

Barron County Wisconsin LIDAR PROJECT

ACCURACY ASSESSMENT REPORT

PROCESS DESCRIPTION

Raw LIDAR range, GPS and IMU data was imported into Applanix Posproc software and Optech's REALM software and processed to final first return and last return x y z i point files in UTM NAD 83, zone 15, ellipsoid meters. The ASCII point files were converted to Wisconsin County Coordinate system Barron County-9503 State Plane NAD83, NGVD29 US Survey Foot and GRS80, US Survey Foot using GEIOD03 in WIScon V2.2. Removal of vegetation and other above ground features was completed in Terrascan software V005. The LIDAR x y z i data was compared to ground control points and LIDAR flight lines that crossed said control points were vertically adjusted to best fit said points and called control lines. The remaining flight lines were then vertically adjusted to seamlessly match the control lines. Any remaining noise was removed from the LIDAR x y z bald earth point files to create a surface model of irregularly spaced points.

QUALITY CONTROL AND ACCURACY ASSESSMENT PROCEDURES

AREA COVERAGE

All LIDAR elevation measurements were imported into the project area polygon and checked and verified to be free of data voids or gaps, except in the bald earth surface model where voids or gaps were created by vegetation, buildings, water or other removed features.

AVERAGE RAW POINT DENSITY

No deviation was made from the planned survey parameters calculated to meet the required LIDAR average raw point density, therefore the average raw point spacing will be approximately the same as our planned flight as set forth below:

LIDAR Flight Parameters

Laser Firing Rate: 25000
Altitude (ft. AGL): 2800
Swath Overlap (%): 50
Approx. Ground Speed (mph): 150
Scan Rate (Hz): 28.0
Scan Angle ($^{\circ}\pm$): 19.0
Computed Along Track Spacing (ft): 4.2
Computed Cross track Spacing (ft.): 4.2
Average Raw Point Spacing (ft.) 3.0
Computed Swath Width (ft.): 1928
Number of Lines Req'd: 178
Line Spacing (ft.) 964

