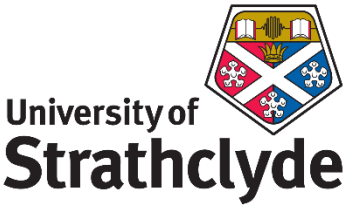
ONSIDE

Open Network Shared Spectrum
Innovation and Design Environment

Final Project Report



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Executive Summary

The ON-SIDE project has addressed key challenges associated with deploying private 5G stand-alone (SA) networks operating in shared access radio spectrum. There is significant opportunity for private 5G (and 6G) networks to complement the public networks and support a growing number of applications and use cases that would benefit from such network connectivity.

A number of very successful use cases were progressed in the project. These include: (i) Cisco and Logicalis working with Peel Ports Liverpool Terminal 1 to implement a private 5G Proof of Value (PoV) – this succeeded beyond expectations and a commercial roll out to expand the deployment is now underway; (ii) the University of Strathclyde and Neutral Wireless deploying private 5G for live broadcast in sports stadia; (iii) BBC R&D, the University of Strathclyde, Neutral Wireless, and Cisco deploying private 5G for live studio connectivity for wireless cameras and equipment, and (iv) the University of Glasgow using private 5G connectivity for immersive training.

Spectrum-related issues have also been explored, and the project developed an intelligent spectrum management Proof-of-Concept system which was demonstrated at the IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN) 2025 and at the UK Spectrum Policy Forum's Future Spectrum Policy Summit in May 2025. The system incorporates novel wideband spectrum sensing technology that was developed by ON SIDE to support and augment spectrum access and management. A detailed proposal was produced for 6 GHz co-existence testing between Wi Fi and 5G/6G.

With Ofcom considering a move towards 'user-led coordination' in certain circumstances, a fully automated spectrum management system, augmented with real-time spectrum monitoring, could help to resolve interference issues automatically, without users (i.e. network owners) having to manually intervene. This is an ambitious target, but it would have tangible benefits and would help the UK to maintain its lead in innovative spectrum management and spectrum policy.

Several O-RAN Split 7.2 approaches have also been investigated and evaluated, and this has led to significantly improved understanding of the pros and cons from both a technical perspective and a commercial perspective.

ON SIDE has established some key technical and commercial learnings that are being put into practice for real deployments, and the project has been represented at a number of conferences and events.

Contents

1 Introduction

ON-SIDE was a 24-month co-innovation project whose overarching goal was to turn the vision of private 5G networks into a practical reality by driving innovation and proving viability, benefits, and value in real-world settings. Key aims of the project, which ran from 1st October 2023 to 30th September 2025, were to address key challenges associated with deploying private 5G stand-alone (SA) networks operating in shared access radio spectrum, and to develop and understand the business opportunities for using private 5G technology for a number of applications and use cases.

A number of very successful use case deployments were progressed. These include: (i) Cisco and Logicalis working with Peel Ports Liverpool Terminal 1 to implement a private 5G Proof of Value (PoV) – this succeeded beyond expectations and a commercial roll out to expand the deployment is now underway; (ii) the University of Strathclyde and Neutral Wireless deploying private 5G for live broadcast in sports stadia; (iii) BBC R&D, the University of Strathclyde, Neutral Wireless, and Cisco deploying private 5G for live studio connectivity for wireless cameras and equipment, and (iv) the University of Glasgow using private 5G connectivity for immersive training.

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In addition, a structured set of spectrum-related tests and measurements was made in the Glasgow City area, complementing the work of the three DSIT regulatory spectrum sandboxes[1], and a detailed proposal was produced for 6 GHz co-existence testing between Wi-Fi and 5G/6G.

Several O-RAN Split 7.2 approaches have also been investigated and evaluated, and this has led to significantly improved understanding of the pros and cons from both a technical perspective and a commercial perspective.

ON-SIDE has established some key technical and commercial learnings that are being put into practice for real deployments, and the project has been represented at a number of conferences and events.

This report outlines the various activities that were carried out by the consortium partners, and presents key results and conclusions from the project.

Section 2 describes the Use Case deployments and investigations that were carried out.

Section 3 gives an overview of the 'spectrum sandbox' test and measurements that were made.

Section 4 describes the technology development activities, focusing on the areas of spectrum management and spectrum sensing, and Open RAN technology.

Section 5 presents the high-level results and benefits of these various activities.

Section 6 discusses aspects related to security.

Section 7 presents some project 'highlights'.

Section 8 summarizes the main project conclusions, while **Section 9** discusses potential next steps.

Finally, **Section 10** presents the high-level project costs, and **Section 11** gives some links to further information for those who would like to explore the project a bit more.

[1] https://www.gov.uk/government/collections/dsit-regulatory-spectrum-sandboxes

2 Use Case Deployments

Deployments were made in various locations, for applications which include ports, sports stadia, broadcast production, and immersive training.

