Autonomy-as-a-Service

UNMANNED LIFE

5G Logistics - White Paper

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Table of content

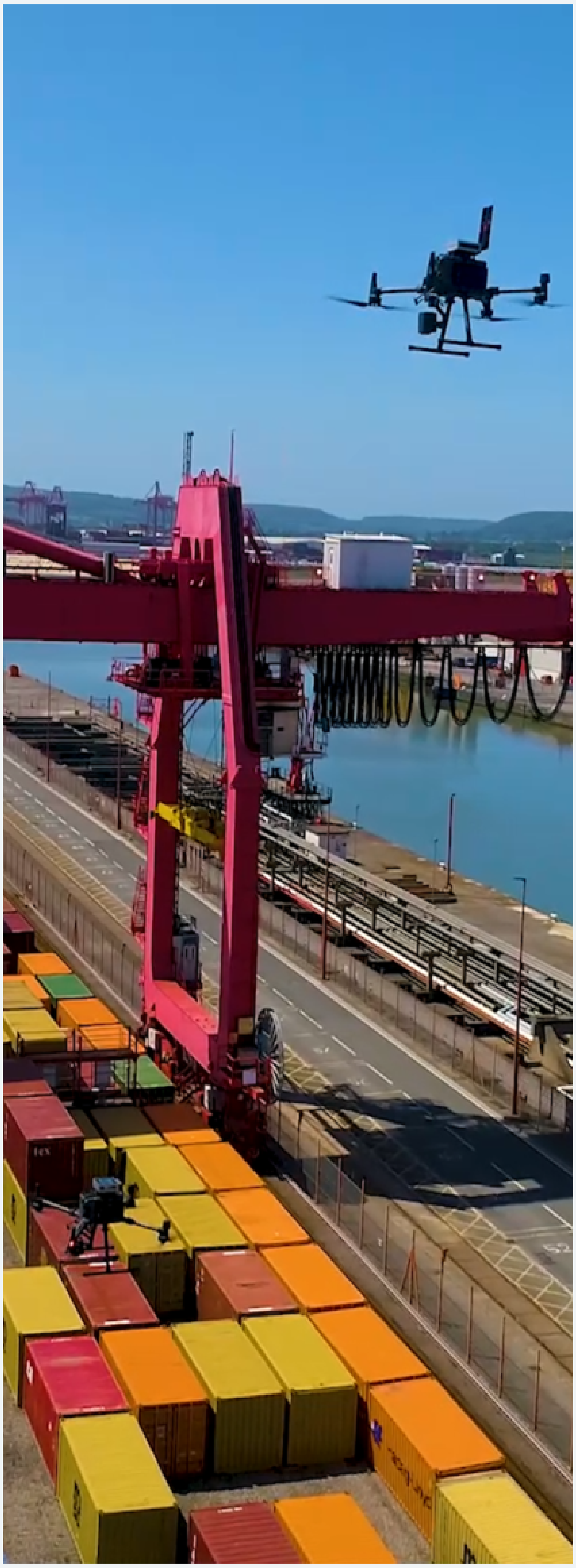
Executive Summary

In order to test and enable smart port operations in the UK and show how 5G private network capabilities could improve efficiency and productivity in the logistics sector, Unmanned Life participated in a consortium of 12 partners, chaired by the West of England Combined Authority.

The aim of the project was to showcase how 5G private network capabilities can boost productivity and sustainable growth in the logistics industry (and wider) and to highlight the potential for tracking the location and condition of containers and individual items in a freeport-freezone setting with extreme accuracy.

It was a great opportunity to bring SMEs, universities, and public organisations together to make progress toward the digital infrastructure of the future and improve road traffic management and air quality. The benefits associated with replacing manually intensive activities with autonomous systems enabled by 5G were also highlighted.

1. Introduction



The purpose of the Port Police Drone operations case was to leverage the full potential of 5G wireless networks in combination with Mobile Edge Computing (MEC) infrastructures for port security and surveillance.

