Constellation

Project Progress Report – July to December 2022

Constellation Partners

ABB GE UNIVERSITY of STRATHCLYDE PNDC SIEMENS UK Power Networks Delivering your electricity vodafone

Contents

1. Executive summary

1.1 Project background

1.1.1 Situation

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

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

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

1.1.2 Complication

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

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

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

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

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

1.1.3 Solution

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

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

- Method 1: Local 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.

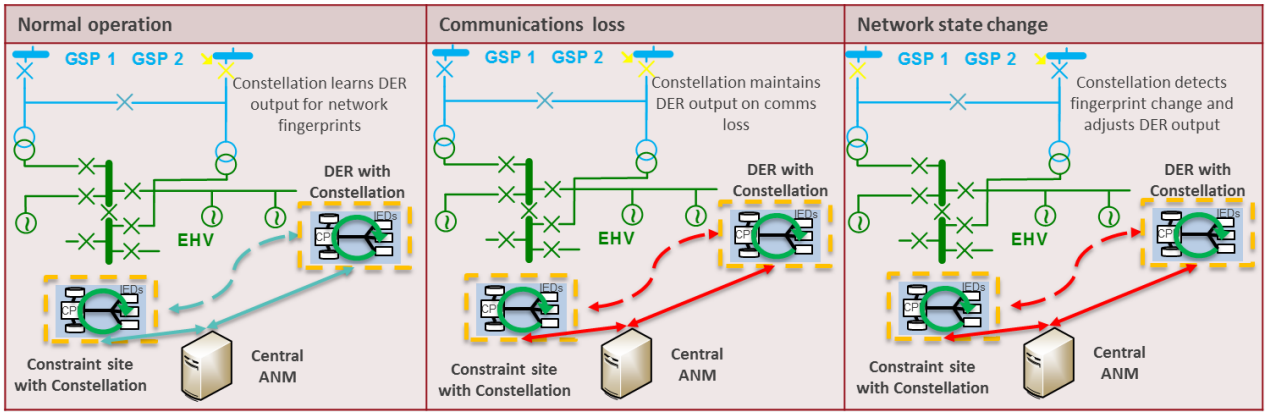

Figure 1 - Local ANM (Method 1) summary diagram

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

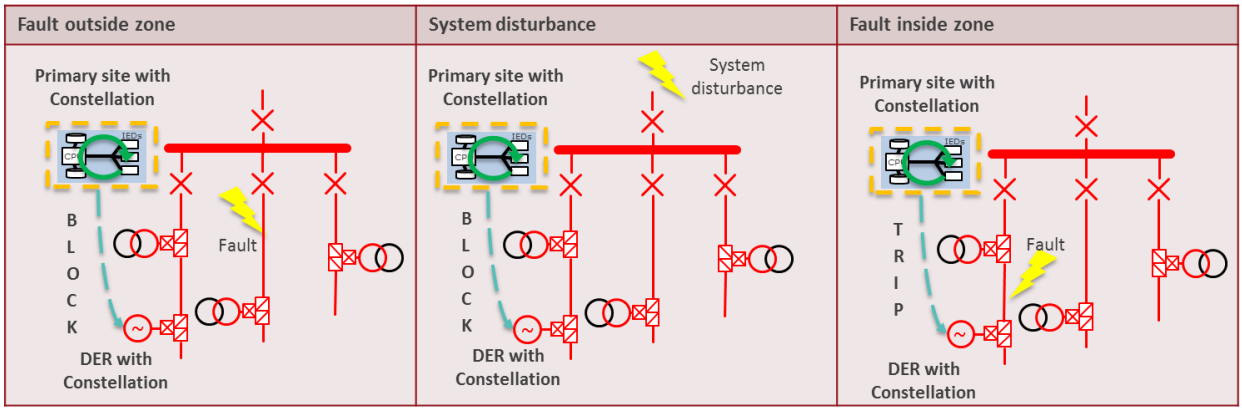

Figure 2 - Wide area protection (Method 2) summary diagram

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

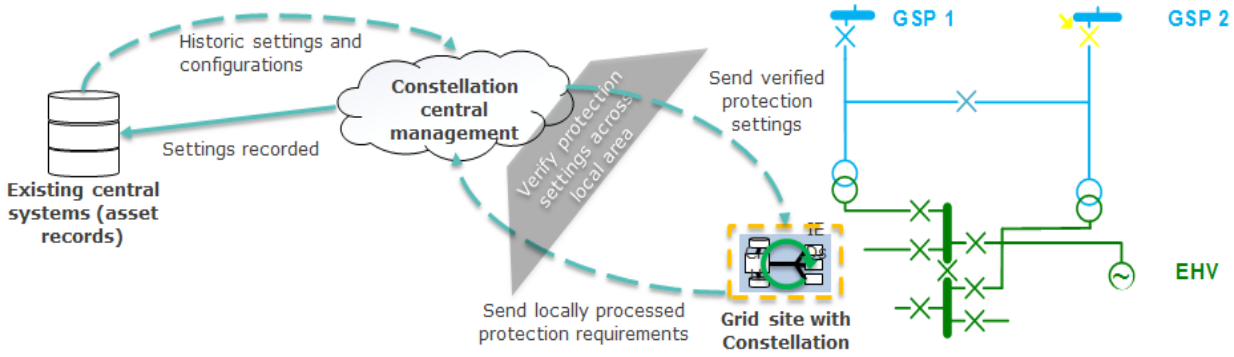

Figure 3 - Adaptive Protection (Method 2) summary diagram

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

If proven successful, UK Power Networks estimates that by 2030 the solutions trialled as part of Constellation could save customers in GB £132m. 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 fourth for Constellation, covers the period between July 2022 to December 2022. This document, together with the previous six-monthly report, which was published in June 2022, 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 2023. The general project progress is presented first, and then followed by workstream detail of the progress – starting with workstream 1 and finishing with workstream 6.

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

- Submitted Deliverable 2 on time and published on UK Power Networks' innovation website;
- Completed the overarching trial methodology for Constellation;
- Completed the test specifications for:
  - Local ANM;
  - Wide area and virtualised protection;
  - Adaptive protection and central management system; and
  - 5G site-to-site communication;
- Finalised the site selection activities;
- Continued engagement with DER in the trial areas; and
- Continued the trial preparations for PNDC and UK Power Networks' trials.

[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. In this reporting period, testing on virtualisation software was carried out in collaboration with ABB to ensure a suitable virtualisation environment is available for the trials. Additionally, the Azure environment required for Local ANM was deployed and is currently being configured for the next reporting period;

- **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 commission works as well as all hardware specification and procurement. This workstream is on track. In this reporting period trial preparation continued and site designs have been developed. Procurement of equipment is ongoing and installation and commissioning are progressing as network outages become available. We have continued providing the project partners with data required for the development and testing of the solutions;

- **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 on track. PNDC concluded partner engagement to elicit trial requirements for each of the respective methods. PNDC revised and issued the second version of the trials test specification. Work is currently being undertaken to develop the virtualisation testing and update the cyber-security penetration testing specifications. Finally, PNDC completed the procurement of test equipment with some items pending delivery and the PNDC site preparations are well under way;

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

- **Workstream 5** is responsible for the academic insights and research into the future governance. This workstream will feed into the requirement specification for workstreams 1 and 2. This workstream is on track. Two academic insights activities have been completed by the University of Strathclyde covering protection, virtualisation and 5G communications. The remaining academic insights activities will be scoped and initiated at a later date in the project; and

- **Workstream 6** is responsible for the dissemination of the knowledge generated from the project. The workstream is on track. The project team continued to engage with the PNDC digital substation working group to share and discuss design outcomes and preparations for the FATs and trials phases. Furthermore, paper abstracts have been submitted for the Congrès International des Réseaux Electriques de Distribution (CIRED) 2023 conference. In this reporting period, we also carried out a second wider industry engagement workshop with key stakeholders from other Licence Network Operators (LNOs).

1.3 Risks and issues

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

Since the bid submission, a number of risks have been added to the risk register; all risks are shown in Section 11. Some of these risks have the potential to impact the critical path, however suitable mitigations are implemented and

continuously reviewed. The project team carefully track these risks on a frequent basis and ensure further mitigations are applied where necessary.
The largest immediate risk is the delay in commencing the PNDC trials in Q2 2023 (as described in section 4.2). This is due to considerable delays in the delivery of equipment required for the testing. This risk can potentially impact Deliverables 3, 4 and 7 as starting one trial later will push all subsequent trial phases to start later as well. We are working closely with PNDC and our equipment suppliers to manage this risk.

2. Project Manager's report

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

- Finalising the site selection for the Constellation trials;
- Engaging with the wider industry to understand priorities and validate design;
- Developing the test specifications for each Constellation solution; and
- Preparing for the PNDC and UK Power Networks trials.

Site selection
During this reporting period, and continuing from the previous reporting period, the site selection assessment was finalised and the sites were selected. A robust site selection process was carried out, focusing on engagement with experts from UK Power Networks. The site selection criteria and assessment are described in Deliverable 2, which is published on the UK Power Networks innovation website[4]. A total of seven sites were selected for the trial, two of which are in the Maidstone area – and five in the Thanet area. This represents a change from the pre-project high level site assessment which identified Maidstone and Lewes as suitable areas. The key reason for selecting the Thanet area instead of the Lewes area is that Thanet is more suitable for the demonstration of Local ANM. More details are available in section 2.2, as well as Deliverable 2.

Engaging the wider industry
In this reporting period we validated the designs and architecture, which were finalised in the previous reporting period, by engaging with the wider industry. We identified suitable groups of stakeholders and carried out another workshop in June to present our designs and understand the key industry challenges. More details are available in section 2.6.

Preparing for the Constellation trials
We continued preparing for the upcoming Constellation trials at PNDC and UK Power Networks. We completed the site designs and are continuously carrying out procurement. We have commenced the site installation and commissioning activities and expect those to continue in 2023. More details are available in section 2.2 and 2.3.

