation Hub, which estimates there are 10,000 commercial drones operating in Denmark, has identified more than 500 enterprises in Denmark using drones for inspection purposes, image capture and safety applications. It forecasts the Danish commercial drone market is set to grow by an average of 34% a year.

However, the 5G innovation Hub recognises that a dedicated APN won't be enough in future. To support drone operations at scale, it believes differentiated 5G quality of service (QoS) will need to be triggered automatically on-demand. TDC NET is testing how such capabilities can be integrated into its 5G network.

With EDM, TDC NET has further tested the technical feasibility of using 5G to provide various building blocks to support automated drone operations BVLOS. As shown in the graphic on page three, potential 5G applications include remote control of the drone, location tracking, video transfer via a dedicated network slice, drone identification and route planning to avoid crowded areas.

"For example, if the automated flight is not going according to plan, 5G connectivity can be used to manually control a drone remotely from a central location. To bolster safety and security, the connectivity could also enable location tracking and drone identification, which are particularly important when the drone is operating BVLOS.

EDM and TDC NET are testing different methods of 5G location technology, such as 3GPP RTK and RAN-based active location, for different use cases. The drone location can be reported to the air traffic control system in real time through standardised

APIs. "We have verified network location reporting in real time," says Fredrik Flyrin, CTO and Co-founder of Ericsson Drone Mobility. "This is crucial for traffic alerts and aerospace monitoring."

EDM and TDC NET believe that mobile networks could be used for authentication and authorisation of individual drones, as well as to authenticate a drone operator's subscription with the air traffic management system.

The drone test cases leveraging telecom network API's demonstrated by EDM and TDC NET are detailed at the end of the document.

Supporting regulators, as well as operators

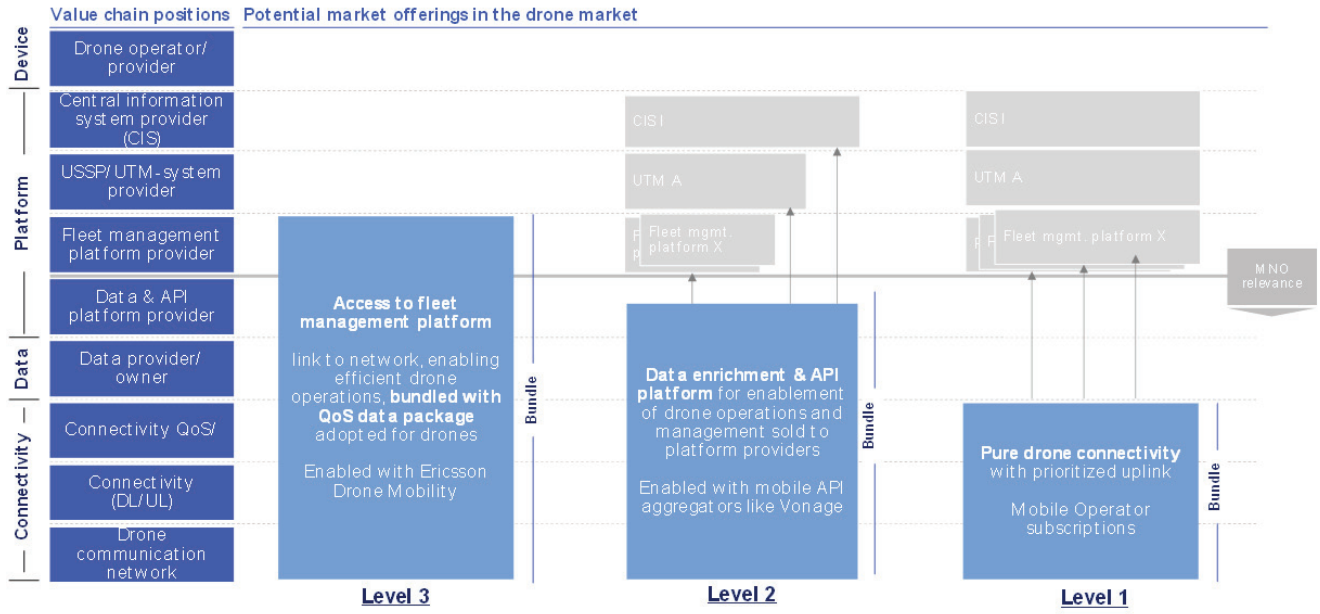
Having tested a range of use cases, TDC NET and EDM are now considering how best to provide both drone operators and regulators with the real-time information and services they will need to support and authorise BVLOS operations. "5G can provide the ground risk assessment for both the regulator and UAS (unmanned aircraft system) operators," notes Lilly Wen, Service Management & Innovation Lead, Ericsson. "Today, the regulators in Denmark don't have a map that reflects real situations. They need something that would be able to provide more dynamic and realistic and real-time data on that."

