REPORT

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

Private and confidential

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Summary

This eighth Quarterly Report (QR8) 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 (QR7) published on 2nd October 2017.

Contents

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 so 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	Complete
		Data Analysis Tool; C-T Curve Production Capability	In Progress...
		Data Analysis Tool; Ability to incorporate LDC	Omitted from project scope
		Validation of CIGRÉ Methodology	Complete
5	Year One	Year One Data Collection Completion	Complete
		Year One Interim Report	Complete as part of QR process
6	Year Two	Year Two Data Collection Completion	Will be completed 5/1/18
		Year Two Interim Report	Not Started
		Update ACE104 and ENA ER P27	Not Started
		Decommission Test-rig	Will start January 2018
7	Integrated Software Tool	Specification Developed	In Progress
		"Beta"/Test version of software released	Not Started
		Final Release of Software	Not Started
8	Project Conclusion	Final Project Report Complete	Not Started

2. 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

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.

3. Data Acquisition Oct17-mid Dec17

The Overhead Line (OHL) conductor test-rig, which has been formally operational since January 4th 2016, has continued to run reliably over the 2½ months since the last Quarterly Report, with the automatic daily data download and checking procedures working well. It is expected to continue running reliably for the last few weeks until the planned switch-off date of January 5th 2018.

3.1 Data Acquisition Summary

The data acquisition system has continued to work effectively over the reporting period with just a few exceptions:

- Occasional unexplained logger glitches occurred on just 3 days in October causing a loss of 66 rows of data (out of 44640). This glitch rate is far lower than that previously reported in QR7. There were no logger glitches in November or the first half of December.
- Occasional unexplained glitches in the Wind Master anemometer readings have continued to occur, with a frequency of approximately four times per month. These do not generally result in any loss of data rows. Neither replacing the anemometer with a similar instrument on 1st July, nor replacing the cable connection between anemometer and logger on 26th September (see QR7) has completely cured the problem, although it does now occur less frequently.
- The 30 conductor temperature thermocouples, deployed in trios at the mid-point of each of the 10 conductor spans, have, with one exception, continued to work effectively over the reporting period. The one exception was TC21, on conductor 22H1 (rig 2 circuit 2 Hazel 1), which started behaving erratically on 23 November during high-wind conditions. It was replaced on 5 December by the back-up spare thermocouple on that conductor, 22H1S.
- One of the four ambient temperature thermocouples, TC43, failed on 9th October. Subsequently, ambient temperature at line height was taken to be simply the TC41 reading rather than average of TC41 & TC43.
- The four constant-current power supplies have performed impeccably throughout this reporting period.

3.2 Output Tables

As previously reported (QR7), automated data validation software based on a data-checking-and-visualisation Excel workbook (CHECKDAT) processes the automatic daily data downloads and validates the integrity of the data. Parameters that show up any malfunctioning of either the datalogger or instrumentation are 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.

The Output Tables for October, November and part of December are shown below (**Table 1**, **Table 2** & **Table 3).**

Table 1 (October) has a lot of red dates (all but 7)

- Most red dates relate to the ratio of the two anemometers readings (column ws1o2), which turns out to be a sufficiently ineffective indicator of malfunction due to the fluctuating nature of the anemometer readings.
- A block of red in the last column (headed Tamb) around the middle of the month relates to the malfunction of one of the four ambient temperature thermocouples, TC43. This required the manual deletion of TC43 data, to prevent their affecting average measured values, until the autocheckdat program could be modified to ignore TC43.
- The three dates with multiply affected parameters (rows of red cells) are victims of unexplained logger glitches which were previously noted in the June Quarterly Report (QR6). During these, the logger randomly omits or adds data or whole rows of data, requiring the deletion of affected rows. Detecting and deleting these glitch rows is carried out automatically.

Table 2 (November) has even more red dates (all but 2)

- Again, most red dates relate to the ratio of the two anemometers readings and are unimportant.
- Three impossibly high conductor thermocouple readings at the end of the month correspond to the intermittent failure of TC21, the left-hand of the trio of thermocouples on conductor 22H1. This required the manual deletion of TC21 data

Table 2 (December up to 13th)

- Again, most red dates relate to the ratio of the anemometer readings and are unimportant.
- Pole-mounted wiring connection box temperature, Tbox2 (col 8) fell below zero on 12th & 13th. Not sure if this would affect measurements.
- Malfunctioning TC21 (22H1L) replaced with spare 22H1S on 5th. Max trio range dropped from ~50K to 3-5K but still high enough to give red most days.

