Title	**ONP Final Project Report Template**
Versions	**V.01**

ONP Final Project Report: This report is expected to be publishable externally and provided to DSIT in an accessible format. The details are outlined in point 98 of the "DSIT Guidance for Live Open Network Projects". This template looks to outline the key sections we'd expect to see in projects final reports and provide prompts and guidance around the content for each section.

NAME OF PROJECT: SONET - Sunderland Open Network EcosysTem	
List of partners	Sunderland City Council Boldyn Networks Sunderland Association Football Club British Esports Federation Perform Green
Total funding amount	**£3,606,563**
Locations	Stadium of Light Monkwearmouth Sunderland SR5 1SU

Executive Summary

Maximum word count: 300 words

This should be seen as an executive summary giving a plain English overview about what the project was looking to achieve over the funding period including the aims and objectives.

A consortium led by Sunderland City Council, working in partnership with Boldyn Networks, Sunderland Association Football Club (SAFC), the British Esports Federation, and Perform Green, collaborated to design, develop, and deliver a prototype of Boldyn's High Density Demand Connectivity-as-a-Service (HDD CaaS) platform. This prototype leverages Open RAN technology to address high-capacity connectivity requirements in two flagship venues: the Stadium of Light (home to SAFC, regularly attracting 40,000+ attendees for football matches and major concerts) and the British Esports National Performance Campus ("Esports Arena") in Sunderland. The project was structured to encompass the full spectrum of R&D activities necessary to build, test, and validate the HDD CaaS platform in real-world, high-demand environments. However, due to construction delays at the Esports Arena, the project pivoted to focus on deploying and operationalizing the HDD Open RAN solution within the Stadium of Light, ensuring continued progress toward the platform's validation and performance benchmarking objectives.

Project Objectives

1. **HDD CaaS Development**
   Build a neutral-host infrastructure to reduce MNOs' TCO through lower power use, more space efficient, and managed via replicable streamlined delivery and operations model.
2. **Service Framework**
   Deliver a full-service wrap including infrastructure design, build, testing, NOC, SOC, performance optimisation, and SLA-based service assurance.
3. **Open RAN Validation**
   Demonstrate that a DAS can be powered by a cloud-native, O-RAN-compliant vRAN, benchmarked against legacy systems.
4. **4G/5G Network Deployment**
   Design and operate an O-RAN network for two MNOs, tailored to venue-specific use cases.
5. **Business Model Innovation**
   Establish a scalable, multi-operator neutral-host model using vRAN, NFV, open interfaces, and cloud-native tech.
6. **Commercial Viability**
   Assess Open RAN's impact on time-to-market, supply chain, space, and energy efficiency in live deployments.
7. **MNO Collaboration**
   Enable process reuse across MNOs to support a broader HDD neutral-host market.

Additional 5G Use Cases

With additional funding secured through to September 2025, the project has implemented two new 5G-enabled use cases:

- **Enhanced Stadium Safety**: Deploying 5G-enabled CCTV and real-time video analytics to improve crowd monitoring and incident response during football matches, concerts, and other events.
- **Immersive Fan Engagement**: Leveraging the XRAN platform's high bandwidth and low latency to support immersive content creation and delivery, such as AR/VR experiences and real-time fan interaction, to enhance the in-venue experience and broaden the stadium's appeal for diverse event formats.

These additional 5G use cases build on existing project benefits, demonstrating the platform's versatility and ability to support both operational and experiential innovation.

Deployment Summary

Maximum word count: 500 words

Methods, technologies used and deployment approaches.
Description of the products or use cases.

Deployment Summary

The HDD CaaS deployment at the Stadium of Light (SoL) is designed to validate a virtualised Open RAN-based neutral host platform capable of supporting high-density demand (HDD) environments. The solution is designed to deliver multi-operator 4G and 5G services using a cloud-native, software-defined infrastructure, with JMA Wireless as the RAN vendor and Boldyn Networks as the neutral host integrator.

Methods and Technologies

The deployment leverages a virtualised RAN (vRAN) architecture, with JMA's XRAN software running on Commercial Off-The-Shelf (COTS) hardware. The system is designed to support both 4G LTE and 5G NR (NSA, SA-ready) technologies. The fronthaul architecture connected the XRAN baseband units to a Distributed Antenna System (DAS), enabling wide-area coverage across the stadium bowl and concourse zones.

The transport network is built on a secure IP/MPLS backhaul, incorporating a Security Gateway (SecGW) and cyber-security controls for the management plane. Network segmentation has been implemented to isolate MNO traffic, and high availability is ensured through redundant power supplies and failover mechanisms.

