Flexible Urban Networks – Low Voltage

Project Progress Report: January – June 2015

UK Power Networks
Delivering your electricity

Contents

1. Executive Summary

1.1 Project Overview

The Flexible Urban Networks LV (FUN-LV) Low Carbon Networks Fund (LCNF) project has been awarded £6.53m as a 2013 Tier 2 project. The project started in January 2014 and runs through to December 2016.

The overarching aim of this project is to explore the use of power electronics to enable deferral of reinforcement and facilitate the connection of low carbon technologies and distributed generation in urban areas, by meshing existing networks which are not meshed and by removing boundaries within existing meshed networks. It will do this by trialling three different approaches or three methods (Methods 1, 2 and 3) across 36 trial sites, 24 in London and 12 in Brighton. The first of these methods (Method 1) can provide uncontrolled capacity sharing between two substations. The second of these methods (Method 2) can provide controlled capacity sharing up to 200kVA between two substations. The third of these methods (Method 3) can provide controlled capacity sharing up to 400kVA between three substations.

1.2 Progress to date

In this reporting period the project has focused on a number of areas in delivering of IT solutions along with the installation and commissioning of the three types of power electronics devices (PED) enabling the project to achieve SDRCs 9.2 and 9.4 which demonstrate the capacity sharing capabilities of all three methods. These include:

- the final design and testing of the power electronics equipment;
- managing issues associated with the supply of the low voltage monitoring equipment;
- further improving the soft open point algorithm;
- resolving site selection issues including permitted development queries raised by Westminster and Brighton and Hove City Councils;
- preparing UK Power Networks' control system (PowerOn Fusion) for the trials;
- the designing and building of the communication architecture for the PEDs.;
- preparing the network planning and study tool (DPlan) which will be used to analyse results; and
- installation and commissioning of equipment to deliver SDRC 9.2 and SDRC 9.4

UK Power Networks were notified by the product's manufacturer Turbo Power Systems (TPS) of an issue with one of their suppliers which impacts the manufacture and delivery of the Method 2 PEDs.

Since that initial notification, TPS have had multiple meetings with the cabinet supplier including factory visits to challenge and improve the delivery dates of the PED cabinets. The cabinets comprise not only the external fascias with ventilation grilles and locks, but also provide the internal structure for the device, creating compartments into which individual sub-components are slotted in. As such, there is no off-the-shelf alternative, and sub-contracting to an alternative supplier will not be viable on these timescales.

The project was advised of the final delivery schedule following these meetings on 13 May 2015. This schedule and which currently has a forecast date of the final three units being delivered in w/c 22 June 2015 means that there is not enough time after delivery to install these PEDs on the low voltage network.

The project has explored alternatives ways of meeting the 30 June 2015 deadline but UK Power Networks has two concerns. One alternative would be to prepare the site, leaving it barriered off and then return to fit the unit once it is available. However local authorities have expressed a strong preference for short excavations and opening notices which cover the complete installation as one activity, in order to avoid disruption to their residents and businesses. The two-step approach introduces a hazard which must be managed through barriering off and would be better avoided.

As such, the project wrote to Ofgem on 28 May 2015 to seek a change to the Project Direction to extend the delivery date for this successful delivery reward criteria by eight weeks to 28 August 2015.

1.3 Equipment Design and Development

The project team have finalised the design and functionality of both the remotely controlled circuit breakers and link box switches with EA Technology Limited and the dual and multi terminal power electronic devices with TPS.

Testing of the three-terminal (i.e. Method 3) power electronics devices, LV monitoring and communications solution at the Power Networks Demonstration Centre (PNDC) in Scotland was successful completed in May 2015.

1.4 Soft Open Point control algorithm

The primary version of the Soft Open Point (SOP) control algorithm has been produced and was delivered to TPS in time for the testing in January. The enhanced version of the algorithm which will be used in the trials enables the control of capacity sharing between the connected substations by receiving data from substation monitoring installed at remote ends and combining it with the data measured at the SOP to provide the required response from the PEDs has been delivered to TPS for further testing. The progress in this area is a significant achievement and represents one of the more complex interfaces within the project. Credit is due to both Imperial College and to TPS to be able to co-develop software at Imperial College which will run on TPS's hardware to the required quality standards.

1.5 Stakeholder Engagement

FUN-LV project partner Ricardo AEA (formerly known as PPA Energy) are presenting a paper on "Selecting sites for FUN-LV field trials" at the 23rd International Conference on Electricity Distribution hosted by Congrès International des Réseaux Electriques de Distribution (in English International Conference on Electricity Distribution aka CIRED) in Lyon between 15 and 18 June 2015. Further information about the conference can be found at http://www.cired2015.org/.

The team have also held four further stakeholder engagement meetings, three Project Partners Steering Groups and one Internal Stakeholders Group. Additionally the Project Office Manager attended a knowledge sharing event hosted by the Project Lead of the ENWL Smart Street project to maintain awareness and a connection between the two projects.

The project team also held a session in March with representatives of the equipment installation teams, to introduce them to the Multi Terminal Power Electronics Device. During the session, the installation representatives familiarised themselves with the equipment and provided recommendations aimed at ensuring a safe installation of the devices.

1.6 Cost Benefit Analysis

The cost benefit analysis work has continued to make progress including the development and production of the cost benefit analysis plan. The project has now robustly collated:

- business-as-usual costs and processes, with the input and support by relevant commercial teams within the business;
- method costs using cost elements available pre-trial and mapping for summary costs (including installation) upon completion of method costs being finalised; and
- A view of example costs and benefits, prior to trials commencing. This presentation was delivered to business stakeholders to demonstrate sample financial benefits of deferring reinforcement and expected additional site benefits.

1.7 FUN-LV Risks and Issues

1.7.1 Procurement Risks and Issues

In addition to the issues stated above related to delivery of the PEDs associated with Method 2, a procurement issue arose related to the provision of low voltage monitoring equipment.

The further issue is that the original supplier of low voltage monitoring equipment informed the Project Lead late in the contract negotiation process (at contract signature stage), that its new product, intended for use by the project had failed testing and that its estimated delivery date was 1 September 2015. A part solution has been created by reconfiguring recovered equipment had been previously supplied for use on a T1 LCNF project. This is on track to fulfil a part, but the minority, of the monitoring required.

Due to the risk to the project delivery timelines and the incomplete solution provided by re-using equipment from a previous LCNF project, the project immediately went back to the procurement process and sourced an alternative supplier who was able to supply similar equipment which had been used on previous UK Power Network projects. The lead time involved in the delivery of the alternative equipment is significantly longer than expected (8-12 weeks from the time of placing an order) but still shorter than those of the original supplier's re-forecasted delivery. The order was placed on 24 April 2015 and the supplier is currently estimating delivery dates in the final week of June.

1.8 Costs

Costs are currently tracking slightly behind plan, but do not yet include the costs which will be incurred with installations over the coming period. A full update on the labour element of the project costs will be included in the next 6 monthly report. There have been additional equipment costs associated with LV monitoring and with purchasing additional (13) units for use in test, beyond the twelve units of each type being installed on the network.

1.9 FUN-LV Learning

Within this third reporting period the project has captured the following learning:

- Technical design documents for the PEDs
- Approved UK Power Networks Engineering Operating Standards
- Commissioning documents for use with the trial installations
- Installation Manuals for Method 1, 2 and 3 equipment
- Technical design and test documents for the delivery of the projects IT requirements

These documents have been detailed in section 6

2. Project Managers Report

The FUN-LV project aims to demonstrate the benefits of using PEDs on the LV distribution network to facilitate deferring costly network reinforcement and enabling faster connections. The FUN-LV project started on 1 January 2014 and is due to complete on 31 December 2016.

This section describes the progress made on the FUN-LV project in the reporting period January 2015 through to June 2015, including the key milestones and deliverables met, any issues encountered, and provides a high level outlook into the next reporting period through to December 2015.

During this period the project team have successfully addressed a number of issues by working flexibly with internal and external partners. Some of these issues include issues with sites selected, permitted development approvals and product delivery by suppliers. Additionally there has been a need to work closely with partners to further define their milestones and deliverables.

During this reporting period PPA Energy was acquired by Ricardo AEA and IGE Digital Energy have changed their UK trading name to GE Grid Solutions (UK) Ltd. Both have undergone contract novation's to resolve these changes in company names. GE and Imperial Consultants Limited have also further defined their contracted milestones in order to improve their contracted deliverables.

2.1 Development and Testing

During this reporting period, FUN-LV has successfully tested all three Methods of power electronics to be trialled during the project. This included the testing of the dual and multi terminal devices at the Power Networks Demonstration Centre (PNDC) which was successfully completed in May 2015.

The project team's focus for the next reporting period will be as follows:

- Running the trials;
- Gathering data;
- Cleansing and analysing data;
- Developing the final SOP algorithm;
- Continuing in development of the cost benefit analysis;
- Hosting a number of knowledge dissemination events; and
- Promoting the learning gathered from the site selection process along with early trials data.

2.2 Workstream 1 – Enhanced Network Assets

This workstream is responsible for the approval, procurement, installation and commissioning of all equipment required to demonstrate the benefits of flexible urban LV networks using PEDs.

The key stages for this workstream are:

- **Approval and Procurement:** To approve and procure PEDs for use in the FUN-LV trials.
- **Prepare sites:** To implement wireless transformer temperature sensors and LV network sensors to gather information about current loadings before any load sharing through meshing takes place.
- **Test, Install and Commission:** To test, install and commission PEDs for use in the FUN-LV trials.
- **Demonstrate:** To operate the devices, measure the impact and calculate benefits for customers using substation monitoring and the PEDs.

2.2.1 Progress in this reporting period

In this reporting period, the workstream progressed with the design, manufacturing and delivery of the Methods 1, 2 and 3 trial devices. All the key supplier contracts, including the LV monitoring equipment, signed and orders raised for services and materials. The prototype Multi-Terminal PED was also tested during this period at the PNDC to test the functionalities of the equipment in a controlled electrical network similar to a live electricity distribution network Meetings were also held with the local council representatives in London and Brighton, where the Dual Terminal PEDs will be installed, to inform them of our impending installation works and trials in their respective areas. Installation works are underway in Brighton, with London following shortly thereafter.

The supply contract for the low voltage monitoring devices was finally agreed between UK Power Networks and GMC-I PROSyS Ltd in April 2015. The choice of GMC-I PROSyS was informed after a protracted pre-order arrangement with the preferred supplier for the devices' supply fell through, due to late confirmation from the supplier that they would not be able to meet our specified deadline. The devices will be delivered to UK Power Networks in June, with installation of the devices expected to take place in over 70 substations in the LPN and SPN areas.

Since the last reporting period, EA Technology has progressed development and design works on the Method 1 equipment, the remote control devices. During this period the final design was completed by EA Technology, with the Factory Acceptance Test and witness testing completed in EA Technology's test laboratory in Chester. The Method 1 equipment was successfully tested in UK Power Networks' test network in London, using prototype equipment manufactured by EA Technology. Some of the functionalities successfully tested included the External Trip Input and Reverse Power Protection functions. After the functionality tests were completed, UK Power Networks successfully carried out a User Acceptance Test on the new equipment. EA Technology also supplied all the Method 1 equipment ordered for the trial installation, with installation works completed at the London and Brighton sites. As part of the Method 1 trial, link boxes in London and Brighton were replaced with Prysmian link boxes to accommodate the link box switches and link box controllers required for the trial.

