Flexible Plug and Play

SDRC Reward Application

UK Power Networks
Delivering your electricity

Contents

1. Executive Summary

This document constitutes the application by UK Power Networks on behalf of its licensee, Eastern Power Networks (EPN) plc, for a Successful Delivery Reward Criteria (SDRC) reward for the Flexible Plug and Play (FPP) project. The FPP project has been delivered on time, has met in full, and in many cases has exceeded, its SDRC, and has been managed using best practice project management methods. UK Power Networks is applying for the full 100% reward for the FPP project in consideration of the following successes:

- Provision of a technical and commercial solution that has saved the 15 Distribution Generation customers £44m on their connection offers.
- Enabled 54.4 MW of generation to connect to the distribution network that would have been previously unviable.
- Embedded the learning from FPP into UK Power Networks business-as-usual to enable a second flexible connection zone in the Norwich area.
- The project has been shortlisted for five awards, winning two of these; the Energy Institute Innovation award and the Low Carbon Innovation Award at the East of England Energy Group Awards.
- The first Quadrature-booster to be designed, installed and operating on a distribution network to achieve optimal load sharing.

The project had two key components: firstly, to design a new commercial arrangement in consultation with generators and which would allow more distributed generators access to the network sooner and for lower cost in the selected trial area. Secondly, the project set out to demonstrate how technology could help to measure power flows in real-time and how devices could be used to divert or direct power, so that capacity could be identified in real time and in some cases additional capacity created by diverting energy.

The first of these components, designing new commercial arrangements, had three sequential SDRCs (9.1, 9.2, and 9.7) which were related to consultation with customers, the design of the arrangements, and their demonstration. The final SDRC (9.7) was set out in the project direction as being met "through the provision of one connection offer to generators using the FPP methods." In practice, the SDRC 9.7 report was able to report that a total of 15 customers had accepted offers, the quota of available capacity has been sold out, and a total of 5 customers and 6.75MW are now energised to their agreed dates (*Close Down Report, 2015, p. 5*). In fact, at the time of writing, a second area of the network around Norwich has been opened for "flexible connections" and the first customer quoted, accepted and energised as part of now BAU flexible connection. The FPP project has delivered over £44m of connection cost savings to the connecting customers (*Close Down Report, 2015, p. 38*). We believe this is substantial evidence of exceeding these SDRC, and set out in more detail in the body of the document evidence for each of SDRC 9.1, 9.2 and 9.7 in turn.

The second aspect of identifying and creating capacity using technical solutions had four SDRCs related to it (9.3, 9.4, 9.6 and 9.8). The project's name "Flexible Plug and Play" indicated that interoperability of components from various vendors was a fundamental goal of the project. As such, the goals set out in the SDRC and the goal of the project entirely coincided: when the communications network was established early in the project it was rigorously tested (as required by the SDRC) with lab tests and then field tests with physical simulators acting as "dummy" generators positioned in the trial area, ahead of any real generators being signed up.

The project were able to successfully complete the design, installation and operation of the first 33kV Quadrature-booster to be operated on a distribution network. It was tested in situ to ensure that it would have the desired effect of diverting or directing 10MW of generation, and this was subsequently followed by a year of trials and further demonstration in the report (*Quadrature-booster Trial, 2015*) that the device has introduced controllability of up to 10MW of line load on overhead lines which were constrained. The associated SDRC was subject to an Ofgem approved change request to allow a short extension of time to overcome unforeseen technical challenges in the first of a kind installation. The key learning generated from the deployment of the Quadrature-booster has been disseminated through learning reports, events and at relevant conferences.

The final component was the system of weather sensors, protection devices, active network management system, dynamic line rating (DLR) systems and remote terminal units (RTUs) required to make the remaining key pinch points on the trial area visible and the generators themselves manageable. These were delivered from five different manufacturers, all operating over the communications infrastructure delivered in SDRC 9.3 and all obeying the IEC61850 protocol to allow them to be interchanged with other equipment or to communicate with other applications in future. Extensive testing and conformance certification was collated to ensure that the system was fit for purpose as it was installed in September 2013 and which met the requirements of SDRC9.4.

SDRC 9.6, demonstrated the system's operation over a period of 15 months. It met the SDRC criteria and concentrated on the most useful aspects to other DNOs: how to configure devices such as Active Network Management (ANM) in which there is little field experience and, as yet, no industry-wide guidance beyond the manufacturer's own operating manuals.

Finally, the project worked with Imperial College to develop a Strategic Investment Model which can be used by UK Power Networks and other DNOs to identify areas which would benefit from an active management approach to allowing renewables to connect. The model met the functionality agreed as part of the SDRC and was disseminated to the industry at a learning event on 5 March 2015.

These successes were delivered through steady and deliberate planning throughout the project. The project used expert advice in stakeholder engagement (project partner Garard Hassan) in order to engage early, and this philosophy has been taken through into our roll-out of a second area of flexible connections and which involved a stakeholder consultation event with developers to gather their feedback before its launch. It has been exemplified by customers acting as advocates for the project, culminating in one of our customers being willing to be part of our team presenting to the judging panel of the prestigious National Business Awards, explaining the benefit which the projects had brought to their business, not only in financial terms but in terms of the way that the project had engaged with them. Customers have presented at two public events we have delivered, allowing other DNOs to hear first-hand from our customers and who in many cases are pursuing renewables projects in their areas as well (*FPP Website*).

2. Timeliness and Quality for Successful Delivery Reward Criteria

2.1 Timeliness – Overall approach

The Flexible Plug and Play project, in accordance with its project direction, met the eight defined SDRCs, (9.1 – 9.8). For each SDRC, UK Power Networks provided a report marking its completion on or before the completion date stated in the project direction. The reports were submitted via e-mail to the Ofgem project officer and were uploaded to the project website. The evidence demonstrating compliance with the project direction for each SDRC is summarised in Table 6 in Appendix 1.

Each SDRC submission was assured by the Regulatory Returns & Compliance Manager. The assurance took the form of a formal review of the SDRC report, an interview with the authors and sample audit on statements included in the report. The statements had to be evidenced providing the necessary artefacts. All evidence documents were subsequently signed-off by the head of Future Networks and the Director of Strategy and Regulation.

A concrete example of the evidence that UK Power Networks internally sought as an assurance on the health of the project was the evidence which was collated alongside SDRC 9.6. The outcome associated with SDRC 9.6 was to ensure that all of the remaining equipment outside of the communications network and the Quadrature-booster were installed by September 2013 to allow a fully-functioning system to be trialled for a 15-month period. This comprised the weather sensors, protection devices, active network management systems, Dynamic Line Rating systems and remote terminal units (RTUs) required to make the remaining key pinch points on the trial area visible and the generators themselves manageable. Our internal assurance process sought and collated the evidence to ensure that the SDRC had been met in full and that the project was indeed on track against its milestones, examples of which include Acceptance Test certificates, IEC 61850 certification certificates and Commissioning certificate issued for Active Voltage Control, Remote Terminal Units (RTUs), Dynamic Line Rating and the Quadrature-booster Control System.

By looking not only at dated certificates, but also at delivery against specification (whether the IEC61850 standard or a Factory Acceptance Test specification was met) this assurance simultaneously ensured both timeliness and quality.

2.2 Timeliness – Delivery against SDRC completion dates

As stated in Ofgem's "Response to Licensee Feedback on Successful Delivery Reward Guidance Notes" (*SDRC Guidance Notes, 2015*), performance of timeliness is to be judged against expectations set in the original full submission and Project Direction documents from the end of 2011. Against these measures, SDRC 9.1 – 9.7 were delivered before or by the completion date defined in the original project direction (*Project Direction, 2011*)

SDRC 9.8 was delivered in accordance with the revised project direction which granted six weeks extension to the original completion date (*CR to Ofgem 9.4 and 9.8, 2013*). Summary and evidence of delivery can be found in Appendix 1.

According to the original bid submission document the Quadrature booster was due to be supplied by Alstom, a contract partner (*Bid Submission, 2011, p. 23*). However, due to contractual issues with Alstom, procurement of an alternative supplier was required to avoid further delays. Wilson Transformer Pty limited was subsequently selected as the supplier of the Quadrature booster. The project had successfully managed the delays caused from this change of supplier at its earlier stage and prolonged investigation on the protection scheme sign; however this had exhausted any available float.

At the final commissioning stage, two issues were identified which required extensive additional validation and site tests. The Quadrature booster protection scheme was initially designed for transmission networks. Quadrature boosters used at transmission level have different characteristics and network integration requirements. This raised a number of unexpected questions about the proposed scheme and therefore a validation exercise was required to confirm the actual configuration to be used. Additionally, a number of technical issues were raised during the cold commissioning of the Quadrature booster. This resulted in the need for additional site testing that stimulated real operational conditions. Accurate and reliable operation of the Quadrature booster technology was critical to the project being successful and therefore influenced the success of the majority of the project's SDRC.

As a result of this, UK Power Networks submitted an official Change Request to Ofgem explaining that causes of the delay and requesting a revised deadline of 9 August 2013, instead of the end of June. Ofgem granted the Change Request (*CR to Ofgem 9.4 and 9.8, 2013, p. 2*) stating:

> *"…we accept that much of the delay could not have been reasonably foreseen and reflects the innovative nature of the project. We also recognise that the extension requested to the SDRC is relatively short and will not have any significant impact on other parts of the project. EPN should ensure that it fully records and disseminates the learning from this experience.*
>
> *We accept that much of the delay could not have been reasonably foreseen and reflected the innovative nature of the project. We also recognised that the extension requested to the SDRC was relatively short and had minimal impact on other parts of the project.".(CR to Ofgem 9.4 and 9.8, 2013, p. 2)*

UK Power Networks was successful in completing the commissioning and meeting the SDRC by the 9 August 2013 which was the revised agreed completion date as agreed by Ofgem (*PPR Dec 2013, 2013, p. 3*).

Commissioning of the Quadrature booster scheme was a complex engineering project which was delivered successfully in tight timescales despite numerous challenges encountered. The total duration of time from contract signature with the new supplier to energisation was less than 12 months. Given that the technology was the first 33kV Quadrature-booster to be designed, manufactured, installed and commissioned worldwide, was on a site with development rights but otherwise a greenfield site with no foundations in place and included first-of-a-kind acceptance tests, we regard our ability to manage the unexpected issues as evidence of exceptional performance in our ability to demonstrate measured, responsible judgement in weighing the trade-off often encountered between timeliness and quality. The proof of the quality gained from the additional six weeks of testing was evidenced in that the live tests and full trial experiments were successfully completed without interruption to Wissington generator (*Quadrature-booster Trial, 2015, p. 53*) .

The expectation is that future installations would be able to rely almost completely or with minimal modifications on the design and specification stage and/or the Factory Acceptance Tests (FATs) and 'traditional' commissioning tests (see Appendix 6 for FAT test result certificates). Future users would not need to repeat the depth and robustness of tests which took place on site for this project.

UK Power Networks fully recorded and disseminated the learning from this experience and a full learning report which compliments the SDRC and describes the trials phase, final results and lessons learnt has been produced and published on the FPP website. This was presented at a public event (*FPP Website, p. Image and Video Gallery*) with colleagues from all relevant disciplines (protection, project management, plant specification, network planning), other DNOs and other industry stakeholders as well as shared on the FPP website (*SDRC 9.8, 2013*).

2.3 Quality – Key differentiators

The project's original ambition was to make one DG connection offer under the new framework by March 2013. However, we surpassed our own expectations and out of a total of 45 DG eligible connection requests, we eventually made 39 flexible connection offers for a total of 176MW of generation (*PPR Dec 2014, 2014, p. 5*). Of those offers, 15 customers (totalling 54.4MW) accepted their offer.

The number of requests, offers, and commissioned connections has continuously been increasing since initially opening up the project to applications in 2013. To avoid confusion when referencing, the timing of FPP participation is summarised in Table 1 below. The remaining 10 offers made are currently planned to be commissioned by mid-2016 (*Close Down Report, 2015, p. 4*).

Table 1: Summary of cumulative (not additional) FPP 'interruptible' connection offers over time

Date	Ref	Cumulative as the FPP Project Progressed		
		Offers Issued	Offers Accepted	Commissioned Connections
June 2013	(*PPR June 2013, 2013, p. 18 and 19*)	6	3	-
Dec 2013	(*PPR Dec 2013, 2013, p. 6 and 19*)	18	5	-
June 2014	(*PPR June 2014, 2014, p. 2 and 6*)	24	10	1
Dec 2014	(*SDRC 9.7, 2014, pp. 4, 5 and Appendix 1*) (*PPR Dec 2014, 2014*)	39	14	4
Mar 2015	(*Close Down Report, 2015, p. 4 and 30*)	40	15	5

The Flexible Plug and Play project delivered high quality outputs and significant benefits. The key differentiators of FPP that we are using to measure the success of the project are:

1. Delivering benefits for customers
2. Ensure the learning is generated, captured and disseminated
3. Innovate
4. Get the right people involved
5. Gain external recognition
6. Replicability

Quality –Delivering benefits for customers

The FPP project offered cost-effective grid connections to 54.4MW of renewable generation that would not have otherwise been viable (*Close Down Report, 2015, p. 38*). It delivered £44m of connections cost savings for the fifteen contracted customers. These benefits have far exceeded the initial expectations. Central to the success of the project was customer participation and uptake.

The strategy adopted was to engage early (Q2 2012) with the DG community through the Stakeholder Engagement exercise and later through a separate exercise of identifying customers with high connection offers in the trial area and engaging with them (the process is described in Six Monthly report June 2012) (*PPR June 2012, 2012, p. 31 and 32*). By March 2013, 15 months after its kick off, the project had already engaged with customers, developed the commercial and contractual framework and made the first six formal offers (*PPR June 2013, 2013, pp. 7-9*). This demonstrates the high level of focus on ensuring customers benefit from the project output.

In total, the project offered connections to 40 customers in the trial area, a volume engagement which drove awareness and interest at wider UK Power Networks and national level for this new connection type offering. For example, a series of meetings with the prospective FPP customers were held in the first year to test the ideas and the proposed commercial terms to ensure that these would work for them. Specific to generators, information such as the cost of curtailment for different types of technology were reviewed by the participating customers to ensure their validity.

The process has been iterative and feedback from the customer interaction over the last three years has shaped not only the commercial proposition and templates that are currently used, but also the trials themselves. For example, the first connection commissioned was in April 2014. This provided operational data and formed part of the trial design and evaluation. This initial commissioning of the first FPP flexible connection provided information that was used to improve the end-to-end commissioning process which translated into more efficient and effective for subsequent flexible connections (*PPR June 2014, 2014, p. 8*). This has resulted in an attractive commercial framework and public endorsement of the FPP process and commercial arrangements by customers such as Ecogen and Wind Direct at the FPP events.

The flexible connection offer has proven popular and as such we have engaged with over 54 customers, issued 40 connection offers and 15 customers have accepted an FPP connection offer. As such, another indicator of success is the increase in customer requests that UK Power Networks received for FPP-type offers. This has led to a RIIO-ED1 commitment to roll out such offers in other parts of the network. UK Power Networks has since accelerated the rollout of flexible DG connections with the area of Norwich being the second zone where flexible generation requests have invited since November 2014. This is being managed by business-as-usual teams, therefore accelerating the handover of the FPP trial area and project learning.