Mobile operators could use APIs to expose this intelligence to a Common Information Service Provider (CISP) that would then be able to publish dynamic traffic alerts. Alternatively, a mobile operator could become a CISP itself (see graphic).

The tests indicate that mobile operators could play a role in the fleet management and the U-space midterm and long-term via partnerships. "To really make a fleet management platform strong, it needs integration into the network and that gives a competitive advantage, boosting the connectivity via the application based on where you are," says Kapil Mittal, Head and Co-founder of Ericsson Drone Mobility..

Value chain possibilities for a Mobile Network Operator

Device	Drone operator/ provider	• Provider and/or operators of drones
Platform	Common information system provider	• Centralized overview of manned & unmanned air traffic at national level
	USSP/UTM-system provider	• Consolidation and steering of unmanned air traffic in a given area (e.g. region)
	Fleet management platform provider	• Operational management and steering drone fleets for enterprises
	Data & API platform provider	• Provisioning of enriched data and APIs required for flight operations and steering (e.g. positioning, coverage maps)
Data	Data provider/ owner	• Owner or provider of data necessary for flight operations (e.g. coverage or positioning)
Connectivity	Connectivity QoS provider	• Provisioning of QoS optimized for drone behavior and operations
	Connectivity provider (DL/UL)	• Provisioning of UL:DL data packaged optimized for drone behavior and operations
	Drone communication network operator	• Owner and operator of communication network infrastructure optimized for drone operation and behavior



The tests by the 5G Innovation Hub suggest mobile operators could provide three levels of service ((see graphic above):

- Level 1: This would simply involve the provision of managed connectivity with a specified Quality of Service (QoS).
- Level 2: This package would supplement Level 1 with APIs that make valuable information available to external platform providers.
- Level 3: This package would incorporate end-to-end fleet management / mission control solutions deeply integrated with dedicated drone connectivity using platforms, such as EDM.

Ericsson and Vonage, a wholly owned subsidiary of Ericsson and an aggregator for mobile APIs, are working together with mobile network operators and application service providers to drive the adoption of new network and communication capabilities exposed by 5G networks and to enable new innovative applications supporting drone services. “By aggregating these networks capabilities across multiple mobile operators and providing access to them for the drone developer community, network-aware applications will be deployable with a uniform experience that can be extended to drone adoption on a global scale,” explains Kapil.

Standardised APIs, such as a QoS-on-demand API for throughput and latency optimisation, could be used to support high definition interactive video streaming for critical applications, such as those employed by first responders, remote security and remote auditing (e.g. wind farm turbines). “The provision of other standardised APIs, such as device location and device status, in an easily consumable format will allow the acceleration of more advanced drone functions in a standardised, scalable manner,” adds Kapil.

All in all, EDM and TDC NET believe 5G networks capabilities already bring value to drone operators in Denmark, indicated strong willingness to pay, and will bring considerable additional value to drone operations, particularly as BVLOS flights become commonplace. The use cases tested by their 5G Innovation Hub show that 5G networks will be able to support the route planning, remote control, identification and location tracking of large numbers of drones, while also enabling operators to view video streams in real-time.