Changes to the shape of the Dual Terminal PED's roof (from flat to pitched) and the inclusion of a point of isolation between the LV network's waveform cable termination and the PED's flexible cables were some of the main design changes made during this reporting period. The design of the heat exchanger for the Multi Terminal PED's cooling system was also completed during this period. Factory Acceptance Tests have also been carried out on the PEDs to ensure that the specifications and requirements were met. The Technical Design Authority for the project also held various design review sessions with selected technical personnel from UK Power Networks' Asset Management, Network Operations and Health and Safety departments. Demonstration tests were also successfully carried out at the PNDC in Cumbernauld, using the prototype Multi Terminal PED. The tests served as a good opportunity to confirm the viability of the algorithm being developed by Imperial College, through various test modes. The testing at PNDC began on 3 February with extraction of the PED's inverter and control cubicles from the shipment packages and moved into the low voltage test bay, where the earth plate, the powerlock connectors and coolant system were all connected and set up before connecting it to the live network. The picture below shows the schematics of the testing for the PED.

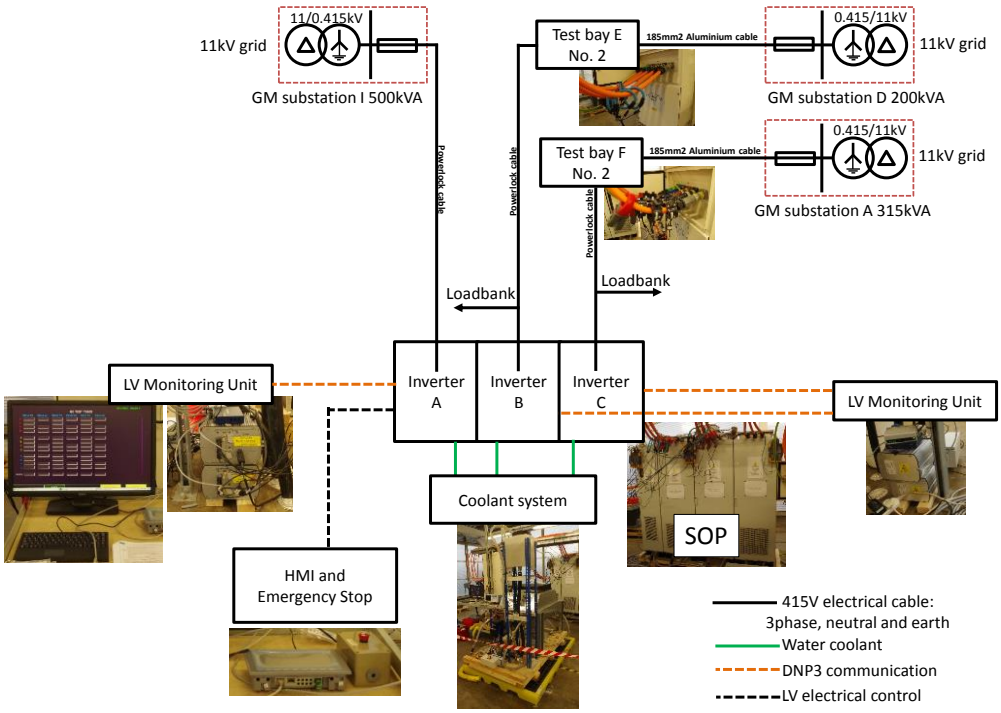

Figure 1. Showing schematics of the prototype Multi-Terminal PED testing at PNDC

Some of the tests carried out after the prototype PED was set up include: balanced three-phase load test; load cycle; reactive power support; phase unbalance improvement; voltage support and end to end testing. The end to end test utilised the full test equipment setup to demonstrate the expected operation of the Multi-Terminal PED and Dual Terminal PED in a live network. Fault scenarios were also included in the test by applying one single phase to earth 11kV fault connected onto the feeder. A comprehensive report on the tests has been produced by PNDC and UK Power Networks and will be included in the SDRC 9.2 and SDRC 9.4 submissions.

Figure 2. Picture of Prototype Multi-Terminal PED wired up for Testing at PNDC

Extensive site surveys were carried out on the 36 trial sites during this reporting period. Apart from the site surveys carried out by the equipment installation teams, the project team also visited and surveyed over 60 substations in London and Brighton areas, where the LV Monitoring Devices would be installed. Meetings were held with the Brighton and Hove City, Westminster City, Lambeth Borough, Merton Borough and Tower Hamlets Borough councils to discuss

the trials, with notification of works letters submitted and permits requested for installing the Dual Terminal PEDs as street furniture on road pavements.

The project team also held a training/equipment appreciation session in March 2015 with representatives of the equipment installation teams, to introduce them to the Multi Terminal PEDs. This session was held at the UK Power Networks' training centre in Sundridge. During the session, the installation representatives familiarised themselves with the equipment and provided recommendations aimed at ensuring a safe installation of the devices.
The main installation works commenced in May 2015, with the successful installation and commissioning of Methods 1 and 3 trial devices at various SPN sites. Further installations and commissioning activities were carried out in the LPN trial sites. The installation and commissioning of the Method 2 trial devices, the Dual Terminal PEDs, commenced in June 2015,

Figure 3. Showing first Multi Terminal PED delivered to an SPN Substation

2.2.2 Key Issues Encountered

The key issues encountered during this reporting period are stated below:

- Changes to the original design of the Method 2 PED had to be incorporated after the original designs had been approved. The additional requirements included changes to the height of the Dual Terminal PED, due to suggestions from Westminster City Council , and the UK Power Networks Operations directorate's' recommendation for phase barriers to be included between the flexible cable ends of the PED, to serve as a point of isolation.
- Issues were also encountered during the demonstration testing of the prototype Multi Terminal PED at PNDC. A number of technical issues relating to communications between the LV monitoring devices and the Multi-Terminal PED led to significant delays in completing the demonstration tests.
- The project team also encountered issues with some local authorities in London while notifying them of the trial installation works for Method 2, as the works involve installation of the trial PEDs as street furniture. Whilst Merton, Lambeth and Tower Hamlets Local Councils did not require UK Power Networks to apply for Planning Permission to carry out the installation works, Westminster City Council's planning department advised that the installation works may require planning permission. This issue has caused some delays for the project team as survey works on the affected sites have been limited, until the outcome of Westminster's deliberation were complete and a Certificate of Lawful Permitted Development (CLOPD) was issued to the project.. The installation works in such areas incurred a delay as a result of these issues.
- TPS, the supplier of the Dual and Multi Terminal PEDs, experienced delays in completing the manufacture and delivery of the trial devices to UK Power Networks. This adversely impacted the workstream's installation

programme as the installation window and the project team worked very closely between the installation teams in LPN and SPN and the suppliers to ensure that all deliveries and installations remain on schedule.

- The project team also experienced delays in completing the order for the LV monitoring devices on time, when the preferred supplier informed UK Power Networks in March 2015 that they were no longer able to meet the project's delivery date for supply of the LV monitoring devices. Due to the criticality of the LV monitoring device to the trial, a new supplier, GMC-I PROSyS Ltd, had to be engaged, albeit very late into the project. This has impacted the installation program of the LV monitoring devices. A part solution has been created by reconfiguring recovered equipment they had previously supplied for use on a previous LCNF project. This is on track to fulfil a part, but the minority, of the monitoring required.

2.2.3 Key Deliverables

The key deliverables for Workstream 1 this period are stated below:

- **Completion of Equipment Designs:** One of the key deliverables for Workstream 1 this period is the completion of all outstanding designs for the Methods 1, 2 and 3 trial devices. The hardware design for the Methods 1, 2 and 3 devices were completed during this period
- **Testing of Trial Devices:** Apart from completing all outstanding supplier and user acceptance tests for the methods 1, 2 and 3 devices, the demonstration test on the prototype Multi Terminal PED was completed.
- **Receive Approval from Local Authorities:** The workstream obtained approval/go ahead where required from all the local authorities, for installation works to be carried out in areas that required approval/notice in place before the installation works commenced.
- **Delivery of Equipment from Suppliers:** The Workstream is on target to receive all the equipment that would be installed for the trials.
- **Installation of Trial Equipment:** During this reporting period, the workstream commenced the installation and commissioning of the trial equipment at the various LPN and SPN sites.
- **Produce and Collate SDRC Evidences:** One of the deliverables for this period includes the production and collation of evidences required to produce the SDRC 9.2 and 9.4 reports.
- **SDRC 9.2 and 9.4 Report Submission:** The project team is on course to complete and submit the SDRC 9.2 and 9.4 reports to Ofgem.

2.2.4 Planned Activities for the next Reporting Period

The Workstream 1 team plans to carry out the following activities for the next reporting period;

- **Installation and Commissioning of Trial Equipment:** Complete the commissioning of remaining Method 2 PEDs and the remaining LV monitoring installations associated with them.
- **Documentation of Installation and Commissioning Activities:** Final documentation of installation and commissioning activities plan to be carried out, with drawings and documents handed over to the responsible persons and departments.

2.3 Workstream 2 – Communications, System Integration, Data management (CSID)

2.3.1 Progress in this reporting period:

Workstream 2 completed the design inputs relating to the IT and communications solution and have completed the associated testing activities. The current focus within the workstream has been to make available the PowerOn Fusion (PoF) control system for the commissioning of the Method 1, 2 and 3 equipment. Partners have been involved in planning and undertaking various activities in developing and finalising deliverables like testing, data extraction and analysis, communication architecture implementation, symbol design and development etc.

2.3.2 Project Acceptance Testing Documentation

The purpose of these acceptance-testing procedures is to ensure that the workstream 2 deliverables meet the functional requirements of the project relating to:

- The new PoF diagrams for the trial sites
- New symbols for controlling the PEDs
- The capture of trials data ready for analysis

The two software modifications made for this project to the standard PoF have been correctly implemented.

- Automatic update of Secondary DNP3 TCP/IP address: The SCADA front-end has been modified to support the fact that a link box may switch IP address.
- Transmission of HV connectivity changes: The SCADA has been modified to import the current state (live or dead) of targeted secondary substation.

2.3.2.1 Method 1 Substation Symbols

The following diagrams demonstrate how the Method 1 equipment is represented on the PoF system. Menus within the symbols are used to select and operate the equipment. Figure 3, Figure 4 and Figure 5 relate to the circuit breakers and Figure 6 and Figure 7 are for the linkbox switches.

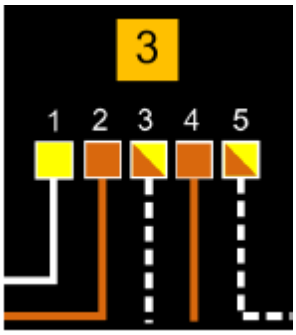

Figure 4. Secondary Substation overview with circuit breakers

Figure 5 RTU on site communications representation

Each Method 1 CB is operated using the symbol displayed in Figure 6 below

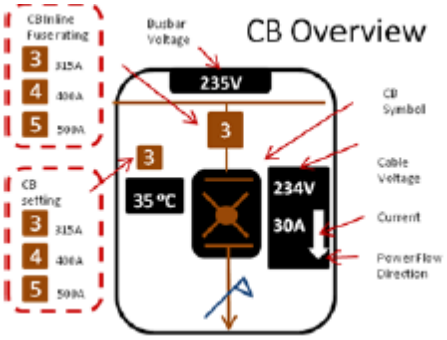

Figure 6 Circuit breaker representations

The Method 1 linkbox switch is operated using a symbol similar to the one below in Figure 7.