More areas, within the Eastern and South Eastern region of UK Power Networks' distribution areas, will become open to flexible connections once the necessary analysis of constraints, the communication strategy and the POA have been carried out (*Close Down Report, 2015, pp. 46-47*).

Independent assessments from Cambridge University and Imperial College London using different methodologies have shown that the FPP solutions deliver favourable cost-benefit for the connectees. This work is summarised in the Cambridge University Reports 2 and 3 (*Cambridge 2, 2013*; *Cambridge 3, 2014*) and the SDRC 9.2 Principles of Learning report (*SDRC 9.2, 2012*).

Quality – Ensure the learning is generated, captured and disseminated

The FPP project put in place a systematic process to ensure continuously tracked progress against the delivery of SDRCs and the learning outcomes as included in the use case document of the bid submission. The output of this work is captured in the key learning documents included in the Close Down Report (*Close Down Report, 2015, pp. 49-50*). These include the delivery of four additional key trial learning reports (*Comms Trial, 2015*; *DLR Trial, 2015*; *Novel Protection Relay Trial, 2015*; *Quadrature-booster Trial, 2015*) to compliment the information included in the 8 SDRC reports on these important topics and summarise the findings from the trials phases of the project. The twelve reports are supplemented by presentations, papers and YouTube recordings that can be found on the FPP website (*FPP Website, p. Image and Video Gallery*).

The learning and dissemination roadmap for the project was finalised during the first quarter of the project and outlined the detailed plans for knowledge sharing. It ensured that they interested parties benefit from the FPP work and also raised awareness and understanding of the novel business model across the DG community stakeholders promoting this way its take up. Specifically, the project produced the following learning events and material during the three years:

Table 2: Learning events and material during the three years

Activity	Quantity	Description / Evidence Reference
FPP learning reports generated and published	12	See Appendix 1 for links to the 8 SDRC Learning Reports. (*Comms Trial, 2015*; *DLR Trial, 2015*; *Novel Protection Relay Trial, 2015*; *Quadrature-booster Trial, 2015*)
University of Cambridge papers	4	1. Understanding best practice regarding interruptible connections for wind generation: lessons from national and international experience 2. Finding the Optimal Approach for Allocating and Realising Distribution System Capacity: Deciding between Interruptible Connections and Firm DG Connections 3. Distributed Generation: Opportunities for Distribution Network Operators, Society and Generators 4. The role of Distribution Network Operators in promoting cost-effective Distributed Generation: Lessons from the United States for Europe 5. Integrating Distributed Generation: Regulation and Trends in three leading countries (*Cambridge 1, 2013*; *Cambridge 2, 2013*; *Cambridge 3, 2014*; *Cambridge 4, 2014*; *Cambridge 5, 2014*; *EPRG Workshop, 2014*)
FPP learning events	5	Commercial arrangements (*Commercials Learning Event, 2013*) Telecommunications (*Telecoms Learning Event, 2013*) Quadrature-booster (*Quadrature-booster Guide, 2014*) Smart Connections (in collaboration with the University of Cambridge) (*Smart Connections Learning Event, 2014*) FPP Final Learning Event (*PPR Dec 2014, 2014, p. 33*).
FPP replication event	1	Workshop with 12 DG customers to re-visit the commercial and technical FPP proposition and discuss how best it would rollout in other UKPN areas (August 2014)
Published papers	12	Highlights include accepted papers to CIRED conference, IET Conference on Power System Protection, and Journal of Applied Energy (*Applied Energy Paper, 2015*). (*Cambridge 1, 2013*; *Cambridge 2, 2013*; *Cambridge 3, 2014*; *Cambridge 4, 2014*; *Cambridge 5, 2014*; *CIRED ANM, 2013*; *CIRED Commercial Arrangements, 2013*; *CIRED Quadrature-booster, 2013*; *CIRED Telecoms Platform, 2013*; *EPRG Workshop, 2014*; *Int'l Principles of Access, 2012*)
National and international speaking slots	Over 60	Including national and international conferences, industry fora such as the DG Fora and other events. The FPP project has held regular slots at UK Power Network's Quarterly DG Customer forums, keeping the wider DG community informed of the progress and developments on the project.
Internal dissemination/ training activities	Over 50	(*PPR Dec 2014, 2014, pp. 30-32*)

The statistics demonstrate the active stance in sharing the knowledge that the project took. The learning events were attended by an average audience of 80 which typically included Ofgem, DECC, DNOs, National Grid and the supply chain.

In addition, there were bi-lateral meetings with other DNOs throughout the three years to share key findings that would aid replication (*PPR Dec 2014, 2014, p. 31*). UK Power Networks has held meetings and provided information to:

- Scottish Power on commercial arrangements and the technical platform (*PPR June 2014, 2014, p. 31*),
- WPD on the Quadrature-booster (UKPN standard has been issued), telecommunications platform and commercial arrangements (templates shared) (*PPR Dec 2014, 2014, p. 31*).
- Northern Powergrid on overall project findings (*PPR Dec 2014, 2014, p. 31*).

Information and experience has also been shared at the ENA Active Network Management working group with all DNOs and National Grid and through participation at other industry working groups.

In addition, UK Power Networks had knowledge sharing sessions with ERDF, the French electricity distributor who have been closely following the FPP project progress as they are considering a similar implementation in France (*PPR Dec 2014, 2014, p. 31*). The project has been a topic of interest for other utilities across the world (Australia, US, Canada) and has been covered as a topic in knowledge sharing sessions between UK Power Networks and the respective utilities (*FPP Website, p. Presentations*).

Quality – Innovate

The FPP project's vision to offer a technical flexible plug and play solution that enables cost-effective, flexible connections was ambitious and forward-looking; these developments are at the heart of the evolution of distribution networks. The project carried its innovation through delivery and worked systematically and very hard to deliver GB's most advanced active network management integrated with other power systems devices and the FPP communications platform and the world's first 33kV Quadrature-booster amongst others.

The capacity quota is a commercial innovation for allocating access in constrained networks developed solely from concept to implementation by the project team. It is the only practical alternative to the LIFO mechanism currently and has demonstrated its benefits in a fairer allocation of curtailment, increasing the network utilisation and providing a link to the future reinforcement of the assets.

The FPP trials on this area have been the point of reference on this evolving topic both at academic, industrial and policy making levels (Table 2).

Quality – Get the right people involved

The FPP project team was primarily comprised of key UK Power Networks staff chosen for their skills, expertise and experience on relevant projects. This has ensured that the most significant body of knowledge and experience generated is kept in-house and supports the replication of the project.

The recruitment phase for the phase was a time consuming task for the management team. The result, however, was a highly skilled, motivated and committed to success team that enhanced the quality of the delivery and its outputs. As an example, the FPP team was comprised of:

- An ICT Design Authority with over ten years' experience in operational telecommunications
- A Power Systems Design Authority with expert skills in power systems
- A Project Management Office Manager with extensive project and financial management background
- A Commercial Arrangements Manager with background in renewable energy
- A Smart Devices Manager with project management, commissioning and field deployment experience
- A dedicated Learning and Dissemination lead with background in marketing and communications

The team was led by the project manager and project director for the first year, after which the two positions were integrated from the second year onwards to capture project savings

Quality – Gain external recognition

The FPP project has been externally recognised for its contribution by its stakeholders:

- By other DNOs for its work on the commercial arrangements, through public statements in conferences and other events
- By its customers, two of the customers have presented at the FPP learning events (March 2012 and March 2014) and have positively commented on the outputs of the project. Other customers have requested similar arrangements to be extended and typically "more of FPP" is a message received at the DG Customer Experience workshops that UK Power Networks receives, under the category of "what to do more of".
- By Ofgem and DECC as an expert reference project on its field. Adriana Laguna sits on the Ofgem/DECC Smart Grid Forum WS6 and contributes to the Storage and DG working group, Sotiris Georgiopoulos sat at the DECC Solar Strategy Grid working group contributing to the development of UK's Solar Strategy (of which only two DNOs took part).
- By a number of independent organisations in their annual awards process (*PPR Dec 2014, 2014, p. 30*):
    - East of England Energy Group – Winner, Low Carbon Innovation award 2014
    - Energy Institute Awards – Winner, Innovation award 2014
    - Utility Week Achievement Awards – shortlisted
    - National Business Awards – shortlisted

Quality – Replicability

Driven by the potential for customer benefits and the interest from the customers; UK Power Networks committed in its RIIO-ED1 business plan that will start offering FPP-style connection offers to other parts of the network by Q2 2015. In November 2014, two months ahead of project closure, the area around Norwich was opened to FPP-style connections (now termed Flexible DG Connections or FDG). To date, approximately 200MW of Flexible Distributed Generation (FDG) connection offers have been issued, 55MW have been accepted out of which 20MW are already operational (*Close Down Report, 2015, p. 4*).

The Norwich rollout has been based on the FPP systems, it utilises the same ANM system and contracts whilst a different communication platform is used (satellite) which was deemed more suitable for the application and it demonstrates the interoperability of the overall solution. Networks are inherently varied due to the distances between customers and the existing configuration. Norwich has different requirements which necessitated using a different communications platform, but this demonstrates that the FPP method is flexible enough to interchange components to maximise the scalability of the technology and commercial solutions. LIFO is been utilised as the principle of access consistent with the FPP project conclusion which showed that capacity quota is currently difficult to apply in more complex interconnected networks like Norwich. Capacity quota is now been considered for application in future areas.

The contracts developed by the project have formed the basis for the templates currently used by the new areas. UK Power Networks has published a rollout programme that shows an area across its Eastern and South Eastern networks being enabled for FDG connections every three months.

One of the successful output of the protection trial was the load blinding protection scheme, which has been deployed at March Grid. It is now part of the business as usual toolkit and is considered, where appropriate, to enable additional generation connections above what was previously possible. The same applies to the Dynamic Line Rating technology and Quadrature-booster, where the planning teams are actively looking for opportunities to deploy them.

In addition, the sharing of the commercial agreement templates with other DNOs and participation in discussions to aid understanding and share experience has aided the ability of replication for other network operators..

3. Cost-effectiveness

The FPP project was awarded customer funding of £6.7million by Ofgem, under the Low Carbon Networks Fund (LCNF) scheme. A further £2 million was invested from UK Power Networks, with the final £1m provided by the FPP project partners making a total budget of £9.7 million. The FPP project met all of its SDRC and learning outcomes, within the agreed original budget of £8.8m[1].

The final total cost of the project (net of interest) was £8.6m, which was £272k (3%) underspent (*Close Down Report, 2015, p. 33*). This underspend can be attributed to the timing and type of resources joining the project, the re-phasing of certain project activities and delivery of the work at costs lower than originally budgeted for. The under spend did not have any impact upon the successful delivery of the projects eight SDRCs or Use Case learning outcomes. Some categories did finish over budget, but these were in total less than the under spend work categories, resulting in the net savings.[2]

Commitments to Return Customers' Funding

While the under spend in itself is a sign of success, the fact that this became a return to customers' funding demonstrates cost effectiveness of the project's success in creating a quality outcome. A provision of £100k had been included within the project direction to de-commission the trial equipment, but in practice customers are dependent on the system for their access to the network and only a handful of lower cost equipment required de-commissioning (which is reflected in Table 3 below). The remainder of equipment originally thought to be commissioned will be adapted and/or gradually interchanged with alternate equipment to maintain the operational system after the transition to BAU.

Similarly, a provision of £30k to contract outside support in further stakeholder engagement leading up to the wider roll-out of the solution proved unnecessary, since groundwork laid in the first year of the project enabled UK Power Networks to complete the stakeholder engagement directly with generators and without the need for intermediaries. These two items result in £125k being returned to customers, which is incorporated in the £272k referred above. This will be refunded through the standard LCNF funding allocation process.

Use of Contingency Budget

The budget included £486k of contingency; of which £380k was used to cover some of the additional Quadrature-booster costs. The Quadrature-booster overspend is attributed to the variance between budgeted costs and the contracted actual. The total installed cost of the Quadrature-booster was £1,900k against an original estimate of £540k, e the cost of the Quadrature-booster, associated civil and electrical works was higher than initially budgeted. The Quadrature-booster remains competitive in an environment in which the average saving against a business-as-usual connection quotation of £2.6m.

The following sections seek to provide evidence of both responsible management of project finance as well as evidence that SDRCs have been delivered such that they provided consumer value for their investment.

[1] Note that £8.8m assumed net interest earned would be higher than what was actually earned. This explains the difference between the widely quoted £8.8m throughout the project and the £8.6 figure which is used to calculate the real underspend.
[2] Note that the project did not reallocate funds across the different work categories, but did a simple net calculation.

3.1 Management of costs and project finances

3.1.1 Actual project expenditure against budget

Table 3 below presents the view of the budget requested and the variance is shown against the number and does not take into consideration any variance due to interest earned. Line items with a variance of +/-5% have been discussed below in terms of the process taken to ensure value for money and efficiencies.

Table 3: Budget variance by original line item(*[Close Down Report, 2015, p. 36](#)*)

Flexible Plug & Play Financials £k	Original	Change Request	Net of Interest	Total FPP Actual	Variance (£)	Variance (%)	% of Total Budget
WS1 PM, Design & Implementation	1,011	1,011	996	525	-471	-47%	11
WS2 PM, Design & Implementation	557	481	474	1,204	730	131%	6
WS3 & WS6 PM, Design & Implementation	544	544	536	559	23	4%	6
WS4 PM, Design & Implementation	528	528	520	591	71	13%	6
WS5 & WS7 PM, Design & Implementation	316	316	311	356	44	14%	4
WS8 PM, Design & Implementation	420	420	414	419	5	1%	5
Overall Project Management	609	609	600	605	5	1%	7
Labour Total	**3,985**	**3,909**	**3,852**	**4,259**	**407**	**10%**	**45**
WS1 - Communications Platform	320	320	316	207	-109	-34%	4
WS2 - DLR & Protection study & trial	62	62	61	113	52	84%	1
WS2 – Quadrature-booster	396	396	390	750	360	91%	4
WS2 - Frequent use switches & tap changer relays	127	120	118	78	-40	-32%	1
WS4 - ANM scheme	380	380	375	207	-168	-44%	4
WS8 - System integration	345	345	340	305	-35	-10%	4
Equipment Total	**1,630**	**1,623**	**1,600**	**1,659**	**59**	**4%**	**18**
WS2 Contractors	187	187	184	217	32	17%	2
WS8 Contractors	863	863	851	1,080	229	27%	10
Overall Project Management	634	634	624	190	-435	-69%	7
Contractor Total	**1,684**	**1,684**	**1,659**	**1,486**	**-173**	**-10%**	**19**
WS1 & WS4 software licences	284	284	280	232	-48	-17%	3
61850 Configuration tool	18	18	18	16	-1	-7%	0
Project website	45	45	44	10	-34	-76%	1
Power systems studies, SI & Learning	142	142	140	151	11	8%	2
IT Total	**489**	**489**	**482**	**410**	**-73**	**-15%**	**5**
IPR Cost Total	-	-	-	-	-	-	-
Travel & Expenses Total	**132**	**132**	**130**	**122**	**-8**	**-6%**	**1**
Payments to Users Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Contingency Total	**486**	**486**	**479**	**380**	**-99**	**-20%**	**5**
Decommissioning Total	**100**	**100**	**99**	**5**	**-94**	**-94%**	**1**
Accommodation for project team, PM & SI	70	**70**	**69**	**55**	**-14**	**-20%**	1
Learning & Stakeholder engagement events	324	**324**	**319**	**116**	**-203**	**-63%**	4
Other Total	**394**	**394**	**388**	**171**	**-217**	**-55%**	**4**
Total expenditure	8,900	8,817	8,690	8,493	-197	-2%	
Actual Interest Earned	**-**	**-**	**-**	**-**	**-75**	**-**	**-**
Total expenditure	**8,900**	**8,817**	**8,690**	**8,493**	**-272**	**-3%**	

*Following the change request (Ref: CR0014) approved by Ofgem on 15 August 2013.

