

13 Appendix C: On-Road Results – Addendum

The measurement terrains, vehicle speeds, ambient wind conditions, turbulence levels and calculated length scales for all measurements taken during on-road testing are summarised below.

Length scales are only provided for those measurements with sufficiently long samples, i.e. generally 600 seconds, except for some initial 150 mm spaced measurements where the sample lengths were 100 seconds. This is because length scales cannot be calculated from short measurement samples with any degree of accuracy, as atmospheric length scales are typically very long (of the order of tens of metres), take a finite time to convect past a measurement point, and therefore long samples are required in order to estimate them.

The longest measurement samples of 600 seconds are still not ideal for such calculations, as can be seen by the variation in calculated length scales for a given terrain and wind condition. In order to use length scale as a normalising factor in data reduction, better accuracy is desired. In future it is recommended that samples of half an hour to an hour (1800 - 3600 seconds) would be more appropriate for better estimation of length scales. This could be achieved by having separate instrumentation recording such data, with a much-reduced sampling frequency, slightly upstream of the test location while testing is underway.

13.1 Measurement results summary – 50 mm probe spacing

Results from the main series of on-road tests with 50 mm probe spacing are shown in Table 6a below. Only the results from the fourth probe are shown in the table, however, the mean velocities from all four probes were generally within 0.2 m/s of each other for all measurement sessions over the entire on-road testing phase. Assuming a Gaussian distribution of values, this equates to all four probe values lying within bounds of ± 0.2 m/s at 95% confidence for all measurements, both moving and stationary.

Turbulence intensity magnitude measured directly by the probes during moving measurements (i.e. measurements including vehicle speed) were less than 20%, and generally less than 10%, and therefore well within the probes capabilities. The variation between the longitudinal turbulence intensity measured by the four different probes for a particular moving measurement was generally well within 0.2%, or assuming a Gaussian distribution of values from the four probes, within $\pm 0.2\%$ at 95% confidence.

Turbulence intensity measured directly during stationary measurements (i.e. vehicle stationary) ranged from 15% to 35%, still within the Cobra Probes core region of accuracy. However, intermittent data dropouts affected some of these measurements. Longitudinal turbulence intensities measured by the four probes for measurements without dropouts were, assuming a Gaussian distribution of measured values, within $\pm 0.3\%$ at 95% confidence. While the variation between the longitudinal turbulence intensities measured by the four probes for measurements with dropouts were within $\pm 1.0\%$ at 95% confidence. It is also likely that other factors might affect stationary measurements with larger turbulence levels ($> 30\%$), such as the greater variation in flow angles causing interference effects between probes as the wakes of upstream probes start to influence those downstream.

Table 6a: Turbulence intensities and length scales of the atmospheric measurements with 50 mm probe spacing, various terrains and wind speeds (4th probe data only). Length scales are only given for stationary measurements (i.e. long time samples).

