Constellation

Project Progress Report – January to June 2022

Constellation Partners

ABB

GE

UNIVERSITY of STRATHCLYDE
POWER NETWORKS
DEMONSTRATION CENTRE

SIEMENS
Ingenuity for life

UK Power Networks
Delivering your electricity

vodafone

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1. Executive summary

1.1 Project background

1.1.1 Situation

The energy industry is at the heart of the UK's journey to Net Zero as more consumers shift their behaviour and increase their reliance on electricity. Consumers will depend on electricity to heat, eat and move, in addition to keeping the lights on. It is therefore essential to increase the whole electricity system's resilience. UK Power Networks is keenly aware that we must do this cost effectively to ensure the impact on energy bills is kept to a minimum.

To facilitate Net Zero at the lowest cost to consumers, Distribution Network Operators (DNOs):

- Have developed sophisticated and powerful central capabilities, such as Advanced Distribution Management Systems (ADMS) and Active Network Management (ANM); and
- Will employ smart services such as flexibility to allow quick and efficient connection of more Low Carbon Technologies (LCTs) to the distribution network.

1.1.2 Complication

Network resilience: The existing central network management systems deliver significant benefits in terms of the ability to actively control large volumes of demand and generation on the network. However, these systems have limited resilience, specifically in their ability to continue to operate optimally when communication links are unavailable.

Furthermore, as DNOs increase their reliance on smart services provided by Distributed Energy Resources (DER), there is a significant future risk to the network resilience. Previously the loss of Distributed Generation (DG) was of little consequence to the operation of the distribution network, as it did not provide services in significant volumes to the distribution network. However, as we increase our reliance on DER to provide smart services, the loss of a high proportion of generation at the distribution level could lead to an increase in disconnection events and potentially blackouts. More specifically, UK Power Networks estimates that 2.9GVA[1] of smart services in GB will be at risk of being impacted by loss of communication with central systems or by unnecessary interruption of DER by 2050.

Network capacity: The expected increase in DER required to achieve Net Zero will require significant amount of network capacity to be available in specific areas, so our first step is to ensure we fully utilise the existing network capacity. However, DNOs'' existing protection systems can limit the available capacity in some instances. Specifically, protection is designed to protect the network from faults, but in specific cases it limits the amount of DG that can be connected. Load blinding is the latest solution which allows the protection to use a pre-calculated power factor to differentiate between network faults and generation/load. This solution is limited by the single static setting which is unsuitable for the changing power flows of the future network. By 2050, this will result in parts of the GB network having an estimated 1.4GVA[1] of inaccessible spare capacity to connect more DER and support our transition to Net Zero due to static protection settings.

Digitalisation: Existing protection, control and communication functionality within substations are supplied within dedicated hardware and require lengthy installation, commissioning and maintenance processes. The current products are also difficult to integrate and have limited flexibility to adapt their functionality. The Energy Data Taskforce recommend maximising the value of smart digital solutions, rather than solely relying on the mass deployment of equipment. As such, there is a growing need for single hardware containers hosting a number of flexible and easy to implement virtual (software) solutions.

[1] https://www.ofgem.gov.uk/system/files/docs/2020/11/constellation_nic_2020_fsp_-_public_27.11.2020_0.pdf

1.1.3 Solution

Technology is evolving at a rapid pace and UK Power Networks recognises the opportunities this presents to enhance our resilience and facilitate Net Zero at the lowest cost for consumers. In order to overcome the complications above we will leverage the newest advances in 5G communication and software engineering to enhance our local substations by making them more intelligent, digital, interoperable and enable secure, scalable communication between them.

Constellation achieves this through a flexible and future proofed system for local intelligence working in partnership with the existing central systems. There are two distinct Methods:

- Method 1: Local ANM – Local network optimisation at the substation level to provide resilience to DER operation against loss of communication with the central systems.
    - Whenever the central systems are unable to communicate with our local network assets, the local intelligence will take over optimisation for that specific provider, substation or area. This will enable the network to be operated more optimally, controlling the area locally, compared to curtailing the provider.

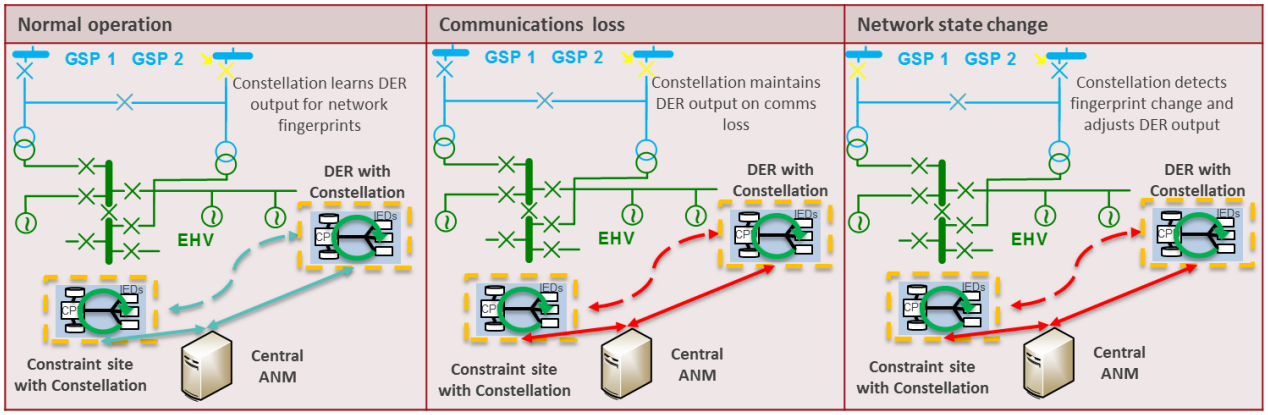

Figure 1 - Local ANM (Method 1) summary diagram

- Method 2: Wide area and adaptive protection:
    - Provide resilience to DG operation against instability events triggering the conventional generator protection. Constellation will develop sophisticated protection algorithms to identify when the DER should disconnect, if events have caused islanded operation. This will rely on low latency communications via 5G slicing.

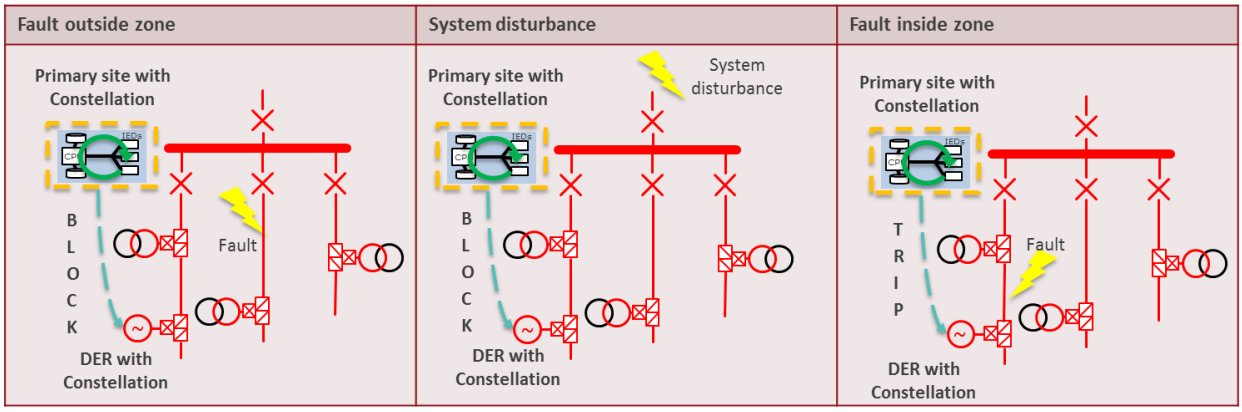

Figure 2 - Wide area protection (Method 2) summary diagram

    - Dynamically assessed protection settings and enhanced wide area control to enable more capacity for DER to connect. Constellation will develop the ability to provide real time protection settings from the substation to dynamically validate and modify them. This will allow the load blinding to adapt to the power flows on the network and correctly discriminate between genuine faults and generation/load.

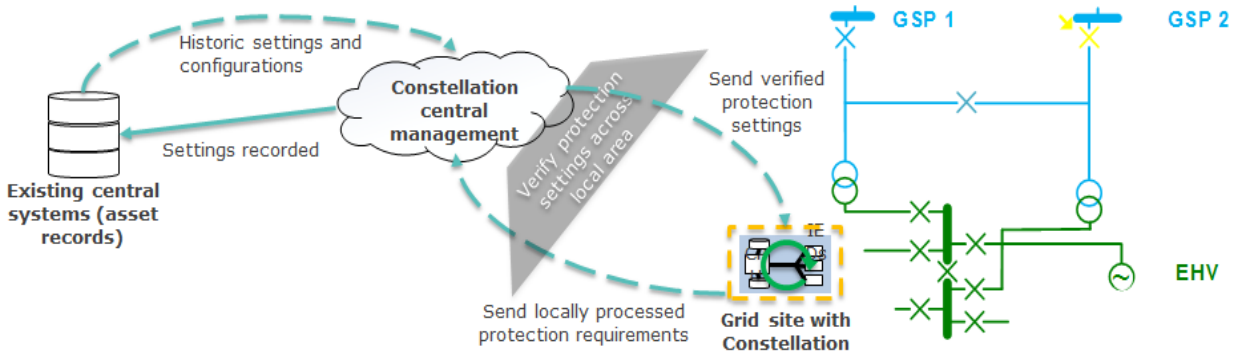

Figure 3 - Adaptive Protection (Method 2) summary diagram

Constellation is UK Power Networks' newest flagship innovation project which will be delivered between 2021 and 2025 in partnership with ABB, GE, Siemens, the Power Network Demonstration Centre (PNDC) and Vodafone and was awarded funding in 2020 by Ofgem as part of the Network Innovation Competition (NIC) funding mechanism.

If proven successful, UK Power Networks estimates that by 2030 the solutions trialled as part of Constellation could save customers in GB £132m in cost efficiencies. The project Methods will also enable carbon savings of 1.9m tCO_2 and will release an additional 1.98GVA of network capacity by 2030 in GB.

1.2 Project progress

This Project Progress Report (PPR), the second for Constellation, covers the period between January 2022 to June 2022. This document, together with the upcoming six-monthly report, which will be published in December 2022, will fulfil the reporting requirements of Sections 8.11 – 8.15 of v3.0 of the NIC Governance Document[2]. The Constellation team prefers to publish PPRs every six months, which is more regular than the minimum requirement of annual reporting because the project advances substantially in a six-month period. It is anticipated that other NIC projects and stakeholders would therefore benefit from being informed of the progress and learning on a six-monthly basis. The next reporting period will cover July to December 2022. The general project progress is presented first, and then followed by workstream detail of the progress – starting with workstream 1 and finishing with workstream 6.

To date, good progress has been made and the project is on schedule for delivery aligned to the Project Direction. Over this period, the project has successfully:

- Submitted Deliverable 1 on time and published on UK Power Networks' innovation website;
- Completed the design for:
  - The overall Constellation architecture;
  - Local ANM;
  - Wide area and virtualised protection;
  - Adaptive protection and central management system; and
  - 5G site-to-site communication;
- Continued site selection activities in preparation for Deliverable 2;
- Continued engagement with DER in the trial areas;
- Commenced the trial preparations for PNDC and UK Power Networks' trials; and

[2] https://www.ofgem.gov.uk/system/files/docs/2017/07/electricity_network_innovation_competition_governance_document_version_3.0.pdf

- Carried out the Stage Gate process to ensure Constellation continues to provide value for money for our customers.

- **Workstream 1** is responsible for the specification, design and development of the software, architecture, integration, and cyber security aspects across all Constellation elements. This workstream compliments workstream 2 as it will provide input to the hardware requirements. This workstream is on track. The Azure cloud servers required for the Adaptive Protection and Local ANM solutions have been designed and approved. Cyber security has been a focus during this reporting period, detailed attack trees and context diagrams have been developed through internal engagement with Subject Matter Experts (SME), and a detailed cyber security design document is being developed. Hardware specifications for the substation environment have been finalised, test hardware has been obtained and is currently being evaluated;

- **Workstream 2** is responsible for the specification, design and development of the functionality (performance) of all Constellation elements and the equipment which will be trialled. This workstream is on track. The solutions, developed by the partners for Method 1 and Method 2, have been designed and approved by the Technical Design Authority (TDA) following a design review process. The trial preparation has progressed through site design and preparation works. A site-works delivery programme was created to manage the site preparation works at the selected trial sites. In line with the delivery programme, we completed the electrical design for the Maidstone area and initiated site preparation activities. The first outage for equipment installation is scheduled for the end of May 2022;

- **Workstream 3** is responsible for the design and management of the Constellation trials, which incorporate off network trials hosted at the PNDC and live trials hosted on the UK Power Networks' distribution network. This workstream is on track. The PNDC are leading testing requirements workshops with project partners to inform the trials designs for each of the project Methods. Significant progress has been made in developing testing specifications for each of the Methods and are due to be completed in the next reporting period. Finally, trial site preparations at the PNDC and Maidstone have been initiated;

- **Workstream 4** is responsible for running the Open Innovation Competition (OIC), which involves incubating and testing additional Methods for deployment on the Constellation platform. The activities related to this workstream will start later in the project, and it is currently on track. Industry stakeholders have been consulted on use cases of interest for potential incorporation in the OIC;

- **Workstream 5** is responsible for the academic insights and research into the future governance. This workstream will feed into the requirement specification for workstreams 1 and 2. This workstream is on track. Two academic insights activities have been completed by the University of Strathclyde covering:
    - State of the art research on Loss of Mains (LoM) and adaptive protection.
    - State of the art research on secure and resilient communication architectures enabling Constellation Methods.

  The remaining academic insights activities will be scoped and initiated at a later date in the project; and

- **Workstream 6** is responsible for the dissemination of the knowledge generated from the project. The workstream is on track. The project team continued to engage with the PNDC digital substation working group to validate outcomes. Furthermore, the project is also represented by the PNDC on the Institute of Electrical and Electronics Engineers (IEEE) P21 study group on system architectures supporting the virtualisation of substation protection and control applications, as well as the Council on Large Electric Systems (CIGRE) B5.73 UK shadow working group on centralised substation and virtualised protection. Constellation was presented at the Institution of Engineering and Technology's Developments in Protection System Protection (DPSP 2022) conference.

1.3 Risks and issues

The project continues to apply robust risk management procedures to reduce the probability and impact of risks materialising. To date, one risk has materialised as an issue and is actively managed by UK Power Networks and GE (as described in section 4.2).

Since the bid submission, a number of risks have been added to the risk register; all risks are shown in Section 11. Some of these risks have the potential to impact the critical path, however suitable mitigations are implemented and continuously reviewed. The project team carefully track these risks on a frequent basis and ensure further mitigations are applied where necessary.