A Network Management System (NMS) platform is deployed to provide end-to-end visibility, incorporating Performance Management (PM), Fault Management (FM), and integration with Zabbix for real-time monitoring. The system also includes a Network Operations Centre (NOC) and Security Operations Centre (SOC) wrap to support SLA-driven service assurance.

Deployment Approach

The deployment followed a phased approach:

1. **Design and Integration**: The HLD defined the XRAN, DAS, and transport layers, including logical and physical topologies, security domains, and integration points with VMO2's core network.
2. **Pilot Area Activation**: The initial deployment focused on the Quinn Bar and SoL Bowl area, enabling functional testing under live event conditions.
3. **Testing and Validation**: Functional and QoS tests were conducted for both 4G and 5G services, including throughput, latency, and accessibility KPIs. BMON smartphone probes were used to validate user experience during a live football match.
4. **Operational Readiness**: The platform was transitioned from DEV to PROD mode, with full NOC/SOC support and monitoring dashboards activated.

Use Cases

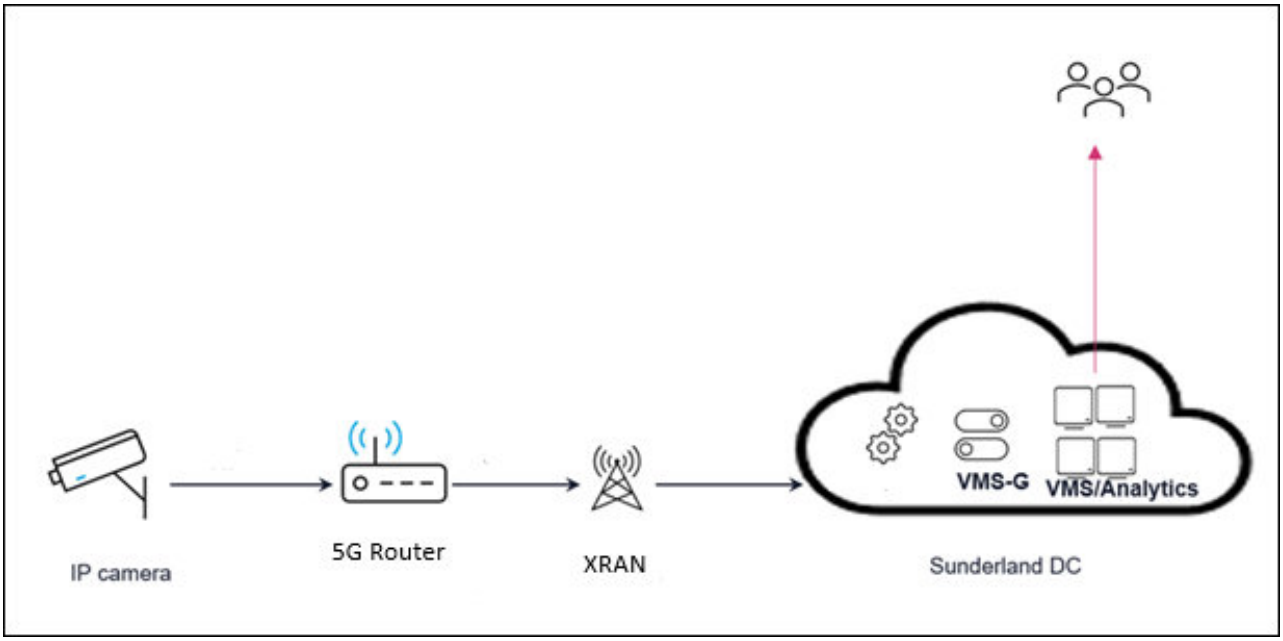
1. HDD Neutral Host 5G Solution
The primary use case was to deliver high-capacity, multi-operator mobile connectivity during football matches and concerts. The platform also demonstrates the feasibility of a neutral-host model that reduces MNO TCO through shared infrastructure, automation, and energy-efficient design.

The solution is replicable across other HDD venues, including esports arenas and transport hubs, and supports rapid time-to-market through its modular, cloud-native architecture.

2. CCTV over 5G Network
26 CCTV with onboard AI Object Analytics engine were deployed in and around the perimeter of the Stadium of Light, using the 5G network to transmit video footage to a central control room.