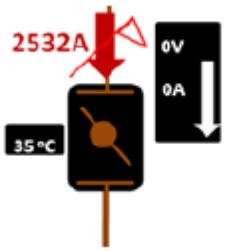

Figure 7 Linkbox switch representation

The single-line diagram overview of the link box 610699 and its surrounding network is displayed in Figure 8.

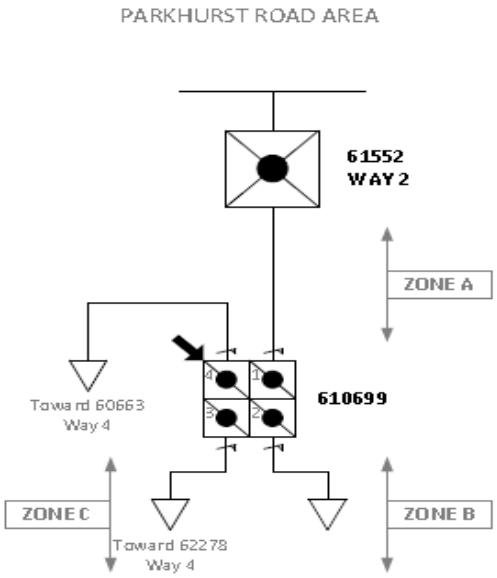

Figure 8. Link box representation

2.3.2.2 Data Provision Specifications

Network topology data, including electrical/thermal characteristics and exit point connections, will be obtained from DINIS and Strumap for LPN and Netmap for SPN. A measurement index containing details of the available PI tags will be obtained from PI and linked into the topology data for DPlan so it can subsequently request historical data for these tags when required.

The topology data and PI tag lists will be fed into Data Quality Management (DQM) databases implemented in Microsoft Access, based on the approach successfully used on Low Carbon London (LCL). These databases have been used to:

- identify any relevant source data quality issues so these can be reported back to the relevant data stewards for correction;
- merge data from the various source systems where required, e.g. to link PI tags to the network topology; and
- generate data files used to populate PoF with the network topology.

2.3.2.3 PI Interface Specifications

The workstream has also developed the processes and tools required to populate the network master data, i.e. the network topology, electrical/thermal characteristics, exit point connectivity details and currently available PI tag information into DPlan and PowerOn Fusion. This master data is the core dataset that both these systems need to fulfil their functions. Subsequent provision of measurement data for use in power flow studies, such as historical PI values and historical or estimated half-hourly consumption data for exit points, is addressed by the other elements of the FUN-LV architecture.

Figure 9 below illustrates the context and scope of the UK Power Networks PI to DPlan in the overall FUN-LV solution

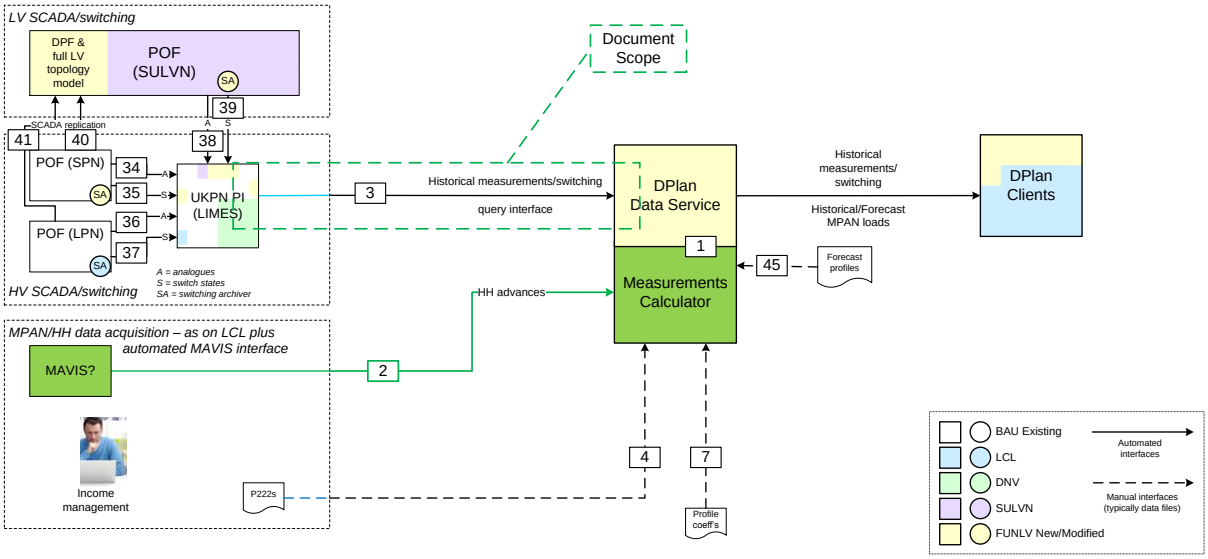

Figure 9 DPlan Interfaces

The purpose of this interface is to provide the DPlan with the actual values of the measures and switch states in order to have historical information of the network configuration and measurements.

Figure 10 below provides a technical overview of this interface including key processing steps.

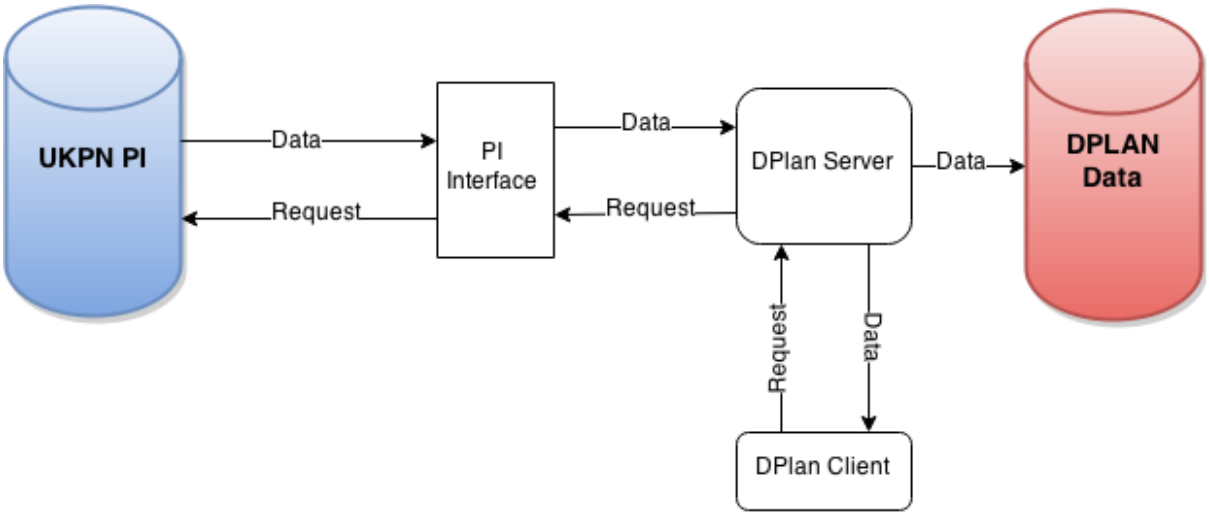

Figure 10 Technical Overview of PI-DPlan interface

2.3.2.4 Trial Zones

Two of the trial zones loaded onto PoF with their geographical background are displayed below

Montford Place

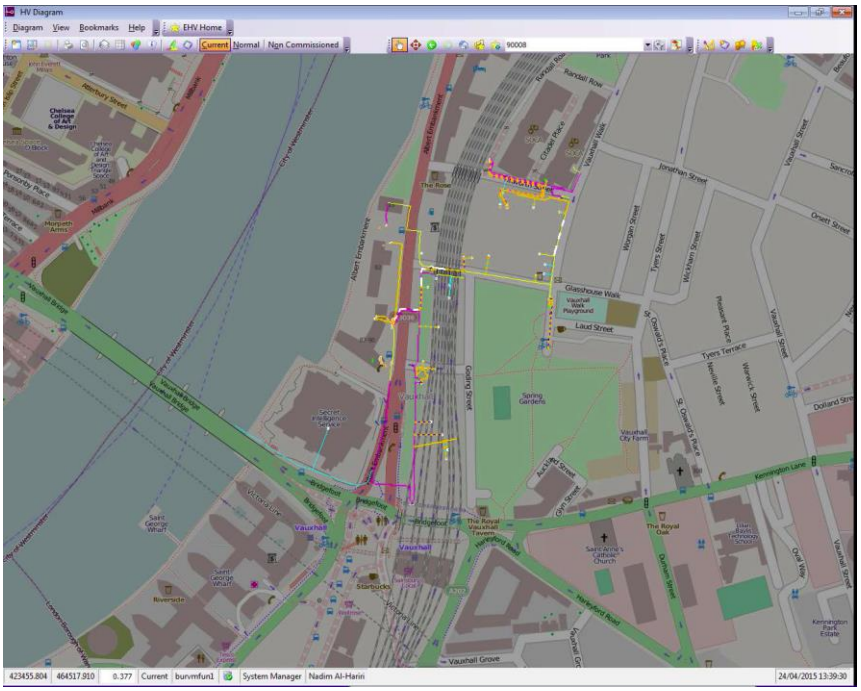

Figure 11. Snapshot of Montford Place trial zone

Leicester Sq / Bloomfield Pl – Trial 1.1i, 2.1i, 2.2i, 2.3i, 3.4i

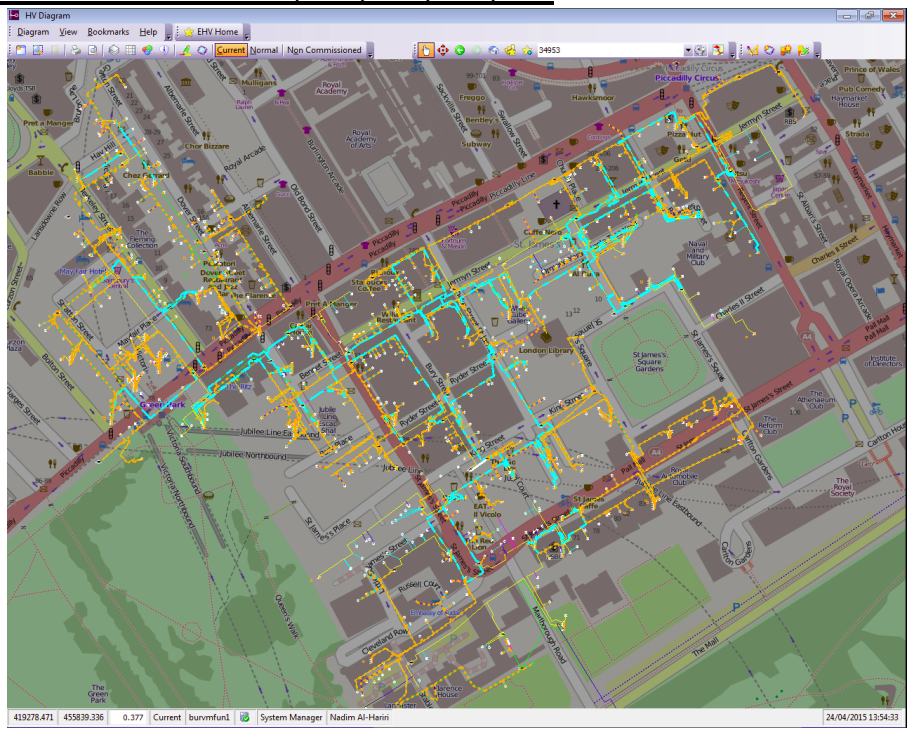

Figure 12 Snapshot of Leicester Sq/Bloomfield Pl Trial zone

2.3.2 Key Issues Encountered

The main issues encountered in this reporting period have been:

- **Change in Vendor**: Change in the vendor for LV Monitoring equipment supplier prompted the communication design to be revised and a new iHost solution to be introduced. The iHost product provides many features like data concentrator, protocol converter, historian and data visualisation. This involved new engagement in the middle of the projects delivery phase starting from signing of the contracts to the redesign of the communications solution.
- **New Templates**: On further engagement with business as usual teams, the requirement for automatic template loaders was given to expedite the process of loading of substation information into PoF was identified. The requirements of these templates were collected and GE engaged to deliver the templates.
- **DPlan Features**: Some of the requirements of having visualisation tools and scenario manager required further developments not in the scope of the project. This was addressed by selecting suitable alternates and workaround to meet the project requirements.
- **Resource Planning** : Due to the fact that project depends on regular business support teams for some of its key resources, the resource involvement required extra planning and approvals from management.

