Constellation

Project Progress Report – July to December 2023

Constellation Partners

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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. Our traditional responsibility will evolve from keeping the lights on, to ensuring consumers can effectively heat their homes and charge their electric vehicles to travel. 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.

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 Distributed Energy Resources (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 DERs by 2050.

Network capacity: The expected increase in DER required to achieve Net Zero will require a 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. 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 a 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 by dedicated hardware, which 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 these complications we will leverage the latest advances in 5G communication and software engineering to enhance our local substations; making them more intelligent, digital and interoperable enabling them to have a 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 Active Network Management – 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.

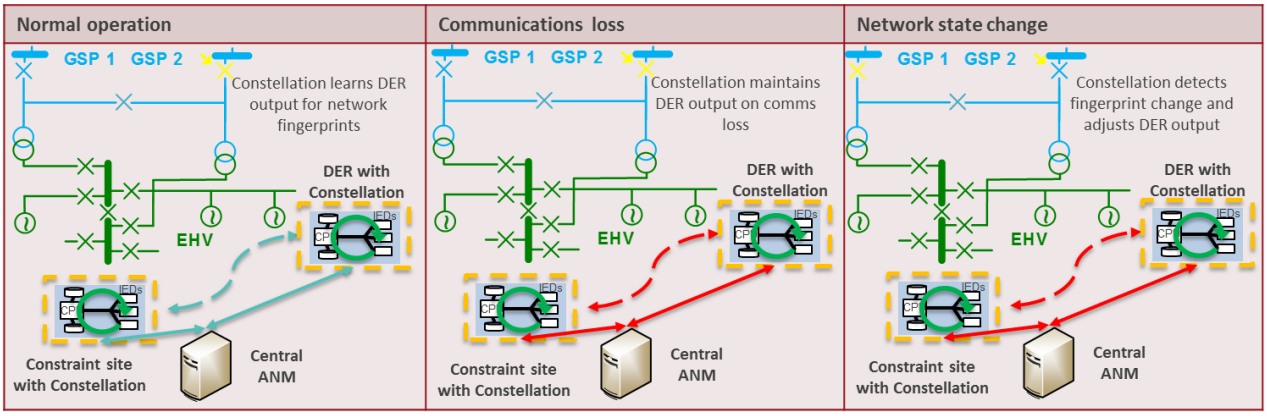

Figure 1-1 - Local ANM (Method 1) summary diagram

- 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.

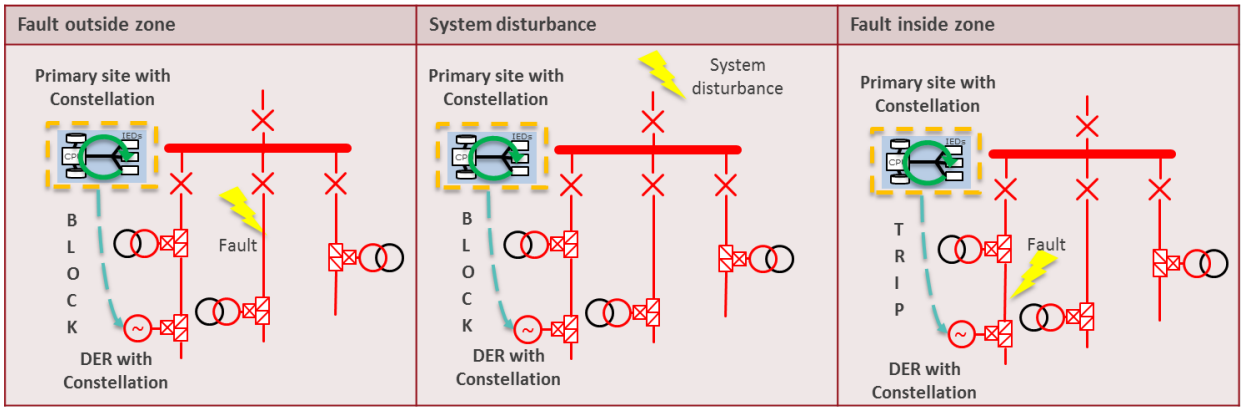

Figure 1-2 - Wide area protection (Method 2) summary diagram

    - 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.

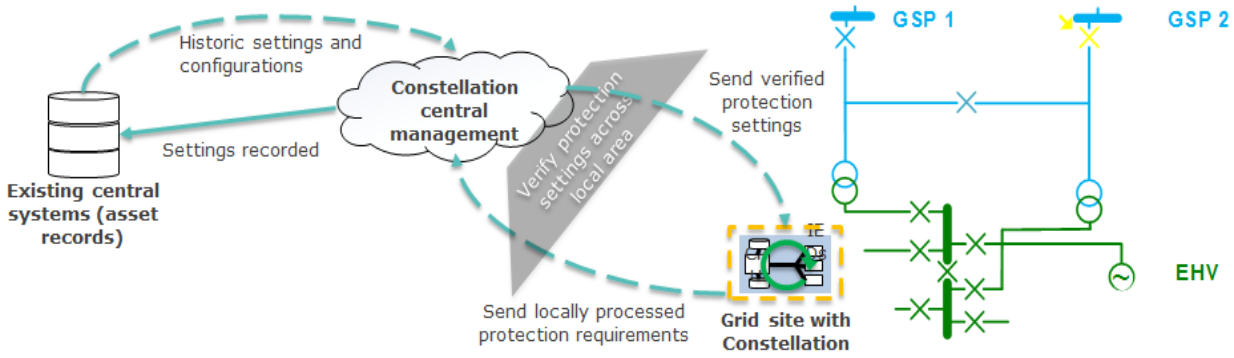

Figure 1-3 - Adaptive Protection (Method 2) summary diagram

Constellation is one of UK Power Networks' flagship innovation projects, which will be delivered between May 2021 and September 2025 in partnership with ABB, GE, Siemens, 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. The project Methods will also enable carbon savings[2] 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 sixth for Constellation, covers the period between July to December 2023. This document, together with the previous six-monthly report, which was published in June 2023, fulfil the reporting requirements of Sections 8.11 – 8.15 of v3.0 of the NIC Governance Document[3]. 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 January to June 2024. 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 in line with the Project Direction. Over this period, the project has successfully:

- Completed and kicked off the PNDC trial;
- Completed full deployment of the central Azure servers;
- Completed the preparation of the digital substation environment at PNDC;
- Finished Maidstone area phase one site works and good progress made on Thanet area;
- Made significant progress in integrating the solutions in PNDC environment;
- Launched the tender for Local ANM and Wide Area Protection;
- Continued engagement with DER owners and operators in the trial areas;
- Preparation of the third project Deliverable, to be issued in late December; and
- Appointed a new Project Lead and a Workstream 2 Lead following successful recruitment exercises.

[2] UK Power Networks Innovation - Constellation – Full Submission Proforma
[3] https://www.ofgem.gov.uk/system/files/docs/2017/07/electricity_network_innovation_competition_governance_document_version_3.0.pdf

- **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. Significant progress has been made, with the landmark deployment of the virtualised environment at the PNDC, which included integration testing and solution demonstrations; the deployment of the final central Azure servers was also completed. A secure method for project partners to remotely access their software during PNDC testing was designed and implemented. The layer two and three substation network designs were refined as part of preparations for the deployment of the substation servers at Maidstone.

- **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 manages the on-site installation and commissioning works, as well as all hardware specification and procurement. This Workstream is on track. This reporting period was marked by the commencement of a new lead responsible for Workstream 2, who started at the end of July. The key achievements include resolving the issues related to the transmission of synchrophasor data to the Local ANM solution, the completion of Maidstone phase one site works, the assessment and update of network architecture within the substation, the development of Merging Units and phasor measurement units (PMU) device configurations, and the progress of site works at Thanet Grid.

- **Workstream 3** is responsible for the design and management of the Constellation trials, which incorporate off network trials hosted at PNDC and live trials hosted on the UK Power Networks' distribution network. This Workstream is impacted by the non-material change request, described in the June 2023 report and summarised in section 2. During this reporting period, the PNDC test environment build has been completed with significant effort invested in implementing the designed Local Area Network (LAN) and Wide Area Network (WAN) (including 5G) communications. Significant progress has been made in integrating the Constellation Methods in this environment. Integration of the Maidstone Wide Area Protection solution has been completed and concluded with a formal Site Acceptance Test (SAT) overseen by Omicron and UK Power Networks. Local Active Network Management (LANM) and Adaptive Protection solutions integration are close to completion with respective SATs carried out over the next three months.

- **Workstream 4** is responsible for running the Open Innovation Competition (OIC), which involves incubating and testing additional solutions for deployment on the Constellation platform. The activities related to this Workstream will start during the upcoming reporting period, and preparations are on track.

- **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 insight activities have been completed by the University of Strathclyde covering protection, virtualisation and 5G communications. The remaining academic insight activities will be scoped and initiated later in the project.

- **Workstream 6** is responsible for the dissemination of the knowledge generated from the project. The Workstream is on track. During this period one co-authored conference paper on the PNDC test environment has been presented in the PACWorld conference in Glasgow. Furthermore, three synopses submitted for the CIGRE 2024 have been accepted. The project has also been presented in four major events before an audience of industry stakeholders, to disseminate the learnings from the project. Additional details can be found in section 2.6.

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, two risks have materialised as issues and are actively being managed by UK Power Networks (as

described in section 4.2). One of the issues was successfully closed in the previous reporting period through a non-material change to Deliverables 3, 4 and 5 under Workstream 3, 4 and 5 respectively.

Since the bid submission, several 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 monthly basis and ensure further mitigations are applied where necessary.

In this reporting period, a key risk being closely monitored is the submission of the project's fourth Deliverable on time. As this Deliverable has a strong dependency on the PNDC trials progressing sufficiently to allow for the passive network operation to commence, there is an inherent risk of delay should any of the innovative technologies being tested at the PNDC generate any unexpected faults or require additional time for re-testing and issue resolution. The project team is managing this risk by establishing a bi-weekly PNDC trial workshop to review test results and effectively agree on any mitigation plans.

2. Project Manager's report

The project has made good progress during the reporting period (July to December 2023), focusing on the following areas:

- Successful kick-off of the PNDC trial;
- The completion of the Maidstone area phase one site works;
- Engagement with partners and DER owners and operators;
- Launched the tender for Local ANM and Wide Area Protection; and
- Management of changes in key personnel.

PNDC Trial Kick-off

Following the completion of the PNDC test environment build and significant progress in carrying out PNDC SATs associated with the project solutions, the PNDC trials phase has been formally kicked-off. A two day in person kick-off meeting held at PNDC brought the project partners together to agree clear ways of working and communicating the outcome of the trials to ensure a successful outcome of this phase – an important prerequisite for the subsequent network trials. To achieve this important milestone, the PNDC team, in collaboration with the project partners, successfully completed the following key activities:

- Full deployment of the substation virtualisation platform including substation servers and configuration of the hypervisors and virtual switches;
- Installation and commissioning of all trial equipment in the PNDC laboratory including communication and test equipment;
- Configuration of LAN using layer two communication equipment in accordance with the UK Power Networks' design;
- Configuration of WAN (including 5G) using layer three communication equipment in accordance with the UK Power Networks' design;
- Completion of the integration testing for the Wide Area Protection solution;
- Completion of the integration testing for Adaptive Protection solution;
- Commissioning of Distributed Network Protocol 3 (DNP3) and IEEE C37.118 protocol interfaces for the LANM solution.

