



Visualisation of Real Time System Dynamics using Enhanced Monitoring (VISOR)

[Public]

Project Progress Report July 2014 – December 2014

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Executive Summary

ScottishPower Transmission Ltd (SPTL), supported by other transmission licensees and the academic partner, made a full proposal submission for Visualisation of Real Time System Dynamics with Enhanced Monitoring (VISOR), under the Network Innovation Competition (NIC) mechanism in 2013, the first year of RIIO-T1 transmission price review period. Ofgem (the Office of Gas and Electricity Markets) approved the proposal and issued the Project Direction on the 19th of December 2013, which forms part of the electricity transmission license as per the Special Condition 31.

This report covers the second six months of the project delivery (July - Dec 2014). It fulfils the Project Reporting obligation for SPTL as the funding licensee.

Project Highlights

The project delivery so far is in line with the original proposal regarding project programme, resources, budget, risk management, intellectual property rights (IPR) and knowledge sharing. The project has made significant achievements by the following activities:

- ✓ Concluded the full procurement activity and contracted Alstom Grid as the supplier (led through Edinburgh-based Psymetrix – an Alstom Company): 31-July -2014
- ✓ Total 4xVISOR servers (including one VISOR Data Hub for GBSO) have been procured & received: 14-Nov-2014.
- ✓ SP & NG server hardware has been installed
- ✓ VISOR server software – Psymetrix PhasorPoint – FAT (factory acceptance test) completed and Training delivered: 14-16th Oct 2014
- ✓ Total 10x WMUs (“Waveform Measurement Units” or ‘SSO outstation devices’) for detection of Sub-Synchronous Oscillations (SSO) have been manufactured and received by each TO partner: 6-Nov-2014
- ✓ FAT (factory acceptance test) and technical evaluation were completed: 28-Nov-2014
- ✓ SSO outstation device installation onto SPT network: 15-December-2014
- ✓ Further outstation device installations scheduled for NG on 8th January 2015

Over this reporting period, VISOR has met three more specific conditions outlined in the Successful Delivery Reward Criteria (SDRC):

9.1.1 in the Project Direction: by making the SSO Outstation Device qualification report available in December

9.6.1 in the Project Direction: Establish an online portal and keep up to date throughout project (WP5.2, Sept 2014)

9.6.1 in the Project Direction: Presentations and show-casing at the annual innovation conferences (WP 5.4, Dec 2014)

Project Risks

The most significant project management risk during this reporting period was commitment, coordination and communication between each project partner. This risk was identified in the

original proposal, and covers the potential inconsistent understanding of the project scope, level of commitment and the potential difference in the internal governances among partner organisations. This risk is still obvious and can be referenced in every stage of the development over the past twelve months: the latest evidence is the installation of servers and outstation devices. Both National Grid and ScottishPower have installed the server, and identified appropriate network outages to install SSO outstation devices onto their transmission network before the commissioning of the Series Compensation reinforcement. SHE Transmission are planning to install the WAMS server in February 2015, approximately eight weeks behind NG TO and SO and SHE Transmission's infrastructure requirements, physical location and data sources have been agreed. Such an imbalance of delivery pace poses the risk of meeting one specific SDRC:

Visualisation of data in SPT, NGET, SHE Transmission including real-time and historic (WP 4A, Dec 2015)

In that case, pro-active engagement activities have been planned including a dedicated visit to that individual organisation on 18-December. The Project Manager will continue to monitor this risk and update the Project Steering Committee regularly.

The most challenging technical risk over the past six months has been the development and production of a fit for purpose device for monitoring Sub-Synchronous Oscillations. This device, the Waveform Measurement Unit (WMU) is to cover the wide range of frequency (4 Hz to 46 Hz), production of such a device requires expertise in power system as well as information communication technology. This device has been provided by Reason, an Alstom Grid company based in Brazil due to technical consideration. Such an approach came with risks including different industrial standards and potential delays in shipping. Mitigation measures were put in place by Alstom Grid and the project team to ensure that project milestones would not have been comprised even under those scenarios. Those measures included an early shipment of one sample device and the advancement/adjustment of project programme. All the 10 WMUs arrived in the UK on 6-November, and the factory acceptance test was completed on 28-November; such a timely and satisfactory result safeguarding future delivery could not have been achieved without the vision and strong support from Psymetrix, Alstom Grid.

In addition, there are risks in the interfaces between project partners and the same supplier, as this will involve different legal and commercial approaches by individual organisations. The details of Risk Management including Technical Risk and Project Management Risk can be found in a dedicated section on page 13.

Summary of Learning Outcomes

From the technical view point, the past six months witnessed most significant activity, where VLF (very low frequency) and SSO application specifications were approved and the outstation device and Server Software FATs were completed. Those specification documents would inform the industry and help plan the future roll out.

The first deployment of WMUs on the GB transmission network will be completed at transmission substations of Eccles (within SPT area) and Hutton (within National Grid). The key risks will be the timescale of completed deployment of the all monitoring devices and the successful data transfer. Important technical learning in device, network modelling and information communication

technology are ongoing within such a complicated project. Such learning forms part of the VISOR contribution to the industry.