2.3.3 Key Deliverables

In this reporting period, the following progress and key deliverables within workstream 2 are shown below:

- **Requirements**: Requirements were revised and finalised for PoF, Dplan, iHost and other tools.
- **Symbol Design and Development:** Symbols were designed and tested for the three methods during this period.
- **Communications Architecture:** Reviewed the communication architecture addressing the changes in the equipment vendor and introduction of the new functionality that is not available in our existing comms infrastructure.
- **Data extraction & analysis process:** Data was extracted from existing systems UK Power Networks, analysed and then loaded into PoF and DPlan. **Testing undergoing:** Test systems created for our project partners were used for testing, geographical background loading and testing the new symbols for PoF.
- **Vendor Management:** Undertaken key activities for bringing new vendor up to speed on selected for iHost solution. Engagement for starting designing, requirement capturing and planning to deliver the iHost solution with the rest of the project was also undertaken.

2.3.4 Planned Activities for the next Reporting Period

In the next reporting period the workstream will be focusing on development, testing and installation of the equipment required to deliver SDRC 9.3. Workstream 2 plans to deliver the following major activities:

- **Learning Report:** Various reports describing how increased levels of awareness have improved planning processes and network operations
- **Planning Tools:** Complete the planning tool configuration to be based on the commissioned systems and the data received.
- **PED modes:** Providing data and assisting the study of various enhanced modes of operation of PEDs; with comparisons of early modes of operation with those proposed by Imperial Consultants
- **Analysis:** Supporting various analysis of the PED performance, distribution network monitoring data etc.
- **SDRC Delivery:** Delivery of SDRC 9.3 and IT requirements for the projects remaining SDRC commitments.

2.4 Workstream 3 – Network Awareness and Process Improvement

The aim of this workstream is to realise the benefits of PEDs and demonstrate the value that can be realised from the data collected and visualised for both control engineers and network planners.

There are two key elements to this workstream:

1. Defining the requirements for enhanced awareness tools and evaluating the effectiveness of the tools developed for the business; and
2. The development of the soft open point control algorithm for the Method 2 and Method 3 soft open point hardware, to achieve enhanced capabilities.

There are two key phases of work:

1. Design and development of both the soft open point control algorithm and the tools supporting FUN-LV (the development of the tools takes place under Workstream 2).
2. Deployment of the soft open point devices and tools developed, and evaluation of performance of different operating modes.

2.4.1 The Approach

2.4.1.1 Enhanced Tools

The development of the requirements for enhanced tools is a set of activities currently led by Ricardo-AEA. In the last reporting period, this activity focussed on documenting requirements for DPlan (provided by CGI), but in this reporting period has also covered PoF and DPF (provided by GE). Sessions between Ricardo-AEA and CGI/GE, both by face-to-face and remotely, have been held in this reporting period, to continue discussions on tool scope and capability for FUN-LV, and to clarify requirements previously documented. The tools themselves are being developed in Workstream 2, and will then be evaluated in Workstream 3.

2.4.1.2 Soft Open Point Control Algorithm

The development of the SOP control algorithm is a set of activities led by Imperial Consultants. Sessions between Imperial College and Ricardo-AEA have been and are being held approximately monthly, for Imperial Consultants to present their progress and for Ricardo-AEA and UK Power Networks to provide feedback and guidance on design decisions. These sessions are well attended by other interested project partners and suppliers (i.e. CGI and TPS), and provide a means of integrating with UK Power Networks business areas, for example in the form of considering the communication requirements. In this way, the SOP sessions provide a good platform for cross-workstream interaction, covering the hardware requirements (Workstream 1), impact on tools (Workstream 2) and design of the control algorithm (Workstream 3).

It is intended that the SOP control algorithm will be developed using three version releases:

- Version 1 – Factory acceptance tests
- Version 2 – Field trials
- Version 3 – Updated version improving on results from field trial results

The activity in this reporting period has focussed on testing Version 1 and finalising Version 2 of the algorithm.

2.4.2 Progress in this reporting period

Enhanced Tools

There have been a number of key activities in this area in this reporting period:

- Contingency Scenarios – A report has been produced providing examples and details on what is required for, and of, a contingency analysis package for FUN-LV solutions where the protection and operations of equipment being used potentially have significantly different scenarios than seen in conventional LV networks. This included events to consider and types of faults; requirements for a contingency analysis package; examples of contingency analysis; and a review of the contingency toolset currently available in DPlan.

- Developing Visualisation and Awareness Systems Part 1 – Consideration of the business requirements for real-time/operations solutions for the FUN-LV project, including an assessment of the high-level business requirements of real-time/operations solutions; an evaluation of the proposed solutions against the Use Cases (workstream 3 deliverable from 2014) and the business requirements (low-level requirements, an activity co-ordinated by workstream 2); and a review of tool developments so far (DPlan only).
- Maximising Circuit Transfer Capacity – This activity is exploring making the maximum use of both transformation and existing cables, given that the key functionality of the FUN-LV PED solution is the ability to finely control power flow. This has encompassed a literature review and meeting with Prof Lewin and Dr Pilgrim, of Southampton University and other experts in the field; setting up a laboratory test facility to gather data on temperature and load; and starting to analyse results from testing cable samples; documentation of activity and key learning outcomes is almost complete.

In addition to the above key activities, a number of supporting activities have taken place, including:

- A workshop with Ricardo-AEA and members of the UK Power Networks planning department, as part of the process of engaging BAU staff with the project. This covered an introduction to FUN-LV Methods, a site selection example (including background to the selected site and example costs and benefits), and an overview of FUN-LV Planning-Modelling Tool requirements (see Figure 13 below).
- Workshops on understanding the SOP algorithm specification to allow CGI/IOA to develop a SOP model for DPlan, attended by CGI/IOA, Imperial Consultants, Ricardo-AEA and UK Power Networks.
- A workshop on load allocation between CGI, GE, Ricardo-AEA and UK Power Networks.

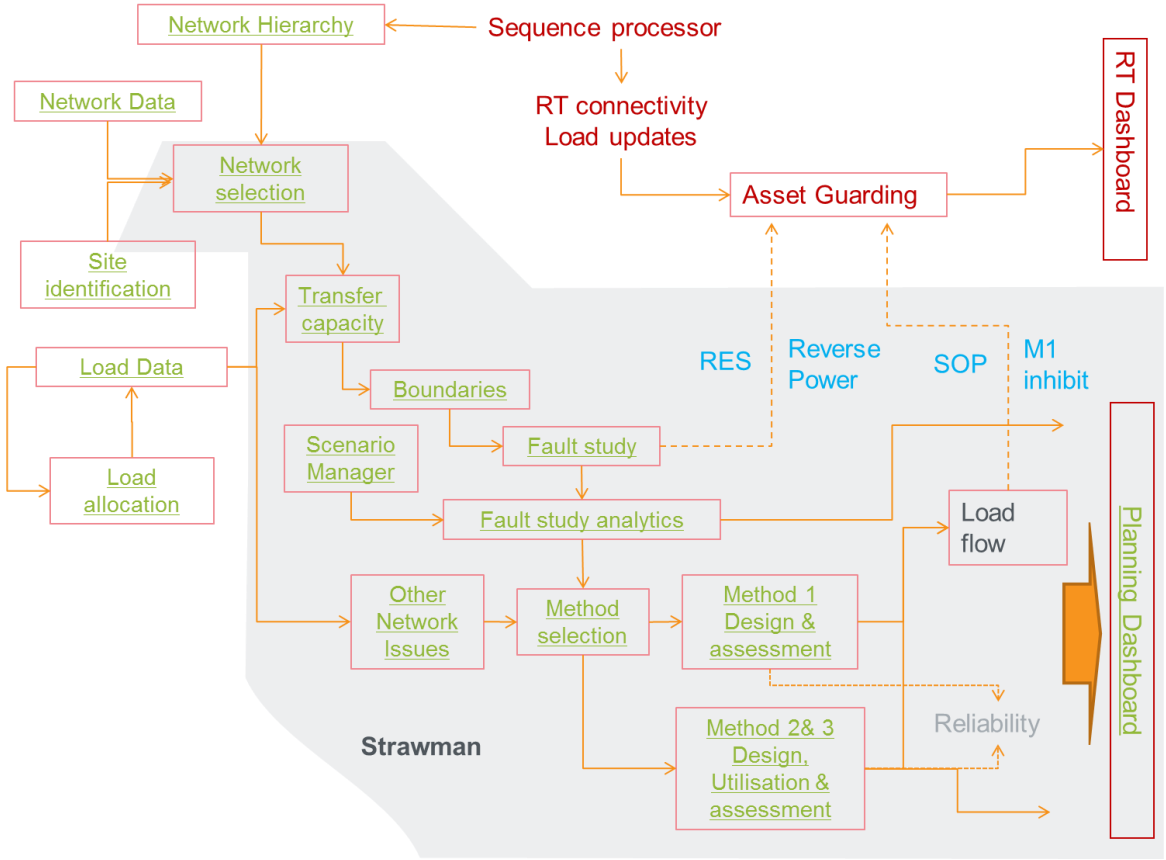

Figure 13. Overview diagram of LV Connectivity Model requirements for FUN-LV, which was delivered in the last reporting period and has been discussed between partners during this reporting period