The installation incorporated:

- IP Cameras – Equipped with edge analytics to support real-time detection and monitoring.
- 5G Routers – Enabling high-speed, low-latency connectivity across the deployment.
- The XRAN Network – Providing scalable, flexible radio access infrastructure.
- VMS/Analytics Engine – Centralizing video management and AI-driven insights for security, operations, and crowd intelligence.



Using intelligent AI-based algorithms, AXIS Object Analytics can detect, classify, track, and count humans, vehicles, and types of vehicles. Thanks to AI-based classification, CCTV controllers can focus only on objects of interest and events that need attention, making the monitoring more effective. It's possible to run multiple use cases simultaneously and set up triggers for various events based on your needs. This allows controllers to respond appropriately to events in real-time, while helping optimise the SAFC business with automated processes and valuable insights into trends.

Applications include:

Security and Safety
Track and trigger security and safety events based on:

- Intrusion detection
- Restricted areas protection
- Damage prevention
- Loitering and unauthorized parking
- Occupancy levels

Operational Efficiency
Measuring events and automating tasks based on:

- Visitor count
- Traffic flow
- Occupancy levels
- Dwell time
- Queue management
- Wrong way detection
- Tailgating detection

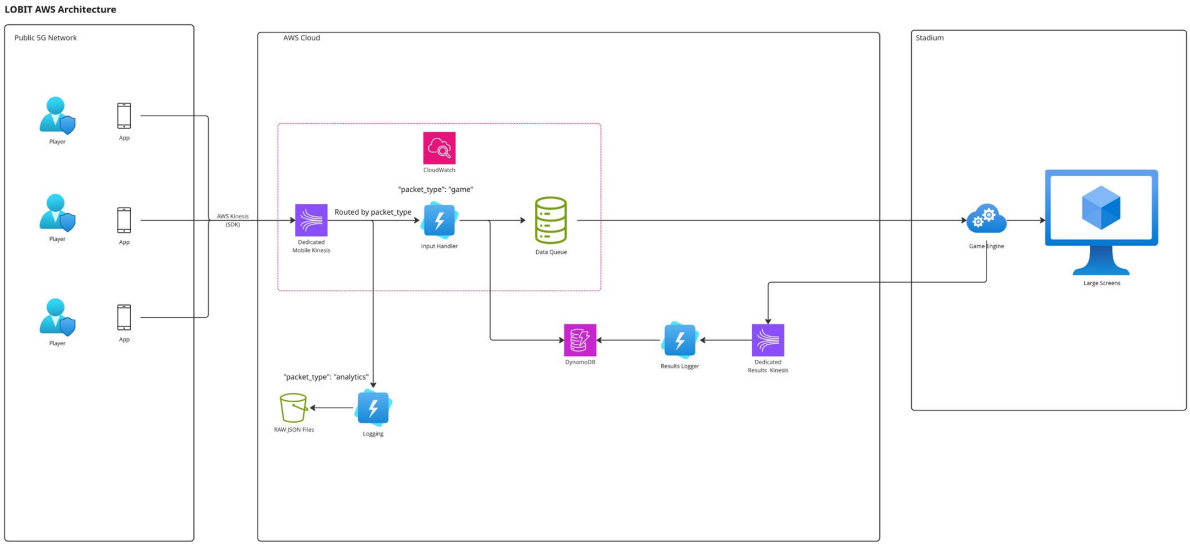
Data Visualisation
Visualise your data in a dashboard or spreadsheet to gain valuable insights, for instance by tracking:

- Peak/off hours
- Occupancy levels
- Crowds
- Types of object present
- Flow/direction of movement

