Aerial Lidar Report

Madison-Otsego, New York

15002-2

Table of Contents

Section 1:   Lidar Processing

1.1   Generation and Calibration of Laser Points

After LiDAR acquisition is completed calibration and final adjustments need to be performed on the LiDAR swaths. Please reference the LiDAR acquisition reports for both the Axis GeoSpatial and Keystone datasets for background information. The initial step of calibration is to verify availability and status of all needed GPS and Laser data against field notes and compile any data if not complete. Subsequently, the mission points are output using Optech's LMS and Trimble's LP Master post processor with the most recent boresight values. The initial point generation for each mission calibration is verified within TerraScan using distance colored points to identify errors. If a calibration error greater than specification is observed within the mission, the roll, pitch and scanner scale corrections that need to be applied are calculated. This was the case with the lidar swath files received from Keystone Aerial Surveys. It was found that after performing distance coloring on the Keystone swaths high relative match results were found between swaths. Keystone had applied some corrections for heading, roll, and pitch that could not be reversed by Axis. Axis requested to have the swaths reprocessed without corrections applied to the swath files. Once validated each output mission is ready to be imported and processed within TerraMatch. Here a project level supplementary coverage check is carried out to ensure no data voids unreported by Field Operations are present.
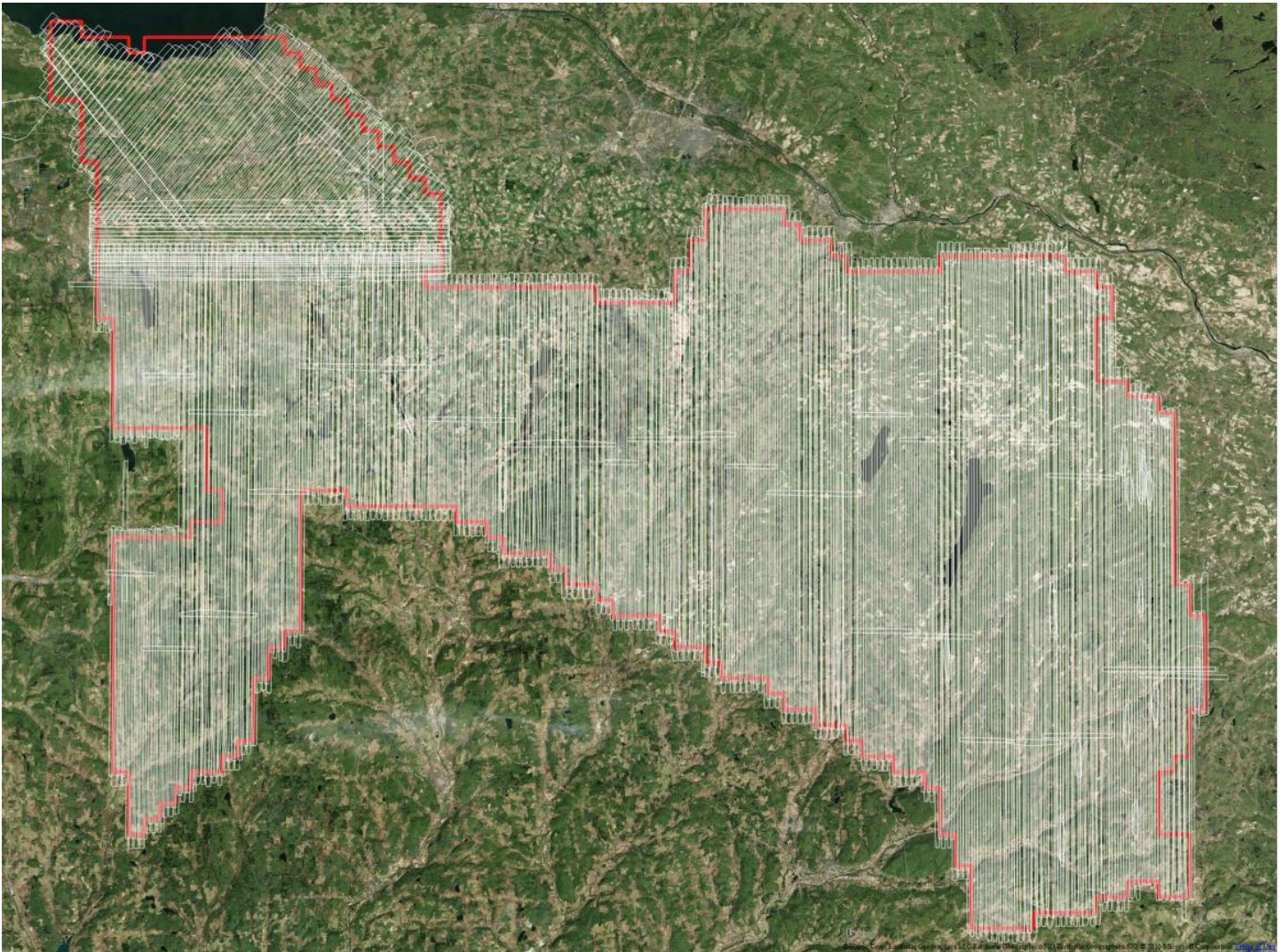
Figure 1: Lidar swath data showing complete coverage

1.2 Reference System

Horizontal Datum:	North American Datum of 1983 (2011)
Coordinate System:	Universal Transverse Mercator Northern Zone 18
Vertical Datum:	North American Vertical Datum of 1988
Geoid Model:	Geoid12A
Units:	Meters

1.3   Lidar Point Cloud Statistics

Table 1 illustrates the overall lidar point cloud statistics for this project.

Point Cloud Statistics	
Category	**Value**
Total Points	33,856,079,262
Aggregate Nominal Pulse Spacing (m)	0.542
Aggregate Nominal Pulse Density (pls/m²)	3.62

Table 1: Lidar Point Cloud Statistics

1.4   Relative Accuracy

For effective data management, each imported mission is tiled out in TerraScan to a project specific tile scheme or index. Relative accuracy and internal quality are then checked using a number of carefully selected tiles in which points from all lines are loaded and inspected. Vertical differences between ground surfaces of each line are displayed by the generation of Z-Difference colored intensity orthos in LasTools. The color scale of these orthos are adjusted so that errors greater than the specifications are flagged. Cross sections are visually inspected across each block to validate point to point, flight line to flight line and mission to mission alignment. When available, surveyed control points are used to supplement and verify the calibration of the data.
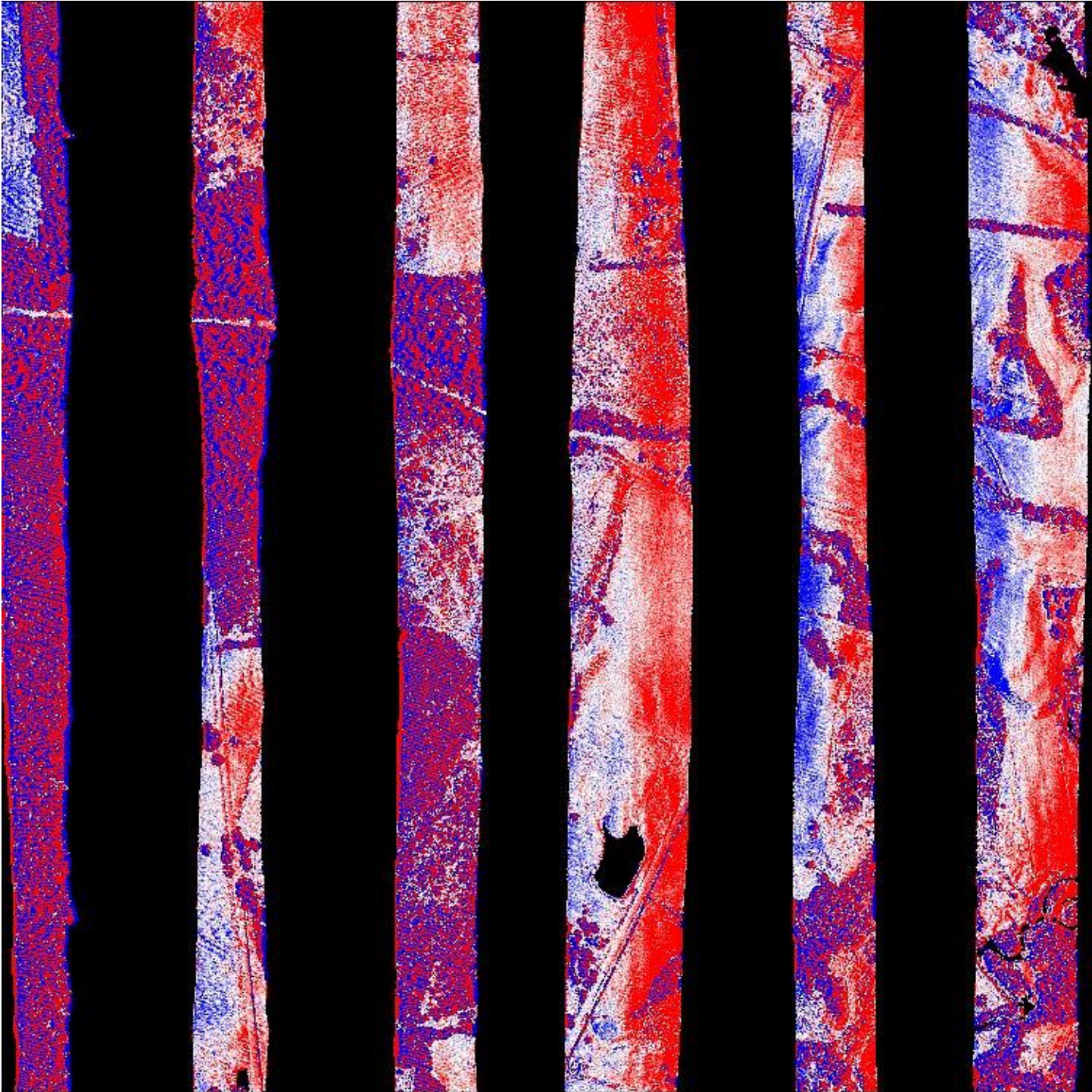
Figure 2: Dz ortho sub-sample

1.5 Relative Accuracy Results

An overall statistical assessment of the relative accuracy using TerraMatch Tie Line Report between lidar swaths can be found in Tables 1, 2, 3, and 4 below. The values provided are in Meters.

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
Flight line	X	Y	Z	Flight line	E	N	Z	Flight line	Z
1	-0.005	0.07	0	1	660	34	1071	1	0.022
2	-0.001	0.046	0.001	2	553	27	928	2	0.017
3	-0.003	-0.008	0	3	69	42	170	3	0.012
4	0.003	0.001	0	4	63	44	168	4	0.012
5	-0.006	0.002	-0.001	5	52	40	134	5	0.011
6	0.003	0.019	-0.001	6	41	40	116	6	0.013
7	-0.002	0.02	-0.001	7	40	32	94	7	0.014
8	-0.019	0	0.001	8	32	18	73	8	0.014
9	-0.019	0	0	9	95	53	206	9	0.011
10	-0.018	-0.005	0	10	75	63	203	10	0.01
11	-0.002	0.003	0	11	77	71	222	11	0.011
12	0.001	0.014	0	12	74	75	240	12	0.01
13	0.016	0	0	13	88	88	281	13	0.01
14	-0.024	0.007	0	14	90	80	311	14	0.011
15	-0.033	0.012	0.001	15	70	83	293	15	0.01
16	-0.011	0.009	0	16	73	103	316	16	0.011
17	-0.01	0.006	0	17	70	132	344	17	0.011
18	-0.013	-0.006	0	18	85	135	354	18	0.011
19	-0.007	0.004	-0.001	19	76	120	330	19	0.011
20	-0.019	0.016	-0.001	20	91	111	330	20	0.011
21	-0.001	0.001	0	21	105	135	370	21	0.011
22	-0.001	0.002	0	22	98	137	365	22	0.012
23	0.01	-0.002	0	23	95	148	398	23	0.011
24	0.008	-0.01	0	24	101	136	385	24	0.011
25	0.001	0.012	0	25	115	174	426	25	0.012

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
26	-0.008	0.008	0.001	26	135	156	437	26	0.011
27	0.024	0.058	-0.002	27	133	25	217	27	0.023
28	-0.002	-0.005	0	28	94	91	303	28	0.01
30	-0.004	0.001	0.003	30	2	5	14	30	0.007
31	-0.025	0.028	0.001	31	6	16	40	31	0.009
32	-0.03	0.022	-0.001	32	8	26	71	32	0.008
33	0	0.005	-0.002	33	13	39	119	33	0.011
34	0.031	-0.014	0	34	10	32	116	34	0.011
35	0.03	-0.024	0.001	35	8	29	135	35	0.009
36	0.046	-0.025	0	36	10	34	178	36	0.01
37	0.039	-0.022	0	37	11	50	227	37	0.012
38	0.048	-0.008	0.001	38	16	52	270	38	0.013
39	0.079	-0.02	0	39	18	38	257	39	0.013
40	0.033	-0.001	-0.001	40	24	46	244	40	0.011
41	0.002	0.016	-0.001	41	34	55	225	41	0.011
42	0.016	0.001	0	42	31	52	231	42	0.012
43	0.024	-0.014	-0.001	43	25	57	246	43	0.011
44	0.004	-0.016	0	44	18	51	264	44	0.011
45	-0.006	-0.003	0	45	18	60	298	45	0.011
46	-0.017	0.01	0	46	31	81	331	46	0.012
47	0	0	0.003	47	0	0	15	47	0.009
48	-0.031	0.019	0.001	48	32	101	377	48	0.013
49	-0.055	0.043	0.001	49	28	102	401	49	0.013
50	-0.009	0.019	0	50	19	49	263	50	0.012
51	0.065	-0.006	0	51	16	45	275	51	0.013
52	0.441	-0.081	-0.003	52	3	8	53	52	0.009
53	-0.018	0.021	0	53	64	102	454	53	0.012
54	0.001	0.006	0	54	79	109	517	54	0.011
55	-0.014	0.008	0	55	74	112	520	55	0.011

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
56	-0.02	0.013	0	56	78	117	556	56	0.012
57	-0.011	0.012	0	57	79	121	571	57	0.012
58	-0.021	0.012	-0.001	58	82	152	601	58	0.012
59	-0.005	0.004	-0.001	59	78	155	635	59	0.013
60	0	-0.015	0	60	68	162	665	60	0.013
61	0.01	-0.022	0	61	96	169	701	61	0.012
62	0.017	-0.026	0	62	86	167	668	62	0.011
63	-0.015	0.013	0	63	81	148	606	63	0.012
64	-0.004	-0.008	0	64	159	205	737	64	0.011
65	-0.003	-0.001	0.001	65	167	202	761	65	0.012
66	-0.001	-0.009	0	66	175	181	762	66	0.012
67	-0.023	0.007	0	67	152	175	734	67	0.01
68	-0.022	0.013	0	68	141	162	728	68	0.011
69	-0.015	0.008	0.001	69	139	154	746	69	0.011
70	0.006	-0.01	0.001	70	137	165	721	70	0.01
71	-0.002	-0.011	0.001	71	140	184	711	71	0.011
72	-0.002	-0.002	0	72	122	160	670	72	0.011
73	0.007	0.002	-0.001	73	109	170	666	73	0.011
74	0.014	-0.011	0	74	91	179	664	74	0.01
75	-0.001	-0.012	0	75	62	136	532	75	0.011
76	0.002	-0.003	0	76	139	151	445	76	0.012
77	-0.005	0.006	0	77	138	176	480	77	0.011
78	-0.003	-0.002	0.001	78	131	174	468	78	0.012
79	0.008	-0.011	0.001	79	139	181	492	79	0.013
80	-0.001	-0.005	0.001	80	156	159	509	80	0.013
81	-0.013	0.012	0	81	112	178	495	81	0.013
82	-0.019	0.017	0	82	112	192	526	82	0.012
83	-0.034	0.02	0.001	83	106	204	562	83	0.012
84	-0.01	0.013	0	84	119	158	569	84	0.012

