



Improved Statistical Ratings for Distribution Overhead Lines (Phase 2)


Quarterly Report; March 2017

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Summary

This fifth Quarterly Report for the Improved Statistical Ratings for Distribution Overhead Lines (Phase 2) project at the Western Power Distribution (WPD) Stoke site provides an update of operation since the last Quarterly Report published in December 2016.

The Overhead Line (OHL) conductor test-rig has been formally operational since January 4th 2016, and in a predominantly stable condition throughout the first twelve months of operation with only a small number of issues arising until the equipment fire within the test rig site portacabin on June 3rd 2016, which was successfully resolved by the EA Technology project team. Where any operational issues have arisen with the rig, they have been addressed swiftly by the EA Technology project team, with support and guidance from Project Sponsor, Sven Hoffmann, in order to maintain stable rig operation.

Since the test rig was re-commissioned on 5th August 2016 following the major fire incident at 19.14hrs on Friday 3rd June 2016, which was detailed in the September 2016 Quarterly Report, the rig has remained generally operational and stable, with only minor missing data operations. The continued stable operation of the test rig following the June 2016 fire incident can be attributed to improvements to various equipment within the portacabin, coupled with the hard work and dedication of the EA Technology project team.

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1. Project Activity List

The table below illustrates the current status of the activities aligned with Key Deliverables of this project which attempt to ensure continued, uninterrupted operation and timely completion:

Activity / Project Deliverable		Item Description	Status
1	Test-rig Running and Maintenance	Operation and Management Plan	Complete. However, this is a “live” working document: therefore, the appropriate reviews, amendments and additions are made as the project evolves.
		Decommission Plan	Started but incomplete.
2	Data Entry Checking and Validation	Data Collection and Validation Method Statement	Complete
3	Data Collection and Validation	Data Download Tool	Complete
4	Data Analysis	Data Analysis Method Statement	In Progress
		Data Analysis Tool; OHRAT & OHTEMP Functionality	In Progress
		Data Analysis Tool; C-T Curve Production Capability	In Progress
		Data Analysis Tool; Ability to incorporate LDC	In Progress
		Validation of CIGRE Methodology	In Progress
5	Year One	Year One Data Collection Completion	In Progress
		Year One Interim Report	In Progress
6	Year Two	Year Two Data Collection Completion	In Progress
		Year Two Interim Report	Not Started
		Update ACE104 and ENA ER P27	Not Started
		Decommission Test-rig	Not Started
7	Integrated Software Tool	Specification Developed	Not Started
		“Beta”/Test version of software released	Not Started
		Final Release of Software	Not Started
8	Project Conclusion	Final Project Report Complete	Not Started

1.1 Test-rig Running and Maintenance

A “live” Test-rig Operation and Management Plan (TOMP) has been developed by the EA Technology project team to ensure the successful operation and optimal evolution of the Overhead Line (OHL) rig at Western Power Distribution (WPD) Stoke. The current version of the TOMP comprises a list of all items that need consideration aligned with:

- Appropriate OHL rig spares, suppliers and delivery lead times.
- Performance feedback monitoring mechanism.
- External component performance support.
- Scheduled EA Technology review meetings.
- Appropriate level of approval.
- Appropriate resources to perform each task
- Appropriate Risk Assessments & Method Statements (RAMS).

Additional documents were produced during the development of the TOMP, and include:

- Outstanding Task List for the Test-rig.
- Reactive Maintenance Strategy.
- Maintenance Inspection Check-sheet.
- Calendar of Scheduled Events

The **Outstanding Task List for the Test-rig** provides a contemporary record of the ongoing project management status that enables prioritisation and forward planning of tasks. An updated extract of current “live” tasks is shown in 0.

The **Reactive Maintenance Strategy** was formed to minimize down-time and enable efficient response and deployment of resources (Shown in Appendix II).

The **Maintenance Inspection Check-sheet** was composed to ensure that a suite of preventative maintenance activities was performed during site visits to improve rig performance and component service-life longevity (Shown in Appendix III).

The **Calendar of Scheduled Events** was produced, and is coupled with the electronic calendar of the Test-rig Manager, in order to ensure timely planning and execution of significant development or operational activities (Shown in Appendix IV).

EA Technology has made a significant number of scheduled and reactive visits to the Test-rig site since commencement of data collection in order to progress task completion and improve rig performance.

Remote monitoring systems, including web-cams, sensory threshold alarms and remote isolation apparatus, have been incorporated into the test-rig control system and continue to assist the EA Technology project team in trying to prevent component failure and mitigate unnecessary down-time.

All activities to date have facilitated improvements in the quality of the test-rig management processes, documentation and performance.

2. Data Collection, Checking and Validation

A specific **Data Collection and Validation Method Statement** has been produced and is available to view separately to this quarterly report.

2.1 Data Collection

The main parameters measured in this project are conductor temperature, conductor current and ambient conditions. Other measurements enable the running state of the rig to be monitored and any incipient faults to be detected and dealt with.

Measured values are logged every minute using a commercial datalogger which also carries out some limited averaging and other processing.

The logged data are automatically downloaded every day and saved in a backed-up location.

2.2 Data Checking and Validation

Automated data validation software based on a data-checking-and-visualisation Excel workbook (CHECKDAT) processes the daily data downloads and validates the integrity of the data. CHECKDAT first converts the raw data into engineering units and stores them in a separate worksheet (condat). Parameters that show up any malfunctioning of either the datalogger or instrumentation are then evaluated and any variation from set values is notified to members of the project team via email. The daily values of these integrity parameters (which are a mixture of daily totals, daily averages and daily max or min values) are automatically recorded as a row in a monthly output table (one row per day), which features conditional colouring based on how close to a parameter is to its set value. This provides a visual monthly record of the data gathering process.