Maidstone area phase one site works completion

During this reporting period, the site works designated for Maidstone phase one have been successfully completed. This plays a crucial role in preparing for the necessary SATs. The site works encompass various design, configuration and commissioning activities as well as installations of additional components on the switchgear to enhance the retrieval of

data, such as current transformers (CT) and voltage transformers (VT). This data is then sent to the substation system hosted within the Constellation cubicle. Currently, the focus within the Maidstone area is on finalising the assembly of the Constellation cubicle and connect all cables according with network architecture, which will facilitate communication among the main devices. Section 2.2 provides additional details regarding site works and the Constellation cubicle in each of the Maidstone and Thanet grid sites.

Engagement with partners

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

- 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;
- Monthly review sessions with all partners to review the plan, risks and issues log; and
- Executive board meetings to ensure senior and executive representatives from each organisation are informed of current progress and can influence the delivery of Constellation.

Methods 1 and 2 tender launch

As part of the preparation for business-as-usual (BAU) rollout, a mini-tender with several selected vendors has been issued. The mini tender is for the procurement of Local ANM and Wide Area Protection to prove interoperability and BAU market options. Learnings from the tender will be used to inform future procurement activities within UK Power Networks and provide an indication of technology and market readiness for Local ANM and Wide Area Protection. The following activities have been undertaken as part of the tender process.

- Tender documentation preparation and review with input from subject matter experts and procurement officers;
- Vendor selection with input from subject matter experts;
- Publishing of the mini-tender;
- Review of submissions from vendors;

Personnel

In this reporting period, recruitment to replace the Workstream 2 Lead has successfully concluded, with a new Workstream Lead being recruited and joining the team to take over all the associated activities within Workstream 2. Additionally, both the Project Lead and Workstream 1 Lead have transitioned to new roles within UK Power Networks. Recruitment to replace the Project Lead successfully concluded in this reporting period and a new Project Lead has taken over all relevant activities. Recruitment to replace the Workstream 1 Lead is still ongoing and the aim is to onboard a new member at the start of next year. All activities which were led by the Workstream 1 Lead were handed over to a number of colleagues internally within UK Power Networks.

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 the PNDC who will test all Constellation elements.

Progress during this reporting period

Architecture and integration

The architecture and integration activities include the development and implementation of the overall Constellation architecture and identification of integration requirements.

The remote connectivity required to enable project partners to remotely access and manage their virtual machines (VM) at the PNDC facility was also approved and implemented, the summary architecture is shown in Figure 2-1. The architecture required the use of an Internet Protocol Security (IPSec) VPN tunnel between UK Power Networks' corporate network, and the PNDC's internal network to allow users to access the virtual machines deployed on the substation server at the PNDC. This link will be used throughout the project to facilitate the development and testing of solutions before they are deployed to the designated testing sites on UK Power Networks' distribution network.

The architecture for the substation network was reviewed and redesigned during this reporting period, with the aim of improving the design and ensuring the layer two network is resilient and secure. This activity was initiated by UK Power Networks, with Siemens (Ruggedcom) providing professional services and consultancy. The resulting redesigned and improved network architecture has been implemented and tested at the PNDC, with a similar activity planned for UK Power Networks' trial sites during the next reporting period. Hardware for the layer two and layer three networks was also procured during this reporting period.

Central servers

The central servers store the data and additional software required for the Adaptive Protection and Local ANM solutions. During this reporting period, the primary focus was on deploying, configuring, and troubleshooting the deployment of the central servers for Adaptive Protection and the redeployed central servers for Local ANM.

The central servers for Adaptive Protection consist of two servers, one for the management of power system models, and a second for the central management of protection settings. The power systems model management server consists of a Microsoft SQL database server which was deployed and configured on the UK Power Networks' active directory to enable database administration, and additional software for communications and data processing. The central management server is a Linux-based server needed to communicate with a protection settings management virtual machine on the substation server. The Adaptive Protection central servers are currently being used for the PNDC trials via a secure IPSec VPN tunnel.

During this reporting period, the deployment and integration of the Constellation central servers on Azure was completed. This included the central servers for Adaptive Protection, which were approved during the previous reporting period. With the deployment of the Adaptive Protection central servers completed, the core integration of the central servers for Constellation trials has been completed. Some additional integration with UK Power Networks' business systems will be required for BAU operation, and this integration is planned for the first half of 2024.

The Local ANM central servers were redeployed to a different environment, which is suitable for long term testing. Once redeployment was completed, the data stream between Maidstone and UK Power Networks was reestablished and retested successfully.

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 localised Constellation solutions.

The virtualised environment was implemented and tested during the previous reporting period. During this reporting period, the virtual machines were tested and subsequently updated to resolve any issued identified during those tests where required. PNDC substation server integration was also completed in preparation for the PNDC trials.

The implementation of an alternative virtualisation solution within a test environment has been postponed due to resourcing mobilisation for Workstream 2 and the Project Lead, as well as prioritising preparations for testing at the PNDC. There was also a delay in the delivery of the substation server to Maidstone Grid substation due to the layer two and three network redesign work. This delay was managed by the project team to ensure no impact on the project plan occurs.

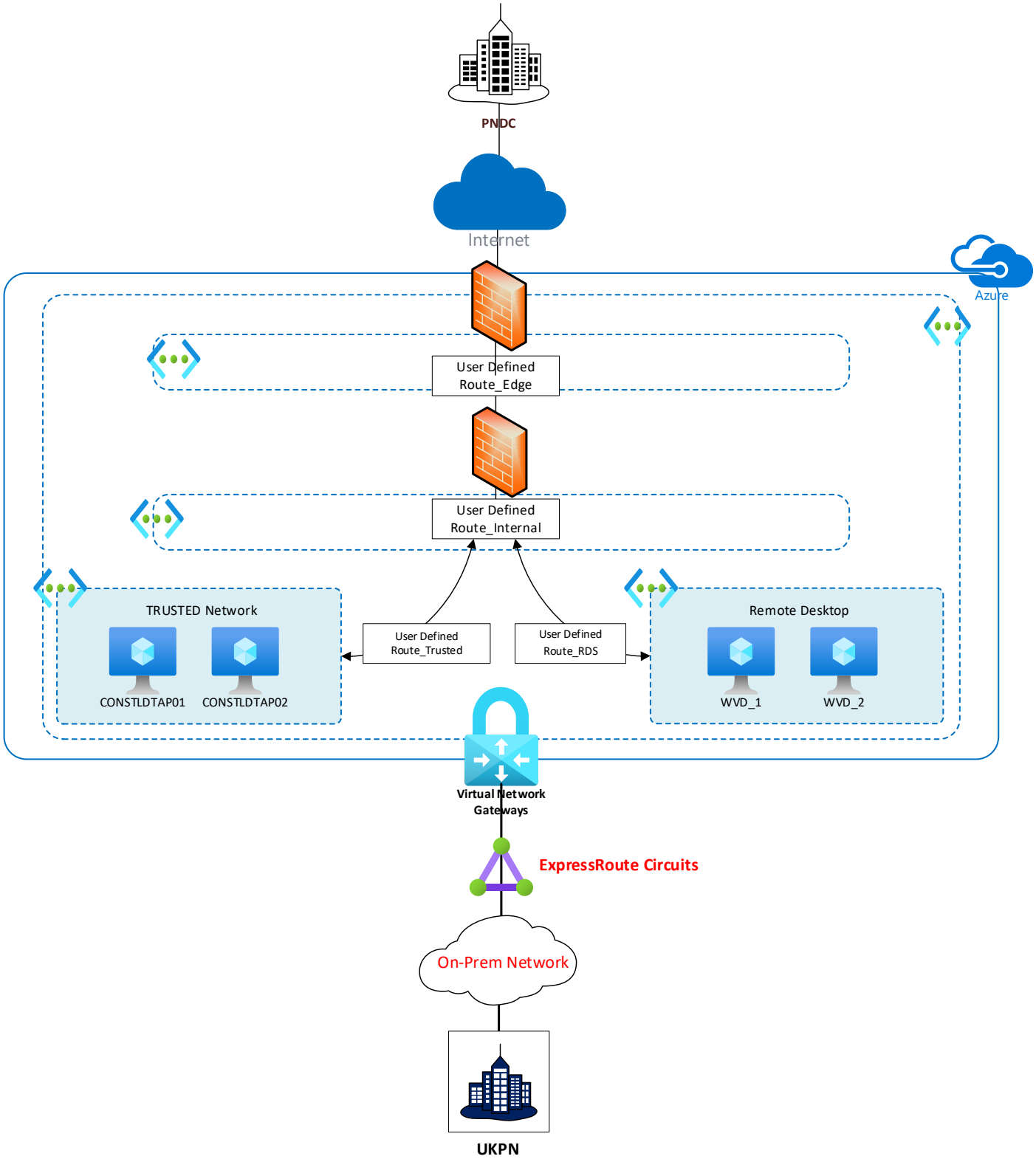

Figure 2-1 - IPsec VPN tunnel

During the next reporting period, the virtualised environment will be deployed to the substation server in Maidstone in preparation for the network trials at UK Power Networks and the testing for the alternative virtualisation solution is due to restart after the new Workstream 1 Lead has been recruited.

Site-to-site communications

The 5G communications link will make use of public 5G infrastructure to enable fast, secure, and scalable site-to-site communications for messages used in Wide Area Protection and synchrophasor data (as IEEE C37.118) 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. For the purposes of the Constellation trials, dedicated 5G coverage will be deployed in the trial locations, where the public 5G network is not available within the project timescales (more details in section 2.2).

During this reporting period, integration testing for the PNDC trials kicked-off, and as part of the integration testing process, the 5G slice has been used to send Generic Object Oriented Substation Event (GOOSE) messages from site to site. This activity has been useful for the further development and optimisation of the 5G slice, with minor packet loss issues (data failing to arrive at destination) being identified and investigated as part of the testing ahead of the network trials.

Cyber security

Constellation will introduce several cyber security mitigations to ensure the solution is secure, functional, and scalable. During this reporting period, the primary focus has been on starting the implementation of Role-Based Access Control (RBAC) for access to UK Power Networks' Azure servers and user accounts required for remote access during the PNDC testing.

Constellation will be implementing approximately eight distinctive virtual machines distributed between UK Power Networks' central Azure estate and the substation server. Each virtual machine has different access, authentication, and connectivity requirements, which necessitates the creation of unique team groups. The team groups have allowed for the separation of users based on organisation and role, this has greatly improved user security and kept the project compliant with internal UK Power Networks' standards for RBAC.

As part of the project, a Privileged Access Management (PAM) system will be implemented at a later stage, this will enable the access and central management of Constellation virtual machines via a standard user database.

During this reporting period, the primary activity has been the design and implementation of a secure IPSec VPN tunnel between UK Power Networks and the PNDC. The IPSec VPN tunnel is a crucial requirement for the management and development of Constellation solutions at the PNDC, but ensuring the link remains secure and reliable was the focus. The remote connection provides a segregated active directory group, which allows each partner to securely connect to their virtual machines at the PNDC without interacted with other virtual machines or devices on the network.