Regarding project management, the key learning is to ensure that all risks can be identified in the early stage with clear ownership and specific mitigation measures. The mitigation actions for these risks should be built into the project plan and tracked like any other project milestone. The evolving nature and the interactions between technical and management challenges require regular review (weekly rather than monthly) over the past six months.

The knowledge sharing and effective engagement with stakeholders can be found in our presentation at the Low Carbon Network Innovation Conference in Aberdeen in October 2014.

Project Manager's Report

This report covers VISOR project the key activities, milestones, risks and knowledge learned over the past six months (July-December, 2014).

VISOR is on course for a satisfactory delivery over this reporting period regarding the project programme over the past six months. The most significant achievement during this reporting period is:

- ✓ First SSO outstation device installation onto GB network: December-2014

To achieve such a milestone, the following key pre condition elements had been completed:

- ✓ Concluded the full procurement activity and contracted Alstom Grid as the supplier: 31-July - 2014
- ✓ Total ten SSO outstation devices have been manufactured and received by each TO partner: 6-Nov-2014
- ✓ 200 Hz IEEE C37.118 Stream Processing specification approved
- ✓ SSO outstation device FAT (factory acceptance test) and technical evaluation were completed: 28-Nov-2014
- ✓ SSO outstation device Training delivered: 19th Nov 2014

Other achievements include:

- ✓ Total four VISOR servers (including one VISOR Data Hub for GBSO) have been procured and received 14-Nov-2014
- ✓ VISOR server software – Psymetrix PhasorPoint – FAT (factory acceptance test) completed and Training delivered: 14-16th Oct 2014
- ✓ Very Low Frequency (VLF) Oscillation Management Application specification approved
- ✓ Sub-Synchronous Oscillation (SSO) Management Application specification approved

In addition to the positive technical contributions named above, two elements set out in SDRC were completed, including a dedicated online portal for VISOR and the active participation of Low Carbon Innovation Conference in Aberdeen. Both were associated with knowledge sharing and knowledge transfer (as explained in the later SDRC section).

Application Specification:

VLF (Very Low Frequency) Oscillation Management

Common mode oscillations usually have a frequency under 0.16Hz. These oscillations can be seen in the grid frequency across the whole system with approximately the same amplitude and phase.

The Very Low Frequency (VLF) application analyses PMU measurements in order to provide real-time alarming on, and also identify sources of, common mode oscillations in the range 0.002 – 0.16Hz. From this information, the user can identify a course of action to resolve the issue, either as a short-term operational response by generation re-dispatch, or by longer-term governor tuning.

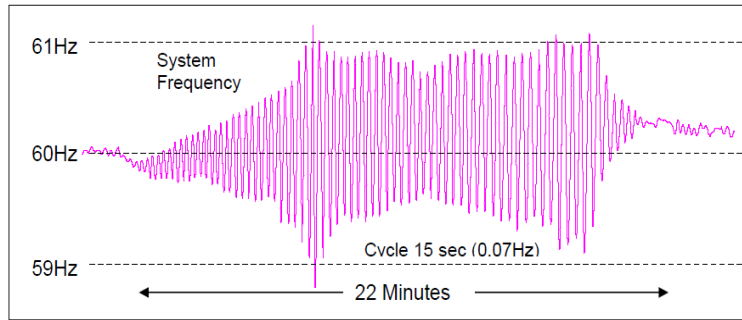


Figure 1. Sample of VLF at South American Transmission Network (Psymetrix/Alstom Grid)

Source location is done in two steps:

1. Voltage angle measurements are used to find the substation or region which is the closest to the main sources of oscillations. The minimum requirement for this step is a small number of PMUs covering the main regions of the network.
2. Power measurements are used to differentiate between buses which are very close, or to differentiate between generators connected to the same bus.

The second step is optional and is only done if power measurements are available at the location identified by the first step. This can be particularly useful in governor and system tests.

Specifications to Enable the Detection of Sub-Synchronous Oscillations

Conventional WAMS (Wide Area Monitoring Systems) use phasor data to provide visibility of the fast dynamic behaviour of the power system which allows for more precise and faster system stability analysis and detection of developing problems before they become a failure.

A traditional Phasor Measurement Unit (PMU)-based WAMS utilises phasor data at 50Hz to provide visibility of dynamic behaviour up to 4-10 Hz. The SSO Outstations deployed as part of VISOR provide waveform samples at 200Hz. This extends visibility of dynamic behaviour up to 46Hz, facilitating the detection of Sub-Synchronous Oscillations. By the end of 2014, the following specifications to enable the detection of SSO have been approved:

Enhancement Specification: 200Hz IEEE C37.118 stream processing

Application Specification: Sub-Synchronous Oscillations

200Hz IEEE C37.118 Stream Processing

It should be noted that as this data contains waveform samples rather than phasors (magnitude & angle), its usefulness in other WAMS applications such as live data charts, alarms and other displays is minimal. Hence, the functionality focuses on:

- Receiving the data via IEEE C37.118-2005
- Forwarding the data to other PDCs via IEEE C37.118-2005
- Storing the data
- Retrieving the data for historical review
- Debugging – e.g. connection, data quality, or data availability issues

SSO Outstation Device Production, Shipment and FAT

The supply contract with Alstom Grid-Psymetrix completed negotiation by the end of July. This left four months for the manufacture of the Waveform Measurement Units (WMUs) and development of the required firmware enhancements. This activity was performed by Reason, an Alstom Grid company based in Brazil. Project partners worked closely with Psymetrix & Reason to ensure the risks associated with the production, shipping and deployment could be captured and mitigated. The measures included the mapping exercise of industrial standards this device needed to satisfy so that it could be accepted to be installed onto GB transmission network. Original project plan designed three shipments, which was combined into one cohort to reduce the shipping time.