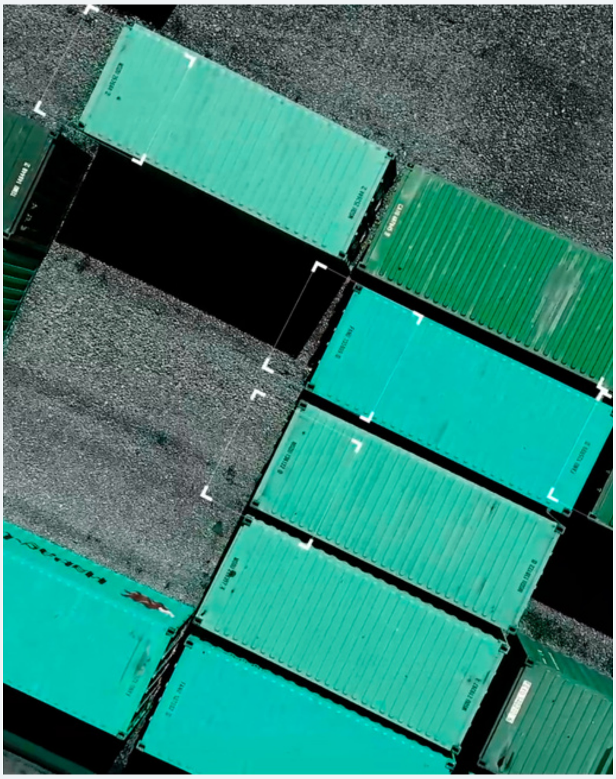
The sheer magnitude of Ports and the large geographic areas it covers, makes it difficult to have all parameters secured and surveyed throughout the day. Secure and efficient surveillance systems in port premises have always been a priority.

Traditional security systems operational in commercial or public ports come with their own challenges. CCTV cameras for fixed surveillance are immobile and have vulnerabilities like blind spots and electrical or mechanical failures. The manual method of surveillance is often time-consuming, expensive and menial with security personnel walking up and down the perimeter. And for aerial surveillance the costs of using and maintaining a helicopter and its piloting personnel are substantial.

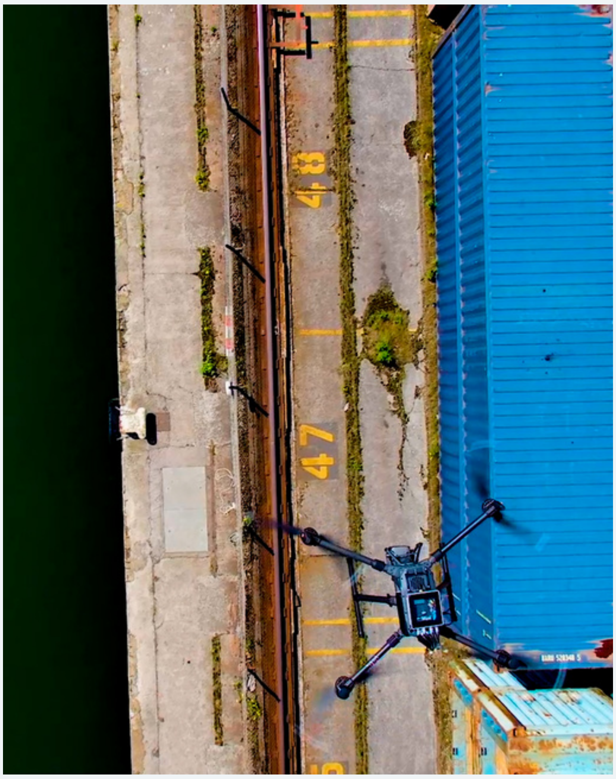
By utilizing 5G network connectivity, autonomous drone fleet surveillance can offer aerial monitoring with wider coverage for tracking and flexible camera movement to ensure coverage of blind spots. Moreover, it can be scaled quickly. Unmanned Life's platform made it possible to deploy, manage, and coordinate a drone swarm autonomously and seamlessly.

2. Geo-Fenced Tracking and Port Surveillance Use-Cases:

Unmanned Life was involved in two use-cases. In the first use case we implemented for this project, inspection and surveillance were conducted by using an off-the-shelf drone, controlled and monitored via a centralised platform in charge of orchestrating and processing the drone sensor data (such as proximity sensors, visual cameras for location, GPS coordinates, etc)



The use case experiments allowed a comparison between time taken for drone surveillance and manual surveillance by a police officer when monitoring specific areas. The intention of the experiments was to confirm the potential time reduction for surveillance tasks.