2.1 Ports

In ports, reliable connectivity is essential for tracking, managing, and assigning workloads to cranes and straddle carriers, and is key to gaining operational efficiency. Any disconnections cause significant downtime with consequential costs and overheads, and impact on customer service. Private 5G offers superior coverage, capacity, and security compared to public 5G or Wi-Fi, and is highly customisable to meet industry-specific needs.

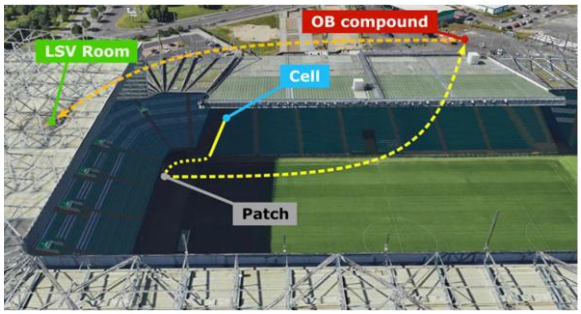
A Private 5G Proof of Value (PoV) was implemented at Peel Ports Liverpool Terminal 1 to enhance automation and operational efficiency by addressing connectivity challenges with existing Wi-Fi solutions. The private 5G solution uses Cisco's cloud-managed 5G core and Logicalis managed services.

Key issues addressed by the deployment of private 5G include unreliable Wi-Fi connectivity, signal loss during mobility and roaming, and the impact of physical port structures on signal transmission. The private 5G solution has been extensively tested by the Port, and has provided stable connectivity for horizontal transport and quay side cranes.

2.2 Live Broadcast in Sports Stadia

Throughout the ON-SIDE project, significant work has been undertaken to understand the opportunities and commercial, technical, and logistical challenges of deploying private 5G networks within stadium environments.

Working closely with two Glasgow-based football clubs, the University of Strathclyde and Neutral Wireless carried out a number of match-day demonstrations and empty-stadium tests of live broadcast via pop-up private 5G network connectivity, with multiple 5G-enabled wireless HD cameras connected to the network.

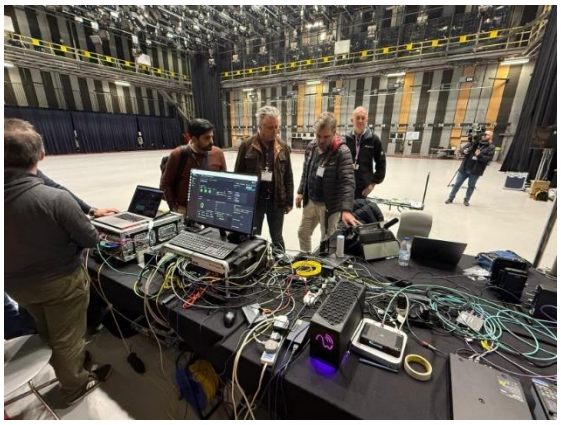


2.3 Broadcast Production for Programme Making and Special Events

There are three main opportunities for private 5G in traditional wireless broadcast production:

1. Contribution links for electronic newsgathering where public networks become congested;
2. Supplementing or replacing point-to-point COFDM links;
3. Facilitation of entirely new paradigms of live content creation.

There have been a number of high-profile demonstrations of private 5G standalone networks — many by members of the ON-SIDE consortium — that showcased how private 5G can support these opportunities.[2]

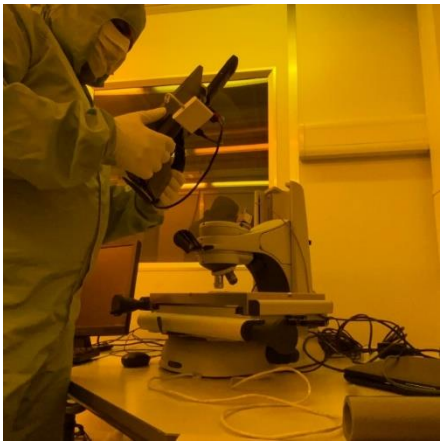


Within ON-SIDE, testing undertaken in Studio A at BBC Scotland has demonstrated how private 5G could provide comprehensive coverage within the studio environment, with support for broadcast-quality, ultra-low latency video. Several off-the-shelf video implementations were tested using the upper n77 and n40 spectrum bands, with handover between the two and from inside to outside.

2.4 Immersive Training

Engineering laboratories, and cleanroom facilities in particular, are under pressure to deliver faster, safer, and more consistent induction training while scaling access for diverse learners and staff. Within ON-SIDE, two important pieces of work were carried out:

- A comparison of private 5G vs Wi-Fi technical performance in real-time Virtual Reality (VR) streaming scenarios associated with immersive training;
- An investigation of how immersive training content delivered over livestream, made feasible by private 5G, compares with other modalities such as AI-avatar–led instruction and self-paced VR tours.



