Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Close Down Report Document

Date of Submission

Jun 2022

Project Reference

NIA_WPD_050

Project Progress

Project Title

LTE| Connecting Futures

Project Reference

NIA_WPD_050

Funding Licensee(s)

WPD - Western Power Distribution (East Midlands) Plc

Project Start Date

January 2020

Project Duration

1 year and 7 months

Nominated Project Contact(s)

Faithful Chanda

Scope

This project will be the UK's first multi-site, multi-vendor LTE trial designed to mimic on a small scale, and develop proposals for, the roll-out of a telecommunications network to support Active Management functionality. This is an important follow up to the a single vendor; single base station LTE evaluation trial at Portishead which provided data on the fundamental design and capabilities of LTE and illustrated how such a communications network might be integrated into WPD infrastructure. This showed that an LTE network is better equipped than a traditional narrow-band Supervisory Control and Data Acquisition (SCADA) network in the harsh environment [e.g. electrically noisy sites, RF interference, multipath etc.] to be found in the context of an energy network and that the likely data throughput would be as predicted.

The recent NIA funded 'Next Generation Wireless Telecoms' analysis was carried out jointly with JRC and established a provisional model of the radio network planning methodology and technical infrastructure for an LTE radio network deployment across single or multiple DNO area(s). This project is important as a traditional narrow-band SCADA system will not be able to support the number of connections and services required in future. It is therefore essential to plan to deploy a more advanced technology and this project is an important step in reducing the risks associated with achieving the predicted coverage and throughput in any subsequent full-scale rollout with the required availability and resilience. The project runs for 12 months and has been broken down into 4 Phases which are defined according to various stages of the project.

Objectives

The objective of the project is to develop learning on:

- Confirmation that LTE is a suitable solution for providing communications for the energy industry
- Confirmation regarding using an Frequency Division Duplex (FDD) or Time Division Duplex (TDD) system
- Confirmation on bandwidth requirements
- Confirmation on types of data that can be passed over an LTE system
- Confirmation on antenna solutions for different situations
- Confirmation on training requirements and test equipment for staff

Success Criteria

- Confirmed propagation predictions and performance in a multi-site environment;
- Confirmed seamless interoperability of multi-vendor CPE and EPC equipment;
- Security & authentication successfully tested on LTE ecosystem;
- Testing of mobile and handheld device connectivity including Wi-Fi;
- Confirmation that LTE will support low-latency applications such as tele-protection;
- Document(s) outlining installation practises, test regimes and training requirements for LTE.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

On closing, the project has met the following with regards to its aims, objectives, and success criteria:

Confirmation of the propagation predictions and performance in a multi-site environment – complete
o The ability to measure the signal contribution from each sector (eNodeB), using the 'Rohde & Schwarz TSMA Autonomous Mobile Network scanner', allowed mobile measurements to be compared with predictions. The distribution of measured vs predicted signal levels for each sector (eNodeB) matched expectations. This allowed the correct RF performance of the installed network to be confirmed.

o This objective is complete, and concludes that the actual received signal levels closely align with the respective received signal level predictions generated.

Confirmation of the seamless interoperability of multi-vendor CPE and EPC equipment – complete
o The project was successful in integrating Encore EN2000, EN4000 and EN4000ie's to the Nokia Evolved Packet Core (EPC) and successfully established both clear channel and Internet Protocol security (IPSEC) tunnel connections across the network, from the gateway local area networks (LANs) to the CPE LAN. The Encore Networks EN4000 series is a high performance low–cost router designed for LTE cellular networks.

o The project was also successful in integrating Nokia service aggregation router (SAR-Hmc) CPE's to the Nokia EPC utilising IPSEC tunnelling.

o This objective is complete, and concludes that multi-vendor CPE's can seamlessly integrate with existing RAN and core components.

Security & authentication successfully tested on LTE ecosystem – complete
o The penetration tests took place in February 2020 and April 2021, and identified a number of vulnerabilities in the LTE platform. Both Nokia and Encore networks developed firmware updates for the CPE's, the eNodeB's, and the EPC, and these updates were implemented. The EPC, which comprised of Nokia's Micro Core Network (MCN), was a legacy product and it was replaced with Nokia's latest generation – the Compact Mobility Unit (CMU).

o This objective is complete, and the recommendations from these tests are in the process of being fully implemented.

Testing of mobile and handheld device connectivity, including Wi-Fi – complete

o The project successfully connected Mission Critical Push to Talk (MCPTT), and fixed telephony Voice, over IP (VOIP) equipment across the LTE network.

o Inter-system test calls, including mobile voice and mobile video connectivity via Wi-Fi connections to the CPE, were also established.

o This objective is complete, and concludes that the LTE platform can successfully integrate both MCPTT and VOIP voice and video services.