Ensuring a secure and reliable link required extensive consultations with UK Power Networks' security, firewall and infrastructure management team and the PNDC's networking and cyber security experts. A detailed architecture was drawn up and approved, then the required firewall rules were identified and implemented, RBAC was implemented using Windows Active Directory to define user roles and segregate user interactions.

Challenges and lessons learned

Architecture and integration

The remote connectivity architecture was designed and implemented during this reporting period. There were significant challenges during the testing phase, and coordination between endpoint configuration parameters. This lengthened the time required between the firewall rule changes and establishment of connectivity between UK Power Networks and the PNDC.

Central Servers
Ensuring the PMU streams from the Maidstone substation servers could reach the Azure server proved challenging. Weeks of troubleshooting the link between the substation and Azure eventually revealed that the PMU data stream was not recognised as IEEE C37.118 synchrophasor data traffic by the central firewall although a limited amount of data was being allowed through the firewall for a limited amount of time.

This experience has demonstrated the necessity of understanding how the specific firewalls recognise which traffic to block, whether it's by port, IP address or traffic type.

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

- Commissioning of layer two and layer three networks at Maidstone Grid substation;
- Delivery, configuration and testing of the substation server for Maidstone Grid substation;
- Integration testing for central Azure servers with Maidstone Grid substation servers; and
- UK Power Networks' trial preparation in readiness for Deliverable 4.

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

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

- Hardware requirements: in line with IEC 61850-3 and applicable national standards;
- Method 1: deployment of Local ANM functionality at the trial sites;
- Method 2: Wide Area Protection functionality: islanding prevention and response to voltage and frequency events. This includes virtual protection functional requirements: provision of protection and control functions that run in a virtual platform at the substation server; and
- Method 2: Adaptive Protection functionality: automatic update of protection settings via IEC 61850 Multimedia Messaging Service (MMS) protocol. This includes the 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 solutions
The design of the Constellation solutions was approved in early 2022 and revised in the last reporting period as part of the preparations for the Factory Acceptance Testing (FAT). During this reporting period, design updates have been implemented for all solutions. These design changes were an outcome of the learnings from each FAT, which are described in Deliverable 3. With Constellation being a highly innovative project, it is anticipated that the design will continue to be continuously improved and updated as more testing is carried out.

Trial preparation
The trial preparation activity for Workstream 2 is focused on preparing the two trial areas in UK Power Networks' distribution network for the Constellation trials, starting with hardware installation in Maidstone and followed by Thanet. The work is delivered sequentially to alleviate operational resource limitations as well as to allow learnings from site works to be implemented in the following sites and improve the project efficiency.

We have planned to split the work in the Maidstone area into two phases due to space restrictions on site, which require more time to resolve as we need to safely decommission some existing equipment before we can install the new equipment. By splitting the work in two phases, we can commence the trials in UK Power Networks' distribution network without any delay:

- Phase one: installation of all the Constellation equipment required for the passive trials. The passive trials will allow the demonstration of the Constellation solutions, without allowing them to directly control the live electricity network. This activity was completed as part of this reporting period.

- Phase two: installation of all the Constellation equipment required for the active trials. The active trials will allow the Constellation equipment to directly control the distribution network. This phase is scheduled for the second quarter of 2024.

Unlike Maidstone, the Thanet Grid substation does not have the same space restrictions. Therefore, all the work for phase one and phase two will be conducted simultaneously.

Site design

In order to prepare the trial areas (Maidstone and Thanet) for the Constellation trials, the electrical and civil work in each individual site needs to be designed. The site design has focused on production of drawings to support site works. For each device and panel these include AC schematics, DC schematics, device application diagrams and general arrangement drawings.

During the last reporting period, the design for phase one site work in Maidstone was completed, and progress was being made for Thanet. In this reporting period, the site design for the Thanet Grid is completed, with only the design for the DERs sites in the Thanet area planned for next reporting period.

We have also updated the network architecture design including the Remote Terminal Unit (RTU) device and one PMU device in the architecture. Additionally, we changed some connections between layer two switches and redundancy box (Redbox) in the architecture. This enables Single Attached Node (SAN) devices to be connected to the redundant PRP network.

Configuration of protection relays, merging units, and PMU devices

In this reporting period, there was significant progress on the configuration of protection relays, merging units, and PMU devices for each trial area:

Maidstone Grid Area:

- ABB has completed the configuration of the ABB merging units for phase one, and this configuration is currently under testing in the PNDC trials.
- UK Power Networks has configured the GE merging units (for Maidstone Grid) and the Siemens PMU/merging unit (for DER site).
- UK Power Networks has also configured the GE PMU device and the GE Phasor Data Concentrator (PDC).

Thanet Grid Area:

- ABB has completed the configuration for Thanet, which is currently under review by UK Power Networks, this will also be tested in the PNDC trials in the next reporting period.
- UK Power Networks has configured the Siemens MU/PMU devices.

The configuration of devices for Maidstone phase two and Siemens PMU/MU devices for DERs in Thanet is planned to be completed in following reporting periods.

Installation and commissioning

Site works encompass all modifications and actions necessary to deploy and put into operation the required Intelligent Electronic Devices (IEDs) for the Constellation project. These activities must adhere to the site designs for each bay. The following tasks are the most important activities of the site works:

- Install new IEDs and the auxiliary components: the items classified as auxiliary components are Miniature Circuit Breakers (MCBs), test blocks, terminal blocks, auxiliary relays. They are important for the connections between the switchgear components and IEDs;
- Wire all electrical connections: Ensure correct wiring between the devices mentioned above and the switchgear components (CTs, VTs, Circuit Breakers, Disconnectors), power supply, etc;

- Deploy communication cables: Install fibre optics and/or patch cords to enable IEDs to connect with other devices via the Constellation network;
- Load the latest configuration to the IEDs; and
- Test and validate if the equipment and connections were deployed properly.

It is important to emphasise that conducting the site works requires scheduling outages for the bays under work. The sophisticated coordination activity requires extra care to avoid affecting the existing protection and control systems in operation and impacting the supply of electricity to customers.

During this reporting period, the installation and commissioning of the IEDs and auxiliary components of Maidstone phase one have been completed. In Thanet Grid, five feeders and four income feeders have also been completed, leaving 10 feeders and one bus section to be completed in the next reporting periods. In summary we have completed:

- The site works for two 33kV incomers, two 33kV bus sections and nine 33kV feeders in Maidstone Grid;
- The site works for the DER site in the Maidstone area; and
- The site works for four 33kV incomers and five 33kV feeders in Thanet Grid.

Figure 2-2 displays two switchgears of the Maidstone Grid, while Figure 2-3 shows two switchgears of the Thanet Grid. It is important to note that in the Maidstone Grid one, only one ABB device is currently deployed. The second ABB device will be deployed during the Maidstone phase two implementation.

The plan is to continue with site works in Thanet Grid next year. The commencement of Thanet DERs sites will follow sequentially after the completion of the Thanet Grid.

Constellation cubicle

Constellation cubicle is an essential part of the smart substation developed in Constellation. The purpose of the cubicle is to house key equipment required for the Constellation solutions. The main parts housed in the cubicle are:

- Layer two switches;
- Layer three switch;
- Redundancy box (Redbox), responsible for connecting Single Attached Node devices (SAN) to Parallel Redundancy Protocol (PRP) networks;
- GPS time server clock;
- Omicron testing devices;
- Substation servers (each containing one Virtual Machine for each solution);
- 5G router; and
- PMU device.

The Constellation cubicle also hosts the communication network, enabling communication between the devices listed above, as well as the merging units and protection devices installed in the bays. Additionally, it facilitates communication with other substation servers in neighbouring sites. Given these functions, the Constellation cubicle is considered an integral part of all solutions and therefore requires detailed and extensive testing.

Figure 2-3 - New devices deployed in Maidstone Grid

Figure 2-2 - New devices deployed in Thanet Grid

The assembly and commissioning of the Constellation cubicle are currently in progress in both Maidstone and Thanet, with the Maidstone Grid in a more advanced phase and the Thanet Grid in a commencement phase. The project team is currently focused on completing all the necessary works to commission the cubicle in Maidstone so that passive operation can commence and the learnings from this exercise can be used to streamline activities in the remaining sites.

Table 1 below contains a short list describing the primary activities outlined in our plan for Constellation cubicle, currently being implemented in Maidstone. These tasks are forecasted to be completed within the upcoming reporting period. As stated above, activities in Maidstone will be used as a baseline to review and revise as required the works and durations associated with every activity. It will also allow the project team to identify the optimal sequence of activities and to benefit from parallelisation wherever possible.

Table 1 – A short activity list to put Constellation Cubicle in operation.

Activity List (tasks are not strictly sequential, as some are carried out in parallel)		**Status**
Activity 1	Install the cubicle in a suitable location within the substation	Complete
Activity 2	Install the devices in the cubicle	Complete
Activity 3	Power up devices	In progress
Activity 4	Purchase patch cords and fibre optic cables based on the network architecture	Complete
Activity 5	Configure layer two switch/s	Not Started. Waiting for power up devices
Activity 6	Configure Redbox	Not Started. Waiting for power up devices
Activity 7	Configure GPS (Meinberg)	Not Started. Waiting for power up devices
Activity 8	Configure layer 3 switch	Not Started. Waiting for power up devices
Activity 9	Mount network – The patch cords and fibre optics will be connected, assessing the performance of the network	In progress

5G coverage

Trial preparations also include ensuring that all trial sites have sufficient 5G coverage. To achieve this, Vodafone is carrying out site work to connect our locations with their 5G communications network. In the previous reporting period, we reported that the provision of the 5G network had been completed for Maidstone Grid, Thanet Grid and two (of the four) Thanet associated DERs.

In this reporting period, the deployment and integration of 5G network have successfully finished for an additional DER site belonging to the Thanet area, leaving only one Thanet DER site outstanding. Works on the last site will be carried out in parallel with UK Power Networks site works in this location next year.

Figure 2-4 - Vodafone 5G cubicle installed at the Maidstone Grid 33kV telecoms room

Standards, procedures and approval documents

In order to ensure the resilience and safety of the electricity network, Asset Management has a policy to document the approval, design and configuration of any new devices being introduced on the live network. These documents come in the form of internal standards. In this reporting period, the design documents submitted for review include IEC 61850, an international standard defining communication protocols for intelligent electronic devices at electrical substations. These documents dictated functional specifications for 33kV bays, a dedicated document for each type of bay, using merging units and centralised protection solution. These documents detail and illustrate the following information:

- Illustration of electrical connections between the merging units and switchgear components (CTs, VTs, Circuit Breaker and Disconnectors).
- Processes detailing how merging units handle data received from switchgear, allocate IEC 61850 addresses, and transmit this data to centralised protection devices.
- Explanations of how centralised protection devices receive and process data from merging units, allocate IEC 61850 addresses, and then transmit data back to the merging units.
- Descriptions of the actions undertaken by merging units upon receiving data from centralised protection devices, such as the operation of binary outputs and LEDs

IEC 61850 functional specification documents are important for generating an understanding of the configuration of merging units and centralised protection devices. They also support the commissioning and maintenance tasks associated with this system. Activities such as this are key to facilitate the BAU transition of Constellation once the project has been proven successful. This also ensures that the knowledge gained and expertise are not linked to individuals, which may put the project at risk due to movement of personnel.