Table 1: Output Table for October 2017

Date	No. of raw dat row s	No. of condat row s	Count A = 4	Count B = 4	TC13, TC14, TC15 max	Tbox max	Tbox min	Thutmax	TPSsmax	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	WS1o2	WAA1m2	Rain reset (	Solh1m2	TC1..TC15 TC21..TC35 max	TC1..TC15 TC21..TC35 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 22H2 max range	Tamb (line ht)
	raw dat row s	condat row s	countA (w spd avg)	countB (pow er avg)	hottest conductor	Tbox1 & 2 max	Tbox1 & 2 min	Thut1 & 2 max	TPSUs max	IC1 max & min	IC2 max & min	IC3 max & min	IC4 max & min	w s1/w s2	w aa1-w aa2	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 22H2 max range	Tamb for graphs
alarm val	1440	1440	0	0	120	50	0	40	80	1.0%	1.0%	1.0%	1.0%	2	10	1.0	50	150	0	4	4	4	4	4	4	4	40
														ratio >critval & w s2>1													
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<cril+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	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-5 Y>=crit-10
01 October 2017	1440	1440	0	0	53	29	16	21	47	-0.4%	0.5%	-0.6%	-0.5%	0	3	0.25	11	53	18	2.2	1.1	1.7	1.2	2.2	2.6	2.4	13
02 October 2017	1440	1440	0	0	56	30	19	23	50	0.4%	0.5%	-0.5%	-0.6%	0	0	0.25	10	56	20	1.6	0.9	1.0	0.9	2.4	2.0	1.6	15
03 October 2017	1440	1440	0	0	49	30	17	22	49	-0.4%	0.4%	-0.6%	-0.5%	1	-3	0.25	9	49	17	2.0	0.9	1.1	0.8	1.4	2.4	1.0	15
04 October 2017	1440	1440	0	0	48	28	16	21	47	-0.4%	0.4%	-0.6%	-0.5%	1	-1	0.00	12	48	19	1.9	0.9	1.0	1.1	2.7	2.7	0.9	14
05 October 2017	1440	1440	0	0	44	27	16	21	47	-0.4%	0.4%	-0.6%	-0.5%	2	-1	0.25	9	44	15	2.6	1.0	1.3	1.0	2.4	2.6	1.8	13
06 October 2017	1440	1440	0	0	58	28	15	21	48	-0.4%	0.4%	-0.6%	-0.6%	0	0	0.25	15	58	14	1.9	1.1	0.8	0.8	1.2	2.0	1.0	15
07 October 2017	1440	1440	0	0	62	29	15	21	47	-0.4%	0.4%	-0.6%	-0.6%	1	1	0.25	16	62	19	2.3	1.1	1.9	1.1	2.6	2.5	2.1	15
08 October 2017	1440	1440	0	0	57	28	18	21	48	-0.3%	0.4%	-0.6%	-0.6%	0	0	0.25	9	57	16	2.1	1.1	1.3	1.0	2.4	2.5	2.2	14
09 October 2017	1440	1440	0	0	82	30	18	22	48	-0.4%	0.4%	-0.6%	-0.6%	0	1	0.00	11	82	20	2.4	1.3	1.4	1.1	2.0	2.6	2.3	68
10 October 2017	1440	1440	0	0	67	31	19	23	49	-0.4%	0.4%	-0.6%	-0.6%	0	-1	0.00	10	67	25	1.9	1.1	0.9	1.0	2.6	2.2	1.2	311
11 October 2017	1440	1440	0	0	50	141	20	43	52	-98.8%	-99.8%	-96.5%	-99.8%	3	0	26.60	9	50	0	2.0	1.2	3.1	11.6	2.7	2.4	3.0	359
12 October 2017	1439	1439	0	0	55	28	14	22	48	-96.5%	-95.6%	-95.3%	-91.3%	1	0	10.45	#DIV/0!	55	18	2.2	1.4	1.5	1.2	2.5	2.7	2.3	171
13 October 2017	1440	1440	0	0	51	31	14	23	49	-0.4%	0.4%	-0.6%	-0.6%	1	3	0.00	17	51	21	2.0	1.4	0.8	1.4	3.2	2.3	1.2	197
14 October 2017	1440	1440	0	0	45	33	21	26	53	0.5%	0.5%	-0.5%	-0.5%	6	6	0.00	11	45	24	1.7	1.1	0.8	0.9	2.4	2.1	1.1	248
15 October 2017	1440	1440	0	0	53	34	20	27	54	0.6%	0.6%	-0.5%	-0.6%	19	4	0.00	11	53	21	1.7	1.3	0.9	1.1	2.8	2.1	1.3	252
16 October 2017	1440	1440	0	0	70	32	20	25	52	0.5%	0.5%	-0.5%	-0.6%	11	2	0.00	10	70	23	1.9	1.2	0.9	1.1	3.1	2.2	1.8	338
17 October 2017	1440	1440	0	0	39	33	18	26	53	0.5%	0.5%	-0.5%	-0.6%	1	4	0.00	12	39	19	1.6	0.9	0.7	0.9	2.2	2.0	1.1	423
18 October 2017	1440	1440	0	0	75	31	12	22	49	-0.4%	0.4%	-0.6%	-0.6%	151	6	0.00	23	75	22	2.4	1.5	1.2	1.1	2.7	2.4	2.0	423
19 October 2017	1440	1440	0	0	72	26	13	20	46	-0.4%	0.4%	-0.6%	-0.6%	23	8	0.00	10	72	21	2.2	1.1	0.8	1.0	2.3	2.4	1.6	326
20 October 2017	1440	1440	0	0	67	27	18	21	48	-0.4%	0.4%	-0.6%	-0.6%	0	2	0.25	#DIV/0!	67	17	2.4	1.5	1.9	0.8	1.6	2.3	2.2	12
21 October 2017	1440	1440	0	0	48	28	17	20	47	-0.4%	0.4%	-0.6%	-0.6%	2	0	0.25	9	48	16	2.2	1.0	1.5	1.1	2.8	2.7	1.8	12
22 October 2017	1440	1440	0	0	39	26	16	20	46	0.4%	0.5%	-0.6%	0.5%	2	-3	0.25	12	39	15	1.7	1.0	1.4	0.9	2.0	2.3	1.6	11
23 October 2017	1440	1440	0	0	64	27	16	20	46	-0.3%	0.3%	-0.6%	-0.6%	28	-12	0.00	13	64	14	1.9	1.0	1.3	1.1	2.8	2.1	1.4	14
24 October 2017	1440	1440	0	0	64	30	17	22	49	-0.6%	0.4%	-0.6%	-0.5%	2	5	0.00	11	64	20	1.9	0.9	1.9	1.0	2.5	2.1	2.2	13
25 October 2017	1440	1440	0	0	47	32	18	24	52	0.9%	0.5%	-0.6%	0.6%	6	1	0.25	7	47	16	2.8	1.1	1.9	1.0	2.7	2.6	2.1	17
26 October 2017	1440	1440	0	0	75	30	17	22	49	-0.4%	0.4%	-0.6%	-0.6%	66	1	0.00	15	75	24	2.1	1.5	1.1	1.2	2.8	2.3	1.7	15
27 October 2017	1440	1440	0	0	79	30	14	21	48	-0.4%	0.4%	-0.6%	-0.6%	7	-3	0.00	10	79	19	2.2	1.5	1.3	1.1	2.1	2.4	2.0	14
28 October 2017	1440	1440	0	0	73	30	12	21	47	-0.4%	0.4%	-0.6%	-0.6%	25	-15	0.00	33	73	20	2.5	1.3	1.0	1.6	3.4	2.4	1.9	16
29 October 2017	1440	1440	0	0	59	29	16	22	49	-0.3%	0.4%	-0.6%	-0.6%	16	-14	0.25	11	59	15	1.9	0.8	0.9	1.0	2.2	2.2	1.1	14
30 October 2017	1440	1440	0	0	73	28	7	20	46	-0.4%	0.4%	-0.6%	-0.6%	0	16	0.00	17	73	18	2.5	1.3	1.0	0.9	1.9	2.5	1.8	13
31 October 2017	1439	1439	2	3	74	59	7	494	236	#VALUE!	#VALUE!	-99.5%	-100.0%	225	8	489.62	12	381	4	2.3	1.4	1.5	1.1	2.8	15.5	48.3	438