2.4.1 Private 5G vs Wi-Fi Performance

Ensuring an optimal VR learning experience is largely dependent on network performance. Several critical factors affect the quality of immersive education, including latency, jitter, packet loss, and bandwidth requirements. Research indicates that VR applications require latency to remain below 20 milliseconds to prevent motion sickness, feedback delays, and interaction errors.

With this in mind, a comparative analysis of private 5G and Wi-Fi 6 in VR-based immersive education was carried out, using a custom-built VR-based immersive education framework that provides a real-

[2] The use of dedicated, licensed spectrum to support bonded-cellular devices for newsgathering and contribution feeds was exemplified at the Coronation of King Charles III, and the private 5G network deployed along 6 km of the River Seine for the Paris 2024 Opening Ceremony illustrated how mobility and QoS management can be used to support a large number of devices and concurrent use cases.

world educational environment where an instructor streams a 360-degree live video to remote students using VR headsets. This is designed to enhance specialized educational experiences, particularly in environments that are difficult to access, such as clean rooms used for nanofabrication.

2.4.2 Training Modalities User Study

A comparative evaluation of three VR-based training modalities for cleanroom induction was carried out, encompassing synchronous instructor-led Livestream VR; EON XR agent/avatar–led training; and self-paced 360-degree VR tours. A controlled experiment was conducted with three groups: Livestream (n=11), EON XR (n=8), and 360-degree VR tour (n=8). Outcomes were measured across knowledge gain, cognitive load subcomponents, confidence, satisfaction, enjoyment, and simulator sickness.

2.5 Connected Social Care

Connectivity resilience and availability are key for social care and telehealth monitoring moving to delivery in home and at care home sites. However, 70% of people in social care don't have a home broadband connection. One proposed workaround is to use the public mobile network to connect the devices. However, the availability and usability of the public mobile networks are impacted by heavy network traffic when concerts, football or other events are operating nearby. The ON-SIDE project considered whether a pop-up private 5G network could provide the required connectivity, even when the public network is congested.

A study of the key features and implications associated with various connectivity approaches that may be considered for the provision of telecare services in care homes was carried out, using a large, 120-room care home in Glasgow as the basis for the study. Two aspects were considered: Connectivity **to** the care home, for scenarios in which the care home does not have a good broadband connection; and connectivity **within** the care home. In both cases, private 5G was considered as a potential connectivity solution.

3 Spectrum Sandbox Test & Measurement

In addition to the Use Case deployments, a structured set of spectrum-related tests and measurements were made in the Glasgow City area, complementing the work of the three DSIT regulatory spectrum sandboxes[3]. Extensive field measurements were carried out, to investigate various aspects of radio network performance and co-existence potential:

- **Propagation Models vs. Real-World Measurements:**
  Assessing the accuracy of propagation models against real-world measurements.
- **Independent Private 5G Network Interference Measurements:**
  Evaluating interference between independent low-power private 5G networks operating in both co-channel and adjacent channel configurations.
- **Interference Between Low-Power Private 5G and High-Power MNO 5G:**
  Assessing potential interference scenarios between low-power private 5G networks and high-power Mobile Network Operator (MNO) deployments.
- **Antenna Radiation Pattern Validation:**
  Empirical measurements of commonly deployed antennas, and comparing with manufacturer specifications (important aspects of propagation modelling).
- **Towards Hybrid Sharing in the Upper 6 GHz Band:**
  A preliminary analysis of hybrid spectrum sharing mechanisms in the upper 6 GHz band.

Key test locations included:

- **On the streets:**
  - Open field space (Stepps University Playing fields)
  - Universities of Strathclyde and Glasgow campuses
  - George Square – City Centre (G1 postcode)
  - Glasgow Green – City Centre Park
  - Dennistoun Suburb - Urban zone
- **In-Lab testing:**
  - StrathSDR 5G labs at University of Strathclyde
  - Anechoic chamber and CSI 5G labs at University of Glasgow

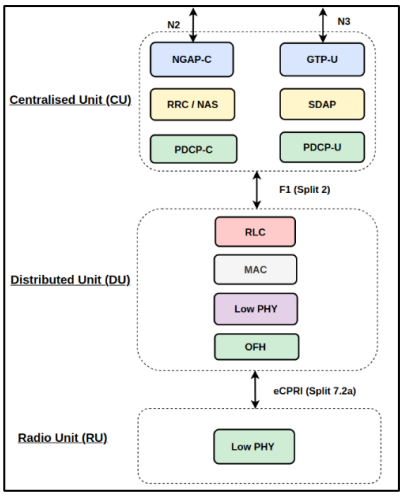
[3] https://www.gov.uk/government/collections/dsit-regulatory-spectrum-sandboxes

4 Technology Development Activities

As an Open Networks Ecosystem project, it was important for ON-SIDE to explore and evaluate Open RAN principles. Also, spectrum access approaches were developed with the aim of informing future spectrum access mechanisms that are suitable for private 5G networks operating in a wide range of use cases and deployment scenarios.