Whenever the automatic process flags up a problem, the condat sheet of the CHECKDAT file for that day is inspected manually and the row(s) of data responsible for the flag identified and, if possible, corrected. If correction is not possible, the data are (or will be) deleted leaving a blank line for the time(s) concerned.

2.3 Validation of Cigre Equations

CIGRÉ Technical Brochure TB601, "Guide for thermal rating calculations of overhead lines" (2014)¹ contains a set of equations for calculating the temperature of overhead conductors under specified conditions. It is an update of the equations previously compiled by CIGRÉ WG22.12 and published in *Electra* in 1992.

OHTEMP is a spreadsheet tool that calculates the temperature of a conductor that is carrying a specified current under specified ambient conditions. It was developed in 2010 by EA Technology for members of the Overhead Line Module of the STP and uses calculations based on the 1992 CIGRÉ equations. A revised version, OHTEMP2, based on the new (2014) CIGRÉ equations has now been developed.

Comparison of the measured conductor temperatures with the corresponding values calculated from the measured ambient data using OHTEMP2 has been carried out on a limited scale and the initial results are promising. Specifically, I have done a comparison with the Cigre equations for each of the conductors for each minute of a selected "high-temperature" day (29-30 October 2016, Ash500 max temp 78, avg temp 52). For the Ash and Elm conductors, the agreement was generally within about 2 degC on average over the day, with the trio means giving slightly better agreement than the trio maxima (0.73 ± 2.0 and 1.33 ± 1.9 respectively for Ash500, where the \pm figure is the standard deviation). With Hazel, the agreement was not so good (~4 degC different), possibly due to erroneous calibration of the Hazel current transducers. We are currently in the process of checking these calibrations.

Since the calculated temperatures fluctuated much faster than the measured ones, mainly due to fluctuations in wind speed and direction, better overall agreement was obtained if a 10-minute running mean was used for the calculated values. However, using delayed measured values rather than instantaneous ones gave no improvement.

The intention is to repeat this comparison for a limited selection of other days,

3. Compilation of the Cleansed Dataset

The validated daily data comprise a minute-by-minute record of the readings of each measurement transducer (thermocouple, current transducer, anemometer etc), converted into engineering units. Each day's data are stored in the condat worksheet of the relevant CHECKDAT workbook for that day.

The **Cleansed Dataset** will essentially comprise a concatenation of all the daily condat data, initially in monthly blocks but then, if required, in seasonal and/or annual blocks.

Before they are concatenated, the daily condat files each need to be checked and, if necessary, cleansed (see Section 2.2). It is not obvious whether it is worth trying to automate this process.

After cleansing, the data need a certain amount of data processing since many of the measuring instruments are duplicated or triplicated in order to provide redundancy in the event of a malfunction. For these parameters, a suitable "best" value, needs to be defined. This is usually the mean of the several readings. The odd ones out are the conductor thermocouple trios. In previous work it was found that a low conductor thermocouple reading was often an indication of poor thermal contact between the thermocouple and the conductor and so the maximum of the trio was deemed the most appropriate choice. In the present work, this is less-obviously the case. In the absence of a decision on whether the maximum or the mean is the best value to use, the draft dataset includes both of these. It will be a simple matter to remove the unwanted ones in the final version.

The parameters in question are:

				complication
Tcon	conductor temperatures	trios of thermocouples	mean or max	max = best contact?
Tamb	ambient temperature (line height)	pair of thermocouples	mean	
Wspd	wind speed (line height)	pair of anemometers	mean	different outputs
Waa	wind attack angle	pair of anemometers	mean	different outputs
Sol	solar insolation	pair of solarimeters	mean	shadows

Production of a template for the cleansed dataset based on manually adding data in daily blocks is complete. The next step, automation of the concatenation process, is work-in-progress.

4. Project Summary Activity Log

The Overhead Line (OHL) conductor test-rig has been formally operational since January 4th 2016, and in a predominantly stable condition throughout the first twelve months of operation with only a small number of issues arising until the equipment fire within the test rig site portacabin on June 3rd 2016, which was successfully resolved by the EA Technology project team. Where any operational issues have arisen with the rig, they have been addressed swiftly by the EA Technology project team, with support and guidance from Project Sponsor, Sven Hoffmann, in order to maintain stable rig operation.

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As detailed in previous quarterly reports, in order to prevent recurrence of the 2016 fire fault incident, the rig monitoring and control equipment has been re-designed to reduce the likelihood of overheating.

Conductor thermocouples have continued to work effectively since the OHL rig went live in January 2016 and as stated in previous quarterly reports, one thermocouple suspected of malfunction had been replaced as a precaution. To date, this has been the only issue associated with thermocouple performance.

The automatic daily data download procedure had been working well prior to the fire incident, with automated data checking in place. It is hoped that now the test rig is operational following the fire incident, the overall performance will be settled and the project team can continue updating the parameters that need to be monitored for reliable operation.

A back-up independent alarm and automatic trip system, incorporating an Eltek Squirrel data logger, has been installed in addition to the primary automated alarm function hard-wired into the DT-85 Datataker logging system.

Ambient sensors (temperature, wind, sunshine, rainfall) are generally working satisfactorily. Exception is the WindMaster 3D anemometer which frequently produced nonsense readings in January for no apparent reason. We have systems set up that detect instances of misreading and the affected data can be weeded out by hand. Following a manual cleaning of its connector and sensors on 17th January 2017, the WindMaster's faults have gradually decreased in number to a level that is no longer (as of 22nd March,) a cause for concern.

