Final Project Closure
Date: 08/12/2025
Version 1.0

Table of Contents

1.0 Executive Summary

The Small Cells Open RAN in Dense Area (SCONDA) Project is a landmark initiative that marks a significant leap forward for mobile network innovation in the United Kingdom. It represents the first live integration of Open Radio Access Network (Open RAN) with traditional RAN technologies in a high-density urban setting. The project was spearheaded by AWTG and delivered in close partnership with Three UK. A large consortium of industry leaders and academic institutions contributed to the project, including Freshwave, Accenture, Mavenir, P.I. Works, the Universities of Glasgow and Surrey, and the Scotland 5G Centre.

The core objective of the SCONDA project was to demonstrate the technical feasibility, commercial viability, and strategic value of Open RAN in environments characterized by high user density and fluctuating demand. Glasgow City Centre was selected as the ideal testbed for this purpose due to its status as a mobile traffic hotspot. The project successfully proved that Open RAN can seamlessly integrate with existing legacy systems, support dynamic traffic loads, and enable the cost-effective deployment of small cells to densify networks. Beyond densification, SCONDA also explored intelligent orchestration, automation, and AI-driven analytics to optimize network performance and user experience.

A key finding is that Open RAN's open and modular architecture allows operators to mix and match components from different suppliers, fostering innovation, reducing costs, and preventing vendor lock-in. This flexibility was leveraged to build a hybrid network that combines the stability of traditional RAN with the agility of Open RAN, creating a scalable and future-proof solution for urban connectivity.

The benefits and impacts of the project were extensive and measurable:

- **Enhanced Network Performance**: The project delivered a dramatic uplift in network performance, with an average 5G download throughput of 152.4 Mbps, significantly exceeding the target of 100 Mbps.
- **Operational Efficiency**: The use of automated deployment models and containerized network functions accelerated site turn-up times by approximately 35%, providing a repeatable and low-risk model for future rollouts.
- **Macro-Layer Offload**: The small-cell layer successfully offloaded 18% of the traffic burden from the macro layer, which in turn enhanced macro-cell throughput by 77% in download and 19% in upload for the remaining users.
- **Strategic Alignment**: The SCONDA project provides a direct contribution to the UK Government's mandate to route 35% of national mobile traffic through open and

interoperable RAN architectures by 2030.

The SCONDA project's comprehensive approach, from rigorous lab testing to live-site deployment, serves as a blueprint for future urban rollouts and positions the UK as a leader in mobile network innovation. It is more than just a technical trial; it is a strategic step toward a more resilient, inclusive, and future-ready mobile ecosystem.

2.0 Aims and Scope

The SCONDA project was a multifaceted initiative with clear technical, commercial, and research goals. It sought to validate Open RAN's viability in high-density urban environments by benchmarking its performance against traditional RAN technologies. A key aim was to enable vendor diversity and reduce the total cost of ownership by leveraging commercial off-the-shelf (COTS) hardware. The project also aimed to provide empirical evidence to support the UK government's mandate for Open RAN traffic, while fostering a vibrant ecosystem of innovators and researchers.

2.1 Technical Validation of Open RAN in High-Density Scenarios

At its core, SCONDA was designed to rigorously assess the viability of Open RAN in environments that present the most formidable challenges for mobile networks: exceptionally high user density, unpredictable traffic patterns, and stringent performance demands.

- **End-to-End Interoperability**: A primary technical aim was to demonstrate seamless end-to-end interoperability between Open RAN components supplied by Mavenir (RU, DU, CU) and Three UK's existing EPC core network, which was anchored via Nokia SeGW tunnels.
- **Performance Benchmarking**: The project sought to benchmark critical performance indicators such as throughput, latency, handover success rates, retainability, and spectral efficiency. This was done in both controlled lab environments and live field trials to capture comprehensive data.
- **Automation Validation**: A key objective was to validate closed-loop and open-loop automation through the deployment of a RAN Intelligent Controller (RIC). The project focused on using bespoke rApps to demonstrate optimization for coverage, capacity, and energy efficiency.
- **Operational Security and Resilience**: The project aimed to ensure operational security and network resilience by integrating robust security solutions, including

CyberArk PKI and IPSec failover mechanisms, to meet Three UK's stringent compliance standards.

- **Repeatable Deployment Process**: SCONDA sought to establish a repeatable and efficient build-and-deploy process. This was accomplished by leveraging containerized network functions and automation tools like Helm charts and Ansible playbooks to minimize human error and accelerate rollout velocity.

2.2 Commercial and Strategic Goals

Beyond the technical ambitions, SCONDA was designed to create a commercially viable small-cell densification model that could be scaled across the UK and beyond.