Labour Costs: Budget Variances:

WS1 PM – Design & Implementation **Variance: -47%**
The budgeted cost for this category is £1,0011k, which relates to resource cost for WS1 UK Power Networks and Vodafone labour costs. This line item equates to 11% of the total project budget. The total £525k actual costs relate to UK Power Networks WS1 Manager and Operational Telecoms support and Vodafone cost of programme management. The saving of £471k reflects a significant cost reduction to the bid partner pricing that the project managed to negotiate during the final contractual negotiations. To support the savings the project also utilised an internal resource to manage the work stream rather than using a contracted resource.

WS2 PM – Design & Implementation **Variance: +131%**
The budgeted cost for this category is £557k which relates to UK Power Networks WS2 Manager, Capital Programme delivery, Alstom and Wilson resource costs. The total actual cost for this line item was £1,204k, an over spend of £647k. In particular, the cost of the Quadrature-booster was higher than originally budgeted as the original budget for this line item did not include the labour required to install additional switchgear and more extensive civil works for a new 33kV substation than initially budgeted. The labour costs for these works totalled £113k.

WS4 – Design & Implementation **Variance: +13%**
The budgeted cost for this category is £528k which relates to UK Power Networks WS4 Manager and Smart Grid Solutions labour costs. Total cost is £559k, a variance of £71k which reflects that there additional support required to deliver the ANM system activities. As part of the contractual negotiations the project was able to secure a 10% discount on the Smarter Grid Solutions resources and labour costs required for the project, which supported keeping the overspend to a minimum.

WS5 & WS7 PM – Design & Implementation **Variance: +14%**
The budgeted cost for this category is £316k which relates to UK Power Networks WS5 Manager, WS7 Manager and Garrad Hassan stakeholder engagement labour costs. The total cost of this category line is £356k, with a variance of £44k. The variance is a result of the change in strategy to utilise an external consultancy to deliver the final 12 months of the Learning Dissemination activities. To select the Learning Dissemination contractor, during early 2014 a competitive tendering process was undertaken, led by the UK Power Networks procurement team. This saw the most suitable supplier selected, with a proportion of costs based upon successful delivery a set of key performance indicators to ensure value for money was received.

Equipment Costs: Budget Variances:

WS1 – Communications Platform **Variance: -34%**
The budgeted cost for this category is £320k which covers the equipment for the RF Mesh Communications hardware and relevant backhaul network circuits. The actual costs of £207k are for payments to Vodafone to cover equipment costs for the deployment of the communications platform. The variance reflects a significant cost reduction to the bid partner pricing that the project managed to negotiate.

WS2 – DLR & Protection Study & Trial **Variance: +84%**
Budget costs of £62k for this category cover the procurement and design of the dynamic line rating equipment and the reverse power flow protection schemes. Actual costs of £113k relate to the payment to Alstom for the delivery dynamic line rating and reverse power flow equipment. The over spend of £52k can be attributed to the additional equipment required for the dynamic line rating and protection schemes that were not included within the original budget.

WS2 – Quadrature-booster **Variance: +91%**
The budgeted costs of £396k relate to payments for the associated equipment for the Quadrature-booster. The actual costs of £750k relate to payments for the Quadrature-booster including all the necessary civil works, electrical works and control systems. The over spend of £360k can be attributed to a variance between the budget costs for the

equipment and the contracted actual. In particular, the cost of the Quadrature-booster was higher than originally budgeted and the original budget for this category did not include the additional equipment required, such as switchgear and civil works for a new 33kV substation. £380k of this overspend has been covered using the funds available under the contingency category.

As included within the December 2012 six-monthly report, there were contractual issues with the original Quadrature-booster supplier. To mitigate the risk of delays delivering the SDRC 9.8 an alternative supplier, Wilson Transformer Pty, were subsequently selected after going back to the market. The selection was made on the basis of their technical capability, the price quoted, and ability to commit to an accelerated programme that would guarantee meeting the project's timescales.

The contract negotiations with all project suppliers was undertaken in parallel, which gave the project the opportunity to offset the additional contracted Quadrature-booster costs of against the significant saving made in negotiating the communication platform contract.

WS2 – Frequent Use Switches & Tap Changer Relays **Variance: -32%**

The costs are only relevant are the tap changer relays, as the frequent use switches budget has all been returned as part of the change request (Ref: CR0014) approved by Ofgem on 15 August 2013. The budgeted costs of £127k relate to payments for the Tap Changer Relays equipment. The actual costs £78k relate to the Tap Changer Relays. No materials expenditure has been incurred in terms of the frequent use switches.

WS4 – ANM Scheme **Variance: -44%**

The budgeted cost for this category is £380k which relates to the procurement of the Active Network Management (ANM) system. The actual costs of £207k are for the payment to Smarter Grid Solution for the delivery of ANM system. This line item was completed £168k underspent. The ANM equipment provided agreed to provide the first 8 ANM units for free, which reduced project equipment costs as well as decreasing offer estimates for the first 20 generators (*PPR Dec 2014, 2014, p. 20*).

WS8 – System Integration **Variance: -11%**

The budgeted costs of £345k relate to substation monitoring equipment and the development of the advanced IEC 61850 functionality for the Remote Terminal Units (RTU). The project has incurred £305k on the development and installation of equipment costs relating to the RTU upgrade. This line item was completed £35k underspent, as a result of effective project management.

Contractor Costs: Budget Variances:

WS2 – Contractors **Variance: +17%**

The budgeted cost for this category is £184k against actual costs of £217k due to the WS2 Manager being initially a contract resource for the first year of the project and also incurring costs of a consultant supporting the workstream.

WS8 – Contractors **Variance: +27%**

The budgeted costs of £863k for this category include resource costs for Technical Design Authority and the cyber security expert. Actual spend £1,080k relates to resource costs for interim Technical Design Authority (employed until August 2012), cyber security expert, WS4 and WS8 managers and Commercial Design Authority. Contractors were utilised due to there being no available resource with suitable capabilities within UK Power Networks.

Overall Project Management **Variance: -69%**

£634k was budgeted for a Project Office Manager, Project Planner and Project Administrator, which equates to 7% of the project budget. The underspend can be attributed to the Project Planner being part-time basis, rather than on a full-time basis as initially budgeted. The planning activities were incorporated within team, so the specific planning resource is no longer required. Also the contractor Project Office Manager resource was replaced in January 2013 by an internal resource to provide further savings.

IT Costs: Budget Variances:

WS1 & WS4 software licences **Variance: -17%**

The budget costs for this category is £284k against actual costs of £232k. The differences relates to additional work undertaken to support the Communications trial. This line item finished £48k under budget.

61850 Configuration Tool **Variance: -7%**

The budget costs of £18k are for the licences relating to IEC 61850. The actual spend of £16k is for the payment to Helinks, Triangle and, Kema for software equipment and licences relating to IEC 61850.

Project website **Variance: -76%**

The budgeted costs of £50k are for the development of the FPP website. The project benefited from internal developments and the re-branding of the UK Power Networks website, so has managed to develop the external facing website at low additional cost. The actual costs of £10k are for further development to the FPP website. Additional work on the FPP website will see this category slightly increase.

Power systems studies, SI & Learning **Variance: +8%**

The budgeted costs of £142k relate to power system studies. Actual spend £151k relates to additional power systems studies to support the commercial arrangements work and the development of the Quadrature-booster protection scheme. The overspend in this category is a result of the uptake in flexible connections and the curtailment analyses that need to take place to offer the connection and also manage the quota.

Other Costs: Budget Variances:

Travel & Expenses: **Variance: -6%**

The budget costs for this category is £132k against actual costs of £122k. This category finished under budget due to less than anticipated costs in during planning from regular project uncertainty.

Contingency Budget Variances: **Variance: -20%**

See the paragraph on “Use of Contingency Budget” in the above pages.

Decommissioning: **Variance: -94%**

This category has a budget of £100k, with only £5k of actual costs. This underspend is a result of the significant uptake in the Flexible Connections, which has seen 15 DG customers accept offers and there being no requirement to decommission the FPP Technical Infrastructure.

A provision of £100k had been approved within the licence direction to de-commission the trial equipment, but in practice customers will be dependent on the system for their access to the network once the FPP connection offers convert to BAU. Therefore, at present, only low cost items have been de-commissioned and the majority of the FPP technical solution will be left in situ whilst the BAU approach is further explored. The equipment may ultimately see the FPP technical platform adopted as-is and/or gradually interchanged with alternate equipment to implement and maintain a UK Power Networks standard operational system that supports future flexible connections.

Accommodation: **Variance: -20%**

The budgeted cost for project accommodation is £70k. The actual spend on this category is £55k, as a result of lower cost being charged to the project than anticipated. This was due to planning uncertainty.

Learning & Stakeholder engagement events: **Variance: -63%**
Under this line item, £324k has been budgeted for major learning and stakeholder engagement events. £116k has been spent on dissemination material and activities to date. The underspend is mainly due to delivering the dissemination activities in a more cost effective manner than originally budgeted.

3.2 Cost effectiveness in delivering customer value

This section seeks to demonstrate cost effectiveness in delivering the value to the customer. We measure this by the extent that we kept costs low through effective management and by capturing the benefits/outcomes from each SDRC by comparing the outcome benefits to BAU. The sections below provide evidence that both of these approaches were undertaken throughout the project.

3.2.1 Controlling costs

Cost can be lowered in two potential ways. The first looks at procurement and contracting to lower costs. The second finds cost savings through efficient project management, whether by eliminating the need to carry out tasks or seeking cheaper ways to achieve the same result.

UK Power Networks have a clear Project Governance and Control (PG&C) process, which defines the governance and authorising process for projects and contracts. As part of this process, the project engaged with numerous organisations to ensure the right supplier/partner was selected. Organisations were selected for their suitability and for providing value for money. Both the UK Power Networks Legal and Procurement teams were heavily involved within the process to ensure costs savings were identified and delivered where possible. Evidence of savings from our procurement processes can be identified in several different work streams in Table 4 below. A saving of £599k was captured through negotiation to reduce costs from contracts.

Efficient management of project tasks was also able to lower costs. Through efficient use of labour resources, contractors, and engagement activities, savings of £1,035k can be attributed to project management efficiencies, as evidenced in Table 4 below.

Table 4: Savings over original budget

Line Item	Budgeted Cost (k)	Actual Cost (k)	Savings (k)	How Savings were achieved	Savings Type
<u>Labour Costs</u>: WS8 PM – Design & Implementation	£420	£419	5	The project secured an internal permanent appointment for the Technical Design Authority role, which was originally budgeted as a contractor. Additionally, the Project Manager role was removed from the structure and the role responsibilities were distributed mainly between the Project Director and Project Office Manager. The savings were offset by the hiring of an internal resource to carry out these functions.	Project Management Efficiency
<u>Labour Costs</u>: Overall Project Management	£609	£605	£4		
<u>IT Costs</u>: Project website	£50	£10	£40	The project benefited from internal developments and the re-branding of the UK Power Networks website, so has managed to develop the external facing website at low additional cost.	Project Management Efficiency

Line Item	Budgeted Cost (k)	Actual Cost (k)	Savings (k)	How Savings were achieved	Savings Type
IT Costs: **WS1 & WS4 software licences**	£284	£232	£48	The differences relates to additional work undertaken to support the Communications trial. This line item finished £48k under budget. The savings stemmed from leveraging existing licenses where possible.	Project Management Efficiency
Contractor Costs: **Overall Project Management**	£634	£190	£444	A Project Office Manager, Project Planner and Project Administrator were originally budgeted at the onset of the project. The underspend can be attributed to the Project Planner being part-time basis, rather than the originally planned full-time basis, and due to the planning activities being incorporated within team to avoid the need for a planning resource. Additionally, the contractor Project Office Manager resource was replaced in January 2013 by an internal resource to provide further savings	Project Management Efficiency
Other Costs: • **Travel & Expenses** • **Accommodation** • **Decommissioning**	 £132 £70 £100	 £122 £55 £5	 £10 £15 £95	• This is this a result of the careful management of the requirement for travel and expense. re • Lower costs were charged to the project than budgeted due to the lower rate charged and the lower amount of UK Power Networks office space required. • This underspend is a result of the significant uptake in the Flexible Connections, which has seen 15 DG customers sign up and there being no requirement to decommission the FPP Technical Infrastructure(*Close Down Report, 2015, p. 36*).	Project Management Efficiency
Learning & Stakeholder engagement events	£324	£116	£208	The underspend is primarily due to delivering the dissemination activities by leveraging the existing relationships and contacts built from early engagement activities, which wound up requiring less duplicative activities.	Project Management Efficiency
Equipment Costs: **WS4 – ANM Scheme**	£380	£207	£168	The cost relates to the procurement of the ANM system. The ANM equipment supplier agreed to provide the first 8 ANM units for free, which reduced project equipment costs as well as decreasing offer estimates for the first 20 generators. Subsequent 7customers funded the ANM units as part of the connection charge. (*PPR Dec 2014, 2014, p. 20*).	Procurement Process
Labour Costs: **WS1 PM – Design & Implementation**	£1,011	£525	£486	The saving reflects a significant cost reduction to the bid partner pricing that the project team managed to negotiate during the final contractual negotiations. To support the savings the project also utilised an internal resource to manage the work stream rather than using a contract resource.	Procurement Process
Equipment Costs: **WS1 - Communications Platform**	£320k	207k	£113	The cost for this category covers the RF Mesh Communications hardware and relevant backhaul network circuits' equipment costs for the deployment of the communications platform. The variance reflects a significant cost reduction to the bid partner pricing that the project managed to negotiate.	Procurement Process

3.2.2 Maximising benefit by comparing the outcome to BAU

The project was able to deliver the smart technology infrastructure and commercial arrangements to enable 15 flexible connections in the FPP trial area at a cost of £8.5m. Utilising the FPP method, as opposed to the conventional BAU connection offer, the project has saved the 15 DG customers in total £44m, providing an average of £2.9m saving per customer (*Close Down Report, 2015, p. 38*). Based upon the total cost, the project has provided £5.2m in avoided connection costs for every £1m spent on the project.

Due to the 54.4 MW of accepted generation schemes within the trial area, the project has enabled £54 million worth of low carbon generation projects to be built that otherwise would not have been financially viable (assumption of £1 million per MW). Generators immediately saw the value of the FPP connection offers and demonstrated this by actively working to accept offers. For example, at the beginning of the project, out of the original 6 offers made, three were not able to accept due to the lack of appropriate planning permissions (*PPR June 2013, 2013, p. 9*). Of these three, two went back through the cumbersome and time consuming permission process in order to gain the required planning permissions needed for the FPP scheme. They eventually re-applied and accepted new offers from UK Power Networks (*PPR Dec 2014, 2014, p. 6*).