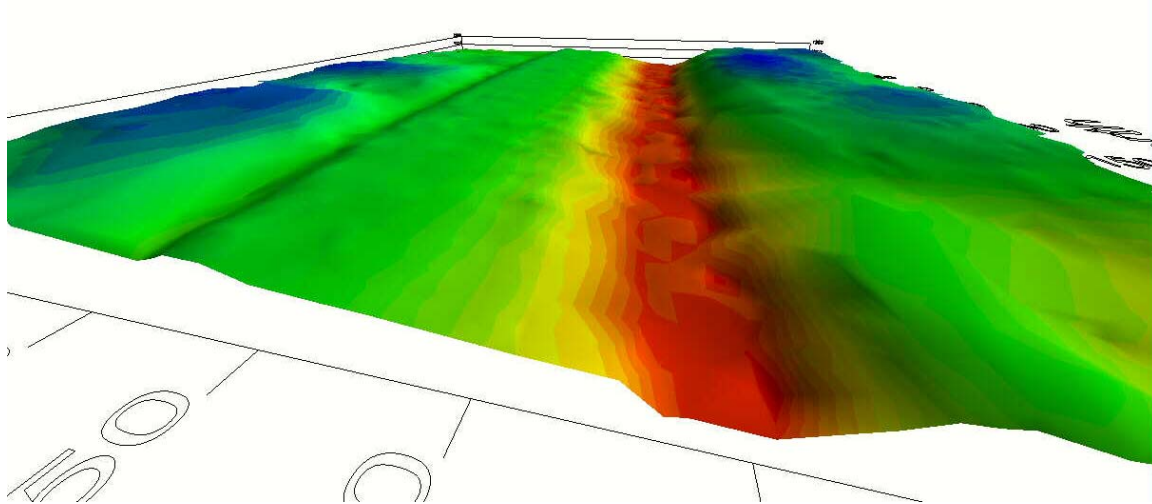
VERTICAL POSITIONAL ACCURACY

The LIDAR data was collected, processed and mapped under the direct supervision of professional land surveyors. Airborne GPS trajectories were carefully processed and analyzed with proprietary methods to produce long baseline solutions in the few centimeter range. Proprietary data analysis and adjustment methods were then utilized to form a LIDAR DTM model of both the first and last return surfaces that were best fit into static GPS ground control points that had been set to both control and validate the LIDAR survey. The vertical accuracy of the LIDAR DTM surface was then determined by comparing the best fit of the LIDAR DTM to the ground control points. Since the LIDAR DTM surface model was totally intact relative to the airborne trajectory, any point falling inside the DTM point coverage relative

to the GPS ground control network will produce similar vertical accuracies. Ground truth points were also collected by Barron County throughout the typical vegetation classifications around the county as shown on the attached spread sheet. The overall project RMSE based upon the ground truth surveys was 0.29'.

HORIZONTAL POSITIONAL ACCURACY

The horizontal accuracy of a LIDAR DTM surface is more difficult to validate than the vertical DTM comparisons to ground control, however, we have utilized the technique set forth hereafter and have successfully produced high accuracy LIDAR surveys for over 8 years that have been used for engineering planning and design. The LIDAR data was collected and processed as described above. Then the horizontal accuracy was analyzed by comparing data from opposing LIDAR flight lines having a 50% sidelap in flight coverage to the adjoining flight line. This gives a comparison of terrain features contiguous to one flight line overlapped and overlaid on top of the adjoining flight line. This produces millions of check points from each line as compared to the adjoining line. The overlapped data is carefully compared for alignment of features and checked for the clarity and consistency of said features. Specific sloping features are selected along the flight trajectory and at perpendicular angles. If there is any shift in the horizontal alignment of the LIDAR data from the adjoining line, it will appear as noise along the perpendicular sloped features. Shown below is a graphic used only to demonstrate this technique using all last return shots.



The above graphic is two overlapping flight lines along a perpendicular road surface with relatively steep side slopes. The color bands on the graphic are at 1 foot increments. You can see that small terrain relief features visible on the side slope of the road are almost in perfect alignment with very little noise. This indicates a very close alignment horizontally between the two flight lines. Using this method, we can determine that the horizontal accuracy of the LIDAR DTM is easily sub foot. A shift of 1 foot or more horizontally would have produced a very apparent roughness in the sides of the slopes along the road surface.