Provision of data – Data for Local ANM

The data requirements from Local ANM's design include synchrophasor data at the low voltage side of the transformers in grid sites; and at each DER site. To achieve this, UK Power Networks is deploying PMU merger units and PDC to collect measurements data and produce standard IEEE C37.118 synchrophasor data. These data streams will then be sent to the Azure server which is provisioned for Local ANM.

In the previous reporting period, all the connections were established, however we were facing some issues to send PMU data. During this reporting period, we managed to understand the configuration and communication issues and update the settings to enable the transmission of PMU data to Azure Server. Furthermore, in this reporting period, two PMU data streams from Maidstone Grid 11kV South are successfully being transmitted to Azure Server.

It is anticipated that as soon as the Network architecture is completed in Maidstone Grid, we will be able to send PMU data from income feeders of 33kV Maidstone Grid. The next steps involve initiating the transmission of PMU data from Allington Waste and the Thanet Grid.

Omicron Training

During September, Omicron provided a training session for UK Power Networks' staff on the following topics:

- Basics of the IEC 61850 standard with a focus on GOOSE protocols, MMS, and sampled values.
- Omicron tools – CMC356, IED Scout and Station Scout – and how they can be used to assess the operation of IEDs and RTUs.

Figure 2-5 - Omicron training structure

In the upcoming reporting period, Omicron will provide an additional training session for UK Power Networks' staff, covering advanced topics related to the assessment of an IEC 61850 network and the use of additional Omicron assessment tools.

The training is essential to ensure the project team and operational teams have the capability to work with the novel protection and control functions in the digital substations.

Challenges and lessons learned

Site works

Scheduling outages with DER site owners are complex as additional engagement and notices of outage need to be considered. To mitigate this, we have been engaging with site owners continuously through the project to make them aware of the upcoming outages and mitigation measures that we have implemented.

Data provision

The provision of PMU data to GE for the Local ANM solution is still ongoing. We have encountered three technical issues that were preventing the transmission of PMU data to the Azure Server:

- Data saturation on GE PMU and PDC ports: High data volumes flowing through the PDC and PMU devices were causing communication losses and, consequently, operational failures. To address this issue, we created rules on the switch to filter and release only the necessary data traffic on the ports of these devices, effectively resolving the problem.

- Failure in Spontaneous UDP communication between the Maidstone PDC and the Azure Server: The Azure server was receiving data for only a few seconds before the communication suddenly broke. There was a rule on the firewall blocking this communication.
- Incorrect configuration of two Merging Units on the same network with identical IEC61850-9-2LE parameters: We resolved this by adjusting the configuration of one of the Merging Units and modifying the PMU configuration to receive the new Sampled Measured Values (SMV) data.

Network architecture

A reliable and stable layer two network is a crucial factor for the success of the solutions developed as part of Constellation. Despite our confidence in the network architecture design and the plan we have created for configuring switches, GPS, and Redbox in Maidstone, it is essential to conduct key tests to validate that the network is set up correctly and in a stable manner. This will help mitigate potential errors during the SAT. It is also important to gather all the lessons learned from this phase so that they can be efficiently applied to Thanet area.

Outlook for next reporting period

The next report will update on progress on site works and preparation for trials on UK Power Networks' distribution network. The items to be included in the next report:

- Update on site works regarding the installation and commissioning of merging units in the Thanet area;
- Update on training for protection functions, IEC 61850 protocols and Omicron tools;
- Preparation for the UK Power Networks' network trial, especially related to Network architecture;
- Update on the designs, site works, and procurement activities for the DER sites.

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 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 the Figure below.

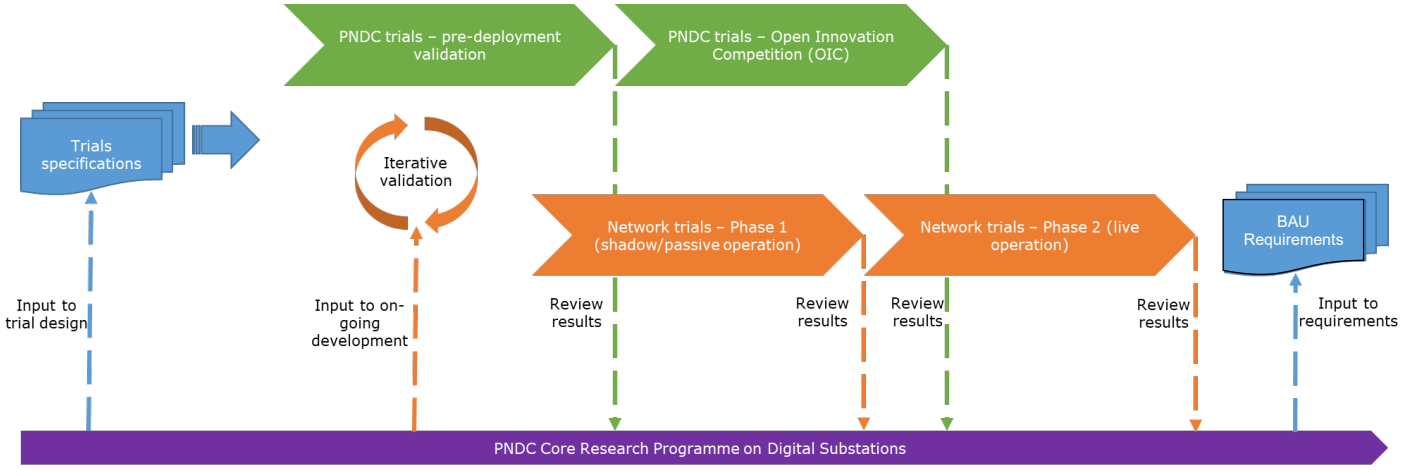

Figure 2-6 – Constellation trials process

Progress during this reporting period

PNDC trials environment build

To achieve the PNDC off-network trials objectives, the following design principles guided the PNDC trials environment development and implementation:

- **Realism:** in order advance the TRL of the project during PNDC trials, the trials environment as well as designed test must be realistic. That is, it makes use of the same equipment, architecture and software solutions as intended for deployment in the live substation. Consequently, lessons learned from this phase can be transferable to the field.
- **Flexibility:** performing trials in PNDC at an early stage in the project allows the investigation of various functional and performance related aspects of the implemented solutions that are not envisaged to be experienced during field trials. This is afforded by the use of the Real-Time Digital Simulator (RTDS) to run standard and non-standard network running arrangements, in addition to modelling DER assets or control modes that are not currently operation but could be in the future.
- **Scalability:** the focus of the PNDC trials is to de-risk the functionality and performance of solutions developed during the project. Therefore, installing a full complement of substation IEDs used in the trial network is not necessary nor practical. By making use of the RTDS it is straightforward to implement additional virtual IEDs publishing (generate) or subscribing (receive) to process bus packets (the same applies to PMU streams). Additional equipment such as stacks of layer two switches could also be readily introduced if necessary to investigate aspects such as link aggregation and redundancy.

Work undertaken to install the Constellation equipment in the PNDC laboratory aimed to create a flexible and small footprint, whilst maintaining a realistic digital substation environment so that trials can be undertaken effectively for the duration of the project. In this reporting period, two racks were installed at PNDC – one is for grid site equipment and the other is for DER site equipment. Additional pieces of test equipment were spread across both. Having both racks in the same space allows for more efficient integration and troubleshooting. The Final PNDC trials environment installation is shown in Figure 2-7.

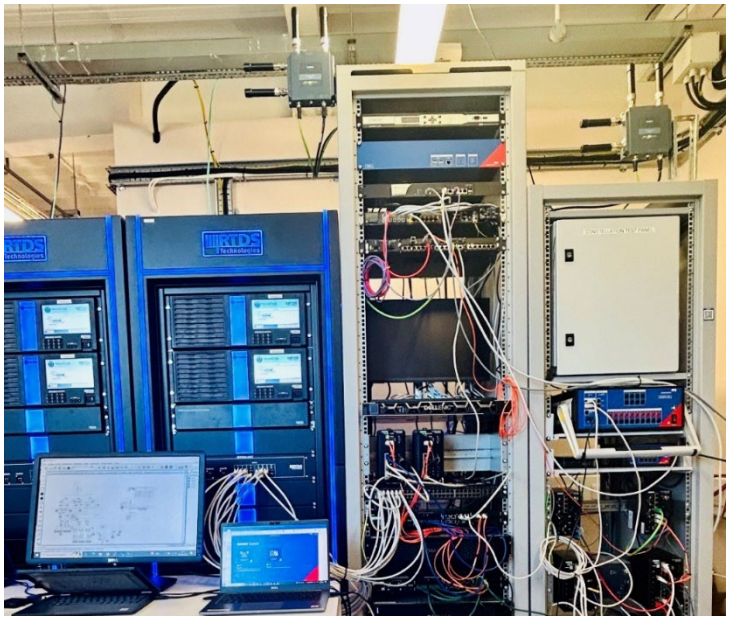

Figure 2-7 - Constellation PNDC trials environment consisting of RTDS, substation and test equipment

Moreover, 5G coverage at PNDC was achieved using equipment installed by Vodafone as shown in Figure 2-8 and 5G communication with the substation equipment is achieved using the Siemens Scalance MUM 856-1 router shown in Figure 2-9.

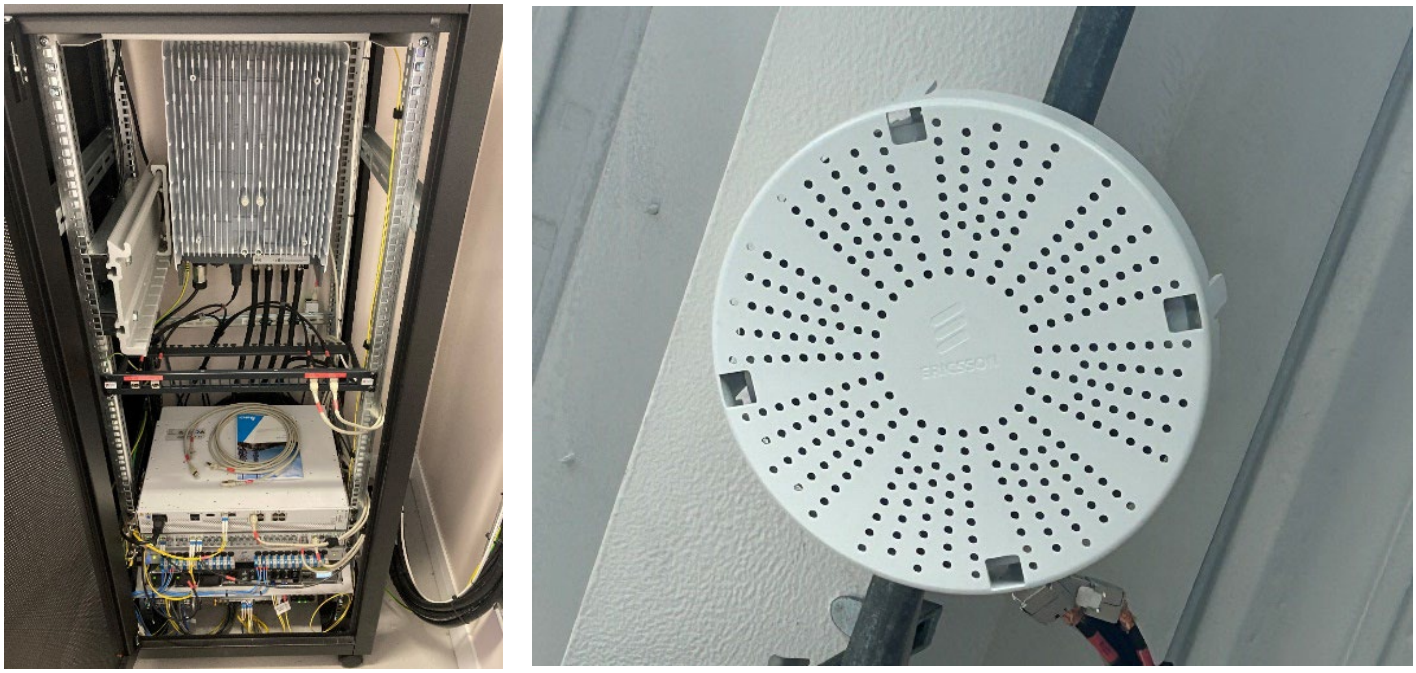

Figure 2-8 - 5G rack and dot installed by Vodafone to provide 5G network coverage at PNDC