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Kapil Mittal - Head of EDM

The Demonstrated Use Cases

Each of the use cases tested by the 5G Innovation Hub is outlined below. For aviation and mobile standards related acronyms the following online glossary can be referred to https://www.gsma.com/iot/gsma-glossary-of-aviation-and-mobile-terms/

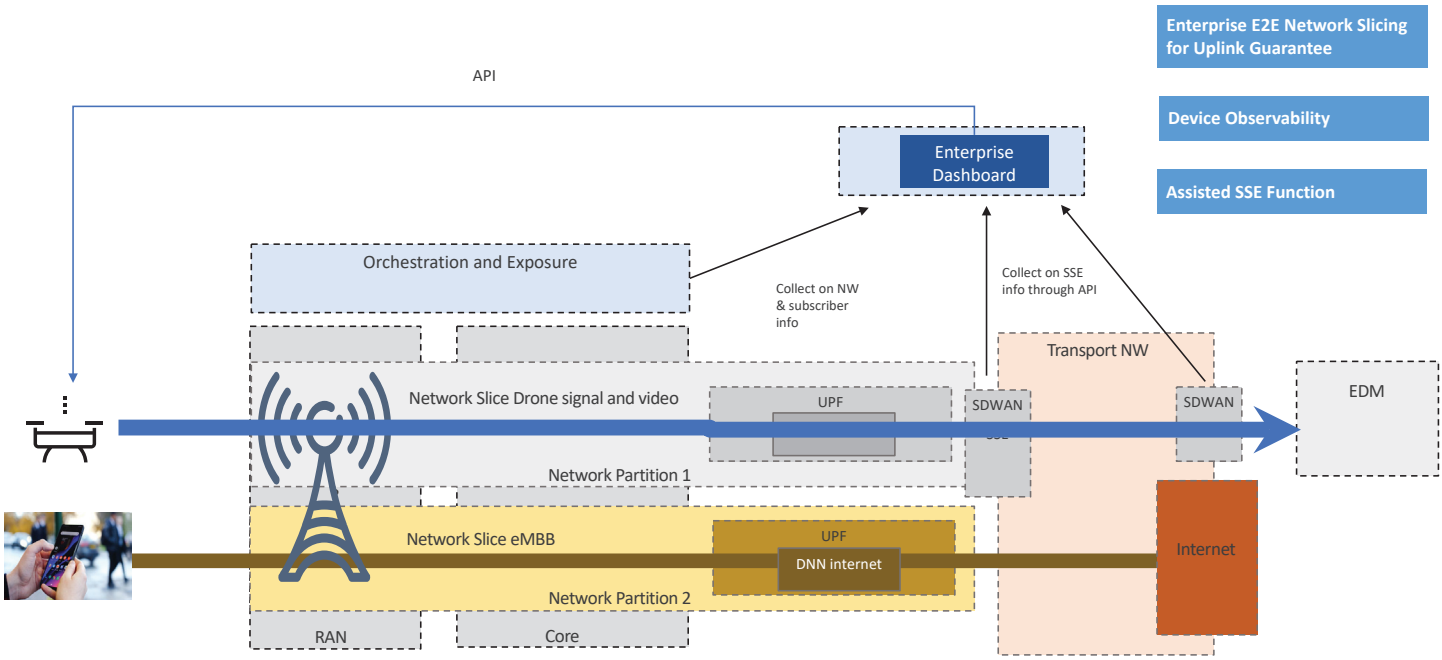
Use case 1: Network connectivity utilising slicing and control

During a flight, an operator may require real time reporting of a drone's location and remote control. Standards body 3GPP is studying how to support 5G network QoS for both the command and control of drones and the delivery of video from drones.

To enable this kind of critical communications with observability, a guaranteed and predictable network resource (end-to-end from the drone to the traffic management system) is required. To deliver both signalling and video, EDM tested an enterprise E2E SLA solution (shown in the graphic below) in TDC NET's macro network. The solution was able to support continuous uplink video streaming traffic of 2 Mbps.

TDC NET and EDM say they demonstrated how the solution can provide the consistent uplink band-width required for a stable drone control signal and a live video stream for surveillance. The solution was also able to provide observability of network slicing utilisation for each drone, while enabling decisions on the required network coverage for drone operation actions, such as emergency landing.