- **Enabling Vendor Diversity**: The project aimed to integrate Mavenir Open RAN alongside incumbent vendors like Ericsson, Huawei, Samsung, and Nokia. This approach was intended to reduce vendor lock-in and mitigate supply-chain risks.
- **Lowering TCO**: SCONDA sought to demonstrate the economic case for Open RAN adoption in urban hotspots by leveraging dark fiber and COTS (commercial off-the-shelf) hardware.
- **Informing UK Government Policy**: A critical strategic goal was to provide empirical evidence to inform UK government policy. The project's findings would support the Department for Science, Innovation and Technology's (DSIT) mandate for at least 35% of national mobile traffic to be carried over open, interoperable RAN architectures by 2030.
- **Accelerating Time-to-Market**: The project aimed to prove that non-standalone (NSA) deployments could be anchored on existing LTE cores, thereby reducing disruption and capital expenditure for new 5G services.
- **Cultivating an Ecosystem**: SCONDA intended to foster a vibrant ecosystem of systems integrators, RIC vendors, and research institutions to drive sustained innovation in RAN orchestration and automation.

2.3 Research & Innovation Objectives

SCONDA was a unique project because it combined large-scale industrial deployment with focused academic research.

- **Advancing RIC-Driven Intelligence**: The project aimed to prove the efficacy of rApps in real-time network optimization, paving the way for future AI/ML-based network management.

- **Generating Open Data Sets**: The project sought to generate open datasets on user experience metrics, crowdsourced telemetry, and drive-test logs. This data would be made available to inform broader 5G research and innovation.
- **Publishing Methodologies**: The consortium intended to publish methodologies for multi-vendor coexistence, closed-loop automation, and small-cell RF planning in dense urban environments.
- **Fostering Knowledge Transfer**: SCONDA aimed to ensure a lasting impact by fostering knowledge transfer through workshops, runbooks, and training materials delivered to Three UK field engineers and other partner organizations. The involvement of the Universities of Glasgow and Surrey, along with the Scotland 5G Centre, ensured rigorous academic validation and dissemination of the findings.

3.0 Why the Project Was Worth Undertaking

The SCONDA project was a strategically vital initiative that addressed key national and commercial priorities. It directly aligned with the UK Government's mandate to route 35% of national mobile traffic through Open RAN by 2030, a policy aimed at fostering a more resilient and diverse vendor ecosystem. The project proved the economic case for Open RAN by demonstrating that the cost per additional Mbps was lower than traditional solutions when deploying COTS-based DU/CU clusters. By pioneering automation and intelligence with a RAN Intelligent Controller (RIC) and associated rApps, SCONDA showed that network performance could be improved, and energy could be saved without manual intervention, achieving a 15% capacity uplift and 10% energy saving during off-peak hours. This provided a repeatable and de-risked model for future nationwide rollouts.

3.1 Aligning with National Policy & Future-Proofing the UK RAN

The UK Government, through DSIT, has mandated that 35% of national mobile traffic should traverse Open RAN architecture by 2030. This mandate is intended to build a more resilient, diverse, and competitive vendor ecosystem. SCONDA directly supports this policy by providing a validated, repeatable deployment model that integrates Open RAN into a live network and demonstrates its ability to meet stringent service-level objectives. By de-risking the technology and providing a blueprint for future rollouts, SCONDA serves as a cornerstone for future policy frameworks.

3.2 Addressing High-Density Urban Demand

Glasgow City Centre exemplifies the modern urban hotspot, with mass gatherings, events, and dense footfall creating a high demand for mobile services. Traditional macro cells alone cannot sustainably accommodate such demand without incurring capacity bottlenecks and uneven coverage. The small-cell densification realized through SCONDA's Open RAN layer offloads traffic, enhances network efficiency, and delivers seamless experiences. This is critical for laying the groundwork for future 5G-centric services like URLLC (Ultra-Reliable Low Latency Communications) and edge-driven content. Without SCONDA, operators risk customer dissatisfaction and lost ARPU (Average Revenue Per User) in these high-value areas.

3.3 Catalyzing Vendor Diversity & Cost Efficiency

Prior to SCONDA, RAN densification in urban environments often meant proprietary, single-vendor expansions with high CAPEX (Capital Expenditures) and limited process automation. SCONDA proved that multi-vendor Open RAN, coupled with dark-fiber fronthaul and COTS compute, can reduce hardware costs, simplify fiber usage models, and avoid vendor lock-in. The project demonstrated that the cost per additional Mbps of capacity is demonstrably lower when deploying COTS-based DU/CU clusters compared to traditional RAN shelf expansions. This commercial validation incentivizes broader Open RAN adoption, enhances competition, and drives down long-term costs for operators and, ultimately, consumers.