A revised version of OHTEMP incorporating the new (2014) CIGRÉ equations has now been developed (OHTEMP2). Comparison of the measured conductor temperatures with the corresponding values calculated from the measured ambient data using OHTEMP2 has been carried out on a limited scale and the initial results look promising.

A summary of the most significant issues attended to since data collection commenced is shown below:

Start Date	Issue Description	Date Resolved	Action and Consequence
23/12/15	Porta-cabin reached 30°C during pre-start and project rig running operation.	24/12/15, 21/01/16	Ventilation methods improved including installation of additional 16" cooling fan adjacent to injection transformers, thermostatic controllers for existing extractor fans and two new floor vents.
04/01/16	Formal start of Project Phase 2 and operation of the OHL rig	04/01/16	N/A
19/01/16	Integrity of certain thermocouples giving cause for concern	21/01/16	Thermocouple THUT1 behind PSU4 repositioned
19/01/16	Omni advised updating the logger's "firmware" to resolve potential reset instability.	10/02/2016	Complete. Changes in logger configuration and overall issues fixed. Logger operation stable
29/01/16	Minor mistakes discovered in the Logger Channels file	29/01/16	Updated version; logger channel 12a is now consistent with the current CONFIG and checkdata programs.
01/02/2016	Squirrel Logger Installed	10/02/2016	Backup Trip Alarm and Relay installed to complement existing logger trip circuit.
02/02/16	Logger stopped at 07.14am	03/02/16	Manually restarted: 26hrs of data lost.
05/02/16	Logger stopped at 20.35pm	06/02/16	Manually restarted: 14hrs of data lost.
10/02/16	Logger firmware updated	10/02/16	Fix firmware bugs, improved operational stability.
14/02/16	Logger stopped at 15.20pm	14/02/16	Manually restarted: 43hrs of data lost. Configuration issues resulting from logger firmware update. Fixed.
16/02/16	Power supply unit (PSU) 3 had ceased automatic regulation,	24/02/16	A repair was carried out by modifying the

Start Date	Issue Description	Date Resolved	Action and Consequence
	consequently, the output voltage and current were tracking the line input		micro-switch assembly of the maximum limit switch. Modification rectified fault and method was approved by the manufacturer.
19/02/16	Conductor 14A peaked at 80degC at 08.00. It was noted there was no wind and low sun	ongoing	Monitoring of this situation, but nothing to report since this temperature excursion.
19/02/16	Distributed thermocouples on 14A very variable e.g. 50 - 53 - 50 while TC15 reading 49	ongoing	Monitoring of this situation on regular basis
24/02/16	Successful modification of PSU 3 replicated in PSU 1, 2 and 4 following recent malfunction of PSU 3	24/02/16	Checked operation of motor to confirm symptoms were the same as PSU 3 and made mods on PSU 4. It was decided to perform mods on PSUs 1 and 2 also.
24/02/16	Logger reformatted	24/02/16	Logger reloaded with saved configuration to try and alleviate unexplained stoppages
24/02/16	One of thermocouple trio on 14A (rig1, circuit 4, Ash) reading low (-3K).	24/02/16	Replaced Thermocouple 13 with spare and now operating without incident.
4/03/16	Conductor current transducer correction factors rechecked - TCF4 found to be significantly lower than previously thought - now similar to TCF1-3.	8/3/16	Altered correction factors in checkdata (rather than altering logger config, so logger data are consistent)
22/03/16	Solarimeters sol1 & sol2 found to be reversed on logger	22/3/16	Added correction factors in checkdata (rather than altering logger config, so logger data are consistent)
05/05/16	Logger malfunctioned - lost a line of data	18/5/16	Ongoing discussions with DataTaker

Start Date	Issue Description	Date Resolved	Action and Consequence
08/05/16	Hut ambient temperature hit 40 degC - rig cut out	10/5/16	Additional ventilation added in hut and rig restarted
03/06/16	Power Factor Correction Unit failure and resultant fire	05/08/16	Significant reparation program (detailed earlier in this report) Rig returned to operation.
16/08/16	Reliability problems with datalogger - Omni (supplier) unable to fix	08/09/16	Installed new power supply adapter to Datalogger logger. Installed new internet-based Power Cycle Box to datalogger Rig restarted successfully and now fully operational
13-Sep-16	WindSonic (Anemometer 2) readings dubious	22-Sep-16	WindSonic power supply reconnected - problem solved.
22-Sep-16	Commissioning fine-tuning	22/09/16	Adjusted PSU auto-control current settings in line with revised calibration factors. Repaired cable termination fault at power supply to Windmaster.
22-Sep-16		7-Nov-16	Data collection perfect (7 weeks)
07-Nov-16	Electricity supplier (Npower) required isolation of test rig to replace faulty electricity meter. EATL maintenance inspection. Omni requested return of 12V power supply (on-loan)	7-Nov-16	De-energised test-rig temporarily and accompanied Npower. Replaced 12V Omni power supply with 24V unit (Omni). Filled in rodent hole near electricity meter-box cable duct. Lubricated porta-cabin entrance door plate, locking mechanism & hinges. Inspected Test-rig control equipment using FLIR cam. Completed new Maintenance Inspection Check-sheet. Missed 18 logs.