Enterprise e2e SLA solution with EDM for UAV/Drone use case



Use Case 2: 5G network service creation and exposure

To support different scenarios during a flight, a 5G network can extend or limit the bandwidth available to a drone in a dynamic manner. EDM has demonstrated how network exposure APIs can be used to dynamically control the QoS for individual drones. In the demo, drone network QoS was upgraded or limited by the drone operators in real time in line with the demands of the mission. When greater bandwidth was required, a dedicated bearer (see graphic) was established with defined QoS to support a specific video streaming quality.

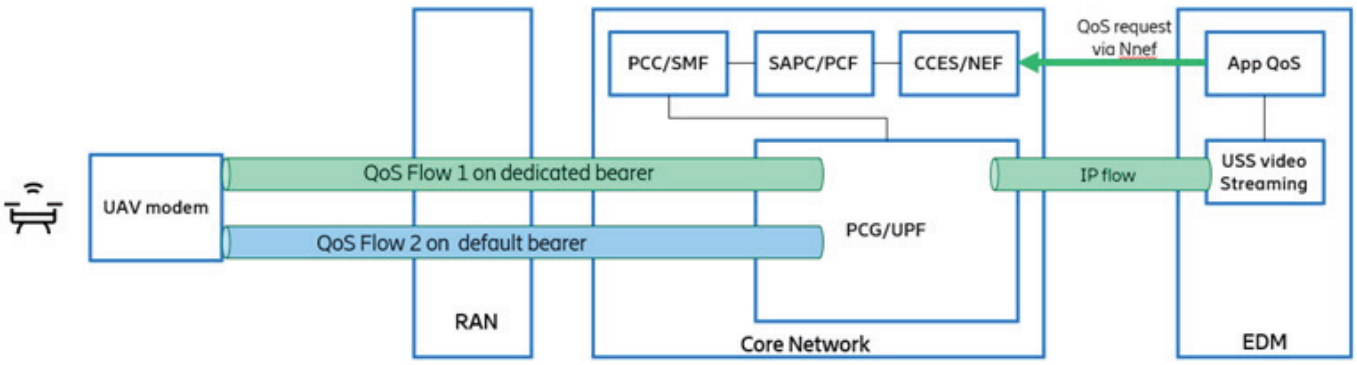
For example, a drone could request lower bandwidth during long distance travel, thereby conserving network resources. On reaching its destination, the QoS can be increased to support detailed surveillance.

EDM says aerospace regulators could use this approach to control network QoS for drone users in flight during an emergency and to comply with security requirements. In such cases, network resources can be prioritised for emergency services over normal traffic.

During the tests run by EDM and TDC NET, the QoS for a drone user could be dynamically upgraded and downgraded almost immediately. However, the real-time video stream improvement was slightly delayed due to the cache mechanism built into the video encoder. The difference in video quality with lower QoS and after QoS upgrade is shown in the pictures on the right.

Before user QoS upgrade, a blurred video image for observing object

After user QoS upgrade, a much sharper video image in real time has been observed.



Use case 3: Drone network identification and profile management

Regulators increasingly require drones to be electronically identifiable for safety and security reasons. For example, the EU's U-space regulation 2021/664 mandates the deployment of services that can identify drone operators and the location and trajectory of the drone during operations.

A new network identifier for drones called Networked Remote ID (NRID) provides a method for a drone to be automatically identified by both the telecoms network and the UAS (unmanned aircraft system) service supplier (USS). This mechanism can be used to ensure an eligible drone can fly in a safe manner in compliance with both the regulator's rules and multiple network service subscriptions. This also enhances security by supplying the USS with the additional drone equipment knowledge, subscription knowledge, and session knowledge logged by the telecoms network.