3.4 Pioneering Automation & Intelligence in RAN Operations

The RAN Intelligent Controller (RIC) and associated rApps deployed in SCONDA established the first real-world closed-loop automation use cases in a live Open RAN setting. By dynamically adjusting antenna tilts, power levels, and resource allocations based on observed KPIs, the project demonstrated up to a 15% capacity uplift and 10% energy saving during off-peak hours, all without manual intervention. This automation blueprint not only reduces operational expenditure (OPEX) but also accelerates mean time to repair (MTTR) and ensures SLA consistency across varying traffic patterns.

3.5 Academic & Ecosystem Benefits

By partnering with leading universities and the Scotland 5G Centre, SCONDA generated open datasets, white papers, and methodologies that advance the collective knowledge on topics such as RF planning in dense urban canyons, multi-vendor interoperability testing frameworks, and AI/ML model performance in live network optimization. These contributions bolster the UK's reputation as a global leader in 5G/6G research, attract further investment, and cultivate local talent in telecommunications engineering.

3.6 Investor & Stakeholder Confidence

SCONDA's structured, gate-driven approach with rigorous exit criteria at each phase instilled confidence among network operators, equipment vendors, regulators, and investors. By transparently publishing lab test results (52 SIT cases with zero P1/P2 defects) and field KPIs (≥99.9% availability, 152 Mbps average DL in 5G), the project delivered quantifiable proof points that underpin future capital allocation decisions for small-cell deployments.

3.7 Sustainable, Long-Term Impact

The project's outputs, including comprehensive runbooks, automated playbooks, and optimized parameter baselines, form a lasting operational framework. Three UK's field engineers and NOC operators now possess a clear playbook for rolling out further small-cell clusters in other UK cities, confident that they can replicate SCONDA's success. The project thus ensures that network densification can proceed at scale, sustainably, and with minimal incremental risk.

4.0 Methods, Technologies, and Architecture

The SCONDA project was executed with a clear, disciplined approach, leveraging modern methodologies and cutting-edge technologies. It adopted the O-RAN 7.2x functional split, utilizing Mavenir Radio Units (RUs) and containerized Distributed Units (DUs) and Centralized Units (CUs) hosted on Dell servers. The entire deployment was cloud-native, running on Red Hat OpenShift clusters. Automation tools like Helm charts and Ansible playbooks were used to ensure repeatable deployments. A representative lab environment was also built in Three UK's Green Park and Farnborough data centers to de-risk the live rollout through extensive Network and System Integration Testing.

4.1 Governance, Method & Process

A formal governance framework was established at the project's kickoff to define roles, responsibilities, and accountability.

- **Consortium & Roles**: AWTG served as the System Integrator and Technical Lead, orchestrating cross-domain delivery and overseeing the RIC deployment. Three UK acted as the Project and Delivery Lead, defining requirements and providing core network anchors. The Mavenir was the Open RAN Vendor, supplying RU/DU/CU software. Freshwave handled site services, and PI Works provided the RIC platform. Accenture led performance benchmarking, while universities and the Scotland 5G Centre provided research support.

- **High-Level Design Processes**: The HLD phase followed a structured lifecycle that included strategy workshops, requirements consolidation, and architecture definition. This phase also incorporated a security and compliance review, an OSS/automation strategy, and operational planning. The HLD review and sign-off served as a critical exit gate before the detailed design phase began.

4.2 Open RAN Architecture & Deployment

The SCONDA project adopted the O-RAN 7.2x functional split, a disaggregated architecture that separates the RAN into multiple components.

- **Radio Units (RUs)**: The project used Mavenir MR44NA RUs for LTE B1 and MU44UA/VA RUs for 5G n78.
- **Distributed Units (DUs)**: These units hosted the RLC/MAC layers and communicated with the RUs via an eCPRI fronthaul over 10 GE EtherChannel.
- **Centralized Units (CUs)**: The CUs contained the PDCP/RRC layers and interfaced with the DUs (F1-C/U) and the EPC core network (S1 C/U, X2).
- **Management & Orchestration**: The network was managed by Mavenir's NEMS (mCMS, Analytics, MDCA) and the PI Works RIC platform, which hosted closed-loop rApps for optimization.
- **Security & Transport**: All traffic was secured using IPSec tunnels managed by a Security Gateway (SecGW). The transport fabric used BGP/SR-MPLS for the underlay and VLAN segmentation for O-RAN domains. PTP and SyncE profiles were used for time synchronization.

4.3 Cloud & Container Platform

SCONDA leveraged a fully containerized, cloud-native deployment model.

- **Platform**: The project used Red Hat OpenShift (RHOCP) clusters, which leveraged Kubernetes for Containerized Network Function (CNF) orchestration.
- **Hardware**: Dell PowerEdge R650/R750 servers were used for CNFs and the cloud platform, while Dell XR11 servers were used for DU workloads.
- **Automation**: Helm charts were used for deploying vDU and vCU functions, and Ansible playbooks were used for configuring switches and the SecGW.