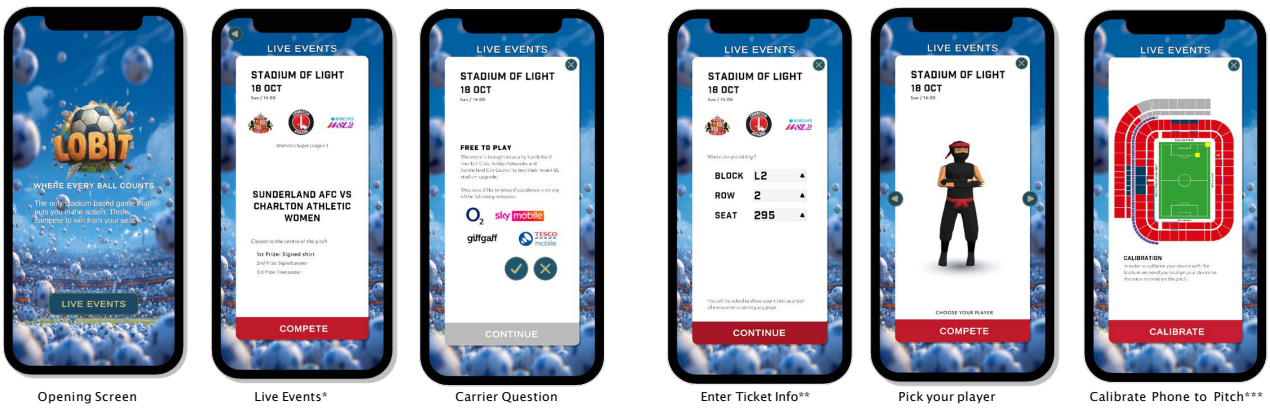
3. LOBIT Interactive Fan Experience

The LOBIT Challenge is a fast, fun, and fully interactive stadium experience that turns fans into participants using nothing but their smartphones. Within LOBIT, thousands of fans launch virtual footballs from the stands toward the centre of the pitch using a mobile app, with the closest ball to the target winning a prize. The action unfolds live on the big screen, creating a moment of shared excitement, competition, and sponsor visibility. The experience is powered by a custom-built app and a scalable AWS cloud infrastructure capable of handling thousands of simultaneous inputs in real time. Designed to be accessible, family-friendly, and commercially attractive, the LOBIT Challenge is a new kind of mass participation game made possible by 5G connectivity and smart mobile interaction.

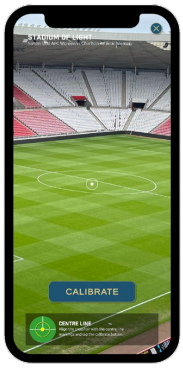
AWS Cloud Based Architecture:



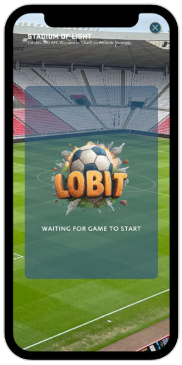
LOBIT App Flow



Opening Screen | Live Events* | Carrier Question | Enter Ticket Info** | Pick your player | Calibrate Phone to Pitch***

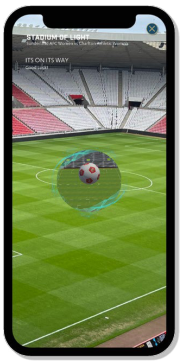


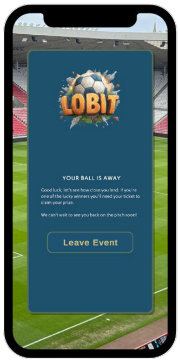
Live Calibration



Sync to Server Game*


Game Dynamics**

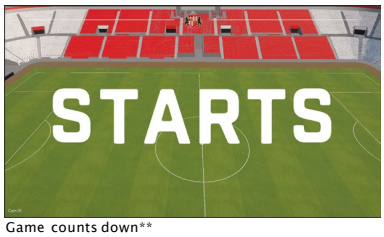

Portal transfer***



Ball Sent Confirmation

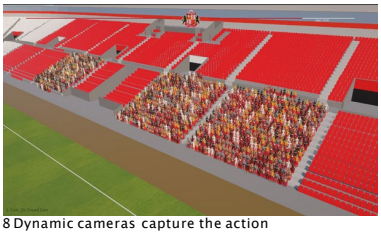
LOBIT Server Game Flow

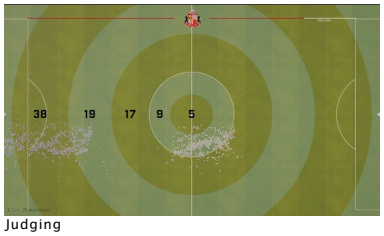
Pre-check*,



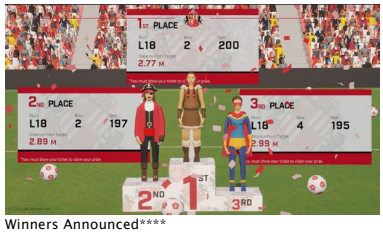
Game counts down**


Live Stadium Action***


8 Dynamic cameras capture the action



Judging



Winners Announced****

*Checks the AWS queue is ready before game starts.
**Notifies AWS IoT that the game has started.
***Server Game monitors AWS Queue and reads the data package, this sets vitual seat location, player, Ball direction, loft and force.