BARRON COUNTY WISCONSIN LIDAR QUALITY ASSURANCE DATA									
			PROJECT ACCURACY STATISTICS						
Total # shots = 166 - 5% outliers = 158				Coefficient of Skew	0.37				
				RMSE (ft.)	0.29	NSSDA Accuracy Reporting - 0.29' RMSE x 1.9600 = 0.568'			
		Std Deviation	0.27	Mean	0.13		Median	0.10	
	Bare Earth - Low Grass	High Grass, Weeds & Crops	Brush Lands & Low Trees	Forested, fully covered in Trees					
RMSE by Category	0.17	0.32	0.47	0.40	0.14				
Ground Truth Points	Easting	Northing	Elevation		LIDAR Points	Δ		TILE #	GROUND CATEGORY
100	236850.32	38348.84	1199.53		1199.18	-0.35		38_236	Bare Earth - Low Grass
101	236838.72	38290.19	1196.27		1196.18	-0.09		38_236	Bare Earth - Low Grass
102	236844.69	38228.91	1194.82		1194.53	-0.29		38_236	Bare Earth - Low Grass
103	236845.61	38142.33	1194.77		1194.61	-0.16		38_236	Bare Earth - Low Grass
104	236945.74	38123.33	1204.22		1203.93	-0.29		38_236	Bare Earth - Low Grass
105	236996.71	38157.33	1204.82		1204.64	-0.18		38_236	Bare Earth - Low Grass
106	237056.52	38170.38	1203.17		1203.06	-0.11		38_236	Bare Earth - Low Grass
107	237071.86	38335.28	1205.95		1205.81	-0.14		38_236	Bare Earth - Low Grass
108	233911.40	38341.68	1142.26		1142.22	-0.04		38_232	Bare Earth - Low Grass
109	233916.00	38265.11	1140.55		1140.70	0.15		38_232	Bare Earth - Low Grass
110	233953.38	38116.74	1141.40		1141.46	0.06		38_232	Bare Earth - Low Grass
111	233999.41	38109.94	1141.45		1141.56	0.11		38_232	Bare Earth - Low Grass
112	234057.15	38106.92	1141.78		1141.78	0.00		38_232	Bare Earth - Low Grass
113	234133.40	38106.94	1141.58		1141.58	0.00		38_232	Bare Earth - Low Grass
114	234231.18	38111.07	1141.51		1141.43	-0.08		38_232	Bare Earth - Low Grass
115	234350.66	38083.15	1140.69		1140.58	-0.11		38_232	Bare Earth - Low Grass
116	234265.96	38170.71	1141.01		1141.04	0.03		38_232	Bare Earth - Low Grass
117	234201.83	38187.21	1141.24		1141.14	-0.10		38_232	Bare Earth - Low Grass
118	234124.48	38207.31	1141.25		1141.26	0.01		38_232	Bare Earth - Low Grass
119	234032.17	38222.17	1141.14		1141.14	0.00		38_232	Bare Earth - Low Grass
120	234014.85	38307.91	1141.95		1141.95	0.00		38_232	Bare Earth - Low Grass
121	234104.03	38309.27	1141.65		1141.53	-0.12		38_232	Bare Earth - Low Grass