4.4 Lab Build and Testing Methodology

A fully representative lab environment was established in Three UK's Green Park and Farnborough data centers to de-risk the live rollout.

- **Lab Topology & Infrastructure**: The lab included DU/CU servers, SecGW CNF pods, and RU simulators connected via fiber patch panels.
- **Configuration & Verification**: The process began with rack builds and cabling, followed by switch provisioning and server/CNF deployment. Initial connectivity checks were performed to validate Layer 2/3 connectivity and SNMPv3 sessions.
- **Testing**: The team executed 41 scripted Network Integration Tests (NIT) and 52 functional System Integration Tests (SIT). Security and resilience testing included simulating SecGW pod failures and validating audit logging.
- **Exit Criteria & Deliverables**: The lab phase was completed with a formal Exit Gate that required zero open P1/P2 defects and a test pass rate of at least 95%.

5.0 R&D, Products, Solutions, and Use Cases

The SCONDA project combined a large-scale industrial deployment with focused R&D workstreams to push the boundaries of Open RAN technology. This included designing and prototyping rApps for network optimization, such as a Coverage Balancing rApp and an Energy-Saving rApp. The project delivered a full end-to-end Open RAN solution, including Mavenir RUs and containerized DU/CU functions. The R&D outcomes were demonstrated through use cases like a Coverage rApp that improved throughput and an Energy-Saving rApp that reduced power consumption without impacting service quality. These efforts successfully validated the efficacy of RIC-driven automation in a live network setting.

5.1 R&D Planning: Objective, Scope, and Deliverables

The R&D workstream targeted three intertwined goals: Technical Validation, Automation & Intelligence, and Ecosystem Enablement. These objectives were translated into concrete deliverables, including a Network Optimization Strategy and a Network Optimization Report. The R&D activities were organized into four parallel streams: Lab Emulation & Testing, Automation Framework, RIC & rApp Innovation, and Network Optimization Strategy. Each milestone had rigorous exit criteria to ensure success.

5.2 Lab-Based R&D: Emulation, Integration, and Testing

A representative Open RAN environment was mirrored in Three UK's data centers for R&D purposes. This setup enabled deterministic evaluation of Open RAN functions under controlled load and failure scenarios. The team automated CNF lifecycle management using a combination of Helm charts and Ansible roles, which reduced manual errors and cut build times by 40%. Engineers executed 41 NITs and 52 SITs, achieving a high pass rate and receiving formal approval to exit the lab phase.

5.3 RIC & rApp Innovation

A PI Works RIC platform was deployed in Three UK's central data center, serving as the execution engine for closed-loop optimization workflows.

- **rApp Development & Trials**: Two initial rApps were designed and trialed: a Coverage Balancing rApp and an Energy-Saving rApp. Each underwent A/B testing in the lab before being deployed in the field.
- **Field Validation**: During the field rollout, the Coverage rApp increased 4G and 5G cluster-level availability by +0.3%, and the Energy rApp achieved average energy savings of 8% per site without service degradation. These results informed algorithm refinements and future feature enhancements.

5.4 Products & Solutions Delivered

The project delivered a complete, end-to-end Open RAN solution, including:

- **Hardware**: Mavenir Radio Units (MR44NA and MU44VA), Dell servers (XR11, R650, R750) for CNF hosting, and transport network solutions.
- **Software**: Containerized DU and CU functions, Mavenir NEMS, PI Works RIC, and an automation toolchain using Ansible and Helm charts.
- **Reference Architecture**: The solution combined these products into a vendor-agnostic template, with defined interfaces and transport paths, serving as a blueprint for future deployments.

5.5 Use Cases: Demonstrations of R&D Outcome

The R&D outcomes were demonstrated through several key use cases:

- **Coverage & Capacity Optimization**: The Coverage rApp fine-tuned antenna tilts to maximize signal overlap, leading to a 182% improvement in 4G DL throughput and a doubling of 5G session share.

- **Interference Management**: Automated adjustments to PRBs and scheduler weights reduced RRC re-establishment incidents by 23% during peak hours.
- **Mobility Management**: EN-DC handovers between Mavenir small cells and Ericsson macro layers maintained high success rates with zero handover-related call drops.
- **Special-Scenario Adaptations**: During a local festival, the capacity rApp pre-emptively reallocated PRBs, preserving KPI thresholds despite a 30% surge in data traffic.

6.0 Approach to Security

Security was a fundamental aspect of the SCONDA project, built on a "security by design" methodology that permeated every phase. The project adhered to Three UK's security policies (3SF) and the UK's TSA Code of Practice. A formal threat modeling exercise was conducted to identify risks before any design work began, including data-plane, management-plane, and physical threats. The security architecture applied a "defense-in-depth" model with network micro-segmentation and IPSec-secured transport for all users, control, and management traffic. Privileged access was managed through a CyberArk vault, and all changes were executed via a formal ITIL change process.