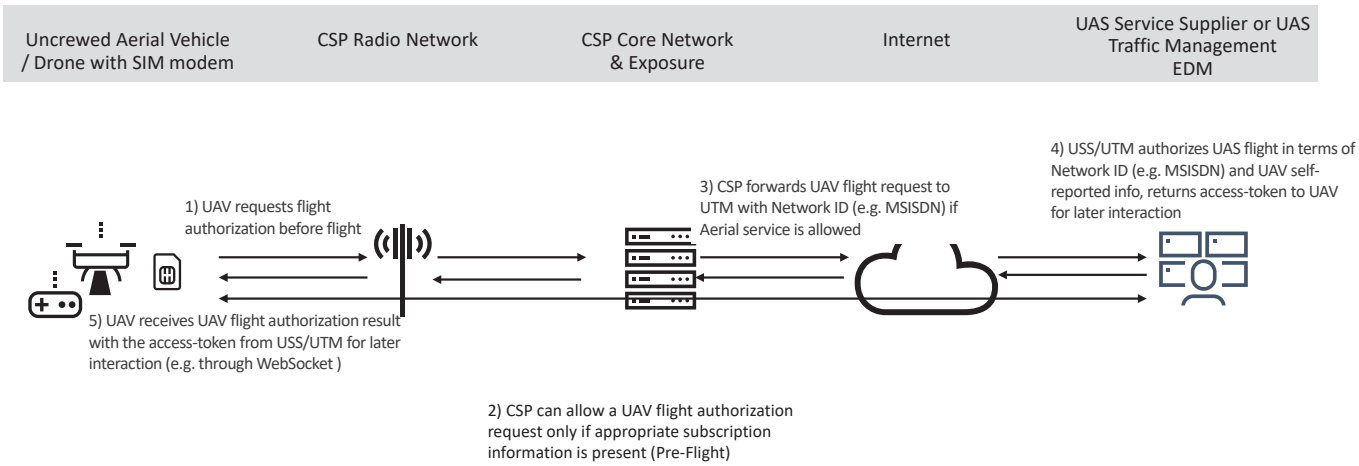
EDM and TDC NET demonstrated how a drone can send out a flight request with a drone electronic ID (see graphic). The telecoms network subscriber management system recognises and authenticates the embedded NRID in the drone's SIM card. The telco network service then passes on the enhanced information, including the NRID, to the USS for further approval on USS service subscription and eligibility.

EDM and TDC NET demonstrated how a drone that subscribes to both the 5G network and drone service can be authenticated and authorised successfully.

The drone was then able to stream video to EDM after the pre-flight check. However, a drone that subscribed to the 5G network service, but not the drone service subscription was rejected by EDM pre-flight as an unwanted drone user. Finally, a drone that hadn't subscribed to the 5G network service or the drone service was rejected by the TDC NET network at pre-flight as an unknown subscriber.

Using this approach, a drone and its operator can be automatically authenticated and authorised for both a network service and an UAS (unmanned aircraft system) service. TDC NET and EDM say this solution could be used to authenticate and authorise tens of thousands of drone users simultaneously and enable continuous drone tracking in the U-space.

UAV/Drone Flight Authentication and Authorization



Use case 4: Remote control

A telecoms network can be used to remotely control drones over longer distances than the wireless technology used today. Remote control of a drone depends on a live video feed from the drone for situational awareness.

With the support of a cellular network, a ground pilot could hand over the control of the drone to an inspection expert, who will decide what to inspect and when to capture images or videos. In this way, a single inspection expert can log into several different flights during the day and be more efficient. This approach also removes the need to educate the ground pilots about different inspections.

EDM and TDC NET tested remote control of a BVLOS flight through a 5G network with real-time camera surveillance and location tracking (see graphic). It was demonstrated that it is possible for remote pilots to request and take control of cellular-connected drones. They also successfully tested flights of remotely control drones from Denmark to Sweden.