****Each Ball contains the ticket information of the player.

Results and Benefits Achieved

Maximum word count: 500

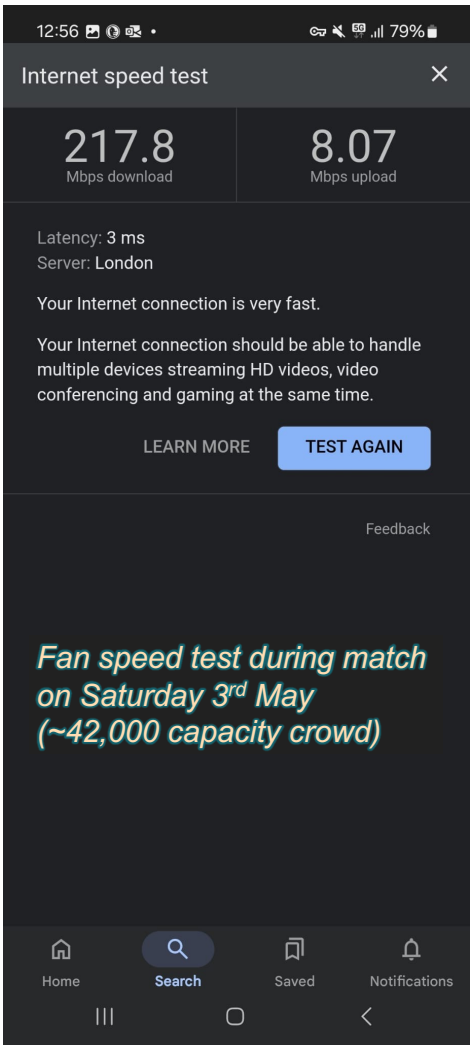
Results and key findings, with supporting evidence.
Impact of the results including key impacts and benefits using qualitative and quantitative data.
Drawing on and/or referring to the benefits realisation.
How are the results better than what has come before?
How will the results affect your or someone else's business?
This section should answer the 'so what?' question
How could others repeat the successes? If someone else wanted to achieve the same benefits, how might they do it?

The deployment of the HDD CaaS platform at the Stadium of Light delivers measurable technical, commercial, and strategic outcomes. The project validates the viability of a virtualised Open RAN (vRAN) neutral-host model in a high-density demand (HDD) environment, setting a new benchmark for mobile connectivity in large venues.

Results and Supporting Evidence

Independent benchmarking by GWS confirms significant improvements in network performance. Compared to the legacy system, the CaaS platform delivers:

- Nearly 10-fold increase in downlink throughput (22 Mbps to 209 Mbps)
- A 2.5-fold increase in uplink throughput (2.7 Mbps to 6.9 Mbps)
- A 33% reduction in ping latency
- Noticeable improvements in jitter and session retainability.
- Network Accessibility from 45% to 100%
- Network Retainability from 67% to > 99%



These results were corroborated by BMON probe testing during live events, demonstrating consistent Quality of Service (QoS) and Quality of Experience (QoE) under peak load conditions.

The platform also achieves technical parity, and in some areas, superiority over traditional DAS-BTS-fed systems. It supports more frequency bands, enables dynamic resource allocation, and delivers feature parity in spectrum, functionality, accessibility, retainability, mobility, carrier aggregation and deployability and manageability.

Impact and Benefits

The project delivers:

- 76% reduction in power consumption
- 86% reduction in equipment footprint
- Faster and streamlined deployment through automation and containerisation

These outcomes translate into lower Total Cost of Ownership (TCO) for MNOs and a more sustainable, scalable infrastructure model. The neutral-host approach enables infrastructure sharing, reducing duplication and enhancing supply chain resilience—an increasingly important factor in national security strategies.

Why This Is Better Than Before

Legacy DAS systems fed by legacy BTS technology are hardware-heavy, slow to deploy, and costly to scale. The HDD CaaS platform is cloud-native, software-defined, and modular—enabling rapid deployment, real-time optimisation, and seamless multi-operator integration. It represents a step-change in how mobile networks are delivered in complex venues.

Business Impact

- **Boldyn Networks**: the project validates a replicable commercial model for stadiums, arenas, and transport hubs
- **MNOs**: it demonstrates a viable path to reduce CapEx and OpEx while maintaining service quality.
- **SAFC**: The complete sell-out play-off final match demonstrated that high-density performance is still exceptional even at absolute capacity
- **Sunderland City**: This first-of-its-kind network in the UK delivers reputational benefits, driving economic and social value by using innovation to bring people together, enhance experiences, and improve safety
- **For public sector stakeholders**: it showcases a scalable digital infrastructure model that supports economic growth and innovation.