122	234164.70	38313.88	1141.58		1141.55	-0.03		38_232	Bare Earth - Low Grass
123	234221.33	38327.82	1141.51		1141.48	-0.03		38_232	Bare Earth - Low Grass
124	234053.57	38363.25	1141.95		1141.90	-0.05		38_232	Bare Earth - Low Grass
125	233837.74	38329.83	1141.43		1141.22	-0.21		38_232	Bare Earth - Low Grass
126	233768.16	38326.97	1140.57		1140.22	-0.35		38_232	Bare Earth - Low Grass
127	233642.57	38333.35	1138.58		1138.38	-0.20		38_232	Bare Earth - Low Grass
128	233607.36	38373.91	1139.79		1139.52	-0.27		38_232	Bare Earth - Low Grass
129	233536.05	38343.20	1139.07		1138.83	-0.24		38_232	Bare Earth - Low Grass
130	233637.28	38260.72	1137.58		1137.37	-0.21		38_232	Bare Earth - Low Grass
131	233636.41	38170.40	1138.28		1138.05	-0.23		38_232	Bare Earth - Low Grass
202	379656.09	36427.56	1142.67		1143.02	0.35		34_376	High Grass, Weeds & Crops
203	379645.53	36370.78	1142.22		1142.68	0.46		34_376	High Grass, Weeds & Crops
204	379620.59	36321.90	1141.31		1141.80	0.49		34_376	High Grass, Weeds & Crops
205	379570.13	36290.45	1139.39		1140.01	0.62		34_376	High Grass, Weeds & Crops
207	379449.32	36288.14	1136.11		1136.68	0.57		34_376	High Grass, Weeds & Crops
208	379438.52	36341.61	1135.53		1136.02	0.49		34_376	High Grass, Weeds & Crops
209	379399.58	36424.89	1134.39		1134.42	0.03		34_376	High Grass, Weeds & Crops
210	379305.14	36451.48	1132.03		1132.21	0.18		34_376	High Grass, Weeds & Crops
211	379215.21	36523.97	1131.07		1131.35	0.28		34_376	High Grass, Weeds & Crops
212	379105.91	36593.98	1130.07		1130.56	0.49		34_376	High Grass, Weeds & Crops
213	379053.46	36664.28	1130.93		1131.36	0.43		34_376	High Grass, Weeds & Crops
214	378983.12	36676.39	1131.39		1131.68	0.29		34_376	High Grass, Weeds & Crops
215	378940.82	36665.31	1131.32		1131.62	0.30		34_376	High Grass, Weeds & Crops
216	373629.71	45190.71	1072.74		1072.95	0.21		42_372	High Grass, Weeds & Crops
217	373618.08	45167.43	1071.84		1072.18	0.34		42_372	High Grass, Weeds & Crops
218	373657.60	45133.69	1071.52		1072.07	0.55		42_372	High Grass, Weeds & Crops
219	373682.23	45043.41	1070.77		1070.90	0.13		42_372	High Grass, Weeds & Crops
220	373740.46	45097.95	1070.69		1070.80	0.11		42_372	High Grass, Weeds & Crops
221	373776.28	45149.73	1072.22		1072.74	0.52		42_372	High Grass, Weeds & Crops
222	373805.73	45182.23	1074.17		1074.28	0.11		42_372	High Grass, Weeds & Crops
223	373826.57	45131.41	1072.90		1073.07	0.17		42_372	High Grass, Weeds & Crops
224	373920.69	45090.81	1074.20		1074.27	0.07		42_372	High Grass, Weeds & Crops
225	373969.90	45087.35	1074.16		1074.12	-0.04		42_372	High Grass, Weeds & Crops
226	373995.62	45105.11	1073.38		1073.21	-0.17		42_372	High Grass, Weeds & Crops
227	374039.52	45182.95	1074.28		1074.35	0.07		42_372	High Grass, Weeds & Crops
228	374083.95	45217.58	1073.71		1073.67	-0.04		42_372	High Grass, Weeds & Crops
229	374139.16	45253.16	1075.51		1075.42	-0.09		42_372	High Grass, Weeds & Crops
230	374153.50	45270.97	1075.26		1075.36	0.10		42_372	High Grass, Weeds & Crops
231	374204.77	45218.75	1077.15		1077.32	0.17		42_372	High Grass, Weeds & Crops
232	374256.46	45176.98	1078.40		1078.67	0.27		42_372	High Grass, Weeds & Crops
233	374244.52	45133.28	1078.92		1079.03	0.11		42_372	High Grass, Weeds & Crops
300	232398.77	122461.47	1235.60		1236.14	0.54		122_232	Brush Lands & Low Trees
301	232372.77	122462.54	1235.74		1235.99	0.25		122_232	Brush Lands & Low Trees