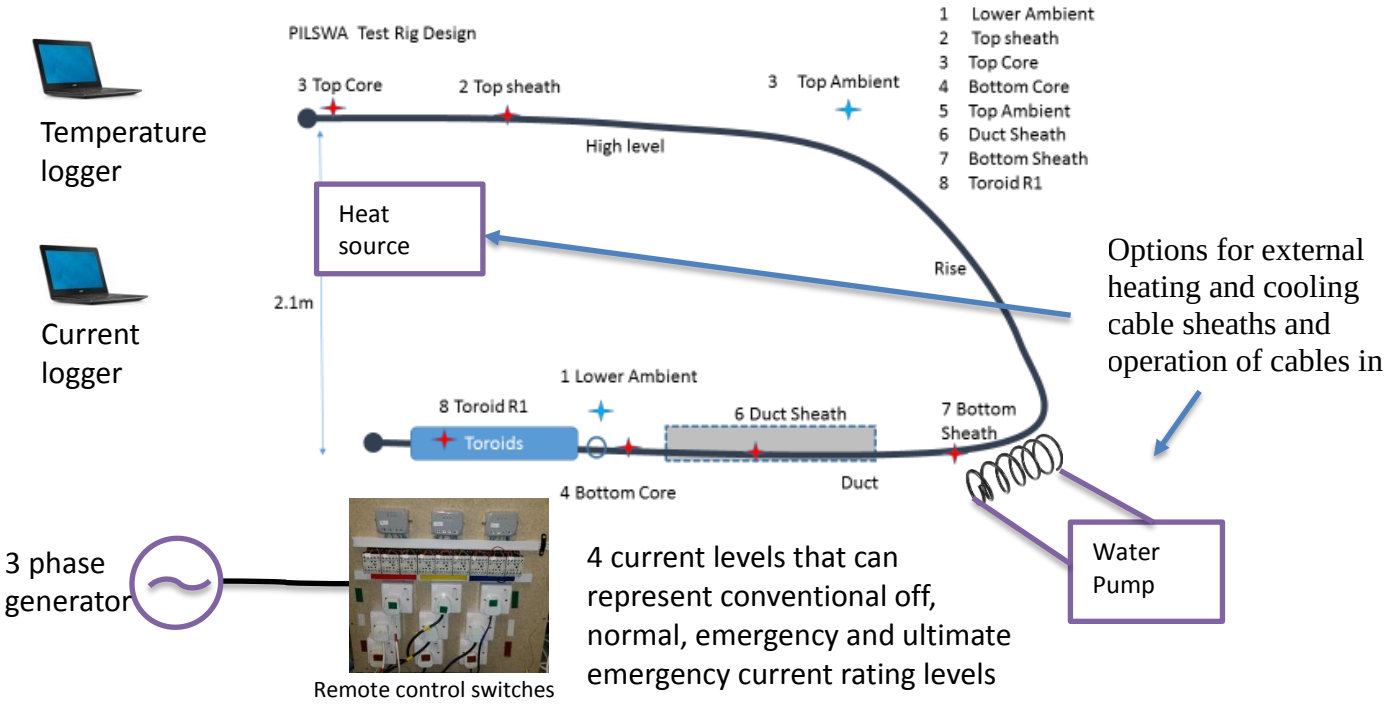

Figure 14. Overview of test rig for activity exploring Maximising Circuit Transfer Capacity

2.4.2.1 SOP Control Algorithm and Performance

In this reporting period Imperial has finalised the first version of the algorithm following various levels of tests, and has developed the second version of the SOP control algorithm. There have been a number of issues of the algorithm to TPS for Version 1; the functionality and status of the key Versions and Issues have been summarised in the tables below. Version 1 Issue 3 has been tested at the PNDC. The intention was to test Version 1 Issue 5, however technical reasons meant this was not possible as the working memory of the Programmable Logic Controller (PLC) was too small. The PLC has been upgraded for the field trials and this is no longer expected to be an issue with Version 2.

Version and Issue	Status / Comments
Version 1 Issue 1	Initial concept developed for two-terminal SOP in simulation
Version 1 Issue 2	Variable data types optimised in response to concerns about Version 1 Issue 1 using only real data types
Version 1 Issue 3	Code provided to TPS and tested at TPS test bench. Problems identified as part of TPS test bench testing have been addressed in Version 1 Issue 4.
Version 1 Issue 4	Includes modifications as a result of test bench testing. Algorithm documented in report, including simulations.
Version 1 Issue 5	Required by UK Power Networks to provide some additional functionality for PNDC testing. Code issued to TPS, but constraint with PLC working memory size (too small for algorithm to be loaded).
Version 2 Issue 1	Designed for field trials with enhancements. Simulations run, finalising code following simulations.
Version 2 Issue 2	To be developed following PNDC tests. To incorporate any changes required to address issues identified at PNDC testing. Working memory upgrade required to fit this on PLC.

Table 1. Summary of SOP Control Algorithm Versions and the status of each

SOP Support Function	Version and Issue
Transformer support	Version 1 Issue 1 onwards*
Transformer equalisation	Version 1 Issue 5
Feeder support	Version 1 Issue 1
Voltage support	Version 1 Issue 1
Unbalance support	Version 1 Issue 3
Power Factor support	Version 1 Issue 5
Harmonic voltage support	To be explored for Version 3

*Each support function is available in all subsequent issues and versions of the algorithm

Table 2. Summary of SOP Support Functions in algorithm versions

SOP Operation / Feature	Version and Issue
Two-port support	Version 1 Issue 1
Three-port support	Version 1 Issue 3
Asset guarding	Version 1 Issue 3
Input data corruption	Version 1 Issue 5
Connection to teed circuits	Version 2 Issue 1
Support function prioritisation	Version 2 Issue 1
Function time delay	Version 2 Issue 1

Table 3. Summary of SOP operation features in algorithm versions

As part of the algorithm testing, Imperial College has visited the PNDC, in February and in April. The algorithm was tested in April, and two main issues were identified. These are being addressed in Version 2.

2.4.2.2 Trials

Following one of the partner meetings, it was agreed that workstream 3, in conjunction with workstream 4, would prepare a trials plan, particularly considering testing the different support modes of the SOP. The aim of the trials plan is to indicate which operating mode each SOP site will be operating in for the first few months of the trials period. The trials plan has been designed to test individual modes separately, before they are tested together. In order to develop the trials plan, key learning questions were identified for the trials and reviewed by project partners, and for each key learning question the following were considered:

- Learning sub-question (more specific than the broader learning question)
- "Owner" (i.e. party responsible for answering the question using trials data)
- Data source and data requirements
- Link to SDRC and Use Cases

This has now been developed into a trials plan to manage the 36 sites during the operational phase.

2.4.3 Key Issues Encountered

The main issues encountered in this reporting period have been:

- When run through the Programmable Logic Controller (PLC) and submitted to TPS by Imperial College, later versions of the algorithm have been larger than the available working memory, and have not been able to be run on the SOP PLC. TPS has upgraded the PLC to double the working memory available, which should accommodate Version 1 Issue 5, and Version 2 of the algorithm.
- There were delays in obtaining cable samples for the lab tests for the Maximising Circuit Transfer Capacity activity. This was due to the type of cable that Ricardo-AEA wanted to include in the lab tests. All cable samples have now been received.
- The PNDC testing delays have resulted in a narrower window than originally planned to review and finalise the algorithm after testing.

2.4.4 Key Deliverables

The key workstream 3 deliverables during this reporting period are:

- **Documentation of credible operational and contingency scenarios** for CGI to assist with CGI's development of DPlan.
- **Developing Visualisation and Awareness Systems (Part 1)** for UK Power Networks and GE/CGI on real-time business requirements, with an evaluation of proposed solutions.
- **Trials data considerations** to inform the design of the trials plan.
- **Trials plan** as an initial view of the schedule of operating modes of the SOPs at different sites, to be reviewed once trials data becomes available

2.4.5 Planned Activities for the next Reporting Period

During the next reporting period the activities are as follows:

- **Maximising Circuit Transfer Capacity** to capture learning from lab tests to contribute to the understanding of SOP transfer profiles.
- **Version 2 of the SOP control algorithm** to TPS (and associated documentation of the concepts and simulation results).
- **DPlan studies on potential benefits** from deploying Power Electronics based on demand curves for a sample of FUN-LV sites
- **Developing Visualisation and Awareness Systems Part 2** to test and evaluate the developed tools
- **Provision of initial data samples from the trials** to Workstream 4 for understanding of the type of data available for the Cost Benefit Analysis
- **A lab-based activity** to develop and lab test solutions for PEDs and conventional protection
- **Reviewing data from the trials** for learning of the performance of the SOP algorithm

2.5 Workstream 4 – Cost Benefit Analysis

The responsibility of this workstream is conducting the Cost Benefit Analysis and proving the Business Case for the FUN-LV trials. The deployment of PEDs as a method of deferring the traditional reinforcement will be measured in relation to associated costs and stakeholder benefits. The analysis aims to firstly demonstrate economically viability of power electronics and secondly to highlight the most cost-effective solution based on various scenarios. As well as deferring reinforcement the workstream aims to quantify additional benefits, resulting from the equipment capabilities such as improved resilience and power quality.

2.5.1 Progress in this reporting period

2.5.1.1 Business As Usual Costs and Processes

In this reporting period, Workstream 4 has progressed in preparing input material for the site specific cost benefit analysis, which will form a site by site representation of the FUN-LV method installations business case. This deliverable will ultimately compare the estimated Business As Usual (BAU) option cost-benefit (counterfactual) against the actual FUN-LV option cost-benefit including quantified benefits validated from trial data. The cost estimates for BAU options were summarised by producing reinforcement cost estimates for each of the 36 sites with the support of Distribution Planning and Connection teams. A network solution was proposed using traditional planning processes in response to a customer connection request or reinforcement initiated by incremental load growth. The magnitude of the BAU response aligns with the maximum capacity shared from each of the FUN-LV methods, this to ensure a like for like reinforcement response between the FUN-LV method and the BAU option. Therefore in the BAU option, the reinforcement response supposes additional capacity required of 200, 240 and 400kVA, which corresponds to the alternative FUN-LV capacity sharing from methods 1, 2 and 3 respectively.

The reinforcement cost estimates of the network solution were summarised by matching the site characteristics to a set of cost guidelines that are representative of the key cost elements from a given solution. These cost guidelines indicate a bottom-up cost estimate based on specific design considerations including: LV/HV underground works (metres), LV board upgrades/extensions, capacity request, transformer size and enabling works, other plant equipment, confined spaces access, delivering requirements, traffic management and property ownership..

The cost guidelines were selected with the intention of having a view on drivers for high-cost reinforcement which may be suppressed through FUN-LV capacity sharing methods. The findings from this are expected to tie into a method selection tool subsequent to the trials running. Following the detailed site estimates the cost guidelines assumptions and summary site costs were reviewed in several cost verification meetings to provide feedback from commercial teams in relevant business departments.

2.5.1.2 Method Costs

During this installation phase the project does not have a finalised view of site specific FUN-LV methods costs of which to compare with the BAU counterfactual. The itemised PED equipment costs are known as is the cost of dispatch of these items to trial sites, however, the incurred labour and additional materials costs will be confirmed upon completion of installation and commissioning works. In anticipation of these costs being booked into the company account management software ‘SAP’, each site was allocated a service order that can be mapped to each trial site identification reference. The cost data from these service orders can be automatically attributed to individual sites alongside pre-determined PED equipment costs using an export from the SAP software. The format of summarising these method costs is comparable to the BAU option costs and additionally provides visibility in categorising costs according to the key drivers. In the next reporting period it is expected that both the BAU costs and processes estimates and Method Costs will be integrated with a site by site cost benefit analysis template, which will form the basis for the low-level assessment.

2.5.1.3 Tender Process

During this period a tender process was progressed as a means to decide whether to contract for this work externally, as foreseen at the time of bid, or to carry it out internally. The external providers will be focused on support and assurance and scaling up the business case to the wider GB, whilst core activities are continually being carried out by the project team and UK Power Networks personnel. Bids are currently being reviewed.

