Report

Improved Statistical Ratings for Distribution Overhead Lines (Phase 2) Quarterly Report June 2017

Private and confidential

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Summary

This sixth Quarterly Report for the Improved Statistical Ratings for Distribution Overhead Lines (Phase 2) project being carried out at the Western Power Distribution (WPD) Stoke site, provides an update of operation since the last Quarterly Report published in April 2017 (which covered the period January to March 2017).

The Overhead Line (OHL) conductor test-rig has been formally operational since January 4th 2016, and continues to remain in a predominantly stable condition. Where any operational issues have arisen with the rig operation, they have been addressed swiftly by the EA Technology project team, with support and guidance from Project Sponsor, Sven Hoffmann, to maintain a stable and reliable rig operation.

Following a major fire incident during June 2016, the overhead line test rig was re-commissioned on 5th August 2016 and has remained operational and generally stable since, with only minor, ad-hoc, 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.

The conductor test rig is now running reliably with automatic daily data download and checking procedures. Conductor thermocouples have continued to work effectively and ambient sensors (temperature, wind, sunshine, rainfall) are generally working satisfactorily, the one exception being the Wind-Master 3D anemometer which frequently produces spurious readings for no apparent reason. Fortunately, there are two anemometers installed on the test rig and the adjacent unit has operated satisfactorily since the start of the rig operation.

A revised version of OHTEMP incorporating the new (2014) CIGRÉ equations has 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, with the initial results looking promising. A Cleansed Dataset, comprising a concatenation of the cleansed daily data files into monthly blocks, is being compiled.

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Appendices

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	Complete
		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	Complete
		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) test 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 demonstrated in Appendix I.

The **Reactive Maintenance Strategy** was formed to minimize down-time and enable efficient response and deployment of resources and is demonstrated in Appendix IV.

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 and is demonstrated in Appendix V.

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 and is demonstrated in Appendix VI.

EA Technology has made a significant number of scheduled and reactive visits to the OHL test-rig site since commencement of data collection 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 OHL test-rig management processes, documentation, and performance.

2. Summary of Progress

The Overhead Line (OHL) conductor test-rig has been formally operational since January 4th 2016, and continues (as at 1st August 2017) to remain in a predominantly stable condition. Where any operational issues have arisen with the rig operation, they have been addressed swiftly by the EA Technology project team, with support and guidance from Project Sponsor, Sven Hoffmann, to maintain a stable and reliable rig operation.

Following a major fire incident during June 2016, the overhead line test rig was re-commissioned on 5th August 2016 and has remained operational and generally stable since, with only minor, ad-hoc, 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.

As detailed in previous quarterly reports following the June 2016 fire fault incident, in order to prevent any reoccurrence, the rig monitoring and control equipment has been re-designed to reduce the likelihood of overheating and subsequent catastrophic failure.

The rig is now running reliably again and the automatic daily data download and checking procedures are working well.

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.

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.

Ambient sensors (temperature, wind, sunshine, rainfall) are generally working satisfactorily. The exception is the WindMaster 3D anemometer which frequently produces nonsense readings for no apparent reason. These glitches are generally short-lived but occasionally they last for several hours. Fortunately, the 2D WindSonic anemometer is behaving more reliably so during a WindMaster glitch we can simply blank out the WindMaster reading so that the average of the two anemometers is effectively just the Windsonic reading. We have programs set up that detect these instances of misreading, allowing the affected data to be weeded out automatically.

Neither a manual cleaning of the WindMaster connector and sensors on 17th January 2017, nor the replacing of the anemometer with another unit of the same type, has cured the problem.

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 Cleansed Dataset, comprising a concatenation of the cleansed daily data files into monthly blocks, is being compiled.

OHRAT and OHTEMP2 are currently being transformed into a single function with all the equations written in software code rather than as formulae in an Excel spreadsheet. This will allow it to be used independently of Excel spreadsheets.

3. 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.

3.1 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.

3.2 Data Checking and Cleansing

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. Red indicates the set value has been exceeded. This provides a visual monthly record of the data gathering process – see Table 1.

If the data checking program flags up a problem, the condat sheet of the CHECKDAT file for that day is inspected and the row(s) of data responsible for the flag identified. If necessary, the responsible data are corrected or deleted. This is part of the data-cleansing process. In many cases, correction or deletion is not necessary and the flag can be ignored, such as when the integrity parameter is the ratio of the of the two anemometer readings and the wind speed is close to zero.

Generally, correction is not worthwhile, and the offending row of data is deleted leaving a blank line for the time(s) concerned.

To date, the inspection and cleansing of the daily data files has been carried out manually but an automated cleansing routine has now been developed and is currently undergoing trials.

Table 1: Monthly Output Table warning of any malfunctioning of datalogger or instrumentation.

Conditional colouring based on how close parameter is to set value. Red indicates the set value has been exceeded.

Provides a visual monthly record of the data gathering process.