2. Project Manager's report

The project has made good progress during the reporting period (January - June 2022), focusing on the following areas:

- Development of the design for the Constellation elements;
- Commencement of the trial preparation for PNDC trials and the UK Power Networks trials; and
- Carried out the Stage Gate process, following the design of Methods 1 and 2, to ensure Constellation is delivered at the lowest cost to customers.

Design of Constellation Elements

During this reporting period collaborative workshops were run in conjunction with all the partners to define the functional, non-functional, cyber security and architecture design for Constellation. The outputs of these works and the formalised design and architecture documents form the basis of the development of the Constellation solutions. More details are presented in sections 2.1 and 2.2 and in Deliverable 1.

Trial Preparation

In this reporting period, we used the requirements and designs for Methods 1 and 2 to begin developing the trial design for Constellation. PNDC are working closely with all project partners to set out the trial strategy, describe the test environments and specify the performance evaluation. More details are presented in section 2.3. Additionally, site preparation work has begun for the PNDC trial and the trial in the Maidstone grid area. This includes the site design and procurement activities. More details are presented in sections 2.2 and 2.3.

Partner meetings

Constellation is an ambitious and complex Network Innovation Competition project with five partners delivering aspects of the solution. Therefore, it is essential to have continued and open communication between UK Power Networks and the partners. To support this several regular meetings are continued from the previous reporting period.

- Fortnightly one-to-one sessions with each individual partner to discuss progress and highlight any potential challenges or risks;
- Fortnightly sessions with all partners to discuss upcoming priorities and any areas where support is required from another partner; and
- Monthly review sessions with all partners to review the plan, risks and issues log.

Personnel

As per the previous Project Progress Report, recruitment was ongoing for the workstream 1 lead. In December 2021, the successful candidate for the role started working. Since then the workstream 1 lead has taken full ownership of all workstream 1 activities and has supported the delivery of the other workstreams.

Stage Gate

As part of the Full Submission Proforma, UK Power Networks committed to work with the project partners to assess the remaining project scope after the design activities were completed (Deliverable 1). In this reporting period, all partners have reviewed their remaining scope and have confirmed any necessary adjustments to their remaining project milestones. Further details are available in the confidential annex.

2.1 Workstream 1 – Software & Cyber Security Requirements, Design and Development

Workstream 1 is responsible for the specification, design and development of the software, architecture, integration and cyber security aspects across all Constellation elements. This workstream is delivered in collaboration with ABB, GE and Siemens as they will be designing and developing software solutions for Methods 1 and 2. This workstream is also in collaboration with Vodafone (partner) and Ruggedcom (supplier), who will provide the secure site-to-site communication, and PNDC who will test all Constellation elements.

Progress during this reporting period

Developing the Non-Functional Design

The non-functional requirements, technical architecture, cyber security specifications and data requirements, which were developed during the last reporting period, have been integrated into the design and further developed during this reporting period:

- The non-functional requirements dictated the final design characteristics produced by the project partners for both software and hardware components of Constellation;
- The technical architecture has been realised as a detailed architecture diagram based on the central server, data, integration, and cyber security requirements;
- Cyber security specifications have been used to develop detailed cyber security context diagrams and attack trees. A detailed “Secure by Design” document is also being developed;
- Data requirements for the central servers have been defined and confirmed through the UK Power Networks’ Information Systems (IS) architecture review process; and
- The 5G slice, based on requirements for data transfer speed, latency and security, has been designed and is currently being developed.

As a result, detailed designs were developed for each Method, which included both functional (described in section 2.2) and non-functional components. The designs were validated through a robust design review mechanism and finally approved by the Technical Design Authority.

The requirements have been developed through several Methods, these include:

- The production of academic works on communications, virtualisation, and protection by the University of Strathclyde PNDC. These documents assisted in identifying gaps that need to be addressed when implementing and testing the software solutions;
- OMICRON being brought into the wider project team, bringing with them years of expertise in formulating and executing test procedures using specialised test equipment; and
- Trial design workshops with Constellation Subject Matter Experts (SME), PNDC experts and OMICRON. These sessions were used to enhance the already developed test methodology and brainstorm additional considerations.

Architecture and Integration

The conceptual architecture diagram was created during the previous reporting cycle to define the systems, subsystems, and integration requirements. During this reporting cycle a new, more detailed architecture was created, which includes the central servers on the Azure platform and is in line with the designs for Methods 1 and 2.

As presented in Figure 4, the new detailed architecture diagram showing the interfaces, integration details and connectivity of the system has been developed. Based on the original conceptual architecture diagram, this new diagram was created to unify the detailed architecture diagrams provided by the project partners into a single logical architecture diagram. The main enhancements of the architecture are:

- Detailed application architecture and specifications of the Siemens and GE Azure servers for the central systems;
- Connectivity with the UK Power Networks' corporate and Supervisory Control And Data Acquisition (SCADA) networks;
- Firewall and interface locations within the network; and
- Detailed architecture of the substation environment, including the substation server's virtualised environment.

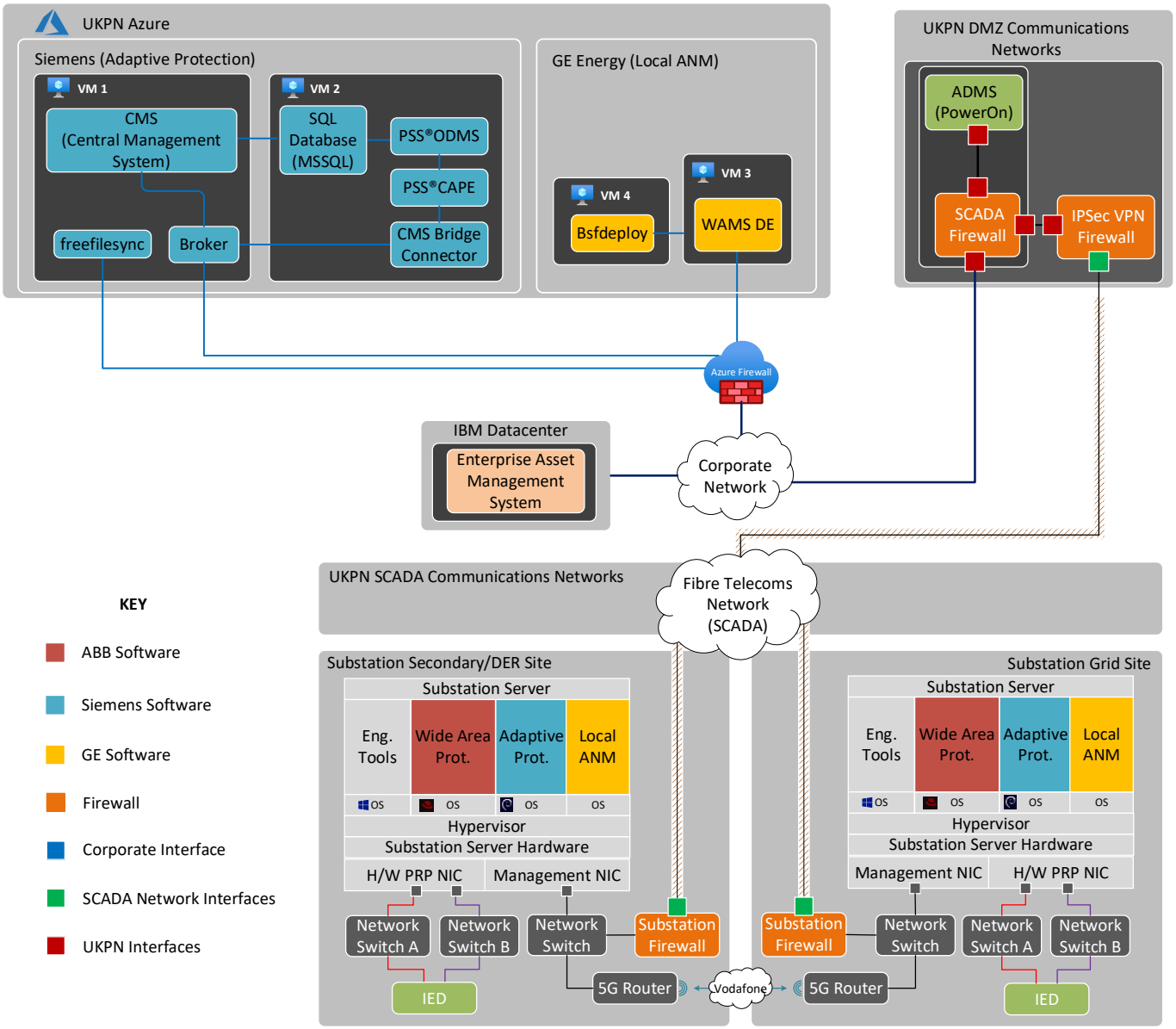

Figure 4: Constellation detailed architecture diagram

Central Servers

The central servers store the data and additional software required for the adaptive protection and local ANM solutions. During this reporting period, a technical solution for implementing the central servers was specified, designed, and approved. The central servers will be deployed as Azure servers in the UK Power Networks' Azure cloud and will connect to the substation environment via the corporate and SCADA network as shown in Figure 4.

The process of designing the approach for setting up the servers required the Workstream 1 lead and an IS Architect to gather information pertaining to the central server requirements from Siemens and GE. Once the necessary information was gathered, a Logical Architecture Design Document (LADD) detailing the functional, non-functional, data, integration, cyber security, and connectivity requirements for the central servers was developed. This design was presented to UK Power Networks' architecture review board (ARB), who approved the design.

The GE Azure servers are due to be delivered in 2022, because they will store the synchrophasor data needed for Local ANM. The Siemens servers are scheduled for provisioning when required for the testing on the live network.

Software Virtualisation Environment

The software virtualisation environment includes the software and hardware platforms that Constellation will use for deploying the virtualised applications and smart functionality required for the Constellation solutions.

During this reporting period, after a series of technical discussions with key stakeholders, it was decided that the virtualised environment will be implemented using a Type 1 hypervisor as the virtualisation solution. Currently, work is underway to validate the solution for real-time applications. ABB have collaborated with VMWare to ensure the ESXi hypervisor is suitable for the deterministic operation of the protection functions.

Through continued collaboration and engagement between the Constellation team, ABB and VMWare, we have identified suitable solutions for the limitations. VMWare have begun deploying software resolutions for the identified limitations in this reporting period.

Finally, the server hardware for the virtualised environment has been specified according to our technical software and hardware requirements, and test hardware has been delivered (provided by DELL). The hardware platform is currently undergoing evaluation within a substation environment, once its suitability has been determined, the decision to move forward with the hardware will be made with approval from key expert stakeholders.

Cyber Security

Constellation will introduce several cyber security mitigations to ensure the solution is secure, functional, and scalable. During the previous reporting period, the cyber security specifications were defined and documented, but the need for a privileged access management (PAM) system was identified as required; to that end, an initial meeting and demo session was held with CyberArk. Following the demo session, the solution has been identified as a key component for enhancing cyber security for Constellation and the wider UK Power Networks' operational network during RIIO-ED2.

A cyber security context diagram was also developed, this diagram provides an overview of the security zones within the wider network and how they interact and interface with the Constellation solution. A brainstorming session with Constellation's SME was held to identify the potential risks and consequences on operations if a cyber security breach was experienced. The ideas and insight gained from the brainstorming session led to the development of detailed attack trees for Constellation solutions. The attack trees provide a detailed overview of the possible security breaches for each solution, they also inform the development of detailed cyber security policies and mitigations.

Finally, following the creation of the attack tree, a detailed constellation security design document is being drafted. The "Secure by Design" document will combine all the learnings from the cyber security requirements, brainstorming session,

attack trees and context diagram to ensure that the system is designed to be cyber secure from the beginning. The "Secure by Design" document will be ready for the testing phase of the project.

Site-to-site communication

The 5G communications link will make use of public 5G infrastructure (once it is available) to enable fast, secure, and scalable site-to-site communications for R-GOOSE messages used in Wide Area Protection and c37.118 synchrophasor data for Local ANM. The 5G slice is being developed and deployed by Vodafone. Vodafone will be providing a "slice" of their network, which is a logically separated portion of their public 5G network, designed to transmit Constellation data securely.

During this reporting period, the Constellation team worked closely with Vodafone to develop a detailed design for the 5G slice. Due to the novelty of 5G technology in the energy industry, we recruited the Joint Radio Company (JRC) to support in validating the 5G design. After several workshops and Q&A sessions, the design was approved by the Technical Design Authority. The final document is listed below:

Table 1: Vodafone design document details

Ref	Document Title	Version	Doc. Date
5G Slice Design	UKPN Project Constellation Solution Description – Vodafone UK	F3	13/05/2022

Challenges and lessons learned

Software Virtualisation Environment

A primary aim of Constellation is to virtualise functions on standard server hardware that would otherwise be delivered on bespoke Intelligent Electronic Device (IED) hardware. However, the deterministic requirements for protection functions proved to be a challenge to replicate in a virtualised environment. The lack of direct access to hardware resources by ABB's virtual PAC application has resulted in issues with CPU cache, network latencies and PTP synchronisation which are causing unreliable and unpredictable functionality. We are currently working closely with key experts in cyber security, software architecture and operational telecommunications to resolve these issues.

These issues have resulted in delays in confirming the Type 1 hypervisor to host the virtualised applications. Another unforeseen challenge is that one of the solutions to the latency issue introduces additional hardware in the form of a dedicated Network Interface Card (NIC) to mitigate the network latency. This solution would involve one-to-one mapping of the virtual machine to a specific NIC, and therefore impacts the scalability of the design.

Work is currently underway to find more favourable solution to the network latencies issues which ensure scalability to business as usual (BAU).

Central Servers

It proved challenging to identify a suitable solution for the central servers due to missing or incomplete data pertaining to the server architecture. This required the creation of a more detailed architecture diagram (Figure 4) that depicted all of the interfacing and data requirements for the servers. While this delayed architecture approval by a month, it was valuable and enhanced the overall Constellation solution.

Outlook for next reporting period

The following activities are planned for workstream 1 during the next reporting period:

- Provisioning of GE Azure servers through IS and external service providers. These servers will allow the Wide Area Monitoring system (WAMS DE) central server to start gathering data and begin training the machine learning algorithm for Local ANM;

- A Type 1 hypervisor will be confirmed as the virtualisation platform of choice; and
- Evaluation of the server hardware will be completed, and a decision will be made on whether the hardware will be selected as the hardware platform for Constellation apps. This is a major milestone as it will allow the procurement of hardware and the installation of software to begin.