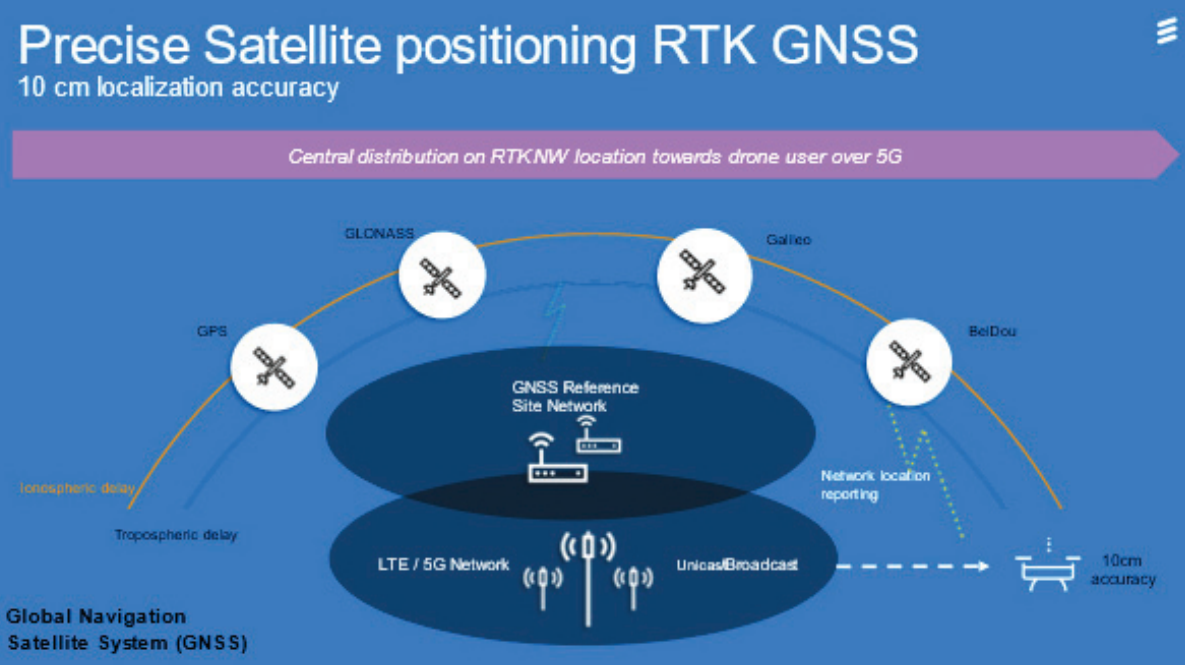
Use case 5: Drone location tracking

A cellular network can be used as a secondary positioning system to enable position redundancy and network validation of the drone flight. This capability can be used to reduce flight risk and make it easier to retrieve a flight permission. It is also important to validate the flight from a trusted source, such as a telecom network.

EDM and TDC NET demonstrated precise drone positioning, including altitude, using 3GPP's RTK GNSS over 5G standard, which can be used to enable accurate navigation and monitoring in 3D (see graphic). Conducted with SDU at Odense airport, weekly test flights have demonstrated that RTK verification through the TDC NET network can provide an accurate position within 2 cm, according to EDM. That is significantly better than the 10 cm accuracy targeted by this technology.

EDM and TDC NET also demonstrated a 5G-network estimated location, which can be used to validate that the satellite position can be trusted or provide location information when satellite positioning is not available. These tests encompassed both the Cell ID and Enhanced-Cell ID positioning methods.

EDM and TDC NET concluded that both the RTK and network estimated position approaches can provide the location accuracy and liability required by regulators for U-space services in a continuous and automatic manner. Therefore, mobile operators could provide a secure network remote location to a regulator or an unmanned aircraft system traffic management. As the drone's position would be determined independently of the drone application, it is not easily spoofed.