Date	No. of rawdat rows	No. of condat rows	Count A = 4	Count B = 4	TC13, TC14, TC15 max	Tbox max	Tbox min	Thutmax	TPSsmax	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	WS1o2	WAA1m2	Rain reset ((	Solh1m2	TC1..TC15 TC21..TC3 5 max	TC1..TC15 TC21..TC3 5 min	Trio 11H1 max range	Trio 11A max range	Trio 11H2 max range	Trio 14E max range	Trio 14A max range	Trio 22H1 max range	Trio 22A max range	Trio 22H2 max range	Trio 23E max range	Trio 23A max range
	rawdat rows	condat rows	countA (wspd avg)	countB (power avg)	hottest conductor	Tbox1 & 2 max	Tbox1 & 2 min	Thut1 & 2 max	TPSUs max	IC1 mean	IC2 mean	IC3 mean	IC4 mean	IC1 max & min	IC2 max & min	IC3 max & min	IC4 max & min	IC1 st dev	IC2 st dev	IC3 st dev	IC4 st dev	ws1/ws2	waa1-waa2	rain (max mm/min)	abs(solh 1-solh2)	Tcond too high	Tcond too low	Trio 11H1 max range	Trio 11A max range	Trio 11H2 max range	Trio 14E max range	Trio 14A max range	Trio 22H1 max range	Trio 22A max range	Trio 22H2 max range	Trio 23E max range	Trio 23A max range
alarm val	1440	1440	0	0	120	50	0	40	80	0.7%	0.7%	0.7%	0.7%	1.0%	1.0%	1.0%	1.0%	0.5%	0.5%	0.5%	0.5%	2	10	1.0	50	150	0	4	4	4	4	4	4	4	4	4	4
																						< critval diff'nt or either < 0.5															
Date	R<>crit	R<>crit	R<>crit	R<>crit	R>crit O>crit-10 Y>crit-20	R>=crit O>=crit-5	R<crit, O<crit+1	R>=crit O>=crit-2	R>=crit O>crit-2 Y>crit-5	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>critval O>crit*0.7	R>crit O>crit*0.7 Y>crit*0.3	R>critval O>crit*0.7	R>critval (tip=.254)	R>critval O>crit*0.7 Y>crit*0.3	R>critval	R <critval	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2	R>crit O>crit-1 Y>crit-2
01 June 2017	1440	1440	0	0	82	38	20	29	55	383	440	443	503	0.8%	0.6%	-0.5%	0.5%	0.2%	0.2%	0.2%	0.2%	2.0	-3	0.00	17	82	28	3.1	1.5	1.1	1.4	3.3	2.5	1.6	1.9	2.0	2.0
02 June 2017	1440	1440	0	0	71	38	22	31	58	384	441	443	503	1.0%	0.7%	0.6%	0.6%	0.2%	0.2%	0.2%	0.2%	2.4	-5	0.00	18	71	28	2.0	1.4	1.2	1.4	3.4	2.4	1.6	1.8	1.7	1.9
03 June 2017	1440	1440	0	0	67	34	19	26	53	383	440	442	503	0.6%	0.5%	-0.6%	-0.5%	0.2%	0.2%	0.2%	0.2%	2.3	0	0.25	16	67	21	2.1	0.9	1.3	1.3	2.6	2.5	1.4	2.5	1.4	1.5
04 June 2017	1428	1428	6	6	64	35	16	27	53	381	439	441	501	-100.0%	-100.0%	-100.0%	-100.0%	5.1%	5.1%	5.1%	5.1%	2.7	0	0.00	16	64	22	2.2	1.4	0.9	1.4	3.4	2.9	1.6	1.2	1.8	2.1
05 June 2017	1436	1436	2	2	59	32	16	25	51	382	440	442	502	-49.9%	-50.1%	-50.1%	-50.0%	2.0%	2.0%	2.0%	2.0%	2.7	-2	0.25	17	59	18	2.3	1.5	1.5	1.5	3.2	2.5	1.5	2.2	1.8	2.0
06 June 2017	1440	1440	0	0	38	28	17	21	47	382	440	442	502	-0.4%	0.4%	-0.6%	0.5%	0.1%	0.2%	0.1%	0.2%	3.2	-4	0.25	18	38	13	2.0	1.1	2.0	0.9	1.7	2.4	1.2	2.7	1.2	1.7
07 June 2017	1440	1440	0	0	33	29	17	22	48	382	440	442	502	-0.4%	0.4%	-0.6%	-0.5%	0.1%	0.1%	0.1%	0.2%	4.5	2	0.25	20	33	13	1.8	0.8	0.9	0.9	1.3	2.3	0.9	1.8	1.3	1.8
08 June 2017	1401	1401	6	6	49	33	19	25	52	381	438	441	501	-100.0%	-100.0%	-100.0%	-100.0%	5.2%	5.2%	5.2%	5.2%	6.1	-1	0.25	22	49	18	1.9	1.0	1.9	0.9	2.3	2.4	1.2	2.1	1.3	1.7
09 June 2017	1434	1434	3	3	52	34	17	27	53	382	439	442	502	-100.0%	-100.0%	-100.0%	-100.0%	3.1%	3.1%	3.1%	3.1%	1.9	-5	0.25	20	52	18	2.2	1.4	1.4	1.7	2.6	2.4	1.4	2.1	1.4	1.9
10 June 2017	1434	1434	1	1	62	35	19	28	55	383	440	442	502	-33.3%	-33.3%	-33.4%	-33.2%	1.0%	0.9%	0.9%	1.0%	5.0	-1	0.25	20	62	17	2.3	1.4	1.8	1.4	3.3	2.6	1.5	1.9	1.9	2.1
11 June 2017	1440	1440	0	0	51	33	19	26	52	383	440	442	503	0.5%	0.5%	-0.6%	0.5%	0.2%	0.2%	0.2%	0.2%	1.6	-6	0.25	14	51	20	3.2	1.1	1.9	1.3	2.8	2.6	1.6	2.6	1.8	1.8
12 June 2017	1440	1440	0	0	45	32	19	25	51	383	440	442	503	0.5%	0.4%	-0.6%	-0.5%	0.2%	0.2%	0.2%	0.2%	10.6	-3	0.00	17	45	21	1.9	1.3	1.1	1.2	2.9	2.2	1.4	1.3	1.4	1.9
13 June 2017	1440	1440	0	0	51	30	19	23	50	382	440	442	502	0.4%	0.4%	-0.6%	-0.5%	0.1%	0.2%	0.1%	0.2%	2.3	2	0.00	14	51	21	1.8	1.0	1.0	1.1	2.6	2.1	1.4	1.2	1.2	1.6
14 June 2017	1440	1440	0	0	84	33	17	26	53	383	440	443	503	0.6%	0.5%	-0.6%	-0.5%	0.2%	0.2%	0.2%	0.2%	17.1	1	0.00	19	84	28	2.3	1.3	1.0	1.3	2.9	2.5	1.5	1.8	1.7	1.8
15 June 2017	1440	1440	0	0	78	41	21	33	60	384	441	444	503	1.1%	0.8%	0.7%	0.6%	0.3%	0.2%	0.3%	0.2%	2.1	-4	0.00	19	78	26	2.0	1.3	0.9	1.4	3.1	2.2	1.5	1.5	1.7	2.1
16 June 2017	1440	1440	0	0	54	35	20	28	55	383	440	443	502	0.9%	0.7%	-0.6%	-0.5%	0.2%	0.2%	0.2%	0.2%	8.5	4	0.00	22	54	22	1.9	1.3	1.0	1.3	3.1	2.3	1.6	1.2	1.7	1.9
17 June 2017	1440	1440	0	0	63	36	20	29	56	383	441	443	503	0.8%	0.6%	-0.5%	0.5%	0.2%	0.2%	0.2%	0.2%	6.4	0	0.00	18	63	24	2.1	0.9	0.9	1.1	2.6	2.2	1.5	1.5	1.5	1.5
18 June 2017	1440	1440	0	0	83	45	20	36	64	385	441	444	503	1.6%	1.1%	1.0%	0.8%	0.4%	0.3%	0.3%	0.3%	11.2	1	0.00	22	83	30	2.4	1.5	1.1	1.6	3.3	2.6	1.9	1.9	2.2	2.3
19 June 2017	1440	1440	0	0	84	47	23	38	66	385	442	445	503	1.8%	1.2%	1.2%	0.8%	0.5%	0.3%	0.4%	0.3%	26.6	-2	0.00	23	84	36	2.3	1.5	1.1	1.7	3.7	2.6	1.9	2.1	2.3	2.2
20 June 2017	1440	1440	0	0	86	48	24	39	67	385	442	445	503	1.8%	1.2%	1.2%	0.8%	0.5%	0.3%	0.4%	0.3%	21.4	-5	0.00	18	86	29	2.1	1.4	1.0	1.6	3.3	2.4	1.7	1.8	2.2	2.1
21 June 2017	1440	1440	0	0	67	41	22	33	60	384	441	444	503	1.1%	0.8%	0.7%	0.6%	0.3%	0.2%	0.2%	0.2%	14.4	6	0.00	22	67	24	2.0	0.9	1.1	0.5	2.2	2.1	0.9	1.7	1.4	1.5
22 June 2017	1440	1440	0	0	86	40	23	34	62	385	441	444	503	1.3%	0.9%	0.8%	0.6%	0.3%	0.2%	0.2%	0.2%	4.2	1	0.00	16	86	25	2.5	1.0	0.9	1.2	2.8	2.4	1.6	2.2	1.6	1.8
23 June 2017	1440	1440	0	0	64	35	21	28	54	383	440	443	503	0.6%	0.5%	-0.5%	-0.5%	0.2%	0.2%	0.2%	0.2%	67.2	-1	0.25	24	64	21	1.8	1.0	0.9	1.0	2.5	2.1	1.3	1.1	1.4	1.5
24 June 2017	1440	1440	0	0	47	32	21	26	53	383	440	443	502	0.5%	0.5%	-0.5%	-0.5%	0.1%	0.2%	0.1%	0.2%	75.8	12	0.00	15	47	21	2.7	1.0	0.9	1.0	2.6	2.1	1.3	1.0	1.3	1.5
25 June 2017	1440	1440	0	0	51	34	21	28	54	383	440	443	502	0.7%	0.5%	-0.5%	-0.5%	0.2%	0.2%	0.2%	0.2%	113.6	1	0.00	18	51	23	1.9	0.9	1.0	0.8	2.0	2.0	1.2	1.3	1.2	1.5
26 June 2017	1440	1440	0	0	79	31	16	24	50	382	440	442	502	0.4%	0.5%	-0.6%	-0.6%	0.2%	0.2%	0.2%	0.2%	1.8	0	0.25	16	79	23	2.5	1.5	2.2	1.0	2.5	3.4	1.4	2.3	1.5	1.6
27 June 2017	1440	1440	0	0	75	35	18	26	53	383	440	443	503	0.6%	0.5%	-0.5%	-0.5%	0.2%	0.2%	0.2%	0.2%	43.0	2	0.00	18	75	21	2.3	1.2	1.3	1.2	2.7	2.4	1.4	2.1	1.6	1.6
28 June 2017	1440	1440	0	0	51	33	20	25	51	383	440	442	502	0.5%	0.5%	-0.5%	-0.5%	0.1%	0.2%	0.1%	0.2%	1.9	5	0.25	20	51	20	2.5	1.0	1.7	0.8	1.2	2.8	1.0	2.7	1.2	1.9
29 June 2017	1440	1440	0	0	49	27	17	21	48	382	440	442	502	-0.4%	-0.4%	-0.6%	-0.5%	0.1%	0.2%	0.1%	0.2%	1.9	-3	0.25	15	49	15	2.4	0.9	0.9	0.6	1.6	2.5	0.9	1.5	1.3	1.7
30 June 2017	1440	1440	0	0	60	28	18	21	48	382	440	442	502	-0.4%	0.4%	-0.6%	-0.5%	0.1%	0.1%	0.1%	0.2%	2.8	1	0.25	13	60	16	2.2	1.0	1.0	0.8	1.3	2.7	1.2	1.3	1.4	1.8