Figure 2-9 - Siemens Scalance MUM 856-1 5G router

Solution integration testing (PNDC SATs)

In this reporting period, a significant collaborative effort between all project partners has been invested in the deployment and integration of the project's solutions in the PNDC trials environment. This integration included the following key activities:

- Set up of LAN and WAN communication networks including Layer Two Tunnelling Protocol (L2TP) tunnels between DER and grid site equipment using both fibre and 5G links;
- Establishing secure remote connectivity between PNDC and UK Power Networks' Azure cloud to enable secure remote access for project partners to their respective pieces of software deployed in virtual machines;
- Configuration of IEC 61850 test equipment for monitoring GOOSE and SMV traffic for the purposes of verifying the test configuration as well as troubleshooting communication integration issues;
- Commissioning of DNP3 interfaces of a physical UK Power Networks' RTU (shown in Figure 2-10) for use in LANM testing
- Set up of RTDS GOOSE, SMV, DNP3 and PMU interfaces for publishing/streaming and subscribing to/receiving signals specified in the substation design and trials specification.

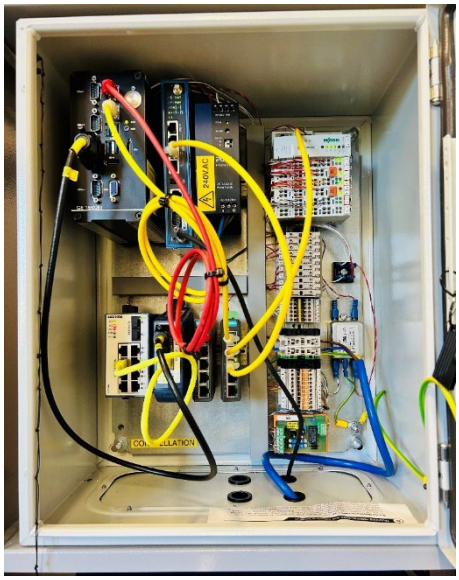

Figure 2-10 - DER site RTU deployed at PNDC for LANM testing

At the time of writing this report, the integration activities for the Maidstone Wide Area Protection solution have been completed and formally concluded with a SAT. The integration testing procedure was specified by Omicron based on the defined interfaces for this solution. All relevant signals for Wide Area Protection at PNDC have been monitored and documented for approval by UK Power Networks. Figure 2-11 shows the GOOSE intertrip message received from at DER site during one of the SAT checks. Intertripping means that as a trip signal is received at the receiving end relay, it is directly transferred to the circuit breaker for operation. The PNDC SAT was overseen by colleagues from Omicron (see Figure 2-12).

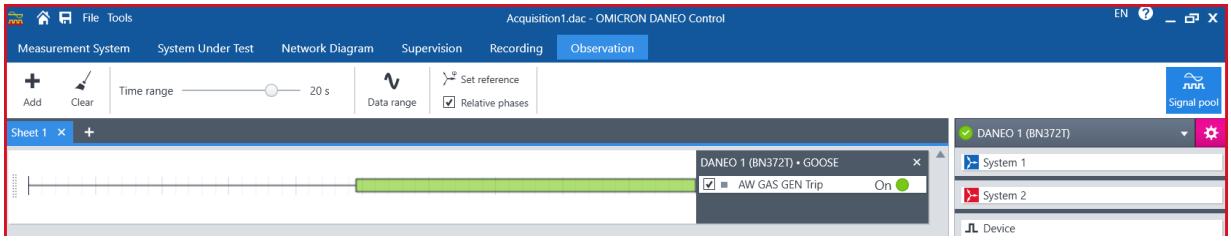

Figure 2-11 - DER site intertrip receive signal verification

Figure 2-12 - Project team carrying out integration testing at PNDC

SATs for the LANM and Adaptive Protection Methods are scheduled for completion in the next reporting period and are currently at an advanced stage of integration.

Constellation trials launch

PNDC hosted the first project wide in-person meeting on 18th and 19th October in order to officially launch the PNDC trials phase of the project (see Figure 2-13). All project partners were represented and the objectives of the meeting were to:

- Provide an overview of the implemented PNDC trials environment;
- Demonstrate PNDC testing methodology to collect early feedback prior to trials commencement;
- Agree a framework for communicating test outcomes, their approval, resolution of issues and translation into successful live network trials. A workshop took place during the first day of the meeting to define this framework. The workshop discussions were documented in a mind map (depicted in Figure 2-14); and
- Ensure continued close engagement between project partners using PNDC trials as a vehicle to promote this.

Figure 2-13 - Project partners participating in the PNDC trials launch workshop

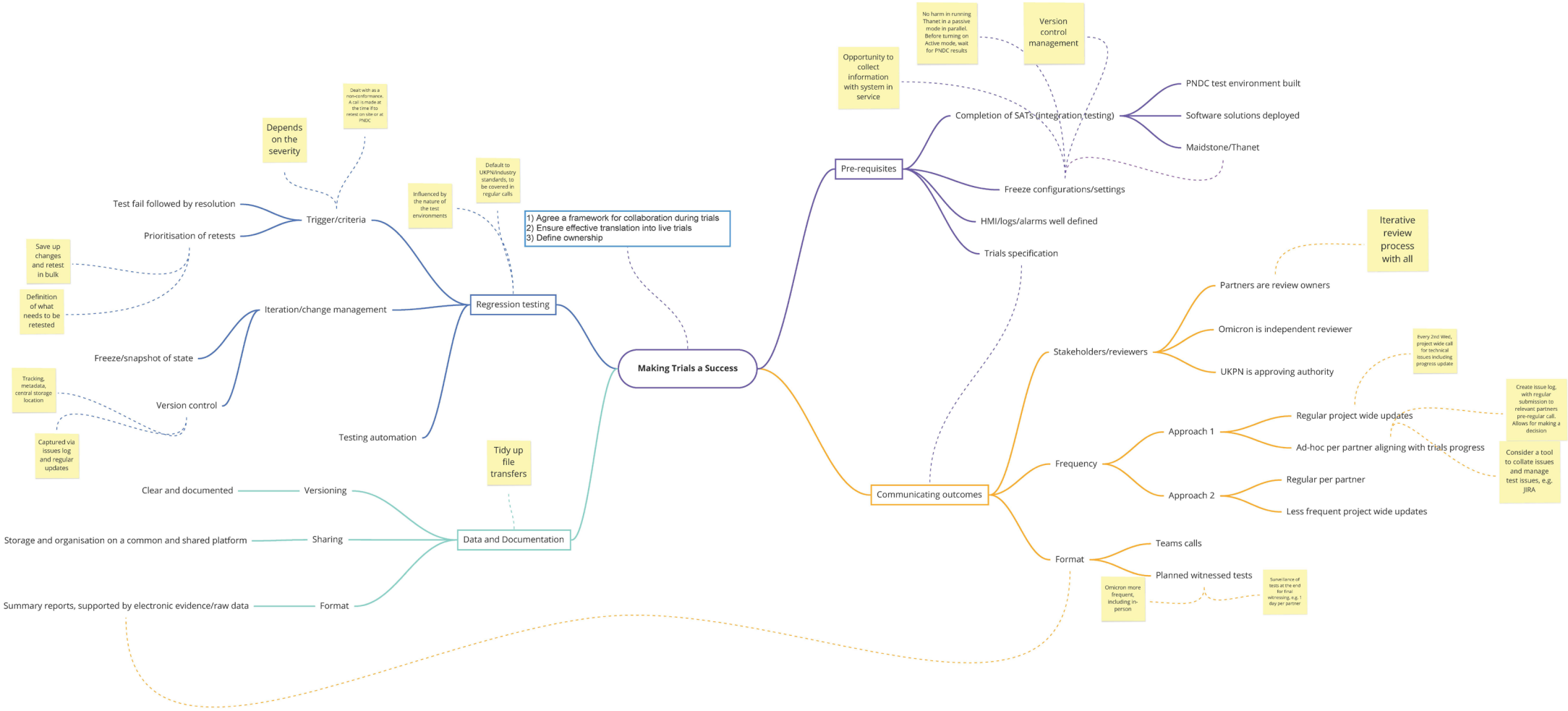

Figure 2-14 - Mind map summarising workshop discussions

Challenges and lessons learned

During the preparations for the PNDC a number of challenges were faced and resolved. The following lessons were learnt:

- Configuration of the virtualisation hypervisor is key to ensuring proper hardware resource allocation for various VMs. This was particularly the case for time-synchronisation via a dedicated physical network interface controller for the SSC600 VM. Although a dedicated NIC may be configured for pass-through (i.e., for exclusive use by the VM), additional VM settings in the hypervisor may override this for Precision Time Protocol (PTP) if not disabled. As such, using the virtual switches within the hypervisor for PTP dissemination is not suitable.
- Virtual local area network (VLAN) configuration and consistency is important for ensuring traffic is switched properly within the network. This also applies to the virtual switches in the hypervisor as it may block the transmission of process bus traffic if there is a misconfiguration in VLAN IDs. Essentially, the virtual switches in the hypervisor must be considered as part of the LAN design similar to physical switches.
- In a digital substation environment where most connectivity is via ethernet, the use of advanced visualisation and analysis tools/equipment that are compliant with the IEC 61850 standard is paramount and preferred over traditional packet sniffing. It not only presents the data exchange in a human readable form, but also verifies data integrity against a reference SCD file. Thus, ensuring interoperability between connected devices (physical or virtual).

Outlook for next reporting period

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

- Conclusion of all PNDC SATs for all Constellation solutions for both Maidstone and Thanet configurations.
- Commencement of PNDC trials as per agreed trials specification including regular communication of outcomes and resolution of issues.
- Completion of virtualisation platform test specification and agreement of testing approach with project partners.

2.4 Constellation 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 planned start for this Workstream was towards the end of this reporting period. However, due to the non-material change request and changes in personnel in the project team, the Workstream activities are anticipated to start during the upcoming reporting period. Although, the project team have continuously engaged with the industry to informally gauge interest. During these discussions, suppliers have provided suggestions on additional solutions that can be implemented as part of the OIC.

Challenges and lessons learned

The Workstream activities are anticipated to start during the upcoming reporting period.

Outlook for next reporting period

The Workstream activities are anticipated to start during the upcoming reporting period. However, stakeholder engagement and wider dissemination of the Constellation project will continue in an effort to prime potential suppliers.