Factory Acceptance Tests (FAT) is an effective measure to reveal potential technical issues. FAT procedures had been prepared for this newly developed device and approved by the Project Delivery Team (PDT) prior to FAT being carried out in Edinburgh. FAT covered a relevant subset of the WMU functionality, in particular the streaming of 200Hz data. The FAT involved replaying waveform signals through the SSO Outstation and recording the output of the SSO Outstation, and included:

Tests to validate the frequency response bandwidth that was proposed

- 50Hz waveform with a modulated amplitude, with selected modulating frequencies in the range 1 to 46Hz
- 50Hz waveform with an added frequency component with selected frequencies in the range 1 to 200Hz
- Tests to prove rejection of higher frequency harmonics

The FAT set-up included a single SSO outstation, waveform generation facilities e.g. an Omicron Test Set, and means to observe data output via the IEEE C37.118 protocol.

Project partners witnessed and approved the SSO outstation FAT on 28-November, with no major or critical issues having been observed.

Waveform Measurement Unit and Server Installation

A total of ten “Waveform Measurement Units” (WMUs - SSO outstation devices) have been procured under VISOR. Apart from the one unit sent to the University of Manchester to facilitate hardware-in-the loop test (which will monitor the enduring performances of the unit with simulated network signals), all other nine devices would have been installed onto the GB transmission network by the end of 2015. The proposed locations can be found in Table 1.

#	VISOR Partner	Locations (circuits) - tbc	Status
4	Scottish Power	Eccles (Stella West 2) Torness (Eccles 2) Hunterston (Inverkip 2, to be Strathaven) Coylton (Auchencrosh)	Eccles scheduled for 14-15 th Dec 2014, Others tbc
2	National Grid	Hutton 1 & 2	Scheduled 8 th Jan 2015
2	Scottish Hydro Electric	Peterhead, Blackhillock	Tbc
1	University of	Manchester	Received by University of

	Manchester		Manchester 19 th Nov
1	Spare	To be confirmed during course of project.	Ready to be shipped to appropriate VISOR Partner.

Table 1. Proposed WMU outstation device locations and status

Those outstation devices will then transfer the data to a local data centre (installed at each TO control centre) before going to a national VISOR hub (installed at the GBSO control centre).

#	Description	Responsible VISOR Partner	Location	Status
1	Data Centre	Scottish Power	Kirkintilloch	Hardware installation complete. Networking and VPN estimated Jan 2015
1	Data Centre	Scottish Hydro Electric	Perth	Server procured & received. Estimate installation Feb-Mar 2015
1	Data Centre	National Grid (TO)	Wokingham	Hardware installation complete. Networking and VPN estimated Jan 2015
1	Data Hub	National Grid (SO)	Wokingham	
1	Study Platform <i>Software only</i>	University of Manchester	Manchester	University of Manchester server procurement under way

Table 2. Location & status of VISOR data centres

Knowledge Sharing and Stakeholder Engagement

The VISOR Team has a strong commitment in knowledge sharing and effective stakeholder engagement. This is to ensure that VISOR can adopt the latest technology advancements, share the lessons learned by/with other stakeholders, facilitate new entry to the market and disseminate the key learning captured along the VISOR delivery.

The following are meeting/events that the project team have organised or been part of during the reporting period:

- CIGRE: Biannual meeting, August, Paris; where Douglas Wilson, Chief Scientist at Alstom Grid-Psymetrix presented the technical findings of SSO outstation device (200Hz specifications) to a dedicated working group
- Interactions and engagement with OFTO and Offshore Renewable Developers – 11th September, Glasgow
- Hub Net Engagement, Manchester, 14th, Oct
- Low Carbon Network Innovation Conference, Aberdeen, 20-22nd, Oct
- Engagement with EPRI, Cumbernauld, Scotland, 4th November, where software development information was exchanged
- Top Tail Engagement, Southampton, 17-18th Nov

Outlook to the Next Reporting Period

The project has been focused on the software enhancement specifications and hardware development over the past six months and will hopefully complete the hardware installation (including outstation devices, data hubs and communication links) within the coming six months. Those WMUs in SPT and NGET area should have been commissioned before the series compensation commissioning (currently scheduled for completion summer 2015) so that network performance can be baselined by using data captured from the current network configuration. This performance baseline will be delivered as part of a System Behaviour Report & workshop to be provided in early 2015.