2.2 Workstream 2 – Functional Requirements, Design, Development and Hardware Specification

Workstream 2 is responsible for the specification, design and development and agreement of the functionality (performance) of all Constellation elements and the equipment which will be trialled. The topics covered include:

1. Hardware requirements: in line with IEC 61850-3 and applicable national standards;
2. Method 1 functional requirements: deployment of local ANM functions at the trial sites;
3. Method 2 – wide area protection functional requirements: islanding prevention and response to voltage and frequency events;
4. Method 2 – adaptive protection functional requirements: automatic update of protection settings via IEC 61850 MMS protocol ;
5. Method 2 – virtual protection functional requirements: provision of protection and control functions that run in a virtual platform at the substation server; and
6. Central management system (of remote devices in substations) functional requirements: provision of a central platform to store and manage a wide range of protection and control data that is continually updated.

Progress during this reporting period

Design of Constellation Elements

The functional requirements and architecture, which were developed during the last reporting period, have been integrated into the designs for Methods 1 and 2 and further developed during this reporting period.

Each partner submitted a Statement of Compliance of the design against UK Power Network's specifications. This provides clarity on design details that will be developed and implemented later in the project.

In parallel, the Constellation team and our partners finalised the designs of the Method 1 and Method 2 solutions. Together, the statements of compliance and designs were discussed at the Design Review Meeting in January, which resulted in the approval by the Technical Design Authority with minor comments of the design solutions. The final design documents are listed below:

Table 2 - Design documents details

Ref	Partner	Document Title	Version	Doc. Date
Method 1	GE	UKPN Constellation - Local ANM Architecture & Design	Version 4	09/03/2022
Method 2 (WAP)	ABB	Virtualised and wide area protection Constellation detailed design	Rev A	17/03/2022
Method 2 (AP)	Siemens	UK Power Networks Constellation Project – Design Document	V1.0	21/02/2022

The site specific 5G coverage design for the site-to-site communications was also developed in collaboration with Vodafone following a series of site surveys. The design for each site was approved with minor comments by the Technical Design Authority. The final design documents are listed below:

Table 3 - 5G coverage design documents

Ref	Document Title	Version	Doc. Date
Site Specific Design – PNDC	21673_0_NET_CAD_V1	V1	01/12/2021
Site Specific Design – Maidstone Grid	21814_0_NET_CAD_V2	V2	29/03/2022
Site Specific Design – Allington Waste Gen	21819_0_NET_CAD_V3	V3	29/03/2022

Site Specific Design – Thanet Grid *	21815_0_NET_CAD_V2	V2	29/03/2022
Site Specific Design – Westwood Cross PV	21817_0_NET_CAD_V3	V3	29/03/2022
Site Specific Design – Manston PV	21818_0_NET_CAD_V3	V3	29/03/2022

* Includes coverage for the sites Strasbourg Street and Enterprise Way 11kV Generation as they are geographically close to Thanet Grid. Details of the 5G slice design are available in section 2.1.

Site Selection

In order to evaluate the success of Constellation and ensure BAU adoption, the solutions need to be fully assessed and proven as functional. The testing needs to assess the operation, performance, integration and security of each Constellation element. To do this, we will first trial the solutions in a simulated environment in the Power Networks Demonstration Centre. Following that, the testing will move to the live distribution network. During this reporting period, workstream 2 continued the work from the last reporting period to finalise the site selection for the network trials.

A selection of sites that can effectively demonstrate the performance of all the solutions developed during the project is essential for achieving the project outcomes. Site selection activities started with creating the site assessment criteria and selecting the suitable trial areas. In line with this, UK Power Networks has considered and assessed the trial areas of Maidstone, Lewes, and Thanet.

- Maidstone Grid is connected to one DER site and experiences protection setting changes and restrictions on the 132kV side of the network;
- Lewes Grid is connected to five PV generation sites with firm connections and multiple points of network reconfiguration; and
- Thanet Grid is connected to four DER sites with firm and flexible generation connected. In addition, this is the only area in the SPN region that has flexible generation, which makes it a suitable area for validation of the local ANM solution.

Following that, the Maidstone and Thanet areas were selected as most suitable, with further details provided in the upcoming Deliverable 2 report. The sites were surveyed by both Vodafone and UK Power Networks to validate their suitability. The assessment includes engaging with the DER customers which are connected to the trial areas to ensure the project learnings are maximised (refer to section 2.6). Site selection activities are ongoing and will be finalised in the next reporting period with the submission of Deliverable 2 (August 2022).

Trial Preparation

In order to prepare for the network trials, the sites in the selected trial areas need to be prepared. The preparation includes electrical, civil and communication design, procurement of equipment, site work planning and mobilisation, outage scheduling and site work delivery. After these activities are completed at all trial sites, the Constellation solutions can be deployed and commissioned for testing. The two trial areas will be prepared sequentially due to the complexity of the preparation activities, starting with the Maidstone area first and then Thanet area.

In this reporting period, site works have been initiated at the Maidstone Area. At Maidstone Grid 33kV telecoms room, UK Power Networks will install a Constellation cubicle while Vodafone will install a cubicle with equipment for 5G coverage.

The Constellation cubicles were also designed in this reporting period. They are 2.2m tall cubicles with standard 19inch racks that are used to accommodate devices which form the substation environment. The purpose of this cubicle is to host the Constellation computer, network switches, testing devices and other hardware. On grid sites, these cubicles will include redundant devices, to increase resilience, and will be managed by UK Power Networks only. On DER sites, these cubicles will host equipment from UK Power Networks as well as from Vodafone. This approach is more suitable due to space constraints and the lower redundancy requirements in comparison to grid sites. The cubicle and general arrangements are shown in Figures 5 and 6.

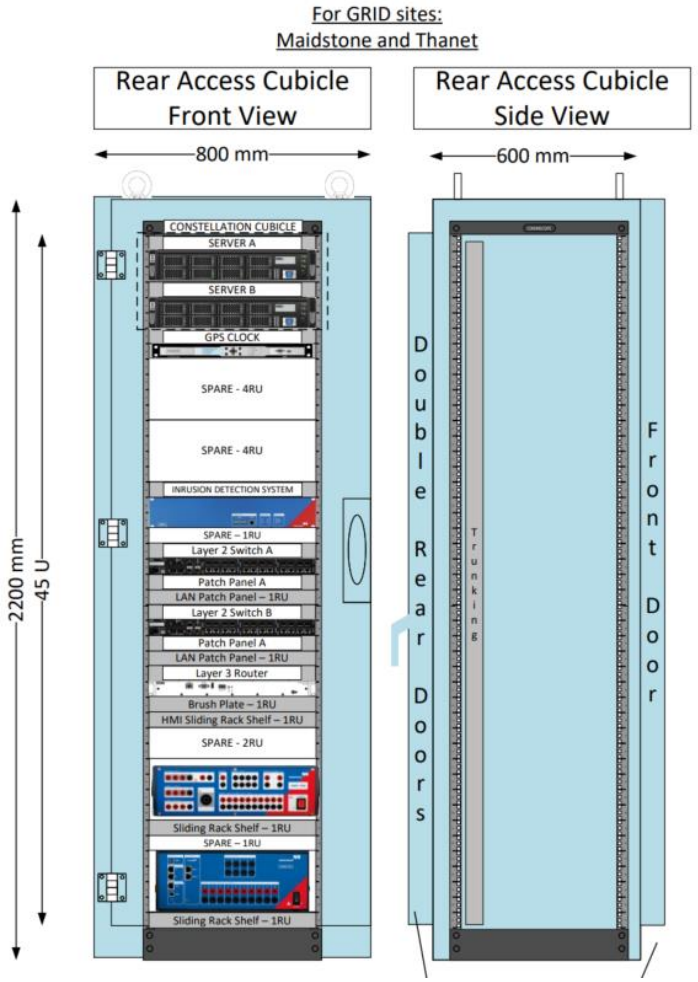

Figure 6 - Constellation cubicle - general arrangement for Grid sites.

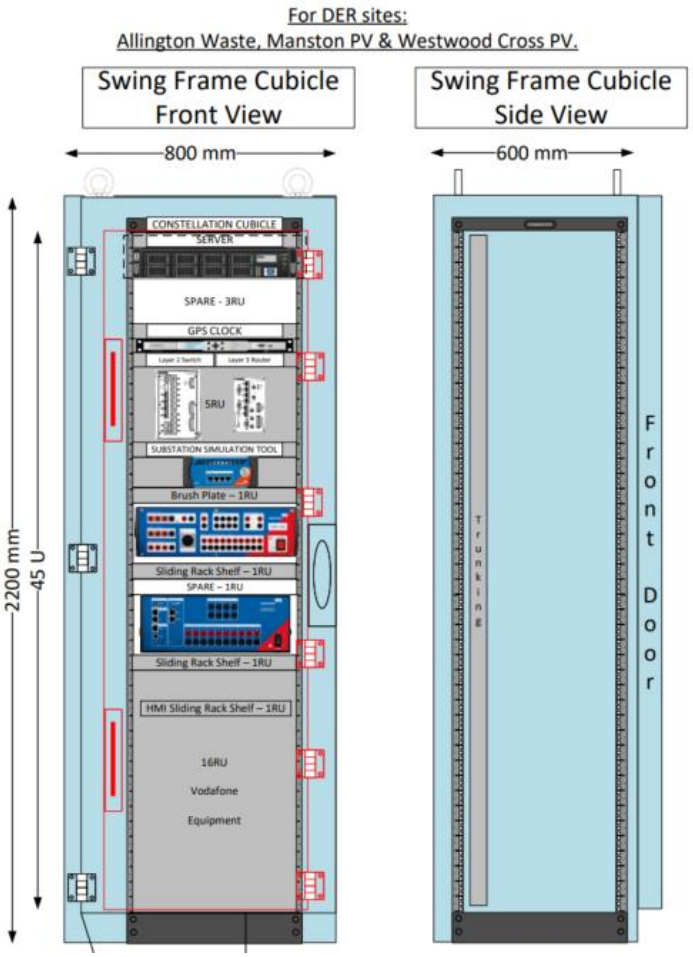

Figure 5 - Constellation cubicle - general arrangement for DER sites.

t Maidstone Grid 33kV switchgear room, UK Power Networks will install devices compatible with IEC 61850 protocols. These will be wired via Ethernet and fibre optic to the Constellation cubicle at the nearby telecoms room. The scope of works covers all the panels at the switchroom. Due to space constraints, a number of relay replacements will be carried out while at panels with no space constraints, new devices will be added alongside existing ones. Overall, these include five work groups as given below:

- 4x feeders with high setting overcurrent protection;
- 3x feeders with differential protection (where relay replacement is required at both ends of a feeder);
- 2x feeders with high setting overcurrent protection that are shared with National Rail;
- 2x panels for data collection at 132/33kV transformers G4 and G5; and
- 2x panels for data collection at the busbar sections breakers 61 and 62.

In addition, relays will be installed at the Maidstone Grid 11kV South, and Maidstone Grid 11kV North substations. These buildings are within the same compound of the Maidstone Grid site and data collection is required for application of the Method 1 Local ANM solution. The timeline of Maidstone site works is subject to outage and operational resource availability, as well as procurement of equipment.

In this reporting period, the site electrical and civil designs have been completed. The preparation of site works has been initiated and the first outage for device update is scheduled for the next reporting period.

Furthermore, procurement activities are ongoing following the completion of the site design works. The selection of specific functions and volumes for IEDs has been concluded. In addition, equipment that have been ordered include Constellation cubicles, OMICRON test equipment, several IEDs and auxiliar relays. Procurement forms part of the critical path as lead times for devices range from 7 weeks to 22 weeks, due to shortage of equipment that suppliers are experiencing. Workstream 2 is actively managing the site preparation delivery plan according to these prolonged and uncertain lead times for procurement of equipment.

Provision of Data

Data for Adaptive Protection: The live network model for adaptive protection settings comprises of data exports of network impedance, network switch positions and live measurements. UK Power Networks hosts the required data in different software applications. The data export from these systems with the partner application (PSS ODMS) is challenging due to data specification and mapping issues.

To manage this, we are working closely with Siemens to understand their data requirements in more detail. We hosted a series of workshops to understand the issues and agree resolutions. Currently, experts from UK Power Networks and Siemens are validating the network data.

Data for Local ANM: The data requirements from local ANM's design include synchrophasor data at the low voltage side of the transformers at grid sites; and at each DER site. For these, UK Power Networks will deploy merger units (GE MU320) to collect measurements data and produce standard IEC 61850-9-2 sample measured values (SMVs). SMVs will be sent to a GE RPV311 which in turn, is able to provide synchrophasor measurements in the widely used IEEE C37.118 protocol. These data streams will then be sent to a GE TPCON device, which acts as a phasor data concentrator. This device aggregates data from multiple devices, stores historical data, and works as a programmable controller. The installation of these devices is ongoing and will occur after installation of merger units.

Data for Wide Area Protection: The data requirements from wide area and virtual protection's design include network diagrams, existing protection and control functions, and settings. In this reporting period, workstream 2 has provided extensive data to support the wide area protection design. The provision of functions and settings in the IEC 61850-7-4 format is ongoing at the moment. In addition, ABB will provide support on merger units per panel as they have in-depth visibility of protection and control functions at hardware devices, which will translate to virtual devices as per Constellation's purpose. This activity is ongoing at the moment in parallel with procurement of physical merger units.

Data for PNDC: The data requirements include network data of the trial areas for modelling and testing purposes. In this reporting period, workstream 1 and 2 have shared network diagrams and impedance data tables for this process. The modelling data and network area have been agreed with PNDC, GE and Siemens. This work is ongoing according to the plan. Workstream 2 has reviewed network models and is supporting GE on creating a model of the Constellation trial areas on PNDC's ADMS system.

Challenges and lessons learned

5G Design

The new technologies around 5G design are a new area of expertise that is not naturally present within UK Power Networks. In order to better understand the design and the proposed solutions, external and independent expertise (Joint Radio Company) have been contacted to assist the validation and provide technical advice. This has proven beneficial for the approval of design solutions.

Procurement

There is global increase in demand of raw materials and microchips that is affecting the supply chain of our suppliers. For example, the approved IED has a lead time of 22 weeks, where normally it would be six weeks. Hence, workstream 2 is prioritising procurement activities, ensuring devices and compatible and fit for purpose, and contacting several suppliers in parallel to reduce lead times and costs.

Data Provision

Lastly, the network model for the adaptive settings solution requires data exports of network impedance data and network operational data. The availability of data, provision of it by UK Power Networks, and subsequent ingestion of data by the partner (using PSS ODMS software) has made good progress but it's not complete yet. Workstream 2 is engaging internally and working with the supplier (Siemens Germany and USA teams) to progress on the data extraction and manipulation.