2.5.2 Key issues encountered

In this reporting period, the workstream encountered the following issues:

- Verifying costs with several business departments that use different structures for estimating costs. This meant that it was necessary to engage each of the departments individually and develop cost guidelines that considered each of the common cost drivers in these structures.
- Improvements to the business management and accounting systems meant that estimating costs would change to a business wide system. This provided an opportunity for the project to engage with the change early and create routes to more easily integrate the FUN-LV methods if successfully adopted into the business as usual.
- Where method equipment has changed in accordance with suppliers or additional requirements the workstream has had to revise costing estimates to understand that the business case is not undermined.
- Identifying complexity in validating benefits other than simple power transfer across several substations. This lead to specifying activities to investigate valuation of benefits and enhancing the original trials plan such as monitoring the overlap effect.

2.5.3 Key deliverables

In this reporting period, the key deliverables are defined as below:

- **Cost Benefit Analysis Plan**: This approach document was reviewed by the Technical Design Authority and shared with suppliers for initial discussion. It is expected that this approach and related assumptions will develop as the workstream progresses.
- **BAU Costs and Processes**: This spreadsheet and the assumptions associated with it were reviewed by relevant commercial teams within the business.
- **Method Costs**: This spreadsheet was developed using cost elements available pre-trial and mapping for summary costs (including installation) upon completion of method costs being finalised.
- **Resourcing Justification Case**: This report was developed and reviewed by SRO to accompany the tender process and as a spreadsheet tool to complement the project plan in workstream 4 resource scheduling.
- **Pre-trial Sample Site Costs & Benefits**: This presentation was delivered to business stakeholders to demonstrate sample financial benefits of deferring reinforcement and expected additional site benefits.

2.5.4 Planned activities for next reporting period

During the next reporting period the workstream will be focused on recording trial costs and planning how data from trials will be incorporated into the projects benefits case, this will include the following major activities:

- **Assumptions for quantification** of additional benefits (identifying and validating);
- **Expected low carbon benefits** (identifying, quantifying and refining);
- **Development of Cost Benefit Analysis Site by Site template**;
- **Collating detailed itemised costings** for method installations at trial sites;
- **Conducting sample analysis** for preliminary trial method data; and
- **Refining benefit focus** (primary and secondary) through further stakeholder engagement.

2.6 Workstream 5 – Knowledge Dissemination

This workstream is dedicated to sharing the learning and knowledge generated from the other workstreams. The framework for this activity is contained within the Knowledge Dissemination Roadmap (version 2). This document defines the project's key stakeholders or target audience, outlines the knowledge to be shared from other workstreams, proposes appropriate communication channels and sets out the timetable for knowledge dissemination activities. The roadmap is a 'living' document that will be continuously reviewed and updated throughout the lifecycle of the project.

2.6.1 Progress this period

These last six months of the project have seen a continuation of awareness raising activity about the project and its aims and objectives within UK Power Networks and externally. The project has continued to refine its list of key stakeholders, both internal and external, with particular emphasis on securing internal buy-in to support the delivery of the project and sharing the potential benefits with both internal stakeholders and other DNOs. In addition to information about the project being available on UK Power Networks' Innovation website –.a summary of activity that has taken place between January and June 2015 is summarised below:

- Partner communications: In addition to regular communication with representatives from all project partner organisations, Project Partner Board meetings were held in January, March and April providing an opportunity for a structured sharing of progress within all workstreams and against all milestones. This enabled a sharing of learning within the project and ability to re-affirm targets and objectives.
- Internal stakeholders: Internal Stakeholder meetings continue to be held with key 'business as usual' stakeholders attending. These meetings provide an opportunity to engage internal staff on technical design matters as well as keeping them abreast of how the project is developing and what the installation and operation of equipment will look like.
- A workshop with Ricardo-AEA and the UK Power Networks planning department has held, as part of the process of engaging BAU staff with the project. This covered an introduction to FUN-LV Methods, a site selection example (including background to the selected site and example costs and benefits), and an overview of FUN-LV Planning-Modelling Tool requirements. The workshop gave the opportunity to discuss and clarify technical capabilities and potential benefits of the FUN-LV Methods, and for the project team to understand the particular benefits that planning staff are interested in (e.g. connected Radial Embedded Substations or parasitic loads in interconnected networks)
- Engaged with the LPN Connections team to discuss Business As Usual Connection Designs and the role that FUN-LV could provide in alternative connection arrangements. Several meetings were held including connection designers and lead designers and connection policy regulation. These sessions involved highlighting several sites that would be expected to have very high reinforcement costs and subsequently undesirable connection quotes for customers. Additionally, it was proposed that providing customers with a lower upfront cost for a connection (even for finite validity period such as 8 years) would offer additional flexibility to existing connection arrangements. The potential for such arrangements will depend on the results from project trials and conducting further investigation on new customer connections.
- Meetings with the LPN Distribution Planning team on various occasions. In the lead up to the installation of PEDs on the network this involved discussing anticipated connection requests and network reinforcement jobs occurring in proximity to the FUN-LV trial networks. Discussing planned jobs provided an opportunity to inform several members of the team on the FUN-LV methods being trialled for capacity sharing. Through this engagement, the FUN-LV project team was able to share the project storyboard as an effective knowledge dissemination tool.
- Meetings with senior managers in the Business Planning and Business Performance departments to discuss potential effects of the RIIO-ED1 settlement on the FUN-LV project business case. This involved highlighting the importance of maximising utilisation of the existing capacity on the network and encouraging flexibility around the deployment expensive reinforcement decisions. Through this engagement, the FUN-LV project team was able to share the project storyboard as an effective knowledge dissemination tool.
- Engaged with a team of graduates placed across departments in the business. These meetings included sharing several opportunities for developing network innovation and specifically the use cases being demonstrated through the FUN-LV project. Several graduates from Network Operations, Distribution Planning and Engineering Design have attended FUN-LV project meetings as part of gaining exposure in the business rotational placements. Through this engagement, the FUN-LV project team was able to share the project storyboard as an effective knowledge dissemination tool.

- **External audience**: A paper on Selecting Sites for FUN-LV Field Trials was accepted for CIRED, the International Conference and Exhibition on Electricity Distribution. The authors of the paper, Ricardo-AEA and UK Power Networks, were invited to bring a poster and take part in a "poster tour" at the conference. This will have helped to raise the awareness of the project with distribution companies, and other industrial and academic stakeholders, internationally.

2.6.2 Activity planned for the coming six months include:

- **Internal stakeholders:** links between the project and the core group of internal stakeholders will continue to be strengthened through meetings and workshops. Further briefings and engagement will be arranged for a wider group of internal stakeholders to increase the awareness and understanding of the project.
- **Key messages:** to inform all product communication products including brochures, reports, webpages, videos etc. will continue to be reviewed and developed during the lifecycle of the project.
- **Workshop:** to enable key stakeholders from both UK Power Networks and other DNOs to find out more about the power electronics devices being installed as part of the project roll out, UK Power Networks is in discussion with the PNDC where extensive testing of the equipment is taking place, to host the workshop on completion of the prototype testing.
- **SDRC 9.1 learning event**: The project is planning a learning event to be held during Q3 2015. This will cover the planning considerations necessary for selecting, designing and installing power electronics devises, along with the lessons the project has learnt as part of this process.

Work will continue to identify any further opportunities to increase awareness of the project and to share any early learning and all will be evaluated and acted upon if considered appropriate and timely.

3. Consistency with Full Submission

The FUN-LV project is on track to deliver the learning consistent with the full submission. The sites chosen for Method 2 are judged to have imbalance between neighbouring substations ranging between 101kVA and 270kVA. As such, on some occasions the Method 2 device will be slightly over-sized and on other occasions the imbalance which can be corrected will be limited by the 200kVA rating of the device. In total, the sites offer good potential to trial the equipment. Similarly, the sites chosen for Method 3 are judged to have imbalance between neighbouring substations ranging between 158KVA and 373kVA. Similarly, some sites will be more than capably of being balanced and in other cases the imbalance which can be correct will be limited by the 400KVA rating of the device.

Since the last reporting period there have been changes in Partners Company names with PPA Energy being purchased by Ricardo AEA and IGE Digital changing their UK trading name to GE Grid Solutions (UK) Ltd. Both have undergone contract novation's to resolve these changes in company names. GE and Imperial Consultants. Limited have also further defined their contracted milestones in order to improve their contracted deliverables.

4. Risk Management

FUN-LV has established a rigorous and proactive risk management process, as described in the FUN-LV Project Handbook. It allows for the recording, communication and escalation of key risks and issues within the project. It also defines where decisions will be made and how this will be communicated back to the workstream level where the risk or issue has arisen. Risks are reviewed regularly between each Workstream Lead and the Programme Management Office. The risks are escalated to and discussed by the Project Board as required. Key project decisions are documented in a decision paper or internal change request.

4.1 Full Submission Risks – Update

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
Installation				
R029	Closed	Permitted development is not allowed requiring planning permission to be granted, prevents installation of power electronics at chosen sites, resulting in delays.	Determine whether permitted development is sufficient.	Westminster City Council have agreed in principle to issue a Certificate of Lawful Development pending final agreement on locations on the footpath and consultation with any remaining affected parties. Lambeth and Tower Hamlets councils have explicitly agreed that the devices fall under permitted development. Good progress is being made in Brighton and Hove where streetworks permits are being prepared
R012	G	When shipping the power electronics device from the manufacturer to site the device is damaged beyond repair causing delays.	Use proven safe methods of shipping. Consult insurance manager to ensure appropriate levels of insurance are in place.	Project team has informed suppliers that reputable shipping companies must be used for product delivery
R009	G	The power electronics fails with severe consequences after commissioning, resulting in limited confidence in the device, so it is disconnected until all tests have been completed.	A full set of quality tests to be completed before installation, with the design and operation meeting the UK Power Networks requirements helping to ensure full confidence in the equipment installed. Monitor defects and issue reports supplied by power electronics device manufacture for existing installs.	Testing for Method 2/3 at PNDC and for Method 1 at Nelson street is complete. Elements around power transfer have been evidenced on test networks and risks around power transfer capability are low.
R002	Closed	Equipment suppliers do not produce designs acceptable to UK Power Networks' Asset Management team, which will result in re-design and delays.	Asset Management team were involved in the tendering process. PED device manufacturers will design a prototype that will be tested at the PNDC before production units are built.	Specifications have been agreed with Asset Management and the suppliers. The critical design of the Method 3 prototype has been approved by UK Power Networks. Method 2 PED has had the preliminary design approved.

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
Installation				
R005	R	PED manufacture reliance on single factory source resulting in delays in delivery.	UK Power Networks are monitoring the situation.	Regular contact with the suppliers to identify issues. All long lead items have been ordered by the suppliers.
R006	Closed	The PED manufacturer goes out of business before any payment has been made for the PED, leading to project delays.	Carry out full financial due diligence checks in line with approved standards of practice and the UK Power Networks procurement procedure(s). Identify alternative supplier(s).	UK Power Networks internal Procurement Contract Governance approval has been obtained for Methods 1, 2 and 3 and included checks on financeability of suppliers.
R010	R	The PED is not commissioned on time causing project delays.	Regular progress meetings/reports to track progress against the plan.	Project team currently working closely with TPS and EATL to ensure that trial kits are delivered on time and installation and commissioning are carried out without further delays. Manufacturing delays of one of TPS suppliers means that the final 3 Method 2 devices will not be commissioned until after 30 June 2015. The project have assessed this impact and determined that the overall trial will not be affected by these delays.
R034	G	IT integration requires further development not proposed in the bid stage.	Engage with UK Power Networks IS Solutions Architect and Partners to ensure IT integration requirements are documented	High and low level requirements have been approved by the project. IT designs utilising existing UK Power Networks methodologies around comms and control systems.