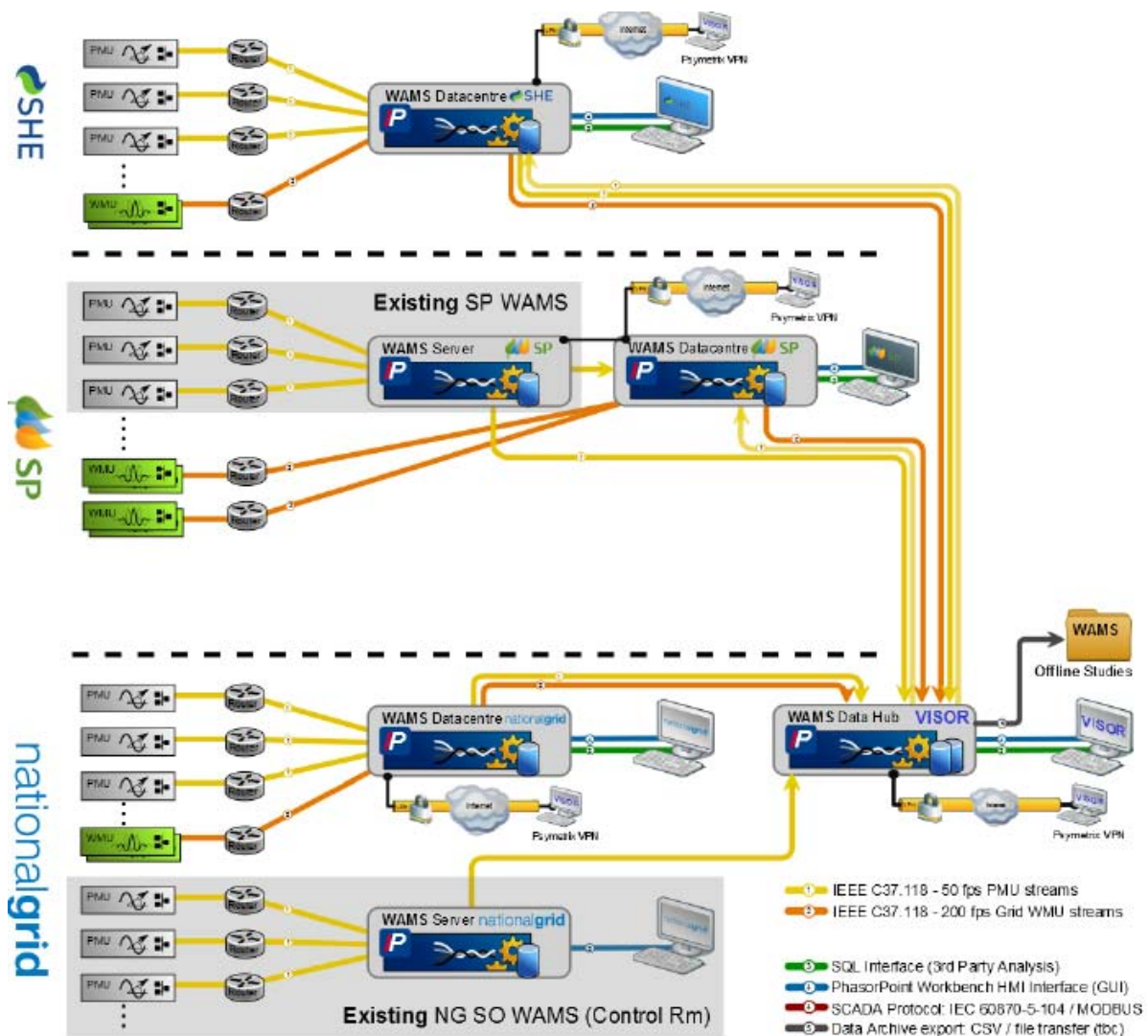


Figure 2. VISOR Infrastructure Configuration

IT and communication experts from the GBSO are working on the communication infrastructure between three TO and the GBSO. Those WMUs, data hubs and the communications associated form the VISOR supporting infrastructure, which would capture, transfer and store the data from the transmission network. It should be noted that there are both technical risks and project management risks associated with this task in that:

1. The outstation device and data hub need to pass the site acceptance test at system level before formally commissioning;
2. The installation resources are limited and the appropriate network outage needs to be coordinated- it is possible that some of the sites named in Table 1 might change subject to the availability of those conditions.

It is envisaged that enhanced functions can then be installed, updated and loaded to the data hub remotely. In that case, there is one specific delivery over the next reporting period set out in SDRC:

9.3.1

Report on PMU based line parameter estimation and variability (WP 2.1, March 2015)

This period will see further engagement activities with stakeholders and knowledge sharing, namely:

- Interactions with other NIC projects following the latest Ofgem decision, Jan 2015
- ENTSO-E Horizon 2020 Proposal Contribution, March 2015