Confirmation that LTE will support low-latency applications such as tele-protection – incomplete

o DIP5000 Tele-Protection relays were installed within the lab environment. However, due to the unavailability of the C37.94 over IP multiplex equipment, it was unfeasible to connect the relays together over the LTE platform. The equipment had not been released from Customs in time for completion of the project.

o Therefore, this objective was not completed in time for the project end date. However, latency testing identified that LTE, in its current configuration, would not be able to meet the required minimum latency to successfully transport Tele-Protection services.

Document(s) outlining installation practises, test regimes and training requirements for LTE – complete

o Nokia provided digital copies of the standard Nokia installation documentation, as well as the High Level Designs (HLD) outlining the specifications of the solution.

o Test plans provided step by step instructions on test procedure, in addition to associated commands, and were delivered for the various project work packages.

o WPD were provided with both hands on training, and logins for formal Nokia 'on-line' modular training.

o This objective is complete: WPD received formal online module training, hands-on training, specialised one-on-one training and delivery of technical manuals for reference.

Confirmation that LTE is a suitable solution for providing communications for the energy industry – complete

o LTE is an IP based carrier platform, and as such allows for the connectivity of a diverse range of services. Existing utility spectrum is 'service' based, and as such cannot 'share' resources, whereas LTE is a shared resource. The project successfully carried voice, data, and video from a number of substations back to the central test lab, connected to various application servers.

o Testing and analysis was carried out to evaluate traffic flows and resource usage, including the implementation of traffic shaping techniques such as Quality of Service (QOS) and priority queueing.

o This objective is complete, and confirms that LTE is a suitable solution for providing communications for the energy industry.

Confirmation regarding using a Frequency Division Duplex (FDD) or Time Division Duplex (TDD) system – complete

o The Nokia LTE system deployed FDD as its mode of operandi in Band 87 (410-430 MHz), which separated the Downlink and Uplink segments into distinct frequency bands. The choice of using either FDD or TDD was determined by the frequency band for which the LTE system was deployed.

o This objective is complete, and concludes that FDD can be deployed locally, regionally or nationally within the UHF spectrum.

Confirmation on bandwidth requirements – complete

o Our LTE system was configured to operate in a 2 x 3 MHz FDD channel. Evaluation of channel usage has been completed, and provided evidence of the bandwidth requirements.

o This objective is complete, and concludes that 2 x 3MHz is an absolute minimum bandwidth necessary to carry WPDs anticipated services over LTE.

Confirmation on types of data that can be passed over an LTE system – complete

o The project successfully connected H.264 compressed video, SIP's and VOIP telephony, MCPTT voice, DNP3 and IEC870-5-104 SCADA data, Simple Network Management Protocol (SNMP), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) data streams, Hypertext Transfer Protocol (HTTP) and Hypertext Transfer Protocol Secure (HTTPS), and File Transfer Protocol /Secure File Transfer Protocol (FTP/SFTP) file transfers.

o Hence, this objective is complete as the types of data that can be passed over an LTE system were confirmed.

Confirmation on antenna solutions for different situations – complete

o The project involved the installation of two versions of omni-directional antenna to a number of substation locations, which allowed for the assessment of 'best practice' installation techniques.

o Therefore, this objective is complete as antenna solutions for different situations were confirmed.

Confirmation on training requirements and test equipment for staff – complete

o Nokia provided access to an LTE training programme where WPD staff were able to work through various aspects of the LTE eco-system at their own pace.

o On site and remote training was carried out during active system configurations.

o An assessment of RF Drive test equipment from a single supplier was beneficial in providing training requirements and technical evaluation of LTE test equipment.

o WPD received datasheets, documentation manuals, and interaction with a number of vendors for evaluation which will be used to develop a 'shopping list' for any future test equipment procurement.

o This objective is complete as training requirements an test equipment for staff was confirmed

Required Modifications to the Planned Approach During the Course of the Project

Due to the ongoing effects of the coronavirus pandemic, various project activities were postponed and delayed, and hence the LTE Connecting Futures project was awarded a 6 month extension. Project changes were managed internally through Change Requests, as per internal governance procedures.

Lessons Learnt for Future Projects

Lessons learnt as a result of the LTE Connecting Futures project are outlined below, and include:

· Network Management

Through the project, we were able to provide end to end services. However, no network management platform was instigated at the outset of the project, which made it difficult to implement IP/MPLS and QoS services across all devices. Whilst these service areas were possible, they were significantly more challenging to implement.