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
85	0.01	-0.01	0.001	85	125	177	604	85	0.012
86	0.009	-0.008	0.001	86	119	181	610	86	0.012
87	0.008	-0.011	0	87	121	199	621	87	0.012
88	0	-0.001	0	88	134	191	632	88	0.012
89	-0.004	0.005	0.001	89	131	191	630	89	0.011
90	-0.014	0.013	0	90	140	196	674	90	0.012
91	0	0.011	-0.001	91	143	208	695	91	0.011
92	0.007	0.003	0	92	141	227	742	92	0.011
93	0.005	0	0	93	151	234	739	93	0.012
94	0.005	-0.008	0	94	155	190	713	94	0.012
95	-0.004	-0.002	0	95	152	192	739	95	0.011
96	-0.001	0.011	0	96	169	167	728	96	0.011
97	-0.006	0.055	0.001	97	548	30	887	97	0.016
98	0.001	0.021	0.001	98	495	20	797	98	0.015
99	-0.007	0.034	0.001	99	640	24	1027	99	0.018
100	-0.004	0.064	0	100	625	30	978	100	0.017
101	0.009	0.072	0	101	608	31	956	101	0.017
102	0.003	0.036	0	102	721	27	1109	102	0.014
103	-0.005	0.071	-0.001	103	767	18	1133	103	0.013
104	0.005	0.065	-0.001	104	570	23	910	104	0.015
105	-0.006	0.047	0	105	688	16	1057	105	0.012
106	-0.004	0.02	0	106	635	40	1053	106	0.013
107	-0.008	0.019	-0.001	107	551	88	1074	107	0.011
108	0.002	0.01	-0.001	108	451	127	975	108	0.012
109	-0.009	0.009	0	109	407	163	935	109	0.012
110	-0.003	-0.008	0	110	425	213	981	110	0.012
111	-0.003	-0.002	0	111	468	281	1075	111	0.012
112	-0.016	0.019	0.001	112	124	114	430	112	0.014
113	0.032	-0.01	0.001	113	10	59	83	113	0.013

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
114	0.019	0.008	0.001	114	5	103	133	114	0.013
115	-0.086	0.014	0.002	115	3	91	119	115	0.014
116	-0.004	0.032	0	116	3	97	121	116	0.017
117	-0.015	0.014	0	117	3	101	130	117	0.018
118	-0.001	0.034	0.001	118	7	270	358	118	0.019
119	0.107	0.014	0.001	119	6	381	505	119	0.018
120	0.068	0.002	0.001	120	8	313	414	120	0.018
121	0.012	-0.003	0.002	121	16	295	413	121	0.019
122	-0.06	-0.017	0.001	122	17	315	427	122	0.02
123	-0.069	-0.018	0.001	123	9	379	540	123	0.018
124	0	0.007	0	124	13	478	676	124	0.014
125	0.02	0.013	-0.001	125	17	484	667	125	0.016
126	-0.008	0.004	-0.002	126	16	489	649	126	0.018
127	-0.038	-0.022	-0.002	127	18	526	682	127	0.017
128	0.048	0.013	-0.001	128	23	512	670	128	0.017
129	0.005	-0.009	0	129	35	595	824	129	0.019
130	-0.027	-0.001	0.001	130	29	575	822	130	0.019
131	-0.062	0	0.001	131	21	461	668	131	0.021
132	-0.011	0.01	0	132	18	453	666	132	0.021
133	-0.011	0.001	0	133	13	452	642	133	0.02
134	-0.05	0.015	0	134	10	477	667	134	0.023
135	0.002	-0.033	-0.002	135	18	471	657	135	0.024
136	0.023	0.022	-0.003	136	38	51	98	136	0.03
137	0.097	0.039	0.002	137	3	51	72	137	0.018
138	0	-0.001	0	138	0	37	48	138	0.015
139	0	-0.062	-0.003	139	0	9	12	139	0.027
140	-0.053	-0.025	-0.001	140	23	498	658	140	0.019
141	-0.013	-0.005	-0.001	141	16	515	676	141	0.019
142	-0.044	-0.012	0.001	142	16	506	658	142	0.019

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
143	-0.016	-0.013	0	143	18	513	676	143	0.018
144	0.007	-0.019	0	144	27	652	863	144	0.02
145	-0.013	0.006	0	145	28	684	877	145	0.022
146	-0.014	0.006	0	146	21	549	721	146	0.022
147	-0.049	0.015	0	147	15	527	711	147	0.022
148	-0.008	0.01	0	148	16	546	706	148	0.021
149	-0.03	0.003	0.001	149	22	678	879	149	0.018
150	-0.075	-0.02	0.001	150	21	730	924	150	0.022
151	-0.022	0.019	0	151	20	638	828	151	0.022
152	-0.04	-0.013	-0.001	152	58	49	129	152	0.022
153	0.004	0.014	-0.001	153	24	628	826	153	0.016
154	-0.001	0.014	0.001	154	17	614	801	154	0.017
155	0.019	0.001	0.001	155	18	630	851	155	0.017
156	-0.014	0.001	0.001	156	33	750	1018	156	0.017
157	-0.016	-0.009	0	157	35	761	1020	157	0.019
158	0.029	0.012	-0.002	158	28	643	868	158	0.022
159	-0.009	0.005	-0.002	159	24	639	850	159	0.023
160	-0.034	-0.004	-0.001	160	29	678	878	160	0.021
161	-0.044	-0.003	0.001	161	35	747	986	161	0.02
162	-0.078	0.009	0.002	162	25	726	977	162	0.022
163	-0.056	0.007	0	163	14	639	862	163	0.024
164	0.004	0.012	-0.001	164	19	646	856	164	0.023
165	0.024	0.041	-0.003	165	20	684	900	165	0.029
166	-0.076	0.015	-0.002	166	18	716	915	166	0.031
167	-0.022	-0.014	-0.001	167	26	771	1003	167	0.024
168	0.034	-0.002	-0.001	168	22	733	982	168	0.025
169	-0.071	-0.027	0.001	169	27	651	897	169	0.028
170	-0.003	-0.005	0	170	31	649	901	170	0.023
171	0.045	0.01	0	171	23	641	862	171	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
172	-0.042	-0.059	0	172	50	31	93	172	0.03
173	-0.01	-0.033	-0.001	173	39	43	99	173	0.026
174	-0.022	0.017	0	174	28	801	1054	174	0.025
175	-0.064	0.003	0.001	175	27	775	1019	175	0.026
176	-0.008	-0.01	0.001	176	31	642	841	176	0.026
177	-0.045	-0.014	0.001	177	29	660	861	177	0.023
178	-0.057	-0.021	0.001	178	25	653	860	178	0.022
179	-0.064	-0.013	0.001	179	35	656	881	179	0.02
180	-0.018	-0.014	0.001	180	35	717	960	180	0.019
181	0.033	0.005	-0.001	181	25	708	958	181	0.018
182	0.007	-0.002	-0.001	182	23	640	882	182	0.016
183	-0.016	-0.004	-0.001	183	21	623	866	183	0.016
184	0.007	-0.008	0	184	22	637	907	184	0.017
185	-0.011	0.004	0.001	185	25	791	1104	185	0.016
186	0.037	0.009	0	186	28	784	1086	186	0.016
187	0.032	0.009	0	187	27	620	872	187	0.016
188	0.01	0.005	-0.001	188	28	621	894	188	0.015
189	-0.008	0.043	0.004	189	67	13	89	189	0.022
190	-0.051	-0.017	0.002	190	29	20	74	190	0.019
191	-0.028	-0.004	0	191	28	663	908	191	0.014
192	-0.007	0.008	-0.001	192	23	668	889	192	0.013
193	-0.006	-0.003	-0.001	193	19	631	887	193	0.013
194	0.044	0.008	0	194	13	493	729	194	0.014
195	0.062	-0.005	-0.001	195	5	338	477	195	0.013
196	0.008	-0.013	0	196	21	605	838	196	0.015
197	0.01	0.002	0	197	22	606	865	197	0.015
198	-0.021	-0.01	0	198	18	615	871	198	0.015
199	0.043	0.012	0	199	26	790	1117	199	0.015
200	0.019	-0.012	0	200	28	762	1105	200	0.015

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
201	0.051	0.002	0	201	18	560	849	201	0.015
202	-0.011	-0.002	0	202	16	579	836	202	0.015
203	-0.089	-0.003	-0.001	203	17	574	819	203	0.016
204	-0.009	-0.004	-0.002	204	17	543	792	204	0.016
205	0.061	0.01	-0.001	205	19	567	820	205	0.017
206	-0.01	-0.011	0	206	19	542	786	206	0.017
207	0.013	-0.007	0.001	207	25	510	743	207	0.015
208	-0.047	0.009	-0.003	208	16	24	65	208	0.016
209	-0.031	0.024	0.002	209	30	21	80	209	0.018
210	0.007	-0.023	0.002	210	30	511	747	210	0.014
211	-0.002	-0.013	0.001	211	30	536	796	211	0.013
212	0.001	-0.014	0	212	31	663	1072	212	0.014
213	0.013	-0.005	0.001	213	30	643	1051	213	0.015
214	0.006	-0.024	0	214	14	489	771	214	0.018
215	0.055	-0.002	0	215	14	509	750	215	0.018
216	0.034	-0.007	0	216	21	521	758	216	0.019
217	0.041	0.007	0	217	22	520	762	217	0.019
218	0.089	-0.009	0	218	15	539	753	218	0.02
219	0.043	-0.001	0.001	219	20	506	733	219	0.019
220	-0.002	-0.019	0.001	220	14	487	703	220	0.023
221	0.007	-0.002	0	221	12	472	674	221	0.024
222	0.017	-0.012	0	222	12	489	700	222	0.02
223	-0.016	-0.007	0	223	15	649	898	223	0.02
224	0.018	0.001	-0.001	224	26	658	884	224	0.019
225	-0.024	0.008	-0.001	225	20	511	667	225	0.021
226	0.01	-0.013	0	226	17	509	657	226	0.021
227	0.013	0.003	0	227	16	494	646	227	0.023
228	-0.056	0.003	0.001	228	13	482	642	228	0.023
229	-0.001	-0.01	0.001	229	18	482	659	229	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
230	0.014	-0.013	0.003	230	34	28	86	230	0.022
231	0.003	-0.025	-0.001	231	42	30	89	231	0.02
232	0.074	0.002	-0.001	232	13	498	654	232	0.019
233	0.04	-0.007	0	233	20	513	669	233	0.018
234	-0.002	-0.025	0	234	20	509	665	234	0.021
235	0.037	-0.005	0.001	235	19	500	650	235	0.024
236	0.091	0.015	-0.001	236	33	664	873	236	0.02
237	0.111	-0.001	-0.001	237	33	621	852	237	0.019
238	0.024	0.015	0	238	20	425	620	238	0.023
239	0	0.031	0	239	12	438	633	239	0.023
240	-0.062	0.001	0	240	15	455	640	240	0.02
241	-0.052	0.024	0.001	241	19	447	639	241	0.021
242	-0.06	0.015	0	242	16	436	631	242	0.024
243	0.023	0.024	-0.001	243	18	422	647	243	0.023
244	-0.056	-0.001	0	244	8	380	631	244	0.022
245	0.027	0	0	245	6	362	605	245	0.023
246	0.006	0	0	246	7	387	611	246	0.024
247	-0.186	-0.01	0	247	13	560	819	247	0.021
248	-0.088	-0.007	0	248	25	599	827	248	0.019
249	-0.082	-0.006	0	249	22	442	620	249	0.017
250	0	-0.053	-0.002	250	0	34	61	250	0.015
251	0.018	0.038	-0.004	251	27	32	79	251	0.026
252	-0.118	0.006	0.004	252	28	44	90	252	0.025
253	0.018	-0.004	0	253	13	433	593	253	0.016
254	-0.035	0.001	-0.001	254	18	437	600	254	0.014
255	-0.015	-0.003	0	255	18	421	604	255	0.013
256	0.022	-0.007	0.001	256	17	412	615	256	0.016
257	0.034	-0.01	0.001	257	10	390	540	257	0.018
258	0.009	-0.016	0.001	258	12	189	308	258	0.015

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
259	-0.026	-0.01	0.001	259	12	443	566	259	0.019
260	-0.009	0.002	-0.001	260	13	482	602	260	0.018
261	-0.032	0.004	0	261	13	571	727	261	0.016
262	-0.041	-0.008	0	262	11	567	738	262	0.017
263	-0.047	0.001	0	263	18	491	625	263	0.019
264	-0.041	-0.007	-0.001	264	15	483	619	264	0.022
265	-0.148	0.017	0.001	265	14	489	622	265	0.022
266	-0.061	-0.001	-0.001	266	19	475	621	266	0.02
267	-0.048	-0.023	-0.001	267	11	463	613	267	0.023
268	-0.059	-0.005	0.001	268	8	463	618	268	0.025
269	-0.038	-0.012	0	269	16	464	618	269	0.025
270	0.136	-0.012	0	270	13	494	640	270	0.029
271	0.075	0.018	-0.001	271	13	491	641	271	0.028
272	-0.009	0.013	0.001	272	24	540	709	272	0.021
273	0.008	0.001	0	273	18	545	714	273	0.021
274	-0.061	0.003	0.001	274	17	469	636	274	0.023
275	-0.055	-0.01	0	275	11	477	629	275	0.026
276	-0.081	0.006	0.001	276	10	510	649	276	0.026
277	-0.014	0.016	-0.001	277	17	567	706	277	0.024
278	0.009	0.008	-0.001	278	22	533	702	278	0.027
279	0.007	-0.012	-0.001	279	21	485	650	279	0.028
280	-0.023	-0.005	0	280	21	459	628	280	0.024
281	-0.074	-0.026	0	281	25	450	630	281	0.023
282	-0.056	-0.019	0.001	282	20	462	624	282	0.022
283	-0.041	0.009	-0.001	283	51	50	126	283	0.031
284	-0.057	-0.017	0.001	284	20	541	715	284	0.022
285	0.037	0.007	0	285	14	536	707	285	0.025
286	0.048	0.018	0.001	286	9	433	579	286	0.026
287	0.072	-0.002	0.001	287	10	429	599	287	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
288	0.078	-0.065	0.001	288	14	430	611	288	0.027
289	0.013	-0.016	0	289	12	513	701	289	0.026
290	0.032	-0.001	-0.001	290	11	535	725	290	0.022
291	0.034	0.016	-0.001	291	9	485	650	291	0.026
292	-0.042	0.018	-0.001	292	11	478	640	292	0.03
293	-0.069	0.033	0	293	10	470	634	293	0.029
294	-0.087	0.055	0	294	18	465	645	294	0.025
295	0.106	0.006	0.002	295	30	519	742	295	0.026
296	-0.013	-0.012	-0.001	296	29	506	734	296	0.029
297	-0.05	0.011	-0.002	297	18	455	634	297	0.026
298	-0.023	0.006	0	298	10	429	611	298	0.019
299	0.024	0.037	-0.004	299	28	24	69	299	0.029
300	-0.121	0.012	0	300	14	409	606	300	0.02
301	-0.178	0.013	0.001	301	15	500	715	301	0.022
302	-0.136	0.006	0.001	302	11	510	711	302	0.023
303	-0.148	-0.007	0.002	303	9	434	597	303	0.021
304	-0.054	-0.013	0.001	304	9	430	573	304	0.023
305	0.009	0.006	0	305	13	435	585	305	0.025
306	0.017	0.021	0	306	14	431	601	306	0.023
307	-0.025	0.012	0	307	12	455	653	307	0.02
308	0.002	0.035	-0.002	308	11	26	42	308	0.026
309	0.024	-0.03	0	309	15	434	601	309	0.016
310	-0.085	0.007	-0.001	310	11	442	615	310	0.017
311	-0.036	-0.003	-0.001	311	8	383	520	311	0.016
312	0.03	0.001	0	312	14	399	522	312	0.017
313	0.011	-0.005	0	313	18	396	520	313	0.017
314	-0.026	0.003	-0.001	314	17	465	629	314	0.015
315	0.012	0.007	0	315	15	436	617	315	0.017
316	-0.013	0.011	0	316	9	324	489	316	0.017