Outlook for next reporting period

The next report will update on progress on site works, equipment sourcing and testing plans. The items to be included in the next report:

1. Update on the ongoing installation of Constellation equipment for the Maidstone Grid and Allington Waste sites;
2. Update on the ongoing commissioning of the 33kV IEDs for the Maidstone Grid and Allington Waste site;
3. Update on the ongoing installation of Constellation cubicles at Maidstone Grid and Allington Waste site;
4. Update on the ongoing installation of 5G hardware at Maidstone Grid and Allington Waste site;
5. Update on the ongoing procurement of devices for the second trial area of the project;
6. Update on data provision activities;
7. Update on development of Methods 1 and 2;
8. Draft test plans for the Method 1 and Method 2 solutions; and
9. Preparation for Factory Acceptance Testing of the developed solutions for Method 1 and Method 2.

2.3 Workstream 3 – Trials & Analysis

Workstream 3 is responsible for designing, running and evaluating the outcomes of the Constellation trials. The trials aim to ensure sufficient de-risking of the Constellation Methods is achieved by advancing their Technology Readiness Level (TRL) and successfully demonstrating their functionality in an operational environment. The trials consist of two complementary phases – off network trials hosted at the PNDC and live trials on the UK Power Networks distribution network. The iterative nature of the trials process ensures the translation of specifications associated with the Constellation Methods into a set of refined requirements and network management policies and standards for BAU rollout, as illustrated in Figure 77 below.

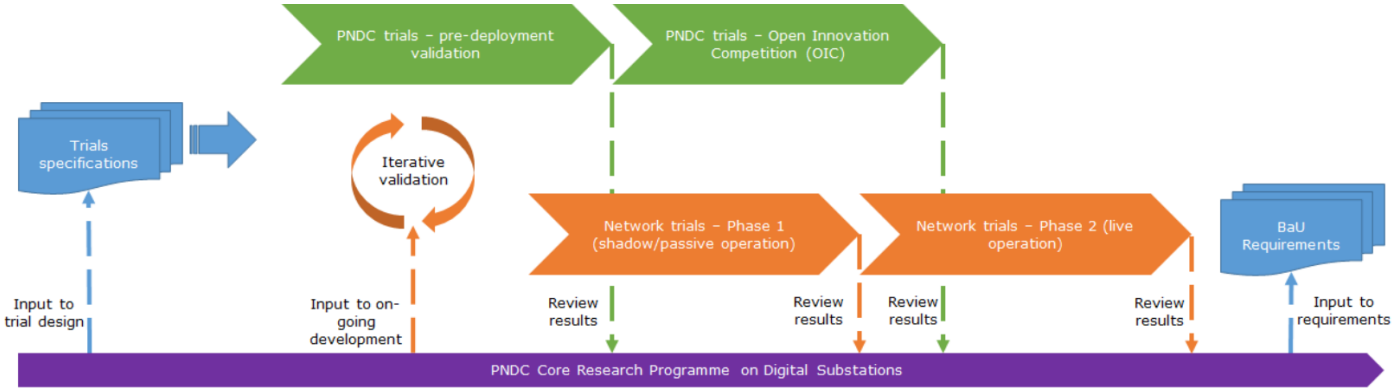

Figure 7 – Constellation trials process

Progress during this reporting period

Clarity of roles and responsibilities are key to a successful outcome of the critical trial phases. Figure 8 provides an overview of the role of each partners in the lead up to and during the trials. Trials documentation will cover Factory Acceptance Test (FAT), Site Acceptance Test (SAT), offline and live network trials. Each of which will be reviewed by internal experts from the Constellation team. Wider industry engagement will also be carried out to ensure the outcomes from trials facilitate BAU rollout for other GB DNOs.

The PNDC, in collaboration with project partners, started developing detailed testing specifications for the Constellation project. This builds on the trials and data analysis methodology developed in the previous reporting period. These testing specifications focused on Methods 1 and 2 and cyber security testing as well design of the PNDC trials environment illustrated in Figure 9. This environment will create a representative testing platform comprised of the simulated trial sites, where all of the Constellation functions will be tested prior to live trials. This environment will also serve to validate the OIC use cases later in the project.

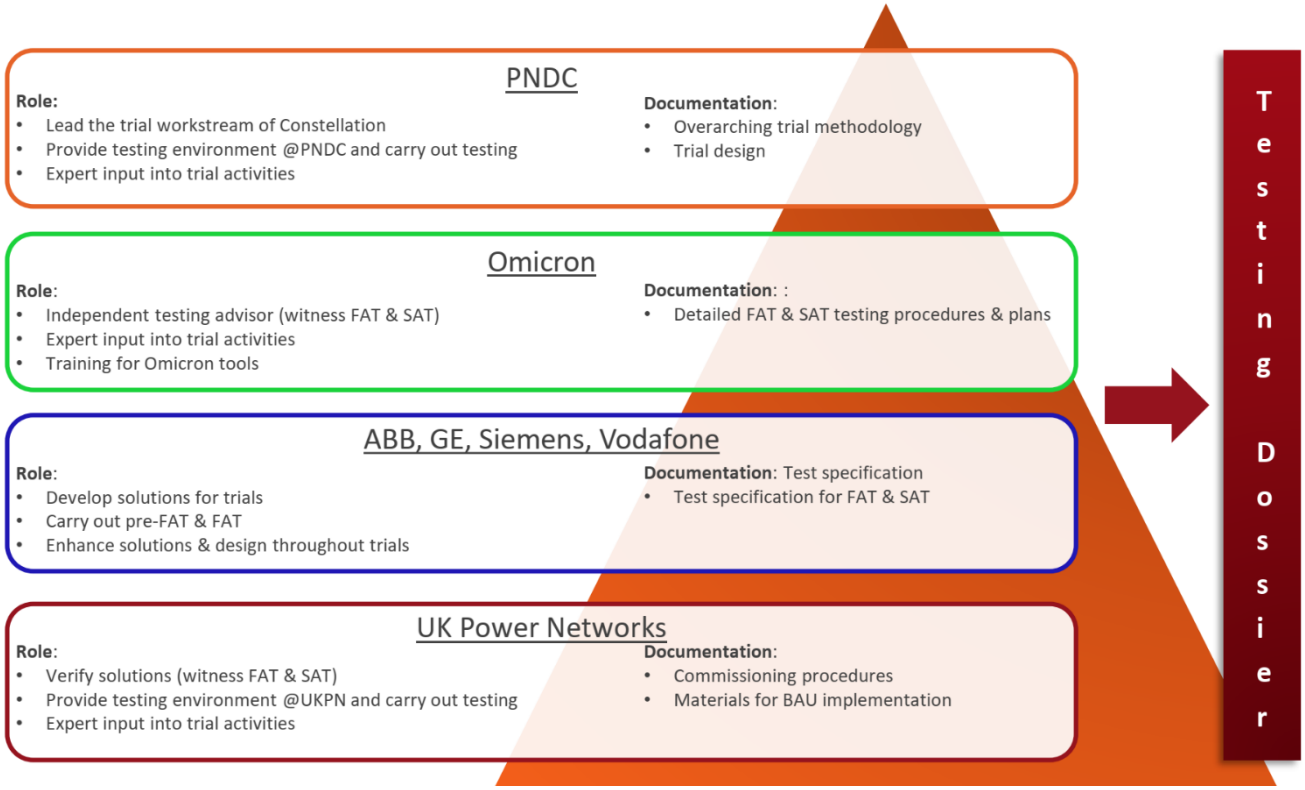

Figure 8 Constellation trials - roles and documentation

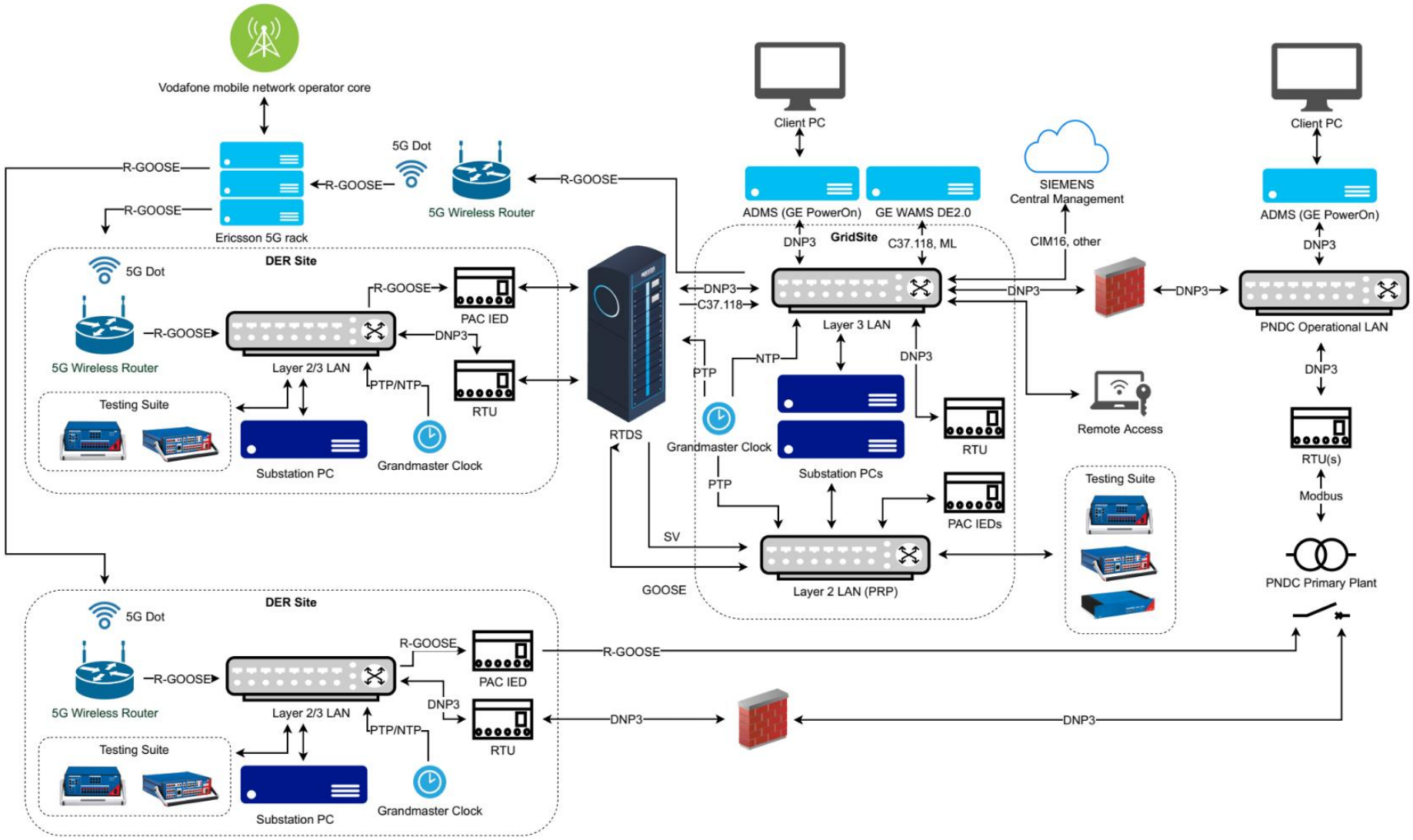

Figure 9 – PNDC trails environment

The PNDC trials environment comprises the following key elements:

- At the core of test environment is a Real-Time Digital Simulator (RTDS) which will run Maidstone and Thanet trial area dynamic models in real-time exposing the Constellation functions to a comprehensive set of test scenarios in a controller and automated fashion;
- A test suite composed of OMICRON test equipment for protection functional testing, LAN monitoring and cyber-security monitoring as well as third party software tools for LAN traffic injection, IEC 61850 device emulation and cyber-security pen testing. Pen testing will follow industry standard practice (Figure 100);
- GE ADMS for monitoring and control of RTDS trial sites and PNDC physical test assets. Further progress has been made to upgrade the GE ADMS version at PNDC to an equivalent of the UK Power Networks version;
- Layer 2 and 3 communication equipment (switches and routers; and
- 5G communication system composed of 5G dots and slices.

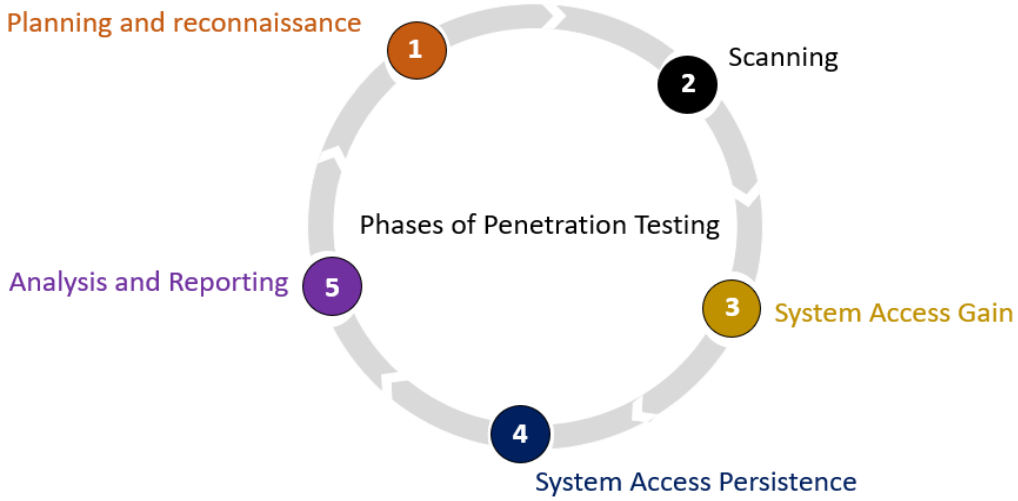

Figure 10 - Phases involved in pen testing

To refine the detailed test specifications, several dedicated workshops have been carried out with the project partners to communicate the objectives and phasing of the trials and to gather specific inputs around testing parameters and test success criteria. Pre-workshop questionnaires were circulated to relevant partners asking about design clarifications and testing requirements to ensure a focused discussion is achieved during each workshop session.

To support the Constellation trials OMICRON has been onboarded to provide tools and act as an independent testing advisor. OMICRON will support PNDC and UK Power Networks in evaluating the Constellation solutions to ensure they are fit for purpose. OMICRON will also provide training on the use of their tools and share best practice through their involvement in relevant industry activities, such as the FITNESS project.

Challenges and lessons learned

Due to the large number of internal and external stakeholders involved in the project it was apparent that it is necessary to communicate the Constellation trials objectives and phasing clearly with different sets of stakeholders. It was decided that dedicated material will be developed to achieve this. It may be necessary to tailor this material to different audiences such as network operators and solution suppliers.

To ensure that the trials designs are based on tried and tested requirements, the detailed test specifications will take into account relevant standards and grid/distribution codes with the latter being more relevant to the performance of DER sites under local ANM control.