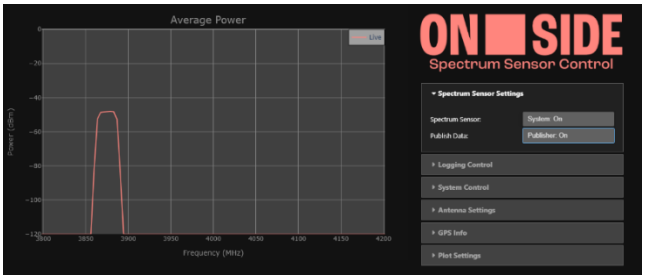
4.1 Open RAN Technology Development & Evaluation

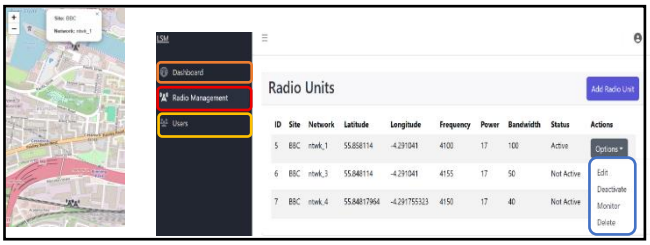
Several approaches to implementing O RAN Split 7.2 were investigated and compared against traditional Split 8 implementations. This work made use of AMD's RFSoC platform as well as a number of O RAN-compliant Commercial Off The Shelf (COTS) components, all of which were evaluated and compared against one another and also against Split 8 implementations. Criteria investigated and evaluated included technical performance, ease of implementation, benefits of the O RAN Split 7.2 approach, and, where possible, cost implications.



4.2 Intelligent Spectrum Management Augmented by Spectrum Sensing

To support and inform spectrum access for private networks, the project worked closely with Ofcom and developed an intelligent spectrum management Proof-of-Concept system which was demonstrated at the IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN) 2025 and at the UK Spectrum Policy Forum's Future Spectrum Policy Summit in May 2025. The system incorporates novel wideband spectrum sensing technology that was developed by ON-SIDE to support and augment spectrum access and management.

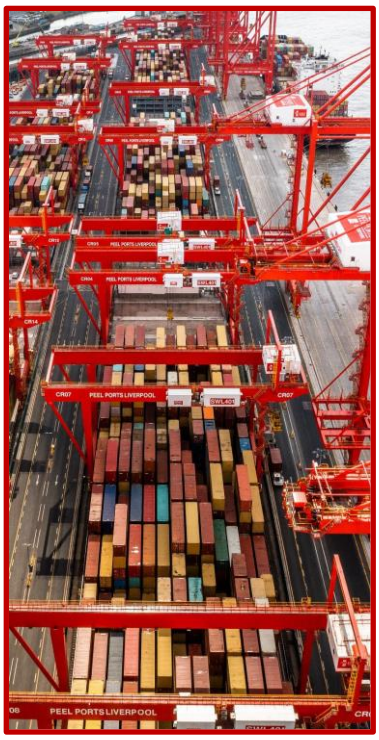




5 Results and Benefits Achieved

5.1 Peel Ports, Liverpool

The private 5G network deployed at Peel Ports in Liverpool has succeeded beyond expectations, having significantly reduced service dropouts and cabling requirements while improving worker safety and operational efficiency. The network supports real-time communication between straddle carriers and other port systems, enhancing logistics and data flow and providing seamless connectivity across the port's vast area, including container terminals and cranes.

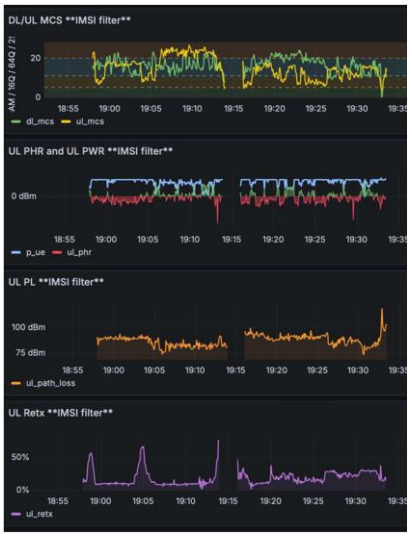


Benefits include:

- Annual carbon reduction: 31% lower power consumption, saving 1.15 tonnes of CO_2 annually.
- Energy cost savings: Approx. £1,075 per year.
- Avoided costs: Replacing 73 obsolete Wi-Fi APs would have cost ~£100k and would have increased both embodied carbon and energy use.
- 70% reduction in unladen travel, saving approximately 318,240 litres of fuel annually.
- CO_2e reduction of approximately 97 tonnes annually.