6.1 Security Governance & Compliance Framework

At the outset, a formal security governance structure was established to ensure accountability and compliance. All solution designs were required to comply with Three UK's internal security policies (3SF) and the UK's TSA Code of Practice. A formal FOA Acceptance Criteria mandated pre-go-live penetration testing, with formal remediation plans for all critical and high-severity findings.

6.2 Threat Modelling & Risk Assessment

Before any design work, a structured threat-modeling exercise identified key assets and potential adversary vectors. This included risks to the data plane and control plane (e.g., eavesdropping, tampering), the management plane (e.g., unauthorized access), and physical and supply-chain threats (e.g., rogue firmware injection). Mitigations were then mapped to these identified risks.

6.3 Security Architecture

The SCONDA security architecture applied a "defense-in-depth" model.

- **Micro-segmentation**: The network was divided into distinct security zones to limit lateral movement, with traffic between zones traversing firewalls with granular ACLs.
- **IPSec-Secured Transport**: All user, control, and management traffic between DUs, CUs, and SecGWs was secured using IPSec tunnels with IKEv2 and certificate-based authentication. Multi-chassis IPSec provided active/standby redundancy for seamless failover.
- **Time Synchronization Security**: Accurate, authenticated time was vital for log integrity. Devices used NTP with MD5 authentication and IGP key-chains to protect PTP sync messages.

6.4 Identity & Access Management

- **Privileged Access**: All privileged operations were mediated through Three UK's CyberArk vault. This enforced unique user IDs, multi-factor authentication, and session recording for audit purposes.
- **Role-Based Access Control (RBAC)**: Within the OpenShift clusters, CNFs operated in separate Kubernetes namespaces, and service accounts were provisioned with least-privilege access.
- **Management-Plane Hardening**: All management APIs used encrypted channels (NETCONF/RESTCONF over TLS), and SSH access was limited by ACLs. Only SNMPv3 with SHA authentication and AES-128 privacy was used for network element monitoring.

6.5 Certificate & Key Management

Certificates for IPSec and TLS were managed by Nokia's NetGuard Certificate Manager. A dedicated subordinate CA was created for Mavenir, and certificates were valid for one year with renewal procedures triggered 30 days before expiry. CyberArk APIs were leveraged to provision certificates and private keys during automated deployments, ensuring keys never existed in plaintext on orchestrator hosts.

6.6 Logging, Monitoring & Audit

A layered logging strategy ensured both fault management and security monitoring needs were met. Fault logs were sent to EPNM, while security logs were forwarded to a Splunk-powered ULAP server for monitoring by the SOC. All logs were carried within IPsec or VRF/transport tunnels and were TSA-compliant, with detailed records of security events, user access, and configuration changes stored for 13 months.

6.7 Vulnerability Management & Penetration Testing

The project implemented a continuous security lifecycle. Pre-production penetration testing was conducted using synthetic traffic, and a formal remediation plan was put in place for all critical/high findings. Automated weekly scans were performed against DU/CU/NEMS hosts, with results fed into a monthly patch management process.

7.0 High-Level Summary of Project Investment

The SCONDA project was delivered under a clearly defined co-investment funding model, with transparent cost tracking and reporting throughout its lifecycle. The project was executed in two distinct phases:

1. the main delivery phase, completed in March 2025 in line with the original project timeline, and
2. a time-limited extension phase, delivered over a further six months, supported by an additional £500,000 budget, fully utilized and involving a reduced subset of

7.1 Total Project Investment

Across both the main delivery phase and the extension period, the total eligible project investment, including the extension investment amounted to approximately:

£14.81 million

This figure represents the aggregate of DSIT grant funding and partner co-investment incurred across all participating organizations over the full duration of the project.

7.2 Funding Model and Subsidy Structure

SCONDA was funded through a subsidy-based co-investment model, with subsidy intensity varying by organization type in line with subsidy control requirements (e.g. commercial entities vs. academic partners). The funding comprised:

- DSIT grant funding, claimed against eligible costs, and
- Non-DSIT partner contributions, representing matched or excess spend.

The extension phase budget (£500k) was funded under the same principles and was fully exhausted within the approved six-month extension period.

7.3 Total Investment by Consortium Partner

The table below summarizes the total eligible investment per partner across the full project lifecycle, together with the effective subsidy percentage applied.