Terrain, location	Test Conditions	Turbulence Levels			Length scales		
	V _v , V _w (sample length)	Ambient wind I _u , I _v , I _w (%)	Equiv IAS 10 m/s J _u , J _v , J _w (%)	L _x (m)	L _y (m)	L _z (m)	
4-2, Geelong-Ballan Rd	0 km/h, 7.5 m/s, (120 s)	16.0, 11.2, 8.5	11.9, 8.3, 6.3	19	5	4	
	0 km/h, 7.1 m/s, (120 s)	15.1, 11.7, 8.3	10.5, 8.1, 5.8	22	8	3	
	49 km/h, 8.4 m/s, (85 s)	25.5, 13.7, 9.4	18.3, 9.8, 6.7	-	-	-	
	49 km/h, 8.6 m/s, (96 s)	23.3, 13.4, 8.4	18.0, 10.3, 6.5	-	-	-	
	49 km/h, 7.9 m/s, (94 s)	26.9, 15.8, 9.1	18.1, 10.7, 6.1	-	-	-	
	50 km/h, 7.6 m/s, (96 s)	24.5, 19.4, 9.2	14.8, 11.7, 5.6	-	-	-	
4-2, Kinloch Ct	19 km/h, 2.2 m/s, (99 s)	16.2, 14.6, 11.1	3.4, 3.0, 2.3	-	-	-	
	22 km/h, 2.5 m/s, (80 s)	22.0, 15.1, 9.9	5.2, 3.5, 2.3	-	-	-	
	21 km/h, 3.0 m/s, (90 s)	15.8, 13.1, 8.2	4.5, 3.8, 2.4	-	-	-	
4-2, Recreation Rd	20 km/h, 3.2 m/s, (120 s)	34.0, 27.2, 14.6	10.4, 8.4, 4.5	-	-	-	
	20 km/h, 3.8 m/s, (60 s)	19.5, 22.4, 11.9	7.3, 8.4, 4.5	-	-	-	
	50 km/h, 3.7 m/s, (30 s)	25.3, 26.6, 13.2	9.3, 9.8, 4.9	-	-	-	
	50 km/h, 3.7 m/s, (26 s)	28.2, 25.1, 13.5	10.7, 9.5, 5.1	-	-	-	
	0 km/h, 3.5 m/s, (600 s)	27.6, 26.5, 15.5	9.9, 9.5, 5.6	32	14	5	
	0 km/h, 2.9 m/s, (600 s)	33.2, 27.5, 14.6	9.6, 7.9, 4.2	38	20	3	
4-2, Recreation Rd	20 km/h, 7.6 m/s, (72 s)	35.3, 26.2, 16.4	25.5, 18.9, 11.8	-	-	-	
	20 km/h, 5.8 m/s, (71 s)	35.3, 30.7, 20.4	18.4, 16.0, 10.7	-	-	-	
	20 km/h, 7.3 m/s, (67 s)	31.4, 26.0, 18.8	21.0, 17.4, 12.6	-	-	-	
	50 km/h, 6.1 m/s, (22 s)	25.0, 23.2, 16.7	12.5, 11.6, 8.3	-	-	-	
	0 km/h, 7.1 m/s, (600 s)	22.9, 20.6, 11.8	16.3, 14.7, 8.4	81	50	5	
	0 km/h, 7.6 m/s, (600 s)	21.8, 17.6, 10.0	16.4, 13.2, 7.5	83	54	5	
4-2, Recreation Rd	0 km/h, 7.2 m/s, (600 s)	21.2, 16.0, 10.0	14.6, 11.1, 6.9	72	30	8	
	0 km/h, 7.9 m/s, (600 s)	19.6, 17.8, 10.2	14.7, 13.4, 7.7	50	50	20	
4-2, Kinloch Ct	50 km/h, 8.8 m/s, (42 s)	28.1, 16.4, 12.6	22.0, 12.8, 9.9	-	-	-	
	50 km/h, 9.3 m/s, (46 s)	19.5, 17.7, 11.2	16.9, 15.3, 9.7	-	-	-	
4-2, Recreation Rd	20 km/h, 5.2 m/s, (76 s)	29.7, 31.0, 18.3	14.7, 15.4, 9.1	-	-	-	
	20 km/h, 6.0 m/s, (71 s)	26.0, 27.5, 18.3	14.7, 15.6, 10.3	-	-	-	
	50 km/h, 6.0 m/s, (26 s)	25.6, 22.0, 16.1	14.2, 12.2, 8.9	-	-	-	
	50 km/h, 6.2 m/s, (33 s)	25.5, 33.1, 19.2	15.1, 19.5, 11.3	-	-	-	
	0 km/h, 7.9 m/s (600 s)	20.9, 21.1, 11.0	16.1, 16.3, 8.5	52	46	4	
	0 km/h, 8.0 m/s, (600 s)	22.3, 18.9, 10.6	17.4, 14.8, 8.3	64	37	4	
6-2, Bridge Inn Rd	88 km/h, 1.5 m/s (30 s)	50.0, 66.0, 34.5	7.9, 10.4, 5.5	-	-	-	
6-2, Sandpiper Way	19 km/h, 4.3 m/s (42 s)	36.6, 20.5, 14.5	16.0, 8.7, 6.3	-	-	-	
	22 km/h, 3.4 m/s (37 s)	26.6, 20.3, 13.5	8.8, 6.7, 4.4	-	-	-	
	18 km/h, 4.0 m/s (44 s)	25.6, 25.1, 15.7	10.4, 10.2, 6.4	-	-	-	
	19 km/h, 5.8 m/s, (37 s)	26.3, 20.1, 14.6	14.8, 11.4, 8.3	-	-	-	
	19 km/h, 3.6 m/s, (38 s)	23.7, 21.7, 15.6	8.5, 7.7, 5.6	-	-	-	
6-2, Building 253	0 km/h, 6.9 m/s, (600 s)	25.7, 30.1, 17.6	17.6, 20.6, 12.0	27	30	6	
6-2, Sandpiper Way	20 km/h, 5.0 m/s, (44 s)	27.6, 19.6, 17.9	13.3, 9.4, 8.6	-	-	-	
	20 km/h, 5.2 m/s, (42 s)	28.4, 26.1, 18.2	14.2, 13.1, 9.1	-	-	-	
	20 km/h, 6.0 m/s, (43 s)	44.4, 27.2, 17.2	26.1, 16.0, 10.1	-	-	-	