3.2.1 Logger and Anemometer Glitches

Most of the significant red flags relate to two particular sources, namely logger glitches, where rows of data are missing or corrupted for some reason, and anemometer glitches, where one or more of the three outputs of the 3D WindMaster anemometer suddenly drop to zero for no apparent reason, corresponding to large negative wind components of minus 45 m/s.

The glitches have been dealt with by deleting part or all of the suspect row in condat, plus one row either side of it. For the logger glitches, complete rows of data are deleted but for the anemometer glitches, only the data relating to the WindMaster anemometer have been deleted, leaving a valid row of data based on the reading of just the second (WindSonic) anemometer rather than the usual average of two anemometer readings.

The logger glitches are apparently caused by the logger stopping and then restarting itself. A cure now seems to have been found, albeit at the expense of reducing our ability to start and stop the logger from Capenhurst during an emergency.

We have been unable to find any cause for the WindMaster glitches and are now in the process of obtaining and installing a replacement unit on loan from the manufacturers while they carry out checks on the original unit.

3.3 Validation of Cigre Equations using Experimental Data

3.3.1 The Cigre Equations and OHTEMP2

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 developed in 2010 by EA Technology for members of the Overhead Line Module of the STP that uses the 1992 CIGRÉ equations to calculate the temperature of a conductor carrying a specified current under specified ambient conditions. A revised version, OHTEMP2, that incorporates the new (2014) CIGRÉ equations (with MPB solar gain revision – see below) has been developed as part of the present project. OHTEMP2 is currently being transformed into a function with all the equations written in software code. This will allow it to be used independently of Excel spreadsheets.

Note that the solar gain equations given in TB601 are seriously wrong[2]. A member of the EA Technology project team (Mark Bertinat) has developed a revised set of solar gain equations which are to be published in a revised version of TB601, and these revised solar gain equations are the ones used in OHTEMP2. They can be found Appendix I of this document.

3.3.2 Comparison of measured and calculated conductor temperatures

A comparison of the measured conductor temperatures and the values calculated from the measured weather data using OHTEMP2 has been carried out on a limited scale and initial results are promising. A relatively "high-temperature day" was selected, namely 29-30 Oct 2016, when the

[1] CIGRÉ Technical Brochure TB601, "Guide for thermal rating calculations of overhead lines" (2014)

[2] For example, they imply that in summer, the sun rises south (rather than north) of East, travels east (!) until 6am by which time it is in the East. It then reverses direction(!) and travels west (correctly) until 6pm when it again reverses direction to set south (rather than north) of West.