Consistency with full submission

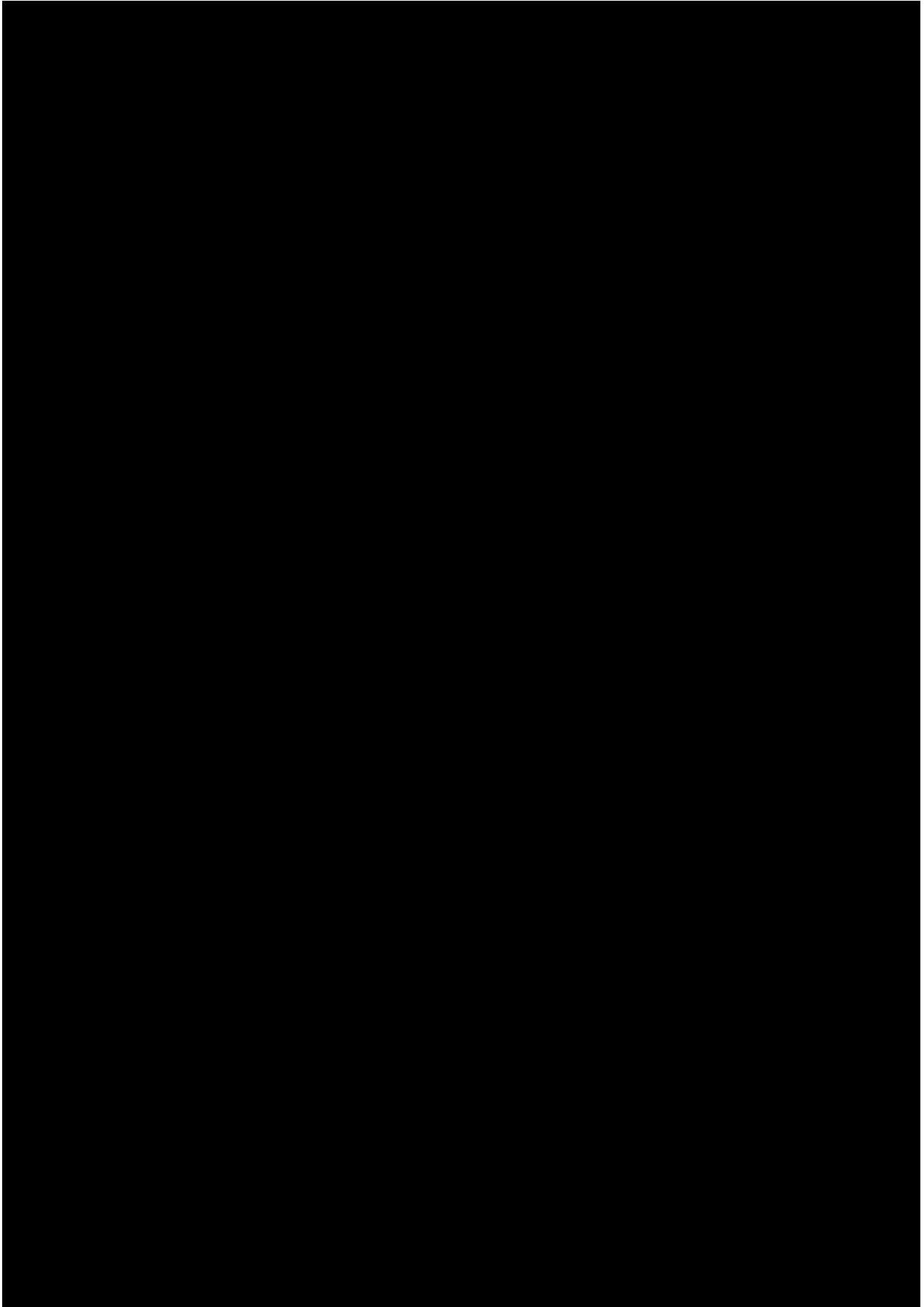
Twelve months into the project delivery, VISOR has been consistent with the original full submission with regards to resources allocation, project management and project programme.