4. Project Management

The FPP project involves multiple organisations based across the GB, so clear project structure, control and governance arrangements were required to keep the project focused on achieving its objectives. A handbook for the project was created with the objective of providing all project participants (partners, team members and key suppliers) a clear and consistent understanding of the background of the project and methodology that was to be followed (*Handbook Original, 2012*). The project handbook became point for reference for all project governance. As the project moved through its life-cycle and the focus moved from design and delivery into trials, the project handbook was updated to reflect governance changes (*Handbook Trial, 2013*).

The project management methodology followed was based upon the UK Power Networks project delivery standard, the PRINCE2 methodology, and lessons learnt from previous innovation projects delivered by UK Power Networks. PRINCE2 was particularly appropriate for this project. The very nature of PRINCE2 is to apply an approach which is outcome focused rather than being procedure or task focused. It is ideal for projects involving innovation as it allows tasks to be flexible enough to respond to unforeseen situations, which are more common for projects involving new ideas or research.

In Q4 2012, the project commissioned PA Consulting to complete a full assurance review to ensure the project was set up for success (*PMO Assurance, 2012*). The assurance review provided an external and objective perspective on the following areas of the project;

- Programme governance and structure
- Programme controls, reporting and management information
- Business Change and Stakeholder Management
- Engagement with the partners

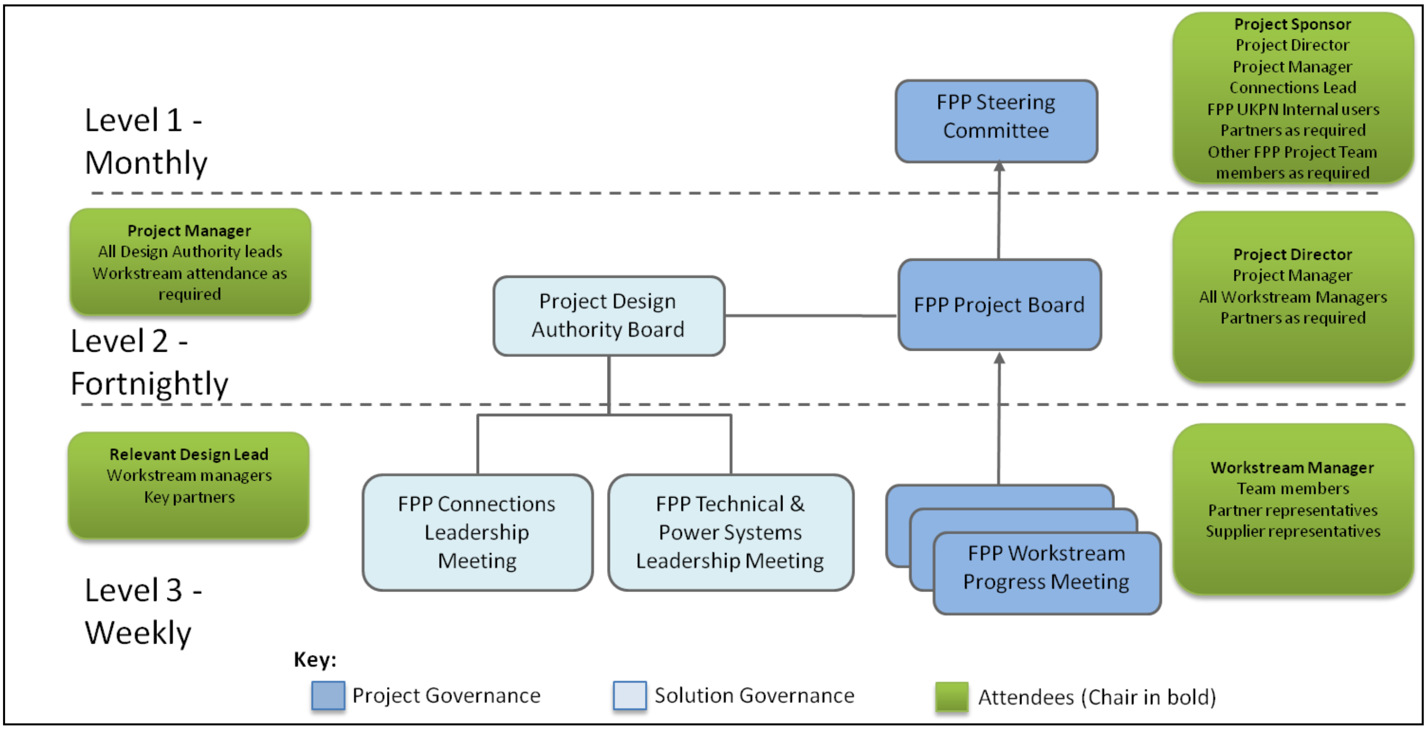
The outcome of the review concluded that the project made good progress creating a collaborative approach and there was clear focus amongst the project and team members to deliver the SDRC milestones. The review highlighted seven areas of focus in order to improve confidence in programme delivery. These were incorporated into the Project Handbook where appropriate(*Handbook Original, 2012*). A summary of the recommendations arising and the improvement actions implements are shown in Table 5 below:

Table 5: Assurance Audit High Level Recommendations

Recommendations	Improvements Implemented in Response to Recommendation
Continue and encourage the collaborative approach, sharing experience and lessons with wider initiatives to continue the good practice across UK Power Networks.	• Documented the approach to partnership and shared this, along with lessons learned, with other UK Power Networks programmes so that they can benefit from adopting the same approach. • Implement a quarterly workshop to share programme information with the partner team members closely involved with delivery. This should complement, rather than replace, the partner workshop by providing those engaged in the detail of delivery with a view of the wider programme.
Conclude contract negotiations and ensure that lessons learned from the process are documented and applied to future UK Power Networks programmes.	• **Conclude the outstanding negotiations as soon as practicable**, ensuring that the appropriate level of detail regarding products, quality and acceptance are in place • **Confirm that there are no funding implications arising from the delay to completing contract agreement**, instigating corrective actions if required • **Compile and share the lessons learned with contract negotiations**, particularly around division of responsibilities and co-ordination with UKPN legal • **Ensure that product descriptions are in place for all key contractual deliverables** that have been agreed. These should include clear quality and acceptance criteria.
Finalise the baseline plans and produce an integrated, forward looking, view of dependencies and resource requirements that is clearly understood by, and agreed with, all partners and internal stakeholders.	Plans were signed off by the Project Director and base-lined. Providing the project the opportunity to define when and what is requirements from the project partners and internal stakeholders.
Enforce use of programme controls to gain confidence in and simplify management reporting that focusses on performance against plan; and facilitates management of risks, issues and dependencies.	Fortnightly (frequency increase closer to key delivery deadlines) Risk and Plan reviews with all work streams, to ensure proactive management of workstream deliverables.
Emphasise programme management disciplines and focus the key governance groups, particularly in relation to timely provision of information; scrutiny of workstreams and formal decision making.	Reporting activities reviewed and streamlined to ensure effective and efficient reporting accuracy
Engage with internal stakeholders to begin planning for handover to live and the associated considerations of innovative contracts and technology on connection approval, asset management and maintenance.	The project continued to engage with key stakeholders at all levels within UK Power Networks. We used the following methods to keep the internal audience and key stakeholders informed (*Close Down Report, 2015, p. 48*): • Internal webpages • Meetings with individual parts of the business • Internal training sessions on new technologies installed • Internal 'lunchtime learning' sessions • News releases at key stages of the project This positive work saw the UK Power Networks make the commitment to offer flexible style connections by Q2 2016.
Increase the focus on customer and stakeholder management as well as communications to ensure that customers remain at the heart of the programme and activities are timely and effective.	Various vehicles such as, UK Power Networks DG forum, FPP web site, were used to engage with customers to ensure they we kept up-to-date with the project.

The governance model in Figure 1, below, was designed for the FPP project to deliver rapid communication of decisions and actions throughout the project, providing effective decision making. Regular communications sessions were arranged on a regular basis to communicate progress across the whole FPP project team and partners.

Figure 1: FPP Governance Approach



The FPP Governance Model, as shown in Figure 1, allows for the communication and escalation of key risks and issues within the project, and defines where decisions will be made and how these will be communicated back to the workstream where the risk or issue has arisen. Risks are reviewed via following the Governance Model, as shown in Figure 1, which see weekly at workstream level and bi-weekly at project level by the Project Board. Key project risks are then escalated to the Project Steering Committee for review and approval of the mitigation on a monthly basis. This was a continuous process, with reviews taking place on a weekly basis to ensure that the project could proactively manage risks.

Risk Management

A total of ten issues were established and escalated to the Steering Group during the project life-cycle. The process was such that the highest impact and likelihood of occurrence risks were categorised as red risks. These were then consistently reviewed and escalated weekly or fortnightly to the Project Board and/or Steering Committee (*Handbook Trial, 2013*).

We highlight three particular examples of risk management from the four phases of the project, from setup, through the installation of the main electrical plant (the Quadrature-booster), the installation of the remaining equipment.

1. During the setup phase, the project was tracking an emerging risk with the selected vendor of the Quadrature-booster. There were contractual issues associated with Intellectual Property, which the vendor needed to get head office agreement to, but in addition the project had formed some concerns around the vendor's

preparedness and ways-of-working. This was escalated to director level within UK Power Networks and decision taken to initiate parallel conversations with an alternate supplier. This bore fruit, in terms of identifying a vendor willing to take on the delivery challenge at short notice, and who was, additionally, willing to allow some of their payments to be performance-based.

2. During the installation of the Quadrature-booster itself, there was an emerging risk associated with the SAT (commissioning tests) and the results being achieved. UK Power Networks ensured that safety was paramount and that the Commissioning Engineers and on-site Project Manager had the final call on matters, but made sure that relevant directors, experts from our protection team, along with senior management from the innovation team, were available to review outcomes, agree and sign-off on next steps, and take decisions or rule on risks where necessary. Teams worked through weekends in order to meet the revised deadline agreed with Ofgem.

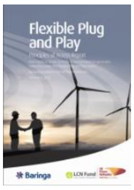
3. As part of the risk management process during the installation phase in 2013 a positive risk was identified through engagement with the UK Power Networks Capital Programme delivery team. The positive opportunity stemming from this risk was the change to leverage the RMU upgrade programme already being undertaken in 2014, rather than installing FUS. The RMUs can provide the same functionality as the FUS. Through further detailed engagement with the Capital Programme delivery team, the RMU upgrade programme was re-prioritise to take into consideration the FPP project requirements and allow the project to return £83k to customers.

   This opportunity stemming from the original risk was tracked and managed initial confirmation from Ofgem and agreements with Capital Programme delivery, through to installation of the RMU at the FPP sites. Throughout the delivery phase of the RMUs frequent updates were provide and by Capital Programme delivery and where required the project risk management process provide solutions and support for the successful delivery. This was demonstrated through escalating the network outages and resource requirements to Steering Group level to ensure the FPP sites were delivered to meet the project deadlines.

The examples above and all red risks which were reviewed, tracked, and mitigated against can be found in the six-monthly project progress reports (*PPR Dec 2012, 2012*; *PPR Dec 2013, 2013*; *PPR Dec 2014, 2014*; *PPR June 2012, 2012*; *PPR June 2013, 2013*; *PPR June 2014, 2014*).

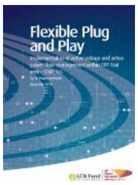
Appendix 1: Evidence Table for Timeliness and Completion

Table 6: Evidence Table for Timeliness

SDRC		Description of SDRC	Original Deadline	Result / Justification	Evidence & Reference
9.1	**Stakeholder Engagement Report 1** 	Completion of a stakeholder engagement report that will record the findings from the first phase of stakeholder engagement activities identifying key technical and commercial challenges to the FPP project.	End of September 2012	**Completed On Time** • The Stakeholder Engagement report was completed on September 14th and submitted to Ofgem on 28 September 2012. • These findings were shared with all relevant stakeholders, including all GB DNOs, and formed a key input to the Strategic Investment Model and Smart Commercial Arrangements FPP project work streams.	• Completion of the first phase of stakeholder engagement activities meant to identify key technical and commercial challenges to the FPP project. – *(PPR Dec 2012, 2012, p. 31)* – *(PPR June 2013, 2013, p. 20)* • A report recording the findings from the phase I of stakeholder engagement activities. – *(SDRC 9.1 2012)*
9.2	**Development of smart commercial arrangements** 	Development of smart commercial arrangements, which will provide a number of options that can be tested and implemented in new types of connection agreements with generation developers. These will be established in conjunction with key stakeholders.	End of December 2012	**Completed On Time** • Principle of Access report submitted to Ofgem on 28 December 2012 as evidence of SDRC 9.2 being complete. • The templates and other supporting reports were developed in consultation with relevant stakeholders, but actually published in the first quarter of 2013, following publication of "Principles of Access" in December of 2012.	*(PPR Dec 2012, 2012, p. 30)* *(PPR June 2013, 2013, p. 20)* • Publication of a report on Principles of Access, which will determine the Principles of Access for smart commercial arrangements. – *(SDRC 9.2, 2012)* • Connection agreements templates (new model forms) for actively managed generator connections, to be established in conjunction with key stakeholders. – *(CIC Flexible Connection Offer, 2013)* – *(Capacity Quota Calculation for March Grid, 2013)* – *(Flexible Connection Briefing, 2013)* – *(Interruptible Connection Offer LIFO, 2013)*
9.3	**IP (Internet protocol) Communications Platform – Go Live** 	Full deployment of an Internet Protocol (IP) communications platform across the FPP trial area to support open standards communication protocols.	End of March 2013	**Completed On Time** • The project successfully installed and commissioned an IP-based communications solution across the FPP trial area by Q1 2013. The Communications Platform SDRC 9.3 Report was delivered to Ofgem on 28 March 2013. • It also demonstrated through IEC 61850 trials that the end-to-end communications solution was and is capable of trafficking IEC 61850.	• Installation and commissioning documentation of Vodafone Multi-Service Platform (MSP) network and Silver Spring Networks Radio Frequency mesh network in trial area and in accordance with specification included in the contracts with relevant partners. – *(SDRC 9.3, 2013)* • Recorded results of IEC 61850 communication trials using IEC 61850 simulators at installed locations in the FPP trial area. – See Appendix 5

SDRC		Description of SDRC	Original Deadline	Result / Justification	Evidence & Reference
9.4	**Demonstrate FPP technical characteristics of FPP solution**  	Demonstration of Flexible Plug and Play capabilities of the overall FPP technical solution following completion of the FPP installation phase.	End of September 2013	**Completed On Time** • The FPP solution was successfully installed and commissioned in September 2013. • The commissioning and the acceptance of the ANM production platform. The integration of the Smart devices including the Dynamic Line Rating system, the Quadrature-booster Control system, the Automatic Voltage Control units and the upgraded RTUs into the ANM production platform. • The field commissioning of the smart devices to the ANM production platform via the RF mesh infrastructure. • The SDRC 9.4 Report was delivered to Ofgem on 30 September 2013.	(*SDRC 9.4, 2013*) (*PPR Dec 2013, 2013, p. 24*) • IEC 61850 certification for all relevant Remote Terminal Units (RTUs), Intelligent Electronic Devices (IEDs) and other IEC 61850 field devices. • Installation and commissioning documentation of IEDs and other field devices necessary to support the trials and in accordance with the specification included in the contracts with the relevant partners. • Installation and commissioning documentation of production of Smart Applications in accordance with the specification included in the contracts with the relevant partners. • Pre-production interoperability test results for FPP's Smart Devices and Smart Applications.