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
317	0.015	0.017	0.001	317	7	317	497	317	0.016
318	0.018	0.022	0.001	318	3	293	500	318	0.018
319	0.012	0.014	0.001	319	2	289	491	319	0.02
320	0.021	0.004	0	320	10	308	496	320	0.02
321	0.031	-0.007	-0.001	321	8	303	465	321	0.019
322	0.006	0.015	-0.002	322	12	298	440	322	0.022
323	-0.016	-0.025	-0.002	323	15	311	426	323	0.022
324	-0.053	-0.002	0	324	10	311	418	324	0.023
325	-0.04	-0.021	0	325	12	393	539	325	0.022
326	-0.095	0	0.002	326	13	393	525	326	0.022
327	-0.013	-0.01	0.002	327	7	303	401	327	0.026
328	0.039	0.001	0	328	7	317	407	328	0.023
329	-0.036	0.008	0.001	329	5	314	402	329	0.025
330	0.174	-0.015	-0.003	330	6	311	414	330	0.027
331	0.146	-0.003	-0.001	331	8	289	434	331	0.022
332	-0.033	-0.017	0.002	332	12	276	427	332	0.02
333	0.028	-0.008	0	333	11	278	415	333	0.02
334	-0.008	0.004	0	334	9	257	400	334	0.022
335	-0.011	0.006	0	335	10	259	405	335	0.026
336	-0.021	0.013	0	336	43	31	109	336	0.024
337	-0.125	0.01	-0.002	337	2	25	38	337	0.022
338	-0.103	-0.01	-0.003	338	9	342	524	338	0.024
339	0.018	-0.015	0	339	13	366	526	339	0.02
340	-0.039	-0.004	-0.001	340	8	281	405	340	0.026
341	0.062	-0.021	0	341	10	271	409	341	0.027
342	0.098	-0.004	0	342	6	286	404	342	0.029
343	0.052	-0.005	0.001	343	6	287	392	343	0.03
344	0.035	-0.003	0.003	344	18	299	398	344	0.021
345	0.069	0.001	-0.001	345	17	281	382	345	0.019

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
346	0.018	-0.028	-0.001	346	16	15	48	346	0.028
347	-0.137	0.008	0	347	1	54	68	347	0.021
348	-0.003	0.004	0.001	348	10	270	359	348	0.016
349	-0.045	0.012	0.001	349	8	293	371	349	0.015
350	-0.042	-0.005	0	350	6	288	380	350	0.014
351	0.025	-0.001	0	351	9	374	519	351	0.014
352	0.024	-0.011	0	352	10	389	518	352	0.015
353	0.016	0.011	0	353	9	288	389	353	0.014
354	0.167	0.009	-0.002	354	3	286	383	354	0.015
355	0.054	-0.005	-0.002	355	4	255	375	355	0.016
356	0.072	-0.029	0	356	8	246	380	356	0.014
357	0.004	0.007	0.002	357	6	268	402	357	0.013
358	0.004	-0.009	0.001	358	9	257	405	358	0.014
359	0	-0.002	0	359	7	256	395	359	0.014
360	-0.079	-0.009	-0.001	360	7	268	402	360	0.013
361	0.02	-0.008	-0.002	361	7	251	390	361	0.016
362	-0.056	-0.001	0	362	7	316	501	362	0.016
363	0.027	-0.015	0	363	9	311	497	363	0.014
364	0.07	-0.025	0	364	10	252	391	364	0.014
365	-0.005	-0.008	0.001	365	10	257	405	365	0.015
366	0.014	0.006	0	366	12	244	396	366	0.015
367	0.03	-0.001	0	367	9	241	405	367	0.015
368	0.009	0.004	0.001	368	10	255	416	368	0.016
369	-0.074	-0.004	0	369	10	251	382	369	0.017
370	-0.053	0.026	-0.002	370	10	224	360	370	0.018
371	0.014	0.033	0.001	371	9	210	360	371	0.016
372	-0.061	-0.001	0.001	372	7	193	359	372	0.014
373	-0.036	0.003	0	373	8	222	450	373	0.014
374	-0.013	-0.009	-0.001	374	5	222	446	374	0.016

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
375	-0.021	0.004	-0.001	375	7	195	362	375	0.017
376	-0.058	-0.018	0	376	8	200	360	376	0.015
377	0	-0.009	-0.001	377	11	202	351	377	0.015
378	0.075	0.023	0	378	8	218	362	378	0.015
379	0.05	0.018	0.001	379	9	226	361	379	0.015
380	0.084	-0.014	0.001	380	6	246	350	380	0.016
381	0.055	-0.006	0.001	381	5	268	359	381	0.017
382	0.011	-0.015	0.001	382	63	52	181	382	0.023
383	0.098	-0.005	0	383	5	259	351	383	0.019
384	0.095	0.009	-0.002	384	5	269	357	384	0.019
385	-0.1	-0.018	-0.001	385	8	340	425	385	0.021
386	0.007	0.001	0	386	12	316	418	386	0.019
387	0.006	-0.004	0.002	387	10	259	347	387	0.018
388	-0.029	0	0.002	388	8	257	343	388	0.02
389	0.013	-0.018	0	389	6	242	332	389	0.021
390	0.016	-0.001	0	390	7	231	324	390	0.021
391	0.043	-0.004	0.001	391	8	236	332	391	0.02
392	0.015	-0.001	0	392	12	225	314	392	0.021
393	-0.038	0.006	-0.002	393	6	219	302	393	0.021
394	0.031	-0.012	-0.002	394	13	229	318	394	0.02
395	0.04	-0.02	-0.001	395	13	213	311	395	0.02
396	0.058	0.002	-0.001	396	8	268	374	396	0.02
397	0.059	0.005	0	397	11	271	389	397	0.018
398	-0.081	0.012	0.001	398	10	222	313	398	0.019
399	-0.042	-0.012	0.002	399	7	234	306	399	0.021
400	-0.1	0.003	0	400	4	227	302	400	0.02
401	-0.117	0.004	-0.001	401	5	223	305	401	0.015
402	-0.018	0.018	0	402	5	225	307	402	0.017
403	-0.047	0.02	-0.001	403	8	212	300	403	0.018

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
404	-0.038	0.01	0	404	11	199	295	404	0.016
405	0.013	0.014	0	405	10	200	292	405	0.018
406	0.022	0.019	0.001	406	9	198	297	406	0.02
407	0.031	0.008	-0.001	407	33	242	386	407	0.019
408	0.052	0.021	-0.001	408	34	247	390	408	0.019
409	0.083	-0.005	-0.001	409	23	208	325	409	0.018
410	0.053	-0.012	-0.001	410	26	210	327	410	0.017
411	0.057	-0.022	-0.002	411	21	214	329	411	0.019
412	0.088	0.003	-0.001	412	26	210	326	412	0.017
413	-0.015	-0.003	0.005	413	46	54	123	413	0.024
414	0.001	0.092	0.001	414	1	6	37	414	0.011
415	0	0.027	0	415	1	10	48	415	0.014
416	-0.074	0.001	0.001	416	7	8	29	416	0.017
417	0.06	-0.012	0	417	30	197	334	417	0.015
418	0.047	-0.023	0	418	25	189	323	418	0.013
419	-0.047	-0.025	-0.002	419	22	197	328	419	0.013
420	-0.006	-0.03	-0.001	420	24	196	323	420	0.015
421	-0.031	0.002	-0.001	421	15	200	310	421	0.014
422	-0.099	-0.001	-0.001	422	23	238	386	422	0.015
423	-0.128	0	-0.001	423	21	234	406	423	0.014
424	-0.053	-0.018	-0.004	424	26	176	337	424	0.015
425	-0.139	-0.002	-0.002	425	26	161	315	425	0.017
426	-0.082	-0.002	0	426	26	152	330	426	0.015
427	-0.079	0.006	0	427	31	152	323	427	0.014
428	-0.032	0	-0.001	428	46	189	336	428	0.016
429	-0.03	0	-0.003	429	34	181	309	429	0.018
430	-0.022	-0.001	-0.003	430	32	181	320	430	0.019
431	-0.11	-0.002	-0.003	431	22	177	315	431	0.017
432	-0.005	-0.013	-0.001	432	24	180	309	432	0.016

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
433	0.074	0.001	-0.001	433	14	247	359	433	0.016
434	0.125	0.003	-0.001	434	22	263	385	434	0.017
435	0.09	0.003	-0.001	435	21	200	306	435	0.016
436	-0.03	0.004	0.002	436	26	208	312	436	0.018
437	-0.038	0.009	0.002	437	27	213	306	437	0.018
438	0.004	0.002	0	438	31	219	329	438	0.018
439	0.092	0.011	-0.002	439	25	214	332	439	0.018
440	0.022	-0.001	-0.001	440	26	213	323	440	0.021
441	0.022	0.008	0	441	27	221	327	441	0.02
442	0.021	0.001	0	442	28	206	333	442	0.021
443	-0.02	0.025	-0.001	443	24	195	320	443	0.022
444	-0.037	-0.002	-0.001	444	39	257	422	444	0.018
445	-0.049	0.026	-0.001	445	33	236	393	445	0.019
446	-0.073	0.037	-0.003	446	44	154	305	446	0.02
447	-0.005	0.018	-0.001	447	31	162	289	447	0.016
448	0.01	-0.005	-0.002	448	30	167	289	448	0.016
449	0.078	0.004	-0.004	449	21	179	305	449	0.019
450	0.057	0.006	-0.003	450	29	188	318	450	0.02
451	0.116	0.007	-0.002	451	22	176	296	451	0.019
452	0.096	0.004	-0.004	452	18	180	299	452	0.02
453	0.09	0.022	-0.005	453	18	183	301	453	0.02
454	0.106	0.03	-0.005	454	25	169	310	454	0.021
455	0.137	0.008	-0.001	455	20	175	365	455	0.02
456	0.078	0.023	0	456	23	185	371	456	0.02
457	-0.054	0.028	0.001	457	18	171	302	457	0.02
458	0.03	0.01	0	458	26	157	304	458	0.019
459	0.038	-0.016	-0.001	459	17	171	307	459	0.021
460	0.032	-0.047	-0.001	460	80	55	221	460	0.024
461	0.09	-0.037	-0.002	461	20	256	455	461	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
462	-0.024	-0.02	0	462	28	315	548	462	0.02
463	-0.051	-0.009	0.001	463	22	285	492	463	0.019
464	-0.008	-0.002	0.001	464	17	287	474	464	0.02
465	0.014	0.005	0.002	465	21	303	493	465	0.022
466	-0.012	0.015	0.001	466	12	309	508	466	0.021
467	-0.002	-0.013	0	467	17	343	563	467	0.022
468	0.022	-0.007	-0.001	468	13	340	539	468	0.023
469	0.041	-0.011	-0.002	469	19	321	498	469	0.025
470	-0.061	0.004	-0.003	470	19	349	517	470	0.024
471	0.007	-0.015	-0.001	471	20	350	524	471	0.022
472	-0.027	0.013	0	472	22	402	569	472	0.021
473	0.033	-0.001	0	473	24	411	605	473	0.021
474	0.022	0.012	-0.002	474	30	341	533	474	0.023
475	0.038	0.005	-0.002	475	27	354	552	475	0.023
476	0.024	0	0	476	28	360	571	476	0.023
477	-0.087	-0.024	0.001	477	31	403	645	477	0.021
478	-0.005	-0.006	0.006	478	50	33	109	478	0.025
479	0.031	-0.01	0.002	479	40	427	704	479	0.017
480	-0.012	-0.005	0.001	480	39	393	655	480	0.016
481	0.058	-0.018	-0.002	481	26	343	586	481	0.018
482	0.003	0.019	0.001	482	31	348	610	482	0.019
483	0.004	0.004	0	483	38	368	646	483	0.02
484	0.005	0.008	0	484	37	376	716	484	0.019
485	-0.021	-0.008	0.001	485	34	354	705	485	0.019
486	0.007	0.023	0.001	486	29	323	626	486	0.02
487	0.054	0.008	0	487	29	344	651	487	0.019
488	0.007	0.015	0	488	23	358	639	488	0.021
489	-0.001	-0.017	-0.001	489	25	402	724	489	0.022
490	-0.044	0.003	0	490	27	438	778	490	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
491	0.015	-0.005	0.001	491	25	362	740	491	0.022
492	-0.139	0.021	0.001	492	18	319	670	492	0.021
493	-0.025	0.015	0.001	493	34	313	674	493	0.021
494	-0.032	0.015	-0.001	494	26	333	658	494	0.022
495	-0.001	-0.023	0	495	37	365	743	495	0.019
496	0.055	-0.015	0	496	29	349	703	496	0.02
497	-0.021	-0.013	0	497	22	343	643	497	0.021
498	0.053	-0.011	0	498	21	350	672	498	0.023
499	-0.022	-0.01	0.001	499	27	344	677	499	0.024
500	-0.023	-0.004	0	500	30	379	710	500	0.023
501	-0.003	-0.016	0	501	32	410	764	501	0.02
502	-0.021	-0.054	0.001	502	64	17	115	502	0.026
503	0.04	0.027	0.001	503	40	43	124	503	0.03
504	-0.053	0.008	0.001	504	41	396	724	504	0.015
505	0.032	0.006	0.001	505	28	421	680	505	0.013
506	0.027	-0.011	0	506	42	401	627	506	0.014
507	-0.022	0.003	0	507	14	249	398	507	0.015
508	-0.023	0.018	-0.005	508	20	136	223	508	0.021
509	0.026	0.016	0	509	27	148	243	509	0.015
510	-0.042	0.004	0	510	12	234	414	510	0.016
511	-0.016	0.005	-0.001	511	7	222	359	511	0.015
512	0.126	-0.014	0.005	512	32	155	247	512	0.017
513	0.09	-0.02	0.004	513	22	140	219	513	0.014
514	0.002	0.001	0.001	514	9	227	362	514	0.014
515	-0.035	0.019	0.001	515	12	230	352	515	0.014
516	0.105	-0.004	0.003	516	27	138	234	516	0.014
517	0.037	-0.001	0	517	20	143	223	517	0.015
518	0.025	-0.003	-0.001	518	13	243	359	518	0.015
519	0.004	0.028	-0.001	519	13	279	422	519	0.014