2.5 Workstream 5 – Academic Insight & Future Governance

Workstream 5 is fundamental in ensuring that the 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

After the successful completion of the two academic insight activities delivered and reported on by the University of Strathclyde in a previous reporting period (January – June 2022), the project will launch two more activities later in the project.

Outlook for next reporting period

The remaining academic insight 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 2-15 below. We have completed the planned dissemination activities in the roadmap so far and have carried out several others in addition. Further details are presented in the section below.

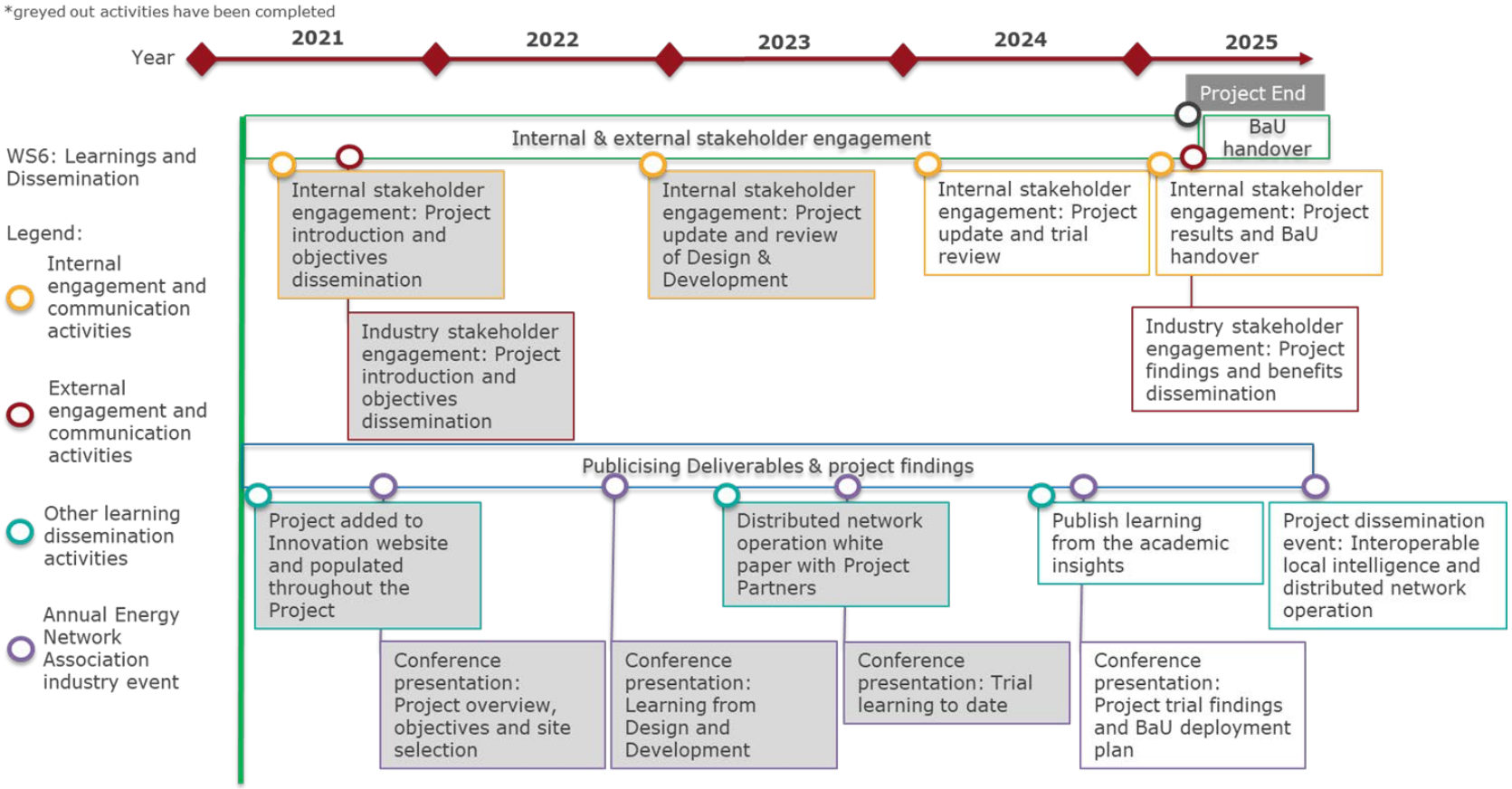

Figure 2-15 - summarising workshop discussions

Progress during this reporting period

The following key activities have been carried out:

Engagement and communication activities

- **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. In this reporting period, a survey for gathering information on technical characteristics of DERs was provided to DER owners, the responses in this survey will be used to more accurately model DERs for PNDC testing and fed into project learnings and insight. A general project update was also provided to each individual DER owner.

- **Technical dissemination**:

The Workstream 3 Lead is a member of the "Power System Relaying and Control Committee (IEEE PSCCC P21 – PSRC I49)" for creating a "Roadmap for Developing New or Updating existing IEEE Standards to Address Issues of Centralised Protection and Control (CPC) Systems", under which one of its core activities is standards related to CPC virtualisation.

- **Presentations**:
  - Presentation during the PNDC 10th anniversary conference to an audience of industry stakeholders including DNOs and technology developers. The presentation focused on using the Constellation collaborative approach to continue development in the area of digital substations and enhanced network control.
  - Presentation at the ABB Digital Substation Products Innovation Seminar. The Constellation project provided context to the drive for digital substations and their role in facilitating Net Zero carbon emissions; and.
  - Poster session at the Energy Innovation Summit where stakeholders were able to have a conversation about the project and gain some insight into test results from the project so far.
  - Presentation at the PNDCs workshop for smart grid, communications and cyber security on learnings from the design work done for Constellation. Stakeholders from GB DNOs and international technology providers were in attendance.

- **Other dissemination activities**:
  - PACWorld 2023 conference paper published: "Test Bed Design to Validate a GOOSE via VxLAN based Virtualised Loss of Mains Protection Scheme". This paper describes the PNDC trials environment design and test methodology for the project with focus on the Wide Area Protection solution.
  - PACWorld 2023 article submitted: "Virtualized Centralized Protection and Control". This article described a virtualised, centralised protection concept that has been developed as a part of Constellation.
  - CIGRE 2024 session synopsis accepted: "Experience from integration, functional and performance testing of virtualised wide area protection". The full paper will showcase how the virtualisation technology enables new Protection and Control (PAC) design methods and strategies for testing, commissioning, maintenance, upgrading and end-of-life replacements.
  - CIGRE 2024 session synopsis accepted: "Demonstration of enhanced and virtualised Protection of the Distribution Network". The full paper will demonstrate the key results from the Wide Area Protection solution testing at PNDC prior to live trials.
  - CIGRE 2024 session synopsis accepted: "Local Active Network Management (LANM) and the role of Smart Substations in Minimising Curtailment of Flexible DER Connections". LANM minimises the curtailment of DER with flexible connections during communication failures that impact the existing Central Active Network Management (CANM).

Challenges and lessons learned

The dissemination activities during this reporting period highlighted the interest from industry stakeholders in the project activities and outcomes. In particular, suppliers expressed great interest in supporting the development or deployment of new solutions to be demonstrated in the Constellation virtualisation platform. Furthermore, discussions with stakeholders and potential end users emphasised the need for standardised approaches to virtualisation platform configurations and testing methods to ensure a robust transition to BAU.

Outlook for next reporting period

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

- Submission of the full approved papers to the CIGRE 2024 review committee.
- Engagement with the PNDC Digital Substation working group
- Press release with owners of the Maidstone area DER to showcase Constellation and its role in releasing additional capacity for additional generation.

3. Business case update

The project team has identified that the hardware and software requirements for hosting the software (virtualisation) solutions 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. We are also continuing the work on a strategic investigation into an alternative virtualisation approach (section 2.1), which will support the business case.

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 (FSP) where the calculations and assumptions are described in detail.

The figure below 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.

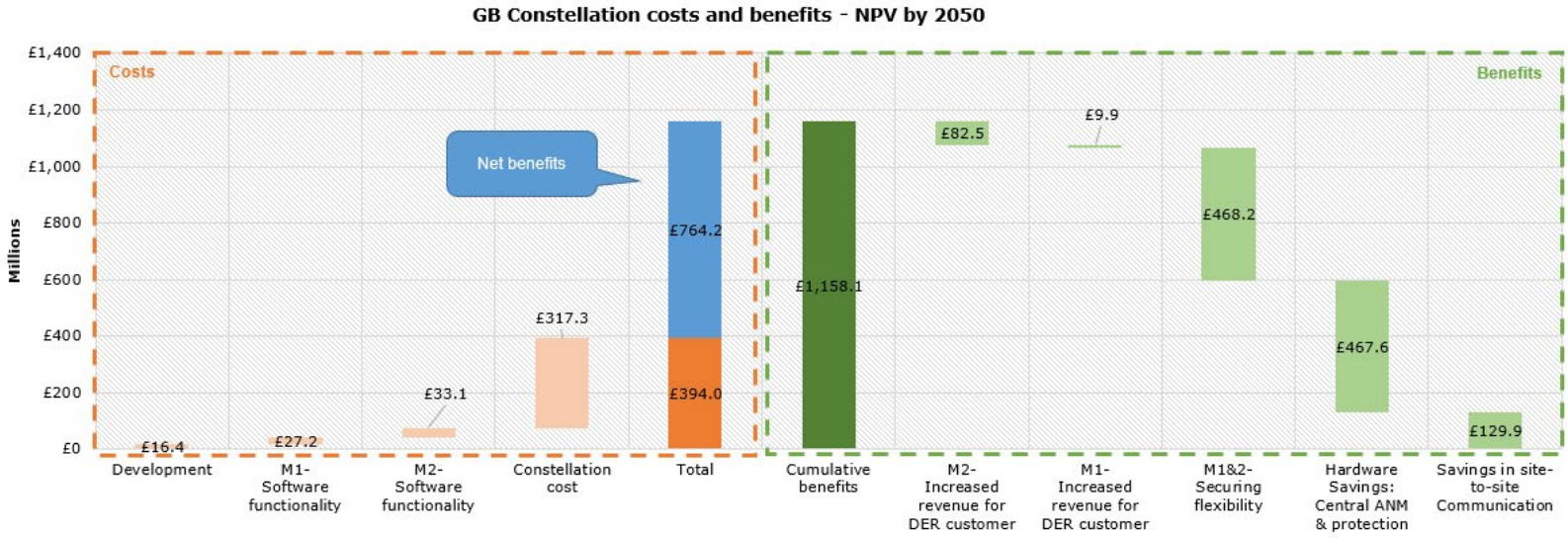

Figure 3-1 - Forecasted financial benefits in GB by 2050

4. Progress against plan

Figure 4-1 shows the high-level project plan for Constellation. The plan is updated to reflect the non-material change request during the previous reporting period. The project remains on track to achieve the Deliverables by the markers shown below. In the next sections the project team describe the progress of more specific items in the detailed project plan.