Table 2: Output Table for November 2017

Date	No. of raw dat row s	No. of condat row s	Count A = 4	Count B = 4	TC13, TC14, TC15 max	Tbox max	Tbox min	Thutmax	TPSsmax	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	WS1o2	WAA1m2	Rain reset (	Solh1m2	TC1..TC15 TC21..TC35 max	TC1..TC15 TC21..TC35 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 22H2 max range	Tamb (line ht)
	raw dat row s	condat row s	countA (w spd avg)	countB (pow er avg)	hottest conductor	Tbox1 & 2 max	Tbox1 & 2 min	Thut1 & 2 max	TPSUs max	IC1 max & min	IC2 max & min	IC3 max & min	IC4 max & min	w s1/w s2	w aa1-w aa2	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 22H2 max range	Tamb for graphs
alarm val	1440	1440	0	0	120	50	0	40	80	1.0%	1.0%	1.0%	1.0%	2	10	1.0	50	150	0	4	4	4	4	4	4	4	40
														ratio >critval & w s2>1													
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<cril+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	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-5 Y>=crit-10
01 November 2017	1440	1440	0	0	69	30	13	21	48	-0.7%	-0.4%	-0.8%	-0.6%	120	5	0.00	7	69	21	2.2	1.4	1.2	1.1	2.8	2.6	1.5	14
02 November 2017	1440	1440	0	0	76	27	11	20	46	-0.4%	-0.4%	-0.6%	-0.6%	80	6	0.00	5	76	23	2.4	1.6	1.4	1.4	3.2	2.6	1.8	12
03 November 2017	1440	1440	0	0	76	27	16	20	46	-0.3%	0.4%	-0.6%	-0.6%	113	-2	0.00	9	76	23	2.1	1.4	1.2	1.2	2.8	2.2	2.2	11
04 November 2017	1440	1440	0	0	68	26	16	19	46	-0.4%	0.4%	-0.6%	-0.6%	60	4	0.25	7	68	15	2.5	1.0	2.2	1.4	2.7	2.6	2.2	10
05 November 2017	1440	1440	0	0	48	24	12	20	47	-0.4%	0.4%	-0.7%	-0.6%	28	-14	0.25	7	48	10	3.1	1.2	2.5	1.3	2.4	2.9	3.9	10
06 November 2017	1440	1440	0	0	74	24	7	20	46	-0.4%	0.4%	-0.6%	-0.6%	14	-1	0.51	19	74	9	3.9	1.6	2.4	1.8	2.7	3.3	3.0	11
07 November 2017	1440	1440	0	0	71	25	7	20	46	-0.4%	0.3%	-0.6%	-0.6%	9	5	0.25	17	71	16	2.4	1.3	1.2	1.2	2.8	2.3	1.2	9
08 November 2017	1440	1440	0	0	67	25	7	19	46	-0.4%	0.4%	-0.6%	-0.5%	1	-5	0.25	#DIV/0!	67	11	2.2	1.4	2.3	0.8	1.5	2.8	2.4	9
09 November 2017	1440	1440	0	0	76	26	6	20	46	-0.4%	0.4%	-0.6%	-0.6%	132	3	0.00	25	76	19	2.5	1.6	1.5	1.1	2.5	2.6	1.8	12
10 November 2017	1440	1440	0	0	57	26	14	20	46	-0.4%	0.4%	-0.6%	-0.6%	75	-10	0.25	12	57	12	1.9	0.9	1.0	1.1	2.5	2.1	0.9	12
11 November 2017	1440	1440	0	0	66	24	14	20	46	-0.4%	0.3%	-0.6%	-0.5%	73	-4	0.25	12	66	11	3.5	1.4	1.5	1.1	2.8	2.8	2.5	11
12 November 2017	1440	1440	0	0	70	24	12	19	45	-0.4%	0.4%	-0.6%	-0.6%	24	-11	0.25	8	70	9	2.2	1.2	1.1	0.9	1.4	2.5	1.7	9
13 November 2017	1440	1440	0	0	60	22	5	19	46	-0.4%	0.3%	-0.6%	-0.5%	5	-8	0.25	17	60	10	2.4	1.5	1.3	0.8	1.4	2.4	1.8	9
14 November 2017	1440	1440	0	0	68	22	5	19	46	-0.5%	0.3%	-0.6%	-0.6%	92	5	0.25	7	68	18	2.4	1.7	1.1	1.2	2.8	2.3	1.5	8
15 November 2017	1440	1440	0	0	77	28	16	20	47	-0.4%	-0.3%	-0.6%	-0.5%	167	4	0.00	5	77	22	2.1	1.5	1.2	1.2	3.2	2.6	1.7	12
16 November 2017	1440	1440	0	0	66	26	16	20	46	-0.3%	0.3%	-0.6%	-0.6%	110	-1	0.00	9	66	21	2.1	1.5	1.6	1.0	2.5	2.2	2.1	9
17 November 2017	1440	1440	0	0	70	24	6	19	46	-0.4%	0.4%	-0.6%	-0.6%	48	-2	0.25	9	70	11	2.4	1.4	1.3	1.0	2.6	2.6	1.7	11
18 November 2017	1440	1440	0	0	69	23	7	20	46	-0.4%	-0.4%	-0.6%	-0.5%	105	-8	0.00	8	69	17	2.4	1.4	1.3	1.3	2.7	2.9	1.5	9
19 November 2017	1440	1440	0	0	69	24	8	19	46	-0.4%	0.4%	-0.6%	-0.6%	56	-23	0.00	4	69	17	2.3	1.8	1.2	1.2	2.7	2.5	1.5	8
20 November 2017	1440	1440	0	0	72	24	7	19	46	-0.4%	-0.4%	-0.6%	-0.5%	112	0	0.25	8	72	15	2.6	1.7	1.8	0.9	1.9	2.5	1.7	11
21 November 2017	1440	1440	0	0	56	29	16	21	48	-0.4%	0.4%	-0.6%	-0.6%	51	-2	0.25	8	56	21	2.2	1.5	2.5	1.1	2.9	2.4	2.3	14
22 November 2017	1440	1440	0	0	48	27	18	20	47	-0.4%	0.4%	-0.6%	-0.6%	7	4	0.25	8	48	17	2.3	1.1	1.4	1.1	2.9	2.9	1.9	12
23 November 2017	1440	1440	0	0	49	28	14	21	48	-0.4%	0.4%	-0.6%	-0.5%	4	4	0.25	8	67	0	2.6	1.1	1.3	1.2	3.0	45.2	1.8	13
24 November 2017	1440	1440	0	0	65	23	8	19	46	-0.4%	0.4%	-0.6%	-0.5%	5	0	0.25	7	65	15	2.2	1.3	1.1	1.3	3.0	2.4	1.2	9
25 November 2017	1440	1440	0	0	62	24	7	19	46	-0.4%	-0.4%	-0.6%	-0.6%	25	-4	0.25	15	62	10	2.7	1.5	1.9	1.2	3.0	2.5	1.6	9
26 November 2017	1440	1440	0	0	43	20	9	19	46	-0.4%	-0.4%	-0.6%	-0.6%	24	-18	0.25	9	43	7	2.6	1.2	1.4	1.1	2.0	2.9	2.6	5
27 November 2017	1440	1440	0	0	44	22	10	19	46	-0.4%	-0.4%	-0.6%	-0.6%	18	-8	0.51	6	181	0	2.7	1.0	1.8	1.2	2.8	159.0	2.7	7
28 November 2017	1440	1440	0	0	46	22	11	19	46	-0.5%	-0.3%	-0.6%	-0.6%	36	-22	0.25	3	423	0	2.0	1.0	1.0	1.1	2.5	400.1	1.5	6
29 November 2017	1440	1440	0	0	58	21	8	19	46	-0.4%	-0.4%	-0.6%	-0.6%	0	-10	0.00	15	58	11	2.0	1.1	0.7	0.7	1.4	2.4	1.0	7
30 November 2017	1440	1440	0	0	41	19	5	19	46	-0.4%	-0.4%	-0.6%	-0.5%	0	-6	0.00	7	41	9	1.9	1.0	0.7	0.9	1.3	1.9	0.6	5

Table 3 Output Table for December 2017 (part)