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
520	0.019	0.002	0	520	29	147	224	520	0.015
521	-0.048	0.004	0.001	521	32	151	272	521	0.015
522	0.006	-0.001	0	522	14	285	428	522	0.014
523	0.048	0.026	0	523	10	234	367	523	0.015
524	-0.036	-0.001	0.002	524	25	124	256	524	0.015
525	-0.069	-0.021	0	525	22	114	221	525	0.015
526	-0.006	0.005	-0.001	526	16	233	371	526	0.016
527	-0.03	0.012	0	527	14	259	383	527	0.014
528	-0.051	-0.02	0	528	25	124	223	528	0.015
529	0.027	-0.007	0.001	529	31	110	216	529	0.016
530	-0.04	0.012	0.001	530	15	314	451	530	0.013
531	-0.017	0.003	-0.001	531	42	24	85	531	0.017
532	0.054	-0.003	0.006	532	27	28	71	532	0.024
533	0.035	-0.008	0.002	533	19	297	443	533	0.012
534	0.178	-0.001	0.006	534	15	102	198	534	0.016
535	0.011	0.028	0.001	535	39	103	212	535	0.014
536	-0.045	-0.005	0.001	536	16	257	387	536	0.011
537	-0.063	-0.007	0	537	12	262	382	537	0.012
538	0.118	-0.023	0.002	538	20	98	182	538	0.014
539	0.194	-0.027	0.004	539	19	112	211	539	0.017
540	-0.004	-0.006	0.001	540	11	273	383	540	0.015
541	-0.046	0.012	0.002	541	10	286	389	541	0.015
542	0.097	0.014	0.004	542	16	111	212	542	0.016
543	-0.009	-0.004	0.003	543	21	103	219	543	0.017
544	0.018	0.017	0	544	10	321	398	544	0.016
545	0.05	0.016	-0.002	545	9	273	344	545	0.017
546	-0.092	0.022	0.004	546	22	136	272	546	0.017
547	-0.258	0.046	0	547	25	155	294	547	0.019
548	-0.005	-0.041	-0.001	548	3	63	85	548	0.019

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line	
549	-0.03	-0.017	-0.001	549	9	173	240	549	0.014
550	-0.03	-0.002	-0.002	550	12	227	300	550	0.016
551	-0.142	0.03	-0.003	551	26	132	229	551	0.016
552	0.027	0.006	0.003	552	28	139	227	552	0.016
553	-0.004	0.003	-0.001	553	8	232	314	553	0.015
554	0.05	-0.001	-0.002	554	10	258	356	554	0.014
555	0.091	0.004	0.004	555	17	154	216	555	0.016
556	0.007	-0.02	0.002	556	31	166	245	556	0.016
557	0.008	0.019	0.001	557	11	177	248	557	0.015
558	-0.015	0.019	0.002	558	4	43	55	558	0.015
559	0.031	-0.016	0.002	559	25	105	174	559	0.016
560	0	0.003	0.002	560	14	29	91	560	0.021
561	0.066	0.051	0.005	561	14	17	88	561	0.017
562	0.159	-0.015	0.009	562	17	19	82	562	0.027
563	0.086	0.003	-0.001	563	12	31	75	563	0.025
564	0.01	-0.025	0	564	10	50	105	564	0.015
565	0.008	0.006	-0.001	565	14	36	86	565	0.016
566	0.051	-0.009	0.001	566	31	14	77	566	0.018
567	-0.028	-0.016	0.002	567	30	22	60	567	0.03
568	0	0.268	0.013	568	0	16	36	568	0.048
569	0	0.147	-0.006	569	0	17	33	569	0.036
570	0	0.083	0.009	570	0	8	12	570	0.048
571	0	0.04	0.016	571	0	7	9	571	0.038
572	0	0.188	0.014	572	0	5	11	572	0.041
573	0	-0.008	0.004	573	0	1	7	573	0.013
574	0	-0.091	0.005	574	0	9	13	574	0.04
575	0.234	0.072	-0.006	575	3	8	14	575	0.032
576	0	-0.124	0.015	576	0	6	13	576	0.06
577	0	-0.087	0.008	577	0	4	7	577	0.021

Tieline Mismatches				Number of Tie Line Observations per Line				Average Magnitude Per Line		
578	0	0.103	0.012	578	0	5	11	578		0.032
579	0.154	0.048	0.001	579	1	4	20	579		0.012
580	0.273	-0.145	-0.02	580	2	9	16	580		0.09
581	-0.059	0.057	0.009	581	1	10	20	581		0.032
582	0	0.026	0.004	582	0	8	16	582		0.023
583	-0.002	0.052	0.004	583	1	3	4	583		0.013
584	-0.3	0.043	-0.029	584	1	3	8	584		0.03
585	0	0.108	-0.006	585	0	6	9	585		0.053
586	0	-0.021	0.006	586	0	3	4	586		0.006
587	0	0.13	0.006	587	0	10	18	587		0.023
588	0	0.088	-0.01	588	0	6	9	588		0.051
589	0	0.093	-0.01	589	0	7	13	589		0.035
590	-0.417	-0.032	0.01	590	2	10	18	590		0.039
591	0	0.081	-0.018	591	0	4	6	591		0.022
592	-0.214	0.038	-0.004	592	1	6	14	592		0.041
593	-0.055	0.082	-0.002	593	2	9	16	593		0.018
594	0	0	0.001	594	0	6	7	594		0.003
595	0	0.008	-0.008	595	0	4	6	595		0.017
596	0.372	0.352	0.018	596	2	6	10	596		0.064
	X	Y	Z		X	Y	Z			Z
Average	-0.00067	0.00408	0.00008	Totals	26390	167066	284003		Average	0.018
RMS	0.06248	0.03128	0.00289						RMS	0.020
Max	0.44100	0.35200	0.01800						Max	0.090

Table 2: Average Tie Line Magnitudes per Line

Internal Observation Statistics	
Category	**Z**
Average Magnitude	0.018
Magnitude Scanner 0 (AGA)	0.013
Magnitude Scanner 2 (KAS)	0.020
RMS Values	0.024
Maximum Values	0.314
Observation Weight	284007.0

Table 3: Tie Line Observation Statistics

Overall Relative Accuracy	
Category	**Mismatch**
Average 3D Mismatch	0.01812
Average Z Mismatch	0.01812

Table 4: Relative Accuracy Results

TerraMatch Tie Lines	
Category	**Observations**
Surface Lines	137,407

Table 5: Total Tie Line

1.6   Project Purpose

The primary purpose of the lidar survey was to establish measurements of the bare earth surface, as well as top surface feature data for providing geometric inputs for modeling, other numerical modeling and economic related assessments.

Section 2:   Vertical Accuracy Assessment

2.1   Ground Surveyed Control Points

AXIS GeoSpatial, LLC established a total of forty-seven (47) control points for this project calibration. Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from lidar points in clear and open areas.

A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of 5 times the NPS exists with less than 1/3 of the $RMSE_z$ deviation from a low-slope plane. Slopes that exceed 10 percent were avoided.

2.2   Control Point Distribution

The following graphic(s) depicts the location and distribution of Control Points established for this project.
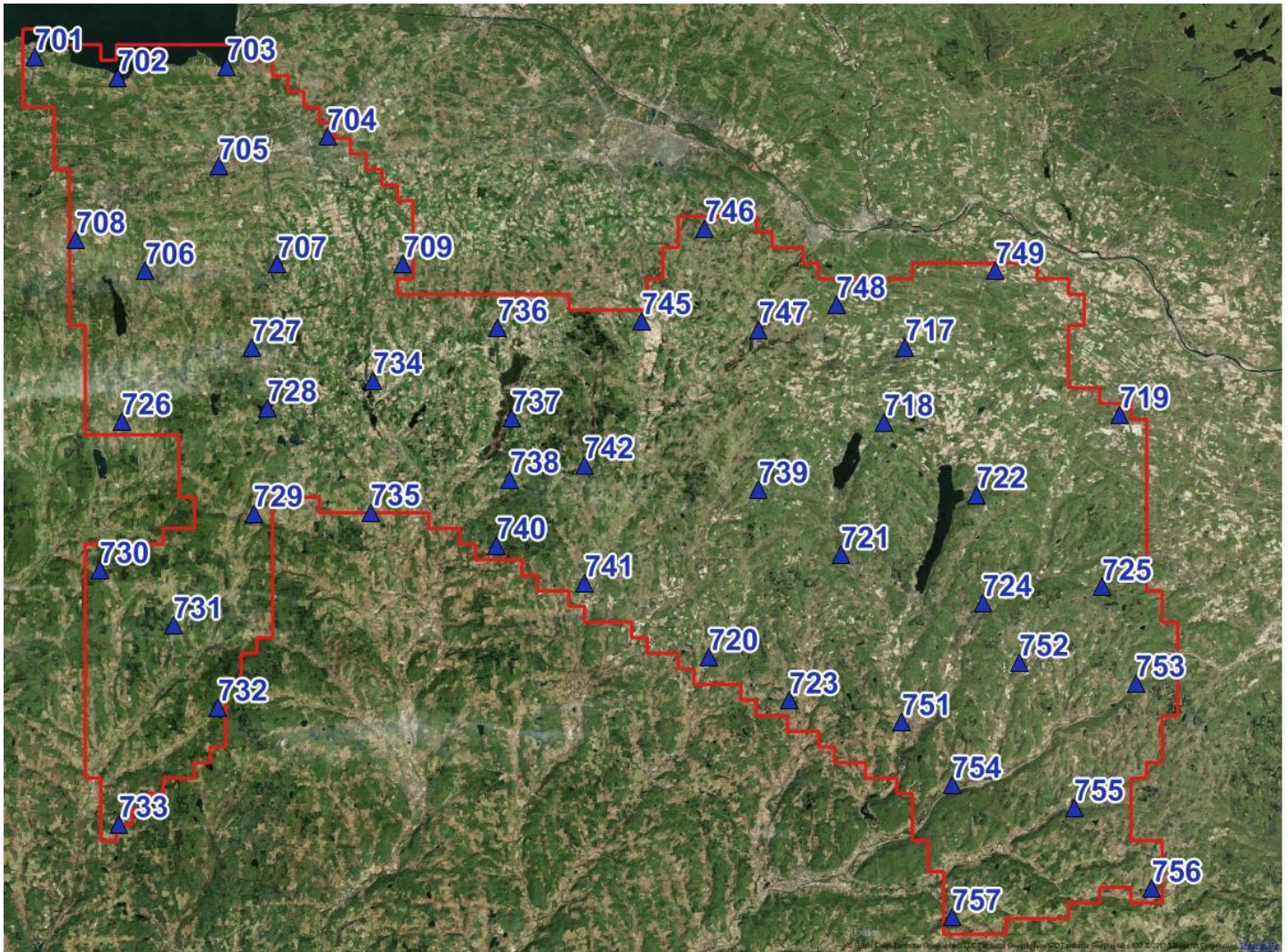
Figure 3: Control Point Distribution