7-2, Beaconsfield Pde	59 km/h, 3.8 m/s, (76 s)	44.4, 54.5, 28.1	18.6, 22.8, 11.7	-	-	-
	59 km/h, 4.0 m/s, (54 s)	43.3, 50.7, 29.6	17.4, 20.4, 11.9	-	-	-
	58 km/h, 3.5 m/s, (22 s)	40.4, 78.3, 29.1	14.1, 27.4, 10.2	-	-	-
7-2, Hoddle St	60 km/h, 3.7 m/s, (55 s)	49.5, 37.3, 25.9	17.8, 13.4, 9.3	-	-	-
	60 km/h, 3.5 m/s, (56 s)	57.2, 44.0, 28.7	18.6, 14.3, 9.3	-	-	-
	65 km/h, 5.1 m/s, (55 s)	30.4, 27.2, 19.3	14.8, 13.2, 9.4	-	-	-
7-2, Langridge St	60 km/h, 2.8 m/s, (13 s)	44.7, 49.3, 33.9	11.6, 12.8, 8.8	-	-	-
	60 km/h, 3.6 m/s, (8 s)	43.8, 44.6, 29.2	14.9, 15.2, 9.9	-	-	-
	60 km/h, 2.8 m/s, (12 s)	65.5, 61.1, 35.5	16.9, 15.7, 9.1	-	-	-
5-3, Hume Fwy (north)	94 km/h, 6.2 m/s, (26 s)	33.1, 34.8, 21.4	7.3, 7.7, 4.8	-	-	-
	107 km/h, 4.7 m/s, (42 s)	45.5, 64.0, 40.3	4.5, 6.4, 4.0	-	-	-
6-3, Fiskville	51 km/h, 5.8 m/s, (60 s)	35.2, 32.8, 17.6	16.2, 15.1, 8.1	-	-	-
	52 km/h, 5.9 m/s, (63 s)	32.0, 29.1, 19.8	14.8, 11.7, 9.2	-	-	-
	50 km/h, 6.1 m/s, (63 s)	37.2, 25.7, 19.5	17.9, 12.4, 9.4	-	-	-

13.2 Measurement results summary – 150 mm probe spacing

Results from the initial tests taken with 150 mm probe spacing are shown in Table 6b. Only the results from the first probe are shown in the table, however, the mean velocities from all four probes were generally within 0.1 m/s of each other. Assuming a Gaussian distribution of values, this equates to all four probe values lying within bounds of ± 0.1 m/s at 95% confidence for all measurements, both moving and stationary.