Date	No. of raw dat row s	No. of condat row s	Count A = 4	Count B = 4	TC13, TC14, TC15 max	Tbox max	Tbox min	Thutmax	TPSsmax	IC1 = 382	IC2 = 440	IC3 = 443	IC4 = 502	WS1o2	WAA1m2	Rain reset (	Solh1m2	TC1..TC15 TC21..TC35 max	TC1..TC15 TC21..TC35 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 22H2 max range	Tamb (line ht)
	raw dat row s	condat row s	countA (w spd avg)	countB (pow er avg)	hottest conductor	Tbox1 & 2 max	Tbox1 & 2 min	Thut1 & 2 max	TPSUs max	IC1 max & min	IC2 max & min	IC3 max & min	IC4 max & min	w s1/w s2	w aa1-w aa2	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 22H2 max range	Tamb for graphs
alarm val	1440	1440	0	0	120	50	0	40	80	1.0%	1.0%	1.0%	1.0%	2	10	1.0	50	150	0	4	4	4	4	4	4	4	40
														ratio >critval & w s2>1													
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<cril+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	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-5 Y>=crit-10
01 December 2017	1440	1440	0	0	36	18	5	19	46	-0.5%	-0.4%	-0.7%	-0.5%	0	-6	0.00	14	36	0	1.9	1.1	0.8	0.9	1.3	19.2	0.6	4
02 December 2017	1440	1440	0	0	70	20	7	19	46	-0.5%	-0.4%	-0.6%	-0.6%	3	-10	0.00	12	70	11	2.8	1.6	1.5	0.8	1.6	2.6	1.6	6
03 December 2017	1440	1440	0	0	70	22	11	20	46	-0.4%	-0.4%	-0.6%	-0.6%	19	-8	0.25	#DIV/0!	70	13	2.7	1.8	2.5	1.0	1.7	2.8	2.2	7
04 December 2017	1440	1440	0	0	63	23	13	20	45	-0.4%	-0.4%	-0.6%	-0.6%	0	-20	0.25	#DIV/0!	63	0	2.1	1.1	1.3	0.7	1.3	56.4	1.0	7
05 December 2017	1440	1440	0	0	45	23	9	20	46	-0.4%	-0.4%	-0.6%	-0.6%	19	-23	0.25	8	63	0	1.9	0.9	1.0	0.9	1.6	46.3	1.0	8
06 December 2017	1440	1440	0	0	50	22	15	20	45	-0.4%	-0.4%	-0.6%	-0.6%	90	-8	0.00	#DIV/0!	50	17	2.0	1.0	1.0	1.3	3.0	4.9	1.1	7
07 December 2017	1440	1440	0	0	47	24	15	20	45	-0.4%	-0.4%	-0.6%	-0.5%	7	6	0.25	9	47	14	1.9	0.8	1.1	0.8	2.0	3.9	1.8	9
07 December 2017	1440	1440	0	0	47	24	15	20	45	-0.4%	-0.4%	-0.6%	-0.5%	7	6	0.25	9	47	14	1.9	0.8	1.1	0.8	2.0	3.9	1.8	9
08 December 2017	1440	1440	0	0	31	25	9	19	46	-0.4%	-0.4%	-0.6%	-0.5%	7	-15	0.25	4	31	5	2.2	0.9	1.4	0.8	1.5	3.4	1.6	10
09 December 2017	1440	1440	0	0	51	17	6	19	46	-0.5%	0.4%	-0.7%	-0.6%	62	-23	0.25	11	51	5	2.2	1.0	1.2	1.2	2.6	4.9	1.0	3
09 December 2017	1440	1440	0	0	51	17	6	19	46	-0.5%	0.4%	-0.7%	-0.6%	62	-23	0.25	11	51	5	2.2	1.0	1.2	1.2	2.6	4.9	1.0	3
10 December 2017	1440	1440	0	0	53	16	6	19	46	-0.4%	-0.4%	-0.6%	-0.5%	292	-1	0.25	7	53	9	2.3	1.5	1.2	1.3	2.6	5.7	1.9	0
11 December 2017	1440	1440	0	0	56	16	6	19	47	-0.5%	-0.5%	-0.6%	-0.5%	0	1	0.00	6	56	5	2.7	1.1	1.1	1.0	1.9	3.4	1.3	0
12 December 2017	1440	1440	0	0	69	17	0	19	46	-0.6%	-0.5%	-0.8%	-0.6%	14	-4	0.25	20	69	9	2.5	1.4	1.4	1.1	1.6	5.1	1.7	5
12 December 2017	1440	1440	0	0	69	17	0	19	46	-0.6%	-0.5%	-0.8%	-0.6%	14	-4	0.25	20	69	9	2.5	1.4	1.4	1.1	1.6	5.1	1.7	5
13 December 2017	1440	1440	0	0	70	17	0	19	46	-0.7%	-0.5%	-0.8%	-0.5%	87	6	0.25	4	70	9	2.6	1.3	1.6	1.1	2.3	4.8	1.8	1

3.3 Daily Notes

The daily data files, produced by, and corrected for logger and anemometer glitches by, autocheckdat, are manually inspected each day, cleansed and corrected if necessary, and a line or two of notes and comments added. The daily notes for the last three months are reproduced below.

Filename[1]	Issue & Action Taken
October 2017	
26m_v38c 2017-10-01cn	OK
26m_v38c 2017-10-02cn	OK
26m_v38c 2017-10-03cn	OK
26m_v38c 2017-10-04cn	OK
26m_v38c 2017-10-05cr	2 WMaster Glitches (6 rows deleted) probably overzealous detection - probably genuine gusts but OK to leave deleted beacause high wspd. Logger OK.
26m_v38c 2017-10-06cn	OK
26m_v38c 2017-10-07cn	OK
26m_v38c 2017-10-08cn	OK
26m_v38c 2017-10-09cr2	TC43 (Tamb3) faulty (-211.6) from 20:39 onwards. Deleted from 2039 in condat.
	Found errors in TC43 notes 12/12 - revised 09/10 to 31/10 notes.
26m_v38c 2017-10-10cr2	TC43 (Tamb3) faulty all day: deleted from condat
26m_v38c 2017-10-11cr2	3 logger glitches between 0835-0841. 2 more 1310 & 1316. Deleted 0834-0843 and 1309-1317.
	TC43 (Tamb3) faulty all day - am mainly -211.6, pm mainly -0.1. Deleted from condat
26m_v38c 2017-10-12cr2	4 Logger glitches between 1721 and 1728. Deleted 1721-1730.
	TC43 (Tamb3) faulty all day. Deleted from condat.
26m_v38c 2017-10-13cr2	TC43 (Tamb3) faulty all day. Deleted from condat. Logger and anemometers OK.
26m_v38c 2017-10-14cr2	TC43 (Tamb3) faulty all day. Deleted from condat. 4 merging WMaster glitches (27 rows).
26m_v38c 2017-10-15cr2	TC43 (Tamb3) faulty all day. Deleted from condat. Logger and anemometers OK
26m_v38c 2017-10-16cr2	TC43 (Tamb3) faulty all day (-0.1 from 0941-0600). Deleted from condat. Logger and anemometers OK
26m_v38c 2017-10-17cr2	Logger and anemometers OK. Very windy (ex-hurricane Ophelia) - auto overzealous
	TC43 (Tamb3) faulty all day. Deleted from condat.
26m_v38c 2017-10-18cr2	TC43 (Tamb3) faulty upto 1503, then OK to 0600 apart from 1656-1659 & 1712. Deleted to 1503, 1656-1659 & 1712 from condat. Logger and anemometers OK.
26m_v38c 2017-10-19cr2	Logger and anemometers OK.
	TC43 (Tamb3) OK upto 1100, then faulty all day. Deleted TC43 from 1100 from condat.
	Swapped TC43 & TC44 on digirail from 1426 to 1444. Wrong-reading channel changed to op44 - so it's the TC that's faulty not the logger.
26n_v38c 2017-10-20cnr2	OK (no TC43 readings)
autocheckdatop26n_v38c	Deleted TC43 readings from condat in driver program (TC43 faulty) so no longer need to do it manually.
26n_v38c 2017-10-21crn2	OK
26n_v38c 2017-10-22cr2	OK (high winds, auto over-zealous)
26n_v38c 2017-10-23crn2	OK (auto over-zealous)
26n_v38c 2017-10-24cnr2	OK
26n_v38c 2017-10-24cnr2	Checked TC43 by undeleting condat readings - read -0.1 all day
26n_v38c 2017-10-25crn2	2 WMaster Glitches (6 rows); possibly 1 WSonic Glitch (3 rows) . Removed all 3 from condat
26n_v38c 2017-10-25cr	Noticed condat row 16 (Count) is a number so doesn't change when data are deleted manually. Row 3 (Count) is a formula and is correct.
26n_v38c 2017-10-26cnr2	OK
26n_v38c 2017-10-27cnr2	OK
26n_v38c 2017-10-28cnr2	OK
26n_v38c 2017-10-29cnr2	OK
26n_v38c 2017-10-30cnr2	OK
26n_v38c 2017-10-31rc	Logger Glitches 0833-0840, 1556-1605, 2252-2301, 0538-0546: duplicate and missing rows. Deleted affected rows & added blank row.