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

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

Personnel
No changes to the immediate project team, consisting of a Project Lead and Workstream Leads, have occurred in this reporting period.

[4] UK Power Networks Innovation - Constellation

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

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

Progress during this reporting period

Architecture and integration

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

During the previous reporting period, the detailed architecture was developed. In the months following the creation of the architecture diagram, the focus shifted to ensuring connectivity between the various components within the developed architecture can be achieved. This has been done through collaboration with UK Power Network's cyber security team and project partners.

The first connectivity related activity involved the GE Azure servers and ensuring external users can remotely connect and manage the virtual machines, this was successfully completed in October. Secondly, in preparation for the PNDC and UK Power Networks trials, a secure method enabling Constellation project partners to remotely connect into the substation environment is currently being developed for the next reporting period. Finally, work is continuing to ensure the substation network can securely communicate with the Azure environment before the UK Power Networks trial starts.

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 servers required for GE's Local ANM solution were provisioned and configured in the UK Power Networks Azure DevTest environment. Ultimately, the GE Azure server will receive synchrophasor data from the substation server, this data will be routed via the corporate and SCADA networks and passed onto GE's Edinburgh Office for research and development purposes, this architecture is shown in Figure 4.

The server specifications as detailed in the Logical Architecture and Design Document (LADD) were used to generate the necessary server build documentation. The server build document contains detailed design and configuration parameters; this document is kept updated as required and represents the most configuration of the as-built server.

Other crucial activities were also undertaken during and following the server build process, these included granting access to GE users, configuration of a secure link to the GE Edinburgh office and enabling communications to the substation network, which is an activity that is currently in progress and will be completed before the trial in UK Power Networks. The Siemens servers are scheduled for provisioning later in the project, when required for live network testing.

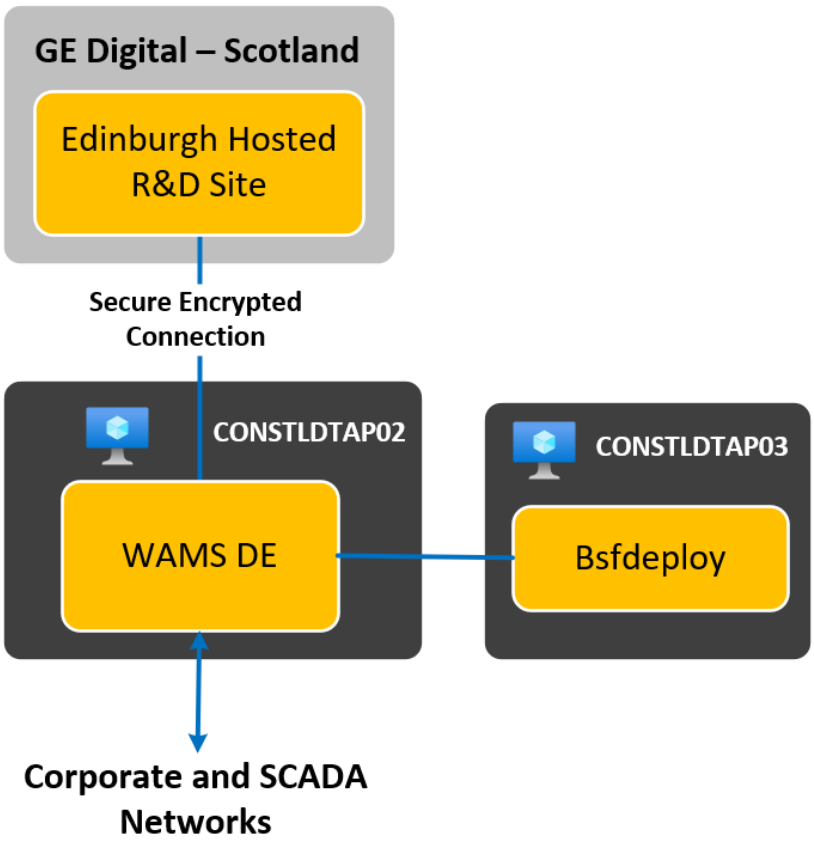

Figure 4: GE Central Server Architecture

Software virtualisation environment

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

During this reporting period, the primary focus shifted from design to the procurement of required hardware and software. As part of the procurement activities, the first batch of server hardware required for the virtualised platform were procured and delivered. The purchased hardware will be installed in the first trial area sites of Maidstone and Allington Waste Generation, and at the PNDC test facility. Test hardware was also purchased for UK Power Networks' lab for configuration and testing.

The required software licenses and packages for the virtualisation solution were also identified following the end of the virtualisation testing which started in the previous reporting period. The Constellation team is focused on ensuring solutions are scalable to business as usual. To that end, an investigation into an alternative virtualisation solution has been initiated. The aim of this investigation will be to determine the suitability of a different virtualisation technology as a low cost alternative for a business as usual deployment.

Site-to-site communications

The 5G communications link will make use of public 5G infrastructure (once it is available) to enable fast, secure, and scalable site-to-site communications for 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 now and will be finalised as part of the factory testing finalisation in the next reporting period. Vodafone will be providing a "slice" of their network, which is a logically separated portion of their public 5G network, designed to transmit Constellation data securely.
During this reporting period, Vodafone began deploying the cloud infrastructure necessary for the 5G Slice. The

continued deployment has included cyber security penetration testing and configuration necessary to support the novel slice which is being deployed for Constellation. Initial network testing using the networking equipment was also undertaken at Vodafone's Research & Development facility in this reporting period. This was the first hardware test of the 5G router being installed in Constellation substations. The testing was completed successfully and a number of updates to the architecture and design were identified and implemented in preparation for the subsequent stages of the project.

Preparation for the Vodafone Factory Acceptance Testing (FAT) also took place during this reporting period. Vodafone developed a FAT specification, which was reviewed and approved by the Constellation Technical Design Authority (TDA). The Vodafone FAT will provide an opportunity for UK Power Networks to gain confidence in the 5G technology as well as the networking hardware that will be deployed in trial substations. The FAT is ongoing during this reporting period and is expected to be completed in the next reporting period.

Cyber security

Constellation will introduce several cyber security mitigations to ensure the solution is secure, functional, and scalable. During this reporting period, the Secure by Design document, which started in the previous reporting period, was finalised and approved by all Constellation partners. The Secure by Design document will also be amended with an additional section for mobile communications security, based on feedback from the PNDC.

An engagement session with Vodafone's security team was held, with the aim of better understanding the security mitigations being implemented on both the UK Power Networks and Vodafone core networks. The engagement session concluded that there was sufficient security mitigation in both networks, but vigilance needs to be maintained to ensure network security continues to be a priority in Constellation.

FAT logistics

The Constellation FAT, as described in section 2.2, present a significant milestone for the development of the solutions being deployed for Constellation, and an opportunity to validate the designs in a controlled environment. During this reporting period, a key task was the confirmation of FAT dates and the subsequent planning and arrangement of travel and accommodation for all attendees across each organisation.

The FAT events require key stakeholders to be in attendance, and this presents a unique challenge in coordinating and arranging travel and accommodation due to the diverse locations and requirements for each FAT. ABB's FAT was hosted in two separate cities in Finland over 5 days, whereas the Siemens FAT was in Nuremberg, Germany, Vodafone`s testing is in Berkshire, and GE`s in Edinburgh. Diverse locations led to diverse challenges, such as, availability of flights from specific airports and finding accommodation in areas close to public transport.

The Workstream 2 Lead managed the coordination of all FATs through engagement with stakeholders, taking a methodical approach to selecting flights and accommodation according to FAT schedules, and ensuring the overall cost was within the project budget.

Challenges and lessons learned

Software virtualisation environment

The virtualised environment will be implemented using enterprise-grade off the shelf virtualisation software. This allows the use of a mature and reliable type 1 virtualisation platform that the business is comfortable working on. However, this approach may be limited in scalability due to licensing challenges. Therefore, as described above, an investigation into an alternative approach will be carried out.

Central servers

Although the GE central servers have been successfully deployed, the process proved challenging. A lack of documented

standard requirements and processes meant that opportunities for further efficiencies were missed along the process. The following were identified as areas of improvement for future relevant activities:

- A defined procedure for adding new users to Azure active directory; and
- A procedure for logging onto Linux VMs securely.

The learnings from the GE Azure server provisioning process will be applied to the provisioning Siemens Azure servers. There will also be a review of the process with the aim of making tangible improvements to internal processes related to implementing changes on the UK Power Network's Azure environment.

Outlook for next reporting period

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

- Implementation of remote connectivity architecture for the PNDC trial. This will enable Constellation partners to remotely connect to substations servers deployed at the PNDC;
- Finalisation of the FAT for 5G site-to-site communication;
- The provision of Azure servers for the Siemens solution will be started in preparation for the UKPN trials;
- The installation and configuration of hypervisors on substation servers will be started ahead of deployment; and
- Commence the research and design of alternative virtualisation solution in a test environment.

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

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

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

Progress during this reporting period

Design of Constellation solutions

The design of the Constellation solutions was approved in the previous reporting period. During this reporting period, minor design updates have been implemented. These design changes resulted as part of learnings from the development and the preparation for the FATs. Constellation is a highly innovative project and it is anticipated that the design is continuously improved and updated.

Development of the Constellation solutions

After the design was completed in the previous reporting period, all Constellation partners focused on developing the solutions. The development process finishes with the FATs with each partner (ABB, GE, Siemens and Vodafone). The purpose of the FAT is to test, validate and witness the performance of each solution in isolation.

The first drafts of the FAT specifications were extensively reviewed and updated after discussions between the partners during the summer period. The FAT specifications were finalised and approved by the Constellation TDA. Overall, UK Power Networks approved two FAT specifications with minor comments and approved two FAT specifications with major comments. All partners enhanced their design and specifications to enable FAT to take place.