For the second use-case Unmanned Life teamed up with the University of Bristol to showcase autonomous drone-based Geo-fenced monitoring and tracking. For this, once a container left a geo-fenced area, highlighted via RFID, a trigger was sent to Unmanned Life's platform prompting the drones to autonomously deploy to the specified area, using this geo-positioning as the trigger. Upon reaching the designated location, the drone equipped with camera provided a bird's eye view of the area that could be viewed through our web interface.

Unmanned Life's Solution

3. Unmanned Life's Solution

An autonomous drone flight solution is provided by Unmanned Life. The user only needs to specify the type of mission to upload, define parameters like flight height or drone speed, and launch the mission via the platform interface. In particular, the mission itself can be modified beforehand based on the actual needs of the customer, allowing for the easy reuse of various mission types as needed. The user can view both the drone's streaming footage and its location in real time.

Unmanned Life platform is composed of the modules below:

- Unmanned Life Central Command Platform (UL-CCP): Located at the heart of the solution and responsible for integrating and managing all the systems involved in the solution via the Multi-access Edge Computing (MEC) infrastructure.

- Unmanned Life Autonomous Control End Node (UL-ACE): Computing unit installed on the drone in addition to its flight controller. Integrates with the flight controller and with the wireless network for command-and-control communication and data transmission.

- Unmanned Life Web Interface (UL-WEB): Online web interface installed on the Edge or on a local machine, allows the user to set-up and control missions and visualize the live streaming feed during a mission.

- UAV (unmanned aerial vehicle) drone: Installed with onboard sensors (like proximity sensors, visual cameras for positioning, GPS, etc.) and used as a tool to carry the payload, for example, cameras for surveillance or inspection.

- Unmanned Life Video Analytics (UL-VA): Collects and processes the sensor data streamed from the drone. This module is usually located on the Edge together with the UL-CCP.

- Payload: Camera serves as payloads to enable specific functions such as streaming video to the UL-VA and enable analytics or manipulations depending on the solution requirements.

Each of these modules is deployed using Docker, an open platform for developing, deploying, and running applications.