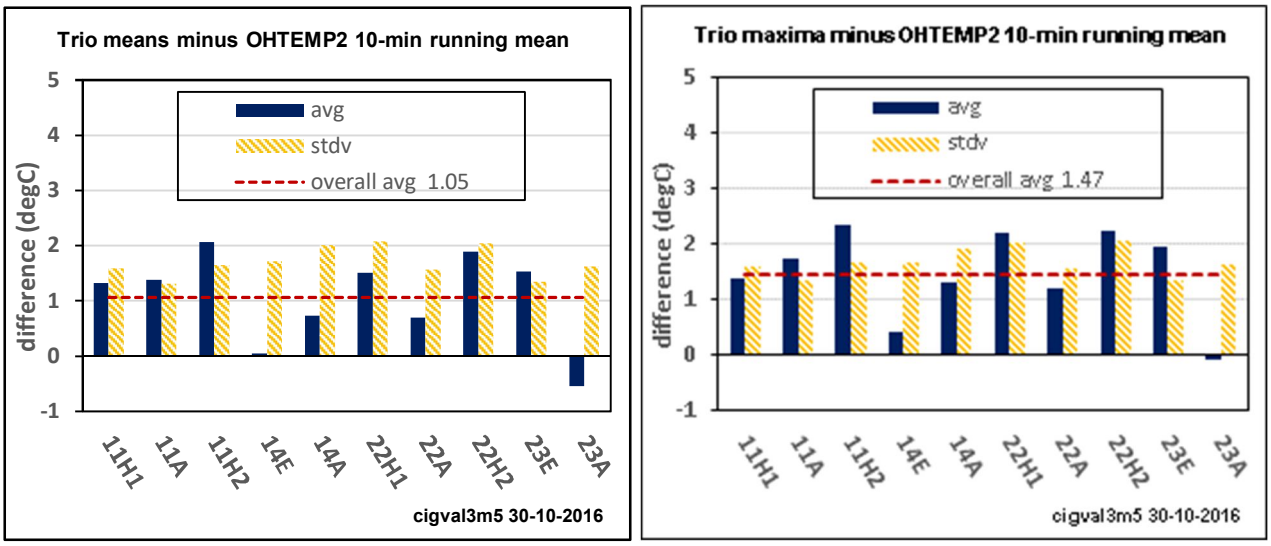
hottest conductor, Ash 500 (14A), reached 78 degC. The measured and calculated values for each conductor were compared every minute of the day and the average difference determined.

Comparisons were carried out using both the trio means (the mean of the readings of the three thermocouples mounted on each conductor) and the trio maxima (the maximum of the three readings).

It was found that

a) The calculated temperatures fluctuated much faster than the measured ones, presumably because a conductor's response to fluctuations in wind speed and direction is constrained by its thermal time constant which is of the order of 10 minutes.
b) Hence, better overall agreement was obtained if a 10-minute running mean was used for the calculated values.
c) Using delayed measured values rather than instantaneous ones had little effect.

Figure 1 shows the average differences (along with standard deviation, or spread) obtained for each conductor using 10-minute running means for the calculated values and either the trio means or the trio maxima for the measured values.



(a) trio means *(b) trio maxima*

Figure 1 Difference between measured conductor temperatures and values calculated using OHTEMP2 (CIGRÉ 2014 equations) for a "high-temperature day" (29-30 October 2016)

The graphs show that

a) Daily averages generally agree to within about 2 degC for all conductors.
b) Trio means give rather better agreement than trio maxima.
c) For the hottest conductor, 14A (i.e. Ash 500), the average differences are
    - 0.73 ± 2.0 for the trio means (the ± figure is the standard deviation)
    - 1.33 ± 1.9 for the trio maxima

    where the ± figure is the standard deviation.
d) The overall averages across all conductors are 1.05 for trio means and 1.47 for trio maxima.

The intention is to repeat this comparison for a limited selection of other days, say one day per month.

3.3.3 Length of Running Mean

The thermal time constants of the conductors had been observed to be of the order of 10 minutes, so a running mean length of this magnitude was expected to give optimum results. Figure 2 shows that this is indeed the case as far as the scatter of the difference data over a day is concerned, with standard deviation, maximum and minimum values all showing a definite optimum for running-mean length of around 10 minutes. However, the average difference shows no obvious optimum value, but rather a very gradual increase with running-mean length.

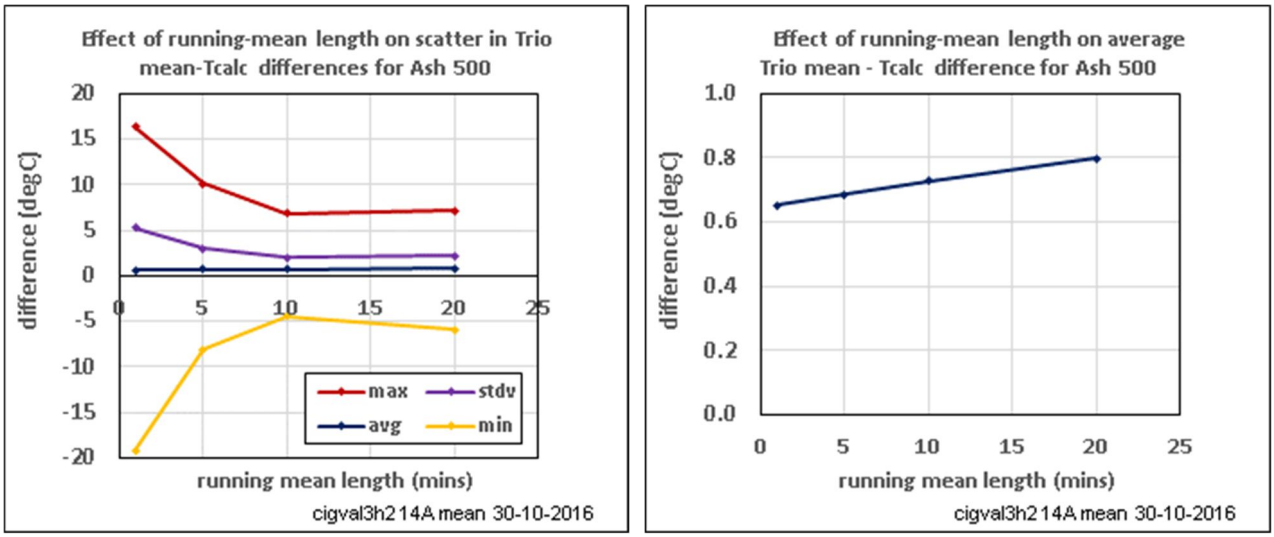


Figure 2: Effect of length of running-mean on difference between measured and calculated temperatures

(a) max, min, and avg difference, and st dev *(b) average difference*

Figure 3 shows the effect on scatter of using a 10-minute running mean rather than instantaneous values.