Consortium Partner	Partner Cost (£)	Effective Subsidy (%)	Partner Investment (£)
AWTG Limited	3,660,000	60%	1,464,000
Hutchison 3G UK Limited	5,350,000	40%	3,210,000
PI Works UK Ltd	1,360,000	60%	544,000
Mavenir Systems Limited	1,110,000	40%	666,000
University of Surrey	1,000,000	80%	200,000
University of Glasgow	720,000	80%	144,000
Freshwave	660,000	50%	330,000
BAI Infrastructure Limited	430,000	40%	258,000
Scotland 5G Centre	300,000	80%	60,000
Accenture (UK) Limited	210,000	40%	126,000

Note: Partner Investment represents the proportion of total eligible costs funded directly by each organization, calculated in line with the applicable subsidy rate.

7.4 Main Delivery Phase and Extension Period

- The main project phase, completed by March 2025, delivered the core SCONDA outcomes, including the Open RAN lab environment and live network deployment.
- The extension phase, supported by an additional £500,000 budget, enabled targeted continuation activities, with participation limited to a smaller number of partners directly supporting extension objectives.
- The extension budget was fully utilized within six months, with no overspend and continued compliance with subsidy control requirements.

8.0 Results and Key Findings

The project delivered quantifiable results that proved the viability and benefits of Open RAN, supported by extensive evidence from lab tests and field trials. It achieved a significant uplift in network performance, with 5G availability reaching 99.33% and average download throughput of 152.4 Mbps, exceeding project targets. Walk tests showed a 182% improvement in 4G download throughput and an increase in 5G session share from 16% to 37%. The small-cell layer also successfully offloaded 18% of traffic from the macro layer, enhancing its performance.

8.1 Dramatic Uplift in Network Performance

- **Availability and Accessibility**: Across the 18-site small-cell cluster, 4G cell availability averaged 99.96%, comfortably exceeding the ≥99% target. 5G availability reached 99.33% against a ≥98% threshold. Data and VoLTE accessibility for 4G remained above 98.6%, with 5G CSSR at 98.71%.
- **Superior Throughput**: Small-cell clusters delivered average 4G DL throughput of 28.28 Mbps and 5G DL throughput of 152.4 Mbps, both exceeding their targets. Spectral efficiency for 4G reached 2.56 bits/s/Hz, with 5G at 2.44 bits/s/Hz, demonstrating optimized resource utilization.
- **Exemplary Retainability & Mobility**: The active 4G ERAB drop rate was just 0.47% (≤1%), and 5G data retention failures stood at 0.04% (≤2%). Mobility performance for intra- and inter-frequency handovers exceeded 92% for both 4G and VoLTE.

8.2 Measurable User Experience Gains

- **Walk Test Throughput**: In comparative “PRE vs POST” walk tests, enabling the small-cell layer yielded an average 182% improvement in 4G DL throughput and a 120% improvement in UL throughput. The share of 5G-enabled sessions nearly doubled, rising from ~16% to ~37% of all sampled connections.
- **Voice Quality**: VoLTE Mean Opinion Score (MOS) remained above 4.0 both before and after small-cell activation, and 100% call success rates were maintained.
- **Coverage Deepening**: Post-deployment data showed a higher density of "good" signal samples, extending reliable coverage into street canyons and building perimeters.

8.3 Significant Macro-Layer Offload

- **Data Payload Redistribution**: With 18 small cells active, they absorbed +15% of the total data volume, offloading macros by 18% and boosting macro DL/UL throughput by 76% and 24% respectively.
- **Voice Offload**: VoLTE attempts on neighboring macro cells dropped by 27% after deployment. This offload effect underscores the small-cell layer’s ability to absorb both high-bandwidth data sessions and voice traffic.

9.0 Impact and Benefits Achieved

The project’s successful outcomes had a profound impact on operations, costs, and strategic alignment, demonstrating the tangible benefits of Open RAN. The use of automation cut site turn-up times by 35% and reduced mean-time-to-repair by 20-30%. By leveraging COTS hardware, the capital cost per Mbps was reduced by an estimated 20-25%. SCONDA directly supports the UK government's Open RAN mandate by providing a replicable blueprint for nationwide rollouts. The project also advanced the state of the art in RAN automation with RIC-driven rApps that demonstrated a 10-12% capacity uplift and 8-10% energy savings.

9.1 Operation & Automation Efficiencies

The use of Helm charts, Ansible playbooks, and "gold-image" containerized deployments enabled the replication of validated lab configurations in the field with minimal manual intervention. This automation cut site turn-up times by approximately 35%. A fully documented Connectivity Matrix and CIQ templates served as a "single source of truth," ensuring consistent deployments with zero P1/P2 defects. Automated northbound API feeds into systems like Comarch NRM, Splunk, and ServiceNow slashed time to detect and remediate incidents.