2.3   Control Point Horizontal Assessment

A horizontal assessment of the control points against lidar derived intensity imagery can be found in the graphics below. The intensity imagery was produced with a 0.3m GSD and interpolated to fill small gaps.
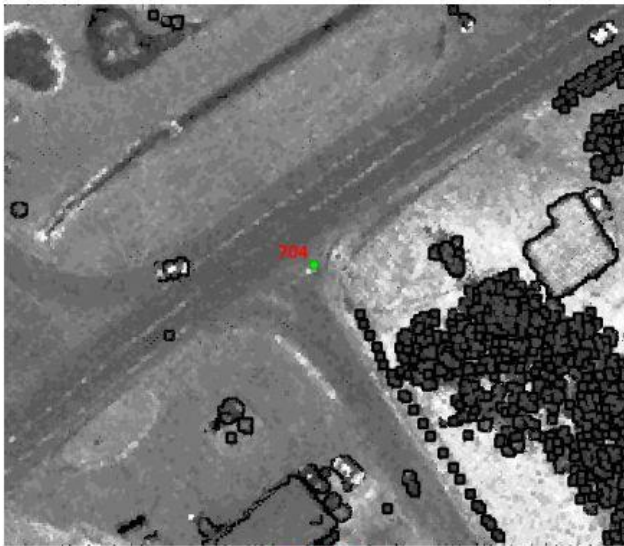
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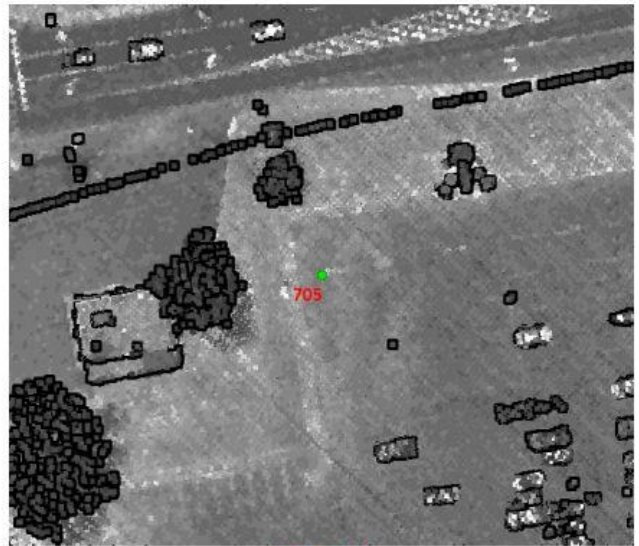
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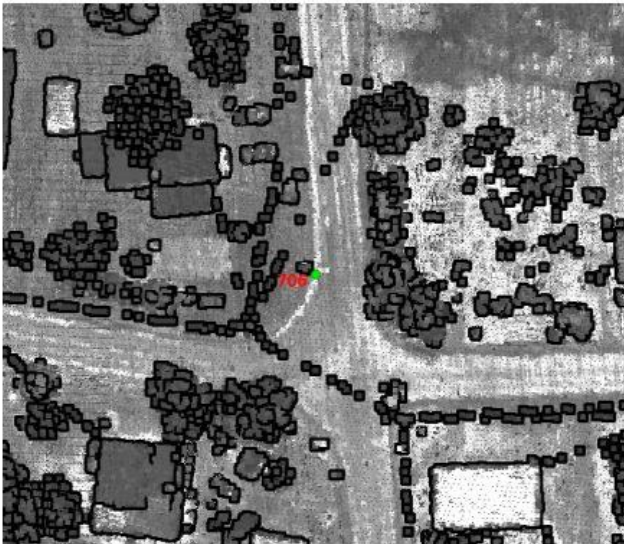
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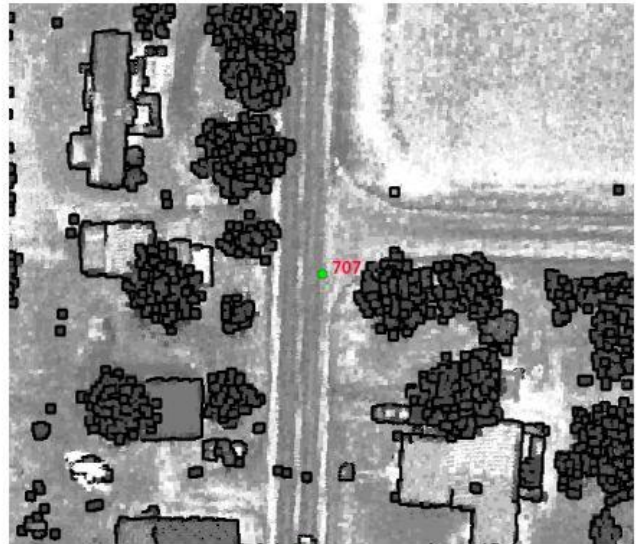
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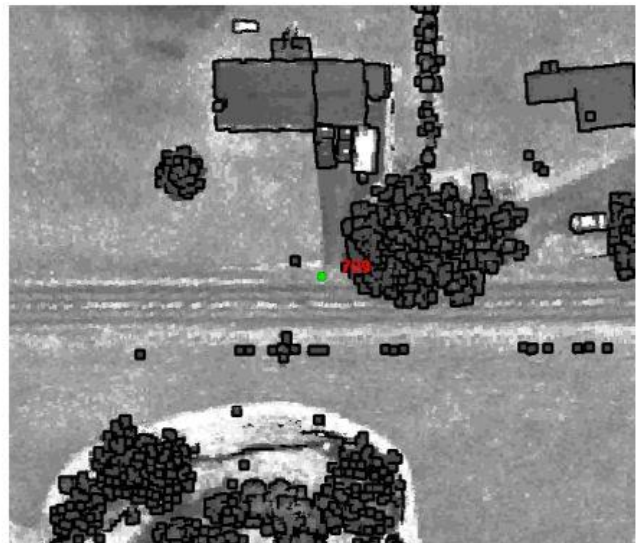
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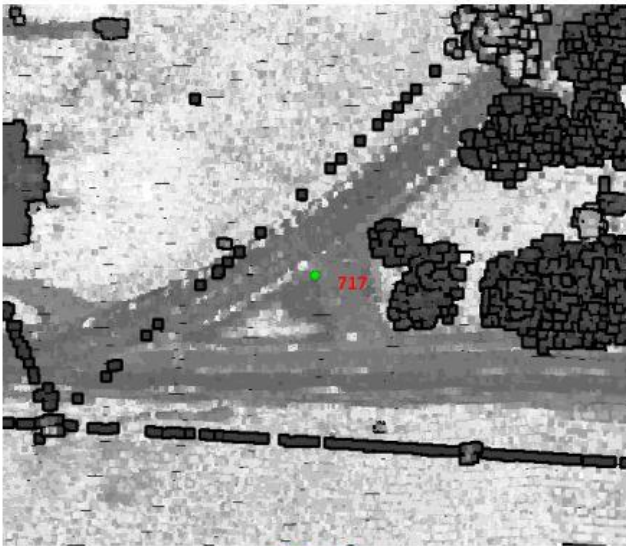
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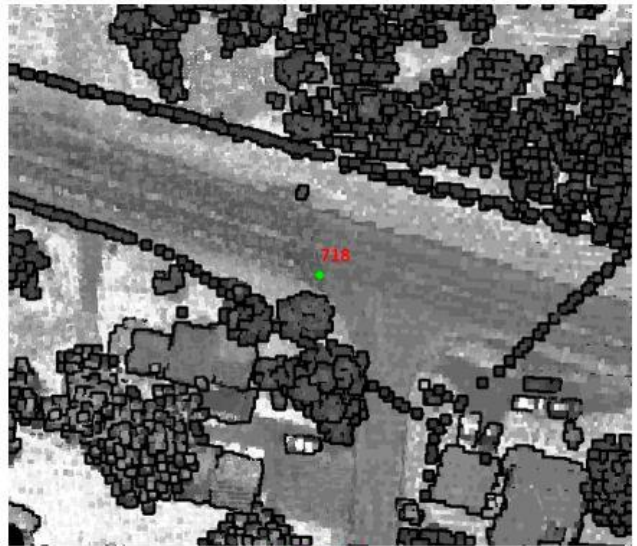
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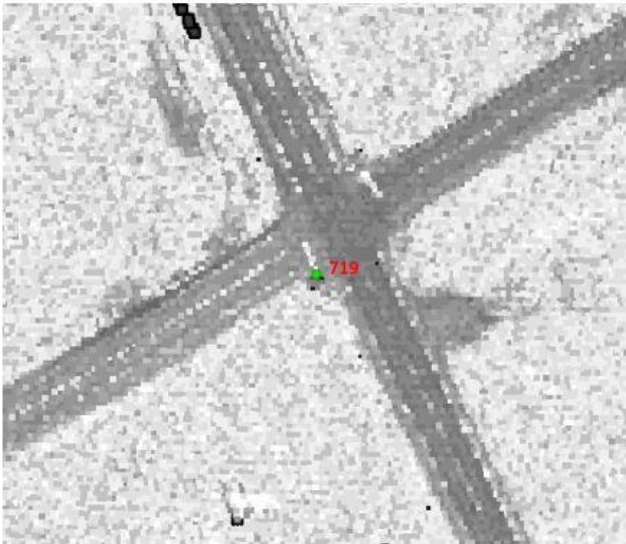
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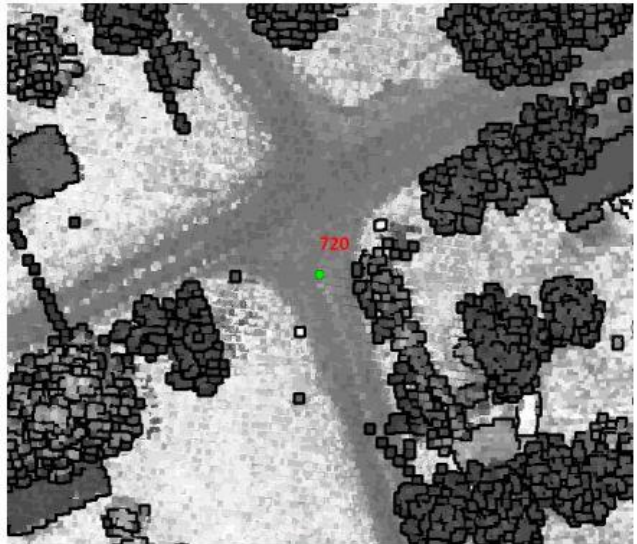
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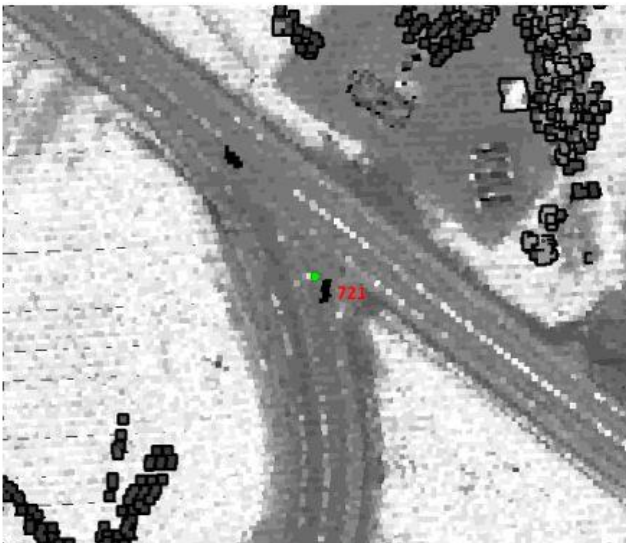
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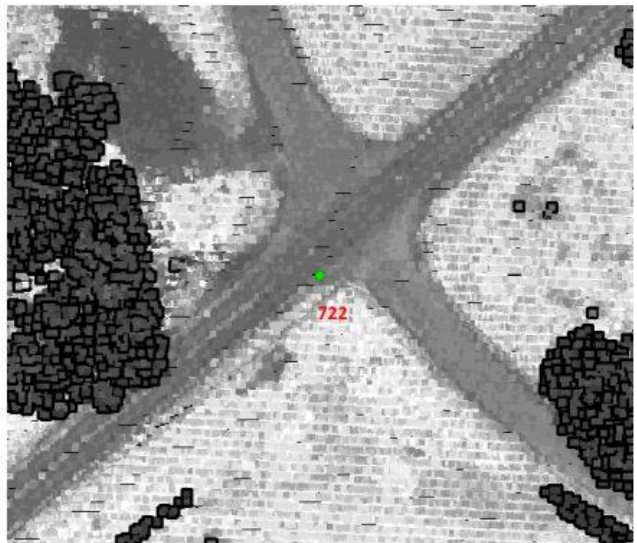
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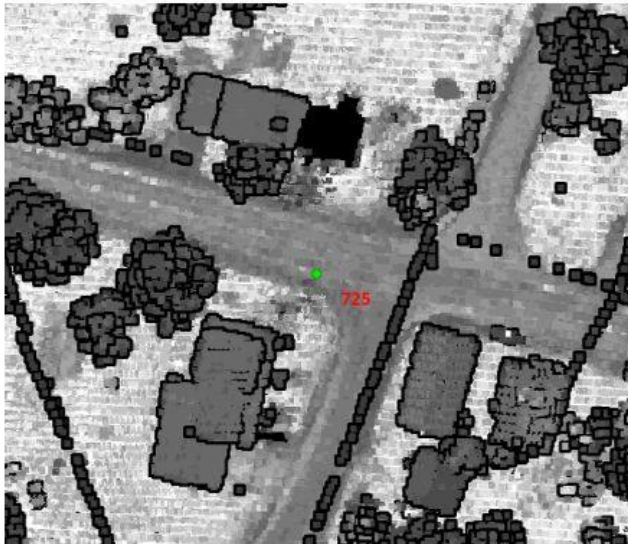
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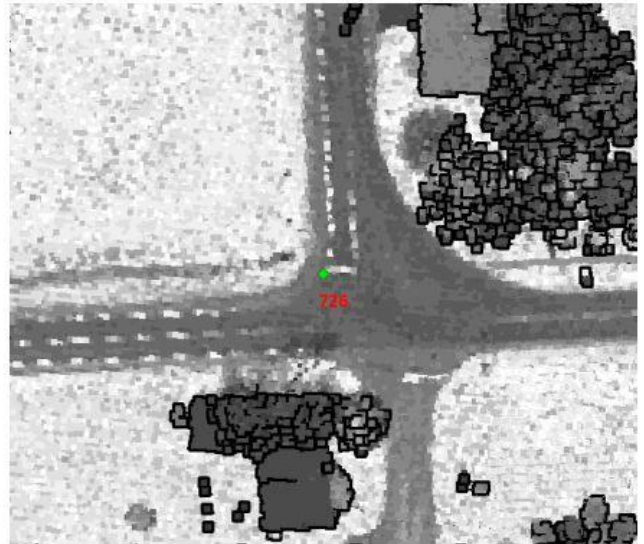
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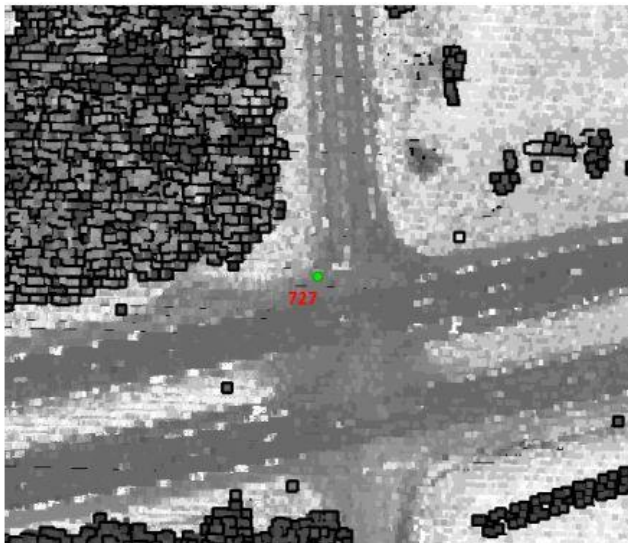
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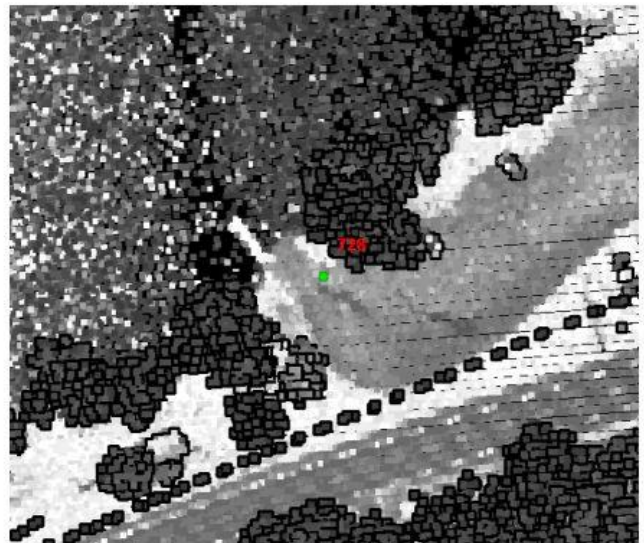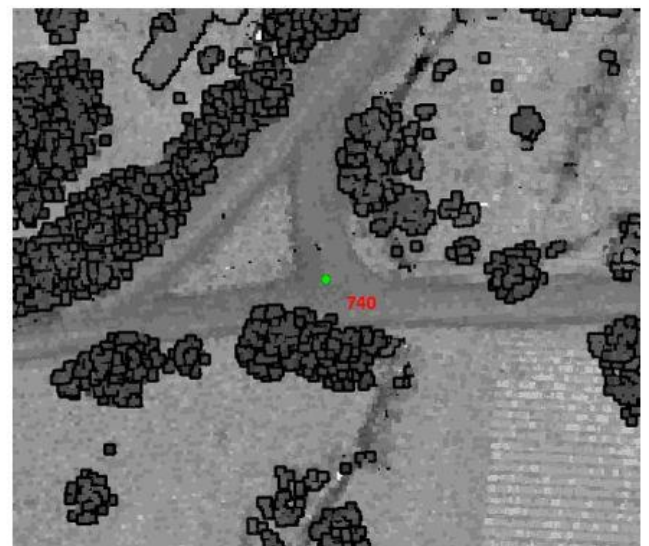