The "So What?" Factor

This project proves that Open RAN-based neutral-host solutions are not only technically feasible but commercially advantageous in HDD environments. It provides a blueprint for transforming mobile network deployment and operations in complex venues.

Replicability

To replicate this success, others should:

- Adopt a modular, cloud-native architecture
- Engage early with MNOs to align on integration and SLAs
- Use containerised vRAN solutions for flexibility
- Implement robust monitoring and automation frameworks
- Leverage a neutral-host model to drive shared investment and faster rollout

Fan Feedback

"My 5G on O2 was immense before, during and after the game. Previously been useless"

CCTV

The CCTV system is in use to support safety, security and operational efficiency at Premier League games at the Stadium of Light.

CCTV Dashboard:

Example of the custom made Grafana Dashboard which is provided to capture and display real time and historical data from count lines that can be programmed using AI onboard analytics engines that reside within the CCTV cameras. Raw data can be exported by .csv file for use in other analytic programs.

LOBIT Interactive Fan Experience

On Monday 3 November 2025, at a Premier League match against Everton. Without much promotion, LOBIT attracted 521 players. The analytics are with Boldyn who are due to report back mid-December.

The club were happy and the game will continue. This is effectively now just going ahead without the SONET project, directly between the club and Maadigital.

More control of the game, promotion and announcing winners is being handed over to Maadigital with the club providing prizes.

Security

Maximum word count: 500 words

Summary of the projects approach to security
This should be a publishable summary of the security report touching on the ambitions outlined in the security strategy, best practice, standards testing, and results and lessons learnt. This will complement the separately required final security report.

Security Summary
The HDD CaaS project adopts a security-by-design approach, embedding robust cyber-security principles across all architectural layers - from infrastructure to operations. The strategy is aligned with industry best practices, including CREST-aligned penetration testing, and tailored to the unique requirements of a virtualised, multi-tenant Open RAN environment deployed in a high-density venue.

Security Strategy and Ambitions
The security strategy is built around four core pillars:

1. **Segmentation and Isolation**: Logical and physical segmentation has been implemented across the management, control, and user planes to ensure tenant isolation and minimise lateral movement risks.
2. **Zero Trust Principles**: Access to all components is governed by least privilege, with multi-factor authentication and role-based access controls enforced across the NMS, SOC, and infrastructure layers.
3. **Operational Resilience**: High availability is ensured through redundant power, failover routing, and secure IP/MPLS backhaul with encrypted tunnels.
4. **Continuous Monitoring and Response**: Integration with Zabbix and the SOC enables real-time threat detection, anomaly tracking, and automated alerting.

Standards and Testing
Security testing was conducted in accordance with the CREST scheme, as outlined in the Boldyn HDD CaaS - Cyber-security penetration testing – SoW.

The scope included:

- **Management Plane**: Penetration testing of the JMA XOAS and DAS OMC components, which are critical for orchestration and remote management.
- **Control/User Plane**: Validation of data path integrity, encryption enforcement, and session isolation.
- **Transport Layer**: Testing of the IP/MPLS backhaul and Security Gateway configurations, including firewall rules and VPN tunnels.

All tests were executed by an independent CREST-accredited provider, and no critical vulnerabilities were found. Medium and low-risk findings were addressed through configuration hardening and patching.

Results and Lessons Learnt

The platform demonstrates strong resilience against common attack vectors, including privilege escalation, session hijacking, and lateral traversal. Key lessons included:

- The importance of early integration between the NMS and SOC for unified visibility.
- The need for automated asset inventory and access management to support scalability.
- The value of DevSecOps readiness in the CI/CD pipeline, which is prepared but awaits licensing for full automation

Why This Is Better Than Before

Legacy DAS systems typically lack integrated security monitoring and are not designed for multi-tenant, software-defined environments. In contrast, HDD CaaS introduced a cloud-native, security-first architecture that supports dynamic scaling, real-time monitoring, and automated response—capabilities not previously available in stadium deployments.

Business Impact and Replicability

The security model enabled Boldyn to deliver a commercially viable, multi-operator platform that meets MNO and venue compliance requirements. It also supports future expansion into other HDD venues with minimal rework.

To replicate this success, others should:

- Embed security from the design phase, not as an afterthought.
- Use CREST-aligned testing and independent validation.
- Integrate NMS and SOC platforms early.
- Adopt a modular, cloud-native architecture with strong segmentation and automation.