Developing tests for some functions in a laboratory environment can be challenging. For example, tests for machine learning algorithm of the local ANM Method require a level of background network "noise" which cannot be readily simulated. This "noise" includes normal network load variations, switching events and small system oscillations. This limitation can be circumvented by the complementary nature of the offline and live network trials. The machine learning algorithm is expected to be exposed to this "noise" in the live network trials phase of the project.

Due to the novelty of 5G technology, preliminary testing will be carried out in Vodafone's research laboratory to ensure their design is suitable for the Constellation trials later in the project. Similarly, preliminary testing of the software virtualisation environment has been progressing and is described in more detail in section 2.1.

Outlook for next reporting period

Over the next reporting period, workstream 3 will focus on the following activities:

- The development of detailed test specifications for the virtualisation platform and communications underpinning the Constellation Methods;
- Progress on the PNDC site preparations and procurement of test equipment and software tools;
- Initiating the build of the PNDC trial environment;
- Progress on the PNDC 5G communication capability build by Vodafone;
- Updated planning of the Constellation trials, specifically for (FAT) and PNDC SAT; and
  Mobilising for the (SAT) of partner solutions at the PNDC.

2.4 Workstream 4 – Open Innovation Competition (OIC)

Workstream 4 is responsible for the incubation and trial of additional Methods (use-cases) that are delivered by third parties and procured from the market in an open competition format.

Progress during this reporting period

The workstream activities do not start until later in the project. However, the project team carried out a wider industry review workshop through which DNOs and suppliers provided suggestions on additional Methods that can be implemented as part of the OIC. Details are presented in section 2.6.

Challenges and lessons learned

The workstream activities do not start until later in the project.

Outlook for next reporting period

The workstream activities will formally kick-off later in the project. However, stakeholder engagement and wider dissemination of the Constellation project will continue in an effort to prime potential suppliers. The project team will develop a plan for shortlisting use case for inclusion in the OIC as well as identifying promising suppliers to ensure an active engagement with this workstream.

2.5 Workstream 5 – Academic Insight & Future Governance

Workstream 5 is fundamental in ensuring that Constellation project delivers a future-proof system capable of increasing the electricity system resilience. It is aimed at answering the complex technical, commercial and contractual challenges of distributed network operation. It will be carried out through four investigation packages delivered by academic researchers and validated across the project consortium and the PNDC core research programme working group.

Progress during this reporting period

Two academic insights activities have been successfully delivered by the University of Strathclyde. These encompass research in:

- **Communication and data architecture**: this work identified security opportunities and requirements for wireless communication and virtualisation serving the Constellation Methods. In particular, the need to ensure adequate separation and isolation of management plans,and ensuring that management services are only exposed on dedicated management networks. The work considered the issues and requirements surrounding security updates and the different approaches for update rollout while minimising the risk and impact of failed updates for substation PCs running critical functions (i.e. protection).
  The work also considered the requirements for deploying wireless communications enabling the Constellation Methods including coverage, capacity, reliability and interoperability. The work then focused on characterising 5G Stand Alone (SA) latency using a physical bench test setup. The initial test demonstrated promising results in terms of low latency performance of 5G communication, which is necessary for implementing teleprotection functions. However, further evaluation is required to determine the consistency and reliability of the 5G wireless link; and

- **Adaptive and loss of mains protection**: a comprehensive review of communication based LoM Methods was carried out to evaluate the sensitivity and stability of different detection techniques as reported in the literature. Most Methods reported good performance with nearly zero non-detection zone (NDZ). A number of the Methods identified make use of measurements readily available such as synchrophasors which could be generated by the Constellation platform. Furthermore, the Methods identified are network topology and generator technology agnostic – an advantage for scalable deployment of such solutions.
  The review was followed by detailed simulation studies on the Maidstone trial area where both of the researched communication based LoM Methods (Voltage Phase Angle Drift (VPAD) and Comparison of Rate of Change of Frequency were modelled and compared against Engineering Recommendation G99 LoM protection (i.e. RoCoF and voltage/frequency protection) in terms of stability and sensitivity. It was found that CoRoCoF was very stable, which gives more confidence in the Method 2 deployment. However, it's sensitivity to true LoM events could be improved. VPAD exhibited the best stability and sensitivity performance and is currently being considered for deployment in Constellation as part of Method 2 or the OIC.

  Finally, this activity reviewed adaptive techniques applied to distance protection to determine whether the Constellation platform can be utilised to deploy additional adaptive protection functions alongside Method 2. Several Methods were reported in the literature to adapt distance protection particularly to deal with varying fault levels, the presence of inverter connected generation and resistive faults. This review was followed by a simulation-based evaluation of distance protection reach based on different fault infeeds in the Maidstone 132kV network. The study identified some conditions where an adjustment of zone reach can be beneficial. Furthermore, the work developed a generalised approach to the adaptation of the reach based on voltage phase angle and fault level information, which could be derived from data accessible from the Constellation platform.

Challenges and lessons learned

Launching the academic insights workstream in parallel with the Constellation design activities proved to be a valuable resource for feeding high quality expertise and researching best practice to develop the Methods requirements as well

as validating some of the key design decisions such as the use of communication based LoM protection and the deployment of 5G SA for teleprotection purposes.

Communication and data architecture

It is important to adopt a secure approach to the software management of the Constellation platform. This is particularly critical when dealing with software supply chains and the need to validate software updates prior to their deployment.

Further laboratory investigation and real-world benchmarking is needed to determine the consistency of the 5G SA latency and link reliability to gain more confidence in the technology's ability to provide a teleprotection service. Future generation hardware featuring Ultra Reliable Low Latency Communication (URLLC) may alleviate some of these concerns.

Adaptive and loss of mains protection

The use of common standards for communication or data exchange such as IEC 61850 and C37.118 ensuring this data is available across different locations via the Constellation platform ensure new functionality (Methods) can be readily deployed, which maximises the value delivered by the digitisation of the substations.

Despite communication based LoM protection offering superior performance compared to local LoM protection functions, reliable communication is required. Nevertheless, local G99 protection can serve as back up to mitigate failure in the communication.

When it comes to practical implementation of adaptive protection functionality, the following factors and limitations should be considered:

- Further validation of proposed adaptive functionality should be carried out using physical protection IEDs or virtual IEDs to ensure dynamic characteristics of protection relays are captured; and
- Dynamic setting changes should consider minimum and maximum limits of settings as well as the need to maintain an acceptable level of stability and sensitivity. This is applicable to distance protection zone reach as well as the blinding of directional overcurrent protection.

Outlook for next reporting period

The remaining academic insights activities will be kicked off at a later stage of the project. These will focus on the following two themes:

- System reliability and distributed control; and
- Future governance in a net zero world with distributed electricity system operation.

2.6 Workstream 6 – Learnings & Dissemination

Workstream 6 is responsible for the dissemination of the knowledge generated from the project. The project has a comprehensive knowledge dissemination plan in place that is outlined in the roadmap in Figure 11. We have completed the planned dissemination activities in the roadmap so far and have carried out a several others in addition. Further details are presented in the section below.

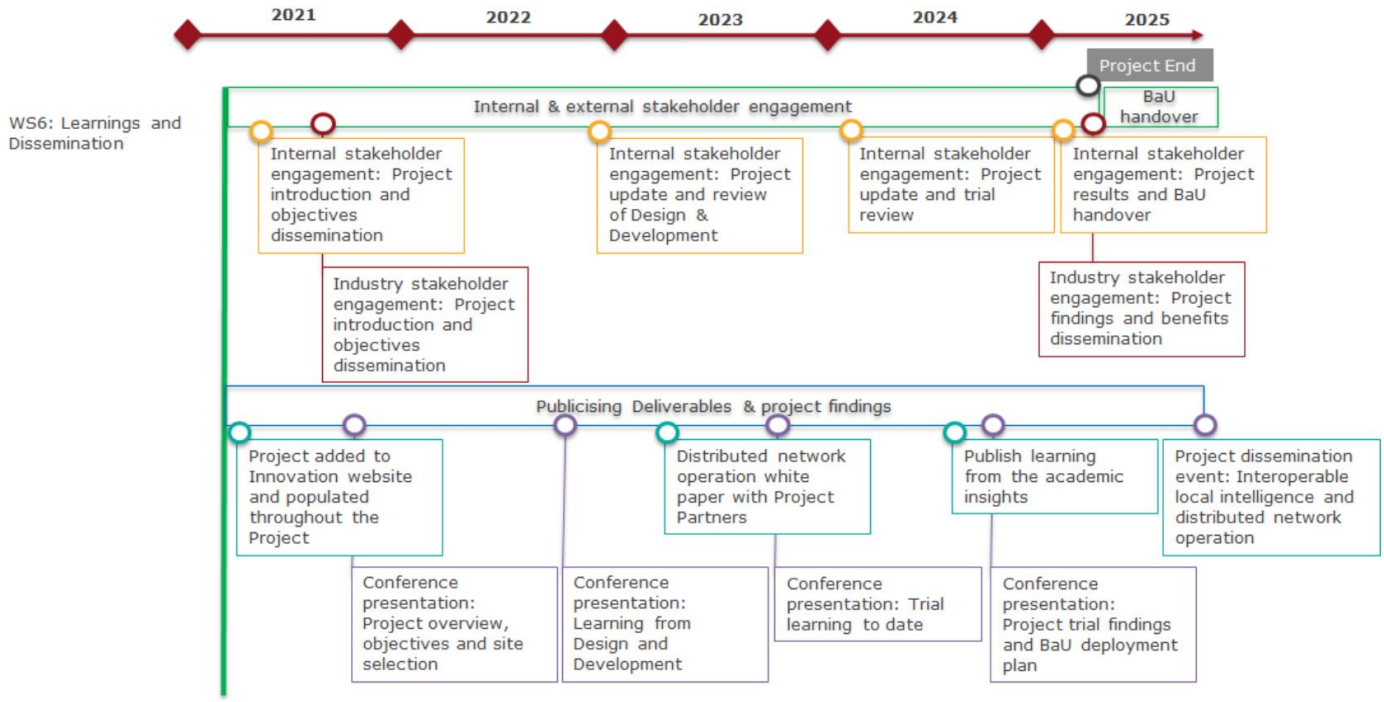

Figure 11 - Constellation knowledge dissemination roadmap

Progress during this reporting period

The following key activities have been carried out:

- Project update and wide industry engagement with the PNDC Digital Substation Working Group members. The continuous engagement with this group provides further validation of the project outcomes and keeps end users (DNOs) and suppliers up to date with developments and identified unique requirements and challenges from different DNOs, thus paving the way for BAU rollout out across GB DNOs;

- **Wider industry review workshop:** As part of the learning from Workstream 1, a wider industry review workshop was held to disseminate knowledge and obtain feedback**.** The industry review workshop provides an opportunity for our peers within the industry to provide feedback on the scalability of the Constellation solutions. The first workshop was held with members of the PNDC Digital Substation Working Group, with a focus on the substation environment. The workshop was delivered fully remotely using the Mural, digital whiteboard, platform. The workshop proved successful, with participants providing valuable insight and feedback through Microsoft Forms surveys and the Mural board. Figure 12 shows part of the Mural board used for brainstorming ideas for server applications during the workshop; this part of the workshop was used as a warm-up for the Open Innovation Competition;

- **DER Engagement:** Constellation will be trialled in the Maidstone and Thanet network areas; these trial areas were selected for their unique network topologies and diversity of distributed generation types. To effectively model the DER sites and their operating characteristics, it's important to gather as much plant data as possible. Therefore, it's imperative that we engage with DER owners in those areas. During the previous reporting period,

a DER charter was drafted and approved. The DER charter is a memorandum of understanding that describes the terms of collaboration between UK Power Networks and DER owners. During this reporting cycle, persons from the companies in the affected DERs were individually engaged via email, one-to-one calls and presentations. Engaging the DER owners of DER sites within the trial areas has proven challenging. Establishing and maintaining lines of communication with these stakeholders is important for gaining and maintaining interest in the project;

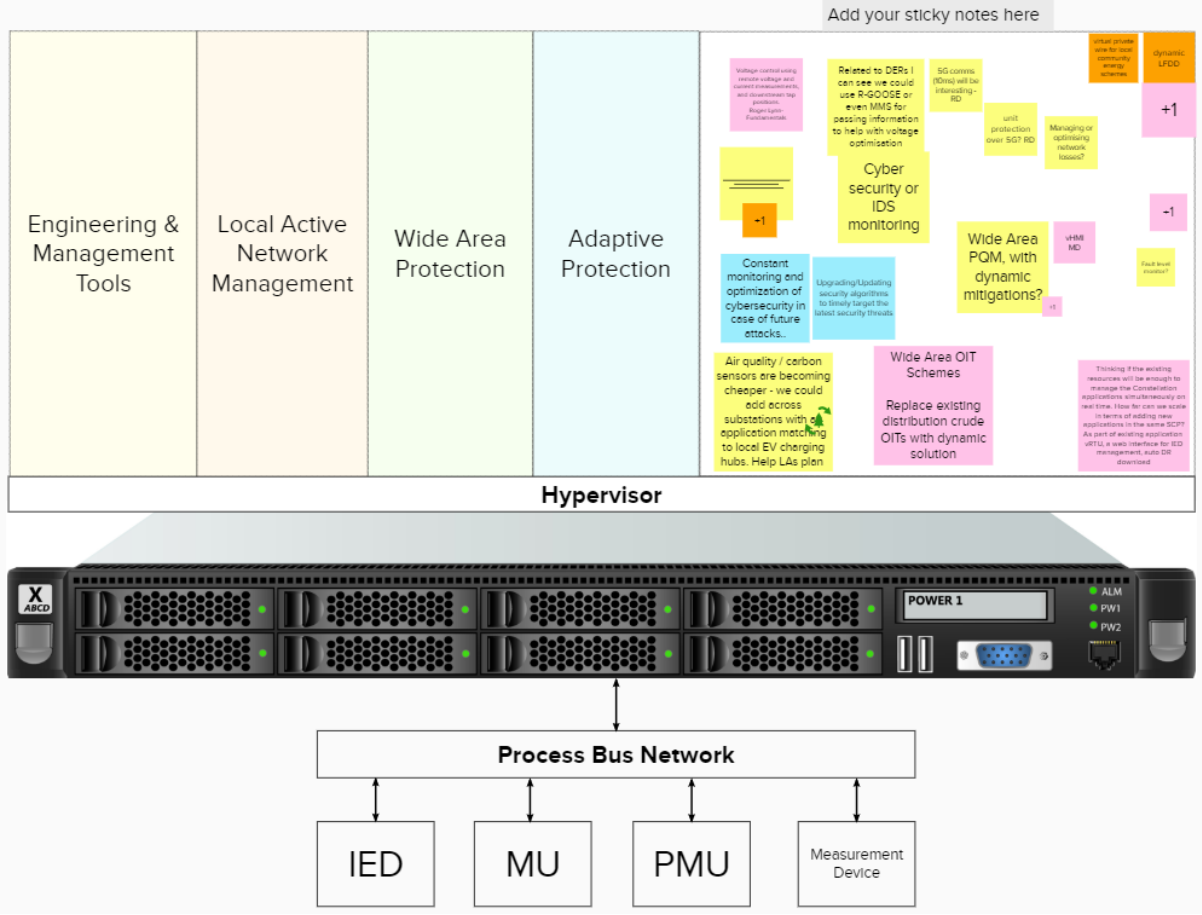

Figure 12: Substation Server Applications Mural Board

- During this reporting period, Constellation was presented at two conferences to disseminate learning:
  - Developments of Power System Protection (DPSP 2022):
    - Tutorial on adaptive protection;
    - Presentation on wide area and virtualised protection, led by ABB; and
    - Presentation on the overall Constellation project.
  - Orchestrate 2022: UK Power Networks were part of a panel discussion on innovation, where Constellation was used as a key example of industry collaboration.