9.5	**Strategic Investment Model**
	
	
		Delivery of the FPP strategic investment model including validation and testing of the model utilising data captured within the FPP trials.	End of December 2014	**Completed on Time**
				• The SIM was designed, built and delivered in December 2014.
				• The SIM was developed, tested and fully validate through a number of a case studies including the utilisation of data captured within the FPP trials.
				• The SIM was completed in a fully usable and external issue format using commercial software (i.e. Microsoft Excel, Fico Xpress) and proprietary code from Imperial College London.
				• Report submitted to Ofgem on 31 December 2014.
					("PPR June 2014," 2014, p. 26)
					• Completion documentation for the strategic investment model development and build phase.
					  – (*SDRC 9.5, 2014, p. xxx*)
					• Recorded validation and test results.
					  – (*SDRC 9.5, 2014, p. xxx*)
					• Delivery of the strategic network investment model in a fully usable and external issue format.
					  – (*PPR June 2014, 2014, p. 26*)

9.6	**Implementation of active power flow and voltage management within FPP trial area**  	Deployment of active power flow management and active voltage management within the FPP trial area.	End of December 2014	**Completed on Time** • The active power flow and the active voltage management was trialled within the FPP trial area and the report completed in December 2014. • The report provides an overview of the trials conducted to demonstrate the capability of active power flow and active voltage management applications to overcome a number of constraints. • The results analysed have come from a combination of both simulation and operational experiments. • Report submitted to Ofgem on 31 December 2014.	*(SDRC 9.6, 2014)* *(PPR Dec 2014, 2014, p. 26)* • Pre-production functional test results for active power flow management and active voltage management applications. • Installation and commissioning documentation of production active power flow management and active voltage management applications in accordance with the specification included in the contracts with the relevant partners. • Suitable agreements with generators in place (if required).Trial results for the active power flow management and active voltage management trials.

SDRC		Description of SDRC	Original Deadline	Result / Justification	Evidence & Reference
9.7	 **Facilitation of faster and cheaper connection of DG to the distribution network, as compared to timescales and costs of connection utilising traditional approaches**	Facilitation of faster and cheaper connection of DG to the distribution network, as compared to timescales and costs of connection utilising traditional approaches.	End of December 2014	**Completed On Time** • The flexible connections that have been offered, accepted and commissioned have all been used to demonstrate that flexible connections are a cheaper and faster method for connecting DG to the network compared to conventional business-as-usual. • Since 1 March 2013 and delivery of the SDRC, 39 flexible connection offers were delivered to DG customers in the FPP trial area. Fourteen of these offers were accepted.	*(PPR Dec 2014, 2014, p. 27)* *(PPR Dec 2014, 2014, p. 25)* *(SDRC 9.7, 2014)* Demonstration that DG connection offers are: • 1 - Cheaper; − *(SDRC 9.7, 2014, p. xxx)* • 2 - Offer faster project connection timescales, than offers based traditional reinforcement. − *(SDRC 9.7, 2014, p. xxx)*
9.8	**Deployment of Quadrature-booster within trial area** 	Successful deployment of a Quadrature-booster within the FPP trial area.	Original: End of June 2013 Actual: August,2013	**Completed On Time per Change Request** • The Quadrature-booster was successfully installed and commissioned in July 2013. • The Quadrature-booster SDRC 9.8 Report was delivered to Ofgem on 9th August, 2013. • The report provides an overview of the deployment phase of the project from concept through to commissioning and includes initial analysis demonstrating the improved balancing between the circuits.	*(PPR Dec 2014, 2014, p. 24)* • Change Request: − *(CR to Ofgem 9.4 and 9.8, 2013, p. 2)* • Installation and commissioning of a Quadrature-booster and in accordance with the specification included in the contracts with the relevant partners. − *(SDRC 9.8, 2013)* • Demonstration of improved balance between the circuits allowing increased power flow headroom of approximately 10MW. − *(SDRC 9.8, 2013)*

Appendix 2: Service Ready for Use Certificates

CUSTOMER MILESTONE
ORDER COMPLETE:
SERVICE READY FOR USE

HANDOVER DOCUMENT

We are pleased to confirm that the service detailed here was activated on the shown date. This date will be the service commencement date under your contract with Cable&Wireless Worldwide.

We will now hand this service over to our Billing and Assure Operations, details of which are below.

Dear .

Customer Name:	UK POWER NETWORKS
Cable&Wireless Worldwide Order ID:	Q5108814-1-1-1
Customer's Own Ref:	.
Site 1 Location & Termination Details:	.Peterborough Central Electrical Relay Room/Ground Floor
Site 2 Location & Termination Details:	.N/a
Customer's Portal/Interim Order Ref:	.
Order Description:	. provide 10M throttled to 2M IPVPNQoS service to the above mentioned site via Onnet
C&W Worldwide Service Ref:	. 3C00943730
C&W Worldwide MSP Bearer Ref:	. EAET00943706
C&W Worldwide Circuit Ref:	. T0563943A
OLO Circuit Ref:	.N/a
Date this comms issued:	30/11/2012
Agreed Delivery Date:	30/11/2012
Service Activation Date:	29/11/2012

Should you need to contact us please contact the Cable&Wireless Worldwide Order Contact quoting your order number. The details of these can be found on previous correspondence.

BILLING

Your Cable&Wireless Worldwide bill for this service will be issued in the usual manner. Any queries regarding this should be directed to C&W through your usual channels.

FAULTS

Should you experience any faults with your circuit please contact the C&W Worldwide 24 hour Assure help desk on 08000728058 or +44 (0) 2070222208 or using the unique number you may already have been given.

CUSTOMER MILESTONE
ORDER COMPLETE:
SERVICE READY FOR USE

HANDOVER DOCUMENT

We are pleased to confirm that the service detailed here was activated on the shown date. This date will be the service commencement date under your contract with Cable&Wireless Worldwide.

We will now hand this service over to our Billing and Assure Operations, details of which are below.

Dear .

Customer Name:	UK POWER NETWORKS
Cable&Wireless Worldwide Order ID:	Q5115180-1-1
Customer's Own Ref:	.
Site 1 Location & Termination Details:	March Grid, Gaul Road, March, PE15 9RH Electrical Relay Room/Ground Floor
Site 2 Location & Termination Details:	.
Customer's Portal/Interim Order Ref:	.OM5115180-1-1
Order Description:	.Provide 2M IPVPNQoS service
C&W Worldwide Service Ref:	. S1057621A
C&W Worldwide MSP Bearer Ref:	. 3C00968995
C&W Worldwide Circuit Ref:	. TA00968843
OLO Circuit Ref:	. MXWB216969
Date this comms issued:	18/02/2013
Agreed Delivery Date:	20/02/2013
Service Activation Date:	15/02/2013

Should you need to contact us please contact the Cable&Wireless Worldwide Order Contact quoting your order number. The details of these can be found on previous correspondence.

BILLING

Your Cable&Wireless Worldwide bill for this service will be issued in the usual manner. Any queries regarding this should be directed to C&W through your usual channels.

FAULTS

Should you experience any faults with your circuit please contact the C&W Worldwide 24 hour Assure help desk on 08000728058 or +44 (0) 2070222208 or using the unique number you may already have been given.

Appendix 3: SDRC 9.3 - Acceptance Test Sign-off Sheets (March 2013)

UK Power Networks | Silver Spring Networks | Cable&Wireless Worldwide

E-2-E Acceptance Tests

From Date:	27/02/2013 - 28/02/2013
To Date:	27/02/2013 - 28/02/2013
Test Reference document & version:	E-2-E Acceptance Tests v1.2
Parties Involved:	UKPN, CWW and SSN
Name of Engineers:	Bill Stokes, Ian Wilmshurst
Name of test approvers:	Tim Manandhar
Test witness by:	Steve Andrews, Lynne McDonald, Roger Yeo — Attended by: Simon Dunkley, Matthew Bourne / 28/02/2013 Steve Andrews, Lynne McDonald
Location of Test:	Fore Hamlet

Test	Name	Description	Expected result	Actual result	Time of Test	Pass/Fail	UKPN Witnes	UKPN Witness	UKPN Approval
NETWORK #1	Master Reconvergence	Reboot a Master Bridge and verify that the Remote Bridges re-acquire the Master Bridge in a timely fashion.	All remotes will re-acquire the master in less than 5 minutes	PC MeB 1: 1min PC MeB 2: [redacted] 50s M MeB1: 45s M MeB2: 49s	12:45 12:55 16:19 16:43	PASS PASS PASS PASS	LMCD	R. YEO	T. MANANDHAR
NETWORK #2	Remote Acquisition	Verify that Remote Bridges reacquire the Master Bridge quickly after a simulated loss and restoration of power.	Remote eBridge will re-acquire the master and become reachable in <90 seconds after restart	① 24s ② 37s	10:15 to 10:16 / 10:56 to 10:58	PASS	L.MCD. -SCA	R. YEO	T. MANANDHAR
NETWORK#3	Access Point Failover	Verify when an Access Point fails over that the active Access Point acquires remote management connection to all FPP end points after a simulated loss of power.	All remote eBridges acquire management connectivity to GridScape from the alternative AP	PC: demonstrated M: demonstrated	12:55 17:05	PASS PASS	L.MCD.	R. YEO.	T. MANANDHAR
NETWORK #4	Firmware Upgrade	Confirm connected Silver Spring devices' internal firmware can be updated via the DA Communication Network.	Device firmware will be remotely upgraded and the device will function on the new firmware. For field networks, assuming good network connectivity and adequate AP coverage, 90% of all SSN devices updated within 24 hours; 95% within 36 hours and 98% within 48 hours.	2 sites upgraded successfully	09:19 to 09:30	PASS		R. YEO	T. MANANDHAR
NETWORK #5	Deterministic Routing	Demonstrate that the Remote Bridge prefers the lowest cost Master Bridge or AP.	Routing log entries will display that nodes evaluate link cost to every master and AP periodically and will choose different upstream next hops when the cost improves	demonstrated	09:26 to 28/02 09:50	PASS	L. McD.	SCA.	T. MANANDHAR
NETWORK #6	Device Latency	After installation of the DA Communication Network, validate round trip time through Master Bridge to Remote Bridge	Verify average RTT RF latency: in average < 1 second or as designed for your network requirements	av. per site <1s (28/02)	28/02 14:38 to 14:41	PASS	L.MCD		T. MANANDHAR
NETWORK #7	Capacity Test	To determine the link saturation (the network constraint where performance begins to degrade) and throughput via simulated traffic.	1. ~8 KBytes per second, max value, for single-hop links; 2. ~2 KByes, per second, average, for [redacted] multiple hop links	① 8KByte = 9.26 KBytes/s 32KByte = 9.26 KBytes/s 64KByte = 9.21 KBytes/s ② 8KByte = 3.75 KBytes/s 32KByte = 3.53 KBytes/s 64KByte = 3.28 KBytes/s	10:34 - 10:44 10:48 - 10:52 10:54 - 10:59 10:34 - 10:53	PASS PASS PASS PASS	L. MCD.	SCA	T. MANANDHAR
NETWORK#8	Self-Healing	Prove the resilience and speed of recovery on the loss of a Remote eBridge and a Relay. The dependant eBridges to re-register via a different route,	After the 'restart target' device has been put down, comms to the chosen Remote will resume and it will be demonstrated that either the chosen Remote or an upstream node has made a nexthop change to route around the downed device	Remote - successful relay - successful	10:05 - 10:30 12:05 - 12:11	PASS PASS	L. MCD		T. MANANDHAR
NETWORK #9	Report: Hop Count to Master	Show histogram of devices against. hop count per Master Bridge	Display a report which shows the hop-count distribution for each Master eBridge	demonstrated	14:29 - 14:33	PASS	L. McD		T. MANANDHAR
NETWORK #10	[redacted] Frame Error Rate	Assess the proportion of network capacity consumed for retransmission of packets not successfully transmitted on the first try.	< 10% aggregate retry percentage						

NETWORK #11	Job Scheduling	Demonstrate support for creating and scheduling jobs and job groups to customizable scenarios.	The created job runs on schedule for the device population selected	demonstrated 28/02	14:53	PASS	L.MCD		T. MANANDHAR
NETWORK #12	On-Demand Data Retrieval	Demonstrate on demand retrieval of diagnostic information via GridScape	Verification of functionality - node QO	28/02	14:56				
NETWORK #13	RF Comms Availability	GridScape Test the RF Comms Availability. Comms availability to be demonstrated by GridScape over 1 week period in % value	Availability of 99% for all devices for which field network optimization has been completed by the start of the tests		Started 28/02				
NETWORK #14 (CWW)	IP Route Summarization	Confirm route summarisation is configured and working on the March Grid and Peterborough Central CE routers	Confirmation that only /27 route advertisements are being propagated into e-BGP, not the original /32 routes learnt from RIP and the RF Mesh, from both the Peterborough Central and March Grid routers.	Confirmed.	14:40	PASS	LMCD	T. MANANDHAR	S. Andrews
NETWORK #15 (CWW)	RF Mesh Address Filtering	Confirm route summarization is configured and working on the March Grid and Peterborough Central CE routers	Confirmation that no /32 route advertisements from the 10.247.3.0.0 range (RF Mesh IP Transit Network addresses) are being propagated into e-BGP, from both the Peterborough Central and March Grid routers.	confirmed	15:10	PASS	L. MCD	T. MANANDHAR	S. Andrews
NETWORK #16 (CWW)	IP Multicast	Confirm route IP Multicast is configured and working between the eBridge Master pairs at Peterborough Central and March Grid (includes CE router configuration) and that the eBridge have a synchronised database	Confirmation that the Peterborough Central and March Grid eBridge Master's are synchronised via IP Multicast.	confirmed	15:30	PASS	LMCD	T. MANANDHAR	S Andrews
NETWORK #17 (CWW)	Ethernet WAN failure	Simulate a WAN link failure of the Ethernet link into the Peterborough Central CE router	The default route that is advertised by the CE router into RIP (eBridge Master) will be withdrawn once the BGP timers have expired; this could be up to >180 seconds. Confirm that the eBridge Master's "poison" their downstream RIP routes to force the RF mesh to re-converge via March Grid.	confirmed. (28/02)	11:51 to 11:56	PASS	L. McD	T. MANANDHAR	S. Andrews
NETWORK #18 (CWW)	Serial WAN Failure	Simulate a WAN link failure of the PPC Serial link into the March Grid CE router	Serial interface, HDLC goes down almost instantaneous The default route that is advertised by the CE router into RIP (eBridge Master) will be withdrawn, almost instantaneous, once the PPC Serial Link goes down and the HDLC timers have expired. Confirm that the eBridge Master's "poison" their downstream RIP routes to force the RF mesh to re-converge via Peterborough Central.	confirmed (28/02)	12:21 to 12:37.	PASS	L. McD	T. MANANDHAR	S Andrews
NETWORK #19 (CWW)	Sub-Interface Failure	Simulate a WAN link failure (sub-interface) on the Fore Hamlet's primary CE router - only affect UKPN FPP VRF1 traffic	Shutting down the IP sub-interface, associated with the FPP VRF, at the PE node connection to the UKPN_FORE_HAMLET_1002_001P CE router, will force BGP traffic via the back-up CE router at Fore Hamlet.	Failed FHCEIA LAN interface and failed successfully onto backup CEB router	18:03 - 18:07	PASS	L. McD	SA	T. MANANDHAR