High level summary of project costs

Maximum word count: 500 words

High level summary of project costs (to DSIT and project participants). (Equipment and deployment costs of any networks are also of interest)

Total project costs (including project extension) are:

Partner	Partner Funding	DSIT Funding	Total	DSIT Funding %
Boldyn Networks	£1,803,736	£1,202,491	£3,006,227	40%
British Esports Federation	£100,000	£150,000	£250,000	60%
Perform Green	£67,136	£100,704	£167,840	60%
Sunderland City Council	£0	£1,821,367	£1,821,367	100%
SAFC	£498,000	£332,000	£830,000	40%
Grand Total	**£2,468,872**	**£3,606,563**	**£6,075,435**	**59.4%**

The split of costs across cost category is:

Expenditure Category	Total Expenditure
Capital Usage	£0.00
Labour	£907,305.96
Materials	£3,66610.36
Other Costs	£969,629.16
Overheads	£181,552.90
Sub Contract Costs	£346,962.39
Travel and Subsistence	£9,374.20
Grand Total	**£6,075,434.97**

Project Highlights

Maximum word count: 500

This could include project awards, events.

Key project highlights include

1. Overcoming challenges with roof loading for heavy equipment
2. Overcoming challenges relating to VMO2 London switch cyber incident to achieve 5G core connection in 2024/25
3. Successfully delivering and demonstrating a European-first HDD 5G CaaS solution for the whole stadium.

Another key highlight for the project was the showcase event at the Stadium of Light attended by DSIT and project partners on 22 May 2025. This event took place following initial testing of the CaaS HDD network and provided a moment for all involved to recognise and reflect on what had been achieved, together with looking forward to the next phase.

A further showcase event was held at the Stadium of Light in October 2025, where details of the CCTV and LOBIT game were shared with DSIT colleagues. Participants took part in a successful interactive live trial of the LOBIT game, viewed some of the CCTV technology installation and had presentations on wider Smart City projects in Sunderland and the North East region.

Highlights for SAFC:

- The network performance far exceeds expectations from a speed/capacity point of view
- The complete sell-out play-off final match demonstrated that high-density performance is still exceptional even at absolute capacity
- With promotion to the Premier League the club will have significantly higher match attendances with many sell out fixtures expected, and the club now has the confidence that the new DAS will deliver even in these circumstances

Highlights for Boldyn Networks:

The development of the Boldyn HDD CaaS based on 5G ORAN technology has surpassed expectations. In particular:

- Feature parity study shows technical features met vs. Incumbent BTS provider
- Spectrum bands increased from three (legacy) to seven, including provision of 5G
- Capacity: system serves well maximum capacity crowd of ~49,000
- Externally verified performance management statistics show significant improvements in performance from the legacy system.

Project Conclusions

Maximum word count: 500

This should include the final findings from the projects and talk about the conclusions gleaned from the activity within the project. Suggestions for policy, regulation or programmes or other things that may need adjustment arising from the project.
Why was the project worth undertaking.

The project successfully demonstrated the technical and commercial viability of the HDD CaaS product based on a virtualised, Open RAN-based neutral host platform in a high-density venue. The prototype deployment at the Stadium of Light (SoL) validates the concept end-to-end, delivering a replicable model for future deployments.

The project proved a cloud-native, software-defined infrastructure can outperform legacy BTS-fed DAS systems in both performance and efficiency. Independent testing confirmed significant improvements in throughput, latency, and user experience. The platform also achieves substantial reductions in power consumption and equipment footprint, directly supporting sustainability and cost-efficiency goals.

One of the most significant challenges was securing MNO participation under the neutral host (NH) model. Despite the technical readiness of the platform, MNOs were cautious in committing to a shared infrastructure delivered through a managed service model. This stemmed from concerns around operational control, integration complexity, and commercial alignment. The project team had to invest considerable effort in building trust, clarifying roles, and demonstrating that Boldyn could independently manage the platform without vendor dependency and without heavy MNO intervention.

This experience highlights a key policy and regulatory gap: the need for clearer frameworks and incentives to encourage MNO adoption. Government and regulatory bodies should consider mechanisms that promote infrastructure sharing, streamline integration processes, and de-risk early adoption for operators. This could include standardised SLAs, reference architectures, and funding support for integration activities. This could contribute significantly to the diversification of the supply-chain, creation of new delivery and operational models that incentivise the deployment of more and better mobile connectivity services to the wider community.

The project addressed a critical bottleneck in the UK's digital infrastructure landscape: the lack of scalable, cost-effective solutions for high-density venues. It delivered a blueprint to accelerate 5G rollout, reduce duplication, and improve service quality for end users.