5.2 Live Broadcast in Sports Stadia

The project has proven that private 5G networks can reliably support connectivity in the face of large-capacity crowds, and can support multiple HD cameras relaying video and audio content in the presence of large crowds. This compares favourably with current industry practice of using COFDM cameras, each of which requires its own separate radio channel.



There is a commercial incentive to explore private 5G for stadia, but the network details and the question of network ownership vary and depend on budgets and investment strategies, along with the age and condition of existing network infrastructure.

Broadcast rights ownership also plays a part in the business case, as it influences what a club is allowed to broadcast and upload to social media.

5.3 Broadcast Production for Programme Making and Special Events

Tests have established that private 5G networks could provide comprehensive coverage for wireless cameras in television studios. Stable video streaming was achieved, with end-to-end latency as low as 80 ms, which is getting closer to the 50 ms touted for COFDM links. In fact, with feedback from our ON-SIDE testing, a hardware partner has improved its product offering and we have since successfully streamed video with 40 ms (2 frames) end-to-end latency in the labs. This is the lowest-latency COTS performance we have seen over 5G, and is comparable with traditional COFDM camera links.

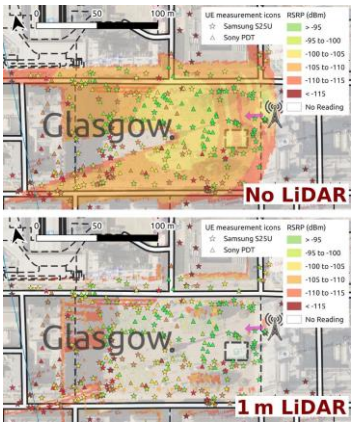
5.4 Immersive Training

It was shown that private 5G outperforms Wi-Fi in sustaining the throughput and latency conditions necessary for real-time VR streaming. Although private Wi-Fi 6 remains a cost-effective option for immersive education, its vulnerability to network congestion and interference makes it less suitable for latency-sensitive VR applications when compared to private 5G.

5.5 Connected Social Care

A key finding of the connectivity study was that many care homes already have good broadband connectivity to the home and extensive Wi-Fi coverage in the home. In such situations, the majority of social care use cases that depend on connectivity are already catered for. In situations where this does not hold true, either because the broadband connectivity to the home is lacking or because the in-home Wi-Fi coverage is poor or non-existent, there isn't necessarily a 'one size fits all' solution; it's possible that a private 5G solution could be the optimal solution, but the best choice will typically depend on specific circumstances on a case-by-case basis. For example, installing Wi-Fi may or not be viable, depending on the level of drilling and re-decorating that would need to be done, and whether the work would require decanting of residents for the duration. Furthermore, if there are any special or unusual requirements – perhaps related to reliability of connection, for example – then these also need to be taken into account and may have a bearing on the optimal choice of solution.

5.6 'Spectrum Sandbox' Measurements

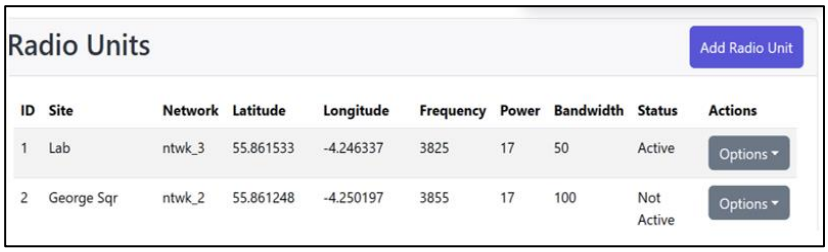


Extensive measurements were made across a wide test area in the Glasgow n77 T&D sandbox zone. Key findings include:

- While LiDAR improved clutter representation in urban environments, it als o introduced anomalies—particularly in tree canopy modelling and antenna height interpretation—which could mislead automated spectrum licensing systems. hybrid simulation approach or manual review is recommended to mitigate these risks.

- For low-power private 5G networks operating in the 3.8-4.2 GHz band in the presence of high-power public networks operating in the 3.4-3.8 band, significant interference from the MNO downlink transmissions on P5G uplink performance was observed when frame structures are not synchronized. External filtering proved effective in mitigating this interference, especially at separation distances under 200m.
- Empirical measurements of commonly deployed antennas showed varying degrees of alignment with manufacturer specifications. The findings underscore the need for independent validation of antenna specifications in spectrum licensing decisions.
- Initial tests on co-channel interference between unsynchronised low-power P5G networks suggest a minimum separation of 1–2 km is sufficient to ensure uplink performance. These results are conservative and further testing is required, but they provide a baseline for safe deployment practices in shared spectrum environments.

5.7 Intelligent Spectrum Management



The Proof-of-Concept demonstrator is based on the geolocation database approach, augmented with real-time wideband spectrum monitoring. The monitored spectrum data can be stored and examined off-line to determine actual usage profiles and help to inform future spectrum policy. The system also paves the way for fully automated spectrum access in the future.