Operations, Administration and Maintenance (OAM) network management tools, and IP/MPLS services are deemed essential for large scale deployment.

· Spectrum Availability

We were able to secure radio spectrum for the trial under OFCOM's Test & Development license terms and conditions. LTE spectrum is governed by international agreements, as defined in the 3GPP (3rd Generation Partnership Project) suite of standards. In order to engage with Radio Access Network (RAN) vendors, spectrum licenses must be deployed in one of the 3GPP frequency bands. This frequency band must also be available in the region of deployment whilst also meeting the conditions as determined by OFCOM. Spectrum availability is challenging within the UK, and the project team had been fortunate enough in obtaining Test and Development licenses. These licenses had to be applied for on an annual basis and there was no guarantee that the project would be successful in procuring future licenses.

The procurement of radio spectrum for the LTE trial highlights the difficulties in obtaining spectrum for private LTE. It is paramount that the utilities, peer groups, lobbyists, regulatory bodies, and vested parties are united in procuring radio spectrum to meet the net zero carbon objectives of the utilities and the UK.

· Security Vulnerabilities

We were able to perform PEN testing on the LTE system, which comprised a mixture of hardware and software components, with an increasing dependence on the software element. This emphasised the extreme importance in evaluating any security vulnerabilities which the software may inherently contain. The discovery of vulnerabilities in the software can have a detrimental effect on the project outcomes. Penetration or PEN testing is the de facto method for evaluating software before it is deployed into any system, and should be carried out as early in the project lifecycle as possible.

· IP Planning

Nokia were instrumental in planning the IP network for the LTE RAN and core network, which also required strategic understanding of our IP network. Nokia were provided with a suite of IP addresses in which to build the LTE platform, which included the list of router connectivity for binding the system together.

Networks are increasingly deploying IP based solutions and whilst this simplifies the physical connectivity, it increases the complexity of network configurations. In a multi-vendor environment, understanding the co-existence and integration of the various components of the system should be planned at the early stage of the project. It's also necessary to recognise that LTE equipment can be sourced from multiple vendors, and IP planning is fundamental in accommodating the different configurations required for each application.

A single vendor solution simplifies the IP planning and system configuration. However, there is a risk that the scope of the project becomes biased to a solution favoured by a particular vendor.

A key learning which developed from this project was the importance of a detailed understanding of the needs of both the system being implemented, and what our Data Core Network (DCN) actually supported. A typical example was Nokia's efforts in deploying an IP/MPLS topology, where we had to change the system to meet the needs of what we can currently support, which was not IP/MPLS based.

We were also able to produce an overview of an IP addressing scheme to facilitate a future 'live' LTE deployment that avoids ambiguity in system configuration and promotes healthy network planning.

· Remote Access

Consideration should be given to deploy remote access for support teams at the outset of any project. The response to remote access for this project was reactive in the light of COVID-19, but the learning is that this has a significant advantage to the project, especially whilst the system is being developed, and where there are specific issues which require 'expertise' to rectify. Planning for future projects should include full contingency for remote access for management and configuration.

· RAN Installation

The hybrid cable development may not necessarily be the optimal solution when installing RAN base stations (eNodeB's). Separate fibre and DC cables may be a simpler and more cost-effective solution. We will be reviewing the installation of the hybrid cables with our installation team as part of the learning process.

· 400 MHz Frequency Band

The radio equipment in this project was able to operate in the 400 MHz (UHF) frequency range. This spectrum band is commonly termed the 'Sweet-Spot' for critical telecommunications and is always in great demand for critical applications due to its capability to provide good coverage, and capacity with a reasonable data payload and relatively compact antenna sizes.

· Bench RF Measurements

Within bench measurements, the possibility of signal leakage and equipment cross coupling should be considered, and the impact on testing fully understood. Separating equipment and using screened enclosures offers mitigation. Carefully calibrated, conducted paths are more preferable than radiated paths.

· Field RF Measurements

The use of a dedicated test receiver that was able to identify and report parameters individually from each eNodeB, was essential in checking and understanding RF performance.

· Connectivity

LTE provides the transport medium for data and voice services such as SCADA, mobile data, mobile voice, mobile video, fixed voice and Closed Circuit Television (CCTV) etc. This trial has been able to assess the capability of LTE to connect these services to our network.

· LTE Core Replacement

As a result of Penetration Testing, Nokia replaced the Micro-core Network (MCN) variant of the LTE Core with their current release called Compact Mobility Unit (CMU+), which included the latest patches and firmware. The original MCN Core was a legacy Nokia product. The CMU+ was intended to mitigate the findings in the PEN tests.