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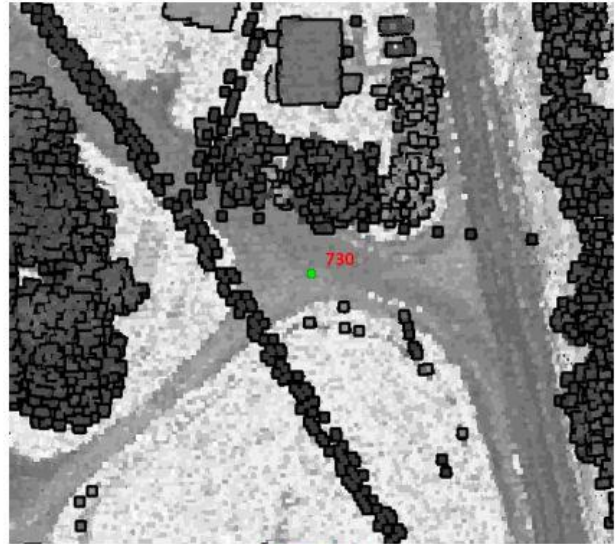
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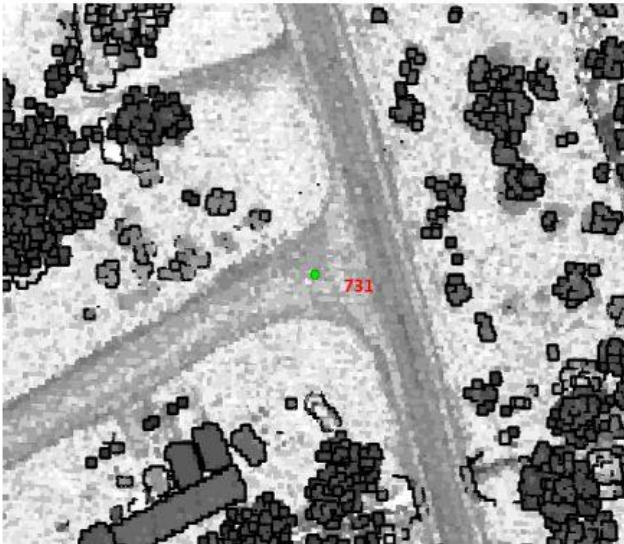
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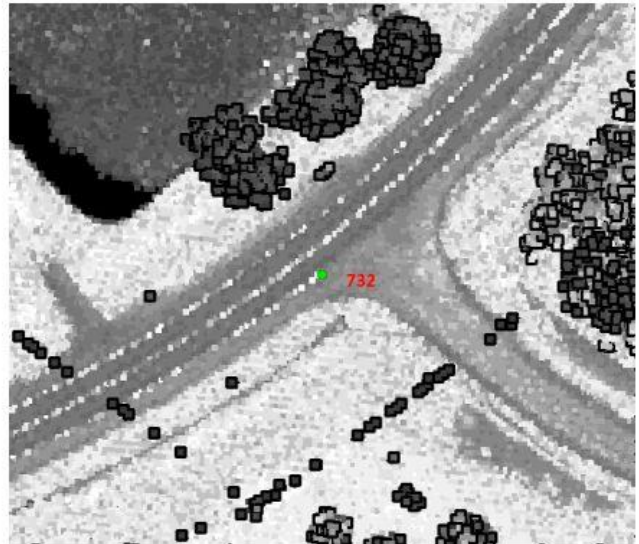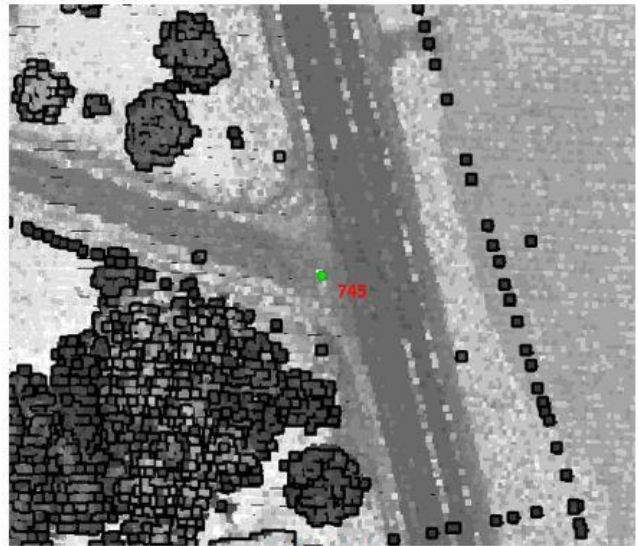

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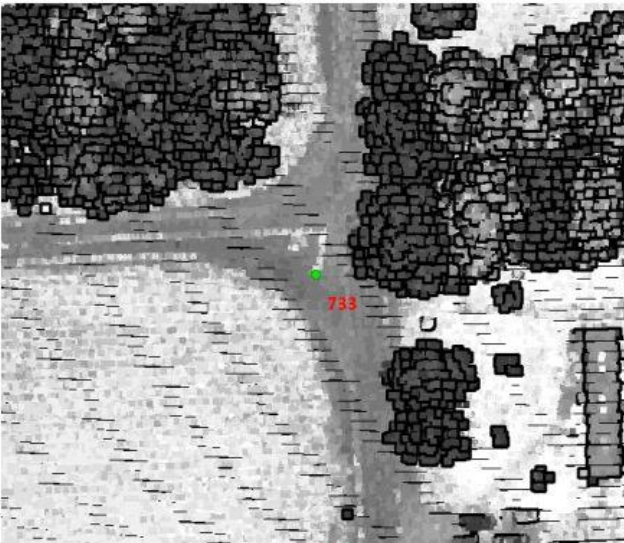
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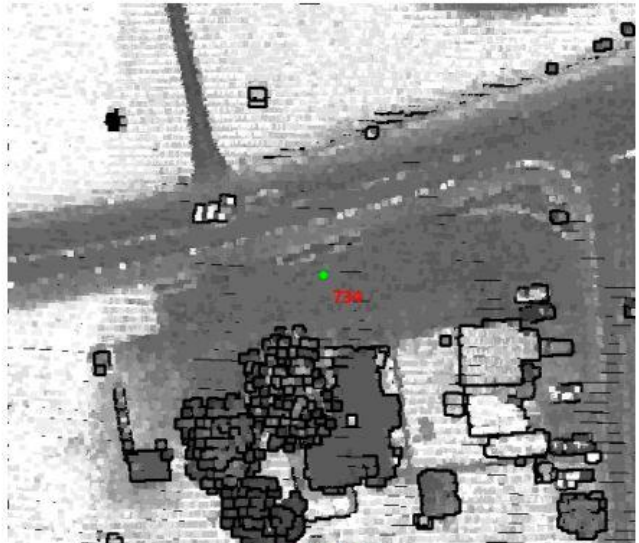
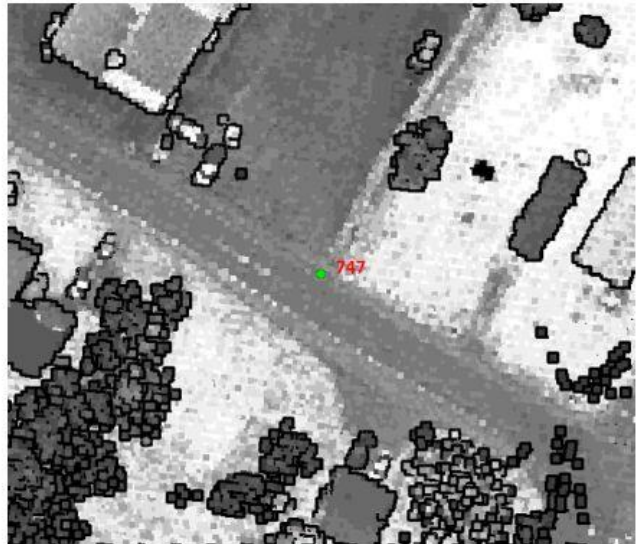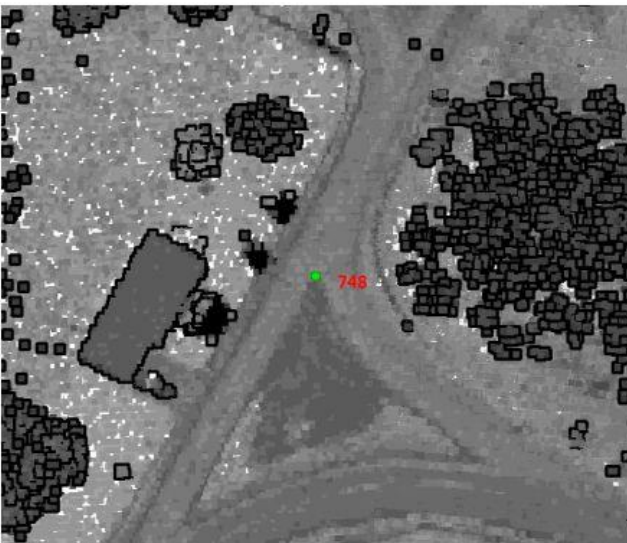734.jpg
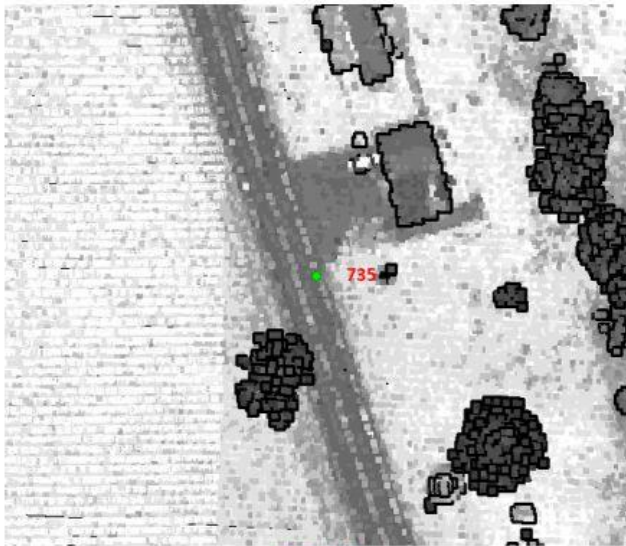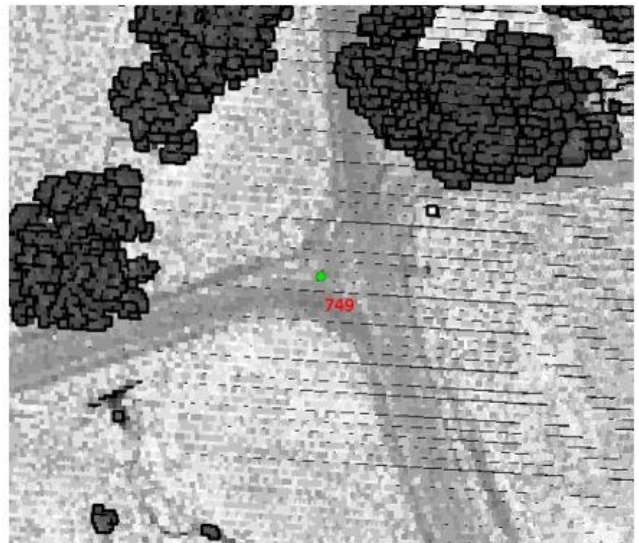
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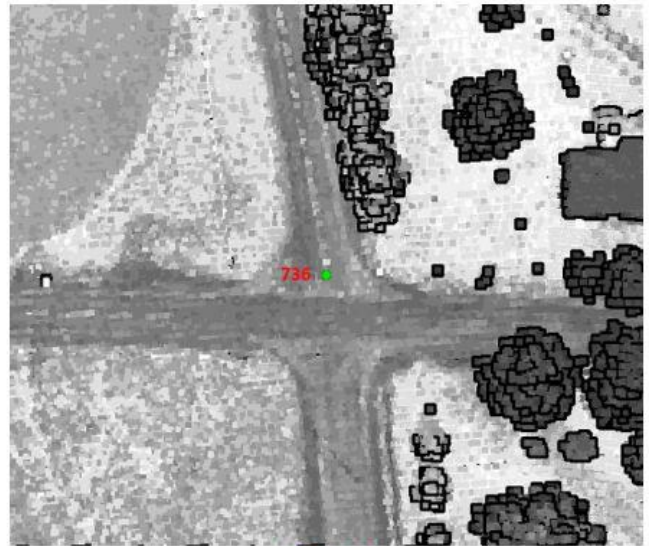
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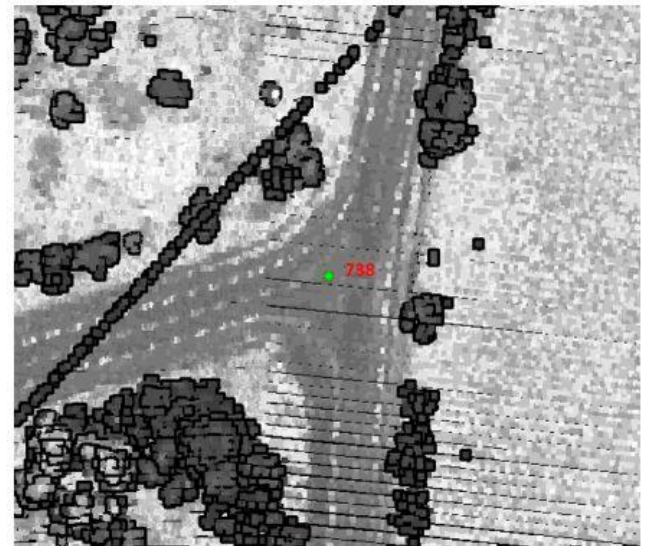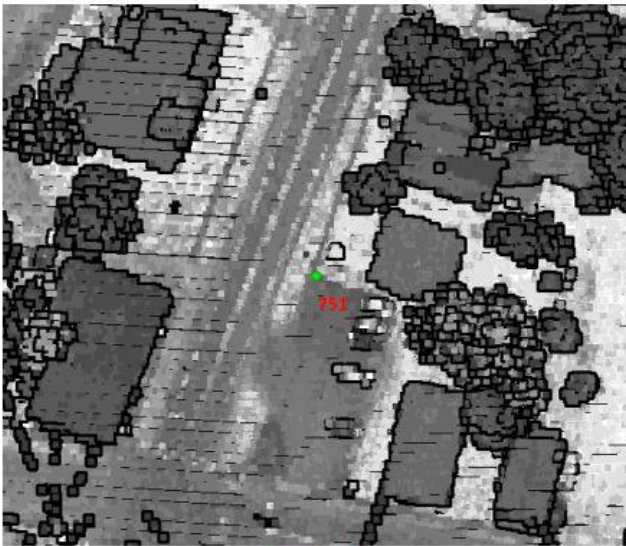

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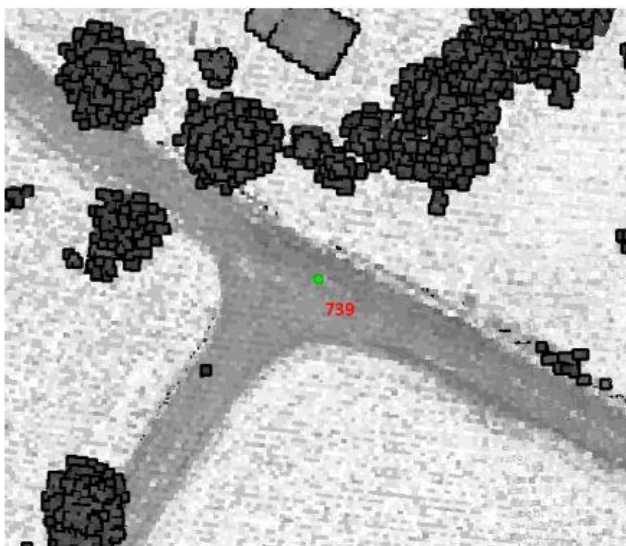
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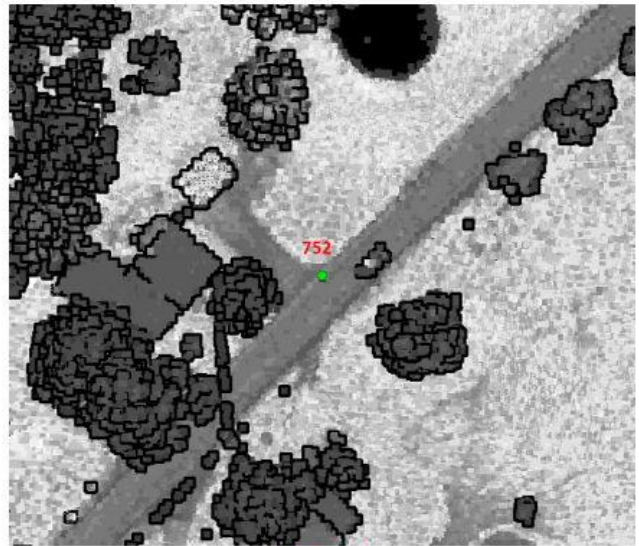740.jpg