Start Date	Issue Description	Date Resolved	Action and Consequence
10-Nov-16	Rig 1 current falling with Thut (-0.5% for -10K, 18°C to 8°C.	2-Dec-16	Fitted thermostats on extract fans. Thut controlled at ~18°C
15-Nov-16	Logger missed single 1-min log plus single 15s scan	?	Contacted Omni
28-Nov-16	Logger missed 4 x 1-min logs plus 16 x 15s scans	?	Be on lookout for other instances
7-Dec-16	Logger missed single 1-min log plus single 15s scan	?	Be on lookout for other instances
09-Dec-16	WindMaster (Anemometer 1) U,V & W all dropped to minus 45m/s for 1 hour (power loss?)	?	Be on lookout for other instances
10-Dec-16	Spike in 22H1 spread of 4.1K (>3K for 4 mins)	?	Be on lookout for other instances
16-Dec-16	WMaster major glitch 0359-0600 preceded by minor one 0259-0307. Fog?	?	Corrected/deleted affected data
17-Dec-16	WMaster glitch continued until 1944	?	Corrected/deleted affected data
18-Dec-16	WMaster glitch 1141 to 1927	?	Corrected/deleted affected data
19-Dec-16	WMaster glitch 1347-1349	?	Corrected/deleted affected data
27-Dec-16	WSonic glitch - WS2 approx zero for 1 min	?	Corrected/deleted affected data
31-Dec-16	Most of 1920 to 1927 data corrupt.	?	Corrected/deleted affected data
04-Jan-17	Raw data corrupt 0841 to 0849 and 1909 to 1918	?	Corrected/deleted affected data
05-Jan-17	Raw data corrupt 1705 to 1713 (data missing, data repeated, dates repeated, dates missing)	?	Corrected/deleted affected data
05-Jan-17	Manual restart of logger from desk using TeamViewer	05-Jan-17	lost data
06-Jan-17	Missing row at 10:27, half-empty row 10:28: result of manual restart yesterday.	06-Jan-17	Corrected/deleted affected data
17-Jan-17	WindMaster "serviced" - pole-top connector disconnected, cleaned and reconnected,	17-Jan-17	lost data

Start Date	Issue Description	Date Resolved	Action and Consequence
	sensor heads wiped. (PSUs switched off for an hour)		
20-Jan-17	WMaster glitch. Spike at 0807	?	Corrected/deleted affected data
22-Jan-17	WMaster glitch. U,v,w all highly negative 1629-1638. Foggy?	?	Corrected/deleted affected data
25-Jan-17	Logger glitch. Corrupt data 1452 to 1458 and at 0140 to 0146.	?	Corrected/deleted affected data
26-Jan-17	Manual logger stop/restart at 1051 on 25th. 1051 scan missing, 1052 incomplete.	26-Jan-17	Corrected/deleted affected data
27-Jan-17	Wmaster single-scan glitches in wsp1 at 23:36, 23:52 and 03:19	?	Corrected/deleted affected data
28-Jan-17	WMaster protracted glitch in wsp1 (-30 to -33m/s) from 01:19 to 01:44.	?	Corrected/deleted affected data
06-Feb-17	Corrupt & missing data 11:32 to 11:38	?	Corrected/deleted affected data
06-Feb-17	WMaster glitch 10:20 - 11:18 - U,V,W all -40 to -50.	?	Corrected/deleted affected data
07-Feb-17	WMaster glitch 06:10 - 06:54 - U,V,W all -40 to -50.	?	Corrected/deleted affected data
17-Feb-17	WindMaster 1-min spikes at 01:04 and 04:47	?	Corrected/deleted affected data
21-Feb-17	Logger download glitch 0626-0633.	?	Corrected/deleted affected data
23-Feb-17	WindMaster spikes at 2313, 0130 & 0151.	?	Corrected/deleted affected data
24-Feb-17	Single reading 5A spikes in IC1-3 (not 4) at 0952. Very high winds (>10m/s) all day	?	Corrected/deleted affected data
04-Mar-17	Logger glitch 1548-1555	?	Corrected/deleted affected data
11-Mar-17	Data missing from 1601 to 1608 due to manual switch-off trying to fix SIM problem	11-Feb-17	lost data
16-Mar-17	Trio 14A range 4.1 at 1215	n/a	n/a
16-Mar-17	WindMaster glitches from 1136 to 1250	?	Corrected/deleted affected data

Start Date	Issue Description	Date Resolved	Action and Consequence
16-Mar-17	Changed criterion for ws1o2 red from avg to max (row17 to row19)	16-Mar-17	Modified autocheckdat
17-Mar-17	Logger glitch for 7 mins	?	Corrected/deleted affected data

Appendix I EA Technology Outstanding Task List for Test-rig

Task List A	Outstanding Tasks at / for Test-site, Stoke			Last updated: 10/03/17	Index page
Priority	Person Responsible	Problem/Action/Event/Comment	Comment or Est'd time (hrs)	Phase (1 or 2)	Contact List
	JDC/MPB/RA (AW)	Integrate 'High Temperature Warning' notification into Datataker system to act as a pre-cursor alert to 'Over-temp Tripping Event'. Identification of TC that will be used to trigger warning is still TBC.	(18/05/16) Determined by JDC & MPB that: Datalogger Warning @ 38°C [MPB] & Trip @ 42°C [RA]; Squirrel Trip at 43°C [AW]	Pre-visit tasks Tasks at Stoke To take	
	RA	Identify/source UPS for PC & Modem and plan installation	Ongoing [1h] PT discuss w/ RA		
	NJH	PAT test equipment onsite	NJH to perform 16/01/17 [1h]		
	All	Monitoring of site Web-Cams during staff visits			
	TBC	<ol style="list-style-type: none"> Adjust PSU auto control current settings after calibration factors have been properly determined by JDC and MPB. Complete new Maintenance Inspection Check-sheet Disco' wall heater if AJ Electrics didn't do during their recent test. 	Most recent Maint. Check Sheet completed and wall heater used whilst onsite; It performed ok; on 07/11/16 by NJH.		
	NH/MPB/RW/RA	With assistance from WPD MEWP, investigate anemometer anomalies. RW: Liaise w/ WPD for MEWP access. Activity to be performed during next visit.	NJH/RA/MPB to visit site on 16/01/17 to investigate. [1.5h for 2 people]		