It should be noted that the development will conclude after all of the FATs are successfully completed and all comments from the FATs are resolved. In this reporting period, the four FATs were started and expected to finish early in the next reporting period.

Site selection

In order to evaluate the success of Constellation and ensure BAU adoption, the solutions need to be fully assessed and proven as functional. Electricity substations represent an ideal place to test Constellation solutions before a wider deployment. During the previous reporting periods, significant effort was dedicated to identify and selecting suitable sites for demonstration. In this reporting period, we finalised the site selection and reported our findings in Deliverable 2.

The areas and sites previously considered included the Maidstone area, Lewes area, and Thanet area. Maidstone area has proven an ideal location due to size, effort to retrofit new International Electrotechnical Commission (IEC) 61850 standard compatible relays, and limited complexity. For a more complex area, Thanet has been selected due to the number of DER sites connected to this substation, which includes a mix of synchronous and asynchronous generation, as well as flexible connections. Lewes area does not include DER sites with flexible generation, hence it will not be

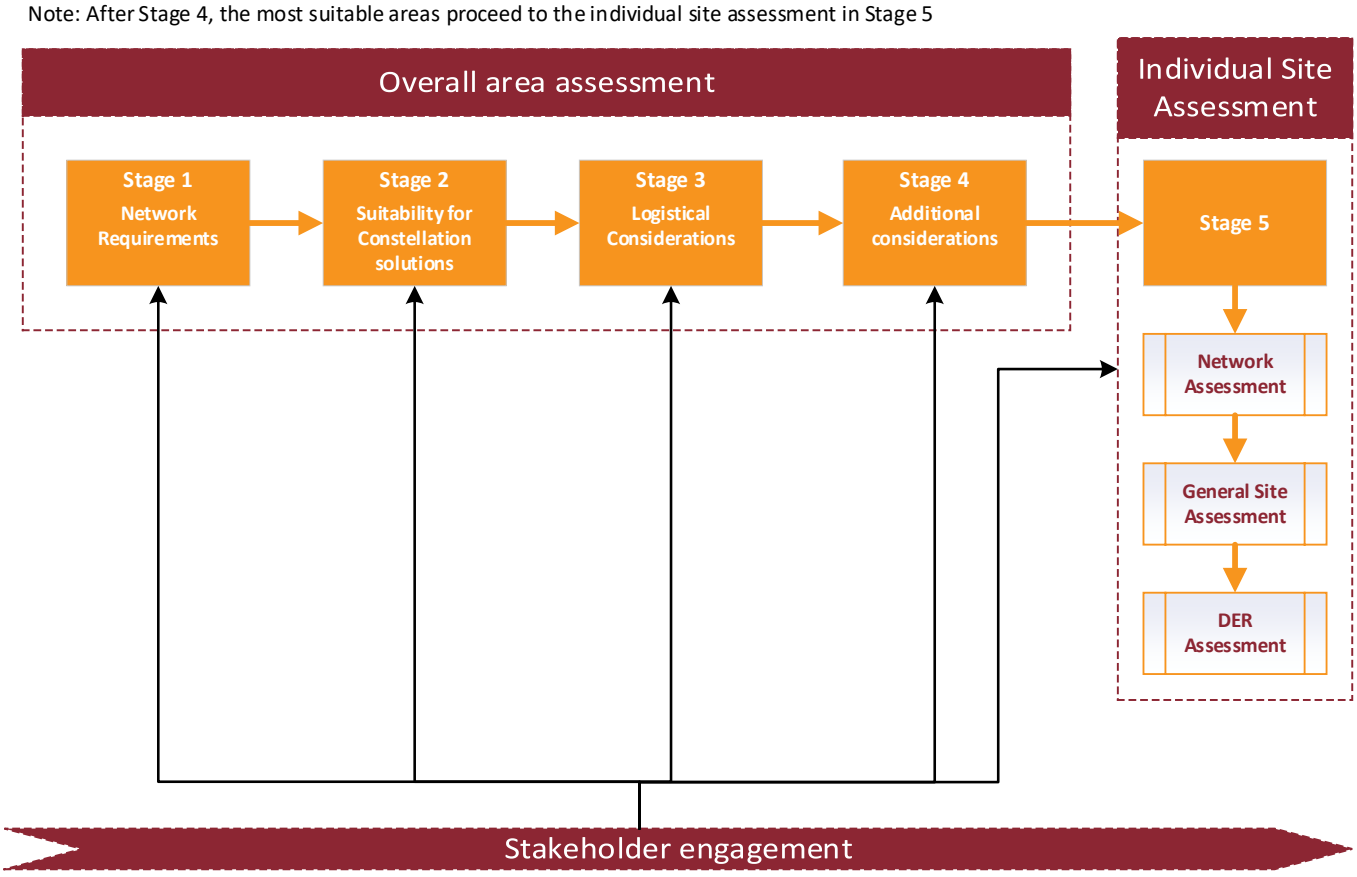

Figure 5 - Constellation site selection approach

considered for Constellation trial works.

A robust site selection approach (Figure 5) was employed to finalise the sites. The process was underpinned by extensive engagement with key stakeholders across UK Power Networks, as well as experts from the Constellation partners. The purpose of this engagement was to understand the solution requirements (presented in Deliverable 1), as well as the practical considerations for the sites. To begin, a detailed four-stage site selection evaluation process was undertaken.

Once the most suitable areas were determined, a fifth stage in the evaluation process commenced in order to confirm the suitability of each individual site within each area.

The net result of this detailed site selection evaluation process provided agreement on which sites in all areas would be selected for installation of the Constellation equipment and demonstration of the two Methods.

In this reporting period, we also identified additional sites that require new equipment due to retrofit design issues. These sites are Maidstone Grid 132/11kV South, Maidstone Grid 132/11kV North and Shepway Primary.

Trial preparation

The trial preparation task for Workstream 2 is focused on installing hardware in the Maidstone Area. After this is completed, we will begin work in the Thanet area. 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.

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. In the previous reporting period UK Power Networks started the design for the Maidstone Area. This includes approximately 110 electrical drawings, general arrangement drawings and layout drawings. These cover the electrical circuitry changes on the protection panels at Maidstone Grid 33kV, and associated DER site.

For the Thanet Area, in this reporting period UK Power Networks have designed general arrangement drawings for all the panels. We are currently reviewing and finalising the design and expect to complete it in the next reporting period.

The next stage is the design of the protection diagrams for the 33kV panels in line with IEC 61850 functions. This design will support the configuration of virtual protection functions. The stage after that will be the electrical design for the Thanet Grid 33kV panels, and for the four DER sites connected to this site.

Procurement of hardware: Orders for the hardware for the Maidstone area have been placed in full. These include the Constellation cubicles, GPS clocks, Layer 2 and Layer 3 network switches, Layer 2 redundancy boxes, merging units, substation servers and testing equipment. Based on the site design for Maidstone, we have so far provisioned:

- A number of cubicles with either rear opening or swing frame design;
- Sub-racks that include sufficient merging units which will act as relays. They will also include terminal test blocks, links and the required small wiring to facilitate quicker installation on site;
- Auxiliary relays for protection replacement works;
- OMICRON test equipment including and software licenses to support the evaluation of the Constellation solutions; and
- Configurations for the protection relays, including functions and settings in use at the substation circuits.

It is noted that the delivery of the merging units was delayed due to global logistics challenges. Furthermore, some of the other required equipment is delayed due to the global supply chain issues. More specifically, the time clock equipment is expected to arrive in late November, while the network switches are expected to arrive in Q2 2023. More information about the risk with equipment delays is in section 4.2.

Configuration of protection relays: As part of Constellation, the protection relays in the trial sites are replaced with modern devices which can support the required Constellation functions. The protection configuration of the physical relays in the Maidstone area has been completed in this reporting period. This has given necessary experience as we will also do the configuration for the virtual protection elements for the same circuits at a later stage in the project.

Installation and commissioning: To date, UK Power Networks have installed and commissioned four circuits in the Maidstone area to compatible with IEC 61850 standard communication. These relays will bring measurements, controls and indications from each circuit to the substation server and enable the Constellation solutions to be demonstrated on the electricity network.

The installation of devices will continue in January 2023. The Constellation team is working closely with network operations in scheduling the site works as higher electricity demand from customers during winter impacts the availability of suitable windows for planned outages to install equipment.

5G coverage: Trial preparations also include ensuring the 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 this reporting period Vodafone has installed antennas and radio equipment at three sites including Maidstone Grid 33kV, a DER site and Thanet Grid 33kV. The 5G site works are delivered in three stages:

- The first stage has been completed on these sites and includes installation of equipment and civil works;
- The next two stages, which are less time consuming, include configuration work of the devices and penetration tests to ensure sufficient 5G coverage; and
- Additionally, UK Power Networks has extended the fibre optic reach to the Thanet Grid 33kV telecoms room to allow sufficient telecommunication availability within the site.

Training

Two training sessions have been provided to UK Power Networks staff during this reporting period. The training is essential for the upcoming Constellation trials. This includes:

- PCM600 training – with a duration of 2.5 days, engineers improved their understanding on the ABB software PCM600, which is used to configure protection relays. This training took place online and in person.
- Security in Industrial Networks – with a duration of 5 days, engineers learned about common cyber threats and how to improve ethernet network security on ethernet switches. This training took place in person.

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 at grid sites; and at each DER site. For these, UK Power Networks will deploy phasor measurement units (PMU) merger units and phasor data concentrator (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 this reporting period, we have made significant progress in the provision of Phasor Measurement Unit (PMU) data. However, one device was found faulty and had to be replaced. In addition, one device, the RPV311 encountered issues with time synchronisation of the PMU streams. A new IRIG-B card has been ordered and installed on the Master Clock device. However, a firmware update was also required and will be completed in December 2022.