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
R004	G	Operational and Health and Safety procedures are not approved for use of the PED, so UK Power Networks' staff are unable to operate the equipment.	Engage with UK Power Networks' Health, Safety Sustainability and Technical Training (HSS&TT) team to design suitable and approved policies and procedures.	HSS&TT representative has been engaged to advise on the required policy and procedure changes. CDM-Coordinator has been engaged to advise the project
R013	G	The system integration platform cannot be delivered in time, causing delays.	Regular progress meetings/reports to track progress against the plan.	IT designs to be signed off by the end of 2014. Work already underway to load data into PowerOn Fusion. Partners working together to ensure June 2015 deadline is met.
R016	G	The system integration platform does not perform to specification.	UK Power Networks specialists have reviewed the specification during planning and preparation	The high level requirements have been agreed and the data flows documented. The low level requirements are currently being validated.
R023	G	During the project delivery stage the appropriate UK Power Networks staff do not engage adequately or in a timely manner with the project resulting in poor engagement and delays.	All relevant governance panels informed and have authorised the work. Additional stakeholder events to be held in Q3 2012.	The installation will be delivered from UK Power Networks' existing delivery team for projects on the LV and 11kV network. Representatives are already engaged.
R021	G	The network configuration changes, preventing full benefits of power electronics not being demonstrated.	Ensure trial sites are selected in accordance with criteria.	Workstream 4 lead has gone through planning database and Distribution Network Visibility to check any active referrals on FUN-LV substations. Distribution Planning team are applying dummy referrals for all substations relating FUN-LV trials, to notify planners/connection designers.

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
R011	G	The PED does not perform to specification, so not all benefits are realised.	Regular design meetings/reports. Key stakeholder engagement to ensure specification can comply with UK Power Networks design policies and procedures.	Critical design for all methods has been approved by the project's design authority.
Procurement				
R032	G	There is a risk that the learning is not disseminated effectively to all stakeholders because different parties will have different interests and learning styles. This risks leads to some of the learning getting lost.	Ensure Dissemination workstream engages with technical project leads early on in project. Ensure learning from other LCNF projects for dissemination is included.	The Knowledge Dissemination Roadmap has been developed. It is a living document and will be used as the basis for engaging all FUN-LV stakeholders.

4.2 Risks raised in the last reporting period

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
R057	Closed	Reliance on UK Power Networks internal staff to carry out installation works may cause program delays due to their prioritisation of BAU deliverables over FUN-LV Project works.	Continuous engagement with LPN and SPN Programme managers and Area managers to ensure resources are secured and FUN-LV work is prioritised	LPN and SPN staff are fully committed to the installation activities
R058	Closed	PNDC test may take longer than planned due to problems with the prototype device	Ensure FAT is completed by TPS before prototype is despatched to PNDC. Also ensure that PNDC gets support from UK Power Networks and TPS	FAT has been completed. Prototype PED was sent to PNDC on 30/01/15. Initial delivery date to PNDC was 01/12/14. PNDC testing completed
R059	G	Reliance on support teams on telecoms infrastructure and control room with limited resources might impact the timescales and for the project.	Continuous engagement with BAU teams to secure the commitments is planned.	Meetings have been organised at Fore Hamlet and Nelson street to engage with teams. A member of staff has been re-assigned to help.
R060	G	Complexity of the legacy telecoms architecture might add unknown design and implementation issues with the communication plan.	Discussions on the architecture undergoing.	Meetings with stakeholders to discuss the telecoms architecture organised.

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
R063	Closed	Insufficient input from BAU during design reviews could lead to design variations and consequent contract variations, with financial and project impacts.	Early engagement with the key BAU personnel undertaken	A number of design reviews already carried out had good BAU input. More detailed input and early BAU engagement would be required in order to obtain valuable comments on time for the equipment suppliers to act on.
R065	G	Staff, materials and other costs are not booked correctly to trial site service orders. This may result in a lack of understanding around method costs for sites and a misrepresentative site by site cost benefit analysis.	Held meeting with partners trying to address some of the challenges in Methods 2 and 3 Test Systems availability.	Strategy of exporting service order bookings from SAP have been devised. Regular exports for service order bookings is being conducted to monitor this.
R066	G	Change in the communication architecture and hardware requirement might have an impact on the project timescales and cost.	Working with architecture and telecoms team to find the best implementation within the project timescales.	A series of meetings has been held with different technology teams in For Hamlet and Nelson Street to finalise the solution.
R067	Closed	There is a risk that the time taken for Imperial to get Version 1 Issue 5 of the SOP control algorithm working (which includes input range checker for PNDC testing) will delay the development of Version 2 of the algorithm (field trials).	The SOPs could be loaded with Version 1 Issue 3 for installation, which has most functionalities. When Version 2 has been tested, it can be loaded (remotely) onto one SOP and trialled before being rolled out to all.	PNDC testing (for which Version 1 Issue 5 was requested) is now completed. Imperial has developed version 2, which is being prepared to be sent to TPS.
R068	R	Risk of delays to installation of LV Monitoring Devices due to delays from supplier to deliver equipment on time	Source for other suppliers who would be willing to provide LV Monitoring devices on time	GMC-I Prosys to supply additional LV monitoring equipment as the existing supplier has expressed inability to deliver equipment on time. More resources have been secured to install the equipment when it arrives.

Ref No	RAG Status	Risk and Impact Description	Mitigating Actions	Update
R72	Closed	Contract Agreement process is more complex than expected e.g. due to Ofgem provisions and specific FUN-LV clauses. Extended delay in WS4 activities due to legal dialogue and contract discussions.	Legal support to be re-engaged following external consultancy spend is approved.	Meeting with legal has assured that process should not incur significant contract agreement negotiations around specific FUN-LV clauses.
R73	G	There is not enough working memory on the SOP PLC to load recent versions of the algorithm. There is a risk that this will limit the functionality of the code, or result in additional work to optimise the code.	TPS is planning to upgrade the PLC to have double the amount of working memory. If so, this should allow Version 2 to fit on the PLC. This will be confirmed when Imperial have run Version 2 through the PLC Coder and sent to TPS.	Imperial sent a compiled Version 2 to TPS, so that they could check the size. It appears to be suitable to fit on the upgraded PLC. TPS to explore upgraded PLC. TPS has a backup plan if Version 2 does not fit on the upgraded PLC, but this has additional complexities.
R74	G	Although the contract with the new Vendor for iHost has been signed, any spill over of time due to configuration, design, development, requirements might have a financial impact on the project deliverables.	Planning to have regular meetings and calls to provide detailed information to Nortech	Regular meetings organised to make the engagement smoother for deliveries within the required timeframe.
R075	R	Risk of delays to installation of Method 2 equipment due to delays in overall design and manufacturing of PED enclosure	Advise TPS to accelerate the design works and demand an earlier delivery date for the PED enclosures.	Due to delays in manufacture only a small number of units will be available for commissioning before the 30 June deadline

5. Successful Delivery Reward Criteria

SDRC	Criteria	Evidence	Progress	Date:
9.1	Successful completion of design and planning for power electronics	• Published guidance document on planning considerations for selecting, designing and installing power electronics devices using the traditional planning systems and approaches currently used by UK Power Networks; • Identification of key learning and planning considerations necessary to demonstrate the benefits of power electronics devices and shared through the project website; and • A list of identified substations, selection criteria and expected benefits.	• SDRC was successfully achieved with guidance documents submitted along with the formal report. Copies of the documents are available on the FUN-LV microsite http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Flexible-Urban-Networks-Low-Voltage/	Completed on time
9.2	Successful and safe installation, commissioning and operation of LV switches and circuit breakers on LV networks	• LV switches and circuit breaker device approvals for application on UK Power Networks' LV networks; • Published guidance document on the safe and appropriate installation of LV switches and circuit breaker devices; • LV switches and circuit breakers electrically connected to LV networks; • Automated reconfiguration of radial networks is demonstrated; • Remote and automated switching between interconnected substations is demonstrated; and • Demonstration of other available modes of operation, where relevant.	On target for details of progress please see report published end of June •	End of June 2015

SDRC	Criteria	Evidence	Progress	Date:
9.3	Integration of IT systems to facilitate the planning and operation of LV networks	• A description of FUN-LV's IT architecture including the interfaces between control systems, geospatial databases and planning and visualisation tools that enable planning and operation of a flexible LV network; • A report describing how increased levels of awareness have improved planning processes and network operations; • Models of power electronics devices to allow benefits to be determined; • Data transfer between the power electronics devices and the data historian; and • Data transfer between UK Power Networks systems and DPlan to build network models.	• Detailed communications architecture has been reviewed and approved with inputs from all stakeholders. • Test bench setup has been done for all the three Method 1, 2, 3 for testing. • Design for the SCADA data has been agreed prior to installation. • Loading of the sample sites for the UAT environment for testing HV – LV interface has been done now. • Infrastructure setup of servers, networks and links has been established.	By 30 November 2015
9.4	Successful and safe installation, commissioning and operation of power electronics devices in London and Brighton.	• Dual and multi-terminal power electronics device approvals for application on UK Power Networks' LV network; • Guidance document on the safe and appropriate installation of dual and multi-terminal power electronics devices on the LV network, which will be shared as learning; • Dual and multi-terminal power electronics device installed on a test network to demonstrate functionality in a controlled environment; • Dual and multi-terminal power electronics device electrically connected to the LV network; • Autonomous power transfer between connected substations is demonstrated; • Power electronics device performance and reliability data; • Distribution network monitoring data; and • Additional LV monitoring data installed for the purpose of the trials.	• Good progress has been made on many constituent parts of this SDRC. However a change request has been submitted to Ofgem	End of June 2015

SDRC	Criteria	Evidence	Progress	Date:
9.5	Successful demonstrations of enhanced modes of operation of power electronics devices	• Documentation of various enhanced modes of operation of power electronics devices; with comparisons of early modes of operation with those proposed by Imperial Consultants; • Provision of the required inputs for the Cost Benefit Analysis to the WS4 contractor; • Provision of demand profiles and other measured analogues to the WS4 contractor; and A report detailing how power electronics actively manages fault current, delivers voltage control and indications of device losses under operational conditions.	• Advanced use cases have been developed to identify the enhanced modes of operation required for the SOP. • Version 1 of the control algorithm has been prepared and documented, addressing the requirement to transfer capacity between substations, as well as some enhanced modes. • Version 2 of the control algorithm is currently being finalised, including more enhanced modes and learning from PNDC testing. • A trials plan is being developed, taking account of data required for WS4 and key learning questions identified by the project team. • Demand profiles have been used in the project's site selection process and have used existing network data in LPN and transformer temperature data in SPN. The trials plan includes "down periods" to obtain base case data, and will be weighted towards transformer and feeder support in the early months. • The voltage support function is on Version 1 and Version 2 of the algorithm. It was tested at the PNDC.	By 31 July 2016