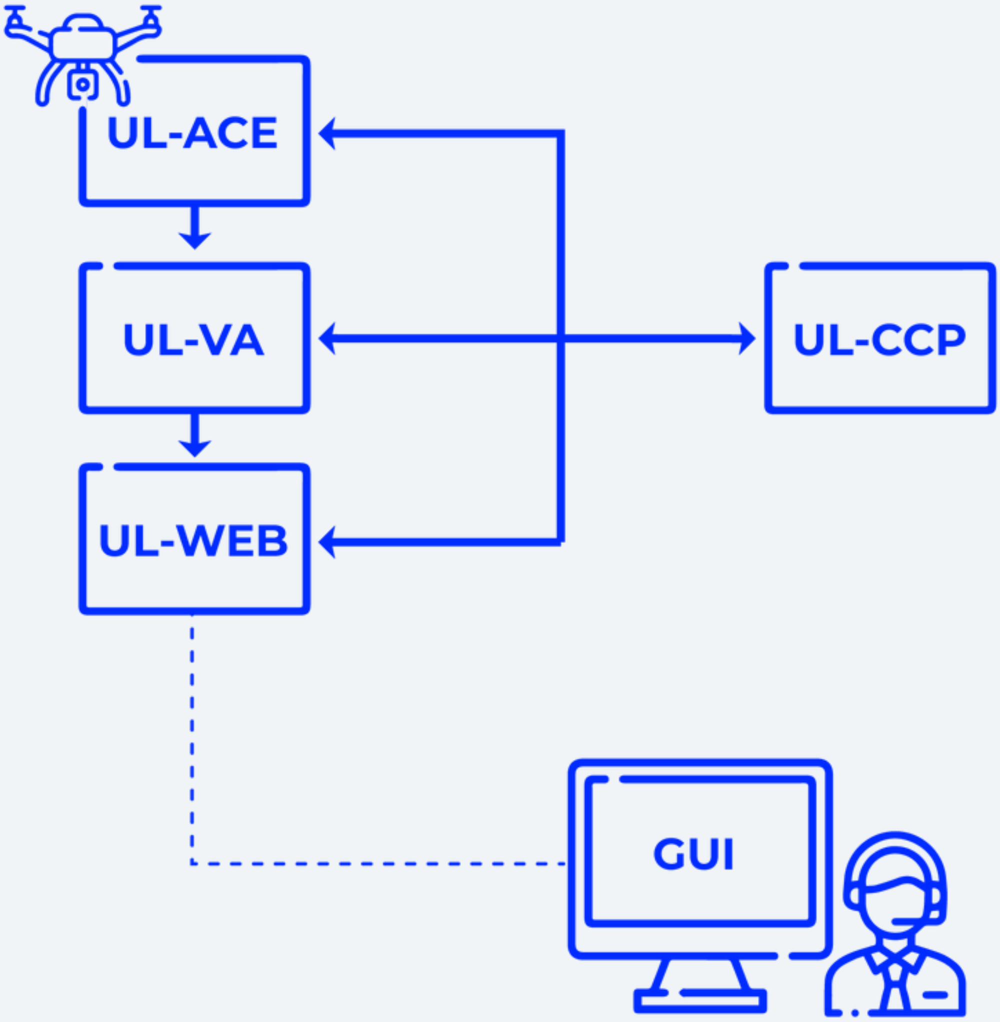


Figure 1 - High-level architecture of the Unmanned Life platform

4. Trials

The use case intended to test and demonstrate a swarm/fleet of Unmanned Aircraft Systems (UAS) flights at the Bristol Port. The UAS' took-off and landed within the parking area of the Avonmouth Container Terminal of the Bristol Port .

The UAS's were utilized to test three different scenarios all of which were tested within the area marked in red below.

- Pre-planned Surveillance (Fence Inspection): To ensure that the same area is monitored, the operator can upload predefined missions to the Unmanned Life platform. This experiment involved creating a predetermined mission to carry out surveillance next to the fence.

- On-demand Surveillance (Incident Response): The required monitoring area and other factors, such as flight altitude and speed, were chosen by an operator. By default, these parameters are set by the platform, however it is possible to adjust them if needed. In this scenario, the boundary of a perimeter was picked for observation.

- Triggered Response and Emergency services: For this scenario, if a specific event is detected through the area (i.e., third party systems triggering an alarm event caused by a breach, a manual deployment trigger from security personnel, etc.), a drone will automatically fly to the triggered location and begin surveillance. After receiving a specific external trigger with the geographic position of the area to be patrolled (sent by the UoB platform), the Unmanned Life platform automatically creates the mission path and launches the drone to execute the mission autonomously.

5. Hardware Used

To complete these experiments, the DJI M300 RTK drone has been used. Together with its payload, the camera Zenmuse H20 Series is depicted below.

Figure 2 - DJI M300 RTK and Zenmuse H20 Camera

6. Defined KPIs

According to the Port Police and Port Authority, Bristol Port inspection times and incident response are key aspects to be considered in enhancing the operations effectiveness and reducing associated costs.

At present, it is estimated that it takes a police officer approximately 4 hours to walk the perimeter fence line at Avonmouth Port, and approx. 6 hours for Royal Portbury Dock. Those checks are executed at random times and locations and are undertaken approximately once a week.

By utilizing the full potential of a high-performance and low-latency 5G network, we used our trials to demonstrate the high efficiency and adaptability of an automated drone-based system to carry out surveillance and inspection tasks within Bristol Port operations. For this reason, we focused on measuring the following key KPIs:

- Average mission time
    - Fence inspection time (travel time + fence inspection time)
    - Incident response (travel time + area inspection time

- Battery Consumption

To assess the differences between an autonomous drone and a human patrol of the perimeter fence, it is important to record each flight duration and then process the average operational time for the specific sample scenario.

Battery life has a direct impact on the extensibility and repeatability of autonomous drone missions for patrolling a perimeter or an area. For this reason, it's crucial to track battery usage per mission as a KPI and corelate it to the length of each flight.

Increased patrolling speed results in better emergency response capabilities and significant cost savings for routine operations.

7. Findings

To facilitate accurate data analysis and be able to extrapolate consistent output, we approached the work in 2 main phases:

1. **Setting the baseline -** to be compared with the final solution deployment
2. **Automatic drone solution deployment -** collection of use case field deployment data for comparison with the baseline.