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

The provision of CIM data of the Maidstone Area has been completed in this reporting period. The provision of CIM data for the Thanet Area has been tested and is expected to be completed by the end of 2022 as per the agreed plan. However, the provision of switch position data is still ongoing due to the complexity in communicating the data attributes consistently.

Challenges and lessons learned

Procurement

The procurement of hardware was initiated in March 2022. Orders for the protection relays with final product codes were placed in May 2022. The lead times for relays from the main supplier were significant (exceeding 20 weeks). We received the first delivery of sub-racks with protection relays 22 weeks after placing the order. Normally, a protection relay should be available in 6 weeks but 2022 has seen a disruption in the market of raw materials and semiconductors which made products more difficult to order. This resulted in the delay of the installation of relays by several months. While the situation is more stable at the end of 2022, the learning points include the need of a continuous engagement with suppliers and the need to be able to flexibly revise the plan and milestones in NIC projects. This is being considered for equipment required for Thanet Area which is due to be installed in a later reporting period.

Site works

While site works are underway, despite the equipment delivery delays, we are now entering the winter period of electricity network operation. The large storms earlier in 2022 (February) disrupted the power networks significantly. This meant that planned works such as maintenance had to be cancelled to prioritise works on the damaged power network due to the storms.

We have outages planned for the winter months of 2023 and there is a risk of cancellation and delay of the site works if the weather conditions worsen and storms occur. The current plan includes a couple of buffer weeks that can be used to move outages if any unexpected cancellations occur.

Data provision

- The provision of protection data for Adaptive Protection has improved as a result of additional site visits and engagement with engineers from the capital programme design team; and
- The provision of PMU data to GE for the Local ANM solution is still ongoing. We encountered technical issues on this task and have relied on close collaboration with GE to resolve issues on site as they arise.

Outlook for next reporting period

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

1. Updates of FATs for all Constellation solutions;
2. Update on site works regarding the installation and commissioning of merging units in the Maidstone area;
3. Update on installation of equipment on the Constellation Cubicles;
4. Update on the ongoing procurement for the Thanet area;
5. Update on site design for the Thanet area;
6. Update on the 5G coverage on every site; and
7. Update on data provision activities

2.3 Workstream 3 – Trials & Analysis

Workstream 3 is responsible for designing, running and evaluating the outcomes of the Constellation trials. The trials aim to ensure sufficient de-risking of the Constellation Methods is achieved by advancing their Technology Readiness Level (TRL) and successfully demonstrating their functionality in an operational environment. The trials consist of two complementary phases – off network trials hosted at the PNDC and live trials on the UK Power Networks distribution network. The iterative nature of the trials process ensures the translation of specifications associated with the Constellation Methods into a set of refined requirements and network management policies and standards for BAU rollout, as illustrated in Figure 6 below.

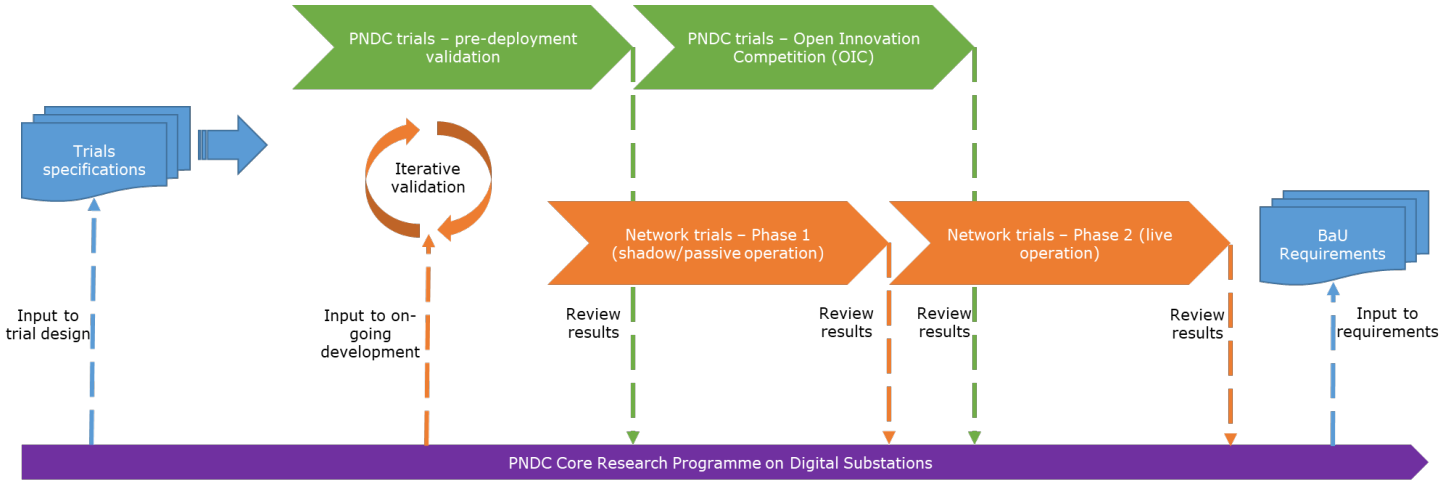

Figure 6 – Constellation trials process

Progress during this reporting period

Trials specification

During this period, the trials specification has been completed for Methods 1 and 2. This specification defines the functional and performance tests to be carried out to verify they Local ANM, Wide Area Protection and Adaptive Protection and Central Management System functions in an integrated virtualised environment. Regular technical discussions have been carried out between the project partners and led by PNDC to elicit the testing requirements for the trials phase of the project and develop the trials specification. The trial specification is divided into PNDC trials and UK Power Networks trials. The focus in this reporting period is the PNDC trials, whereas the UK Power Networks trials will be finalised after sufficient learning is collected from the PNDC testing. The trials specification captures the detailed test objectives and test criteria to avoid ambiguity in defining test success criteria as outline in Figure 7.

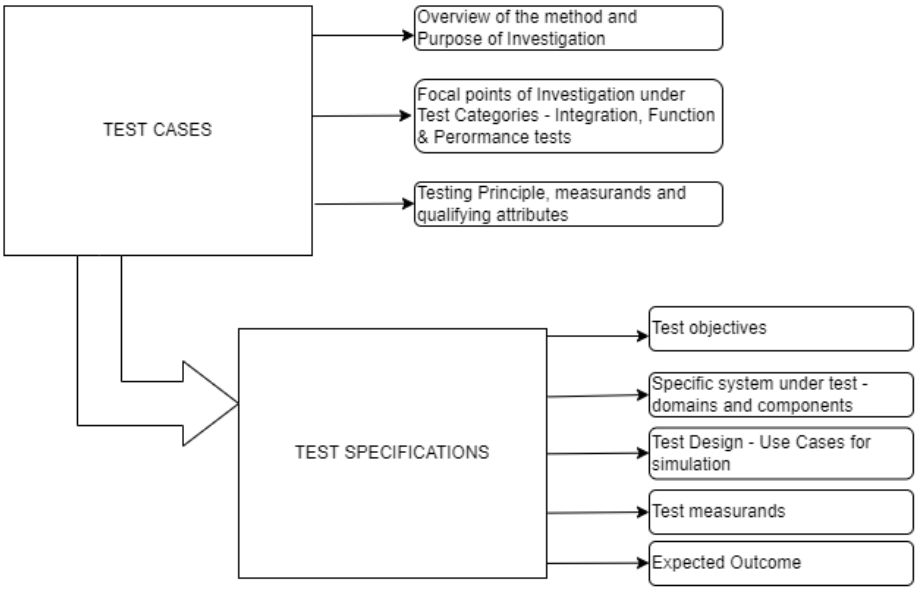

Figure 7 – Outline of the test description

Virtualisation testing strategy

Virtualisation is at the core of the Constellation project. Therefore, it is critical to assess the functionality and performance of the virtualisation platform as part of the trials process. During this reporting period PNDC developed a virtualisation testing strategy to define the key requirements for testing a virtualised solution. This will be used as a basis for creating a testing specification for the virtualisation platform focusing on system configuration, compute resource management and software updates.

Procurement

Since the last reporting period, PNDC procurement has continued based on the equipment and software specifications provided by UK Power Networks to ensure replicability between PNDC and UK Power Networks trials phases. Some equipment specifications have been adapted to suit interfaces specific to the PNDC trials environment. Conclusion of the procurement process is expected to end this year with final deliveries of equipment and software licenses expected in Q1 2023.

However, the equipment delays UK Power Networks encountered (section 2.2) with procuring equipment were also observed by the PNDC. As a result, there is a risk the PNDC trials are delayed and cannot commence at the end of Q4 2022 as initially planned. The risk is further described in section 4.2.

PNDC trials environment

In this reporting period, the PNDC trials environment design has been refined to reflect the latest development status of the project partners' solutions. Furthermore, the following progress has been made specific to the build of the PNDC trials environment:

- **5G coverage**: the PNDC 5G dot system has been installed and commissioned with 5G slices awaiting activation following the 5G communication FAT;
- **ADMS upgrade**: the PNDC GE ADMS upgrade is well underway and is expected to be deployed at PNDC by the end of December. Regular technical discussions between GE, PNDC and UK Power Networks took place to ensure site trials modelling in the ADMS as well as SCADA configuration requirements are implemented correctly;
- **Real Time Distribution System (RTDS) modelling**: Maidstone RTDS modelling validation and SCADA configuration has been completed. Thanet RTDS modelling has been initiated – its validation is due to be completed before the PNDC trial start using a PowerFactory model. These real-time models will be used to drive the majority of the test cases defined in the trials specification. Further modelling work is being undertaken to implement representative inverter-based DER. PNDC is working closely with UK Power Networks and OMICRON to achieve this before trials commence;
- **Test racks**: racks have been situated in the PNDC test lab and as adjacent to the PNDC primary substation. The racks will be fully populated with test equipment once their deliveries are received;
- **Remote connectivity**: secure remote connectivity is being set up to enable partners access to dedicated part of the PNDC trials environment in order to facilitate remote support as well as enable functional testing of some of the solutions, such as the adaptive protection. A remote connectivity architecture has been proposed and is currently undergoing a security review;
- **DER site RTU**: the inclusion of a physical DER site RTU representing a field deployment in the PNDC trials has been agreed. RTU specification is currently under way in collaboration with UKPN; and
- **General site preparations**: additional site works such as power supply provisioning and ventilation for the substation servers have been completed. Works are currently being undertaken to install trip and circuit breaker signalling in the PNDC 11kV switchboard to enable some wide area protection test scenarios.