This project shows that the neutral host model is not just a theoretical construct, it is a practical, high-performance alternative to traditional network deployment. It enables faster time-to-market, lower TCO, and better user experience, all while supporting national goals around digital inclusion and sustainability.

The results will have a lasting impact on…

- Sunderland City: further enhancing its reputation as “the UK’s Smartest City
- SAFC: delivering a highly connected fan experience and operational, commercial and safety benefits for the club.
- British Esports: the arena will create significant local, regional and national impact for UK businesses, and inward investment from global/tech businesses.
- Boldyn Networks: enabling the company to offer a differentiated, future-proof connectivity solution to venue owners and MNOs.
- The broader ecosystem: by providing a tested model that others can replicate .

To replicate this success, future projects should:

- Engage MNOs early and collaboratively define operational models
- Use modular, standards-based architectures to simplify integration
- Prioritise automation, monitoring, and security from day one
- Advocate for policy support to reduce commercial and technical friction

The HDD CaaS project has laid the foundation for a new era of shared digital infrastructure; one that is open, efficient, and ready to meet the demands of tomorrow’s connected venues.

Successful implementation of the CCTV and LOBIT use cases has demonstrated the tangible value that the 5G network can provide to large scale venues, bringing benefits including:

- Improved visitor safety and security
- Improved operational efficiency
- Enhanced fan experience.

Next Steps

Maximum word count: 500

What the project looks to achieve following the funding. This could be explaining plans for commercialisation or further research needed to achieve that. Were there things you couldn’t do that could be done in future? What could help? Next step?

Next Steps

Following the successful delivery of the HDD CaaS platform at the Stadium of Light, the project will transition into a new phase focused on commercialisation, operational scaling, and the development of advanced 5G use cases. These next steps are designed to build on the technical and commercial foundations established during the SONET programme and to unlock further value for venue operators, MNOs, and end users.

Commercialisation and Operational Expansion

Boldyn Networks will continue evolving the HDD CaaS platform into a fully operational, multi-venue product. A key priority is the **onboarding of a second MNO** at the Stadium of Light. While the platform has already demonstrated successful integration with VMO2,

adding a second operator is critical to validating the multi-operator neutral host model in a live environment. This will also strengthen the commercial case for replication across other high-density venues.
The operational model will be refined to support broader MNO engagement, with a focus on transparent SLAs, shared governance, and demonstrating long-term cost and performance benefits. This is essential to overcoming the commercial and operational hesitancy that some MNOs have shown toward neutral host models.

SAFC are now intending further investment this summer to improve the fan experience and commercial returns for the club, enabled by the success of SONET.

British Esports have had contact from two of world biggest games publishers regarding using the arena as a launch for mobile activations.
The first Olympic esports competition will be held in 2027. The arena is envisaged to become the "home" of the British esports team for future, becoming a training base for 2027 Olympic esports athletes.

Research and Development
Further R&D focus:

- Automating the CI/CD pipeline for network updates and security patches
- Enhancing orchestration and analytics capabilities
- Exploring AI-driven optimisation for traffic management and energy efficiency

These developments will ensure the platform remains at the forefront of Open RAN innovation and continues to meet evolving industry standards.

Critical Enablers
Accelerating adoption and scaling needs:

- Policy support for neutral host models, including regulatory clarity and incentives for MNO participation
- Standardised integration frameworks to reduce onboarding friction
- Continued public-private funding to de-risk innovation and support early deployments.

The next phase of HDD CaaS will deepen the impact of the SONET programme and serve as a blueprint for transforming digital infrastructure in high-demand environments across the UK and beyond.

Media Library

This should include any links to project websites, social media handles, key documents etc.

It should also include any videos or photos from the project that would effectively showcase what it achieved.

Sunderland Smart City Website

- https://www.sunderlandoursmartcity.com/challenges/sunderland-open-network-ecosystem-sonet/
- https://www.sunderlandoursmartcity.com/revolutionising-sports-esports-experiences-sonet-project-update/

SAFC

- https://www.safc.com/news/club-news/2023/september/sonet-project-announcement

Media Coverage

- SONET Coverage Book link: https://share.coveragebook.com/b/4e580859deb72750

Headline stats include:

- 43 pieces of coverage
- 1.6M views
- Total audience of 202M
- Domain Authority range of 54 to 94 - Generally, a DA score between 40 and 50 is considered average, 50 to 60 is good, and over 60 is excellent. Higher scores indicate stronger potential for ranking.