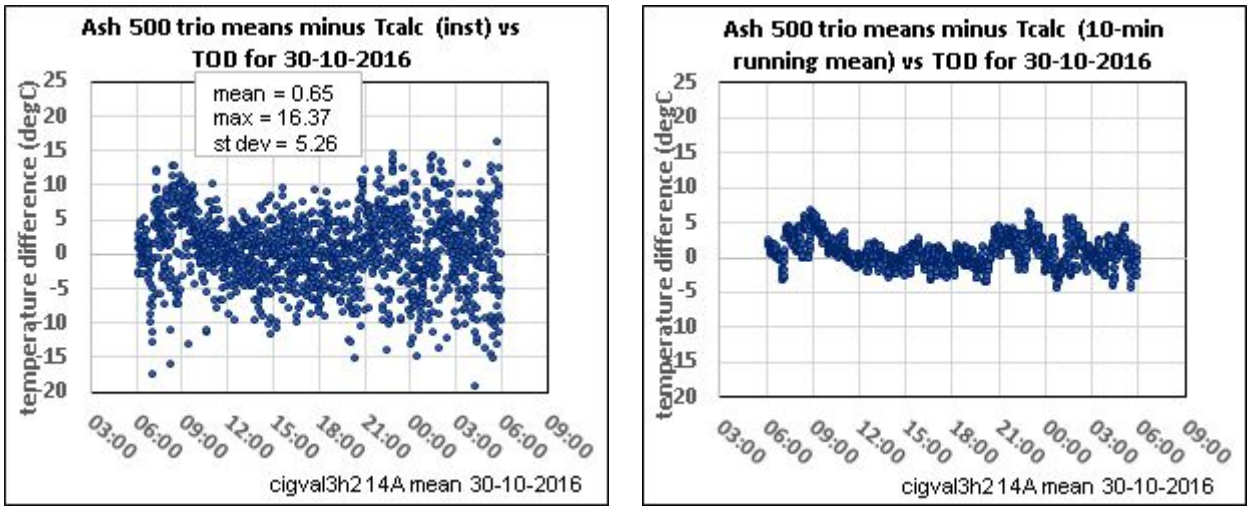


Figure 3: Effect of 10-min running-mean on difference between measured and calculated temperatures

(a) using instantaneous Tcalc *(b) using 10-min running mean for Tcalc*

3.3.4 Validation of data using CIGRÉ Equations

It could be argued that comparing the measured conductor temperatures with the values calculated from the measured ambient data using the CIGRÉ equations (i.e. OHTEMP2) validates the experimental data as well as the CIGRÉ equations. In fact, an example of this actually occurred this comparison which resulted in a considerable improvement in the accuracy of some of the conductor temperatures.

Initially, the agreement between experimental and calculated temperatures was significantly poorer for Hazel, (up to 4 degC difference) than for the Ash and Elm conductors (~1 degC). This led to the discovery of inaccuracies in the calibrations of the transducers used to measure the Hazel currents. Recalibrating these transducers resulted in Hazel differences similar to those of Ash and Elm[3].

4. 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 concatenation, the daily condat files need to be checked and, if necessary, cleansed (see Section 3.2 above). Initially this was done manually but the process has now been automated (1/8/17).

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 two or three readings.

The only possible exceptions 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 fact, as we have seen, the trio means may give better agreement with the calculated values than the trio maxima. The draft dataset will include both trio means and trio maxima. It will be a simple matter to remove the unwanted ones in the final version.

The parameters for which a suitable "best" value needs to be determined are shown in Table 2

[3] It should be noted that recalibrating these transducers directly would have involved partly dismantling the rig, which would have caused major disruption. An alternative method was devised that involved accurately measuring the ratio of the two Hazel currents on the same circuit and comparing this with the total current on that circuit. This allowed an accurate estimate of the Hazel currents to be made.

				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

Table 2: Parameters for which a suitable "best" value needs to be determined

Appendix I Revised Solar Heating Calculation for CIGRÉ Technical Brochure TB601

Solar heating calculation used in OHTEMP2. MPB revision of Section 3.3 of CIGRÉ Technical Brochure TB601, "Guide for thermal rating calculations of overhead lines" (2014). Numbers in square brackets indicate references in original TB601.

Solar heating calculation

The solar heat gain per unit length by a conductor, P_S (W/m), is directly proportional to the outer diameter of the conductor, D (m), the absorptivity of the surface of the conductor, α_S, and the global radiation intensity I_T (W/m^2) [23]:

$$P_S = \alpha_S \cdot I_T \cdot D \qquad (8)$$

The value of α_S varies from around 0.2 for a bright new conductor to around 0.9 for a weathered conductor in an industrial environment [17, 5]. A new conductor in a heavy industrial environment weathers to around α_S = 0.5 after about one month's exposure, and to around α_S = 0.9 after about one year. The rate of weathering is slower in rural areas. It is not easy to measure the absorptivity accurately. The recommended methods are either determining the emissivity of the conductor, by measuring samples and then estimating absorptivity to be slightly higher than this value (0.1 – 0.2 higher), or using a default absorptivity of no less than 0.8 [5].

Devices for measuring global radiation intensity I_T are relatively inexpensive and reliable, and can be easily used for line monitoring systems [64], as they can provide measurements of the mean global radiation intensity for a period of time for the dynamic thermal rating calculations. But there are some considerations that have to be noted. The global radiation received by the conductor is not necessarily the same at all points along the line. It depends on the location, and important differences may arise due to different orientation, sheltered areas, reflectance from ground, etc. The variability with time is also not the same at all points along the line.

For planning or design, it is common to consider a "worst-case" situation, for which the maximum expected value of the global radiation I_T can be anticipated. Care must be taken in anticipating the right values, and their coincidence with other ambient parameters [5]. A value can be estimated for a given location and orientation of the line, and for a specific time and day of the year, from the relative position of the sun (see the formulae below).

The global radiation intensity, I_T, is a combination of the direct solar radiation on a surface normal to the beam, I_B, the diffuse sky radiation to a horizontal surface, I_d, and the incident radiation reflected from the ground or albedo, F. The formula for the total solar power received per unit length of the conductor P_S (W/m) is given by [19, 23, 29]:

$$P_S = \alpha_S \cdot D \cdot \left[I_B \cdot \left(sin(\eta) + \frac{\pi}{2} \cdot F \cdot sin(H_S) \right) + I_d \cdot \left(1 + \frac{\pi}{2} \cdot F \right) \right] \qquad (9)$$

where:

α_S = absorptivity of conductor surface (see the text above)

D = diameter of the conductor (m)

I_B = direct (beam) solar radiation intensity (W/m^2)

η = the angle of solar beam with respect to the axis of the conductor

F = the albedo or reflectance of the ground

H_S is the solar altitude, the height of the sun above the horizon.

An equation to calculate the direct solar radiation at sea level, $I_{B(0)}$, is [66]:

$$I_{B(0)} = N_S \cdot \frac{1280 \cdot sin(H_S)}{sin(H_S) + 0.314} \quad (10)$$

where N_S is a clearness ratio, having the value of 1.0 for the standard atmosphere, 0.8 to 1.2 for clear skies with decreasing amounts of dust and aerosols, 0.5 for an industrial atmosphere and less than 0.5 for a cloudy or overcast sky. With thick cloud, N_S = 0. The direct beam irradiation I_B increases with increasing height above sea level, y, according to the following equation [67]:

$$I_{B(y)} = I_{B(0)} \cdot \left[1 + 1.4 \cdot 10^{-4} \cdot y \cdot \left(\frac{1367}{I_{B(0)}} - 1\right)\right] \quad (11)$$

H_S is given by:

	H_s	= arcsin(sinδ_s.sinφ + cosδ_s.cosφ.cosZ)			(12a)
where	δ_s	Solar Declination (angle between equator and a line drawn from centre of the Earth to centre of the sun)	=	23.45xsin(360(284+N*)/365)	(12b)
	φ	= Latitude (+ to North)			
	Z	is the Hour Angle (angle between the sun's position and its noon position)	=	15x24 (LST-LT0)-180	(12c)
and	N*	Day Number	=	day of the year (Jan 1st = 1)	
where	LST	Local Solar Time (local time adjusted for longitude and time zone)	=	LT+TC/(24x60)	(12d)
	LT	Local Time (clock time)	=	dd/mm/yyyy hh:mm:ss	(12e)
	LT0	Reference Time (previous midnight)	=	dd/mm/yyyy 00:00:00	(12f)
	TC	Longitude Time Correction Factor	=	4(ϑ-LSTM)+EoT	(12g)
where	ϑ	= Longitude (+ to E)			
	TZ	Time Zone (+ to East) - local time minus GMT in h	=	LT - GMT	(12h)
	LSTM	Local Std Time Meridian (angular correction for TZ)	=	15 TZ	(12i)
	EoT	Equation of Time (corrects for Earth's axial tilt and orbital eccentricity)	=	9.87 sin(2B)-7.53 cos(B)-1.5 sin(B)	(12j)
	B	EoT angular parameter	=	360(N-81)/365	(12k)

I_d is the diffuse solar radiation intensity (W/m^2). There is a correlation between direct irradiation I_B and diffuse irradiation I_d, as clouds cause both a reduction in I_B and an increase in I_d. An equation to calculate the diffuse irradiation for all skies is [68]:

$$I_d = (430.5 - 0.3288 \cdot I_B) \cdot sin(H_S) \quad (13)$$

η, the angle of the solar beam with respect to the axis of the conductor is given by:

$$\eta = arccos[cos(H_s) \cdot \cos(\gamma_S - \gamma_C)] \quad (14)$$

where:

γ_S = Solar Azimuth (angle between Sun and N)

γ_C = azimuth of the conductor (angle between conductor and N)

Care is necessary when calculating the Solar Azimuth, $\boldsymbol{\gamma_S}$. It is a function of, but is not necessarily equal to, the Solar Azimuth parameter, $\boldsymbol{\gamma_p}$, see below. Ignoring this fact will produce some very strange results, like the sun moving backwards across the sky at certain times of the day!

	γ_p	solar azimuth parameter (rel. to N)		=	arccos[(sinδ.cosφ - cosδ.sinφ.cosZ)/cosα]	(14a)
	γ_S	solar azimuth (rel. to N)		=	γ_p or (360- γ_p) depending on hour angle Z	(14b)
		Z less than -180	γ_S	=	360 - γ_p	(14c)
		Z between -180 and 0	γ_S	=	γ_p	(14d)
		Z between 0 and 180	γ_S	=	360 - γ_p	(14e)
		Z greater than 180	γ_S	=	γ_p	(14f)

F is the albedo or reflectance of the ground. The albedo F is approximately 0.05 for a water surface ($H_S > 30^\circ$), 0.1 for forests, 0.15 for urban areas, 0.2 for soil, grass and crops, 0.3 for sand, 0.4 to 0.6 for ice and 0.6 to 0.8 for snow. The albedo tends to increase as the solar altitude H_S increases.

The residual gain at night can be considered negligible.

Appendix II Project Summary Activity Log

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 30ºC 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 thermo-couples 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.
01/02/216	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

Start Date	Issue Description	Date Resolved	Action and Consequence
			resulting from logger firmware update. Fixed.
16/02/16	Power supply unit (PSU) 3 had ceased automatic regulation, consequently, the output voltage and current were tracking the line input	24/02/16	A repair was carried out by modifying the 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)

Start Date	Issue Description	Date Resolved	Action and Consequence
05/05/16	Logger malfunctioned – lost a line of data	18/5/16	Ongoing discussions with DataTaker
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 Datataker 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).

Start Date	Issue Description	Date Resolved	Action and Consequence
			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.
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

Start Date	Issue Description	Date Resolved	Action and Consequence
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, sensor heads wiped. (PSUs switched off for an hour)	17-Jan-17	lost data
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

Start Date	Issue Description	Date Resolved	Action and Consequence
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
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
30-Mar-17	4 Logger glitches		Inserted 4 blank rows in condat.
31-Mar-17	Logger glitch. Minor WMaster glitch.		Inserted 4 blank rows and deleted data in 3 others. Deleted 1 row of WMaster data.
06-Apr-17	WMaster glitch	06-Apr-17	Row deleted.
07-Apr-17		07-Apr-17	PSUs switched off while checking Hazel current monitors calibrations.
10-Apr-17	Logger glitches. Corrupt data - missing, jumbled and duplicate rows	10-Apr-17	Deleted data in condat.

Start Date	Issue Description	Date Resolved	Action and Consequence
13-Apr-17		13-Apr-17	Converted Hazel currents to hfac1.IC1 etc.
20-Apr-17		20-Apr-17	Highlight in red times in Output Table if any red in row.
24-Apr-17	Logger glitches. Corrupt data - missing, jumbled and duplicate rows	24-Apr-17	Deleted data in these rows in condat.
27-Apr-17		27-Apr-17	Added row number for maximum Ws1o2 in condat cell CQ15 (uses Match function).
02-May-17	2 Logger glitch: 3 rows missing.	02-May-17	Deleted data in condat.
02-May-17	WMaster glitch	02-May-17	Deleted data in condat.
03-May-17	Logger glitch:3 rows missing.	03-May-17	Deleted data in condat.
03-May-17	WMaster glitch	03-May-17	Deleted data in condat.
05-May-17		05-May-17	Logger power supply replaced in attempt to stop logger glitches.
05-May-17	Noticed hut-end solarimeter (solh2) in hut shadow in afternoon.	05-May-17	Needs repositioning.
11-May-17		11-May-17	Hut-end solarimeter (solh2) relocated
11-May-17		11-May-17	ws1o2 condition for Output Table modified to stop overzealous reds when wsp <0.5.
12-May-17		12-May-17	Altered ws1o2 condition.
12-May-17	Logger glitch: 7 missing rows	12-May-17	Deleted data in condat.
12-May-17	Logger glitch: 2 missing rows	12-May-17	Deleted data in condat.
12-May-17	Logger glitch: 3missing rows	12-May-17	Deleted data in condat.
13-May-17	Logger glitch: 3 rows missing.	13-May-17	Deleted data in condat.
13-May-17	Logger glitch: row 0826 corrupt.	13-May-17	Deleted data in condat.