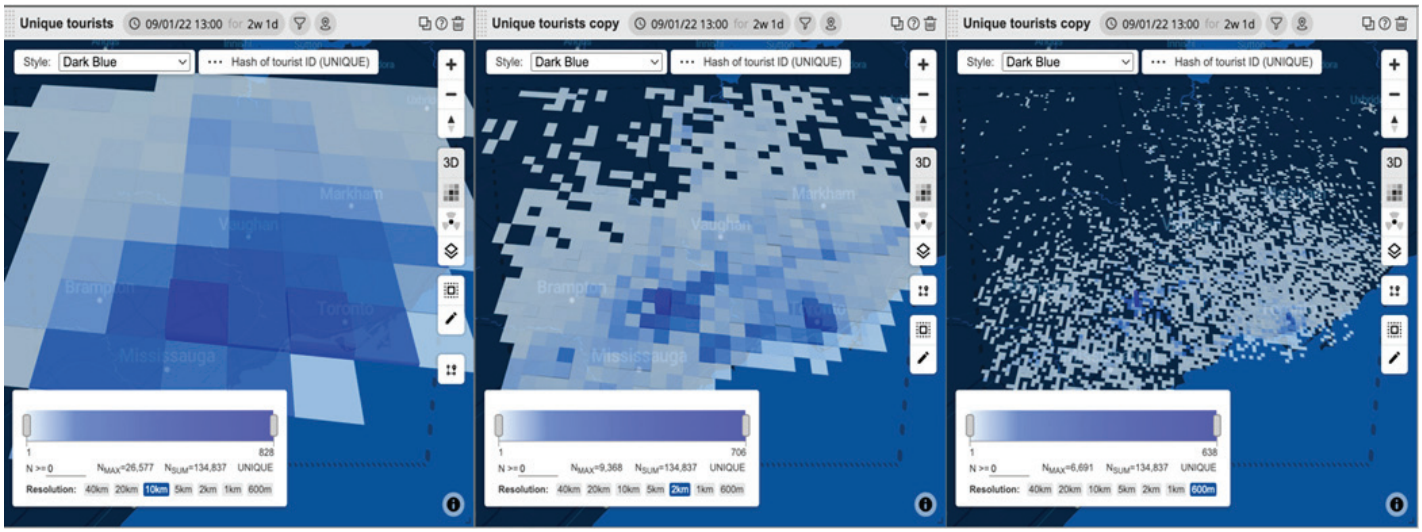
Use case 6: Geographic SIM density map

Security is critical for drone flights. The EASA (European Union Aviation Safety Agency) has published the SORA (Specific Operations Risk Assessment) to support compliance with Article 11 of the EU Regulation 2019/947. The SORA methodology can be used to conduct a risk assessment, identify mitigations and comply with safety objectives. Several civil aviation authorities around the world have accepted these principles.

EDM and TDC NET have demonstrated how a 5G network can continuously monitor ground population movements in an anonymous manner. The mobile network can provide SIM density information, which can be used to assess the ground risk situation both in terms of historical statistics and a dynamic real-time manner to support the SORA.

As noted by the FAA BVLOS ARC working group, the relevant time-based exposure of drone flights is an important factor in determining actual ground risk exposure and probability. EDM and TDC NET say a SIM density map can provide real time dynamic data for ground risk assessment and mitigation. This information can be used for pre-flight assessment and risk mitigation and to lower the drone take-off criteria.

The graphic below shows how the ground risk assessment tool can provide flight area ground population density in different granularities, as requested. Historical SIM density information, such as population density during seasonal cycles and bank holidays, can also be used to predict ground populations during planned flights.



About the GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

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

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About the GSMA Foundry

The GSMA Foundry is the go-to place for cross-industry collaboration and making positive change happen, supported by leading technology organisations and companies. By bringing together members and key industry players, engaging, and unifying the end-to-end connectivity ecosystem, the GSMA is solving real-world industry challenges.

Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. This enables the mobile industry's mission: to connect everyone and everything to a better future.

Find out more, or submit a new project idea, at gsma.com/Foundry

About TDC NET

TDC NET is the largest and most experienced provider of digital infrastructure in Denmark, TDC NET delivers stable and future-proof connections in Denmark. It maintains the existing digital infrastructure, while investing in new technologies that enable us to expand and improve connections nationwide.

TDC NET's copper network reaches 2.8 million addresses. TDC NET connect more than 1.5 million addresses with coax or fibre. TDC NET is Denmark's best mobile network with national 5G coverage.

https://tdcnet.com/

About Ericsson

Ericsson is one of the leading providers of Information and Communication Technology (ICT) to service providers. We enable the full value of connectivity by creating game-changing technology and services that are easy to use, adopt, and scale, making our customers successful in a fully connected world.

https://www.ericsson.com/en

About Ericsson Drone Mobility

Ericsson Drone Mobility (EDM) enables enterprise drones to fly beyond visual line of sight securely and efficiently with telco-grade encryption and data security solutions. The platform empowers enterprise decision makers to securely connect and control drones enabling live steaming of drone data. The EDM team has a strong vision that mobile networks can bring many benefits and address key issues that would help the drone ecosystem to scale.

https://www.ericsson.com/en/ericsson-one/ericsson-drone-mobility

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