302	232312.47	122496.29	1235.56		1235.67	0.11		122_232	Brush Lands & Low Trees
303	232239.93	122489.36	1235.80		1236.37	0.57		122_232	Brush Lands & Low Trees
307	232414.00	122709.85	1234.88		1235.27	0.39		122_232	Brush Lands & Low Trees
308	232386.60	122750.88	1235.20		1235.72	0.52		122_232	Brush Lands & Low Trees
309	232360.97	122784.15	1235.45		1236.10	0.65		122_232	Brush Lands & Low Trees
310	232252.50	123445.35	1234.41		1234.79	0.38		122_232	Brush Lands & Low Trees
311	232149.66	123488.56	1234.09		1234.44	0.35		122_232	Brush Lands & Low Trees
312	232436.28	123884.03	1231.04		1231.50	0.46		122_232	Brush Lands & Low Trees
313	232379.96	123890.66	1230.29		1230.88	0.59		122_232	Brush Lands & Low Trees
314	232314.09	123896.35	1229.96		1230.05	0.09		122_232	Brush Lands & Low Trees
315	232248.12	123929.03	1229.39		1229.74	0.35		122_232	Brush Lands & Low Trees
316	232233.76	124037.11	1229.28		1229.64	0.36		122_232	Brush Lands & Low Trees
317	232231.51	124082.25	1229.23		1229.38	0.15		122_232	Brush Lands & Low Trees
318	232264.38	124172.15	1228.49		1228.70	0.21		122_232	Brush Lands & Low Trees
319	232271.36	124208.02	1228.50		1228.88	0.38		122_232	Brush Lands & Low Trees
320	232221.85	124272.00	1228.83		1229.25	0.42		122_232	Brush Lands & Low Trees
321	232211.72	124359.88	1229.17		1229.66	0.49		122_232	Brush Lands & Low Trees
322	232250.49	124518.69	1227.45		1227.74	0.29		122_232	Brush Lands & Low Trees
323	232198.15	124692.16	1226.71		1226.73	0.02		122_232	Brush Lands & Low Trees
324	232243.76	124779.64	1225.38		1225.76	0.38		122_232	Brush Lands & Low Trees
325	232441.59	124856.70	1224.63		1225.04	0.41		122_232	Brush Lands & Low Trees
326	232553.27	124114.20	1228.88		1229.62	0.74		122_232	Brush Lands & Low Trees
327	232567.37	124040.94	1229.58		1230.33	0.75		122_232	Brush Lands & Low Trees
328	232594.23	123974.95	1230.84		1231.60	0.76		122_232	Brush Lands & Low Trees
329	232575.12	123923.50	1231.44		1232.09	0.65		122_232	Brush Lands & Low Trees
330	232619.79	125925.13	1225.55		1225.69	0.14		122_232	Brush Lands & Low Trees
331	232657.76	125898.45	1225.10		1225.84	0.74		122_232	Brush Lands & Low Trees
400	353677.51	184228.92	1232.51		1232.37	-0.14		182_352	Forested, fully covered in Trees
401	353694.92	184229.71	1232.90		1233.18	0.28		182_352	Forested, fully covered in Trees
402	353719.18	184223.49	1233.60		1233.55	-0.05		182_352	Forested, fully covered in Trees
403	353749.06	184228.16	1235.10		1234.69	-0.41		182_352	Forested, fully covered in Trees
404	353763.08	184227.29	1235.75		1235.56	-0.19		182_352	Forested, fully covered in Trees
405	353789.64	184228.19	1236.29		1236.32	0.03		182_352	Forested, fully covered in Trees
406	353807.00	184201.30	1235.85		1235.94	0.09		182_352	Forested, fully covered in Trees
407	353786.84	184204.12	1236.29		1236.42	0.13		182_352	Forested, fully covered in Trees
408	353741.52	184200.59	1234.69		1234.41	-0.28		182_352	Forested, fully covered in Trees
409	353700.39	184194.37	1233.58		1233.43	-0.15		182_352	Forested, fully covered in Trees
410	353704.64	184128.85	1232.61		1232.74	0.13		182_352	Forested, fully covered in Trees
411	353742.02	184123.27	1233.05		1232.73	-0.32		182_352	Forested, fully covered in Trees
412	353786.86	184115.68	1232.79		1232.88	0.09		182_352	Forested, fully covered in Trees
413	353674.14	184726.02	1233.76		1233.87	0.11		182_352	Forested, fully covered in Trees
414	353667.13	184767.42	1233.47		1233.46	-0.01		182_352	Forested, fully covered in Trees
415	353714.05	184786.36	1233.86		1234.11	0.25		182_352	Forested, fully covered in Trees