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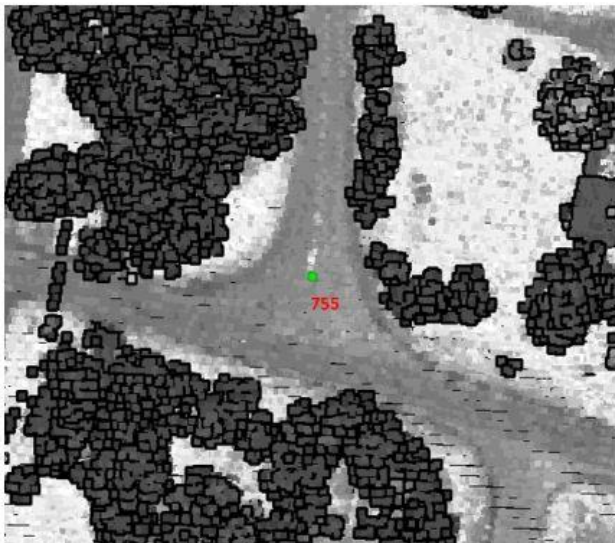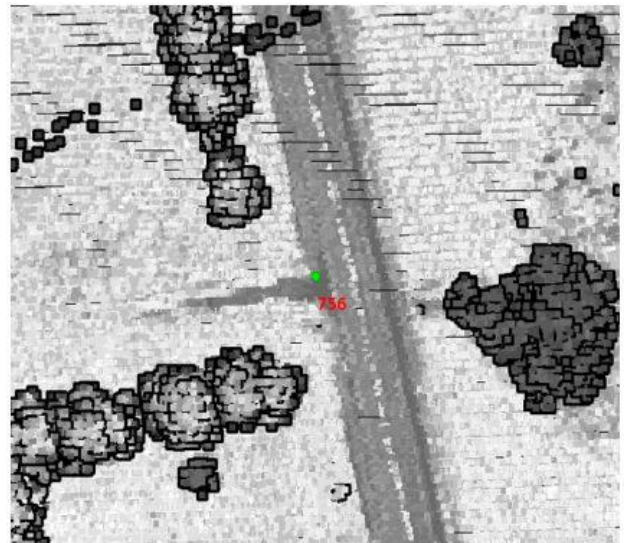
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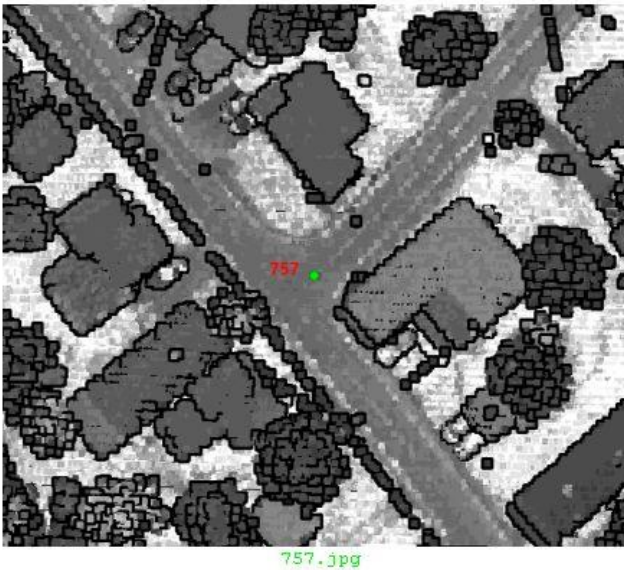753.jpg

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756.jpg

Figure 4: GCP Horizontal Assessment

2.4 Control Point Vertical Assessment

A vertical accuracy assessment of the control points against the lidar point cloud swath data can be found in Table 9 below. The coordinates provided are in NAD83 (2011), UTM Zone 18N, NAVD88 (Geoid12A), Meters.

Control Point Assessment (Swath)							

Point ID	Easting	Northing	Known Z	Laser Z	D_z	Code	Description
701	421130.4	4779342	117.56	117.55	-0.01	CP01	Mag Nail center end of yellow parking paint line.
702	429115.3	4777298	118.93	118.94	0.01	CP02	Mag Nail inside corner of L shaped concrete area.
703	439577.4	4778377	118.38	118.34	-0.04	CP03	Mag Nail at centerline of last diagonal paint stripe
704	449269.6	4771647	135.65	slope	*	CP04	Mag Nail at northeast corner of stop bar at Route 365 & Morgan Road.
705	438831.9	4768806	147.56	147.58	0.02	CP05	Mag Nail Southwest corner of stop bar/ Northwest corner Canastota Commons parking lot.
706	431744.3	4758766	286.43	286.4	-0.03	CP06	Mag Nail southwest corner of stop bar at shoulder stripe- Falls Road @ Carry Hill Road
707	444489.2	4759380	411	411.04	0.04	CP07	Mag Nail center end of white paint stripe at Buyea Road @ Goff Road
708	425124.7	4761747	375.02	375.01	-0.01	CP08	Capped spike Southern end of asphalt driveway. Corner of pavement change driveway/road
709	456566.6	4759418	411.87	411.88	0.01	CP09	Mag Nail southwest corner of driveway pavement patch @ edge gravel
717	504826.9	4751409	465.47	465.54	0.07	CP17	Mag Nail in north end of road triangle.

Point ID	Easting	Northing	Known Z	Laser Z	D$_z$	Code	Description
718	502763.3	4744186	459.61	459.58	-0.03	CP18	Mag Nail center end of white shoulder paint line-Route 20 @ Allen Lake Road
719	525430.2	4744932	227.7	slope	*	CP19	Mag Nail southern center end of stop bar-Route 163 @ Clinton Road
720	485930.5	4721643	396.65	396.74	0.09	CP20	Mag Nail center end of yellow paint stripe-County Rt. 16 @ Route 51
721	498629.4	4731470	399.36	399.35	-0.01	CP21	Mag Nail center southerly end of stop bar-Route 80@ Route 28
722	511660.2	4737241	387.33	387.36	0.03	CP22	Mag Nail center end of white shoulder paint stripe-County Route 31 @ Springfield Hill Rd
723	493654.4	4717479	390.84	390.91	0.07	CP23	Mag Nail Southern corner of driveway where it intersects with Road.
724	512246.6	4726837	393.82	393.88	0.06	CP24	Mag Nail Center end of white shoulder paint line-Route 166 @ Blacks Road
725	523728.3	4728367	478.54	478.56	0.02	CP25	Mag Nail center end of white shoulder paint line-Route 165 @ C.R. 34
726	429501.6	4744297	390.6	390.5	-0.1	CP26	Mag Nail Southwest corner of stop bar at shoulder stripe Bass Road @ Fabius Road
727	442017.8	4751353	476.2	476.14	-0.06	CP27	Mag Nail Southwest corner of stop bar-Pleasant Hill Rd @ Route 20
728	443524.1	4745554	437.9	437.88	-0.02	CP28	Capped spike southeast corner concrete boat launch
729	442178.1	4735446	517.44	517.33	-0.11	CP29	Mag Nail center end of yellow centerline paint stripe-Upham Road
730	427379.2	4730023	403.46	403.48	0.02	CP30	Mag nail center of shoulder paint line at the middle of gravel driveway
731	434470	4724706	415.68	415.7	0.02	CP31	Mag Nail center of road-Mills Corner Road
732	438767	4716784	545.84	545.84	0	CP32	Mag Nail center end of white paint stripe Rt. 23 and Center Road
733	429227.6	4705595	488.86	488.93	0.07	CP33	Mag Nail center end of stop bar-Forty Road @ C.R. 2
734	453662.9	4748250	363.74	363.73	-0.01	CP34	Mag Nail Intersection of paint lines in parking lot for Ray Brother Barbeque
735	453424.1	4735555	331.27	331.35	0.08	CP35	Mag Nail southern corner of driveway where it intersects with road pavement.
736	465668.7	4753295	417.76	417.71	-0.05	CP36	Mag Nail center end of centerline paint stripe Brothertown Road @ Sanger Hill RD
737	466972.9	4744569	371.93	371.94	0.01	CP37	Mag Nail center end of stop bar on Swamp Rd @ highway 12
738	466824.8	4738723	462.88	462.89	0.01	CP38	Mag Nail center end of yellow road centerline of Larkin Rd @ Moscow Rd
739	490738.2	4737734	472.61	472.68	0.07	CP39	Mag Nail center end of yellow paint line of C.R. 22 @ C.R. 19
740	465539	4732345	414.4	414.51	0.11	CP40	Mag Nail in middle of road-Truck Trail 4
741	473999.2	4728726	374.23	374.26	0.03	CP41	Mag Nail center end of white shoulder paint line-Route 8 @ C.R. 41

Point ID	Easting	Northing	Known Z	Laser Z	D_z	Code	Description
742	473944.3	4740082	414.11	414.19	0.08	CP42	Mag Nail south east corner of crosswalk.
745	479474.8	4753946	393.28	393.31	0.03	CP45	Mag Nail center end of stop bar on Larson Road @ C.R. 8
746	485557.3	4762852	398.9	398.91	0.01	CP46	Mag Nail southern corner of driveway where it intersects the road.
747	490735.4	4753123	369.66	369.7	0.04	CP47	Mag Nail southern corner pf parking lot where drive intersects with Cedarville Road
748	498185.7	4755520	435.17	435.12	-0.05	CP48	Mag Nail northern tip of triangle in the road-Polly Miller Road @ Columbia Center Rd
749	513452.9	4758811	204.85	204.86	0.01	CP49	Mag Nail center end of yellow centerline on Newville Road @ Paradise Rd
751	504496.2	4715393	367.67	367.71	0.04	CP51	Mag Nail corner of sidewalk and parking lot.
752	515766.1	4721097	459	459.02	0.02	CP52	Mag Nail northeast corner of driveway where it intersects with the road.
753	526950.5	4719097	445.26	445.28	0.02	CP53	Mag Nail corner of parking lot
754	509308	4709372	376.16	376.16	0	CP54	Mag Nail center end of white shoulder paint stripe on C.R. 54 @ Dog Hill Rd
755	521031.7	4707188	421.15	421.1	-0.05	CP55	Mag Nail center end of Yellow centerline paint on C.R. 39 @ C.R. 40
756	528506.3	4699393	588.83	588.87	0.04	CP56	Mag Nail northern corner of driveway where it intersects with road.
757	509308.9	4696643	424.71	424.72	0.01	CP57	Mag Nail center end of centerline paint stripe on C.R. 12 @ C. R. 10

Table 6: Lidar Point Cloud Swath Control Point Assessment

2.5 Vertical Accuracy Results

An overall statistical assessment of the control points can be found in Table 10 below. The coordinates provided are in NAD83 (2011), UTM Zone 18N, NAVD88 (Geoid12A), Meters.

Check Points Error Statistics							
Category	# of Points	Min (m)	Max (m)	Mean (m)	Median (m)	Skew	Std Dev (m)	RMSE$_z$ (m)
Control Points	47	-0.110	0.110	0.012	-0.010	-0.394	0.047	0.048

Table 7: Control Points Error Statistics

2.6 Ground Surveyed Check Points

AXIS GeoSpatial, LLC established a total of seven hundred seventy-one (761) check points for this project (380 NVA + 381 VVA). Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from lidar points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of 5 times the NPS exists with less than 1/3 of the RMSE$_z$ deviation from a low-slope plane. Check points for the NVA assessment is required to be well-distributed throughout the land cover type, for the entire project area.

2.7   Vertical Accuracy

Below are the vertical accuracy reporting requirements for this project:

Vertical Accuracy Reporting Requirements in Meters:

$RMSE_z$ ≤ 10.0cm (Non-Vegetated Swath)

NVA ≤ 19.6cm 95% Confidence Level (Swath)

*The terms FVA (Fundamental Vertical Accuracy), SVA (Supplemental Vertical Accuracy) and CVA (Consolidated Vertical Accuracy) are from the National Digital Elevation Program (NDEP) Guidelines for Digital Elevation Data (2004). The term FVA refers to open terrain, urban and levee classes; the term SVA refers to classes tested that are in addition or supplemental to the open terrain; the term CVA refers to the consolidated accuracy of the data from all classes (FVA + SVA).

*The terms NVA (Non-vegetated Vertical Accuracy) and VVA (Vegetated Vertical Accuracy) are from the ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas typically produce only single lidar returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return lidar).

2.8   Check Point Distribution

The following graphics depict the location and distribution of NVA Check Points established for this project.
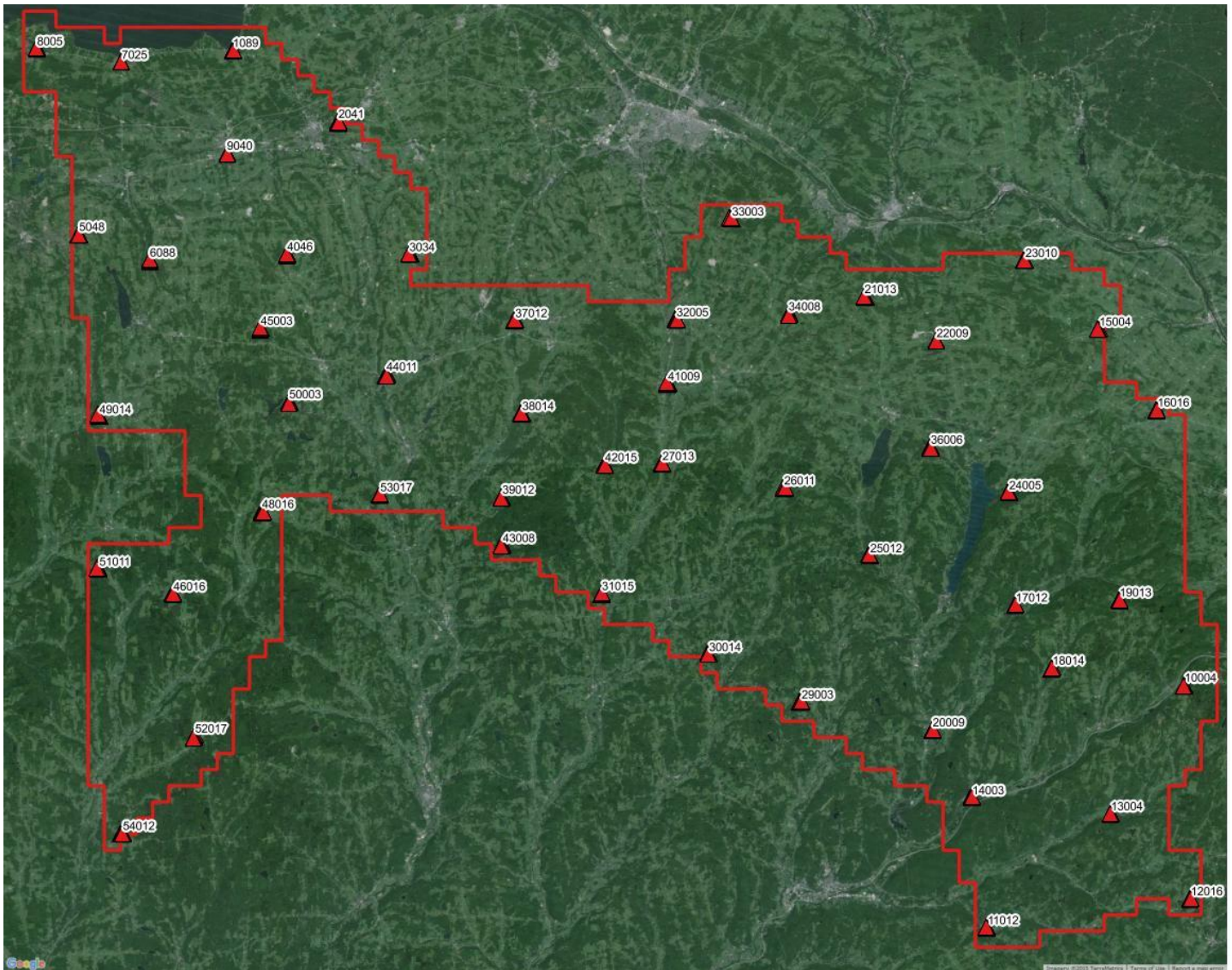
Figure 5: NVA Checkpoint Distribution

2.9 Check Point Assessment

A vertical accuracy assessment of the NVA check points against the lidar point cloud swath data can be found in Tables 8, 9, 10, and 11 below. The coordinates provided are in NAD83 (2011), UTM Zone 18N, NAVD88 (Geoid12A), Meters. Overall, the results proved to be satisfactory. The overall $RMSE_z$ for the NVA checkpoints was 5.8 centimeters (Target < 10 cm) and the NVA at the 95% confidence interval was 11.3 centimeters (Target < 19.6 cm). The last two tables, 12 and 13 provide a summary of the points that are outliers based on the 95th Percentile calculation and seven (7) check points that were not able to be assessed due to slope or abrupt vertical changes of nearby lidar returns such as powerlines, catch basins, or trees. Each of the seven points were checked manually and were found to be within the 19.6 cm vertical tolerance of nearby ground returns.