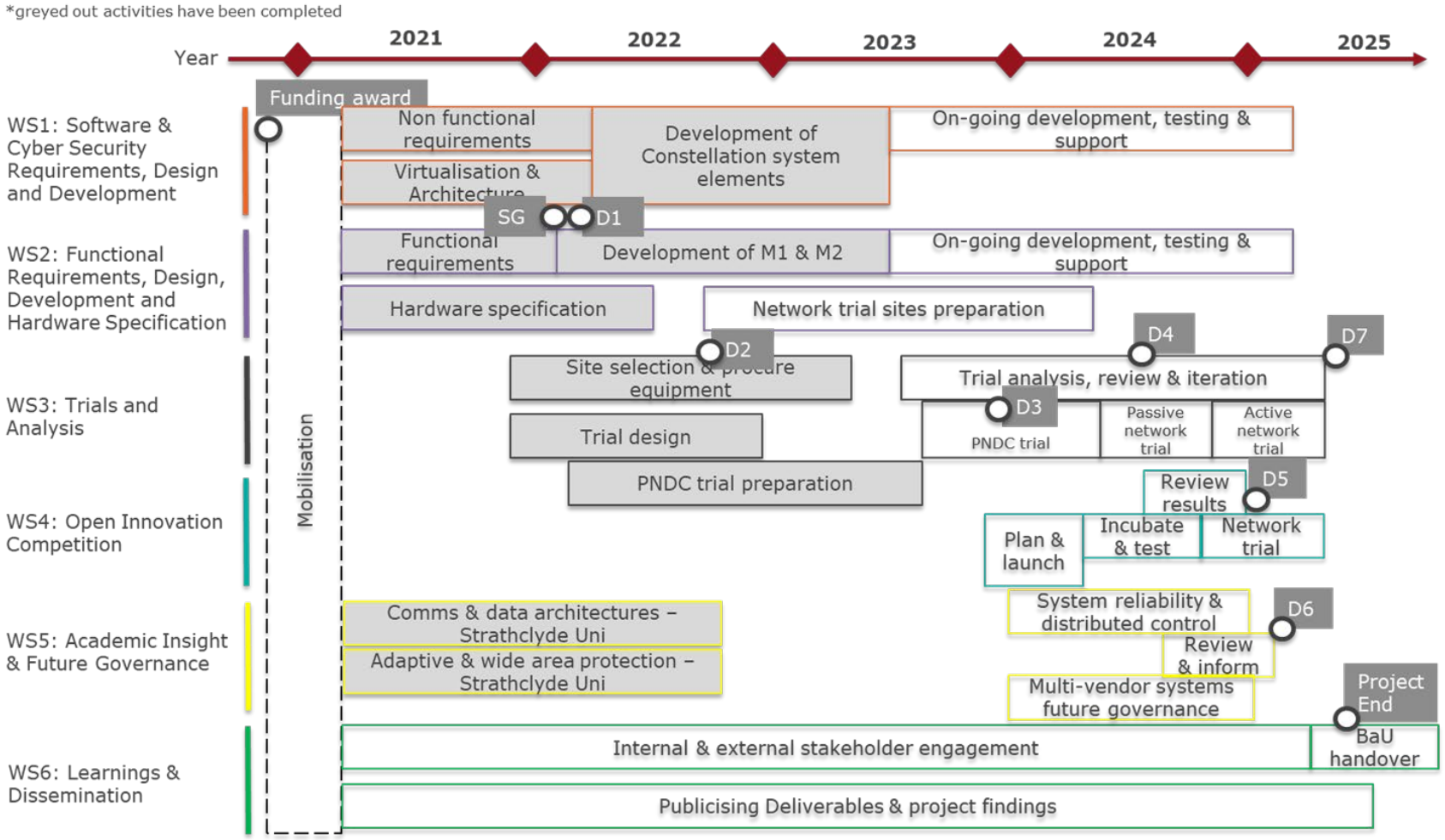

Figure 4-1 - High level plan. Shaded elements are completed.

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 and ad-hoc one-to-one sessions with the individual partners, bi-weekly sessions with all partners as well as regular risks and issues review sessions with all partners.

Overall progress to date is in line with the high-level project plan submitted in the FSP and recently updated following the non-material change request in the previous reporting period. As highlighted in the previous reporting period, we are closely monitoring the progress of the Constellation trials. Should we discover that more testing is required to validate the novel solutions, we may seek to extend the submission of one or more of these Deliverables. We will continue to monitor this risk and update Ofgem appropriately through future Project Progress Reports or separately if necessary. Further details are provided in section 4.2.

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

Table 2 – Summary of tasks started in this reporting period

Task description	Workstream	Status at end of period
PNDC test environment build completed and trial kicked off	3	Completed
Maidstone area phase one site works	2	Completed
Configuration and deployment of the Constellation cubicle in Maidstone area	2	In progress
PNDC integration testing of Local ANM and Adaptive Protection	3	In progress
Preparation of Deliverable 3 for submission	-	In progress
Commencement of the UK Power Networks trial design	2	In progress
Continuation of the preparation of the sites in the Thanet area	2	In progress
Tender exercise for identifying additional suppliers for Constellation	-	In progress
Presentation at industry conference, the Energy Innovation Summit, to disseminate learnings	5	Completed
Recruitment of a new Project Lead and Workstream 2 Lead	-	Completed
Carry out recruitment for Workstream 1 Lead	-	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 an issue in one area might impact the overall project activities and so it is important to track any interdependencies. A full list of project risks identified for Constellation is provided in Section 11.

So far in the project, two risks have impacted the project plan. One of which has materialised into an issue and was managed by the non-material change described in detail in the previous reporting period. The other is currently being closely monitored to minimise its impact.

Project issues:

1. **Delay in starting the project trials** – Deliverables 3, 4 and 5 are impacted.
   - **Cause**: A global electronic shortage of specific components has impacted the telecommunication industry. Our suppliers have informed us that the cause of this electronic shortage is a combination of global factors, including the conflict between Ukraine and Russia;
   - **Solution**: As per our previous Project Progress Reports, we have been working closely with our partners to minimise the impact of the issue. Siemens PLC are a partner in the Constellation project, and as such, have ensured our order is prioritised due to the strategic importance of Constellation. To resolve the challenge,

we have agreed to submit Deliverable 3 by 22 December 2023, Deliverable 4 by 31 May 2024 and Deliverable 5 by 31 October 2024.

2. **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 find 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.
   - The PDC, which is responsible for sending the synchrophasor streams to the central server, was faulty and had to be replaced which added complexity to the installation tasks;
   - The link between the central server and the Maidstone substation required new configurations and security measures to be implemented. This further delayed the data collection.
   - There were synchronisation issues identified with the synchrophasor data on site. To resolve these, we have purchased additional hardware.
   - 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. We expect no impact on any of the expected learnings from the development and trials.

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

- **Delays in submitting Deliverable 4** – There is a risk that the time allocated for collecting material and prepare for Deliverable 4 submission may not be sufficient. This risk is driven by these key factors:
  - The strong dependency between the success of the PNDC trial and the confidence in commencing the network trials. If the testing is mostly successful and no significant additional alterations are required to the Constellation solutions, Deliverable 4 will not be impacted. However, if significant changes are required to the Constellation solutions, commencement may have to be delayed until these are resolved and retested accordingly.
  - The uncertainty associated with testing novel solutions make it difficult to confirm the UK Power Network' trial start data, and subsequently submission of Deliverable 4. However, to ensure that this risk is minimised, the project team has set up biweekly monitoring and troubleshooting sessions with all partners to ensure issues are resolved as soon as they are identified. We propose to notify Ofgem by the end of April 2024 of any delays to the start of the UK Power Networks' trial.

- **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 the previous reporting periods, 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. This change in cost is partially due to global inflation as well as other factors external to the project. 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 without compromising the functionality. We are also investigating an alternative low-cost virtualisation approach to demonstrate as part of Constellation;

- **Delays in provision of data for Adaptive Protection**:
  - Adaptive protection relies on data contained across multiple systems within UK Power Networks. As such, a data validation and mapping 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. In this reporting period, we have made good progress in providing some of the data and validating its integrity. However, we encountered a challenge in exporting and importing data between some of the 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 a focus group with key technical experts from

each organisation who are dedicated to resolve the issues. UK Power Networks has also begun investigation into other possible systems to provide the data. This is being carried out separately from Constellation but may be used during the trials in UK Power Networks' distribution network.

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

- Preparation of Deliverable 3 for submission;
- Appointment of a new Project Lead and Workstream 2 Lead;
- Finalisation of the PNDC integration testing specification;
- Completion of PNDC trial preparation;
- Commencement of the PNDC trials;
- Finalisation of PNDC integration testing for Wide Area Protection;
- Completion of all phase one site works in Maidstone area;
- Full deployment of the central Azure servers required for the Constellation trial;
- Continuation of trial preparation and procurement for the Maidstone phase two and Thanet trial areas;
- Establishment of remote connectivity to PNDC facilities; and
- Presentation at industry conference, the Energy Innovation Summit, to disseminate learnings.

4.4 Look-ahead to next reporting period

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

- Submission of Deliverable 4;
- Recruitment of Workstream 1 Lead;
- Successful integration of the Constellation Methods in PNDC environment;
- Completion of PNDC trial;
- Full deployment of the Constellation cubicle in Maidstone area;
- Commencement of integration testing of Constellation solutions in Maidstone area;
- Finalisation of trial preparation and procurement for the Thanet trial area;
- Completion of all designs, site works, and procurement activities for the DER sites;
- Constellation Methods 1 and 2 tenders' completion; and
- Submission of three scientific papers to CIGRE 2024.

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 3 – 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 was successfully submitted on time.
3	Initial learning from off-network PNDC trial, and learning from development and virtualisation of Methods 1 and 2	22/12/23	(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 slice; and • Testing preparation and early lessons from the off-network testing	The submission date for this Deliverable has been changed by the non-material change request as part of the pervious reporting period. The new date is 22/12/23. The Deliverable is currently on the final review stages and is planned to be issued as scheduled.
4	Review and insights following site installation and learning from mid trial passive network demonstration	31/05/24	(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 submission date for this Deliverable has been changed by the non-material change request during the previous reporting period. The new date is 31/05/24. Preparations are progressing for the UK Power Networks and the PNDC trial outcomes are being closely monitored to ensure no impacts on this Deliverable's timeline. There is a risk that Deliverable 4 is delayed due to unforeseen issues arising during the PNDC trial. We propose to notify Ofgem by the end of April 2024 of any delays to the start of the UK Power Networks' trial.

Ref	Project Deliverable	Deadline	Evidence	Progress
5	Learning from the Open Innovation Competition (OIC)	31/10/24	(WS3) Report containing key learning on the OIC use case prioritisation, participant selection and incubation process	The submission date for this Deliverable has been changed by the non-material change request during the previous reporting period. The new date is 31/10/24
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.
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 is on track.
[Note this is a common Project Deliverable to be included by all Network Licensees as drafted below]				
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.	Fifth 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 https://innovation.ukpowernetworks.co.uk/app/uploads/2023/11/UKPN-InnovationDataSharingPolicy-Nov-23-v1.0.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, updated in 2023, 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. The materials which are available for dissemination as of yet are Deliverables 1 and 2, as well as a number of industry white papers, which are published. Shortly after the issue of this report, the project team will publish the report for Deliverable 3. This will be made publicly available on the UK Power Networks' Innovation website.