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NETWORK #20 (CWW)	SSN eBridge(s) Failure	Simulate a failure to both eBridge Masters at Peterborough Central sub-station.	RF Mesh traffic, original using the Peterborough Central route, will re-converge on to the March Grid eBridge Master devices.	during test #18 + #19	28/02	PASS	L.McD	T.MANANDHAR	S Andrews
NETWORK #21 (CWW)	MAGIC	Confirm MAGIC (Stable net) connectivity to both the Peterborough Central and March Grid CE routers.	CWW MAGIC support team to confirm that the CE router at Peterborough Central and March Grid are showing as active in the Stable net Database.	confirmed. 28/02	13:29 to 13:35	PASS	L.McD	T.MANANDHAR	S Andrews
NETWORK #22 (CWW)	SSN Management	SSN to PING test the new diagnostic route to Fore Hamlet (ANM) Firewall.	The SSN Gridscape and AP Management server should be able to PING the 10.48.1.16/29 network at Fore Hamlet - Note: this is an additional IP route that has been added to the CWW CIG and SSN IPSec Gateway to allow for diagnostic testing.	10.48.1.17 was pinged ok	18:30	PASS	L.McD	T.MANANDHAR	S. Andrews
NETWORK #23 (CWW)	Device Latency	Fore Hamlet DMZ run ping script from a PC connected to FPP ANM DMZ at Fore Hamlet to record time stamps and latency with a destination as a eBridge with the maximum hop (4)	Verify average RTT RF and IP latency: in average < 1 second or as designed for your network requirements	during ping script #2 (28/02) = 245ms	14:54	PASS	L.McD		T.MANANDHAR
61850 #01	GetDirectory	GetDirectory discovery of data components on a remote server		19secs	11:11 to 11:12	PASS	L.McD	R.YEO	T.MANANDHAR
61850 #02	Periodic GetDataValues polling	Periodic GetDataValues polling of data	At 5secs	successfully demonstrated	11:13	PASS	L.McD	R.YEO	T.MANANDHAR
61850 #03	Progressively rapid GetDataValues poll	Progressively more rapid GetDataValues polls of data to demonstrate multiple reads per seconds	Plan to start at once every 5 five seconds and trying to decrease to 1 second.	successfully demonstrated	11:13 to 11:20	PASS	L.McD	R.YEO	T.MANANDHAR
61850 #04	Exception Based Report	Exception Based Report		successfully demonstrated	11:22 to 11:29	PASS	L.McD	R.YEO	T.MANANDHAR
61850 #05	Concurrent Test	Combined test of polling, exception based reporting and Standard Network Time Protocol (SNTP) Time updates of an RTU	Polling at 2 secs. exceptions at 1sec.	demonstrated	15:20 to 15:30	PASS	L.McD		T.MANANDHAR
		SNTP		successfull connection to NTP server 10.60.48.200 and laptop time was correctly updated	11:15 to 11:50. (28/02)	PASS	L.McD.	Bill Stokes.	T. MANANDHAR

Acceptance Tests

From Date:	Jan 21st	To date:	Jan 22nd
Test Reference document & version:	Acceptance Tests v1.0		
Parties involved:	UKPN, CWW and SSN		
Name of Engineers:	Rick Silva, Paulo Reis		
Name of test approver:	Tim Manandhar		
Test witness by:	Lynne McDonald; Roger Yeo		
Test Attendance:	Bill Stokes; Ian Wilmshurst		
Location of Test:	Peterborough Central, Farcet		

Test	Name	Description	Expected result	Actual result	Time of Test	Pass/Fail	UKPN Witness Sign	UKPN Witness Sign	UKPN Approval Sign
NETWORK #1	Master Reconvergence	Reboot a Master Bridge and verify that the Remote Bridges re-acquire the Master Bridge in a timely fashion.	All remotes will re-acquire the master in less than 5 minutes	2:29.7	10:52 Jan 22nd 10:52	PASS	L.McD	R.Y.	T.M
NETWORK #2	Remote Acquisition	Verify that Remote Bridges reacquire the Master Bridge quickly after a simulated loss and restoration of power.	Remote eBridge will re-acquire the master and become reachable in <90 seconds after restart	37 secs	10:58 Jan 22nd 11:02	PASS	L.McD	R.Y	T.M
NETWORK #3	Firmware Upgrade	Confirm connected Silver Spring devices' internal firmware can be updated via the DA Communication Network.	Device firmware will be upgraded and the device will function on the new firmware. For field networks, assuming good network connectivity and adequate AP coverage, 90% of all SSN devices updated within 24 hours; 95% within 36 hours and 98% within 48 hours.	Test undertaken using CATT software. Demonstrated.	Jan 22nd	PASS	L.McD	R.Y.	T.M
NETWORK #4	Deterministic Routing	Demonstrate that the Remote Bridge prefers the lowest cost Master Bridge or AP.	Routing log entries will display that nodes evaluate link cost to every master and AP periodically and will choose different upstream next hops when the cost improves	Demonstrated	Jan 22nd 16:18	PASS	L.McD	R.Y	T.M
NETWORK #5	Device Latency	After installation of the DA Communication Network, validate round trip time through Master Bridge to Remote Bridge	Verify average RTT RF latency: in average < 1 second or as designed for your network requirements	Demonstrated	16:20 Jan 22nd 16:25	PASS	L.McD	R.Y	T.M
NETWORK #6	Report: Hop Count to Master	Show histogram of devices against. hop count per Master Bridge	Display a report which shows the hop-count distribution for each Master eBridge	Demonstrated	16:33 Jan 22nd 16:45	PASS	L.McD.	R.Y	T.M
NETWORK #7	Frame ~~Packet~~ Error Rate	Assess the proportion of network capacity consumed for retransmission of packets not successfully transmitted on the first try.	< 10% aggregate retry percentage	Demonstrated	16:49 Jan 22nd 16:55				
NETWORK #8	Job Scheduling	Demonstrate support for creating and scheduling jobs and job groups to customizable scenarios.	The created job runs on schedule for the device population selected	Demonstrated	Jan 22nd 16:18	PASS	L.McD	R.Y	T.M
NETWORK #9	On-Demand Data Retrieval	Demonstrate on demand retrieval of diagnostic information via GridScape	Verification of functionality	Demonstrated.	16:37 Jan 22nd 16:39	PASS	L.McD	R.Y	T.M
61850 #1	GetDirectory	GetDirectory discovery of data components on a remote server		Demonstrated	11:42 11:45	PASS	L.McD	Jan 23rd	T.M
61850 #2	Periodic GetDataValues polling	Periodic GetDataValues polling of data		Demonstrated	11:46 11:49.	PASS	L.McD	Jan 23rd	T.M
61850 #3	Progressively rapid GetDataValues poll	Progressively more rapid GetDataValues polls of data to demonstrate multiple reads per seconds	Plan to start at once every 5 five seconds and trying to decrease to 1 second.	Demonstrated	11:51 11:54	PASS	L.McD	Jan 23rd	T.M
61850 #4	Exception Based Report	Exception Based Report		Demonstrated	11:55 12:00	PASS	L.McD	Jan 23rd	T.M
61850 #5	Concurrent Test	Combined test of polling, exception based reporting, and Standard Network Time Protocol (SNTP) Time updates of an RTU	SNTP excluded		12:10 12:13	PASS excluding SNTP.	L.McD	Jan 23rd	T.M

Silver Spring NETWORKS

Cable&Wireless Worldwide

Lynne McDonald (LMcD)
Roger Yeo (RY)
Tim Manandhar (TM)

Appendix 4: SDRC 9.4 - IEC 61850 Certification Certificates

IEC 61850 Certificate Level A[1]

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International Usersgroup

No. 74104881-MOC/INC 13-3100

Issued to:

Smarter Grid Solutions
Corunna House
39 Cadogan Street,
Glasgow, G2 7AB
United Kingdom

For the client system:

sgs commshub with IEC 61850 Driver
Version 2.2.0
Hardware: HP Proliant DL385p Gen8 with
Windows Server 2008 R2 64-bit

Issued by: KEMA

The client system has not shown to be non-conforming to:

IEC 61850 First Edition Parts 6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 and UCA IUG Conformance Test Procedures for Client System with IEC 61850-8-1 interface, revision 1.1 with TPCL[2] version 1.2 with client system's protocol, model and technical issue implementation conformance statements: "Protocol Implementation Conformance Statement for the IEC 61850 interface in sgs comms hub v2.2", "Model Implementation Conformance Statement for the IEC 61850 interface in sgs comms hub v2.2", "TISSUES Implementation Conformance Statement for the IEC 61850 interface in sgs comms hub v2.2" and product's extra information for testing: "Protocol Implementation eXtra Information for Conformance for the IEC 61850 interface in sgs commshub IEC 61850 Client v2.2".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases):

1	Basic Exchange (19/22)	12a	Direct Control (6/7)
2	Data Sets (5/9)	12b	SBO Control (8/9)
3	Substitution (1/3)	12c	Enhanced Direct Control (6/7)
5	Unbuffered Reporting (15/18)	12d	Enhanced SBO Control (8/9)
		13	Time Synchronization (1/4)

This certificate includes a summary of the test results as carried out at KEMA in the Netherlands with UniCA Multi IED Simulator version 3.27.02 and UniCA 61850 Analyzer version 5.27.04. This document has been issued for information purposes only, and the original paper copy of the KEMA report No. 74104881-MOC/INC 13-3099 will prevail.

The test has been carried out on one single specimen of the client system as referred above and submitted to KEMA by Smarter Grid Solutions. The manufacturer's production process has not been assessed. This attestation does not imply that KEMA has approved any product other than the specimen tested.

Arnhem, September 4th 2013

i/a S. Smulders

M. Adriaensen
Director Intelligent Networks & Communication

R. Schimmel
Certification Manager

KEMA Nederland B.V.
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International Usersgroup

Applicable Test Procedures from the UCA IUG Conformance Test Procedures for Client System with IEC 61850-8-1 interface, revision 1.1 with TPCL version 1.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	cAss1, cAss2, cAss3, cAss4, cAssN1, cAssN4, cAssN5, cAssN6	cAssN7 cSrv1, cSrv2, cSrv3, cSrv4, cSrv5, cSrv6, cSrv7, cSrvN3, cSrvN4, cSrvN5
2: Data Sets		cDs1, cDs2, cDs3, cDs5, cDsN2,
3: Substitution	cSub1	
5: Unbuffered Reporting	cRp3, cRp4, cRp5, cRp8, cRp9, cRp10, cRpN2, cRpN3, cRpN7, cRpN8	cRp1, cRp2, cRp6, cRp7, cRpN4
12a: Direct control	cCtl4, cCtlN1 cDOns1, cDOns2	cCtl1, cCtl3
12b: SBO control	cCtl4, cCtlN1 cSBOns1, cSBOns2, cSBOns3	cCtl1, cCtl3, cSBOns4
12c: Enhanced Direct Control	cCtl4, cCtlN1 cDOes1, cDOes2	cCtl1, cCtl3
12d: Enhanced SBO control	cCtl4, cCtlN1, cSBOes1, cSBOes2, cSBOes3	cCtl1, cCtl3 cSBOes4
13: Time sync	cTm1	

4085

IEC 61850 Certificate Level B [1]

No. 50745.6341.801

Issued by:
AREVA T&D UK LTD
Automation Products Laboratories

For the product:
Areva MiCOM P341
Generator Protection Relay
Software Version 70A
Hardware Version J

Issued to:
AREVA T&D UK LTD
St. Leonards Avenue
Stafford, ST17 4LX
United Kingdom

The product has not shown to be non-conforming to:

IEC 61850-7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations.

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and TISSUE implementation conformance statements: "MiCOM P341 Generator Protection Relay ver. 70A PICS and MICS", "MiCOM P34X Generator Protection Relay ver. 35A & 70A TICS" and extra information for testing "MiCOM P34X Generator Protection Relay ver. 35A & 70A PIXIT".
The following IEC 61850 conformance blocks are tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the UCA International Users Group Device Test Procedures version 2.2):

1	Basic Exchange (23/24)	12a	Direct Control (5/12)
2	Data Sets (3/6)	12b	SBO Control (8/16)
4	Setting Group Selection (2/3)	12c	Enhanced Direct Control (5/13)
5	Unbuffered Reports (14/18)	12d	Enhanced SBO Control (10/20)
6	Buffered Reports (16/20)	13	Time Synchronization (3/5)
9a	GOOSE Publish (9/11)	14	File Transfer (6/7)
9b	GOOSE Subscribe (9/10)		

AREVA T&D grants this Certificate on account of tests performed at the AREVA T&D's laboratories in Stafford, UK with UniCASim 61850 ver. 3.19.02 with test suite 3.19.00 simulating an IEC 61850 client and the UniCA 61850 analyzer version 4.18.01. The tests are based on the UCA International Users Group Device Test Procedures Version 2.2. This certificate has been issued for information purposes only and the original copy of the AREVA T&D report: No. 50745.6341.301 will prevail.

The tests have been carried out on one single specimen of the above mentioned product(s), submitted by AREVA T&D. The certificate does not include an assessment of the manufacturer's production process. This certificate is valid for the product specified only, which has been tested by Automation Products Laboratories at AREVA T&D.