9.2 Cost-Effectiveness & Commercial Benefits

Leveraging dark-fiber fronthaul and COTS hardware reduced the capital cost per Mbps of capacity by an estimated 20–25% versus traditional RAN shelf expansions. This cost efficiency provides a compelling economic case for Open RAN densification. SCONDA integrated five RAN vendors (Ericsson, Huawei, Samsung, Nokia, and Mavenir), demonstrating interoperability and de-risking supply chains.

9.3 Strategic & Policy Alignment

SCONDA directly supports the UK Government's objective to carry 35% of national mobile traffic over Open RAN by 2030. By demonstrating real-world viability and performance, the project provides a blueprint for other operators to follow. The project also catalyzed a vibrant Open RAN ecosystem in the UK, fostering local talent and stimulating further innovation.

9.4 Research, Innovation & Knowledge Transfer

The deployment and real-world validation of closed-loop rApps for coverage balancing (10–12% capacity uplift) and energy saving (8–10% reduction) advanced the state of the art in RAN automation. The project generated open datasets, white papers, and methodologies that equipped academic and industry researchers with invaluable resources. Comprehensive training workshops and runbooks ensured that Three UK's operations teams are proficient in Open RAN orchestration, troubleshooting, and optimization.

10.0 Learning from the Project

The SCONDA project's “lessons learned” are manifold, but they all point to the central theme that rigorously structured, data-driven, and collaborative processes are paramount to de-risk complex, multi-vendor Open RAN deployments. The project highlighted the importance of a robust, automated lab environment as the single biggest enabler for rapid, low-risk field deployments. It also showed the value of codifying everything, from security policies to runbooks, and embedding security by design from the very beginning. Phased deployments and a focus on data quality for automation were also identified as critical success factors.

10.1 Strong Governance & Clear Decision Frameworks

At project inception, a formal governance structure including a Project Charter, RACI matrix, and Risk Register was established, which proved instrumental in aligning all consortium members on objectives and decision rights. Embedding strict exit criteria at the end of each phase (e.g., zero P1/P2 defects in the lab, ≥98% CSSR in FOA) kept the project on track and prevented "scope creep".

10.2 Holistic High-Level & Detailed Design Practices

Bringing technical leads from each vendor together in cross-functional workshops during the HLD phase fostered early detection of interface mismatches and conflicting requirements. Producing a single "Connectivity Matrix" and "CIQ Template" that covered all flows avoided duplication and version drift. Integrating security architects and OSS specialists into design scrums from day one avoided later rework.

10.3 Investing in a Reusable, Automated Lab Environment

Building a fully representative Open RAN environment in Three UK’s labs with DU/CU CNFs and eCPRI fronthaul patch panels paid dividends by allowing simultaneous Network and System Integration Tests, uncovering issues in a controlled setting before any field deployment. Packaging deployment steps into Helm charts and Ansible roles enabled “gold-image” creation of DU and CU clusters.

10.4 Containerized, Cloud-Native Deployment Models

Leveraging Red Hat OpenShift clusters and immutable container images demonstrated that CNFs can be deployed reproducibly at scale. Parameterizing all network values in Helm files enabled the reuse of the same chart across multiple clusters, reducing human error and allowing for rapid spin-up of new environments.

10.5 Precision in Site & Radio Design

Comprehensive pre-installation surveys covering pole loading capacities, fiber path routes, and RF propagation models were critical to preventing civil-works clashes and costly re-mobilizations. Consolidating equipment lists across multiple spreadsheets into a single "COMBINED BOM" reduced procurement lead-time by 25%.

10.6 Structured Turn-Up & Acceptance

A step-by-step Turn-Up (TTO) checklist ensured repeatability, allowing junior field engineers to execute core tasks with clear guidance. Phasing the initial Proof-of-Concept (2 sites) separate from the Field Operational Acceptance (FOA, 10 sites) cluster provided a "dress rehearsal" for scaled turn-up, enabling process refinement before committing resources to the full cluster.

10.7 OSS Integration & Operational Readiness

Integrating northbound APIs from Mavenir NEMS and the PI Works RIC into OSS systems like Comarch NRM, Splunk, and ServiceNow during the lab phases highlighted data-mapping inconsistencies that were corrected before production. Creating both "Day 1" and "Day 2+" operational runbooks fostered operational confidence, and using Splunk correlation rules to group multi-site alarms reduced “alarm storms” by 40%.

10.8 RIC & Closed-Loop Optimization Learnings

The efficacy of rApps hinged on timely, accurate E2 and O1 telemetry. The project found that deploying rApps to a subset of sites for controlled A/B testing yielded measurable uplifts (10–12% capacity, 8–10% energy savings) without exposing the entire network to risk.

10.9 Security by Design & Resilience

Incorporating security from the HLD and SDD phases prevented late-stage redesigns. Leveraging CyberArk APIs and Ansible modules to provision, renew, and revoke certificates eliminated manual steps and reduced the risk of expired or mis-issued certificates. Weekly Nessus scans coupled with a patch-cycle discipline built a culture of proactive remediation.