- During this reporting period, Constellation put forward two conference applications:
  - Protection and Control World (PACW): for adaptive protection and central management system; and
  - Western Protective Relay Conference (WPRC): for wide area and virtual protection.

Challenges and lessons learned

Wider Industry Review

The wider industry review was successful in its objective to gather insight from industry peers. A few items were identified as contributing factors to the success:

- The content was catered to the expertise and knowledgebase of the audience. Carefully curating the content allowed participants to provide valuable feedback based on experience and institutional knowledge;
- Mural created a space and environment for participants to interactively provide their input, ask questions and collaborate with presenters and other participants; and
- Microsoft Forms surveys offered a structured and easy method of gathering and collating data. The automated nature of Microsoft forms, and the ability to export the responses to excel documents made it possible to present the results of the survey in real time

DER Engagement

It proved a challenge to initiate conversations between UK Power Networks and some of the DER owners for a number of reasons. Two common challenges arose when engaging with DERs:

- DERs were not convinced the system would provide them with any tangible benefits, and were thus reluctant to sign the DER charter. It was identified that DER owners assumed that the lack of flexibility of their generation plant, and the absence of an existing implementation of central ANM meant that they would not receive any benefits from Constellation. Assuring the DER owners that they would benefit from less curtailment as a result of Wide Area Protection regardless of central ANM status assisted in persuading them to support the project; and
- A common concern expressed by DERs was the possible disruption of operations that would potentially be caused by outages related to the installation of Constellation equipment. Having received these concerns, the Constellation team will actively assist in coordinating work during times of little to no generation, or with existing outages where possible.

Outlook for next reporting period

Over the next reporting period, regular and further dissemination activities will be carried out including:

- Regular engagement through the PNDC digital substation working group meetings, particularly to seek input from the technical design authority;
- Additional wider industry review workshops will be held, taking forward the learnings extracted from the initial workshop with the PNDC digital substation working group; and
- DER engagement will continue, with the aim of gaining commitment from all the DERs within the trial areas via the DER charter.

3. Business case update

The project team has identified that the hardware requirements for hosting the software (virtualisation) environment in the substations and DER sites, is different to those initially used in the business case. The business case may be impacted due to higher cost equipment than what was in the original bid, however, the project team will continue to evaluate the hardware costs as the procurement process is still ongoing.

As part of the testing and verification of the project, the business case will be re-evaluated, but during this reporting period it remains consistent with the Constellation Full Submission Proforma.

Figure 13 shows the costs and gross benefits, as well as the net expected benefits of Constellation when rolled out across GB, split between the two different cost and benefit categories. The left side of the graph shows the costs, while the right side shows the benefits.

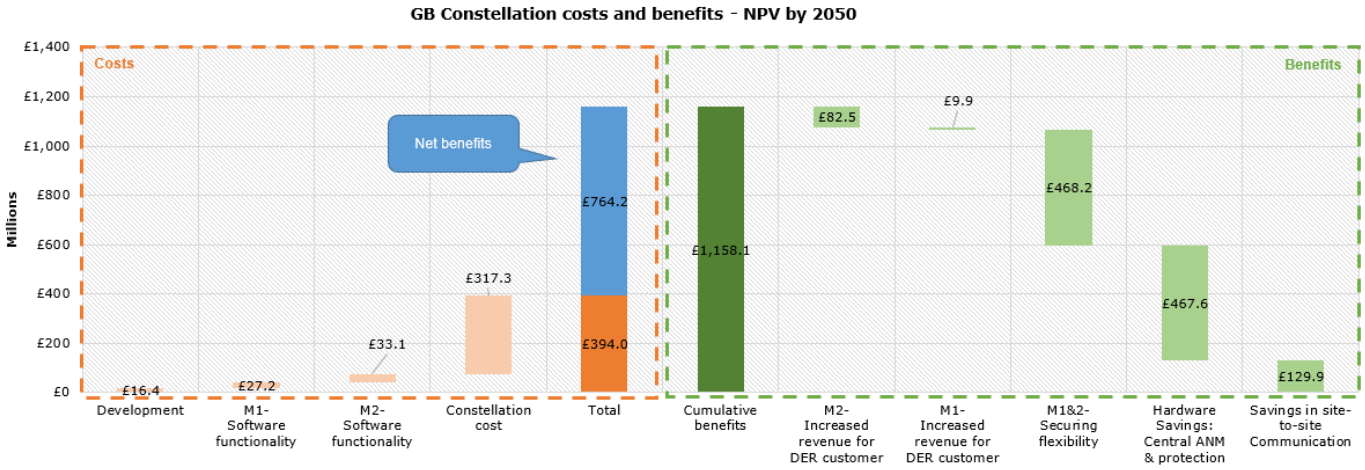

Figure 12 - Forecasted financial benefits in GB by 2050

4. Progress against plan

Figure 14 shows the high-level project plan for Constellation. The project remains on track to achieve the Deliverables by the dates shown below. In the next sections the project team describe the progress of more specific items in the detailed project plan.

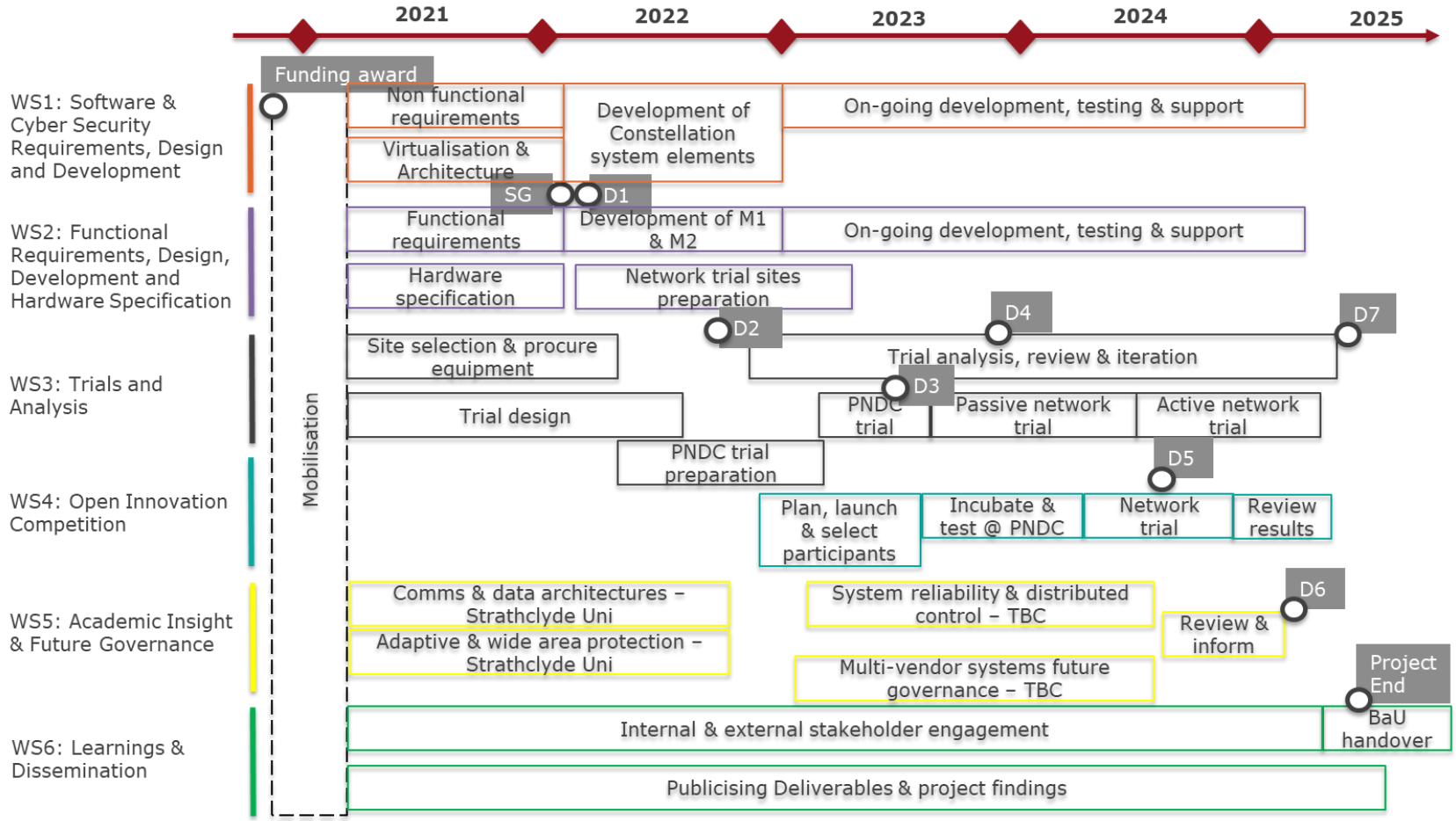

Figure 13 - High level plan

4.1 Detailed progress in the reporting period

In order to monitor project progress against the plan and track any potential risks or issues several regular meetings are held including fortnightly one-to-one sessions with the individual partners, bi-weekly sessions with all partners as well as a monthly risks and issues review session with all partners.

Overall progress to date is in line with the high-level project plan submitted in the FSP. However, the PNDC is at risk of starting in Q1 2023, rather than Q4 2022 due to the logistics of the preceding FATs. The FATs will be in different geographical locations and will be assessed by a common group of key technical experts. As such, we anticipate that the FAT process takes longer which will push the PNDC trial start to begin later. Additionally, equipment suppliers have made us aware of global electronics shortages which are impacting their equipment lead times. We will continue to closely monitor the situation but if the global shortage persists, it may increase the impact the start of the trial period (refer to section 4.2).

A summary of tasks that started in the reporting period is given in the table below, together with their status at the end of the period.

Table 4 – Summary of tasks started in this reporting period

Task description	Workstream	Status at end of period
Produce the trial design for the Constellation trials	3	In progress
Carry out testing to finalise virtualisation environment (software and hardware)	1	In progress
Plan the provision of central servers	1	Completed
Finalise the hardware required in trial substations	2	In progress
Provision of data for all Constellation elements	2	In Progress
PNDC ADMS upgrade	3	In progress
Finalise initial academic research	5	Completed
Engage with DER in the trial areas (continuous task)	2	In progress
Complete the third Project Progress Report		Completed
Submit Deliverable 1		Completed
Develop the detailed design for local ANM	2	Completed
Develop the detailed design for wide area protection	2	Completed
Develop the detailed design for adaptive protection	2	Completed
Develop the detailed design for 5G slice	2	Completed
Design the trial site work for Maidstone trial area	2	Completed
Identify and procure hardware for Maidstone trial area	2	In progress
Identify and procure hardware for PNDC trial area	3	In progress
Prepare Maidstone trial area (site works)	2	In progress
Prepare PNDC trial area (site works)	3	In progress
Provisioning of central Azure Servers	1	In progress
Wider industry review workshops	1	In progress
Develop Secure by Design document	1	In progress

4.2 Identification and management of issues

The project team recognises the importance of robust risk management methodologies for any project, but more specifically for complex innovation projects. Due to the nature of these projects, it is likely that certain risks might impact the overall project activities. A full list of project risks identified for Constellation is provided in Section 11. Since the last reporting period, one risks has materialised into an issue which we are managing to reduce its impact.

- Delays in provision of data for local ANM:
    - Local ANM requires synchrophasor data at key points on the trial network which have high bandwidth requirements. The standard data communication route was not suitable due to bandwidth limitations. As

a result, we had to ensure of a secure and efficient way to communicate the phasor data with GE, which was not anticipated during the project bid. We established this connection for the Maidstone trial area using the operational fibre telecommunication network successfully. Nevertheless, this resulted in a three-month delay in data provision. We will carry out similar work in the Thanet area as well.
    - To manage this issue, GE will proceed with developing the non-data dependent aspects of Local ANM first and once the data is available will proceed with the machine learning aspects. This will not impact any of the expected learning from the development and trials.

The list below presents some risks, which could develop into issues in the next period if they are not mitigated:

- Insufficient budget for substation equipment – there is a risk that the budget allocated for the substation equipment will not be sufficient after the learnings from the design activities. In this reporting period we have identified a higher cost requirement for substation computers, data collection, communication, cyber security and virtualisation, as well as the site preparation works themselves. To manage this risk, we are reviewing the list of equipment after the procurement activities (with accurate equipment costs) with the aim to minimise the hardware requirements at DER sites due to space constraints;

- Delays in provision of data for adaptive protection:
    - Adaptive protection relies on data contained across multiple systems within UK Power Networks. As such, an activity which was not planned for during the project bid (and only became known as part of the design activities) needs to be carried out – data validation and mapping. In this reporting period, we have made good progress in agreeing the data requirements, sources and boundaries. However, we encountered a challenge in exporting and importing data between the various relevant systems. While this is taking longer to resolve, it is providing valuable learning for the industry.
    - To manage this risk UK Power Networks and Siemens will continue to collaborate to test and overcome the data communication challenges. We have established an informal focus group with key technical experts from each organisation who are dedicated to resolve the issues.

- Software virtualisation environment – there is a risk that ABB's software cannot be implemented in parallel with other software due to its real time requirements for protection functionality. As a result, a separate hardware may be required for real time functions, which will increase the project cost. To manage this risk we are working closely with ABB and a third party virtualisation expert to carry out comprehensive testing of the virtualisation. We have made significant progress in overcoming two of the three key challenges in this reporting period. We are currently implementing solutions for the final technical limitation; and

- Delays in starting the project trials:
    - 5G coverage – there is a risk that the deployment of the 5G coverage within the trial sites takes longer than anticipated due to delays in land acquisition in the DER sites. To manage this Vodafone and UK Power Networks had begun the legal process immediately after the trial sites were shortlisted. In this reporting period we have completed the legal approvals for the PNDC testing and have made considerable progress on the other trial locations;
    - Provision of data for development (refer to risks above); and
    - Global shortage of electronic components – our equipment suppliers have made us aware of issues with their supply chains due to shortages of electronic components. To manage this risk we are actively managing the trial preparation works to ensure we can do the installations in line with the expected equipment lead times.