Factory Acceptance Testing

In this reporting period, PNDC is witnessing FATs to facilitate the transition into PNDC trial in the next reporting period. Outcomes and partner feedback from the FATs will be incorporated into the PNDC trial planning and revisions made to the trials specification, where necessary, to address emerging gaps in testing. Furthermore, common and deeper

understanding of the workings of each of the partners' solutions serves to reduce misunderstandings or ambiguity in relation to the trials phase objectives and outcomes.

Preparation for PNDC trial

The PNDC trial will be the first instance when all partner solutions are integrated in the same virtualised platform. Thus, planning for the PNDC trial has been initiated and a PNDC Site Acceptance Testing (SAT) methodology is currently under development. The purpose of this methodology is to:

- Identify the risks and mitigations associated with multi-vendor integration in a virtualised environment
- Define pre-SAT and SAT tasks and responsibilities for each of the partners including assigning lead and supporting roles.
- Identify the critical paths and timelines associated with the PNDC SAT and leading into PNDC trials

Challenges and lessons learned

Procurement of equipment

Long lead times for equipment is posing planning challenges for the upcoming trials phases (PNDC and UK Power Networks). This is being monitored continuously and prerequisite activities are being prioritised to minimise the impact of equipment delivery delays. For example, configuration for communication equipment need to be set up offline ready for deployment on the hardware upon arrival.

Remote connectivity between all partners

Setting up remote connectivity with different partners posed a number of challenges in relation to the difference in organisations' connectivity requirements. This led to the need for simplifying the connectivity architecture while balancing with the secure connectivity requirements. This necessitated the reduction of connectivity interfaces and aggregating the logical remote connectivity pipeline. Through close coordination between all partners, we have progressed towards an acceptable approach to secure remote connectivity.

Power system modelling

Modelling representative inverter based DER behaviour is challenging without access to the specific DER site's data and technical capabilities. To address this, the approach adopted for modelling DER sites in RTDS is to define the characteristics relevant to test case. For example, the ability of inverters or lack thereof to inject negative sequence current during fault conditions and how it may impact the protection functions under test. Furthermore, historic empirical characterisation tests of inverter hardware are utilised to increase confidence in the modelling assumptions.

Outlook for next reporting period

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

- Finalisation of the PNDC trial specification;
- Development of testing requirements for the UK Power Networks live trials phase in close collaboration with all key stakeholders and BAU owners;
- Completion of the PNDC trials environment build and integration;
- Initiation of the PNDC trials and SAT; and
- Development of the UK Power Networks live trials specification.

2.4 Workstream 4 – Open Innovation Competition (OIC)

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

Progress during this reporting period

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

Challenges and lessons learned

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

Outlook for next reporting period

The workstream activities will formally kick-off later in the project. However, stakeholder engagement and wider dissemination of the Constellation project will continue in an effort to prime potential suppliers.

2.5 Workstream 5 – Academic Insight & Future Governance

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

Progress during this reporting period

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

Challenges and lessons learned

No activities were planned for this reporting period.

Outlook for next reporting period

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

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

2.6 Workstream 6 – Learnings & Dissemination

Workstream 6 is responsible for the dissemination of the knowledge generated from the project. The project has a comprehensive knowledge dissemination plan in place that is outlined in the roadmap in Figure 8. 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.

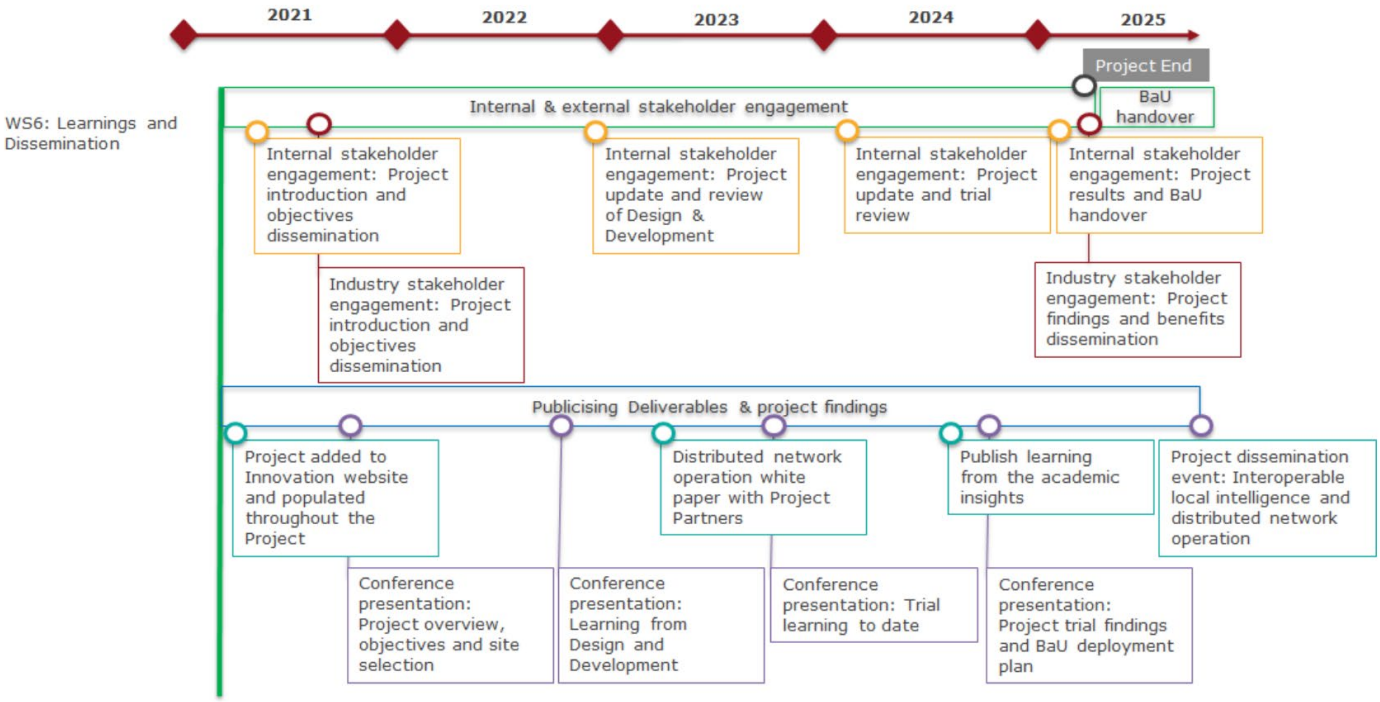

Figure 8 - Constellation knowledge dissemination roadmap

Progress during this reporting period

The following key activities have been carried out:

Participation in conference

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

- **Wider industry review workshop:** As part of the learning from WS1, and continuing from the previous reporting period, a wider industry review workshop was held to disseminate knowledge and obtain feedback**.** The industry review workshop provides an opportunity for our peers within the industry to provide feedback on the scalability of the Constellation solutions. The second workshop (the first one was reported in the previous reporting period) was held with specialists from other LNOs, with a focus on the Constellation solutions. The workshop was delivered fully remotely using the Mural, digital whiteboard, platform. The workshop proved successful, with participants providing valuable insight and feedback through Microsoft Forms surveys and the Mural board. The workshop was also used as a warm-up for the Open Innovation Competition;

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

DER owners was discussed with the DER owners in the trial areas. During this reporting cycle, engagement with DER owners continued;

- **Conferences**: During this reporting period, Constellation was presented in the following conferences to disseminate learning:
    - Energy Innovation Summit (EIS) in Glasgow. There was strong interest from conference delegates in the project and in particular the deployment of virtualisation and virtualising new application from third parties;
    - Energy Network Association (ENA) Working Group: Innovation and Development. The audience consisted of ENA members as well as representatives from GEODE[5];
    - The Global Operational Support Systems (OSS) Conference. The focus of the session was the 5G site-to-site communication and the whole system collaboration between UK Power Networks and Vodafone;
    - Protection and Control Conference in Prague. The focus of the session was Adaptive Protection and it was led by Siemens;
    - Protection Testing Conference and Workshop in Crewe. Constellation was invited to present the novel digital substations and their use-cases;
    - Western Protection Relay Conference, in USA. The focus of the session was Wide Area Protection and it was led by ABB; and
    - Transmission and Distribution World webinar with ABB and Dell. Constellation was invited to present the novel digital substation and their use-cases.

- **Technical dissemination**: During this reporting period, Constellation submitted the following technical conference papers:
    - Abstracts submitted to the CIRED 2023 conference for evaluation:
        - PNDC led paper on the testing of Wide Area Protection;
        - Two ABB led papers on the development and testing of Virtualised and Wide Area Protection; and
        - Siemens led paper on the development and testing of Adaptive Protection.

Challenges and lessons learned

Wider Industry Review

The two workshops, one carried out in the previous reporting period and one carried on in this reporting period, were essential in sharing Constellation`s outputs with the wider industry. Furthermore, the workshops offered an opportunity for discussion and identification of key challenges for digital substations and increased digitalisation of distribution networks. It is essential for the industry to continue collaborating closely to ensure projects, such as Constellation, provide value for all GB customers.

DER Engagement

Some DERs have expressed concerns with the deployment of Constellation due to the site work required on electricity substations prior to the trial phase. UK Power Networks has worked closely with the DERs to clarify the scope of site works required, as well as the associated impact. We will continue engaging closely with DERs in the trial areas to ensure any concerns are alleviated.