Task List A	Outstanding Tasks at / for Test-site, Stoke Last updated: 10/03/17			Index page Contact List
Medium priority	RA	Set up email (text) alert for 'Rig-tripped' alarm; recipients to be PT & RW (plus RA & MPB if they so desire)		
	Team	Consider implication(s) of dry grass-cuttings entering cabin through vent holes in floor.	No issues arose during remainder of 2016. Reassess during 2017 summer period.	
	JDC/MPB	Ongoing review of Datataker & Squirrel over-current/over-temp thresholds Current settings (04/08/16): <ul style="list-style-type: none"> • Datataker: PSUs set at 80°C; THUTs set at 40°C. • Squirrel: PSU 1-3 currents set at >10%; PSU 4 >5%; THUTs 43°C 		
	Team	Review performance feedback loop (Frequency of meetings, sensor threshold alarms, trigger recipients, webcam review, etc.)		
	MPB	Monitor ambient temperature within auxiliary pole cabinets. Consider installation of localised heating if ambient temp. =<0°C. Specification for Digirail Modules TBC by OMNI	Reminder sent to MPB to be alert of ambient temps/performance (11/01/17)	
	JDC/MPB	Confirm how close the PSUs are running to their limits during warmer seasons (MPB to liaise w/ JDC)		
	PT	Ongoing periodic review of Safety Documentation.		
	PT	Identify & source spares required for Stoke. Review team spares list. PT set up workable document in job folder: all team to add to list appropriately.	Ongoing consideration	
	PT	Confirm grass maintenance for 2017 and schedule w/ Hortech		
	RW/PT	1page PR document for WPD (A. Pickering to approve all pics)		
	PT/RW	Closing project review for EATL/WPD/Suppliers/DNOs/STP members		

Appendix II Reactive Maintenance Strategy

Reactive Maintenance Strategy							Last updated:		8/01/2016		
Class of emergency				Actions available		Resources available					
	Emergency	Questionable	Non-emergency			Resource		Contact Details (7am-10pm)			
1	Threat to safety and health of people	Vandalism?	Power outage	A	Do nothing except record details of communication	1	EATL	Project Manager	Richard Wood	0151 347 2387 07854 401802	
2	Threat to rig safety and/or functionality	Foreign objects within compound...		B	Remotely interrogate webcams	2		Test-rig Manager	Peter Thompson	0151 347 2402 077183 40551	
		...close to or touching test-rig components	...remote from test-rig components								
3	Threat to WPD operations	OHL conductor falling/fallen down	Other?	C	Confirm receipt of 'Rig-tripped' text alert	3		Data Manager	Ramiz Ahmed	0151 347 2333 07891 236893	
4	Trespassers within compound	OHL pole crossarm falling/ fallen down		D	Contact WPD reception, security or Electricity Supplier	4		Electrical Engineering Guidance	John Crabtree	0151 347 2337 (O) 07841 492595 (W) 07704 572786 (P) 01244 328961 (H)	
5		Fencing/gate failure		E	Liaise with resource informatively	5		Test-rig design (Primary contact)	Mark Bertinat	0151 347 2391 07817 909797	
				F	Contact emergency services informatively at an appropriate point in time	6		Test-rig design (Secondary contact- ONLY during normal working hours)	Alan Ward	0151 347 2349 (ONLY during normal working hours)	
				G	Isolate power to rig remotely	7	OHL Design	Richard Wood	0151 347 2387 07854 401802		

Note: We currently foresee that the only cause for immediate attendance to the Test-site outside of normal working hours would be if the Emergency Services and/or WPD were to insist that we do so.

H	Contact emergency services immediately
I	Liaise with and deploy resource at an appropriate time
J	Liaise with and deploy resource immediately

8		Health & Safety Advisor	Greg Watson	0151 347 2256
9		Technical Engineers	Ralph Eyre-Walker	0151 347 2375 07894 392833
10	WPD	Test-rig design	Sven Hoffmann	
11		OHL Team	Shane Degg	07989 700472
12		Network Connection Team		
13		Stoke Depot Security	Nigel Morris	01782 403706
14	Electrical Contractor	AJ Electrics (Local to Test-site)	Chris Huxley	01782 205814 07718 027814
15	Data loggers	OMNI (0845 9000 601)	Andy Philpott	07595 120791
16			Steve Duncan	07908 753933
17	PSUs	REO	Steve Hughes	01588 673411
18	ITs	Birmingham Transformers	Mark Waidson	0121 764 5600
19	Npower	Commercial Premises Supplies	Ed Davies	0800 912 7723
20	Grounds Maintenance	Hortech Grounds Maintenance	John Shufflebotham	01782 416653 07866 704854
21			Peter Tilley	01782 416653 07896 832637
22	Porta-cabin	Concept Cabins	Darren Trinder	07733 763864

Appendix III Maintenance Inspection Check-sheet

Task List D		Maintenance Inspection Check-sheet			Version update: 26/01/16	Maintenance Inspection completion date:		
<p>Description:</p> <p>The Maintenance Inspection Check-sheet is a guide for the routine maintenance tasks associated with the OHL Test-rig. A new document should be printed prior to visiting site and completed during each inspection. The completed documents should be returned to the Test-rig Manager and stored at EA Technology's head-office, Capenhurst.</p>								
Module	Component	Action	Frequency	HR	Equipment required	Initials	Comments	
1	Test-rig control & monitoring equipment (Indoor)	A Weld cables	Visual assessment ¹ and comparative sweep across the four supplies w/ FLIR	Each visit ²	TE	FLIR/iPhone FLIR		
			Torque check of terminated lugs (44Nm) and bolted terminations	During quarterly scheduled inspection ONLY when Test-rig is isolated	TE	Calibrated torque wrench, adaptors. Work Instruction including specified torque		
	B Injection Transformers	Visual assessment as 1A	Each visit	TE	FLIR/iPhone FLIR			
		Check tightness of bolted terminations	During quarterly scheduled inspection ONLY when Test-rig is isolated	TE	Calibrated torques wrench, socket set and spanners			