[1] The first number in Filename (e.g. 26m) refers to the version of autocheckdat; the second number (e.g. v38c) refers to the version of correction software, and the crn suffix implies c=autocorrected, r=revised (as in cleansed), and n=only notes revised.

Filename	Issue & Action Taken
November 2017	
26n_v38c 2017-11-01cn	OK
26n_v38c 2017-11-02cn	OK
26n_v38c 2017-11-03cn	OK
26n_v38c 2017-11-04cn	OK
26n_v38c 2017-11-05cn	OK
26n_v38c 2017-11-06cr	1 WMaster Glitch 1104. Deleted 11:03-05 data in condat.
26n_v38c 2017-11-07cn	OK
26n_v38c 2017-11-08cn	OK
26n_v38c 2017-11-09cn	OK
26n_v38c 2017-11-10cn	OK
26n_v38c 2017-11-11cn	OK
26n_v38c 2017-11-12cn	OK
26n_v38c 2017-11-13cn	OK
26n_v38c 2017-11-14cn	OK
26n_v38c 2017-11-15cn	OK
26n_v38c 2017-11-16cn	OK
26n_v38c 2017-11-17cn	OK. WMaster glitch at 1102 also on WSonic so likely a gust: reinstated auto-deleted data.
26n_v38c 2017-11-18cn	OK
26n_v38c 2017-11-19cn	OK
26n_v38c 2017-11-20cn	OK
26n_v38c 2017-11-21cr	1 WMaster glitch 0237-0241 (5 rows).
26n_v38c 2017-11-22cn	OK
26n_v38c 2017-11-23cr	TC21 started misreading in high wind. -0.1 at 1627. Deleted TC21 from 1539-2317 in condat.
	Logger & WMaster OK
26n_v38c 2017-11-24cn	OK
26n_v38c 2017-11-25cn	OK
26n_v38c 2017-11-26cn	OK
26n_v38c 2017-11-27cr	TC21 glitching high & low from 1909 to 0254. Deleted TC21 from 1909 to 0254 in condat.
26n_v38c 2017-11-27c	2 WMaster Glitches (6 rows).
26n_v38c 2017-11-28cr	TC21 glitching hgh & low during 0707 to 1419. Deleted TC21 from 0707 to 1419 in condat.
	Logger & WMaster OK
26n_v38c 2017-11-29cn	OK
26n_v38c 2017-11-30cn	OK

Filename	Issue & Action Taken
December 2017	
26n_v38c 2017-12-01crn	TC21 multiple drops to zero during 1030-1040. Deleted TC21 from 1030-1041 in condat.
	Logger & WMaster OK
26n_v38c 2017-12-02cn	OK
26n_v38c 2017-12-03cn	1 WMaster Glitch (3 rows). TC21 OK.
26n_v38c 2017-12-04cn	TC21 multiple drops to zero: Deleted TC21 0849, 2321-0556 from condat. Logger & WMaster OK
26o_v38c 2017-12-05cr	TC21 (22H1L) intermittently faulty 0600-0707: replaced by Spare 6 (22H1S) at 1557 by rewiring DigiRail Unit 21 channel 1 in pole box 2. Deleted TC21 0601-0707 and 1549-57 in condat.
autocheckdat26o_v38c	Added comment in rawdat re TC21 and TC13 replacements with spares
26o_v38c 2017-12-06cn	TC21 (22H1S) reading significantly higher than 22H1M & R - max trio range 4.9, mean range 2.98. Logger & WMaster OK
26o_v38c 2017-12-07crn	OK (just! - 22H1 max trio range 3.9, mean range 2.42)
26o_v38c 2017-12-08crn	2 WMaster Glitches (6 rows) 0748 & 2243. 22H1 max trio range 3.4, mean range 1.77
26o_v38c 2017-12-09crn	Logger & WMaster OK. 22H1 max trio range 4.9, mean range 1.99 (twice >4).
26o_v38c 2017-12-10crn	Logger & WMaster OK. 22H1 max trio range 5.7, mean range 2.36 (4X >4).
26o_v38c 2017-12-11crn	OK. (22H1 max trio range 3.4, mean range 2.2)
26o_v38c 2017-12-12crn	Logger & WMaster OK. Tbox2 sub-zero. 22H1 max trio range 5.1, mean range 2.14 (3X >4): TC22 odd one out rather than TC21.
26o_v38c 2017-12-13crn	Logger & WMaster OK. 22H1 max trio range 4.8, mean range 2.42 (2X >4): TC22 odd one out rather than TC21.
26o_v38c 2017-12-13crn	Reset headings on trio plots

4. Data Analysis

4.1 Compilation of Dataset

The Cleansed Dataset will essentially comprise a concatenation of all the daily *condat* data, initially into monthly blocks but then, if required, into seasonal and/or annual blocks. Effort has been concentrated during the reporting period on ensuring the "cleanliness" of the daily files.

The cleansed data files need some additional data processing before concatenation since many of the measuring instruments are duplicated or triplicated in order to provide redundancy in the event of a malfunction. For these parameters, the obvious "best" value is usually the mean of the two or three readings.

It was originally thought that the conductor thermocouple trios might be an exception to this since in previous work it was found that if one of the trio read particularly low, it was often an indication of poor thermal contact between that thermocouple and the conductor. The maximum of the trio was therefore deemed to be the most appropriate value to choose. However, in the present project, the trio means appear to give better agreement with the values calculated using the Cigré equations than do the trio maxima and so the means will be used for the conductor thermocouples too.