7.1 Setting the baseline

We asked Port Police to collect baseline data for the main KPI - the average time spent for the patrolling and surveillance of a specified area.

3 measurements were made:

- Travel time to specific location
- Fence inspection time
- Incident Response time

As the response time might vary based on the time of day and the traffic 3 measurements of the travel time were completed by Port Police to the marked location in the port, one measurement in the morning, one around noon, and one in the late afternoon/evening. This allowed us to take an average of the response time as the baseline.

7.2 Travel Time

We measured the time it takes for a police officer to depart from the desk in the office, travel outside to the police vehicle, and drive to the indicated location on the map in the port .

As a result, below are the average times spent on this specific travel:

Date	Time of Day	Time Travelled	Average Travel time
30/04/2022	18:25	13 mins 40 sec	14 mins 09 sec
01/05/2022	20:15	13 mins 03 sec	
01/05/2022	22:38	15 mins 33 sec	

7.3 Fence inspection time

The second measurement taken was to walk from the vehicle to the fence and perform an inspection patrol alongside the fence and the time to return to the car. The fence cover is about 150m. To execute this 150m path, a walking Police officer took on average **3 mins and 30 secs**.

Adding this timing to the average time spent for the officer to reach the Oil Basin, we can conclude that it takes (on average) **17 mins and 39 secs** to patrol the specified fence section.

7.4 Incident Response time

The final measurement was the time to patrol the container area in search of a potential intruder. For this we wanted to record the time for a police officer to walk and survey the area, measured from the police vehicle to the location marked on the map (area highlighted in green in the image below).

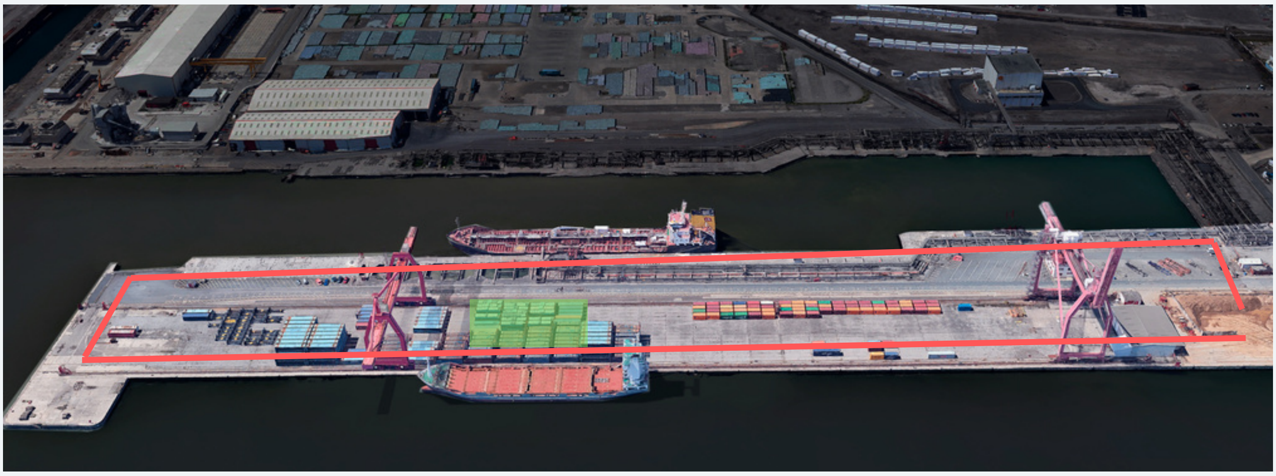


Figure 3 - Area inspection zone

To execute this path, a walking Police officer took on average 4 mins and 31 secs.

Adding this timing to the average time spent for the officer to reach the Oil Basin, we can conclude that it takes (on average) 18 mins and 40 secs to survey the specified area of the port.

7.4 Automatic drone solution deployment

The baseline measurement gave us a solid base to compare the data that would have been collected by performing the same mission described in the section above, this time with an automatic drone.