¹ 'Visual assessment' refers to the observational process of assessing the mechanical condition of each component associated with the stated item, where practicable and safe to do so, by employing an appropriate level of manual handling, tooling, interference and/or component movement in order to assess the actual condition of component materials, assemblies, fixings, and/or wirings without causing unnecessary or irreversible disturbance that could render the components vulnerable to failure or dysfunctional operation. All noteworthy observations, reparatory works, proactive maintenance actions or considerations must be recorded and communicated to the appropriate responsible person in a timely manner for means of traceability and in order that any subsequent actions can be planned accordingly.

² 'Each visit' refers to visits that are >2weeks apart or those directly following severe weather occurrences.

		C	PSUs (x5)	Visual assessment as 1A	Each visit	TE	FLIR/iPhone FLIR		
				6 monthly OEM Service inspection	Scheduled w/ REO	Any	REO require Min 2 week notice. (If fully disco'd: 4 units in 8 hours, w/ reconnection by EATL staff)		
		D	PSU control / measuring equipment	Visual assessment of cables, components and terminations Check only for signs of damage or overheating	Each visit	TE	FLIR/iPhone FLIR		
				PAT checks	Scheduled w/ FMS	FMS/DC/ NJH	PAT Instrument		
		E	Porta-cabin thermo-couples	Visual assessment. Check in place and undamaged, and readings are similar	Each visit	TE			
		F	Data Logger, CEM units, PC / laptop	Visual assessment. Check in place and undamaged, w/ no disconnected wires.	Each visit	TE			
				PAT checks	Scheduled w/ FMS	FMS/DC/ NJH	PAT Instrument		
		G	E-stop & Fire alarm circuit	Functional assessment and test of local operation and detectors	6 months	TE	?		
				Functional assessment and test of remote operation	6 months	TE	?		

		H	32A Radial circuits and consumer unit	Visual assessment of PSU isolators, sockets and extension cables (incl. mechanical switch operation)	Each visit. Switched operational checks ONLY when convenient	TE	FLIR/iPhone FLIR		
		I	Office furniture	Visual assessment of chair functionality and table legs	Each visit	TE			
2	Test-rig control & monitoring equipment (Outdoor)	A	OHL Thermo-couples	Visual assessment of self-amalgamating tape, and cable insulation material localised to ducted elbows at height and all glanded entry ports.	From ground level each visit.	TE	OHL_PGP ³ / Genie boom/ UAV		
					Review remotely using webcam.				
		B	2D Anemometer	Visual assessment of anemometer sensor head and overall cable insulation material, specifically at all glanded entry ports.	From ground level each visit.	TE	OHL_PGP / Genie boom/ UAV		
					Review remotely using webcam.				
		C	3D Anemometer	Visual assessment of anemometer sensor head and overall cable insulation material, specifically at all glanded entry ports.	From ground level each visit.	TE	OHL_PGP / Genie boom/ UAV		
					Review remotely using webcam.	Any			

³ 'OHL_PGP' is the OHL fibreglass poles with a GoPro Camera attached at the upper end

		D	Rain Tipping bucket	Visual assessment of functionality and overall cable insulation material, specifically at all glanded entry ports. Cleaning only if required.	Each visit.	TE			
		E	Solar meters	Visual assessment of sensor head and overall cable insulation material, specifically at all glanded entry ports.	Visual assessment and clean each visit.	TE			
		F	Ambient temp probes and radiation shields	Visual assessment of assembly and overall cable insulation material, specifically at all glanded entry ports.	From ground level each visit.	TE	OHL_PGP / Genie boom/ UAV		
					Review remotely using webcam.	Any			
		G	Auxiliary Cabinets	Check condition and functionality of cabinet, door, seals, mountings & panel keys, and identify any evidence of moisture ingress.	Only external inspection performed EVERY visit; detailed checks performed maximum fortnightly visit	TE			
		H	Ducting & trunking	Visual assessment of material, joints and all cable entry ports. Ensure duct seals are functional. Check that there is no pooled water present within, or evidence of rodent activity.	Only external inspection performed EVERY visit; detailed checks performed maximum fortnightly visit	TE			

3	Porta-cabin	A	Fixtures, fittings, windows, door locks & cable entry ports	Confirm condition, functionality, seals and security. Identify any evidence of moisture ingress. Assess functionality/ integrity of cable entry ports and vermin barriers. Assess vermin traps.	Only external inspection performed EVERY visit; detailed checks performed maximum fortnightly visit	TE			
		B	2-step platform	Visual assessment	3 months	TE	FMS		
		C	Entrance steps	Visual assessment	Each visit	TE			
		D	Fire extinguisher	Quarterly inspection	3 months	TE	FMS		
		E	General	Housekeeping	Each visit	All			
4	OHL	A	OHL conductors and fittings	Visual assessment	From ground level each visit.	TE	FLIR/iPhone FLIR OHL_PGP / Genie boom/ UAV		
					Review remotely using webcam.				
		B	Poles, cross-arms and stay-wires	Visual assessment	From ground level each visit.	TE	OHL_PGP / Genie boom/ UAV		
					Review remotely using webcam.				
5	Electricity supply	A	WPD cabling supply to Test-site	No control measures available					
		B	Contract w/ Electricity Supplier (Npower)	Assess actual usage against estimated. Current contract expires: 14/02/17	Review of most appropriate contract	Any		PT	