Start Date	Issue Description	Date Resolved	Action and Consequence
15-May-17	WMaster glitch	15-May-17	Deleteted row of data in conplot
17-May-17	WMaster glitch	17-May-17	Deleteted row of data in conplot
18-May-17	1 WMaster glitch	18-May-17	Deleted row in condat.
18-May-17	Logger glitch: Power and solar data all down 25% at 1638: suggests logger glitch with only 3 of 4 readings logged (CountB).	18-May-17	Deleted data in condat.
18-May-17	Logger glitch:2 scans missing	18-May-17	Added empty rows in condat and deleted data.
18-May-17	Logger glitch: 13 scans missing	18-May-17	Added empty rows in condat and deleted data.
18-May-17	Logger glitch: 13 scans missing	18-May-17	Added empty rows in condat and deleted data.
18-May-17	Logger glitch: 13 scans missing	18-May-17	Added empty rows in condat and deleted data.
18-May-17	Logger glitch: 12 scans missing	18-May-17	Added empty rows in condat and deleted data.
19-May-17	Flagged ws1o2 error irrelevant - v low ws1 & ws2.	19-May-17	Need to change condition because it deals in avgs.
19-May-17		19-May-17	Further modified ws1o2 condition.
20-May-17		20-May-17	Logger stopped to reinstate 24V Omni power supply.
20-May-17	2 WMaster glitches	20-May-17	Deleted data in condat.
24-May-17	1 Wmaster glitch	24-May-17	Deleted Wmaster data in condat.
24-May-17	1 Wmaster glitch	24-May-17	Deleted WMaster data in condat
24-May-17	Logger missed a scan	24-May-17	Deleted data in condat
25-May-17	4 WMaster W glitches	25-May-17	Deleted WMaster data in condat
25-May-17	sol2 low 1409-1733.	25-May-17	

Start Date	Issue Description	Date Resolved	Action and Consequence
25-May-17	1 Wmaster glitch	25-May-17	Deleted WMaster data in condat.
25-May-17	1 Wmaster glitch	25-May-17	Deleted WMaster data in condat
26-May-17	1 WMaster glitch	26-May-17	Deleted WMaster data in condat.
26-May-17	Main hut cooling fans no longer able to keep max Thut down to 20degC; Coincides with max Tamb reaching 20 degC; Thutmax reached 35.	26-May-17	
27-May-17	sol2 low 1310-1718.	27-May-17	
30-May-17	2 WMaster glitches	30-May-17	Deleted WMaster data in condat.
31-May-17	Logger glitch: scan missing	31-May-17	Added row and deleted data in condat
04-Jun-17	6 Logger glitches	04-Jun-17	Added empty rows in condat.
05-Jun-17	3 Logger glitches	05-Jun-17	Added empty rows in condat.
06-Jun-17	3 WMaster glitches	06-Jun-17	Deleted WMaster data in condat.
07-Jun-17	4 WMaster glitches	07-Jun-17	Deleted WMaster data in condat.
08-Jun-17	8 Logger glitches	08-Jun-17	Added empty rows in condat and deleted before & after data.
08-Jun-17	1 WMaster major glitch, 3 minor glitches	08-Jun-17	Deleted WMaster data in condat.
09-Jun-17		09-Jun-17	Put battery link back in on logger to try and prevent the glitches.
09-Jun-17	3 Logger glitches	09-Jun-17	Added empty rows in condat and deleted before & after data.
10-Jun-17	Major Logger glitch	10-Jun-17	Added empty rows in condat and deleted before & after data.

Start Date	Issue Description	Date Resolved	Action and Consequence
10-Jun-17	Dip in circuit amps at 1300; Minor dip in circuit amps at 1322.	10-Jun-17	Deleted both rows of data.
10-Jun-17	1 WMaster glitch	10-Jun-17	Deleted WMaster data in condat.
12-Jun-17	1 WMaster major glitch & 2 minor glitches	12-Jun-17	Deleted WMaster data in condat.
14-Jun-17	8 WMaster glitches	14-Jun-17	Deleted WMaster data in condat. Logger OK.
15-Jun-17	IC1 excess creeping above 1%.	15-Jun-17	Added IC1-4 XS graphs to daily avg & daily max.
16-Jun-17	2 WMaster glitches	16-Jun-17	Deleted WMaster data in condat. Logger OK.
17-Jun-17	2 WMaster glitches	17-Jun-17	Deleted WMaster data in condat. Logger OK.
18-Jun-17	Max IC1-3 all >1%.	18-Jun-17	Added ICi/Iref plot in conplot2a and copied hut temperatures graph into conplot2a.
18-Jun-17	4 WMaster glitches	18-Jun-17	Deleted WMaster data in condat.
19-Jun-17	WMaster gone haywire; Logger OK.	19-Jun-17	
20-Jun-17	WMaster still haywire.	20-Jun-17	
21-Jun-17	WMaster haywire upto 1800	21-Jun-17	
22-Jun-17	WMaster glitch (only one!).	22-Jun-17	Deleted WMaster data in condat.
23-Jun-17	Major WMaster glitch, mostly reading -45m/s on U V & W; Minor WMaster glitch.	23-Jun-17	Deleted relevant WMaster data in condat. Logger OK.
24-Jun-17	WMaster gave up at 0838 (U V W all -45m/s) till 0600 next day.	24-Jun-17	
25-Jun-17	WMaster missed readings	25-Jun-17	Deleted relevant WMaster data in condat. Logger OK.
26-Jun-17	Single WMaster glitch	26-Jun-17	Deleted WMaster data in condat. Logger OK.

Start Date	Issue Description	Date Resolved	Action and Consequence
27-Jun-17	2 WMaster glitches	27-Jun-17	Deleted WMaster data in condat. Logger OK.
28-Jun-17	Single WMaster glitch	28-Jun-17	Deleted WMaster data in condat. Logger OK.
29-Jun-17	2 WMaster glitches	29-Jun-17	Deleted WMaster data in condat. Logger OK.
29-Jun-17		29-Jun-17	Added count of nos.of valid readings in rows 13-15 (TCs) and rows 1-3 (non TCs).
01-Jul-17		01-Jul-17	WMaster replaced by another loaned from Gill.
05-Jul-17	2 WMaster glitches	05-Jul-17	
06-Jul-17	1 minor WMaster glitch(W = -7.3).	06-Jul-17	
07-Jul-17	1 minor WMaster glitch	07-Jul-17	
08-Jul-17	4 WMaster glitches	08-Jul-17	Deleted WMaster data in condat.
09-Jul-17	1 (maybe 2) WMaster glitches	09-Jul-17	Deleted WMaster data in condat.
10-Jul-17	1 WMaster glitch.	10-Jul-17	Deleted WMaster data in condat.
11-Jul-17		11-Jul-17	Revised Tests to give count of times ws1/ws2 >2 and ws2 > 1.
11-Jul-17		11-Jul-17	Changed to using all criteria in Tests rather than using condat DH conditional data.
12-Jul-17	Max trio spread 4.1 (11H2); other hazels (11h1, 22H1, 22H2) all hit >3.0 following heavy rain.	12-Jul-17	
14-Jul-17	1 WMaster glitch.	14-Jul-17	Deleted WMaster data in condat.
17-Jul-17	2 minor, 1 major WMaster glitches	17-Jul-17	Deleted WMaster data in condat.
18-Jul-17	IC1 max excess 1.13%.	18-Jul-17	