The parameters for which average values need to be determined are shown in **Table 4**.

Table 4: Parameters for which an average value needs to be determined during concatenation

	parameter	sensors
Tcon	conductor temperatures	trios of thermocouples
Tamb	ambient temperature (at line height)	pair of thermocouples (single t/c TC41after 9th Nov)
Wspd	wind speed (at line height)	WindMaster & WindSonic ultrasonic anemometers (only WindSonic during WindMaster glitches)
Waa	wind attack angle	*same as for Wspd*
Sol	solar insolation	pair of solarimeters

Concatenated data files for January to December 2016 (version 2a) were delivered to Sven Hoffmann by email on 1st June 2016. These have now been superseded by version 3a, which incorporates the following improvements:

- Corrects the rainfall column to aggregate mm/h rather than basic mm/min values.
- Makes the handling of changes in the way Hazel currents were derived from the raw data (see QR6 Section 3.3.4) more consistent (see QR7 Section 3.6).

Concatenated data files for January to November 2017 have now been compiled, version 3a for data obtained prior to the 11th May and version 3b for data obtained after 11th May. (The two versions are necessary because of the relocation on 11th May of the hut-end solarimeter, solh2, to the outer H-pole to avoid shadows. Prior to this, version 3a sets sol equal to the higher of two solarimeter readings but after the move, version 3b sets sol equal to the average of the two solarimeter readings.)

4.2 Validation of CIGRÉ Equations - Comparison of Measured and Calculated Conductor Temperatures

An initial comparison of measured and calculated conductor temperatures was carried out for a single day (29/9/16) and reported in QR6. The calculated temperatures were obtained using OHTEMP3, the fixed-data version of OHTEMP2. The measured and calculated temperatures for each of the 10 conductor-current combinations 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) as the measured values. Trio means were found to give rather better agreement than trio maxima. It was also found that better overall agreement was obtained if a 10-minute running mean was used for the calculated values.

As reported in QR7, this comparison was repeated for a selected day in each month of 2016, the day selected being the one when the conductor temperatures were at their highest for that month. Unfortunately, the tabulated differences given in QR7 Tables 4 and 5 were incorrect due to an erroneous solar calculation. The corrected values are given below in **Table 5** and **Table 6**.

Table 5: Measured trio means vs calculated conductor temperatures – 2016 hot days

Trio means minus calculated values with 10-min running mean **Average differences over hottest day of each month**												
2016	20-Jan	27-Feb	13-Mar	14-Apr	27-May	03-Jun	21-Sep	30-Oct	16-Nov	19-Dec	mean	st dev
11H1	4.69	1.61	2.15	0.53	-1.10	-0.94	0.86	1.85	1.31	4.64	1.56	1.96
11A	5.28	1.70	2.32	0.07	-2.46	-0.98	0.18	2.02	1.08	4.53	1.37	2.36
11H2	5.52	2.06	2.66	0.89	-1.01	-0.32	1.14	2.59	1.91	5.24	2.07	2.11
14E	4.61	1.40	0.64	-1.12	-3.72	-2.58	0.01	0.69	0.21	3.98	0.41	2.58
14A	6.07	0.48	1.30	-1.54	-3.50	-3.23	0.06	1.32	0.32	4.94	0.62	3.10
22H1	4.47	1.24	1.01	-0.58	-2.11	-2.21	1.13	2.03	1.15	4.47	1.06	2.30
22A	5.31	1.13	1.56	-0.84	-2.95	-1.87	0.04	1.31	0.69	4.15	0.85	2.51
22H2	5.81	1.81	2.04	0.27	-0.78	-1.06	1.29	2.41	1.48	4.98	1.83	2.21
23E	5.34	1.77	2.23	0.12	-2.27	-0.50	0.97	2.18	1.71	5.64	1.72	2.42
23A	4.14	0.32	0.51	-1.81	-3.92	-2.79	-0.80	0.08	-0.29	3.53	-0.10	2.52
mean	5.13	1.35	1.64	-0.40	-2.38	-1.65	0.49	1.65	0.96	4.61	1.14	2.39
st dev	0.62	0.57	0.75	0.91	1.15	1.02	0.68	0.79	0.71	0.63	0.69	

Table 6: Measured trio maxima vs calculated conductor temperatures – 2016 hot days

Trio maxima minus calculated values with 10-min running mean **Average differences over hottest day of each month**												
2016	20-Jan	27-Feb	13-Mar	14-Apr	27-May	03-Jun	21-Sep	30-Oct	16-Nov	19-Dec	mean	st dev
11H1	5.56	2.39	2.82	1.21	-0.46	-0.27	1.52	2.53	1.95	5.37	2.26	2.01
11A	5.77	2.12	2.76	0.51	-1.99	-0.57	0.62	2.40	1.44	5.01	1.81	2.37
11H2	5.94	2.29	2.92	1.09	-0.81	-0.13	1.33	2.88	2.21	5.69	2.34	2.20
14E	4.98	1.74	1.02	-0.86	-3.49	-2.33	0.25	1.05	0.54	4.24	0.71	2.62
14A	6.91	0.95	1.96	-1.14	-3.09	-2.55	0.45	1.92	0.89	5.40	1.17	3.16
22H1	5.21	1.89	1.71	0.16	-1.47	-1.49	1.79	2.73	1.83	5.18	1.75	2.31
22A	5.62	1.38	1.92	-0.58	-2.69	-1.59	0.31	1.82	1.13	4.54	1.19	2.55
22H2	6.14	2.23	2.34	0.59	-0.36	-0.58	1.69	2.76	1.79	5.31	2.19	2.18
23E	5.86	2.28	2.70	0.59	-1.78	-0.08	1.43	2.60	2.19	6.22	2.20	2.45
23A	4.70	1.10	1.05	-1.28	-3.42	-2.37	-0.30	0.53	0.23	4.09	0.43	2.55
mean	5.67	1.84	2.12	0.03	-1.96	-1.20	0.91	2.12	1.42	5.11	1.61	2.42
st dev	0.63	0.52	0.71	0.92	1.19	0.99	0.73	0.79	0.70	0.66	0.69	

Table 7: Measured trio means vs calculated conductor temperatures – 2017 hot days

Trio means minus calculated values with 10-min running mean **Average differences over hottest day of each month**														
2017	08-Jan	06-Feb	25-Mar	20-Apr	24-May	20-Jun	09-Jul	28-Aug	26-Sep	09-Oct			mean	st dev
11H1	2.70	2.23	0.36	-0.93	-0.72	-1.58	-0.94	0.12	1.16	4.89			0.73	2.03
11A	2.64	2.35	0.57	-1.44	-1.63	-2.48	-2.01	-0.78	-0.02	4.06			0.13	2.23
11H2	3.06	2.82	1.01	-0.26	-0.45	-1.34	-0.68	0.39	1.44	5.22			1.12	2.05
14E	2.15	1.41	-0.23	-2.60	-2.54	-2.85	-2.73	-1.81	-0.49	3.62			-0.61	2.32
14A	1.96	1.73	-0.51	-2.24	-2.39	-3.12	-2.55	-0.55	0.68	4.87			-0.21	2.54
22H1	2.63	1.74	0.00	-1.23	-0.99	-2.00	-1.20	-0.34	1.46	5.14			0.52	2.21
22A	2.24	1.78	0.06	-2.13	-2.31	-3.07	-2.67	-1.27	-0.02	3.91			-0.35	2.36
22H2	2.73	2.08	0.30	-0.76	-0.65	-1.79	-0.96	-0.04	1.75	5.32			0.80	2.16
23E	3.32	3.36	1.26	-1.05	-1.13	-2.03	-1.41	-0.03	1.06	4.81			0.82	2.36
23A	1.51	0.85	-0.85	-3.13	-2.96	-3.83	-3.44	-2.87	-1.20	2.85			-1.31	2.35
mean	2.49	2.03	0.20	-1.58	-1.58	-2.41	-1.86	-0.72	0.58	4.47			0.16	2.24
st dev	0.53	0.71	0.65	0.91	0.91	0.79	0.95	1.01	0.97	0.82			0.77	