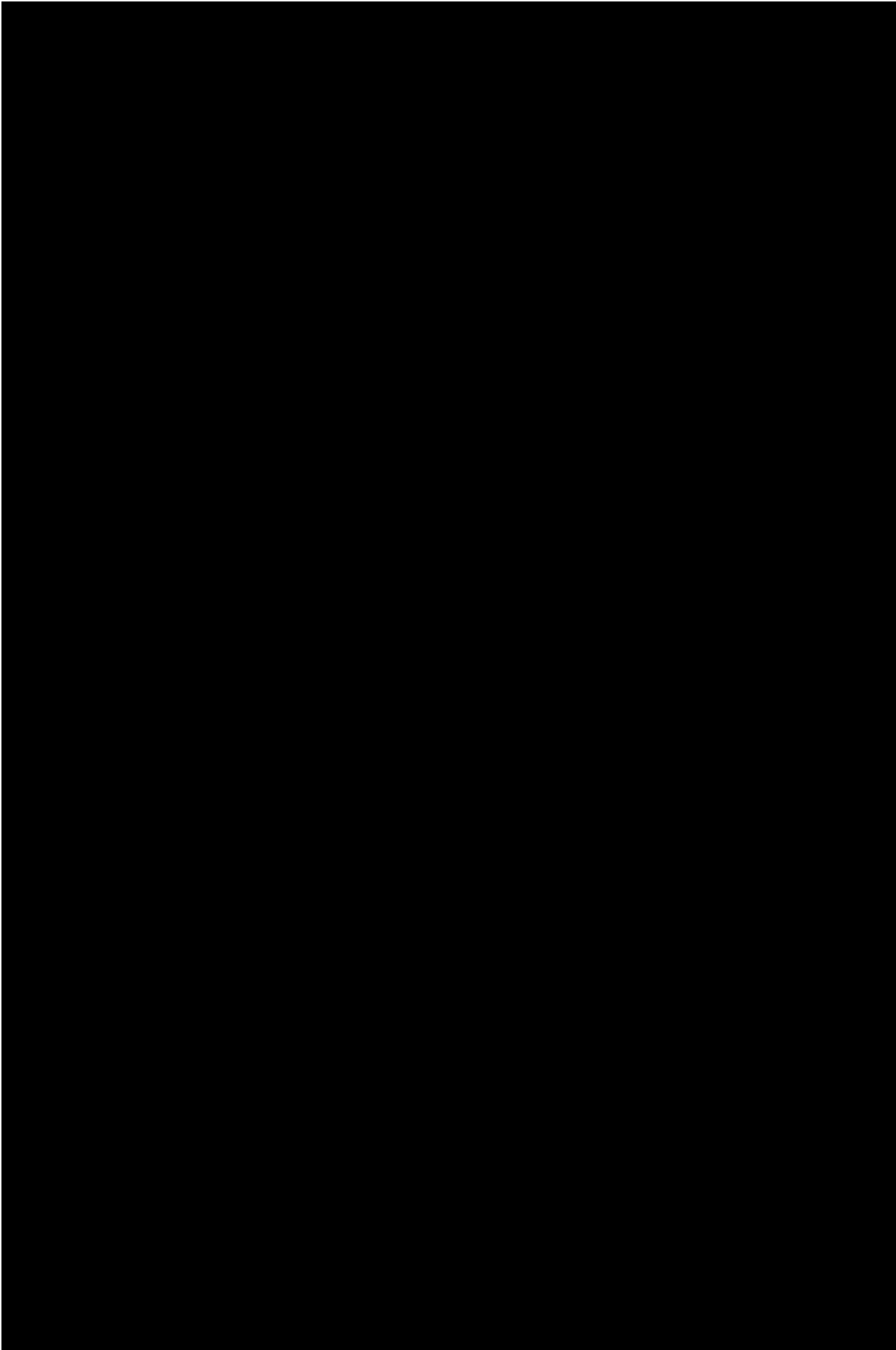
It has been recognised that there was one month delay in completing the procurement activity: the procurement contract was not finalised until the end of July while the original project programme within the full submission estimated the end of June. This was due to the complexity of interface between individual project partners with a single supplier.

Such a delay could have knock on effects in the project delivery. However, this risk was mitigated by effective communications between the project team and the supplier. The project team informed the preferable supplier in May and dedicated legal and procurement resources were allocated to safeguard the legal agreement conclusion. Psymetrix, Alstom Grid recognised the importance of this project. They made necessary arrangements of resources allocation and technical development so that the delay was minimised and the overall project programme is still on course.

These consistencies demonstrate the level of detail of the original submission, robust project management currently in place and set a solid foundation for the future delivery.

Risk Management (Confidential)





Successful Delivery Reward Criteria (SDRC)

The Successful Delivery Reward Criteria set out in the Project Direction links with the Project Milestone and the identified targets directly. This SDRC can be used to check the progress of the project delivery and position the progress against the original proposal.

One element of SDRC associated with this reporting period, based on the target dates, is

9.1.1. SSO Device qualification report (WP 4C, Dec 2014)

This criteria is used to measure whether VISOR can develop a novel product which will fulfil the planned technical requirements in time. The targeted date is linked with existing project plan for series compensation reinforcement (which is summer, 2015) so that the device can be ready to capture the existing network data and baseline the performance. To enable this delivery, quite a few elements have to be completed including:

- Hardware Development: the device which can capture the data (waveform) in a much higher frequency
- Hardware/Software Interface: Software development to be able to accommodate the data captured and provide enhanced frequency coverage.

In addition to the developments named above, factory acceptance test has to be completed on the SSO outstation device. This element was met after TO partners approved the FAT and the SSO qualification report was issued on 04-December.

Two more elements in the SDRC have been met during this reporting period, both of which are associated with knowledge sharing:

9.6.1. Establish an online portal and keep up to date throughout project (WP 5.2, Sep 2014)

A dedicated website has been set up to raise the awareness of the project and to facilitate effective knowledge sharing in a transparent and timely manner. The website is:

<http://visor-project.org.uk/index.html>

This website is the communication window with any interested party and managed by the University of Manchester on behalf of the Project Delivery Team. Any information published on the website will have been approved by the PDT members.

9.6.1. Presentations and show-casing at the annual innovation conferences (WP 5.4, Dec 2014)

The project delivery team participated the Low Carbon Network Innovation in Aberdeen. VISOR informed the conference by presentation and a poster, both of which were well received by participants from the industry.

The coming six months will hopefully see the transition from hardware development to software (enhanced functions) development where the supporting infrastructure including outstation devices, data hub and communication (WAN) are completed and tested at system level.

The following element from the SDRC reflects this logic and expectation:

9.1.1. Baseline and comparator report for SSO behaviour (WP 1, March 2015)

9.1.1. Visualisation of multiple SSO information sources at data centre (WP 1A, prior to the commissioning of series compensation reinforcement)

& 9.3.1.

Report on PMU based line parameter estimation and variability (WP 2.1, March 2015)

Both elements in 9.1.1 demonstrated the expectation that the at least part of the supporting infrastructure of VISOR is in place before March 2015. It further requires that the major part of VISOR hardware system should have been tested, approved and functioning before the summer of 2015.