10.10 Cost Management & Commercial Insights

Integrating BOM line items into a centralized financial dashboard let project managers track burn rates against budgets in real-time. Identifying a per-site Capex early allowed for bulk procurement discounts, and maintaining a contingency fund avoided the need for ad-hoc budget top-ups.

10.11 Ecosystem Collaboration & Knowledge Transfer

Regular cross-vendor “Interoperability Clinics,” where experts from multiple companies resolved integration issues, fostered a collaborative ethos. Engaging academic partners through funded PhD fellowships and joint lab sessions yielded rigorous validation of automation algorithms and produced papers on urban RF propagation.

10.12 Strategic & Policy Alignment

Early dialogue with DSIT and Ofcom on spectrum coordination, live-trial notifications, and data-sharing protocols ensured that regulatory approvals did not bottleneck the go-live process. By demonstrating a production-grade Open RAN model, the project directly informed DSIT’s 2030 mandate and underpinned policy advocacy.

11.0 Key Recommendations for Future Projects

Based on extensive project learning, a key recommendation for future projects is to invest heavily in a reusable, automated lab environment, as it is the single biggest enabler for rapid, low-risk field deployments. All documentation, from security policies to runbooks, should be codified and treated as code to ensure consistency. The project also recommends a phased deployment strategy, using small proof-of-concepts (PoCs) to refine processes before scaling up. Lastly, it is critical to engage regulators early and embed financial controls to ensure cost discipline.

- **Invest Heavily in Lab & Automation**: A robust lab environment with CI/CD pipelines and automated test harnesses is the single biggest enabler of rapid, low-risk field deployments.
- **Codify Everything**: From security policies to BOMs to runbooks, treat documentation as code, ensuring it is version-controlled, peer-reviewed, and testable.

- **Adopt Container-Native Patterns**: Use immutable container images and declarative infrastructure (Helm/Ansible) to dramatically reduce human error and accelerate rollouts.
- **Start Security Up-Front**: Threat modeling, compliance mapping (TSA, 3SF), and PKI integration should be part of design sprints, not post-design add-ons.
- **Structure Phased Deployments**: Use small PoCs to refine processes before scaling FOA clusters and full rollouts; maintain clear acceptance boards at each wave.
- **Prioritize Data Quality for Automation**: Modern RIC-driven workflows are only as good as their underlying telemetry; invest time in defining, validating, and monitoring data pipelines.
- **Foster a Collaborative Ecosystem**: Multi-vendor interoperability clinics, academic partnerships, and open knowledge portals accelerate innovation and de-risk integration challenges.
- **Embed Financial Controls**: Implement real-time budget dashboards, standardized BOM management, and clear contingency rules to ensure cost discipline.
- **Engage Regulators Early**: Proactive engagement with DSIT/Ofcom on spectrum, data-sharing, and trial approvals smooths the path to go-live.
- **Plan for Operational Handoff**: From the outset, build runbooks, training programs, and test-out sessions for field and NOC teams to ensure a seamless transition from pilot to production operations.

12.0 Conclusions

The SCONDA Project's "lessons learned" are manifold but coalesce around one central theme: rigorously structured, data-driven, and collaborative processes are paramount to de-risk complex, multi-vendor Open RAN small-cell deployments. The project's success was not an accident but a direct result of weaving best practices into every layer, from initial concept to large-scale production rollout.

Key to this success was the heavy investment in a reusable, automated lab environment, which proved to be the single biggest enabler of rapid, low-risk field deployments. The project also demonstrated the critical importance of treating documentation as code—version-controlled, peer-reviewed, and testable—to ensure consistency and reduce human error. The adoption of container-native patterns and declarative infrastructure models, such as Helm and Ansible, dramatically accelerated rollouts and simplified management.

Furthermore, the project underscored that security is not a post-design add-on but a fundamental component that must be embedded from the very beginning. Through a phased deployment strategy, the team was able to refine processes in small PoCs before scaling to full rollouts, with clear acceptance boards at each stage to validate readiness. The project also highlighted the vital need for high-quality data and telemetry, as modern RIC-driven workflows are only as good as their underlying information.

Finally, the SCONDA Project's success was built on the foundation of strong ecosystem collaboration and early engagement with regulators. By fostering a collaborative environment among multiple vendors and academia, and by proactively working with bodies like DSIT and Ofcom, the project navigated complex integration and regulatory challenges. By heeding these insights, future projects can not only replicate SCONDA's successes but also accelerate their own time-to-market, reduce costs, and deliver superior network performance—thereby advancing the broader industry's march toward open, interoperable, and intelligent RAN architectures.