5.8 Open RAN Technology Development & Evaluation

Several O-RAN Split 7.2 approaches were developed and tested. While Split 7.2 has a number of potential benefits, such as supply chain diversification through vendor interoperability and cost savings resulting from the migration to a packet switched fronthaul with reduced data rate requirements, our experience nevertheless suggests that these potential benefits are proving difficult to realise.

The technology feels somewhat immature and could be rather daunting for private 5G operators and small to medium-sized enterprises (SMEs). There appears to be a multiplicity of different O-RU fronthaul standards, and the system integrator is required to understand quite complex and lengthy specifications from the O-RAN alliance to make progress.

Most work described in the literature and in online resources has been done using the LLS-C3 configurations, which requires an expensive fronthaul switch with GNSS. This typically adds £10k to the bill of materials (BOM) and is a significant added expense for small private networks with only one or two O-RU cells. The tutorial guides on the Internet give little help with the LLS-C1 configuration that would help to reduce base station cost.

Also, it may be more difficult to realise the performance benefits on smaller scale network deployments such a private 5G network for a stadium or concert venue.

6 Security

As the development and adoption of private 5G networks continues to increase, more and more enterprises and other organisations will benefit from the highly customizable connectivity in application domains which include smart manufacturing, education, utilities, ports and airports, policing, security and military, warehousing, sports stadia, events, healthcare, and live broadcasting, among others. However, these benefits come with security challenges, particularly in networks that are based on disaggregated network architecture such as O-RAN Split 7.2, for example.

ON-SIDE has explored these challenges in detail, focusing on key aspects such as the security of Radio Units (RUs), authentication of network components, encryption of user and management traffic, protection of the overall network infrastructure, and security considerations for spectrum licensing/management systems in fully automated shared spectrum environments.

Recommendations emerging from this work include:

- **RU Security:** The project suggests strengthened RU security by implementing tamper-resistant enclosures, certificate-based authentication, and end-to-end encryption for communication. These measures can enhance both physical and cyber protection of the RUs, which are often deployed in remote and unsecured environments.
- **Authentication Mechanisms:** A robust authentication framework can be established to ensure secure connections between the RU, DU, and CU. The project suggests employing certificate-based authentication and ZTA principles, ensuring continuous verification of devices and users within the network.
- **Encryption for User Plane and Management Traffic:** The use of IPsec and TLS encryption protocols can be implemented across the entire network to protect the confidentiality and integrity of both user plane and management traffic. This end-to-end encryption ensures that sensitive data is protected against eavesdropping and tampering.
- **Network Infrastructure Protection:** The ON-SIDE project suggests to incorporate advanced firewall configurations to protect against unauthorized access and malicious attacks. Additionally, data logging and incident response protocols should be put in place to detect and mitigate potential security breaches.
- **Spectrum Management Security:** In the realm of spectrum management, the project suggests implementing strong access control and encryption protocols to safeguard the spectrum licensing and allocation systems, ensuring that only authorized entities have access to spectrum resources. Furthermore, RBAC and multi -factor authentication found pivotal in securing the management of spectrum resources.

As the landscape of private 5G networks continues to evolve, ongoing advancements in security strategies will be imperative. Future recommendations include the integration of AI and machine learning (ML) for proactive threat detection, the adoption of Zero Trust Architecture (ZTA) across all network layers, and the exploration of quantum-resistant cryptography to protect against emerging threats. Additionally, continuous alignment with evolving industry standards and regulatory frameworks will be critical to maintaining a resilient and secure network ecosystem.

In conclusion, as private 5G networks continue to grow in prominence and importance, the security challenges they face will only become more complex. The integration of O-RAN architectures, AI technologies, and cloud-based solutions opens new opportunities for improved network flexibility and performance, but also increases the potential attack surface for malicious actors. Therefore, it is imperative that robust security strategies are in place, incorporating both physical and cyber protections. This requires a multi-faceted approach encompassing robust authentication, encryption, network segmentation, intrusion prevention, and real-time monitoring.

7 Project Highlights

ON-SIDE has been represented at a number of conferences and events, and the project consortium was delighted to win the **Ecosystem Excellence award** at the DSIT/UKTIN Connected Reflections Live event, which took place on 19th March 2025. In addition, project partner Neutral Wireless Ltd won the **Start-Up and Spin-Out Success award**.[4]

Other events in which ON-SIDE has participated include:

- **Connected Britain, London, September 2025**
  ON-SIDE was represented on a panel session on how advanced connectivity and private networks are reshaping UK businesses. In addition, Peel Ports gave a talk on the private 5G network installed through ON-SIDE at their port in Liverpool.
- **Small Cells World Summit, London, June 2025**
  ON-SIDE partner Neutral Wireless Ltd gave a presentation entitled "Deploying Private 5G Connectivity Solutions for Live Sports Broadcasting".
- **UK SPF Cluster 3 SAL and Sandbox combined session, London, June 2025**
  ON-SIDE was invited to present on the project's sandbox measurement work.
- **IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), London, May 2025**
  ON-SIDE exhibited its intelligent sensing-enabled spectrum management platform and participated in a panel session entitled "Shared Spectrum for Broadcasting and Live Events".
- **UK Spectrum Policy Forum's Future Spectrum Policy Summit, London, May 2025**
  ON-SIDE exhibited its intelligent sensing-enabled spectrum management platform.
- **Connected North, Manchester, April 2025**
  ON-SIDE was represented on a panel session on private networks.
- **Glasgow City Region Innovation Showcase Event, Glasgow, March 2025**
  ON-SIDE exhibited its intelligent sensing-enabled spectrum management platform and participated in a discussion panel on the importance of connectivity.
- **IEEE Conference on Telepresence, California, USA, November 2024**
  The University of Glasgow presented the immersive training use case developed within ON-SIDE.
- **International Broadcasting Convention (IBC), Amsterdam, September 2024**
  Deployment of private 5G RAN on an electric tricycle. (This private 5G Network In a Bike (NIBike) was being utilised within ON-SIDE for real-time spectrum sensing and sandbox measurements.)
- **Connected North, Manchester, April 2024**
  ON-SIDE was represented on a panel session on wireless and 5G delivery in the north of the UK.
- **International Workshop on 'Future Communications And 6G', Glasgow, June 2024**
  ON-SIDE was represented at this event, which was organized and hosted by the University of Strathclyde.
- **Glasgow City Council 5G Connectivity Event, Glasgow, January 2024**
  ON-SIDE was one of three DSIT projects exhibiting at this event.

[4] https://uktin.net/whats-happening/news/uktins-highlights-connected-reflections-live

Research outputs include:

- **IBC 2024** — "Optimising 5G for low latency broadcast production" (https://pureportal.strath.ac.uk/en/publications/optimising-5g-for-low-latency-broadcast-production)
- **NAB 2025** — "Low latency wireless broadcast production over 5G" (https://pureportal.strath.ac.uk/en/publications/low-latency-wireless-broadcast-production-over-5g)
- **IBC 2025** — "Opportunities for emerging 5G and Wi-Fi 6E technology in modern wireless production" (https://pureportal.strath.ac.uk/en/publications/opportunities-for-emerging-5g-and-wi-fi-6e-technology-in-modern-w/)
- **11th International Conference on Virtual Reality (ICVR) *best presentation award*** — "A Comparative Analysis of 5G and Wi-Fi6 for VR Immersive Education", Wageningen, The Netherlands, July 2025.

8 Project Conclusions

ON-SIDE has addressed key challenges associated with deploying private 5G stand-alone (SA) networks operating in shared access radio spectrum, and has demonstrated the potential for such networks to support and drive innovative use cases that require high-quality, reliable connectivity optimized for the particular use case. Examples include ports and airports, where fully private networks allow coverage and performance to be tailored to the needs of the business. Other examples include live broadcast applications, which typically require specific network configuration parameters and may also be operating in High Demand Density environments in which public networks often become overloaded and unable to provide the required connectivity.

There is significant opportunity for private 5G (and 6G) networks to complement the public networks and support a growing number of applications and use cases that would benefit from such network connectivity. However, this requires suitable spectrum to be readily available, and while Ofcom has led the way in opening up spectrum that can be used by low-power and medium-power private networks, and Europe is in the process of developing harmonised requirements for use in EU member states, it is important to recognise that the spectrum access mechanisms are still manual and time-consuming. A move towards fully automated dynamic management of spectrum would facilitate quicker and more agile spectrum allocation decisions, which is important for 'pop-up' use cases of a short-notice, short-duration nature, but also has advantages more generally.

The Intelligent Spectrum Management demonstrator developed within ON SIDE has the potential to pave the way for innovative, fully automated spectrum management for private networks. This is based essentially on the 'geolocation database' approach, but it incorporates innovative real-time wideband spectrum monitoring which supports and augments spectrum access and management.

With Ofcom considering a move towards 'user-led coordination' in certain circumstances, a fully automated spectrum management system, augmented with real-time spectrum monitoring, could help to resolve interference issues automatically, without users (i.e. network owners) having to manually intervene. This is an ambitious target, and there is a lot of work to be done, but it would have tangible benefits and would help the UK to maintain its lead in innovative spectrum management and spectrum policy.

In terms of Open RAN approaches, which were a key part of the ONE competition brief, ON SIDE has investigated and evaluated several O-RAN Split 7.2 approaches, and this has led to significantly improved understanding of the pros and cons as well as the issues and challenges, both from a technical perspective and from a commercial perspective. While it may have some potential benefits, the technology still feels immature and difficult to realize in practice, and it may be more difficult to realise the performance benefits on smaller scale network deployments such a private 5G network for a stadium or concert venue. It is worth noting, incidentally, that the traditional Split 8 architecture can make use of components from different suppliers, so a considerable degree of supplier diversification is possible without necessarily having to adopt a Split 7.2 architecture.