Incident Response experiments

Experiment Description	Battery consumption	Average Flight Duration	Comments
Incident Response - Round 1.	14%	4'27"	Drone speed of 1 m/s from the take-off area to the perimeter and at 2 m/s in the perimeter patrol section.
Incident Response – Round 2.	14%	4' 27"	Drone speed of 1 m/s from the take-off area to the perimeter and at 2 m/s in the perimeter patrol section.
Incident Response - Round 3.	14%	4' 28"	Drone speed of 1 m/s from the take-off area to the perimeter and at 2 m/s in the perimeter patrol section.

Fence Inspection Experiments

Experiment Description	Battery consumption	Average Flight Duration	Comments
Fence Inspection - Round 1.	11% 15% (150m)	3'20" (50m) 5'00" (150m)	Drone speed during fence inspection: 1m/s For safety reasons given by the port operations, we decided to shorten the flight experiment to 50 m instead of 150 m. The flying time for the 100 additional meters has been added as a math calculation (Time = distance/speed)
Fence Inspection - Round 2.	10% 14% (150m)	3' 28" (50m) 5' 08" (150m)	
Fence Inspection - Round 3.	10% 14% (150m)	3' 28" (50m) 5' 08" (150m)	

Triggered Response and Emergency services Experiments

Experiment Description	Battery consumption	Average Flight Duration	Comments
Triggered Response and Emergency services – Round 1	10%	3'50"	The average duration of the flight starting to the take-off, going to the identified coordinates, wait for 30 seconds providing the bird view of the area, and coming back to the landing point.
Triggered Response and Emergency services – Round 2	11%	3' 42"	

"Building the Autonomous Future for Smart Ports"

8. Lessons Learned

The demonstration of the trials in Bristol Port highlighted the advantages of using an autonomous drone-based solution and the potential of a 5G Network to carry out patrolling and surveillance tasks.

- **Efficient incident response and assessment**

As well as the inspection activities, incident response and assessment experiments along the port were made by deploying Police officers to check and assess the situation in a pre-defined area.

Through our experiments and the collected data analysis, we have been able to demonstrate that such activities can be completely managed and executed via an automated drone-based solution leveraged by the 5G network installed in the Port premise.

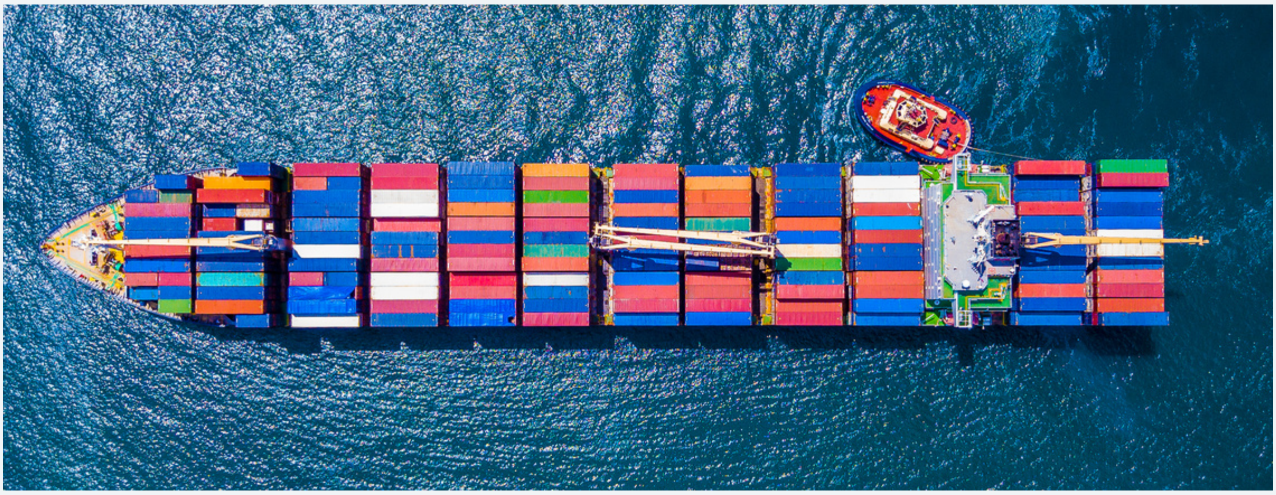
Activity	Type	Average time for completion	Time reduction
Time for incident response and assessment	Manual (Police officer)	18 mins 40 sec	54%

- **Reduced Inspection time**

At present, police officers, stationed around the port fence walk along the parameter for inspection activities, making it an extremely time-consuming task that can only be completed once a week.