SDRC	Criteria	Evidence	Progress	Date:
9.6	Full evaluation of the benefits realised by power electronics devices on the LV network.	• Completion of Dissemination of learning for the operation of power electronics devices on LV network architectures and for network performance; • Completion of Cost Benefit Analysis fully quantifying the benefits for various scenarios and types of customer (case studies). The case studies will be based on site specific examples and operational data available during the trials. The business as usual approach will be compared with the FUN-LV methods; • Report including cost of installation and operation of power electronics devices on the network; • Demonstration of the benefits realised (financial and non-financial) and the capacity released. Multiple benefits will be evaluated for each case study; a primary benefit (i.e. the driver for the method deployment) and secondary benefits; • Assessment of the Cost Benefit Analysis; and • Analysis of Power electronics device performance and reliability data.	• Cost Benefit Analysis Plan has been developed and resource requirements identified • Current BAU reinforcement options have been prepared and costed for selected sites. These will be compared with FUN-LV methods in Q3 2015. • Performance and reliability data has been analysed only as part of the testing phase . • Scenarios/use cases for various PED devices have been shared and discussed with teams in connections to discuss plausible connection arrangements and policies in future.	By 31 December 2016

6. Learning Outcomes

6.1 Summary of key learning

Within this reporting period the project has captured the following learning:

- **Selection Criteria and Approach:** The selection criteria for identifying FUN-LV sites in the different locations are described in the Selection Criteria and Approach report. The report also contains expected benefits and additional considerations for the Method 1 equipment. This is a supporting document for SDRC9.1.
- **DPlan Support for Site Selection:** DPlan is a distribution planning tool that is being enhanced by CGI and IOA to be able to support additional functionality required for FUN-LV. The initial site selection process has been aided by DPlan in advance of these enhancements. This report describes the ways in which DPlan provided initial support for site selection.
- **EOS 09-0080 LV Remote Control Trial Installation:** This is business as usual document EOS 05-9401 required for the approval by the Director of Asset Management to connect the Method 1 equipment to the LV network.
- **PED Connection:** This is the PED connection document which was approved by the Technical Design Authority.
- **CGI Data Provision Specification:** the purpose of this document is to document the data provision specifications.
- **EOS 09-0042 FUN-LV Multi-Terminal Power Electronics Devices:** This is business as usual document EOS 09-0042 required for the approval by the Director of Asset Management to connect the multi-terminal device to the LV network.
- **EOS 09-0043 FUN-LV Dual-Terminal Power Electronics Device:** This is business as usual document EOS 09-0043 required for the approval by Director of Asset Management to connect the dual-terminal device to the LV network.
- **Installation Manual for LV Devices:** The purpose of this document is to describe the installation steps and procedures for the LV Monitoring Devices.
- **Method 2 dual terminal critical design documents**
- **Method 3 multi terminal critical design documents**
- **Method 2 dual terminal installation manual:** The purpose of this document is to describe the installation steps and procedures for the Method 2 Dual Terminal PED equipment.
- **Method 3 multi terminal installation manual:** The purpose of this document is to describe the installation steps and procedures for the Method 3 Multi Terminal PED equipment.
- **Method 2 dual terminal commissioning procedure**
- **Method 3 multi terminal commissioning procedure**
- **Installation Manual for Remote Control Equipment:** The purpose of this document is to describe the installation steps and procedures for the Method 1 remote control equipment.
- **IT Testing Strategy:** This document describes CGI's principles and approach to software testing on the UK Power Networks FUN-LV programme. The scope covers CGI's deliverable items from the project, and where there is interaction with UK Power Networks and other partners, e.g. where there is data provision or system integration, it defines the division of responsibilities.
    - CGI's testing will be designed to ensure that:
        - testing on the programme is effective and efficient;
        - the test approach is structured appropriately on the basis of Risk-Based Testing principles;
        - test activities support the delivery of the new and changed software to agreed quality criteria; and
        - test deliverables presented to the client are consistent;
    - This product is based on CGI's standard Risk and Requirements based Testing methodology, but tailored appropriately for UK Power Networks' FUN-LV programme.
- **Data Cleansing Strategy:** The purpose of this document is to describe the processes that will be followed for resolving data issues within the LPN and SPN network topology and premise connectivity datasets. For LPN data, these processes are based on the corresponding ones used on LCL. For SPN data, similar processes are defined.

- **IT Blueprint:** The purpose of this document is to describe the overall architecture and high level design of the of the CGI FUN-LV solution in context of the wider FUN-LV solution to inform UK Power Networks' Logical Architecture product. The scope of this document includes the architecture and high level design of IS-related elements being created or impacted as part of FUN-LV work stream 2 (WS2).
- **Development and demonstration of algorithms for initial assessment of LV cable loading from temperature sensors (LV Cable Loading):** The objective of this activity was to convert temperature measurements of cables into loading estimation. A number of selected sites in London were used to demonstrate the correlation between cable loading, cable temperature and ambient temperature.
- **LV Connectivity Model**: Documented specification of the LV connectivity model (three phase unbalance network model), data and tools to be provided by CGI and the criteria against which it is to be evaluated.
- **Maximising Circuit transfer capacity:** Documents the development of an algorithm to maximise the circuit transfer capacity of cables, based on temperature monitors.
- **Visualisation and Awareness Systems (Part 1):** Documents the high level business requirements for real-time/operations solutions for FUN-LV; summarises GE/CGI's scope in relation to real-time applications; summarises proposals received from GE/CGI for additional scope; and summarises the developments made to DPlan by CGI/IOA during the course of the project so far
- **Contingency Scenarios for FUN-LV Methods**: This document details the evidence for the Ricardo-AEA milestone, on contingency analysis, for Work Stream 3.13 of FUN-LV. The key deliverable is the documentation of credible operational and contingency scenarios for CGI to assist with CGI's development of operational contingency analysis in DPlan. This includes visualising consequences of next credible fault and specify modelling scenarios.
- **SOP Algorithm Concept report**: This document describes the concepts for the supervisory control algorithm for the three and two port SOP. It is designed to be a working document with the aim of providing an understanding to the algorithm and not a final report about how the algorithm functions.

6.2 Approach to capturing the learning and disseminating

The project has reviewed the lessons learnt from UK Power Networks Tier 2 projects and identified the need to capture learning as soon as it occurs. To facilitate this requirement the workstream leads capture lessons learnt as part of the weekly reporting and this is then stored centrally in the project's lessons log. The learning captured will then be evaluated and using the project's knowledge dissemination roadmap along with stakeholder analysis identify the target audience for the learning and the best method of ensuring the learning is well publicised.

6.3 External dissemination activities

FUN-LV project partner Ricardo AEA (formerly known as PPA Energy) presented a paper on" Selecting sites for FUN-LV field trials" at the 23rd International Conference on Electricity Distribution hosted by Congrès International des Réseaux Electriques de Distribution (in English International Conference on Electricity Distribution aka CIRED) in Lyon 15th – 18th June 2015. A copy of the paper circulated to attendees can be found at appendix C and further information about the conference can be found at http://www.cired2015.org

In the last report mention was made of PNDC offering the use of their facility to provide a learning event where people could view the Multi Terminal PED and observe its operation when connected to a distribution network. Due to the delays in the testing and the window for testing foreshortened it wasn't possible to use this facility in time. .

6.4 Internal dissemination activities

UK Power Networks' Project Partner Group have been meeting on a regular basis to maintain momentum and share information. Additionally a further Internal Stakeholder Group meeting was held to increase visibility of the project and its activities FUN-LV and identify the upcoming activities and the key business resource required to deliver the equipment installations.

UK Power Networks internal stakeholders have been meeting either as part of the Internal Stakeholder Meeting which provides a project progress and impact overview meeting or as focussed delivery led meetings to ensure the resources required for the delivery and commissioning progress smoothly particularly in light of the unexpected events of the Kingsway incident.

The project has continued to be supported by a number of business experts in the project Design Authority and they will be used to ensure the learning from the project is disseminated into their relevant business areas.

7. Business Case Update

The FUN-LV project seeks to explore the way in which PEDs connected to LV networks can respond faster and with more flexibility to the increased demands of our customers when compared against traditional network reinforcement methods. FUN-LV will also assess the suitability of PEDs to defer network reinforcement and for how long.

The project will also assess the use of the three trial methods at different stages to cater for increase of network load during the deferred time period before traditional reinforcement must be implemented.

The business case was built from assumptions about the:

- Cost of the equipment
- Cost of the installation works
- Cost of the business-as-usual reinforcement
- Expected amount of power transfer
- Number of years before reinforcement is required

As part of the site selection process, potential BAU reinforcement solutions have been identified and prepared. Costs have been developed for these proposals and will be validated by Asset Management and Connections planners during Q1 2015.

The total project equipment costs for all three methods are higher than previously anticipated. This cost has been identified as first in kind equipment development costs for the Method 2 and 3 PEDs and higher material and development costs for the Method 1 circuit breakers and link box switches. The per-unit costs remain consistent with the business case submission for Methods 2 and 3. The unit costs for the Method 1 equipment are higher than at bid submission but the benefits remain favourable when compared with the business-as-usual reinforcement option.

The cost benefit analysis work will be assessed throughout the project lifetime. The next phase will commence next year and will continue to validate the assumptions made at the bid submission

8. Progress against Budget

This confidential section is provided in *Appendix A*

9. Bank Account

This confidential section is provided in *Appendix B*

10. Intellectual Property Rights (IPR)

TPS have identified the following background IPR during this period:

PTE	PTE has not been specifically developed for the PED. There are however project specific configurations files.
TP366	3T Inverter control Card software (Software) – everything except the specific files listed below
TP393	2T Inverter control Card software (Software) – everything except the specific files listed below
TP368	Diagnostics and monitoring card (software) – everything except the specific files listed below

The Following Relevant Foreground IPR has been identified in this reporting period

TPS:

105024-a	Inverter Control Card (Hardware)	TP367	PLC firmware (software)
TP366	3T Control.C (C Source file)	TP368	PTE.C (C source file – specific PTE
TP366	3T Control.H (C Source file)	configuration)	
TP366	3T IoControl.C (C Source file)	TP368	Digi.C (C source file – specific
TP366	3T IOControl.H (C Source file)	comms configuration)	
TP393	2T Control.C (C Source file)	TP369	Control Card test software
TP393	2T Control.H (C Source file)	(software)	
TP393	2T IoControl.C (C Source file)	TP375	Digi Module Comms (software)
TP393	2T IOControl.H (C Source file)	TP391	Factory test software (software)

The Foreground IPR identified by Imperial Consultants in the last reporting period has been developed further and is now referred to as follows:

1. Algorithm written for SOP control that shares power flow capacity between feeders and substation transformers; manages feeder-end voltage and voltage imbalance. These functions are deployed to enable as much of the feeder and substation capacity to be utilised as possible. The algorithm is arranged to use local measurements of voltage and substation power flows and to not rely on control centre input.
2. Extension of the algorithm from a 2-port SOP to a 3-port SOP
3. Algorithm written to allow flexible prioritisation of SOP sub-functions when operating at or close to the power rating of the SOP or feeder cables.
4. Developed know-how in using PLC-coder to generate real-time code to implement algorithms on hardware platform.

12. Accuracy Assurance Statement

We hereby confirm that this report represents a true, complete and accurate statement on the progress of the Flexible Urban Networks – Low Voltage Project in the six-month period from Jan 2015 – June 2015 and an accurate view of our understanding of the activities for the next reporting period.

Signed .....

Date 18/6/15

Suleman Alli
Director of Strategy & Regulation UK Power Networks

13. List of Appendices

Appendix A: Progress against Budget (CONFIDENTIAL)

Appendix B Bank Account (CONFIDENTIAL)