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

- Test specifications and trial design;
- Summary of integration testing results from PNDC trial;
- Constellation architecture; and
- Summary of FATs;

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 4 – IPR generated in this reporting period

IPR description	Owner	Type
Summary of approach for remote connectivity to PNDC facilities	UK Power Networks and University of Strathclyde	Foreground IP
Summary of integration testing results from PNDC trial - Wide Area Protection	UK Power Networks, University of Strathclyde, and ABB	Foreground IP

Table 5 – IPR forecast for next reporting period

IPR description	Owner	Type
Deliverable 3 – Initial learning from off-network PNDC trial, and learning from development and virtualisation of Methods 1 and 2	UK Power Networks	Relevant 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 R1-23 are captured in the FSP. We identified Risks 24-67 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 6 – Risk register

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
R55	**Issue**	Active	Access to large store of data for 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 - Early planning for site work to ensure data gathering for ML is prioritised	3	3	**9**	WS2 Lead	24/05/2023	
R52	**Issue**	Active	Delay in data gathering reduces time for ML	Possible delays to the project	5	4	**20**	- Early planning and engagement with relevant experts to ensure data gathering for ML is prioritised	3	3	**9**	WS2 Lead	24/05/2023	
R58	**Risk**	Open	Specification and plan for provision of network data for Adaptive Protection and Local ANM longer than planned	Possible delays to the project	5	5	**25**	- Siemens provide a data specification for UKPN to approve - UKPN to work closely with GE to ensure data can be collected early	4	3	**12**	WS2 Lead	24/05/2023	
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 - Prepare key systems to be ready for integration, while detail design is taking place	**3**	**3**	**9**	WS1 Lead	24/05/2023	
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 - Plan the work to align with resourcing needs	**3**	**3**	**9**	Project Manager	24/05/2023	
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 - Design the trial with Vodafone and PNDC to demonstrate the resilience of the 5G service	3	3	**9**	WS3 Lead	24/05/2023	
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 M1 and M2 - Understand if we can leverage existing ADMS capabilities to provide - Last resort is to manually identify and load the required parameters	3	3	**9**	WS2 Lead	24/05/2023	
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 - Interfaces between systems (and partners) defined early as part of the requirements development stage	3	3	**9**	WS1 Lead	24/05/2023	

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
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 - Close collaboration with partners to manage the delivery of the scope within the available budget	3	3	**9**	Project Manager	24/05/2023	
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	**5**	**4**	**20**	- Engaged with DER operators in the provisional trial areas - Ensured minimal effort and impact on DER operation during trial	**2**	**3**	**6**	Project Manager	24/05/2023	
R53	**Risk**	Open	DER sites available too late for ML	Possible delays to the project	5	4	**20**	- Ensure key lines at monitored at substation during data gathering phase	3	3	**9**	WS2 Lead	24/05/2023	
R10	**Risk**	Active	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. - Ensure knowledge sharing is undertaken across the project team to avoid single point of failure	**3**	**3**	**9**	Project Manager	24/05/2023	
R12	**Risk**	Open	IPR 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	24/05/2023	
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 - Understand resource requirements and plan alternative ways of securing the necessary expertise	3	4	**12**	WS1 Lead	24/05/2023	
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 - Ensure the products meet the BAU requirements or there are plans in place to meet the BAU requirements	2	2	**4**	Project Manager	24/05/2023	
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 - Agree specific data management plans before the trials with the relevant business stakeholders	2	3	**6**	WS3 Lead	24/05/2023	
R65	**Risk**	Active	Inflation related increase in labour cost exhausts the project budget	Project is stopped or re-scoped	4	4	**16**	- Monitor budget continuously and report to Innovation Programme Manager - Discuss inflation with Regulation and Finance	4	1	**4**	Project Manager	24/05/2023	

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
R66	**Risk**	Open	Delays in PNDC trial testing and solutions validation	Delay in Deliverable 4 submission	4	4	**16**	- Biweekly project team workshop to review progress and agree on changes	2	4	**8**	Project Manager	27/11/2023	
R2	**Risk**	Active	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. - Engage provider on fixed priced contract rather than time and materials	**2**	**4**	**8**	Project Manager	24/05/2023	
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 - 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	24/05/2023	
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 - A robust project plan is developed and it is validated and updated closely	**2**	**3**	**6**	Project Manager	24/05/2023	
R27	**Risk**	Open	Single point of failure in resourcing	Project is delayed and/or requires re-scoping	3	5	**15**	- Ensure there is clear and structured documentation to enable handovers - Plan the work to align with the resourcing needs	3	4	**12**	Project Manager	24/05/2023	
R31	**Risk**	Open	Substation PC is not powerful enough to support the virtualised 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 - Collaborate with partners to understand hardware requirements for the software they are developing	2	4	**8**	Project Manager	24/05/2023	
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 - Plan how the necessary testing and integration skills are made available in time for the Project	2	4	**8**	WS1 Lead	24/05/2023	
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 - Develop a suitable cyber security breach response plan	3	3	**9**	WS1 Lead	24/05/2023	
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 - Key interactions with other systems are planned and tested during the project	3	3	**9**	Project Manager	24/05/2023	
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	24/05/2023	

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
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	24/05/2023	
R57	**Risk**	Open	The upgrade of PNDC`s ADMS and simulation of UKPN`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, UKPN and PNDC to ensure PNDC`s test environment is correctly set up - Simulated UKPN network to be reduced and simplified	2	4	**8**	WS3 Lead	24/05/2023	
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 - Leverage the R&D connections and experience of all partners	**3**	**3**	**9**	Procurement	24/05/2023	
R33	**Risk**	Active	Delays caused by extended procurement processes	Project is delayed and/or requires re-scoping	5	3	**15**	- Provide Procurement with early visibility of required procurement activities - Plan sufficient time to carry out all procurement activities	3	2	**6**	Project Manager	24/05/2023	
R11	**Risk**	Open	The specification and procurement of the equipment takes longer than expected	Possible delays to the project	**5**	**3**	**15**	- Ensure timescales on the project are realistic and have built-in contingency for high risk elements - Undertake regular reviews during high risk and critical project activities	**3**	**2**	**6**	Project Manager	24/05/2023	
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 - Frequent and clear communication with stakeholders is carried out throughout the project	3	3	**9**	Project Manager	24/05/2023	
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 - Identified over 15 use-cases for participants to work on	**2**	**3**	**6**	WS4 Lead	24/05/2023	
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 - Get PMU data from trial sites early in the project	**3**	**3**	**9**	WS2 Lead	24/05/2023	
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 - Sufficient risk budget to ensure equipment scope change can be absorbed	**2**	**3**	**6**	WS2 Lead	24/05/2023	
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 - Plan a suitable "plan B" alternative to secure the expertise required	2	3	**6**	Project Manager	24/05/2023	

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
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. - Regularly progress following UKPN established project control methods	**3**	**3**	**9**	Project Manager	24/05/2023	
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 - Coordinate trial preparation with the other on-going activities	2	2	**4**	Project Manager	24/05/2023	
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 - The partners revise the design and the products / services if necessary	2	3	**6**	Project Manager	24/05/2023	
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	24/05/2023	
R46	**Risk**	Open	NG 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 M1 and M2 - Plan how these can be provided to the partners	3	3	**9**	WS2 Lead	24/05/2023	
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 - Ensure tendering/onboarding process focuses on critical project elements	**2**	**3**	**6**	Procurement	24/05/2023	
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 - 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	24/05/2023	
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) - Failure Mode and Effects Analysis is undertaken to ensure such failures are anticipated and designed out	**1**	**4**	**4**	Project Manager	24/05/2023	
R16	**Risk**	Open	IT security standards are not met	Network is rendered open to cyber attack	**2**	**5**	**10**	- OT integration testing is included in the PNDC trial scope - Ensure full engagement with IT security team throughout the project - Key UKPN security requirements need to be fulfilled before the system is commissioned to our network - Ensure test plan encompasses all relevant IT security tests	**2**	**4**	**8**	WS1 Lead	24/05/2023	

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
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 - Review on-going work in the industry to identify if anyone else has demonstrated key Constellation elements	1	4	**4**	Project Manager	24/05/2023	
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	24/05/2023	
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 - Specify what separation is required for all OIC products to ensure safe operation of other systems	1	2	**2**	WS4 Lead	24/05/2023	
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 - Close collaboration during the design stage to ensure design is fit for purpose	2	3	**6**	WS2 Lead	24/05/2023	
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 - 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	24/05/2023	
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 - Off-network testing to simulate various network scenarios	**1**	**3**	**3**	WS3 Lead	24/05/2023	
R67	**Risk**	Open	5G backup solution packet loss issues in failover scenarios	Additional testing would be required for 5G only sites with possible overall project delay	3	3	**9**	- Extensive testing to pinpoint the root cause of the issue - Limit the volume of traffic sent over 5G as a temporary mitigation plan	1	3	**3**	WS1 Lead	27/11/2023	
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	24/05/2023	
R56	**Issue**	Closed	Constellation trials are delayed due to equipment availability among global electronics shortage	Possible delays to the project	5	5	**25**	- Non-material change to Deliverables 3, 4 and 5 to mitigate the impact of the delay - Continue close collaboration with supplier	3	1	**3**	WS3 Lead	24/05/2023	24/05/2023
R59	**Risk**	Closed	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 - Install Siemens software early and do testing to confirm operation	3	3	**9**	WS1 Lead	18/11/2022	18/11/2022

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 - Ensure value can be derived from the off-network testing	**2**	**2**	**4**	WS2 Lead	14/11/2021	14/11/2021
R63	**Risk**	Closed	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	4	**16**	- GE and UKPN working on the Local ANM design to identify solution for adequately managing the Thanet / Richborough area	2	3	**6**	WS2 Lead	24/05/2023	28/07/2023
R49	**Risk**	Closed	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 -Clearly communicate scope of each partner and align it to the plan	2	3	**6**	Project Manager	16/09/2022	16/09/2022
R60	**Risk**	Closed	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	25/01/2023	25/01/2023
R1	**Risk**	Closed	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. - Engage provider on fixed priced contract rather than time and materials	**2**	**3**	**6**	Project Manager	12/12/2022	12/12/2022
R24	**Risk**	Closed	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 - Have a staged approach to specifying the requirements	**2**	**3**	**6**	Project Manager	24/06/2022	24/06/2022
R7	**Risk**	Closed	Failure to agree Project contracts between UKPN 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 - 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**	Closed	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	3	**3**	WS2 Lead	24/05/2023	24/05/2023
R22	**Risk**	Closed	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 - Included in project risk budget which will be governed with a stage gate at the end of detail design (Jan 2022)	**3**	**3**	**9**	WS1 Lead	24/05/2023	31/10/2023

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
R37	**Risk**	Closed	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 - Build in sufficient time to re-iterate the design and development	2	3	**6**	Project Manager	24/05/2023	24/05/2023
R64	**Risk**	Closed	Factory Acceptance Testing is delayed or cannot be completed	Possible delays to the project	4	2	**8**	- Work closely with partners to coordinate on the preparation and execution of all Factory Testing - Secure approval from Technical Design Authority on the test specifications	2	2	**4**	WS2 Lead	24/05/2023	24/05/2023

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 this six-month reporting period and an accurate view of our understanding of the activities for the next reporting period.

Signed 

Date 7th December 2023

Ian Cameron
Director of Customer Service and VICE
UK Power Networks

Signed 

Date 7th December 2023

Suleman Alli
Director of Finance, Regulation, Strategy and Technology
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.