		C	Cut-out / meter cubicle	Check condition and functionality of cabinet, door, seals, mountings & panel key, and identify any evidence of moisture ingress.	Only external inspection performed EVERY visit; detailed checks performed maximum fortnightly visit	TE			
		D	Internal electrical installation	RCCD test	Quarterly ONLY when possible	TE			
				Annual Test & Inspection	Annual	AJ Electrics		PT	
E	Earthing	Confirm condition and security of cable and terminations	Only external inspection performed EVERY visit; detailed checks performed maximum fortnightly visit	TE	Hand tools				
6	Fencing/ Gates	A	Fencing & gates	Visual assessment of fixings	Each visit	Any			
		B	Padlock / keys	Confirm functionality	Each visit	TE			
7	Test-site	A	Signage	Visual assessment of condition & fixings	Each visit	Any	Hand tools Cable-ties		
		B	Safety walkway	Visual assessment	Each visit	Any			
		C	Grass maintenance	Ensure maintenance contract works are performed to WPD expectations	Confirm w/ WPD	TE	Maintenance contract		
		D	General house-keeping	Collection & disposal of wind-blown debris/ refuse	Each visit	All			

Appendix IV Calendar of Scheduled Project Events

Calendar of Scheduled Events 2016/17				Last updated: 23/03/17	
Date	Person Responsible	Problem/Action/Event/Comment	Target Completion Date	Results	
04/01/2016	MPB	Test data gathering commenced	-	-	
25/01/2016	PT	Renewed Electricity Supply Contract w/ Npower (Expires: 14/02/16)	01/02/16	Complete	
21/01/2016	NJH/RA/GDC	Visit to Stoke to continue w/ commissioning tasks (Poss. perform 1 st Visual Inspection?)	-	Visit performed: outstanding tasks and first inspection partially complete	
03/02/16	NH/RA	Logger stopped at 07.14am 02/02/16. Manually restarted: 26hrs of data lost.			
04/02/16	IH	Visit to Test-rig to retrieve Squirrel Logger; passed to AW for repair	-		
06/02/16	NH/RA	Logger stopped at 20.35pm 05/02/01. Manually restarted: 14hrs of data lost.	-		
10/02/16	NH/RA/GPC	Logger firmware updated 10/02/16. Fix firmware bugs, improved operational stability. Continued w/ commissioning tasks (Completed 1 st Visual Inspection)	-		
14/02/16	NH/RA	Logger stopped at 15.20pm 14/02/16. Manually restarted: 43hrs of data lost. Configuration issues resulting from logger firmware update. Fixed. Swapped thermocouples. RA on Camera Monitor	-		
16/02/16	-	PSU3 Variac stopped moving	-		
24/02/2016	JDC/NJH	Visit to Stoke to investigate PSU3 Variac issue plus continue w/ commissioning tasks (Complete 1 st Visual Inspection?)	24/02/2016	Mods made to proximity switches by JDC	
10/05/16	NJH	Nick visited site to reset rig after Cabin over-temp trip (>40°C) had operated on Sunday. No email alerts had been received. Squirrel alarm still not functional. Only noticed by MPB after he returned to work on Tuesday. U/S 12" fan brought back to Capo.	-	Nick performed other tasks whilst on site.	
1/05/2016	PT	Schedule 6mth maint. inspection of PSUs w/ REO and EATL resources/visit. Ensure they check the mods JDC made to all PSUs incl. spare. EM sent to REO by PT 240516	1/06/2016	REO to visit site on 06/07/16	

Calendar of Scheduled Events 2016/17				Last updated: 23/03/17	
07/06/16	PT/JDC	Post-fire visit to assess damage and commence clean-up.	-	Team meeting arranged for 13/06/16	
22/06/16	PT/NJH	Site visit to continue reparation tasks	-		
23/06/16	PT/NJH	Site visit to continue reparation tasks	-	Team meeting arranged for 20/06/16	
30/06/16	SG	Take PSUs to REO	-	Team meeting arranged for 30/06/16	
05/07/16	PT/RG	Site visit to continue reparation tasks	-		
06/07/16	PT/JK	Site visit to continue reparation tasks	-		
06/07/16	REO	Inspection and Service of all 5 PSUs (See update EM from Steve Hughes 11/07/16)		Team meeting arranged for 14/07/16	
15/07/16	AJ Electrics	Complete the replacement of Fire Alarm smoke detector and perform Fixed Electrical Installation Inspection (Retest was originally due: 06/03/16)	-		
18/07/16	PT/JDC/JK	Commence testing of PSUs, IT 1 & 4 and all new ancillary control modules at Capenhurst			
w/c 25/07/16	PT/JDC/JK	Transport all equipment to Stoke and re-commission.	-		
w/c 01/08/16	PT/JDC	Final re-commissioning tasks performed (2 nd & 4 th Aug). Rig fully re-commissioned and logging data as of COP 04/08/16.	-		
8/08/16	NJH	Restart Datataker logger at Stoke	-		
10/08/16	NJH	Restart Datataker logger at Stoke	-		
15/08/16	MPB/NJH	Restart Datataker logger at Stoke w/ tele-assistance from OMNI: OMNI claim that the internal main battery is the most likely cause of the fault. I discussed issue w/ Steve (Omni) on phone.... Awaiting response.	-		
17/08/16	NJH	Restart Datataker logger at Stoke			