Table 8: Measured trio maxima vs calculated conductor temperatures – 2017 hot days

Trio means minus calculated values with 10-min running mean **Average differences over hottest day of each month**														
2017	08-Jan	06-Feb	25-Mar	20-Apr	24-May	20-Jun	09-Jul	28-Aug	26-Sep	09-Oct			mean	st dev
11H1	3.38	2.95	1.07	-0.31	-0.14	-1.01	-0.39	0.73	1.83	5.50			1.36	2.06
11A	3.09	2.79	0.96	-1.11	-1.27	-2.16	-1.67	-0.46	0.45	4.44			0.51	2.26
11H2	3.33	3.13	1.21	0.01	-0.28	-1.15	-0.53	0.55	1.59	5.43			1.33	2.07
14E	2.41	1.70	0.00	-2.25	-2.31	-2.66	-2.56	-1.49	-0.27	3.88			-0.35	2.33
14A	2.39	2.29	-0.07	-1.69	-1.99	-2.68	-2.18	0.03	1.02	5.25			0.24	2.53
22H1	3.28	2.45	0.66	-0.50	-0.26	-1.37	-0.54	0.36	2.13	5.77			1.20	2.19
22A	2.53	2.12	0.33	-1.60	-1.84	-2.65	-2.19	-0.64	0.37	4.43			0.09	2.33
22H2	3.04	2.34	0.61	-0.46	-0.30	-1.38	-0.60	0.31	2.19	5.62			1.14	2.14
23E	3.89	3.93	1.74	-0.62	-0.71	-1.56	-0.94	0.50	1.50	5.25			1.30	2.38
23A	2.12	1.46	-0.25	-2.60	-2.50	-3.32	-2.92	-2.35	-0.67	3.43			-0.76	2.39
mean	2.95	2.52	0.63	-1.11	-1.16	-1.99	-1.45	-0.25	1.02	4.90			0.60	2.25
st dev	0.56	0.72	0.64	0.88	0.93	0.80	0.96	1.00	1.01	0.80			0.78	

Fortunately, the main conclusion that the trio means show better agreement with the calculated values than do the trio maxima still holds for the corrected data. The overall mean difference is 1.14 ± 2.39 °C for the trio means and 1.61 ± 2.42 °C for the trio maxima.

Table 7 and **Table 8** and show the corresponding results for the 1st ten months of 2017. Again, the trio means show better agreement with the calculated values than do the trio maxima, with overall mean differences of 0.16 ± 2.24 and 0.60 ± 2.25 respectively.

4.3 Solar flux values

The calculated values of conductor temperature depend on the choice made regarding the solar flux incident on the conductor. There are three choices for solar flux:

- Assume the sun is always shining and use the TB601 equations (as modified by Mark Bertinat – see QR7) to calculate the solar flux minute-by-minute – this gives the maximum solar flux for any particular time. This is the value used in the Cigre comparisons above.
- Assume the sun is never out and that the solar flux is always zero – this gives the minimum value for any particular time and is the assumption used in deriving the P27 ratings, (their argument being "we are only interested in the worst case, and the worst case is zero wind, and one cannot have zero wind when the sun is shining");
- Use the measured value, which will lie somewhere between the other two.

The 2017 Cigre comparison was repeated using each of these three possibilities to see how much difference the solar assumption makes. The results are summarised in **Table 9** below.

Table 9: The average difference between measured (trio means and trio maxima) temperatures and calculated (various solar assumptions) temperatures on the hottest day of each month in 2017

	trio mean minus Tcalc
solar flux calculated	0.16
solar flux measured	1.07
solar flux zero	2.26

The difference between calculated and measured solar flux is not particularly significant, but the assumption of zero solar flux might well result in low Tcalc values.

4.4 Monthly Excursions and Seasonal Boundaries

The P27 ratings assume three distinct ratings for different times of the year:

- Summer = May, June, July and August
- Autumn/Spring = September, October and November; and March to April
- Winter = December, January and February.

Previous work at EA Technology has indicated that these seasons may not be optimum, and in particular, September should maybe be moved into Summer as is the case with May. One of the aims of the present project is to see whether the data suggest a way of optimising the seasonal boundaries, and also whether it is really appropriate to have four seasons rather than just two (winter and summer) anyway.

To this end, a preliminary analysis has now been undertaken using data from the Ash 500A conductor (conductor 14A), the hottest of the 10 conductors. A complete 12-month dataset from 1 October 2016 to 30 September 2017 (i.e. a year's continuous data) was used to calculate the four most important excursion parameters:

- Count = Number of distinct occasions that conductor temperature Tcon exceeded a reference temperature Tref.
- Total Minutes = Aggregate time Tcon was higher than Tref.
- Maximum (excursion) = Highest excursion i.e. largest value of Tcon minus Tref.
- Total Degree-Minutes = Aggregate value of size of an excursion times its duration.

Tref values were chosen in accordance with the range of rig design values originally calculated from OHTEMP1.10g using the P27 parameters when designing the rig. These are shown in **Figure 1**, from which we can see that the appropriate range of Tref for Ash 500 is 65°C to 85°C.