We have been able to show through our testing and data analysis that such tasks can be fully managed and carried out using an autonomous drone-based solution utilizing the 5G network deployed in the Port premises.

Activity	Type	Average time for completion	Time reduction
Inspection of a Fence (portion)	Manual (Police officer)	17 mins 39 sec	48%



9. Benefits

We were able to verify multiple benefits by analyzing real-world data and comparing it to baselines supplied by the Bristol Port Police and Authority, thanks to the data collected throughout the studies. Some benefits of our software platform are listed below.

1. Autonomous flights – No pilots

For autonomous Navigation our software acts as an intelligent central brain, coordinating and orchestrating different drone missions in real-time.

2. Live-Video stream to the command center

By utilizing the high bandwidth and low latency of 5G network we can stream Live HD video feed in real-time to central command and control centres. Our platform allows secure flow of data through the network. The video feed is used by the platform for intelligent decision making.

3. AI-algorithm identification

Data collected by the drones is processed by our AI-Algorithm to feed intelligent decision making. By leveraging AI analytics, smart threat detection is powered which alerts the system to any identified anomalies. Machine learning models further increase the precision of the algorithm over time.

4. Integration with existing or available platforms.

By combining drone capabilities with those of other intelligent IoT platforms, proficiencies are increased. Through APIs, the platform can be integrated with other systems already in use by the end users. Autonomous deployments' data flows can provide material for a comprehensive analytics dashboard platform

10. Challenges

For this use-case we had to face a few challenges listed below.

1. Flight Permits

For a highly technological and automated solution like this, a flight permit from the Civil Aviation Authority (CAA) is required when flying over industrial areas and over uninvolved people (i.e., port workers).
Normally, it takes 4 to 8 weeks to complete the application process and receive the final approval; however, because this use case required a complicated and automated solution, more time was required. In this particular instance, it took roughly 20 weeks from the time of the initial application to the time of the last on-site evaluation.

2. Network and Setup

There is a high dependency on network reliability to enable the successful deployment of drones. Due to a problem with the on-site network architecture, connecting to the 5G radio automatically was occasionally not possible.

Several cells were built along the Bristol port, as may have been mentioned in earlier publications, to achieve network coverage in a larger area. The 5G radio, however, was unable to flip between the several cells to deliver internet in every location. Due to this problem, it was required to physically transport the modem that needed to connect to the 5G radio, (in this case the modem from the onboard computer of the Unmanned Life drone) to the location where a cell was connected. Once this bonding was established, access to the private network was made possible.

To achieve this connection, we needed support from the University of Bristol and Airspan. For this reason, our testing process was interrupted on several occasions.

Furthermore, network peaks were observed during the flight caused by the physical movement of antennas. That drove us to find a better solution to fix the antennas to the drone onboard computer in a more reliable way.

Finally, network wise, working in a private infrastructure added an additional layer of security to our solution, narrowing down the potential external parties that can affect or try to control the drone operation.

11. Conclusion

Evidently, the use of such an autonomous solution supported by a 5G Network will significantly improve the efficiency of the Port Police personnel while reducing the overall costs with a time reduction of about 50% for carrying out the primary patrolling and surveillance tasks along the port.

In order to handle a swarm of drones in real-time with contemporary video streaming, 5G equipped networks are essential due to the low latency they offer and the bandwidth to transmit content.

Additionally, the limited battery capacity used for each mission (16 percent drain on average per mission, considering the 250s lead time added) will allow for a minimum of 3 safe missions to be run before another charge is necessary, significantly increasing the deployment frequency for such repetitive missions. More missions being run in the same timeframes contributes to better pre-emptive maintenance, and better visibility of changes throughout the day.

In fact, police employees can be assigned to more worthwhile tasks while regular inspection and surveillance are left to highly automated solutions because they can be menial and repetitive for workers. In addition, false call outs create smaller consequences for police workers, especially during the night.

This solution has a great deal of potential to be utilized and seamlessly integrated into existing external and enterprise asset management systems (such as surveillance systems) at the customer's premises. This would enable a deep system-to-system integration and possibly result in highly automated systems that could increase the overall return on investment and increase the efficiency and safety of the processes.