4.3 Key achievements and notable events in the reporting period are shown below:

- Submission of Deliverable 1;
- Trial sites selected in preparation for Deliverable 2;
- Engagement with DER sites connected to trial areas;
- Development of detailed design for local ANM;

- Development of detailed design for wide area and adaptive protection;
- Development of detailed design for the 5G slicing site-to-site communication;
- Development of substation server hardware;
- Development of Constellation architecture;
- Development and agreement of plan for provision of central servers for local ANM and adaptive protection;
- Testing of virtualisation Method for solutions;
- Site design work for Maidstone area;
- First wider industry review workshop completed;
- Finalisation of the two streams of the academic research;
- Commencement of development activities; and
- Commencement of preparation for PNDC trials and PNDC ADMS upgrade;

4.4 Look-ahead to next reporting period

The following major tasks and milestones are planned for the next reporting period:

- Agreement on hardware for software virtualisation environment;
- Continuation of procurement activities for onboarding project suppliers;
- Development of draft secure by design documentation;
- Development of trial design;
- Development of test specifications;
- Trial planning for factory acceptance testing;
- Results from initial testing on 5G and virtualisation;
- Continuation of trial preparation and procurement for PNDC and Maidstone trial areas;
- Procurement of hardware for substation server;
- Deployment of Azure server for local ANM (GE); and
- Continuation of wider industry review workshops.

5. Progress against budget

This section is provided in the Confidential Appendix A.

6. Project bank account

This section is provided in the Confidential Appendix A.

7. Project Deliverables

This section provides an overview of progress against each of the deliverables set out in the Project Direction. The information provided below describe progress on the evidence for each Deliverable.

Table 5 – Constellation Deliverables

Ref	Project Deliverable	Deadline	Evidence	Progress
1	Details of the system design and architecture for protection and control on a substation with local intelligence	28/02/22	(WS1 and WS2) Report on the system design of Constellation and the associated architecture for communication, protection and control across Methods 1 and 2	This deliverable was successfully submitted on time.

Ref	Project Deliverable	Deadline	Evidence	Progress
2	Description of the trial design and site selection criteria process for Methods 1 and 2	31/08/22	(WS1 and WS2) Report containing: • A description of the trial site selection criteria process for each phase of the network trials; and • Details of the trial requirements for the demonstration of each element of Constellation	This deliverable is on track. The project team have identified the trial sites. The PNDC are also working closely with the partners to specify the trial design.
3	Initial learning from off-network PNDC trial, and learning from development and virtualisation of Methods 1 and 2	30/06/23	(WS1, WS2 and WS3) Report containing: • Details of the key learning from the design and development of Methods 1 and 2; • Details of learnings from design of 5G slicing; and • Testing preparation and early lessons from the off-network testing	The deliverable remains on track, with the partners progressing with their development activities. UK Power Networks and PNDC are also progressing with trial preparations. Please note the risk of delays to this deliverable in section 4.2.
4	Review and insights following site installation and learning from mid trial passive network demonstration	30/11/23	(WS2 and WS3) Report containing: • Key lessons from site installation process at DER sites and primary/grid substations; and • Early learning from the passive network demonstration	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme. It should be noted that any delays to Deliverable 3 will impact Deliverable 4 and Deliverable 7.
5	Learning from the Open Innovation Competition (OIC)	31/07/24	(WS3) Report containing key learning on the OIC use case prioritisation, participant selection and incubation process	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme.
6	Learning from academic insights and the governance required to prepare for the future world of distributed network operation	28/02/25	(WS7) Report containing analysis by the academic partner on the opportunities, risks and barriers to full distributed and interoperable future network operation	This deliverable is on track. The project team and the University of Strathclyde have successfully completed two of the four research streams.
7	Analysis and presentation of findings from the trials and plan for BaU deployment	30/09/25	(WS3) Report containing findings from the trials and appraisal of the business case including key learning and plan for BAU deployment	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme.
[Note this is a common Project Deliverable to be included by all Network Licensees as drafted below]				

Ref	Project Deliverable	Deadline	Evidence	Progress
N/A	Comply with knowledge transfer requirements of the Governance Document.	End of project	1. Annual Project Progress Reports which comply with the requirements of the Governance Document. 2. Completed Close Down Report which complies with the requirements of the Governance Document. 3. Evidence of attendance and participation in the Annual Conference as described in the Governance Document.	Third Project Progress Report is completed (UK Power Networks have elected to submit a report every six months). The Close Down Report is N/A at this stage.

8. Data access details

To view the full Innovation Data Sharing Policy, please visit UK Power Networks' website http://innovation.ukpowernetworks.co.uk/wp-content/uploads/2021/11/UK-Power-Networks-Innovation-Data-Sharing-Policy-.pdf.

UK Power Networks recognises that innovation projects may produce network and consumption data, and that this data may be useful to others. This data may be shared with interested parties wherever it is practicable and legally permissible to do so and it is in the interest of GB electricity customers. In accordance with the Innovation Data Sharing Policy, published in 2019, UK Power Networks aims to make available all non-personal, non-confidential/non-sensitive data on request, so that interested parties can benefit from this data.

9. Learning outcomes

The project team recognises the importance of 'best in class' learning and dissemination. Specific lessons learned regarding each of the workstreams are captured in the workstream progress reports. As the project started in May 2021, the only final material which is available for dissemination as of yet is Deliverable 1 which is published. In the next reporting period, the project team will publish the report for Deliverable 2. This will be made publicly available on the UK Power Networks' Innovation website.

The following documents are available to other GB DNOs upon request:

- High level requirements specification;
- Constellation architecture; and
- Results of academic research.

10. Intellectual Property Rights (IPR)

This section lists any relevant IPR that has been generated or registered during the reporting period along with details of who owns the IPR and any royalties which have resulted, and any relevant IPR that is forecast to be registered in the next reporting period.

Table 6 – IPR generated in this reporting period

IPR description	Owner	Type
Constellation architecture	UK Power Networks	Relevant foreground IP
Designs for Methods 1 and 2	ABB, Siemens, GE and Vodafone	Foreground IP
Academic research	University of Strathclyde	Relevant foreground IP
Deliverable 1 – Details of the system design and architecture for protection and control on a substation with local intelligence	UK Power Networks	Relevant foreground IP
Constellation trial methodology	UK Power Networks, University of Strathclyde	Relevant foreground IP

Table 7 – IPR forecast for next reporting period

IPR description	Owner	Type
Deliverable 2 – Description of the trial design and site selection criteria process for Methods 1 and 2	UK Power Networks	Relevant foreground IP
Site selection methodology	UK Power Networks	Relevant foreground IP
Trial design	UK Power Networks, University of Strathclyde	Foreground IP

11. Risk management

This section lists the risks highlighted in the FSP plus any other risks that have arisen in the reporting period. The project team has described how we are managing the risks we have highlighted and how we are learning from the management of these risks. Risks 1-23 are captured in the FSP. We identified Risks 24-61 since the funding was awarded. The project continues to monitor risks and issues on a monthly basis, at a 'deep-dive' risk management meeting. At this meeting, risk impacts and mitigation plans are updated.

Table 8 – Risk register

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
R13	**Risk**	Open	Deployment of equipment and systems is not achievable or is more difficult/takes longer than expected	Project incurs delays or cannot proceed	**4**	**5**	**20**	- Plan integration between systems as part of the design; and - Prepare key systems to be ready for integration, while detail design is taking place.	**3**	**3**	**9**	WS1 Lead	16/05/2022	
R26	**Risk**	Open	Internal expertise is not available to support	The project will not deliver all of the intended outcomes to the expected quality or will be delayed	**4**	**5**	**20**	- Work closely with internal stakeholders to clarify expected input and secure support; and - Plan the work to align with resourcing needs.	**3**	**3**	**9**	Project Manager	16/05/2022	
R43	**Risk**	Open	5G service needs to be resilient to power failures to be used for protection / SCADA	The project will not deliver all of the intended outcomes and will not be accepted to BAU	4	5	**20**	- Specify the requirements for protection and control; and - Design the trial with Vodafone and PNDC to demonstrate the resilience of the 5G service.	3	3	**9**	WS3 Lead	16/05/2022	
R47	**Risk**	Open	Negative sequence and zero sequence data is not available	Project is delayed and/or requires re-scoping	4	5	**20**	- Understand the specific network parameters which are required for Method 1 and Method 2; - Understand if we can leverage existing ADMS capabilities to provide network studies; and - Last resort is to manually identify and load the required parameters.	3	3	**9**	WS2 Lead	16/05/2022	
R48	**Risk**	Open	Integration of equipment and systems (from different Partners) is not achievable due to shortfalls in design	Project incurs delays or cannot proceed	4	5	**20**	- Collaborative requirements gathering and design process is undertaken to ensure integration elements are understood; and - Interfaces between systems (and Partners) defined early as part of the requirements development stage.	3	3	**9**	WS1 Lead	16/05/2022	
R55	**Issue**	Active	Access to large store of data for Machine Learning (ML) development	Possible delays to the project	4	5	**20**	- Carry out FAT without ML at first instance and have separate testing once ML is ready; and - Early planning for site work to ensure data gathering for ML is prioritised.	3	3	**9**	WS2 Lead	16/05/2022	
R58	**Risk**	Open	Specification and plan for provision of network data for adaptive protection and local ANM takes longer than planned	Possible delays to the project	5	4	**20**	- Siemens provide a data specification for UK Power Networks to approve; and - UK Power Networks to work closely with GE to ensure data can be collected early.	4	3	**12**	WS2 Lead	16/05/2022	
R59	**Risk**	Open	ABB and Siemens's software cannot be installed as a VM	Project is delayed and additional scope / cost may be required	4	5	**20**	- Work with VMWare to ensure VM environment is capable of supporting ABB's software; and - Install Siemens software early and do testing to confirm operation.	3	3	**9**	WS1 Lead	16/05/2022	
R61	**Risk**	Open	Additional hardware and software identified as part of the design cannot be accommodated within the project budget	Project overspend requiring additional partner contributions and/or change request for reduction in project scope	4	5	**20**	- Contingency available to support some of the additional cost; and - Close collaboration with partners to manage the delivery of the scope within the available budget.	3	3	**9**	Project Manager	16/05/2022	

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
R9	**Risk**	Closed	Suitable sites for the demonstration of the solution are not available	Trials cannot proceed	**4**	**5**	**20**	- Undertook early research and identified two potential network areas, of which two are proposed in the bid; and - Ensure value can be derived from the off-network testing.	**2**	**2**	**4**	WS2 Lead	14/11/2021	14/11/2021
R63	**Risk**	Open	Richborough constraint monitoring for Local ANM may be unfeasible. Constraint locations are far from Thanet and there is need for additional monitoring	Project is delayed and/or requires re-scoping	4	5	**20**	- GE and UK Power Networks working on the Local ANM design to identify solution for adequately managing the Thanet / Richborough area	2	3	**6**	WS2 Lead	16/05/2022	
R10	**Risk**	Open	Unavoidable changes are made to key personnel on the project	Possible delays to the project	**4**	**4**	**16**	- Comprehensive project documentation is maintained to reduce the impact of any staff changes that may occur; and - Ensure knowledge sharing is undertaken across the project team to avoid single point of failure.	**3**	**3**	**9**	Project Manager	16/05/2022	
R12	**Risk**	Open	Intellectual property requirements deter some innovation competition entrants	Limited outcomes from innovation competition element	**4**	**4**	**16**	- Ensure early publication and full explanation of IPR requirements to ensure entrant buy-in to project requirements	**2**	**3**	**6**	WS4 Lead	16/05/2022	
R23	**Risk**	Open	The DER operators in the trial areas do not wish to participate in trials	Trial results are of lower quality and potentially insufficient to inform BAU roll-out	**4**	**4**	**16**	- Engaged with DER operators in the provisional trial areas; and - Ensured minimal effort and impact on DER operation during trial.	**1**	**3**	**3**	Project Manager	16/05/2022	
R34	**Risk**	Open	Not enough resource to carry out integration	Project is delayed and/or requires re-scoping	4	4	**16**	- Plan key resource requirements and availability; and - Understand resource requirements and plan alternative ways of securing the necessary expertise.	3	4	**12**	WS1 Lead	16/05/2022	
R39	**Risk**	Open	Project and BAU not sufficiently coordinated to transition into BAU	Limited outcomes from the trials	4	4	**16**	- Keep the BAU owners and stakeholders engaged and updated; and - Ensure the products meet the BAU requirements or there are plans in place to meet the BAU requirements.	2	2	**4**	Project Manager	16/05/2022	
R41	**Risk**	Open	There is no appropriate data management in place to support the increased volumes of data	Project is delayed and may not be accepted into BAU	4	4	**16**	- Specify the data management requirements early; and - Agree specific data management plans before the trials with the relevant business stakeholders.	2	3	**6**	WS3 Lead	16/05/2022	
R49	**Risk**	Open	Use-cases are not defined clearly and in time for the development	Project is delayed and additional scope / cost may be required	4	4	**16**	-Define the project use-cases early as part of the initial requirements; and -Clearly communicate scope of each Partner and align it to the plan.	2	3	**6**	Project Manager	16/05/2022	
R52	**Risk**	Open	Delay in data gathering reduces time for ML	Possible delays to the project	4	4	**16**	- Early planning and engagement with relevant experts to ensure data gathering for ML is prioritised	3	3	**9**	WS2 Lead	16/05/2022	
R53	**Risk**	Open	DER sites available too late for ML	Possible delays to the project	4	4	**16**	- Ensure key lines are monitored at substation during data gathering phase	3	3	**9**	WS2 Lead	16/05/2022	
R60	**Risk**	Open	Acquisition of land for the 5G equipment Vodafone is installing	Project is delayed and/or requires re-scoping	4	4	**16**	- Early engagement with legal team to ensure acquisition is possible within timescales of the project	3	3	**9**	Project Manager	16/05/2022	