The element of 9.3.1 is the first milestone of enhanced software function. It marks the fact that the VISOR project will enter into a challenging software development stage from March, 2015.

Learning Outcome

Following the Authority formal approval in December 2013, VISOR made good progresses regarding project partner collaboration agreement, project management and governance establishment, procurement and knowledge sharing. There are challenges and risks (as detailed in the section above and the Risk Register in Appendix 2) along the development, and lessons are derived from every aspect.

Project Management

VISOR identified the project partners in the full proposal development based on the technical nature and the integrated transmission network. This has also been confirmed as part of the project approval. The project partners are:

- SPTL (Funding Licensee)
- NGET (as both the TO and GBSO)
- SHE-Transmission (TO)
- The University of Manchester

From August, 2014, Psymetrix Alstom Grid joined the Project Delivery Team as the supplier. Monthly PDT meeting is a forum to review, discuss and coordinate the project. Each company might have their own project programme and priority. It has been decided that there would be only one project programme clearing labelling all the milestones and key dates.

VISOR project was designed to be a collaborative proposal among the transmission licensees to maximise the benefits of network innovation. However the different paces of development among project partners remain one of the challenges for project management.

While this risk has been recognised in both the risk registration and project programme (by building in sufficient contingency), extra attention and efforts are useful to understand the problem and hopefully can address the challenges in a positive manner. If one project partner has difficulty in attending the delivery meetings, VISOR project manager takes initiative and should make regular visits to ensure the regular information exchange.

Technical Learning

The ambitious engineering target set in VISOR requires innovative and coordinated approach. From the hardware development perspective, the initial tendering procedure during the proposal stage (back in 2013 and Feb 2014) introduced the topic to the market. The project team was informed the potential suppliers and identified the data acquisition frequency range. Detailed functional specifications were included in the contract.

The specifications post contract award have been governed by a robust technical review procedure. By the end of 2014, the following specifications to enable the detection of SSO have been approved:

Enhancement Specification: 200Hz IEEE C37.118 stream processing
Application Specification: Sub-Synchronous Oscillations

Communication infrastructure between outstation device and the local data hub (within each TO) and between the TOs (including GBSO) is the key enabler of the VISOR demonstration. The Wide Area

Network for the communication between the SPT Hub, the SHE Hub and the VISOR Data Hub will be supported by National Grid through its share of the NIC funding.

To support the data transfer rate between the SPT, and SHE T WAMS and the NG WAMS Data Hub, there will be a 2Mbps non redundant MPLS link between NG and each of the Scottish TOs. This should provide the bandwidth required to support the needs of the project.

An IPsec tunnel over the internet was initially considered, but it has been concluded that this would not be reliable enough or support sufficient bandwidth to guarantee reliable data transfer. OPTEL services have also been considered for this project, but don't currently support connections. Therefore the project intends to use Verizon as the WAN supplier between Wokingham and Kirkintilloch, and Inveralmond House.

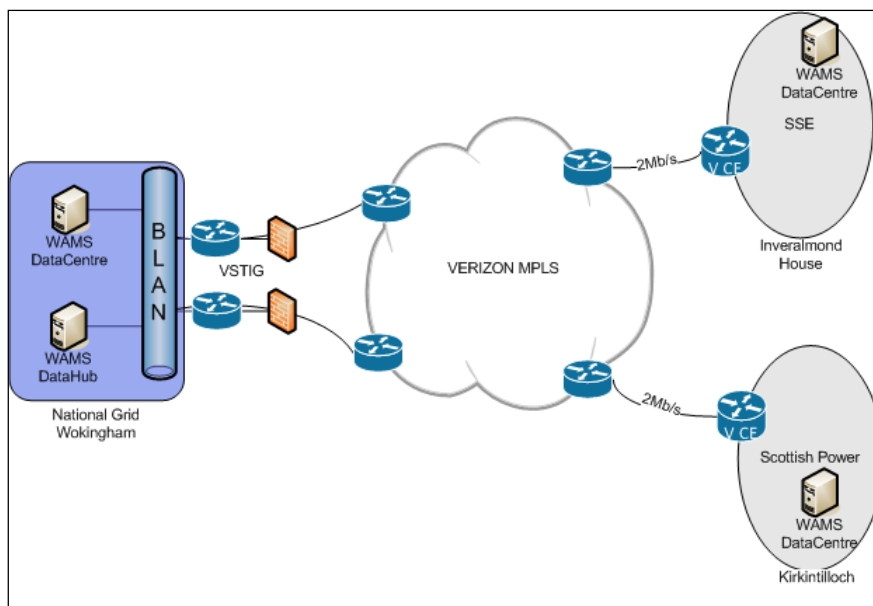


Figure 3 Inter Hub WAM (Nick Hird: National Grid)

	Activities	Lessons Learned
Technical Aspects	Development of a new outstation device	Market diligence; Detailed Specifications; Robust Review/Approval procedure; documentation system
	Outstation Device FAT	Detailed Testing procedure; Clear success criteria
	Communication Infrastructure	Design optioneering; early engagement; data security considerations
Project Management	Imbalanced Development among Project Partners	Effective Communication: Face-Face meeting, Dedicated Visits; Escalating Route
	Constraints of Resources	Early engagement with recruitment agency; Effective communications with stakeholders
	Project Programme, Key Milestone Review/updates	Single point of Project Programme with clear milestones and dates