In summary, private networks are a strategic imperative for a number of applications. However, in order for the full potential of private networks to be realized and adoption to be scaled up, it is important that the device ecosystem better supports private network use and that spectrum regulators and policymakers recognize the need for suitable spectrum to be available, with spectrum access mechanisms that are fit for purpose. Significant opportunity undoubtedly exists, and ON SIDE has established a number of key technical and commercial learnings that are being put into practice for real deployments.

9 Next Steps

The ON SIDE project has led to improved understanding and capability in a number of areas related to private 5G. These include:

- Private 5G use case opportunities and business cases;
- Automated, sensing-assisted intelligent spectrum management;
- Open RAN architecture performance trade-offs and opportunities;

and members of the consortium will seek to build upon the outputs and results in these areas.

With respect to spectrum, for example, an immediate and obvious next step is to take the Intelligent Spectrum Management Proof-of-Concept demonstrator developed within ON-SIDE and use it in live trials to demonstrate and confirm the business and regulatory benefits of fully automating the licensing process to provide agile, rapid access to local shared spectrum for businesses and other organisations. Another endeavour will be to investigate and evaluate 'intelligent' algorithms for automated spectrum management. (The PoC system has been designed such that different spectrum management analysis and decision-making algorithms can be incorporated into the base framework, and these can range from very simple algorithms to highly complex algorithms including AI-based ones.)

These are areas that the University of Strathclyde is actively looking into, and indeed have already joined forces with other partners to prepare funding applications for carrying out such work. We hope that this approach can be developed further and offered to regulators as a dynamic spectrum access tool kit.

Additionally, the BBC's discussions with Ofcom have helped to develop the latest proposals for access to n40 spectrum, and Ofcom is now consulting on this new approach. The BBC anticipates n40 spectrum being made available within 3 days of a licence application, and this is a useful step forward on the 42-day period necessary for upper n77 access.

The BBC will also continue to explore the factors which are limiting the uptake of 5G technology for the broadcast production use case, and will continue to track and review the usefulness of O-RAN architectures as these solutions develop further.

On the commercial front, a number of ON SIDE consortium partners are in the process of defining and agreeing collaborative activities aimed at real-world commercial deployment of private 5G networks in application areas identified within ON SIDE. Also, a commercial roll-out of private 5G deployment at Peel Ports Terminal 1 in Liverpool is underway, and Cisco is working with Logicalis and Neutral Wireless to exploit commercial opportunities in other sectors including Blue Lights, Security, Warehousing, Utilities, Stadia, etc., building upon ON-SIDE.

Furthermore, Cisco is committed to supporting the community in Scotland and national regions with its connectivity ambitions. Cisco has participated in 5G projects in the U.K. for over six years and continues to look for new opportunities to partner with its collaborators, building on the exceptional partnerships developed through ON-SIDE, validating and elevating the wider adoption of private 5G networks.

As a result of the ON-SIDE project, the BBC has developed fruitful relationships with the University of Strathclyde, the University of Glasgow, Ofcom, Cisco, and Neutral Wireless. They have also built contact with several O-RAN vendors and will be reviewing the usefulness of O-RAN architectures as these solutions develop further.

10 High-Level Summary of Project Costs

The project ran in two phases:

- Phase 1:
  1st October 2023 – 31st March 2025 (18 months)
- Phase 2:
  1st April 2025 – 30th September 2025 (6 months)

High-level summary project costs for each phase are shown below in Table 10-1.

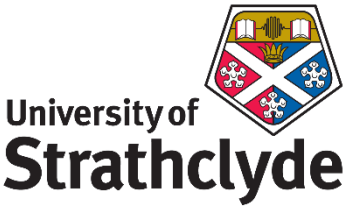
Phase 1:	
DSIT Grant:	£2,013,680
Consortium Investment:	£1,057,468
Total (Phase 1):	**£3,071,148**
Phase 2:	
DSIT Grant:	£406,617
Consortium Investment:	£318,385
Total (Phase 2):	**£725,002**
TOTAL (for both Phases):	
DSIT Grant:	£2,420,297
Consortium Investment:	£1,375,853
Grand Total:	**£3,796,150**

Table 10-1: High-level summary costs.

11 Media Library

- https://www.onside5g.org/
- https://www.uki.logicalis.com/case-study/peel-ports
- https://www.cisco.com/site/us/en/products/networking/wireless/private-5g/index.html
- https://www.linkedin.com/company/project-on-side/?lipi=urn%3Ali%3Apage%3Acompanies_company_index%3B053bd95a-679f-40f0-a96b-35528266c6bb

ON SIDE



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