Turbulence intensity magnitude measured directly by the probes during moving measurements (i.e. measurements including vehicle speed) were less than 15%, and generally less than 10%, and therefore well within the probes capabilities. The variation between the longitudinal turbulence intensity measured by the four probes for a particular moving measurement were generally well within 0.5%, or assuming a Gaussian distribution of values from the four probes, within $\pm 0.2\%$ at 95% confidence.

Turbulence intensity measured directly during stationary measurements (i.e. vehicle stationary) ranged from 30% to 76% and was therefore outside the probes core region of accuracy, although still within its measurement capabilities. The variation between the longitudinal turbulence intensity measured by the four probes for any of these measurements was within 4%, or assuming a Gaussian distribution of probe values, within $\pm 3.2\%$ at 95% confidence. It is also likely that other factors might affect stationary measurements with larger turbulence levels (>30%), such as the greater variation in flow angles causing interference effects between probes as the wakes of upstream probes start to influence those further downstream.

Table 6b: Turbulence intensities and length scales of the atmospheric measurements with 150 mm probe spacing (initial investigation - Nov 2002), various terrains and wind speeds (1st probe data only). Length scales are only given for stationary measurements (i.e. long time samples).

Terrain, location	Test Conditions	Turbulence Levels		Length Scales		
	V _v , V _w (sample length)	Ambient wind I _u , I _v , I _w (%)	Equiv IAS 10 m/s J _u , J _v , J _w (%)	L _x (m)	L _y (m)	L _z (m)
4-2, Yan Yean	40 km/h, 5.0 m/s, (10 s)	36.1, 25.9, 20.0	18.0, 12.9, 10.0	-	-	-
	40 km/h, 6.5 m/s, (10 s)	22.4, 13.1, 10.4	14.1, 8.3, 6.6	-	-	-
	40 km/h, 3.7 m/s, (10 s)	25.9, 29.1, 17.6	8.6, 9.6, 5.8	-	-	-
	40 km/h, 4.1 m/s, (10 s)	22.9, 17.0, 11.7	9.4, 7.0, 4.8	-	-	-
4-2, Yan Yean	60 km/h, 4.4 m/s, (10 s)	50.2, 36.7, 14.3	21.3, 15.6, 6.1	-	-	-
	60 km/h, 5.4 m/s, (10 s)	27.0, 23.5, 14.8	13.5, 11.8, 7.4	-	-	-
	60 km/h, 5.0 m/s, (10 s)	20.0, 33.2, 19.1	9.2, 15.2, 8.8	-	-	-
	60 km/h, 5.0 m/s, (10 s)	24.7, 27.3, 13.7	9.0, 9.9, 5.0	-	-	-
4-2, Yan Yean	80 km/h, 4.7 m/s, (10 s)	50.6, 43.6, 15.0	22.1, 19.0, 6.5	-	-	-
	80 km/h, 5.1 m/s, (10 s)	23.3, 17.0, 12.6	11.9, 8.7, 6.4	-	-	-
	80 km/h, 4.0 m/s, (10 s)	39.4, 27.5, 18.7	15.2, 10.6, 7.2	-	-	-
	80 km/h, 3.0 m/s, (10 s)	36.5, 40.4, 22.7	9.3, 10.2, 5.8	-	-	-
4-2, Yan Yean	100 km/h, 6.2 m/s, (10 s)	22.6, 22.5, 10.6	13.7, 13.6, 6.4	-	-	-
	100 km/h, 5.0 m/s, (10 s)	20.4, 27.4, 13.1	10.1, 13.5, 6.5	-	-	-
	100 km/h, 4.2 m/s, (10 s)	45.5, 58.1, 30.1	10.7, 13.7, 7.1	-	-	-
	100 km/h, 4.1 m/s, (10 s)	43.8, 56.0, 28.3	10.7, 13.7, 6.9	-	-	-
4-2, Yan Yean	0 km/h, 4.2 m/s, (100 s)	29.0, 23.6, 17.9	12.2, 9.9, 7.5	21	8	2
	0 km/h, 3.5 m/s, (100 s)	70.0, 36.6, 25.9	24.3, 12.7, 9.0	11	6	2