Table 3 List of Key Learnings over the reporting period

Business Case Update

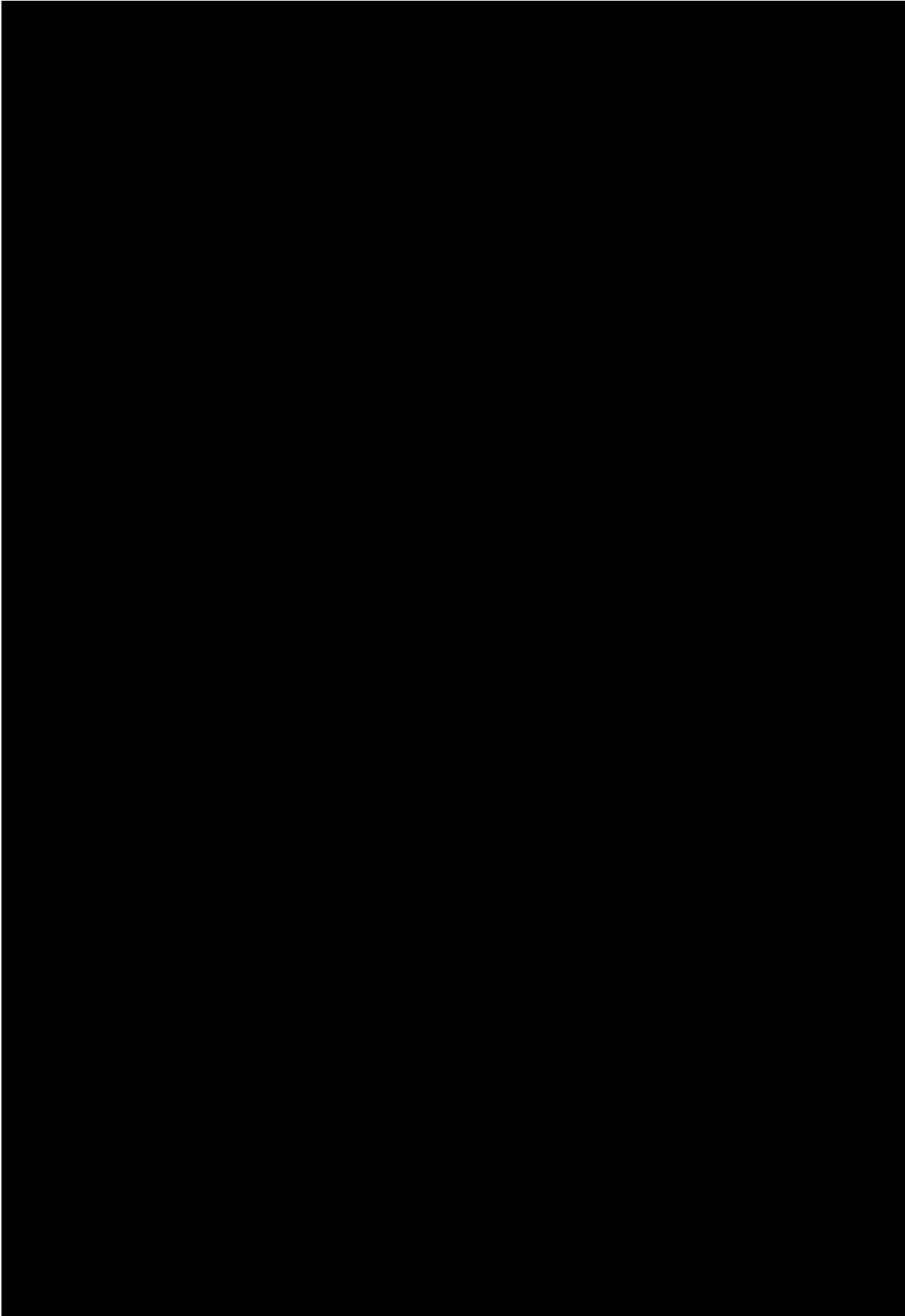
N/A

Bank Account

In line with Section 8 of the NIC Governance Document, a dedicated bank account was made available by SPTL to act as the Project Bank Account. Upon receipt of Funding Direction from the Authority, NGET (as the GBSO) will make equal monthly transfers, for the entirety of the Regulatory Year commencing 1 April 2014 such that the total amount transferred over the Regulatory Year commencing 1 April 2014 equals the net amount set out in Table 2 in the Funding Direction. The enclosed bank statement confirms the compliance with this requirement.

As the Project Collaboration agreement was confirmed at the end of May 2014, the project spending is still at its early stage. It can be confirmed that the expenditure of each organisation is in line with the original plan.

The official bank statement can be seen at: Appendix 3



Other

N/A

Accuracy Assurance Statement

I therefore confirm that processes in place and steps taken to prepare the PPR are sufficiently robust and that the information provided is accurate and complete.

Signature: _____

Name (Print): _____

Title: _____

Date: _____

Signature: _____

Name (Print): _____

Title: _____

Date: _____