GSMA Internet of Things Case Study
Dynamic No-Fly-Zones

INTRODUCTION

Vodafone is committed to positioning mobile network infrastructure as the key enabler for safe beyond-visual-line-of-sight (BVLOS) flights. Over the last three years, the company has conducted a range of cellular network trials, during which it has demonstrated numerous unmanned aerial vehicle (UAV) capabilities such as remote command and control, and network-based geo-location. The latest technological developments shift focus from purely cellular connectivity towards more evolved features such as safety and drone airspace management. By 2025, it is projected that the number of cellular-connected drones worldwide will total 6.5 million. As this number continues to rise, it becomes increasingly important to manage airspace in a safe way. One of the most critical elements in ensuring safe operation is the management of drone accessing area of restricted airspace.

How Vodafone are ensuring safe drone operations with No Fly Zones (NFZ)

Whilst these predefined boundaries already exist for permanently excluded areas, it is not currently possible to generate and communicate new restrictions for drones in response to live events. Vodafone has developed a capability that allows no fly zones (NFZ) to be created dynamically, meaning that they can be generated in anticipation or as a response to unforeseen scenarios.

The latest Vodafone solution introduces flexibility to the creation of the NFZ perimeters by making the typically static feature dynamic. By connecting UAVs to Vodafone's cellular network, drone operators and relevant authorities are able to create and remove NFZs at any given time and location, which the drones respond to in real time.

By incorporating such a feature within the cellular network, it is possible to safely and rapidly manage drone activity in scenarios such as crime scenes and major incidents. Prior to operating network connected drones the NFZ element of drone flight was limited, being guided by a database of pre-set coordinates. Whilst it is possible to update the database and communicate the appropriate instructions to a drone during a given flight, the transfer of information between the UAV and the NFZ database is restricted by the physical limitations of the communication channel between them. Utilising the mobile network, Vodafone has demonstrated that the aforementioned limitation can be eliminated, provided that the drone remains in an aerospace with cellular coverage. For instance, in cases of extreme local weather conditions, it enables authorities to instruct drones already in flight to divert in order to avoid potential incidents.

Mimicking the role of a central control entity, Vodafone displayed how by using an unmanned traffic management (UTM) client, drone operators are able to create NFZs which network connected drones interact with remotely. During the testing phases, network engineers were able to create air restrictions remotely from London, UK, for flights being conducted in Jaen, Spain.

Here it is important to note that Vodafone does not intend to dictate the terms as to how UAVs should be dealt with when entering prohibited airspace. Instead, through the medium of this proof of concept, Vodafone highlights the capabilities that are on offer when utilising a mobile network infrastructure. Although Vodafone's trials demonstrates the use of warnings, alerts, and commands being sent to the drones, the same approach of connecting drones to a central server could have equally been used to send drone operators updates or any other form of appropriate information.

The image in Figure 1 below, depicts the construction of Vodafone's NFZ, with each sector illustrated and labelled. Upon entering Zone-1, the drone operator receives a alert, informing them of the approaching UAV NFZ, and offering an opportunity to change course with ample time. As a precautionary measure, if a given UAV ignores the warning and enters Zone-2, an automatic command will be sent to the drone, forcing it to hover and preventing the drone actually entering the NFZ. This is accompanied by a warning, informing the operator that remedial action has taken place. In a dynamic scenario where a NFZ is created in a region where a UAV happens to operate in Zone-3, an automatic command will be issued to the drone forcing it to land immediately.

Leveraging the identification capabilities of the cellular network, the way UAVs interact with NFZs can be customised and allocated into different categories of control; A NFZ can either be applied to all drones connected to the network, drones located in a certain airspace, or even by selecting drones which have been allocated to a pre-defined category at the users discretion. In the instance of one trial, a NFZ was created to demonstrate how two sets of drones allocated to seperate pre-defined groups behaved in a set airspace according to their authority level. *Drone-A* was assigned to be unable to enter the NFZ, whereas *Drone-B* was cleared to do so. The demonstration displayed how *Drone-A* attempted to cross into the NFZ, but was stopped in its tracks, whilst *Drone-B* was able to fly through the NFZ uninterrupted.

When dealing with a considerably large number of drones, the application of such a technology becomes further apparent. For instance, in a pre-defined NFZ, an operator managing its own fleet of drones for land inspection could conduct its flights, knowing that any UAVs not categorised to operate within the boundary would have prohibited entrance do so. Furthermore, in the case of outdoor events such as music festivals, the NFZs could be deployed only for the duration of the event, creating peace of mind for participating members of society.

Using Radio Positioning System (RPS) technologies to ensure reliable drone tracking

The overall solution also incorporates Vodafone's Radio Positioning System (RPS) technology – a GPS-independent way to geo-locate drones. As GPS may be spoofed with little difficulty, RPS technology offers a way to ensure that the geo-location telemetry can be trusted, an element particularly relevant when enforcing NFZ remedial actions.

Figure 1 - Vodafone developed NFZ categorisation.

Network latency speeds for drone operations

Whilst testing the remote abilities of the solution, a latency analysis was conducted to establish the time delay between a drone breaching a NFZ and it receiving a command perform a remedial action. In order to ensure reliable data insight, testing took place on servers residing in a range of locations. The test pilot measured the time for the command to reach the drone in its flight path location (Jaen, Spain) after being sent from the test server in both Madrid, and London respectively. In all cases, the average latency values were below 60ms. Such figures suggest that the developed solution is sufficiently capable of communicating commands to drones without allowing them to make significant headway into the restricted airspace, even when separated from the server by large geographical distances. However, for instances where the latency is required to be less than 60ms, such as direct control of drones using cellular connectivity and mission-critical services, current LTE networks will struggle to achieve the immediacy required. The introduction of 5G will be able to offer such capabilities, as it is able to offer increased reliability and reduced latencies.

Existing mobile networks are able to accommodate drones

Based on the dynamic NFZ live tests, it can be concluded that the mobile network can already successfully support the deployment of such a technology. Keeping in mind that the trials were undertaken without any modifications to the mobile network designed for ground users, the results of the efforts represent a step in the right direction for also being able to accommodate drones. The fact that the alerts and commands can be triggered remotely, also means that for a central control entity to use the mobile network for conveying information to thousands of UAVs simultaneously is a feasible proposition. The efforts of further improving the safety of drone operation will continue, with Vodafone continuing to work on the NFZ capabilities. Next in line is adding a motion element to the NFZs, meaning that they will no longer be fixed to a geographical location, but instead move along with a given UAV as it completes its mission.

The introduction of dynamic NFZs is just one of the capabilities that the mobile network is able to offer. Vodafone truly believe this will be an important aspect of making drone operation safe and will continue to work on introducing new technologies, to further its case for being the key enabler for BVLOS flights.

About the GSMA

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators and nearly 400 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.

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Further reference materials:

www.gsma.com/drones

About Vodafone Group

Vodafone is a leader in technology communications through mobile, fixed, broadband and TV.
Vodafone has extensive experience in connectivity, convergence and the Internet of Things, as well as championing mobile financial services and digital transformation in emerging markets.

Since making the first mobile call in the UK on 1 January 1985, Vodafone has grown into an international business and one of the most valuable brands in the world. They have mobile operations in 24 countries, partner with mobile networks in 42 more, and provide fixed broadband in 19 markets.

As of 30 September 2019, Vodafone Group had approximately 625 million mobile customers, 27 million fixed broadband customers and 22 million TV customers, including all of the customers in Vodafone's joint ventures and associates.

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