· License Management

We were able to maintain a register of software and spectrum license expiration dates in order to prevent system downtime due to inadvertent system shutdowns. Shutdowns are difficult to fix in emergency situations, and can incur significant delays in restoration due to the requirement to conduct diagnosis and rectification processes.

· Band 87 handsets

We were able to migrate all existing Band 126 CPE's to the 3GPP standardised Band 87.

Training
Nokia had provided access to an LTE training programme where our staff were able to work through the various aspects of the LTE system at their own pace. On site and remote training had also been carried out during active system configurations.

It became clear during the course of the project that 'Hands on' training was the most effective form.

As this was a relatively new technology to us, there was a large element of learning and discovery. Nokia was also subjected to an element of learning, especially after the deployment of the new EPC, as some aspects of the deployment was also new to the key personnel assigned to the project. This created a lag in the teams' ability to progress with the project quickly, but did not subsequently have a significant impact on the overall project.

Whilst this is an excellent way to fully understand a system, it slows the progress to a degree. It might have been preferable for an 'overview' training course to be conducted early in the project to gain a basic understanding of the system, supported by the 'hands on' training which followed.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

Outcomes of the LTE Connecting Futures project include the following:

· Creation of a Multi-Base Station Network

The key outcome of the project was the creation of a multi-vendor multi-base station LTE configuration, consisting of a three sector (cell) base station at Taunton and two single sector (cell) base stations at Elworthy Burrows and Bowdens Hill respectively. This was an important follow up to the single vendor, single base station LTE evaluation trial at Portishead, which mainly provided data on the fundamental design and capabilities of LTE and illustrated how such a communications network might be integrated into our infrastructure. No energy utility or sector service provider had carried out a multi-site, multi-vendor LTE trial with adjacent eNodeB's in a 'real' energy environment. This project has demonstrated that a multi-base, multi-vendor network could be realised.

· Radio Frequency Field & Drive Test Measurements Report

A report on Field Testing and Drive Tests has been produced. Field testing, within the geographic service areas of the three Base Stations, was designed to achieve the following:

o Verification of the accuracy of radio frequency coverage predictions;

- o Provide guidance in the location of test CPE sites;

- o Provide a reference source when examining the selection of best serving base station by each CPE site; and

- o Measure radio frequency noise levels, adjacent to CPE sites.

· Penetration Test Report

A report on PEN Testing has been produced. This report covers the recommendations on the improvements to the operability and integration of the various LTE components.

· High Level Design (HLD) document

A document detailing the structure and the assembly of the LTE configuration has been produced for the project. The document outlines the standard Nokia installation and specifications of the LTE solution.

· Training Materials

Online training materials have been developed for our staff. These are accessible using an approved passcode.

· CIRED Conference 2021

A technical paper on this project was written and accepted for presentation at the CIRED conference in September 2021.

Data Access

All and any of the data produced during the course of the project is available to share in accordance with our data sharing policy, available from:

www.westernpower.co.uk/Innovation/Contact-us-and-more/Project-Data.aspx

Foreground IPR

No IPR was created for the project.

Planned Implementation

We are confident in our ability to deliver a private LTE network linking our primary and distribution substation sites. We own and operate the largest telecommunications network amongst all of the DNOs. Through this experience, we have gained deep institutional capabilities in the deployment and operations of telecommunications assets. Accordingly, we view the deliverability of these works as low risk when considering all of the factors under our control. However, as we are dependent on Ofcom awarding adequate spectrum to support us with the delivery of a smart, flexible energy system, the overall deliverability risk of these works is high.

Phase 1 Install LTE network – Core 2025

Phase 2 Install Network Management Centre platforms 2025

Phase 3 Install LTE network – eNodeB (Base stations) 2025

Phase 4 Migrate primary SCADA from UHF scanning onto LTE 2025/26

Phase 5 Close down UHF scanning network 2026

Phase 6 Install LTE network voice platforms 2025

Phase 7 Migrate from PMR onto LTE 2026

Phase 8 Close down PMR network 2027

Phase 9 Installation of fixed voice system at substations 2025

Phase 10 Close down PSTN phones 2025

Phase 11	Migrate LV monitoring from public network onto LTE	2027-ED3
Phase 12	Migrate automation onto LTE	2027-ED4
Phase 13	Close down DMR	ED3/4
Phase 14	Close down Unlicensed Automation Base Stations	ED3/4

Other Comments

N/A

Standards Documents

N/A