Calendar of Scheduled Events 2016/17

Last updated: 23/03/17

22/08/16	PT	<p>Received pre-programmed DT85 from Omni. Went to Stoke and replaced 'suspect' unit. Replacement unit logger appears susceptible to the same fault as the 'suspect' DT85. Discussed w/ Omni and Mark (Grant Instruments). Andy and Mark (GI) will scrutinise programme line-by-line during next 2 days. Comms w/ DT85 intermittent/unreliable, therefore, the PSUs to the OHL rigs were not energised.</p>	-	
26/08/16	PT	<p>Solo visit to Stoke at request of OMNI. Rebooted 'loan' logger successfully. Andy Omni remotely cleared the existing program completely and all old data from logger. He suspects that:</p> <ul style="list-style-type: none"> • The existing program may have been causing stoppage of the command screen • The latest firmware version may have also contributed to problem <p>He then loaded new modified program and monitored for an hour or so. Andy is going to:</p> <ul style="list-style-type: none"> • Discuss the issues again with Datataker/Mark (Grant Instruments) today • Monitor the logger remotely during the next 2-3 days (There is no bank holiday next week in Scotland). <p>As the comms w/ DT85 were intermittent/unreliable the PSUs to the OHL rigs were not energised.</p>		
03/09/16	RA	<p>Solo visit to Stoke on way to London:</p> <ul style="list-style-type: none"> • Reboot logger • Install new Ethernet s/w • Confirm all LAN/comms cabling between Ethernet s/w, logger, wifi and PC • Install temp. DC supply feeding Squirrel to test supply voltage stability • Photograph all connections for records 		
08/09/16	MPB	<p>Solo visit to Stoke:</p> <ul style="list-style-type: none"> • Installed a new power supply adapter to the Datataker DT85-3 logger. • Installed the new internet based Power Cycle Box to the Data logger, to restart in case it crashes • Checked and confirmed the operation of the power cycle box • Turned the rig power supplies back on. • Ramiz A confirmed access to logger remotely. • Richard Ash changed the settings of the internet router to only allow EA Technology IP address to connect to the logger (reducing external interference). This does not affect the cameras (still accessible via iPhone app). 		

Calendar of Scheduled Events 2016/17

Last updated: 23/03/17

		• The rig is now back on and operational.....		
22/09/16	JDC/MPB	<p>Visited Test-rig:</p> <ol style="list-style-type: none"> Adjusted PSU auto control current settings after calibration factors have been properly determined by JDC and MPB. Taped up PS cable plug to DT85 to ensure connection is sound Collected spare loan DT85 Logger (and grommet) Repaired cable termination fault at power supply to Windmaster 	-	
07/11/16	NJH	<p>Visited Test-rig to:</p> <ol style="list-style-type: none"> De-energised test-rig and accompanied NPower whilst they replaced faulty electricity meter. Then re-energised test-rig. Collected green DT85 connectors to return to Omni. Installed new 24V supply to DT85⁴ (See notes in "Outstanding tasks"). Filled in rodent hole nr electricity meter box cable duct (hockey-stick). Lubricated porta-cabin entrance door plate, locking mechanism & hinges. Inspected all Test-rig control equipment located in porta-cabin using FLIR cam. Completed new Maintenance Inspection Check-sheet. With assistance from WPD MEWP, reassemble 2 TCs on Rig 1 CCT 4 (Ash) due to measurement inaccuracy and check all TCs on Rig 1 CCT 4 (Ash) conductor are correctly identified (Discuss w/ MPB first). RW: Liaise w/ WPD for MEWP access. Activity to be performed during next visit. MPB stated not necessary w/c 31/10/16. Used wall heater whilst onsite; seemed ok. 	-	Complete
Jan 2017	PT	<p>Confirmed Electricity Supply Contract renewal w/ Npower (Was due to expire: 15/02/17) Price comparison checks performed via telephone with representatives of quotemyenergy.co.uk, LoveEnergySavings.com, and npower. Npower's 24mth contract offered the most competitive value. Signed up for next 2 years as of 13/01/17.</p>		Completed
16/01/17	NJH/RA/MPB	<p>Visit site to work on anemometer from MEWP and perform PAT testing on appropriate equipt.</p>		Completed
02/01/2017	PT JDC/NJH	<p>6mth maintenance inspection and contact brush replacement of REO PSUs scheduled for w/c 27/03/17. Spare brush sets received from REO 20/03/17. [REO stated (on 24/06/16) that they will provide spares and a Work Instruction (WI) in order that EATL can perform the next inspection(s). Maintenance date reflects re-energisation of rig c08/09/16] Re-calibration of Current-sensors to be performed during same visit.</p>	1/03/2017	WIP

⁴ Re-install DT85 internal-battery-link upon arrival at site in order to charge internal battery for 1h duration prior to replacing suspect 12V power supply with new 24V power supply. Ensure to remove internal-battery-link from DT85 once new 24V PS is installed.

Calendar of Scheduled Events 2016/17			Last updated: 23/03/17	
Mar 2017	PT	Prepare Site Decommission Method Statement: Deco Statement planning has commenced between PT & RW. RW to discuss various potential options considered with appropriate parties in due course.	July 2017	Ongoing
Mar 2017	PT	PO for 'Grounds maintenance' for 2017 placed with Hortech on 14/03/17.		WIP
1/07/2017	PT	Schedule 6mth maint. inspection of PSUs by EATL/REO	1/09/2016	
1/09/2017 (TBC)	PT/REO/TE	6mth maint. inspection of PSUs by EATL/REO		
Jan 2018		Stop gathering test data		
Mar 2018	PT	Decommission Test-rig and Site	June 2018	
July 2018	MPB	Produce Final Report		
July 2018		Site Lease Expires		

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