Start Date	Issue Description	Date Resolved	Action and Consequence
19-Jul-17	1 WMaster glitch.	19-Jul-17	Deleted WMaster data in condat.
20-Jul-17	1 WMaster glitch.	20-Jul-17	Deleted WMaster data in condat.
20-Jul-17	IC1 max excess back down to 0.83%.	20-Jul-17	
24-Jul-17	Max trio spread 5.0 (22H2); >4 for 5 mins.	24-Jul-17	Deleted 22H2 data in condat.
24-Jul-17	1 WMaster glitch.	24-Jul-17	Deleted WMaster data in condat.
24-Jul-17	Max trio spread 5.3 (22H2); >4 for 12 mins.	24-Jul-17	
25-Jul-17	WMaster stopped working.	25-Jul-17	Deleted WMaster data in condat.
26-Jul-17	WMaster started working again, Single glitch.	26-Jul-17	Deleted WMaster data in condat.
28-Jul-17	WMaster hour-long glitch	28-Jul-17	Deleted WMaster data in condat.
31-Jul-17	11H1 trio max hit 4.0 but no errror message.	31-Jul-17	Change ">=" to ">" in Tests J30-M38.
31-Jul-17	2 WMaster glitches	31-Jul-17	Deleted WMaster data in condat.
31-Jul-17	1 WMaster glitch	31-Jul-17	Deleted WMaster data in condat.

Appendix III EA Technology Outstanding Task List for Test-rig

Task List A	Outstanding Tasks at / for Test-site, Stoke Last updated: 16/05/17			Index page Contact List
Priority	Person Responsible	Problem/Action/Event/Comment	Comment or Est'd time (hrs)	Phase (1 or 2)
	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 @ 38ºC [MPB] & Trip @ 42ºC [RA]; Squirrel Trip at 43ºC [AW]	Pre-visit tasks Tasks at Stoke To take
	PT/NJH	Replace U/S 'curtain-fan' fans: approx. 4 have failed. SUNON, EEC0252B2-000U-A99, DC24V, 3.5W T:\NIA Folders\NIA Projects\Projects\SN0004\SN0004 - Site Visits\Phase 2\photos\2017_04_06 maintenance & check wiring for split currents\IMG_0402		
	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		

Task List A	Outstanding Tasks at / for Test-site, Stoke	Last updated: 16/05/17		Index page Contact List
	TBC	1. Adjust PSU auto control current settings after calibration factors have been properly determined by JDC and MPB. 2. Complete new Maintenance Inspection Check-sheet 3. 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]**	
	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): • Datataker: PSUs set at 80ºC; THUTs set at 40ºC. • Squirrel: PSU 1-3 currents set at >10%; PSU 4 >5%; THUTs 43ºC		
	Team	Review performance feedback loop (Frequency of meetings, sensor threshold alarms, trigger recipients, webcam review, etc.)		

Task List A	Outstanding Tasks at / for Test-site, Stoke Last updated: 16/05/17			Index page Contact List
	MPB	Monitor ambient temperature within auxiliary pole cabinets. Consider installation of localised heating if ambient temp. =<0ºC. 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	
	RW/PT	1page PR document for WPD (A. Pickering to approve all pics)		
	PT/RW	Closing project review for EATL/WPD/Suppliers/DNOs/Project members		

Appendix IV 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	8	Health & Safety Advisor	Greg Watson	0151 347 2256
				I	Liaise with and deploy resource at an appropriate time	9	Technical Engineers	Ralph Eyre-Walker	0151 347 2375 07894 392833

J	Liaise with and deploy resource immediately

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 V Maintenance Inspection Check-sheet

Task List D	Maintenance Inspection Check-sheet	Version update: 26/01/16	Maintenance Inspection completion date:

Description:

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.

Module		Component		Action	Frequency	HR	Equipment required	Initials	Comments
	Test-rig control & monitoring equipment (Indoor)	A	Weld cables	Visual assessment[4] and comparative sweep across the four supplies w/ FLIR	Each visit[5]	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		

[4] '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, pro-active 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.

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

		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		
		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[6] / 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			

[6] '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 VI Calendar of Scheduled Project Events

Calendar of Scheduled Events 2016/17		Last updated: 01/07/17		
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 1st 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 1st 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 1st Visual Inspection?)	24/02/2016	Mods made to proximity switches by JDC

Calendar of Scheduled Events 2016/17		Last updated: 01/07/17		
10/05/16	NJH	Nick visited site to reset rig after Cabin over-temp trip (>40ºC) 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
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		

Calendar of Scheduled Events 2016/17		Last updated: 01/07/17		
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 (2nd & 4th 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		
22/08/16	PT	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.	-	
26/08/16	PT	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:		

Calendar of Scheduled Events 2016/17		Last updated: 01/07/17		
		• The existing program may have been causing stoppage of the command screen • The latest firmware version may have also contributed to problem He then loaded new modified program and monitored for an hour or so. Andy is going to: • 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). As the comms w/ DT85 were intermittent/unreliable the PSUs to the OHL rigs were not energised.		
03/09/16	RA	Solo visit to Stoke on way to London: • 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	Solo visit to Stoke: • 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). • The rig is now back on and operational……		

Calendar of Scheduled Events 2016/17		Last updated: 01/07/17		
22/09/16	JDC/MPB	Visited Test-rig: 1. Adjusted PSU auto control current settings after calibration factors have been properly determined by JDC and MPB. 2. Taped up PS cable plug to DT85 to ensure connection is sound 3. Collected spare loan DT85 Logger (and grommet) 4. Repaired cable termination fault at power supply to Windmaster	-	
07/11/16	NJH	Visited Test-rig to: 1. De-energised test-rig and accompanied NPower whilst they replaced faulty electricity meter. Then re-energised test-rig. 2. Collected green DT85 connectors to return to Omni. 3. Installed new 24V supply to DT85[7] (See notes in "Outstanding tasks"). 4. Filled in rodent hole nr electricity meter box cable duct (hockey-stick). 5. Lubricated porta-cabin entrance door plate, locking mechanism & hinges. 6. Inspected all Test-rig control equipment located in porta-cabin using FLIR cam. 7. Completed new Maintenance Inspection Check-sheet. 8. 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. 9. Used wall heater whilst onsite; seemed ok.	-	Complete
Jan 2017	PT	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		Completed

[7] 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: 01/07/17		
		contract offered the most competitive value. Signed up for next 2 years as of 13/01/17.		
16/01/17	NJH/RA/MPB	Visit site to work on anemometer from MEWP and perform PAT testing on appropriate equipt.		Completed
02/01/2017	~~PT~~ JDC/NJH	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.	1/03/2017	WIP
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		