Outlook for next reporting period

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

[5] GEODE is made up of European independent distribution companies of gas and electricity. The association represents more than 1200 companies in 15 countries, both private & public owned.

- Regular engagement through the PNDC digital substation working group meetings, particularly to seek input from the technical design authority;
- DER engagement will continue, with the aim of gaining commitment from all the DERs within the trial areas via the DER charter; and
- Submission of full conference papers for the upcoming CIRED 2023 conference.

3. Business case update

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

Figure 9 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.

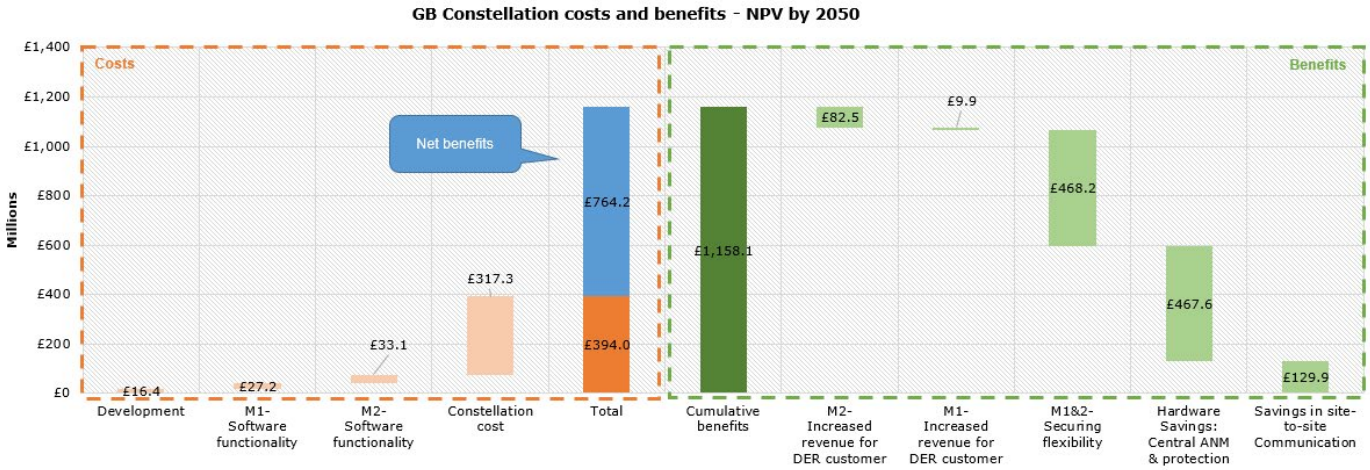

Figure 9 - Forecasted financial benefits in GB by 2050

4. Progress against plan

Figure 10 shows the high-level project plan for Constellation. 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.

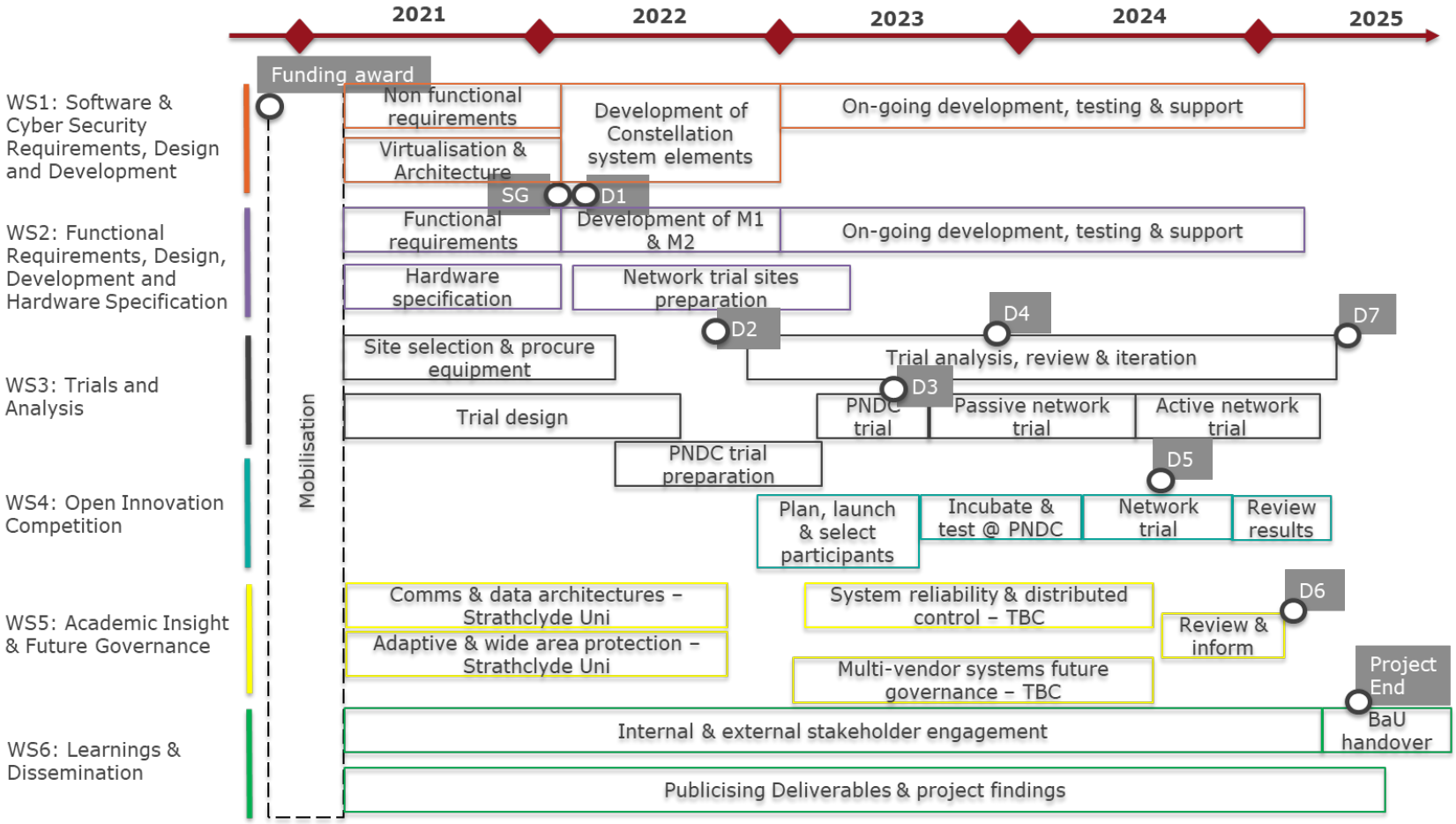

Figure 10 - High level plan

4.1 Detailed progress in the reporting period

In order to monitor project progress against the plan and track any potential risks or issues several regular meetings are held including fortnightly one-to-one sessions with the individual partners, bi-weekly sessions with all partners as well as monthly 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. In the previous reporting period, a key risk with the FATs was raised. The FATs are in different geographical locations and will be assessed by a common group of key technical experts. As such, we were anticipating that the FAT process takes longer which pushes the PNDC trial to begin later. We have overcome the development risks and are on track to complete the development of the Constellation solutions with minor delay. Two FATs are schedule beyond the previously planned November 2022 completion and into January 2023, due to resource and facility availability over the winter holiday period.

However, the PNDC trial is at risk of starting in Q2 2023, rather than the end of Q4 2022 due to the delays in equipment delivery. Equipment suppliers have made us aware of global electronics shortages which are impacting their equipment lead times. We will continue to closely monitor the situation but if the global shortage persists, it may increase the impact on the start of the trial period (refer to 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 1 – Summary of tasks started in this reporting period

Task description	Workstream	Status at end of period
Submit Deliverable 2		Completed
Develop the FAT specifications	1 and 2	Completed
Identify the virtualisation environment (hardware and software) for use during the trials	1	Completed
Deploy a central server for Adaptive Protection	1	In progress
Complete the fourth Project Progress Report		Completed
Develop Local ANM, demonstrate functionality at FAT and resolve all FAT actions	2	In progress
Develop Wide Area Protection, demonstrate functionality at FAT and resolve all FAT actions	2	In progress
Develop the virtualised protection, demonstrate functionality at FAT and resolve all FAT actions	2	In progress
Develop Adaptive Protection, demonstrate functionality at FAT and resolve all FAT actions	2	In progress
Develop the 5G slice, demonstrate functionality at FAT and resolve all FAT actions	1	In progress
Design the site works for Thanet area	2	In progress
Identify hardware for Thanet area	1 and 2	Completed
Plan the remote connectivity and integration for all partners for the PNDC trials	1 and 3	In progress
Finalise site selection activities	2	Completed
Prepare RTDS models for PNDC trial	3	In progress

4.2 Identification and management of issues

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

- **Delays in provision of data for local ANM** – Local ANM requires synchrophasor data at key points on the trial network which have high bandwidth requirements:
    - The standard data communication route was not suitable due to bandwidth limitations. As a result, we had to ensure of a secure and efficient way to communicate the phasor data with GE, which was not anticipated during the project bid. We established this connection for the Maidstone trial area using the operational fibre telecommunication network successfully. Nevertheless, this resulted in a three-month delay in data provision. We will carry out similar work in the Thanet area as well.
    - 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; and
    - 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 some risks, which could develop into issues in the next period if they are not mitigated:

- **Delays in starting the project trials** – Deliverables 3, 4 and 7 can be impacted:
    - Deliverable 3 is focused on the development of Constellation solutions and the early lessons from the PNDC trials. This means that the aim of Deliverable 3 is to show early insights from the PNDC testing, however, the full testing results will be presented in Deliverable 7;
        - Global shortage of electronic components – our equipment suppliers have made us aware of issues with their supply chains due to shortages of electronic components. To manage this risk we are actively managing the trial preparation works to ensure we can do the installations in line with the expected equipment lead times. Nevertheless, it is possible that some equipment arrives later than currently expected and it delays the start of the PNDC trials; and
        - We propose to monitor the situation closely until the end of April 2023 and inform Ofgem if the PNDC trials cannot be started in time for Deliverable 3;
    - Deliverable 4 is focused on the lessons from preparing the UK Power Networks sites, as well as early insights for the UK Power Networks trial. As a result, full testing results from the UK Power Networks trial will be presented in Deliverable 7; and
        - Delays in starting the PNDC trial will result in delays in starting the UK Power Networks trial; and
        - Severe events, such as storms, will result in the delay of all planned site work in UK Power Networks to enable operational staff to be available to support customers. If such events occur during the installation of equipment for Constellation, we may need to postpone some of the site works which will delay the start of the UK Power Networks trial;
        - We will monitor these risks and report the outcomes in the next PPR;
    - Deliverable 7 is focused on summarising the results from all of the Constellation trials.
        - Delays to either the PNDC trial or the UK Power Networks trial start may impact the completion of the project. However, it is possible for the testing to be completed quicker and minimise the impact of any delays to the start of the trials.