416	353673.99	184819.27	1233.93		1234.23	0.30		182_352	Forested, fully covered in Trees
417	353668.06	184882.09	1235.27		1235.36	0.09		182_352	Forested, fully covered in Trees
418	353688.57	184918.62	1235.54		1235.82	0.28		182_352	Forested, fully covered in Trees
419	363987.74	164103.75	1207.36		1207.68	0.32		162_360	Forested, fully covered in Trees
420	363970.10	164109.03	1207.33		1207.83	0.50		162_360	Forested, fully covered in Trees
421	363985.82	164132.17	1208.98		1209.28	0.30		162_360	Forested, fully covered in Trees
423	364175.38	164222.10	1211.60		1211.91	0.31		162_364	Forested, fully covered in Trees
424	364183.34	164239.87	1210.74		1211.21	0.47		162_364	Forested, fully covered in Trees
426	364336.86	163942.97	1213.38		1213.86	0.48		162_364	Forested, fully covered in Trees
427	364307.83	163918.53	1214.61		1214.87	0.26		162_364	Forested, fully covered in Trees
428	364324.33	163909.75	1215.65		1215.99	0.34		162_364	Forested, fully covered in Trees
429	364323.25	163891.23	1216.37		1216.53	0.16		162_364	Forested, fully covered in Trees
430	364344.66	163876.52	1218.48		1219.13	0.65		162_364	Forested, fully covered in Trees
431	364347.59	163822.12	1214.45		1214.65	0.20		162_364	Forested, fully covered in Trees
432	364324.59	163792.22	1212.86		1213.14	0.28		162_364	Forested, fully covered in Trees
500	306066.88	98715.51	1115.34		1115.24	-0.10		98_304	Urban Area
501	306160.41	98632.54	1115.06		1114.82	-0.24		98_304	Urban Area
502	306240.70	98642.10	1115.23		1115.33	0.10		98_304	Urban Area
503	306307.86	98629.23	1115.10		1115.34	0.24		98_304	Urban Area
504	306428.36	98685.66	1114.83		1114.96	0.13		98_304	Urban Area
505	306608.57	98861.92	1113.53		1113.66	0.13		98_304	Urban Area
506	306682.37	98858.55	1112.90		1112.91	0.01		98_304	Urban Area
507	306741.18	98863.49	1113.03		1112.93	-0.10		98_304	Urban Area
508	306622.16	98604.09	1113.42		1113.55	0.13		98_304	Urban Area
509	306316.29	98493.57	1113.69		1113.75	0.06		98_304	Urban Area
510	306460.38	98514.97	1113.75		1113.86	0.11		98_304	Urban Area
511	306242.28	98494.72	1113.76		1113.85	0.09		98_304	Urban Area
512	306078.99	98490.43	1114.26		1114.05	-0.21		98_304	Urban Area
513	305883.29	98656.12	1114.34		1114.34	0.00		98_304	Urban Area
514	305856.58	98620.49	1114.74		1114.67	-0.07		98_304	Urban Area
515	305819.46	96778.43	1113.78		1113.70	-0.08		94_304	Urban Area
516	305731.77	96773.46	1114.14		1114.34	0.20		94_304	Urban Area
517	305666.34	96784.66	1114.02		1113.86	-0.16		94_304	Urban Area
518	305656.84	96858.70	1116.51		1116.32	-0.19		94_304	Urban Area
519	305655.73	96915.75	1117.63		1117.47	-0.16		94_304	Urban Area
520	305547.91	96783.69	1114.04		1114.06	0.02		94_304	Urban Area
521	305450.73	96777.86	1116.11		1116.07	-0.04		94_304	Urban Area
522	305334.06	96784.80	1117.54		1117.67	0.13		94_304	Urban Area
523	305064.85	97064.22	1123.00		1122.76	-0.24		94_304	Urban Area
524	305123.39	97059.40	1122.39		1122.43	0.04		94_304	Urban Area
525	304962.80	96946.01	1129.75		1129.76	0.01		94_304	Urban Area
526	304980.42	96891.14	1129.25		1129.15	-0.10		94_304	Urban Area
527	304864.64	96914.17	1135.96		1135.87	-0.09		94_304	Urban Area

528	304865.33	96893.02	1135.56		1135.58	0.02		94_304	Urban Area
529	304843.58	97392.09	1119.58		1119.58	0.00		94_304	Urban Area
530	304774.59	97365.32	1119.91		1119.66	-0.25		94_304	Urban Area
531	304736.51	97430.78	1120.20		1120.25	0.05		94_304	Urban Area
532	304664.25	97429.05	1120.39		1120.43	0.04		94_304	Urban Area
533	304610.02	96773.99	1121.93		1121.97	0.04		94_304	Urban Area
534	304832.36	96772.31	1123.95		1123.64	-0.31		94_304	Urban Area