Stafford, 18-12-2009

Ben Caunce
Automation Products Laboratories Director

Marcin Wycinka
Test Engineer

[1] Level B – Tester with ISO 9000 or ISO 17025 Quality System

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AREVA T&D UK Ltd., Substation Automation Solutions, St. Leonard's Avenue, Stafford ST17 4LX, England

4085

Applicable Test Procedures from the UCA International Users Group Device Test Procedures version 2.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	Ass1, Ass2, Ass3, AssN2, AssN3, AssN4, AssN5, Srv1, Srv2, Srv3, Srv4, Srv5, SrvN1abcd, SrvN4	AssN6, Srv6, Srv7, Srv8, Srv9, Srv10, SrvN1e, SrvN1f, SrvN3
2: Data Sets	Dset1, Dset10a, DsetN1ae	
4: Setting Group Selection	Sg1, SgN1a	
5: Unbuffered Reporting	Rp1, Rp2, Rp3, Rp4, Rp7, Rp10, RpN1, RpN2, RpN3, RpN4	Rp5, Rp8, RpN5, RpN6
6: Buffered Reporting	Br1, Br2, Br3, Br4, Br7, Br8, Br9, Br12, BrN1, BrN2, BrN3, BrN4, BrN5	Br5, Br10, BrN6
9a: GOOSE publish	Gop2, Gop3, Gop4, Gop7	Gop1, Gop5, Gop6, Gop9, GopN1
9b: GOOSE subscribe	Gos1a, Gos2, Gos3, GosN1, GosN2, GosN3, GosN4, GosN5, GosN6	
12a: Direct control	CtlN3, CtlN8, DOns1, DOns3	CtlN11
12b: SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, SBOns1, SBOns2	CtlN11
12c: Enhanced Direct control	CtlN3, CtlN8, DOes2, DOes5	CtlN11
12d: Enhanced SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, CtlN9, SBOes1, SBOes2, SBOes3	CtlN11
13: Time sync	Tm1, Tm2, TmN1	
14: File transfer	Ft1, Ft2ab, Ft4, FtN1ab	Ft2c, FtN1c

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AREVA T&D UK Ltd., Substation Automation Solutions, St. Leonard's Avenue, Stafford ST17 4LX, England

IEC 61850 Certificate Level A[1]

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No. 30920489-Consulting 10-0718

Issued to:
KALKI Communication Technologies Limited,
#147 & #148, 5th Main Road,
HSR Sector 7,
Bangalore 56 01 02, INDIA

For the product:
SYNC 2000
Protocol Gateway
IEC61850_V2.14.1

Issued by: KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and technical issue implementation conformance statements: "SYNC2000 – IEC61850 Server, Protocol Implementation Conformance Statement (PICS)", "SYNC2000 – IEC61850 Server, Model Implementation Conformance Statement (MICS)", "SYNC2000 – IEC61850 Server, IES61850 Tissues Conformance Statement (TICS)" and product's extra information for testing: "SYNC2000 – IEC61850 Server, Protocol Implementation Extra Information (PIXIT)".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the UCA International Users Group Device Test procedures v2.2):

1 Basic Exchange (19/24) 2+ Data Set Definition (26/29) 5 Unbuffered Reporting (13/18) 6 Buffered Reporting (15/20) 9a GOOSE Publish (5/12)	12a Direct Control (5/11) 12b SBO Control (7/15) 12c Enhanced Direct Control (5/13) 12d Enhanced SBO Control (10/19) 13 Time Synchronization (3/4)

This Certificate includes a summary of the test results as carried out at KEMA in the Netherlands with UniCAsim 61850 version 3.19.02 with test suite 3.19.02 and UniCA 61850 analyzer 4.20.04. The test is based on the UCA International Users Group Device Test Procedures version 2.2. This document has been issued for information purposes only, and the original paper copy of the KEMA report: No. 30920489-Consuling 10-0717 will prevail.

The test has been carried out on one single specimen of the products as referred above and submitted to KEMA by KALKITECH. The manufacturer's production process has not been assessed. This Certificate does not imply that KEMA has certified or approved any product other than the specimen tested.

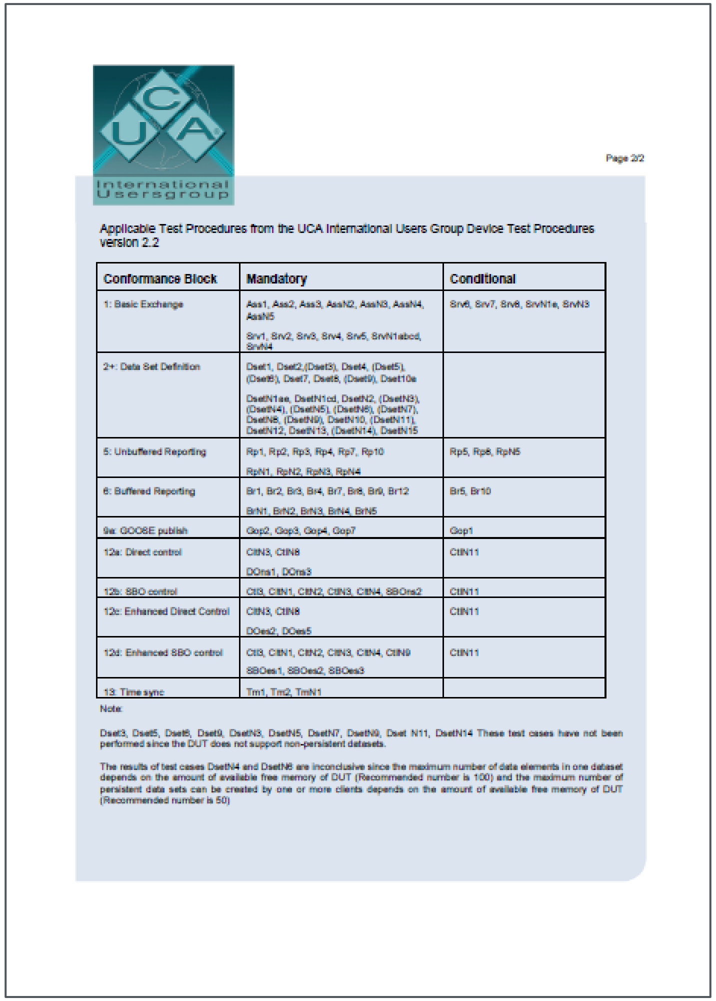
Arnhem, March 26, 2010

W. Strebbing
Manager Intelligent Networks and Communication

T. Xu
Test Engineer

1 Level A - Independent Test lab with certified ISO 9000 or ISO 17025 Quality System

KEMA Nederland B.V.
Utrechtseweg 310, 6812 AR Arnhem P.O.Box 9035, 6800 ET Arnhem The Netherlands
T +31 26 356 61 42 F +31 26 351 54 56 sales@kema.com www.kema.com



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Applicable Test Procedures from the UCA International Users Group Device Test Procedures version 2.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	Ass1, Ass2, Ass3, AssN2, AssN3, AssN4, AssN5 Srv1, Srv2, Srv3, Srv4, Srv5, SrvN1abcd, SrvN4	Srv6, Srv7, Srv8, SrvN1e, SrvN3
2+: Data Set Definition	Dset1, Dset2,(Dset3), Dset4, (Dset5), (Dset6), Dset7, Dset8, (Dset9), Dset10a DsetN1ae, DsetN1cd, DsetN2, (DsetN3), (DsetN4), (DsetN5), (DsetN6), (DsetN7), DsetN8, (DsetN9), DsetN10, (DsetN11), DsetN12, DsetN13, (DsetN14), DsetN15	
5: Unbuffered Reporting	Rp1, Rp2, Rp3, Rp4, Rp7, Rp10 RpN1, RpN2, RpN3, RpN4	Rp5, Rp8, RpN5
6: Buffered Reporting	Br1, Br2, Br3, Br4, Br7, Br8, Br9, Br12 BrN1, BrN2, BrN3, BrN4, BrN5	Br5, Br10
9a: GOOSE publish	Gop2, Gop3, Gop4, Gop7	Gop1
12a: Direct control	CtlN3, CtlN8 DOns1, DOns3	CtlN11
12b: SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, SBOns2	CtlN11
12c: Enhanced Direct Control	CtlN3, CtlN8 DOes2, DOes5	CtlN11
12d: Enhanced SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, CtlN9 SBOes1, SBOes2, SBOes3	CtlN11
13: Time sync	Tm1, Tm2, TmN1	

Note:

Dset3, Dset5, Dset6, Dset9, DsetN3, DsetN5, DsetN7, DsetN9, Dset N11, DsetN14 These test cases have not been performed since the DUT does not support non-persistent datasets.

The results of test cases DsetN4 and DsetN6 are inconclusive since the maximum number of data elements in one dataset depends on the amount of available free memory of DUT (Recommended number is 100) and the maximum number of persistent data sets can be created by one or more clients depends on the amount of available free memory of DUT (Recommended number is 50)

IEC 61850 Certificate Level A[1]

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No. 30920511-Consulting 10-0911

Issued to:
Remsdaq Ltd.
Parkway, Deeside Industrial Park
Deeside, Flintshire
CH5 2NL, United Kingdom

For the product:
Callisto™ Base Unit
IEC61850 Server v1.3.10

Issued by: KEMA

The product has not shown to be non-conforming to:

IEC 61850-6, 7-1, 7-2, 7-3, 7-4 and 8-1

Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 with product's protocol, model and technical issue implementation conformance statements and product's extra information for testing: "Callisto™ Implementation Conformance for IEC61850 Interface USR00410".

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases as defined in the UCA International Users Group Device Test procedures v2.2):

1	Basic Exchange (20/24)	9a	GOOSE Publish (6/12)
2	Data Set Definition (3/6)	12a	Direct Control (5/11)
2+	Data Set Definition (23/23)	12b	SBO Control (7/15)
5	Unbuffered Reporting (15/18)	12c	Enhanced Direct Control (5/13)
6	Buffered Reporting (17/20)	12d	Enhanced SBO Control (10/19)

This Certificate includes a summary of the test results as carried out at KEMA in the Netherlands with UniCAsim 61850 version 3.20.00 with test suite version 3.20.00 and UniCA 61850 Analyzer version 4.21.02. The test is based on the UCA International Users Group Device Test Procedures version 2.2. This document has been issued for information purposes only, and the original paper copy of the KEMA report: No. 30920511-Consulting 10-0910 will prevail.

The test has been carried out on one single specimen of the products as referred above and submitted to KEMA by Remsdaq Ltd. The manufacturer's production process has not been assessed. This Certificate does not imply that KEMA has certified or approved any product other than the specimen tested.

Arnhem, April 21, 2010

W. Strubing
Manager Intelligent Networks and Communication

T. Xu
Test Engineer

1 Level A - Independent Test lab with certified ISO 9000 or ISO 17025 Quality System

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Applicable Test Procedures from the UCA International Users Group Device Test Procedures version 2.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	Ass1, Ass2, Ass3, AssN2, AssN3, AssN4, AssN5 Srv1, Srv2, Srv3, Srv4, Srv5, SrvN1abcd, SrvN4	Srv6, Srv7, Srv8, SrvN1e, SrvN2, SrvN3
2: Data Sets	Dset1, Dset10a, DsetN1ae	
2+: Data Set Definition	Dset2, Dset3, Dset4, Dset5, Dset6, Dset7, Dset8, Dset9 DsetN1cd, DsetN2, DsetN3, DsetN4, DsetN5, DsetN6, DsetN7, DsetN8, DsetN9, DsetN10, DsetN11, DsetN12, DsetN13, DsetN14, DsetN15	
5: Unbuffered Reporting	Rp1, Rp2, Rp3, Rp4, Rp7, Rp10 RpN1, RpN2, RpN3, RpN4	Rp5, Rp6, Rp8, Rp9, RpN5
6: Buffered Reporting	Br1, Br2, Br3, Br4, Br7, Br8, Br9, Br12 BrN1, BrN2, BrN3, BrN4, BrN5	Br5, Br6, Br10, Br11
9a: GOOSE publish	Gop2, Gop3, Gop4, Gop7	Gop1, GopN1
12a: Direct control	CtlN3, CtlN8 DOns1, DOns3	CtlN11
12b: SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4 SBOns2	CtlN11
12c: Enhanced Direct Control	CtlN3, CtlN8 DOes2, DOes5	CtlN11
12d: Enhanced SBO control	Ctl3, CtlN1, CtlN2, CtlN3, CtlN4, CtlN9 SBOes1, SBOes2, SBOes3	CtlN11

Appendix 5: AV Scheme Commissioning Sheet

COMMISSIONING SHEET FOR NEW AVC SCHEME — QF_7_38_1 ISS 1 TX Test

SITE	March Grid S/S	DATE	27/08/2013	TRANSF. No.	T1
Job No.	F 8228				

TRANSFORMER DETAILS			
MVA (MAX)	45	DRIVE MECH TYPE	AEI M54E45
PRIMARY VOLTS	132kV	PRIMARY AMPS	197A
SECONDARY VOLTS	33kV	SECONDARY AMPS	787A
No. OF TAPS	19	VOLTS/TAP	1.67%
IMPEDANCE	12.30%	LDC RATIO	800/1
NOTES			

RTMU SER No.	RTMU SOFTWARE VERSION	n+ TAP COUNTER
F8228/1	T38A	

N+ SER No	N+ SOFTWARE VERSION	MECH TAP COUNTER
F8228/1	1.11	

It is recommended that the following tests should be carried out in the listed order as far possible.

TESTS TO BE CARRIED BEFORE CONNECTING ANY SUPPLIES

TICK WHEN DONE	ITEM No.	CHECKS TO BE CARRIED OUT	RESULTS / COMMENTS
✓	1.01	INSULATION TEST & VISUAL INSPECTION OF ALL CONNECTIONS	
✓	1.02	SET ALL BIT SWITCHES ON RTMU ACCORDING TO No. OF TAPS ETC.	SET TO BCD FOR EXTRA RESISTORS - N/A
✓	1.03	SET TAP CHANGE DRIVE MOTOR OVERLOAD IF APPLICABLE	SET @ 1.8A
✓	1.04	SET ANY TIMERS IF APPLICABLE - LIST IN BOX	TDT- 12 Secs SFT- 180 Secs
✓	1.05	ENERGISE TAP CHANGE SUPPLY, CHECK THAT TAP POSITION INDICATOR IS CORRECT NOTE: If Transformer is on load take precautions to prevent unwanted tapping at this stage i.e. leave motor supply circuit disconnected or switched off.	

X00000101.xls — 1 of 7

COMMISSIONING SHEET FOR NEW AVC SCHEME — QF_7_38_1 ISS 1 TX Test

TESTS TO BE CARRIED OUT WITH CT LINKED AND VT DISCONNECTED AND CONTROL VOLTAGE CONNECTED

TICK WHEN DONE	ITEM No.	CHECKS TO BE CARRIED OUT	RESULTS / COMMENTS
N/A	2.01	VCR BASIC VOLTAGE SETTINGS CALIBRATION Connect a variable ac power supply to the incoming VT Supply terminals of the AVC panel. It will be necessary to link one of the phases if only a single phase supply is available. Phase voltage must appear across terminals 21A and 21B of the RTMU to enable Blocking tests to be carried out. Connect an accurate voltmeter across the Test VT supply. NOTE: With a single phase VT test supply Bit switch 7 will temporarily need to be set to "disabled" (up) With the Basic voltage dial and Band dial set as required for the tests, vary the test VT Voltage until the high or low indicator just comes on. This is the value to be recorded in the table.	NOT APPLICABLE TO N+ TYPE RELAY
✓	2.02	SET RTMU HIGH & LOW LIMITS TO 100% POSITION ADJUST VOLTAGE UP & DOWN TO RECORD VALUE WHEN LIMIT INDICATOR COMES ON AND BLOCKING RELAY OPERATES (RELAY CAN BE HEARD) The HIGH limit LED comes on as the voltage is increased to the set point and the LOW limit LED comes on as the voltage is decreased to the set point.	
✓	2.03	SET RTMU HIGH OR LOW LIMIT BLOCKING ON - USE VARIABLE TEST VOLTAGE NOTE THE TIME TAKEN FOR THE ALARM LED TO LIGHT	RTMU ALARM TIME (MINS): 15
✓	2.04	WITH RTMU SWITCHED TO "MAN" CONFIRM THAT RAISE AND LOWER SWITCH SEND RAISE & LOWER SIGNALS TO MECHANISM CORRECTLY.	
✓	2.05	WITH RTMU SWITCHED TO "AUTO" USE THE VARIABLE TEST VOLTAGE TO CONFIRM THAT RAISE & LOWER OUTPUTS FROM VCR SEND RAISE & LOWER SIGNALS TO MECHANISM CORRECTLY	
✓	2.06	WITH RTMU SWITCHED TO "AUTO" USE THE VARIABLE TEST VOLTAGE TO CONFIRM THAT RAISE OUTPUT FROM VCR IS BLOCKED BY RTMU HIGH VOLTAGE LIMIT CONTACTS	
✓	2.07	WITH RTMU SWITCHED TO "AUTO" USE THE VARIABLE TEST VOLTAGE TO CONFIRM THAT LOWER OUTPUT FROM VCR IS BLOCKED BY RTMU LOW VOLTAGE LIMIT CONTACTS	
✓	2.08	CONFIRM OPERATION OF LOCAL REMOTE SWITCH, N+ RELAY DISPLAYING "MANUAL" AND ALL TAP CHANGE SIGNALS FROM THE REMOTE PANEL PREVENTED WHEN LOCAL CONTROL SWITCH IS IN "LOCAL" POSITION	
✓	2.09	OTHER TEST FOR PARTICULAR MECHANISMS Details in box	OPERATION OF TAP DURATION TIMER TO PREVENT RUNAWAY
	2.10	OTHER TEST FOR PARTICULAR MECHANISMS Details in box	N/A

Basic Voltage % Setting on VCR	BAND %	Display High	Display Low
100	1.0		
95	1.0		
105	1.0		

	INDICATOR ON	RELAY IN
HIGH LIMIT	110.3	107.43
LOW LIMIT	111.12	113.78

X00000101.xls — 2 of 7

UK Power Networks
Delivering your electricity

Appendix 6: FAT and SAT Acceptance Test Certificates

smarter grid solutions

ACCEPTANCE TEST CERTIFICATE

Contract Title : Flexible Plug and Play
Client : UK Power Networks
SGS Project : 200061

Completion of this form certifies that the FPP Production System has successfully completed Site Acceptance Testing subject to any attached reservations. Tests conducted in accordance to 200061 11C Acceptance Test Specification.