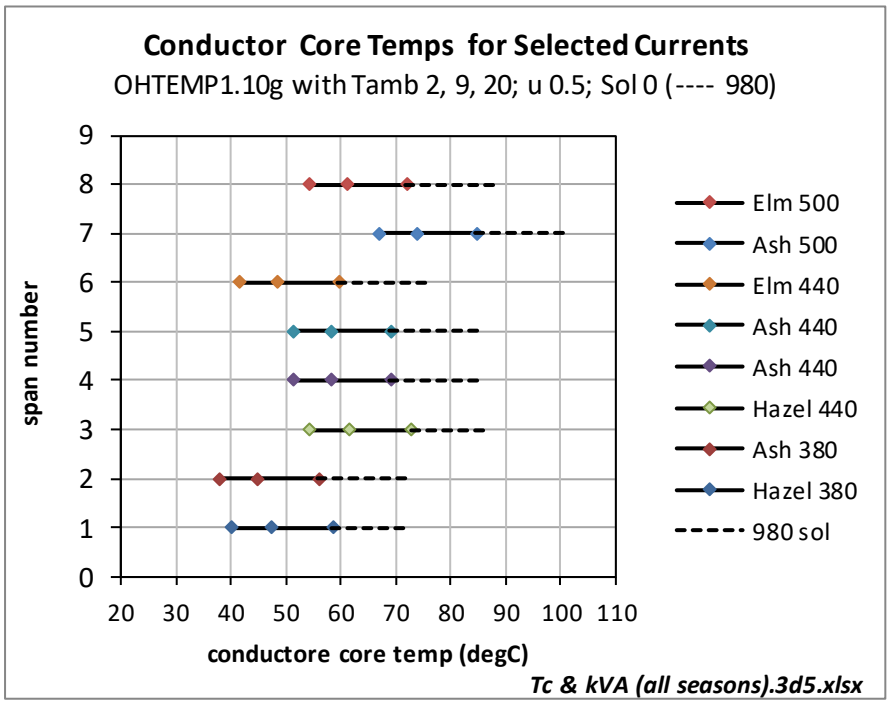

Figure 1: Rig design values of Tcon from OHRAT

Figure 2 shows the values of the four excursion parameters obtained for Ash 500 for reference temperatures of 65, 70, 75, 80 and 85°C. Each row shows the four excursion parameters for a particular temperature and the five rows correspond to the five reference temperatures.

Thus, the bottom row shows that;

- there were 3 excursion events over 85;
- Tcon exceeded 85°C for 6 minutes in all;
- the maximum excursion was 0.5°C, i.e. the maximum temperature was 85.5°C;
- the integral excursion time was 1.6 degree-minutes.

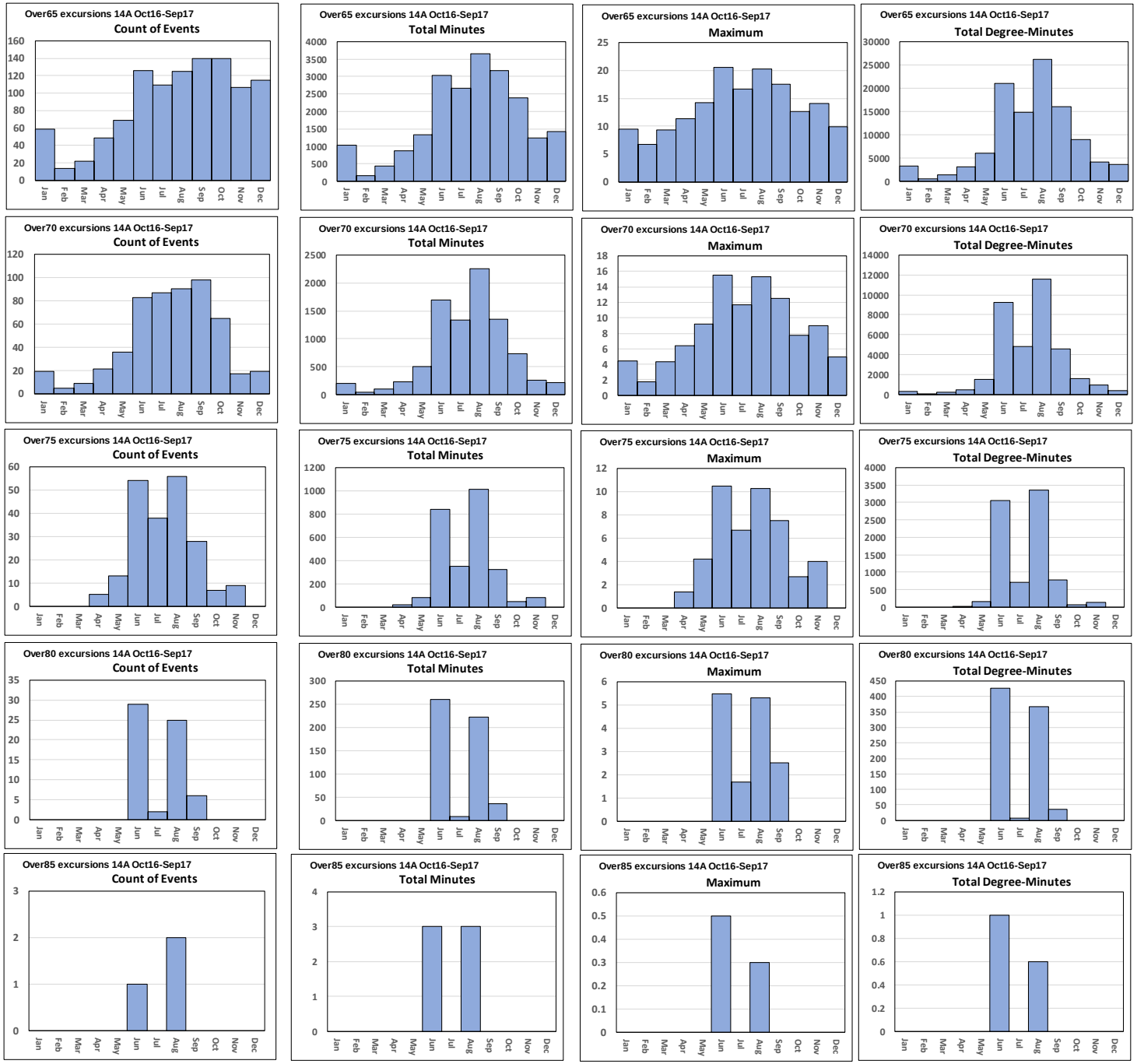

Figure 2: Excursion data for Ash 500 Oct 2016 to Sep 2017

It is apparent from these graphs that for this particular 12-month period

- there is a clear summer period comprising June to September (cf May to August in P27);
- there is a much less clear separation of the non-summer data into autumn/spring and winter;
- overall, the best split is probably into just two seasons, namely a 4-month summer season and an 8-month winter season:
  - summer: June to September (4 months)
  - winter: October to May (8-month).
- if more symmetry is preferred, May and October should be shifted into summer, giving two 6-month seasons;
- a four-season split is not really justified from the data;
- if a four-season split is required, we need to find autumn and spring seasons that give similar results to each other;
- the best choice would appear to be two 2-month seasons: October-November for autumn, April-May for spring;
- this would give a 4-2-4-2 split, i.e.
  - winter: December to March
  - spring: April to May
  - summer: June to September
  - autumn: October to November

Note that these preliminary findings are based on results for only one of the ten conductors, and on only 12 of what will be 21 months of available data. The full dataset may give more definitive results.

4.5 Production of CT Curves

An analysis tool is being developed to produce Ct curves from concatenated monthly data files. The tool requires four inputs – the month to be analysed, a minimum and maximum design temperature and a conductor type. The tool is currently set to count the number of excursions above the design temperature at five-degree intervals between the minimum and maximum values stated. Here an excursion is defined as being any one-minute instance the measured conductor temperature was above the design temperature.

4.6 Software Development

The development of the technical specification for the software tool is under way and software development is due to begin in the new year. The software will be Windows based (x64 Windows 7 and 10 with.NET 4.6.2). The software will have five 'modules' – OHRAT probabilistic, OHRAT deterministic, OHTEMP, batch runs of OHRAT deterministic and OHTEMP and effective re-run of the Stoke project.

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