- **Insufficient budget for substation equipment** – there is a risk that the budget allocated for the substation equipment will not be sufficient after the learnings from the design activities. In this reporting period we have identified a higher cost requirement for substation computers, data collection, communication, cyber security and virtualisation, as well as the site preparation works themselves. This change in cost is partially due to global inflation as well as other external to the project factors. 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. 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, an activity which was not planned for during the project bid (and only became known as part of the design activities) needs to be carried out – data validation and mapping. In this reporting period, we have made good progress in 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.

- **DER engagement** – Two (out of 5) DER sites in the Constellation trial areas have raised significant concerns with the site works required to deploy Constellation. In this reporting period, we have engaged closely with the DERs to understand their concerns and provide additional details to alleviate their concerns. However, the DERs are still reviewing our information and may raise further concerns. We will continue to work closely with the DERs and rely on best practice in engagement and delivery of site work to ensure the DER concerns are resolved.

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

- Submission of Deliverable 2;
- Development of FAT specifications for:
  - Local ANM
  - Virtualised, wide area and adaptive protection
  - 5G slicing
- Planning and coordinating the delivery of four FATs;
- Second wider industry review workshop completed;
- Deployment of a central server for Local ANM;
- Development of secure by design approach;
- Development of overarching trial design;
- Development of site design for the site works in the Maidstone area;
- Commencement of the site design for the site works in the Thanet area;
- Updating all solutions designs with learnings from development and trial preparation;
- Finalisation of development activities;
- Continuation of preparation for PNDC trials and PNDC ADMS upgrade; and
- Dissemination of learnings across a number of conferences and webinars, and submission of four CIRED abstracts.

4.4 Look-ahead to next reporting period

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

- Finalisation of the PNDC trial design;
- Development of the UK Power Networks trial design;
- Finalisation of the PNDC SAT specifications;
- Completion of FATs and all related actions;
- Completion of PNDC trial preparation;
- Commencement of the PNDC trials;
- Continuation of trial preparation and procurement for the Maidstone and Thanet trial areas;
- Deployment of Azure server for Adaptive Protection (Siemens); and
- Continuation of deployment of 5G coverage across Constellation trial sites.

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 2 – 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.
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	30/06/23	(WS1, WS2 and WS3) Report containing: • Details of the key learning from the design and development of Methods 1 and 2; • Details of learnings from design of 5G slice; and • Testing preparation and early lessons from the off-network testing	The deliverable remains on track, with the partners progressing with their development activities. UK Power Networks and PNDC are also progressing with trial preparations. Please note the risk of delays to this deliverable in section 4.2. We propose to notify Ofgem by the end of April 2023 of any delays to the start of the PNDC trials.
4	Review and insights following site installation and learning from mid trial passive network demonstration	30/11/23	(WS2 and WS3) Report containing: • Key lessons from site installation process at DER sites and primary/grid substations; and • Early learning from the passive network demonstration	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme. It should be noted that any delays to Deliverable 3 will impact Deliverable 4 and Deliverable 7.

Ref	Project Deliverable	Deadline	Evidence	Progress
5	Learning from the Open Innovation Competition (OIC)	31/07/24	(WS3) Report containing key learning on the OIC use case prioritisation, participant selection and incubation process	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme.
6	Learning from academic insights and the governance required to prepare for the future world of distributed network operation	28/02/25	(WS7) Report containing analysis by the academic partner on the opportunities, risks and barriers to full distributed and interoperable future network operation	This deliverable is on track.
7	Analysis and presentation of findings from the trials and plan for BAU deployment	30/09/25	(WS3) Report containing findings from the trials and appraisal of the business case including key learning and plan for BAU deployment	The deliverable remains on track, however no progress is due in this reporting period, aligned with the programme. It should be noted that any delays to Deliverable 3 will impact Deliverable 7.
[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.	Fourth Project Progress Report is completed (UK Power Networks have elected to submit a report every six months). The Close Down Report is N/A at this stage.

8. Data access details

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

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

9. Learning outcomes

The project team recognises the importance of 'best in class' learning and dissemination. Specific lessons learned regarding each of the workstreams are captured in the workstream progress reports. As the project started in May 2021,

the only final materials which are available for dissemination as of yet are Deliverables 1 and 2 which are published. In the next reporting period, 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;
- Constellation architecture; and
- Results of wider industry review.

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 3 – IPR generated in this reporting period

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

Table 4 – 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
PNDC trial design	UK Power Networks, University of Strathclyde	Foreground IP
PNDC trial preparation approach and outcomes	University of Strathclyde	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 1-23 are captured in the FSP. We identified Risks 24-64 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 5 – Risk register

RISK & ISSUE LOG													
ID	**Risk / Issue**	**Status**	**Description**	**Impact**	**Risk Probability**	**Risk Impact**	**Risk Score**	**Mitigation / Planned Actions**	**Mitigated Probability**	**Mitigated Impact**	**Mitigated Score**	**Owner**	**Last updated**	**Date Closed**
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	25/11/2022	
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	25/11/2022	
R26	**Risk**	Open	Internal expertise is not available to support	The project will not deliver all of the intended outcomes to the expected quality or will be delayed	**4**	**5**	**20**	- Work closely with internal stakeholders to clarify expected input and secure support - Plan the work to align with resourcing needs	**3**	**3**	**9**	Project Manager	25/11/2022	
R43	**Risk**	Open	5G service needs to be resilient to power failures to be used for protection / SCADA	The project will not deliver all of the intended outcomes and will not be accepted to BAU	4	5	**20**	- Specify the requirements for protection and control - Design the trial with Vodafone and PNDC to demonstrate the resilience of the 5G service	3	3	**9**	WS3 Lead	25/11/2022	
R47	**Risk**	Open	Negative sequence and zero sequence data is not available	Project is delayed and/or requires re-scoping	4	5	**20**	- Understand the specific network parameters which are required for 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	25/11/2022	
R48	**Risk**	Open	Integration of equipment and systems (from different Partners) is not achievable due to shortfalls in design	Project incurs delays or cannot proceed	4	5	**20**	- Collaborative requirements gathering and design process is undertaken to ensure integration elements are understood - Interfaces between systems (and Partners) defined early as part of the requirements development stage	3	3	**9**	WS1 Lead	25/11/2022	
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	25/11/2022	
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

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	25/11/2022	
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
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	25/11/2022	
R52	**Risk**	Open	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	25/11/2022	
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	25/11/2022	
R63	**Risk**	Open	Richborough constraint monitoring for Local ANM may be unfeasible. Constraint locations are far from Thanet and there is need for additional monitoring	Project is delayed and/or requires re-scoping	4	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	25/11/2022	
R10	**Risk**	Open	Unavoidable changes are made to key personnel on the project	Possible delays to the project	**4**	**4**	**16**	- Comprehensive project documentation is maintained to reduce the impact of any staff changes that may occur. - Ensure knowledge sharing is undertaken across the project team to avoid single point of failure	**3**	**3**	**9**	Project Manager	25/11/2022	
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	25/11/2022	
R34	**Risk**	Open	Not enough resource to carry out integration	Project is delayed and/or requires re-scoping	4	4	**16**	- Plan key resource requirements and availability - Understand resource requirements and plan alternative ways of securing the necessary expertise	3	4	**12**	WS1 Lead	25/11/2022	
R39	**Risk**	Open	Project and BAU not sufficiently coordinated to transition into BAU	Limited outcomes from the trials	4	4	**16**	- Keep the BAU owners and stakeholders engaged and updated - Ensure the products meet the BAU requirements or there are plans in place to meet the BAU requirements	2	2	**4**	Project Manager	25/11/2022	
R41	**Risk**	Open	There is no appropriate data management in place to support the increased volumes of data	Project is delayed and may not be accepted into BAU	4	4	**16**	- Specify the data management requirements early - Agree specific data management plans before the trials with the relevant business stakeholders	2	3	**6**	WS3 Lead	25/11/2022	