SGS	UKPN
Smarter Grid Solutions Ltd Glasgow Office Corunna House 39 Cadogan Street Glasgow G2 7AB	UK Power Networks 4th Floor Newington House 237 Southwark Bridge Road London SE1 6NP
Name: Finlay McNicol **Signature:** F McNicol **Position:** Smart Grid Engineer **Date:** 12/08/2013	**Name:** CERQUEIRA **Signature:** [illegible] **Position:** WS4 lead **Date:** 14/08/2013
Comments: SAT initiated at Nelson the 06/06/2013 and completed the 19/07/2013 by SGS. Evidence captured and recorded into the test document.	

 12/08/2013

smarter grid solutions

ACCEPTANCE TEST CERTIFICATE

Contract Title : FPP
Client : UK Power Networks
SGS Project : 200061

Completion of this form certifies that the FPP Production System has successfully completed Factory Acceptance Testing subject to any attached reservations. Tests conducted in accordance to 200061 11C Acceptance Test Specification.

SGS	UKPN
Smarter Grid Solutions Ltd Glasgow Office Corunna House 39 Cadogan Street Glasgow G2 7AB	UK Power Networks 4th Floor Newington House 237 Southwark Bridge Road London SE1 6NP
Name: Finlay McNicol **Signature:** F McNicol **Position:** Smart Grid Engineer **Date:** 12/08/2013	**Name:** CERQUEIRA **Signature:** WS4 lead. **Position:** [illegible] **Date:** 14/08/2013
Comments: The FAT has been started the 27th of March (with UKPN) and SGS finally completed them in May as the records demonstrate it.	

 12/08/2013

Appendix 7: DLR FARCET 1B TEST REPORT

Page 1:

DLR UKPNS	ALSTOM

	DLR Test Report	Substation : FARCET 1B Feeder Ref: Peter Cent/Farcet 1-3C01C

RELAY INFORMATION

Type No. :	P341 / M871	Designation :	DLR
Model No :	P34123AG6M0700J	Model No	M871
Serial Number :	585930	Serial Number	918564
Firmware Version :	700C	Firmware Version	M871 64MB 04.12.0

1. Communication Settings:

P341	10.247.0.133
M871	10.247.0.134
GATEWAY	10.247.0.129
SNTP	10.247.0.130
SUBNET MASK	255.255.255.224

Page 8:

DLR UKPNS	ALSTOM

	DLR Test Report	Substation : FARCET 1B Feeder Ref: Peter Cent/Farcet 1-3C01C

Remarks:

END OF REPORT

ALSTOM GRID		Customer	
Signature	M A	Signature	
Name	MOHAMMED ASLAM	Name	
Date	09/9/13	Date	

P341 SETTINGS.

SYSTEM DATA

00.01	Language	English
00.02	Password	****
00.03	Sys Fn Links	0
00.04	Description	MiCOM P341
00.05	Plant Reference	FARCET 1B
00.06	Model Number	P34123AG6M0700J

Appendix 8: Relay Test Report for Substation MARCH GRID / Feeder GT2

Page 1:

DNPS UKPNS	ALSTOM

P142	Relay Test Report	Substation : MARCH GRID Feeder Ref: GT2

RELAY INFORMATION

Type No. :	P142	Designation :	DOC
Model No :	P14221AA6M0460J	Nominal Current :	1/5 A
Serial Number :	32461262/02/13	Nominal Voltage :	100-120
Firmware Version :	P142-1A-460-A	Aux. Volts :	48-110 VDC
Dc volts	122.5V	Field Volts	NA

1. CT DATA

CT rated primary current set as	800:1
CT rated secondary current set as	800:1
Ignd-CT rated primary current set as	NA
Ignd-CT rated secondary current set as	NA

2. MEASURMENT VALUE TEST:

3.1. Current Measurement

Phase injected	Current injected (Amps)	Current read on relay display (A)			
	PH-N	IR	IY	IB	IN Derived
L1-N	1A	799.2A	0A	0A	799.3A
L2-N	1A	0A	799.3A	0A	799.3A
L3-N	1A	0A	0A	799.10A	799.3A
L1-L2-L3	1A	799.5A	799.7A	799.10A	0A

3.2. Voltage Measurement

Phase injected	Voltage applied (Volts)	Primary Voltage read on relay display in kV						
	PH-N	VR	VY	VB	V_RY	V_YB	V_BR	VN
L1-E	63.5	19.04KV	0	0	-	-	-	-
L2-E	63.5	0	19.04KV	0	-	-	-	-
L3-E	63.5	0	0	19.04KV	-	-	-	-
L1-L2-L3	63.5	19.04KV	19.04KV	19.04KV	32.98KV	32.98KV	32.98KV	-

Page 5:

DNPS UKPNS	ALSTOM

P142	Relay Test Report	Substation : MARCH GRID Feeder Ref: GT2

6. LED Indications Test:

LED No.	LED Label	Color	Result
1	DOC TRIP	Red	OK
2	E/F		NOT USED
3	NPS	Red	OK
4	VCO	Red	OK
5	DOC BLOCKED	Red	OK
6			
7			
8			

Remarks:

The new alarms X210V2A,X210V2B,X210V2C , were proven upto scada wallbox. The existing alarm X6V1 was proven upto annuciator panel. The VT and CT's circuits were proven from the furthest undisturbed point within panel. With CB open the block to GT1 circuit was proven and the Trip to LAKESEND circuit was Checked. Lakesend CB was tripped via GT1 CB open initiation. GT1 CB was also tripped via protection.

END OF REPORT

ALSTOM GRID		Customer	
Signature		Signature	
Name	MOHAMMED ASLAM	Name	
Date	22/8/13	Date	

Appendix 9: Key Project Documents

Below are the key project documents that can be supplied upon request.

Workstream	Document Description
DA	P.0209.Short Term Security Actions Scope
DA	P.0213.Substation LAN design
DA	P.0248.Overall Project Schematic
DA	P.0250.Scope of Work WS8 testing and system integration
DA	P.0269.Scope of Work WS8 substation LAN installation
DA	P.0282.IEC 61850 Test Tool Selection report
DA	P.0283.IEC 61850 Data model and Engineering Tool Selection report
DA	P.0311.Quadrature-booster Trial Design
DA	P.0312.Active Network Management & Generator Control Trial Design
DA	P.0313.Dynamic Line Rating Trial Design
DA	P.0314.Communications Platform Trial Design
DA	P.0315.Modern Protection Relay Trial Design
DA	P.0316.Automatic Voltage Control Trial Design
DA	P.0317.System Integration Trial Design
DA	P.0379.Quadrature-booster Trial Schedule
DA	P.0380.Quadrature-booster Trial Report
DA	P.0381.Dynamic Line Rating Trial Schedule
DA	P.0382.Dynamic Line Rating Trial Report
DA	P.0383.Novel Protection Relay Trial Schedule
DA	P.0384.Novel Protection Relay Trial Report
DA	P.0385.Automatic Voltage Control Trial Schedule
DA	P.0386.Automatic Voltage Control Trial Report
DA	P.0170.Transient Stability Studies - Wissington Site
DA	P.0151.Design Process
DA	P.0217.Directional Negative Phase Sequence (DNPS) protection study
DA	P.0202.High level Test Approach
DA	P.0213.Substation LAN design
WS1	P.0190.End-to-End Acceptance Test Report v6
WS1	P.0205.EnhancedFieldNetworkDesignv1.6
WS1	P.0207.Work Method Statement Silver Spring eBridge Installation v1.0
WS1	P.0208.Work Method Statement Silver Spring Access Point Installation in Substation v1.0
WS1	P.0214.InitialLogicalReferenceDesignv1.3
WS1	P.0230.Work Method Statement Silver Spring Relay Installation v1.0
WS1	P.0260.RF Mesh and IEC 61850 Sub-Set Acceptance Tests Report v2
WS1	P.0265.Work Method Statement Silver Spring eBridge Installation Wissington BSC v1.0
WS1	P.0259.Work Method Statement Silver Spring Relay Decommission v1.0
WS1	P.0157.High Level Design
WS1	P0158.Field_Network_Design_Option3
WS1	P0199.New Cabinets_ Power Supply
WS1	P0191.Master IP Addressing
WS1	P.0152.Results of LV Pole Site Surveys
WS1	P.0076.IEC 61850 Lab test report
WS1	P.0190.Success Measurement Methodology UK
WS2	P.0102.Factory acceptance test for the Quadrature-booster control system
WS2	P.0150.Dynamic Line Rating Design Deployment Brief

Workstream	Document Description
WS2	P.0218.Quadrature-booster control system scheme design drawings
WS2	P.0219.Reverse power flow control drawings
WS2	P.0220.Dynamic Line Rating control drawings
WS2	P.0251.Factory acceptance test for Quadrature-booster
WS2	P.0252.Modern Protection Relays a Solution for Reverse Power Flows Design Deployment Brief v1
WS2	P.0263.Modern Protection Relay Functional Design Specification
WS2	P.0264.Quadrature-booster control system production specification (February 2013)
WS2	P.0270.Dynamic Line Rating Factory acceptance test results
WS2	P.0271.Dynamic Line Rating Protection programmable scheme logic and settings files
WS2	P.0272.Protection programmable scheme logic and settings files
WS2	P.0275.Quadrature-booster engineering operating standard
WS2	P.0276.Quadrature-booster control system engineering operating standard
WS2	P.0278.Dynamic Ratings C50 presentation, technical spec and control unit
WS2	P.0279.Protection programmable scheme logic and settings files
WS2	P.0102.Factory acceptance test for the Quadrature-booster control system
WS2	P.0150.Dynamic Line Rating Design Deployment Brief
WS2	P.0218.Quadrature-booster control system scheme design drawings
WS2	P.0219.Reverse power flow control drawings
WS2	P.0220.Dynamic Line Rating control drawings
WS2	P.0251.Factory acceptance test for Quadrature-booster
WS2	P.0252.Modern Protection Relays a Solution for Reverse Power Flows Design Deployment Brief v1
WS2	P.0263.Modern Protection Relay Functional Design Specification
WS2	P.0264.Quadrature-booster control system production specification (February 2013)
WS2	P.0270.Dynamic Line Rating Factory acceptance test results
WS2	P.0271.Dynamic Line Rating Protection programmable scheme logic and settings files
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WS2	P.0275.Quadrature-booster engineering operating standard
WS2	P.0276.Quadrature-booster control system engineering operating standard
WS2	P.0279.Protection programmable scheme logic and settings files
WS2	P.0374.AVC.11kV Voltage control algorithm
WS2	P.0372.AVC.11kV Voltage control offline test schedule and validation tool
WS2	P.0376.Dynamic Line Rating calculation tool
WS2	P.0375.AVC.33kV Voltage control algorithm
WS2	P.0373.AVC.33kV Voltage control offline test schedule and validation tool
WS2	P.0377.Dynamic Line Rating Assurance report
WS2	P.0378.EOS 09-0070 Dynamic Line Rating Monitoring Equipment on 33kV Distribution Lines
WS2	P.0149.Frequent Use Switch Design & Deployment Brief
WS2	P.0150.Dynamic Line RatingDesign & Deployment Brief
WS2	P.0172.Quadrature-booster Planning Report
WS2	P.0198.WilsonQuadrature-boosterRatingName Plate Drawing
WS2	P.0201.WilsonQuadrature-booster_Control Drawings
WS3	P.0271.Connection Agreement template
WS3	P.0291.Connection Agreement Template Capacity Quota
WS3	P.0361.Comparative curtailment analysis of LIFO vs Pro-Rata
WS3	P.0211.Wilson Quadrature-booster TAP Control Drawings
WS3	P.0215.International Experience Report
WS3	P.0216.Commercial Arrangements_POA
WS3	P.0217.Connections Agreement Template
WS4	P.0130.Active Network Management system Acceptance Test Specification
WS4	P.0202. Active Network Management system Functional Design Specification

Workstream	Document Description
WS4	P.0130.Active Network Management Acceptance Test Specification and Results
WS4	P.0202.Functional Design Specification ANM
WS4	P0397.System Integration Test Plan
WS4	P0399.Integration Test Specification
WS4	P0398.Pre-Production FAT & Test Results
WS5	P.0180.Stakeholder Engagement Report 1 UK Power Networks
WS6	P0184.Strategic Investment Model Scope of works.v1.0
WS6	P.0249.Strategic Investment Model Requirements Document
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WS7	P.0004.TechCon 2013 – full paper/presentation – Quadrature-booster
WS7	P.0302.Smart Grid Mission to Canada – full paper/presentation
WS7	P.0350.Flexible Plug and Play: A Guide to the Quad-booster
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WS8	P.0146.Dynamic Line Rating integration Tests Report
WS8	P.0261.Functional Design Specification_T5500 RTU IEC 61850 Server
WS8	P.0226.Functional Design Specification for IEC 61850 implementation into the RTU
WS8	P.0142.Flexible Plug and Play Test Specification
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WS8	P.0188.IEC 61850 Scope of Work
WS8	P0338.ANM Client Certification
WS8	P0339.SGS Connect Certification
WS8	P0340.GE RTU T5500 Certification
WS8	P0341.Kalkitech SYNC2000 Certification (Communication interface for the SuperTAPP n+)
WS8	P0342.MR TAPCOM260 Certification (QBCS)
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