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
R1	**Risk**	Open	COVID-19 restrictions continue and impact project activities	Cannot hold face-face meetings slowing design process and de-prioritised site work (non-essential)	**3**	**5**	**15**	- Contingency built in and a price review stage gate included at the end of detail design. This will allow costs to be re-negotiated after the architecture and design has completed; and - Engage provider on fixed priced contract rather than time and materials.	**2**	**3**	**6**	Project Manager	16/05/2022	
R2	**Risk**	Open	Architecture and system build costs are significantly higher than anticipated at FSP costing stage	Project overspend requiring additional partner contributions and/or change request for reduction in project scope	**3**	**5**	**15**	- Contingency built in and a price review stage gate included at the end of detail design. This will allow costs to be re-negotiated after the architecture and design has completed; and - Engage provider on fixed priced contract rather than time and materials.	**2**	**4**	**8**	Project Manager	16/05/2022	
R21	**Risk**	Open	5G coverage is not available in the trial areas in time for the trials	Project is delayed and/or requires re-scoping	**3**	**5**	**15**	- Contingency budget to account for the installation of small 5G cells in the trial areas; and - Vodafone to leverage relationship with infrastructure operator (Telefonica) in the trial areas to ensure coverage is delivered in time for the trials.	**2**	**2**	**4**	WS2 Lead	16/05/2022	
R24	**Risk**	Open	Requirements and specifications are not clear or design cannot be approved	Goods and services are of lower quality and fail to deliver the benefits	**3**	**5**	**15**	- Leverage expertise from consortium of Partners to ensure clear requirements and design; - Work out the requirements and design collaboratively in workshops / focus groups; and - Have a staged approach to specifying the requirements.	**2**	**3**	**6**	Project Manager	16/05/2022	
R25	**Risk**	Open	Activities on the critical path are delayed or stopped	Key milestones and deliverables are delayed	**3**	**5**	**15**	- Frequent progress review sessions in place across all Partners; - Frequent coordination sessions in place across all Partners; and - A robust project plan is developed and it is validated and updated closely.	**2**	**3**	**6**	Project Manager	16/05/2022	
R27	**Risk**	Open	Single point of failure in resoursing	Project is delayed and/or requires re-scoping	3	5	**15**	- Ensure there is clear and structured documentation to enable handovers; and - Plan the work to align with the resourcing needs.	3	4	**12**	Project Manager	16/05/2022	
R31	**Risk**	Open	Substation PC is not powerful enough to support the virtualsed protection and control	The project will not deliver all of the intended outcomes	3	5	**15**	- Align virtualisation standards with BAU; - Align substation design and IP addressing with BAU; and - Collaborate with Partners to understand hardware requirements for the software they are developing.	2	4	**8**	Project Manager	16/05/2022	
R35	**Risk**	Open	No suitable expertise for testing and integration	The project will not deliver all of the intended outcomes	3	5	**15**	- Understand the testing and integration requirements early; and - Plan how the necessary testing and integration skills are made available in time for the Project.	2	4	**8**	WS1 Lead	16/05/2022	
R40	**Risk**	Open	There is a cyber security breach	Network is rendered open to cyber attack	3	5	**15**	- Specify robust cyber security requirements; - Compliance with cyber security requirements; and - Develop a suitable cyber security breach response plan.	3	3	**9**	WS1 Lead	16/05/2022	
R45	**Risk**	Open	Conflicting interactions with other systems (DERMS, Distributed Restart, etc)	Project is delayed and/or requires re-scoping	3	5	**15**	- Constellation elements integration and interactions with other systems are specified early; and - Key interactions with other systems are planned and tested during the project.	3	3	**9**	Project Manager	16/05/2022	

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
R50	**Risk**	Open	Poor accuracy of load and generation forecasts required for the modelling	Limited outcomes from the trials	5	3	**15**	-Agree existing forecasting capabilities and identify impact during the design stage of the project	3	3	**9**	WS2 Lead	16/05/2022	
R54	**Risk**	Open	Substation PC unable to run Phasor Data Concentrator as software in short-term delaying data gathering	Project is delayed and/or requires re-scoping	3	5	**15**	- Installation of PDC as hardware at substations as backup plan	3	3	**9**	WS2 Lead	16/05/2022	
R56	**Risk**	Open	5G v16 equipment availability among global electronics shortage	Possible delays to the project	5	3	**15**	- PNDC trials and initial testing in Maidstone to be carried out on 5G v15 technology; and - Testing later in the project (2024) to be on v16 equipment.	5	2	**10**	WS3 Lead	16/05/2022	
R57	**Risk**	Open	The upgrade of PNDC's ADMS and simulation of UK Power Networks's network is not sufficient to enable the testing	Project is delayed and additional scope / cost may be required	3	5	**15**	- Close collaboration between GE, UK Power Networks and PNDC to ensure PNDC's test environment is correctly set up; and - Simulated UK Power Networks' network to be reduced and simplified.	2	4	**8**	WS3 Lead	16/05/2022	
R6	**Risk**	Open	Suitable innovation competition entrants cannot be found	Project is delayed and/or requires re-scoping	**3**	**5**	**15**	- Leverage PNDC core research programme contacts; and - Leverage the R&D connections and experience of all partners.	**3**	**3**	**9**	Procurement	16/05/2022	
R7	**Risk**	Closed	Failure to agree Project contracts between UK Power Networks and Project Partners	Project cannot proceed	**3**	**5**	**15**	- All partners have agreed in principle to NIC terms; - Negotiation of collaboration agreement between all partners to begin after FSP submission; and - long lead in between project award and work start to allow time for negotiations.	**1**	**4**	**4**	Project Manager	30/04/2021	30/04/2021
R62	**Risk**	Open	5G transmission coverage in Manston PV may not be feasible due to location in proximity to the core 5G transmission network	Project is delayed and/or requires re-scoping	3	5	**15**	- Vodafone working with their subcontractors to design solution options which can overcome issue	1	5	**5**	WS2 Lead	16/05/2022	
R44	**Risk**	Open	Not all stakeholders are kept up to date with project results and progress	Project is delayed and may not be accepted into BAU	3	4	**12**	- Stakeholders are identified and engagement approach is specified; and - Frequent and clear communication with stakeholders is carried out throughout the project.	3	3	**9**	Project Manager	16/05/2022	
R17	**Risk**	Open	Insufficient innovation competition entrants who meet the entry/procurement requirements	Project is delayed and/or requires re-scoping, limited outcomes from innovation competition	**3**	**4**	**12**	- Leverage partner experience in R&D incubation; and - Identified over 15 use-cases for participants to work on.	**2**	**3**	**6**	WS4 Lead	16/05/2022	
R18	**Risk**	Open	Insufficient availability of quality training data for machine learning to enable solution to be accurate and effective on the network	Accuracy of algorithm decision making is not assured	**4**	**3**	**12**	- Using simulation early, and ramp up level of autonomous operation throughout the duration of the tests as data is built up; and - Get PMU data from trial sites early in the project.	**3**	**3**	**9**	WS2 Lead	16/05/2022	
R20	**Risk**	Open	The selected hardware is not suitable for the time-critical operation of Methods 1 and 2	The project will not deliver all of the intended outcomes	**3**	**4**	**12**	- Equipment was selected based on its ability to perform the required functionality; and - Sufficient risk budget to ensure equipment scope change can be absorbed.	**2**	**3**	**6**	WS2 Lead	16/05/2022	

RISK & ISSUE LOG

ID	Risk / Issue	Status	Description	Impact	Risk Probability	Risk Impact	Risk Score	Mitigation / Planned Actions	Mitigated Probability	Mitigated Impact	Mitigated Score	Owner	Last updated	Date Closed
R22	**Risk**	Open	The virtualisation approach is not suitable for real time protection & control applications	Project is delayed and/or requires re-scoping	**3**	**4**	**12**	- Carried out investigation to select a flexible approach which can deliver the capabilities; and - Included in project risk budget which will be governed with a stage gate at the end of detail design.	**3**	**3**	**9**	WS1 Lead	16/05/2022	
R29	**Risk**	Open	Unable to recruit suitable / sufficient resource for the project	Project is delayed and/or requires re-scoping	3	4	**12**	- Carry out robust recruitment to ensure expertise is on-board; and - Plan a suitable "plan B" alternative to secure the expertise required.	2	3	**6**	Project Manager	16/05/2022	
R3	**Risk**	Open	Some elements of the technical solution are not achievable to the desired specification within the project timescale and budget	The project will not deliver all of the intended outcomes	**3**	**4**	**12**	- Ensure requirements and solution design is realistic after the detail design stage; - Continuously and quickly adapt to changing requirements, with iteration loops built into the project plan throughout the development; and - Regularly progress following UK Power Networks established project control Methods.	**3**	**3**	**9**	Project Manager	16/05/2022	
R32	**Risk**	Open	Other connections / build at trial sites impact project	Project is delayed and/or requires re-scoping	3	4	**12**	- Understand the expected development activities in the trial areas; and - Coordinate trial preparation with the other on-going activities.	2	2	**4**	Project Manager	16/05/2022	
R33	**Risk**	Open	Delays caused by extended procurement processes	Project is delayed and/or requires re-scoping	4	3	**12**	- Provide Procurement with early visibility of required procurement activities; and - Plan sufficient time to carry out all procurement activities.	2	2	**4**	Project Manager	16/05/2022	
R38	**Risk**	Open	Integrating multi-vendor IEC61850 is harder than anticipated	Project is delayed and/or requires re-scoping	3	4	**12**	- Secure the expertise from the consortium of Partners to ensure the requirements and design are achievable; and - The Partners revise the design and the products / services if necessary.	2	3	**6**	Project Manager	16/05/2022	
R4	**Risk**	Open	Methods do not deliver the anticipated benefits	Lower than anticipated value delivered	**3**	**4**	**12**	- Regularly revise business case to update expected Method costs and expected benefits	**3**	**3**	**9**	Project Manager	16/05/2022	
R46	**Risk**	Open	National Grid equivalent model for impedances and other network parameters is challenging to obtain	Project is delayed and/or requires re-scoping	3	4	**12**	- Understand the specific network parameters which are required for Method 1 and Method 2; and - Plan how these can be provided to the Partners.	3	3	**9**	WS2 Lead	16/05/2022	
R5	**Risk**	Open	Project Partner/Supplier performance is not adequate	Outcomes are delayed, with potential overspend. This may also require a change in partner/supplier as an interim step.	**3**	**4**	**12**	- Ensure shared responsibility for deliverables; - Incentivise partner/supplier for success; and - Ensure tendering/onboarding process focuses on critical project elements.	**2**	**3**	**6**	Procurement	16/05/2022	
R14	**Risk**	Open	Solution has unintended impact on the network causing failure, underperformance, and/or customer equipment failure	Loss of supply, damage to customers' equipment	**2**	**5**	**10**	- Equipment is fully tested off-network; - Sufficient time is included in project plan to resolve any issues fully and re-test; and - No equipment will be deployed on the network into an active trial before it has successfully passed FAT and SAT.	**1**	**5**	**5**	WS3 Lead	16/05/2022	
R15	**Risk**	Open	Catastrophic failure of equipment causes network damage and/or injury	Network equipment is damaged, injury is caused	**2**	**5**	**10**	- Solution consists of mainly software components and the hardware ones cannot fail explosively (substation PC, routers & switches); and - Failure Mode and Effects Analysis is undertaken to ensure such failures are anticipated and designed out.	**1**	**4**	**4**	Project Manager	16/05/2022	

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
R16	**Risk**	Open	IT security standards are not met	Network is rendered open to cyber attack	**2**	**5**	**10**	- Operational Telecommunication integration testing is included in the PNDC trial scope; - Ensure full engagement with IT security team throughout the project; - Key UK Power Networks' security requirements need to be fulfilled before the system is commissioned to our network; and - Ensure test plan encompasses all relevant IT security tests.	**2**	**4**	**8**	WS1 Lead	16/05/2022	
R28	**Risk**	Open	The designs of the project Methods are not innovative	Lower than anticipated value delivered and potentially project is closed	2	5	**10**	- Collaborate closely with all Partners to ensure novel aspects of scope remain in the design; and - Review on-going work in the industry to identify if anyone else has demonstrated key Constellation elements.	1	4	**4**	Project Manager	16/05/2022	
R30	**Risk**	Open	Someone else develop a product which makes Constellation obsolete	Project is stopped or re-scoped	2	5	**10**	- Review on-going work in the industry to identify if anyone else has demonstrated key Constellation elements	1	3	**3**	Project Manager	16/05/2022	
R37	**Risk**	Open	Project Partners/Suppliers do not pass the FAT	Project is delayed and/or requires re-scoping	2	5	**10**	- Work closely with the Partners/Suppliers during the design and development; and - Build in sufficient time to re-iterate the design and development.	2	3	**6**	Project Manager	16/05/2022	
R42	**Risk**	Open	The Open Innovation Competition products break some of the other project elements	Project is delayed and may not be accepted into BAU	2	5	**10**	- Ensure sufficient testing at PNDC before adoption into the DNO network; and - Specify what separation is required for all OIC products to ensure safe operation of other systems.	1	2	**2**	WS4 Lead	16/05/2022	
R51	**Risk**	Open	Bandwidth and network availability for PMU to central server for data gathering is not sufficient for Local ANM	Limited outcomes from the trials	2	5	**10**	- Estimate bandwidth and advise on protocol support; and - Close collaboration during the design stage to ensure design is fit for purpose.	2	3	**6**	WS2 Lead	16/05/2022	
R8	**Risk**	Open	A partner/supplier may withdraw from the project	Partner/supplier must be replaced or project descoped	**2**	**5**	**10**	- Ensure all partners/suppliers are engaged and involved throughout the project; and - Previous engagement with wider industry provides confidence there are a number of potential organisations who can deliver some project aspects.	**2**	**4**	**8**	Project Manager	16/05/2022	
R11	**Risk**	Open	The specification and procurement of the equipment takes longer than expected	Possible delays to the project	**3**	**3**	**9**	- Ensure timescales on the project are realistic and have built-in contingency for high risk elements; and - Undertake regular reviews during high risk and critical project activities.	**3**	**2**	**6**	Project Manager	16/05/2022	
R19	**Risk**	Open	Length of trial period is not sufficient to collate all representative data	Trial is insufficiently representative of potential scenarios with which the solution may be required to cope	**3**	**3**	**9**	- Significant time allocated for testing on the network; and - Off-network testing to simulate various network scenarios.	**1**	**3**	**3**	WS3 Lead	16/05/2022	
R36	**Risk**	Open	Testing scenarios cannot be replicated accurately across the different elements in the project	Limited outcomes from the trials	2	4	**8**	- Prepare a robust trial plan and specify the testing scenarios	1	3	**3**	WS3 Lead	16/05/2022	

12. Accuracy assurance statement

The project has implemented a project governance structure as outlined in our innovation policies and procedures that effectively and efficiently manages the project and all its products. All information produced and held by the project is reviewed and updated when required to ensure quality and accuracy. This report has gone through an internal project review and a further review within UK Power Networks to ensure the accuracy of information.

We hereby confirm that this report represents a true, complete and accurate statement on the progress of the Constellation project in its first six-month reporting period and an accurate view of our understanding of the activities for the next reporting period.

Signed ……

Date ……9 June 2022……

Suleman Alli
Director of Customer Service, Strategy, Regulation & IS
UK Power Networks

13. Material change information

No material changes have been encountered during this reporting period and none are foreseen for the next reporting period.

14. Other information

Currently there is no other information to report to Ofgem.