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**	Open	Acquisition of land for the 5G equipment Vodafone is installing	Project is delayed and/or requires re-scoping	4	4	**16**	- Early engagement with legal team to ensure acquisition is possible within timescales of the project	3	3	**9**	Project Manager	25/11/2022	
R1	**Risk**	Open	COVID-19 restrictions continue and impact project activities	Cannot hold face-face meetings slowing design process and de-prioritised site work (non-essential)	**3**	**5**	**15**	- Contingency built in and a price review stage gate included at the end of detail design. This will allow costs to be re-negotiated after the architecture and design has completed. - Engage provider on fixed priced contract rather than time and materials	**2**	**3**	**6**	Project Manager	25/11/2022	
R2	**Risk**	Open	Architecture and system build costs are significantly higher than anticipated at FSP costing stage	Project overspend requiring additional partner contributions and/or change request for reduction in project scope	**3**	**5**	**15**	- Contingency built in and a price review stage gate included at the end of detail design. This will allow costs to be re-negotiated after the architecture and design has completed. - Engage provider on fixed priced contract rather than time and materials	**2**	**4**	**8**	Project Manager	25/11/2022	
R21	**Risk**	Open	5G coverage is not available in the trial areas in time for the trials	Project is delayed and/or requires re-scoping	**3**	**5**	**15**	- Contingency budget to account for the installation of small 5G cells in the trial areas - 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	25/11/2022	
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
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	25/11/2022	
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	25/11/2022	
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	25/11/2022	
R35	**Risk**	Open	No suitable expertise for testing and integration	The project will not deliver all of the intended outcomes	3	5	**15**	- Understand the testing and integration requirements early - Plan how the necessary testing and integration skills are made available in time for the Project	2	4	**8**	WS1 Lead	25/11/2022	
R40	**Risk**	Open	There is a cyber security breach	Network is rendered open to cyber attack	3	5	**15**	- Specify robust cyber security requirements - Compliance with cyber security requirements - Develop a suitable cyber security breach response plan	3	3	**9**	WS1 Lead	25/11/2022	
R45	**Risk**	Open	Conflicting interactions with other systems (DERMS, Distributed Restart, etc)	Project is delayed and/or requires re-scoping	3	5	**15**	- Constellation elements integration and interactions with other systems are specified early - Key interactions with other systems are planned and tested during the project	3	3	**9**	Project Manager	25/11/2022	

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	25/11/2022	
R54	**Risk**	Open	Substation PC unable to run Phasor Data Concentrator as software in short-term delaying data gathering	Project is delayed and/or requires re-scoping	3	5	**15**	- Installation of PDC as hardware at substations as backup plan	3	3	**9**	WS2 Lead	25/11/2022	
R56	**Risk**	Open	5G v16 equipment availability among global electronics shortage	Possible delays to the project	5	3	**15**	- PNDC trials and initial testing in Maidstone to be carried out on 5G v15 technology - Testing later in the project (2024) to be on v16 equipment	5	2	**10**	WS3 Lead	25/11/2022	
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	25/11/2022	
R6	**Risk**	Open	Suitable innovation competition entrants cannot be found	Project is delayed and/or requires re-scoping	**3**	**5**	**15**	- Leverage PNDC core research programme contacts - Leverage the R&D connections and experience of all partners	**3**	**3**	**9**	Procurement	25/11/2022	
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**	Open	5G transmission coverage in Manston PV may not be feasible due to location in proximity to the core 5G transmission network	Project is delayed and/or requires re-scoping	3	5	**15**	- Vodafone working with their subcontractors to design solution options which can overcome issue	1	5	**5**	WS2 Lead	25/11/2022	
R33	**Risk**	Open	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	25/11/2022	
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	25/11/2022	
R44	**Risk**	Open	Not all stakeholders are kept up to date with project results and progress	Project is delayed and may not be accepted into BAU	3	4	**12**	- Stakeholders are identified and engagement approach is specified - Frequent and clear communication with stakeholders is carried out throughout the project	3	3	**9**	Project Manager	25/11/2022	
R17	**Risk**	Open	Insufficient innovation competition entrants who meet the entry/procurement requirements	Project is delayed and/or requires re-scoping, limited outcomes from innovation competition	**3**	**4**	**12**	- Leverage partner experience in R&D incubation - Identified over 15 use-cases for participants to work on	**2**	**3**	**6**	WS4 Lead	25/11/2022	
R18	**Risk**	Open	Insufficient availability of quality training data for machine learning to enable solution to be accurate and effective on the network	Accuracy of algorithm decision making is not assured	**4**	**3**	**12**	- Using simulation early, and ramp up level of autonomous operation throughout the duration of the tests as data is built up - Get PMU data from trial sites early in the project	**3**	**3**	**9**	WS2 Lead	25/11/2022	

R20	**Risk**	Open	The selected hardware is not suitable for the time-critical operation of Methods 1 and 2	The project will not deliver all of the intended outcomes	**3**	**4**	**12**	- Equipment was selected based on its ability to perform the required functionality - Sufficient risk budget to ensure equipment scope change can be absorbed	**2**	**3**	**6**	WS2 Lead	25/11/2022	
R22	**Risk**	Open	The virtualisation approach is not suitable for real time protection & control applications	Project is delayed and/or requires re-scoping	**3**	**4**	**12**	- Carried out investigation to select a flexible approach which can deliver the capabilities - 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	25/11/2022	
R29	**Risk**	Open	Unable to recruit suitable / sufficient resource for the project	Project is delayed and/or requires re-scoping	3	4	**12**	- Carry out robust recruitment to ensure expertise is on-board - Plan a suitable "plan B" alternative to secure the expertise required	2	3	**6**	Project Manager	25/11/2022	
R3	**Risk**	Open	Some elements of the technical solution are not achievable to the desired specification within the project timescale and budget	The project will not deliver all of the intended outcomes	**3**	**4**	**12**	- Ensure requirements and solution design is realistic after the detail design stage. - Continuously and quickly adapt to changing requirements, with iteration loops built into the project plan throughout the development. - Regularly progress following UKPN established project control methods	**3**	**3**	**9**	Project Manager	25/11/2022	
R32	**Risk**	Open	Other connections / build at trial sites impact project	Project is delayed and/or requires re-scoping	3	4	**12**	- Understand the expected development activities in the trial areas - Coordinate trial preparation with the other on-going activities	2	2	**4**	Project Manager	25/11/2022	
R38	**Risk**	Open	Integrating multi-vendor IEC61850 is harder than anticipated	Project is delayed and/or requires re-scoping	3	4	**12**	- Secure the expertise from the consortium of Partners to ensure the requirements and design are achievable - The Partners revise the design and the products / services if necessary	2	3	**6**	Project Manager	25/11/2022	
R4	**Risk**	Open	Methods do not deliver the anticipated benefits	Lower than anticipated value delivered	**3**	**4**	**12**	- Regularly revise business case to update expected method costs and expected benefits	**3**	**3**	**9**	Project Manager	25/11/2022	
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	25/11/2022	
R5	**Risk**	Open	Project Partner/Supplier performance is not adequate	Outcomes are delayed, with potential overspend. This may also require a change in partner/supplier as an interim step.	**3**	**4**	**12**	- Ensure shared responsibility for deliverables - Incentivise partner/supplier for success - Ensure tendering/onboarding process focuses on critical project elements	**2**	**3**	**6**	Procurement	25/11/2022	
R14	**Risk**	Open	Solution has unintended impact on the network causing failure, underperformance, and/or customer equipment failure	Loss of supply, damage to customers' equipment	**2**	**5**	**10**	- Equipment is fully tested off-network - Sufficient time is included in project plan to resolve any issues fully and re-test - 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	25/11/2022	

R15	**Risk**	Open	Catastrophic failure of equipment causes network damage and/or injury	Network equipment is damaged, injury is caused	**2**	**5**	**10**	- Solution consists of mainly software components and the hardware ones cannot fail explosively (substation PC, routers & switches) - Failure Mode and Effects Analysis is undertaken to ensure such failures are anticipated and designed out	**1**	**4**	**4**	Project Manager	25/11/2022	
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	25/11/2022	
R28	**Risk**	Open	The designs of the project Methods are not innovative	Lower than anticipated value delivered and potentially project is closed	2	5	**10**	- Collaborate closely with all Partners to ensure novel aspects of scope remain in the design - Review on-going work in the industry to identify if anyone else has demonstrated key Constellation elements	1	4	**4**	Project Manager	25/11/2022	
R30	**Risk**	Open	Someone else develop a product which makes Constellation obsolete	Project is stopped or re-scoped	2	5	**10**	- Review on-going work in the industry to identify if anyone else has demonstrated key Constellation elements	1	3	**3**	Project Manager	25/11/2022	
R37	**Risk**	Open	Project Partners/Suppliers do not pass the FAT	Project is delayed and/or requires re-scoping	2	5	**10**	- Work closely with the Partners/Suppliers during the design and development - Build in sufficient time to re-iterate the design and development	2	3	**6**	Project Manager	25/11/2022	
R42	**Risk**	Open	The Open Innovation Competition products break some of the other project elements	Project is delayed and may not be accepted into BAU	2	5	**10**	- Ensure sufficient testing at PNDC before adoption into the DNO network - Specify what separation is required for all OIC products to ensure safe operation of other systems	1	2	**2**	WS4 Lead	25/11/2022	
R51	**Risk**	Open	Bandwidth and network availability for PMU to central server for data gathering is not sufficient for Local ANM	Limited outcomes from the trials	2	5	**10**	- Estimate bandwidth and advise on protocol support - Close collaboration during the design stage to ensure design is fit for purpose	2	3	**6**	WS2 Lead	25/11/2022	
R8	**Risk**	Open	A partner/supplier may withdraw from the project	Partner/supplier must be replaced or project descoped	**2**	**5**	**10**	- Ensure all partners/suppliers are engaged and involved throughout the project - 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	25/11/2022	
R19	**Risk**	Open	Length of trial period is not sufficient to collate all representative data	Trial is insufficiently representative of potential scenarios with which the solution may be required to cope	**3**	**3**	**9**	- Significant time allocated for testing on the network - Off-network testing to simulate various network scenarios	**1**	**3**	**3**	WS3 Lead	25/11/2022	
R36	**Risk**	Open	Testing scenarios cannot be replicated accurately across the different elements in the project	Limited outcomes from the trials	2	4	**8**	- Prepare a robust trial plan and specify the testing scenarios	1	3	**3**	WS3 Lead	25/11/2022	
R64	**Risk**	Open	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	25/11/2022	

12. Accuracy assurance statement

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

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

Signed ……

Date ……9 December 2022……

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

13. Material change information

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

14. Other information

Currently there is no other information to report to Ofgem.