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
1088	439449.732	4778392.213	119.252	119.23	-0.022	0.022	BARE EARTH
1089	439455.648	4778397.232	119.303	119.32	0.017	0.017	BARE EARTH
1094	439485.806	4778328.062	119.324	119.36	0.036	0.036	BARE EARTH
2011	449217.848	4771653.519	135.892	135.9	0.008	0.008	BARE EARTH
2012	449236.857	4771650.192	135.813	135.84	0.027	0.027	BARE EARTH
3020	455985.488	4759402.879	440.457	440.51	0.053	0.053	BARE EARTH
3021	455985.467	4759407.515	440.834	440.84	0.006	0.006	BARE EARTH
3022	455985.461	4759408.434	440.943	440.9	-0.043	0.043	BARE EARTH
3024	455985.549	4759415.374	440.846	440.86	0.014	0.014	BARE EARTH
3039	455845.224	4759406.857	447.49	447.52	0.03	0.03	BARE EARTH
3040	455845.42	4759404.55	447.235	447.26	0.025	0.025	BARE EARTH
4013	444490.877	4759359.376	410.805	410.82	0.015	0.015	BARE EARTH
4018	444466.468	4759293.978	409.535	409.57	0.035	0.035	BARE EARTH
4020	444493.786	4759325.641	410.053	410.12	0.067	0.067	BARE EARTH
4021	444494.658	4759343.15	410.764	410.8	0.036	0.036	BARE EARTH
4048	444475.599	4759444.212	411.781	removed	*	*	BARE EARTH
5011	425074.293	4761218.749	360.866	360.87	0.005	0.005	BARE EARTH
5012	425059.121	4761217.224	360.337	360.36	0.023	0.023	BARE EARTH
6013	431736.595	4758788.016	286.111	286.11	-0.001	0.001	BARE EARTH
6014	431736.4	4758778.593	286.341	286.34	-0.001	0.001	BARE EARTH
6015	431736.459	4758770.597	286.439	286.51	0.071	0.071	BARE EARTH
6058	431744.902	4758721.663	285.26	285.33	0.07	0.07	BARE EARTH
6089	431727.17	4758922.491	286.675	286.66	-0.015	0.015	BARE EARTH
6090	431724.123	4758932.302	287.469	287.5	0.031	0.031	BARE EARTH
7030	429090.102	4777344.752	119.482	119.54	0.058	0.058	BARE EARTH
7031	429091.882	4777356.445	119.521	119.54	0.019	0.019	BARE EARTH
7034	429050.998	4777328.262	119.314	119.36	0.046	0.046	BARE EARTH
7035	429078.573	4777322.72	119.506	119.54	0.035	0.035	BARE EARTH
7036	429085.547	4777320.668	119.663	119.66	-0.003	0.003	BARE EARTH
8013	421245.516	4778520.554	119.321	119.33	0.009	0.009	BARE EARTH
8014	421233.401	4778518.907	119.3	119.29	-0.01	0.01	BARE EARTH
8015	421231.178	4778514.58	119.249	119.24	-0.009	0.009	BARE EARTH
8016	421231.171	4778502.005	119.137	119.12	-0.017	0.017	BARE EARTH
8039	421220.002	4778588.828	119.63	119.65	0.02	0.02	BARE EARTH
8040	421216.833	4778578.387	119.757	119.91	0.153	0.153	BARE EARTH
9044	438930.923	4768846.058	150.474	150.5	0.026	0.026	BARE EARTH
9045	438925.837	4768844.936	150.446	150.48	0.034	0.034	BARE EARTH
10013	527884.343	4719263.816	446.158	446.2	0.042	0.042	BARE EARTH
11003	509509.604	4696769.826	419.276	419.33	0.054	0.054	BARE EARTH
11004	509527.898	4696785.435	419.437	419.49	0.053	0.053	BARE EARTH

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
11005	509557.284	4696778.407	419.386	419.47	0.084	0.084	BARE EARTH
11006	509579.814	4696780.91	419.256	419.32	0.064	0.064	BARE EARTH
12007	528469.278	4699487.998	596.683	596.86	0.177	0.177	BARE EARTH
12008	528442.862	4699467.68	597.233	597.4	0.167	0.167	BARE EARTH
13014	521086.855	4707429.55	431.262	431.3	0.038	0.038	BARE EARTH
13015	521098.305	4707444.331	431.366	431.44	0.075	0.075	BARE EARTH
14005	508156.153	4708910.227	373.536	slope	*	*	BARE EARTH
14006	508136.995	4708930.22	375.574	375.62	0.046	0.046	BARE EARTH
15014	519848.499	4752442.809	192.869	193.02	0.151	0.151	BARE EARTH
16017	525395.686	4744912.32	227.329	227.34	0.011	0.011	BARE EARTH
16018	525425.807	4744941.815	227.779	227.81	0.031	0.031	BARE EARTH
17007	512208.292	4726797.183	392.211	392.26	0.049	0.049	BARE EARTH
17010	512204.857	4726826.308	393.041	393.03	-0.011	0.011	BARE EARTH
17011	512241.296	4726845.027	393.681	393.72	0.039	0.039	BARE EARTH
17012	512259.225	4726854.294	393.959	393.97	0.011	0.011	BARE EARTH
18005	515601.583	4720917.247	455.026	455.08	0.054	0.054	BARE EARTH
18006	515588.635	4720897.394	454.637	454.72	0.083	0.083	BARE EARTH
18011	515636.156	4720939.489	455.969	455.98	0.011	0.011	BARE EARTH
18012	515652.139	4720964.186	457.287	457.32	0.033	0.033	BARE EARTH
19006	521903.945	4727231.761	593.146	593.23	0.084	0.084	BARE EARTH
19007	521901.742	4727260.086	594.287	594.25	-0.037	0.037	BARE EARTH
19012	521915.046	4727312.591	597.018	597.06	0.042	0.042	BARE EARTH
19014	521923.686	4727293.799	594.74	594.77	0.03	0.03	BARE EARTH
20006	504477.176	4715193.926	365.62	365.62	0	0	BARE EARTH
20007	504511.079	4715198.953	364.776	364.87	0.094	0.094	BARE EARTH
20011	504574.816	4715189.339	364.942	364.98	0.038	0.038	BARE EARTH
20012	504595.443	4715172.306	364.866	364.91	0.044	0.044	BARE EARTH
20013	504603.686	4715217.639	365.048	365.03	-0.018	0.018	BARE EARTH
21010	498140.758	4755463.645	435.867	435.88	0.013	0.013	BARE EARTH
21012	498179.501	4755505.459	435.358	435.29	-0.068	0.068	BARE EARTH
22010	504829.163	4751398.975	465.312	465.41	0.098	0.098	BARE EARTH
23006	513053.797	4758850.954	216.47	216.51	0.04	0.04	BARE EARTH
23014	513111.182	4758829.725	216.884	216.91	0.026	0.026	BARE EARTH
24003	511653.592	4737256.371	386.68	386.73	0.05	0.05	BARE EARTH
24004	511634.492	4737271.12	386.092	386.22	0.129	0.129	BARE EARTH
24008	511620.896	4737390.56	384.158	384.2	0.042	0.042	BARE EARTH
24009	511609.442	4737423.629	384.116	384.14	0.024	0.024	BARE EARTH
25003	498588.202	4731522.032	398.676	398.71	0.034	0.034	BARE EARTH
25006	498637.128	4731442.555	400.381	400.39	0.009	0.009	BARE EARTH
25012	498732.093	4731435.984	398.209	398.32	0.111	0.111	BARE EARTH

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
25013	498688.933	4731490.716	398.624	398.68	0.056	0.056	BARE EARTH
26015	490684.57	4737787.206	476.529	476.6	0.071	0.071	BARE EARTH
26018	490828.43	4737690.942	467.852	467.95	0.098	0.098	BARE EARTH
27005	479394.53	4739945.59	350.712	350.8	0.088	0.088	BARE EARTH
27007	479357.892	4739943.464	352.341	352.52	0.179	0.179	BARE EARTH
27011	479342.479	4740016.994	354.333	354.46	0.127	0.127	BARE EARTH
27015	479431.649	4739972.977	349.777	349.85	0.073	0.073	BARE EARTH
29003	492345.333	4717837.289	483.77	483.87	0.1	0.1	BARE EARTH
29004	492326.814	4717827.741	485.117	485.15	0.033	0.033	BARE EARTH
30008	483618.941	4722351.307	481.524	481.58	0.056	0.056	BARE EARTH
30009	483641.416	4722377.1	481.982	482.04	0.058	0.058	BARE EARTH
30010	483666.429	4722367.522	482.481	482.43	-0.051	0.051	BARE EARTH
30011	483691.82	4722355.711	482.576	482.59	0.014	0.014	BARE EARTH
30012	483694.436	4722330.022	482.175	482.24	0.065	0.065	BARE EARTH
30015	483662.14	4722248.45	478.932	478.87	-0.062	0.062	BARE EARTH
31003	473738.228	4727727.97	373.673	373.69	0.017	0.017	BARE EARTH
31004	473743.981	4727752.594	374.679	374.67	-0.009	0.009	BARE EARTH
31005	473728.046	4727776.304	376.127	376.16	0.033	0.033	BARE EARTH
31006	473720.476	4727800.691	376.307	376.35	0.043	0.043	BARE EARTH
31013	473778.879	4727878.61	376.57	376.59	0.02	0.02	BARE EARTH
32020	480665.219	4753329.013	383.039	383.04	0.001	0.001	BARE EARTH
32021	480723.861	4753338.088	382.869	382.9	0.031	0.031	BARE EARTH
32022	480757.496	4753331.923	382.793	382.88	0.087	0.087	BARE EARTH
33004	485866.577	4762710.754	403.86	404.01	0.15	0.15	BARE EARTH
33006	485818.547	4762716.06	403.038	403.17	0.132	0.132	BARE EARTH
33007	485766.25	4762743.893	401.146	401.23	0.084	0.084	BARE EARTH
33014	485773.366	4762792.722	402.567	402.61	0.043	0.043	BARE EARTH
34011	491244.941	4753872.721	381.308	381.33	0.022	0.022	BARE EARTH
34015	491191.292	4753791.491	380.689	380.78	0.091	0.091	BARE EARTH
36012	504307.018	4741471.98	498.634	498.75	0.116	0.116	BARE EARTH
36014	504294.273	4741424.532	498.863	498.91	0.047	0.047	BARE EARTH
36015	504315.867	4741423.887	499.434	499.56	0.126	0.126	BARE EARTH
36016	504355.614	4741427.086	499.855	499.93	0.075	0.075	BARE EARTH
37013	465749.465	4753277.426	419.332	419.43	0.099	0.099	BARE EARTH
37015	465679.89	4753297.285	417.574	417.64	0.066	0.066	BARE EARTH
37018	465648.166	4753327.914	416.55	416.65	0.1	0.1	BARE EARTH
38009	466354.751	4744595.594	363.319	363.35	0.031	0.031	BARE EARTH
38010	466369.23	4744640.538	363.516	363.5	-0.016	0.016	BARE EARTH
38012	466394.27	4744607.569	363.076	363.12	0.044	0.044	BARE EARTH
39010	464474.113	4736834.123	440.101	440.14	0.039	0.039	BARE EARTH

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
41006	479875.186	4747400.583	361.697	361.78	0.083	0.083	BARE EARTH
41007	479892.197	4747398.496	362.347	362.51	0.163	0.163	BARE EARTH
41013	479947.202	4747373.177	362.082	362.21	0.128	0.128	BARE EARTH
41014	479904.024	4747342.163	361.76	361.86	0.1	0.1	BARE EARTH
41015	479893.315	4747320.902	361.432	361.55	0.118	0.118	BARE EARTH
42008	473929.175	4739936.858	411.308	411.38	0.072	0.072	BARE EARTH
42009	473967.517	4739941.03	411.917	412.01	0.093	0.093	BARE EARTH
42010	473989.707	4739922.054	411.533	411.59	0.057	0.057	BARE EARTH
42017	474066.764	4739814.943	411.644	slope	*	*	BARE EARTH
42018	474037.884	4739868.08	411.019	411.08	0.061	0.061	BARE EARTH
42021	474036.807	4739803.36	410.725	410.79	0.065	0.065	BARE EARTH
43016	464395.476	4732323.955	395.616	395.64	0.024	0.024	BARE EARTH
44007	453607.746	4748174.578	362.949	362.98	0.031	0.031	BARE EARTH
44008	453599.395	4748210.944	363.703	363.73	0.027	0.027	BARE EARTH
45007	442014.76	4752502.364	437.142	437.17	0.028	0.028	BARE EARTH
46005	433895.296	4727852.958	487.206	487.19	-0.016	0.016	BARE EARTH
48005	442238.144	4735463.962	519.249	519.09	-0.159	0.159	BARE EARTH
48010	442176.253	4735422.451	514.729	514.59	-0.139	0.139	BARE EARTH
48014	442122.568	4735478.15	520.012	519.98	-0.032	0.032	BARE EARTH
48018	442169.42	4735491.419	522.743	522.64	-0.103	0.103	BARE EARTH
48020	442182.102	4735473.191	519.992	519.84	-0.152	0.152	BARE EARTH
49004	426960.015	4744550.104	398.751	398.73	-0.021	0.021	BARE EARTH
49007	427041.733	4744442.876	401.985	401.91	-0.075	0.075	BARE EARTH
49016	427014.958	4744347.652	397.052	396.98	-0.072	0.072	BARE EARTH
49020	426939.711	4744453.379	394.815	394.84	0.025	0.025	BARE EARTH
49021	426910.747	4744519.126	393.943	393.96	0.017	0.017	BARE EARTH
50005	444684.748	4745709.19	430.635	430.71	0.075	0.075	BARE EARTH
50006	444666.218	4745704.058	428.49	428.62	0.13	0.13	BARE EARTH
50014	444650.527	4745559.797	423.653	423.74	0.087	0.087	BARE EARTH
51010	427020.204	4730197.756	398.978	398.93	-0.048	0.048	BARE EARTH
51011	427043.656	4730201.302	399.947	399.99	0.043	0.043	BARE EARTH
51012	426953.703	4730215.702	396.948	396.87	-0.078	0.078	BARE EARTH
52010	435917.499	4714621.123	470.729	470.69	-0.038	0.038	BARE EARTH
52019	435865.628	4714577.483	470.577	470.55	-0.027	0.027	BARE EARTH
53005	453076.792	4737036.266	339.963	340.02	0.057	0.057	BARE EARTH
53006	453055.932	4737042.703	340.462	340.51	0.048	0.048	BARE EARTH
53009	453118.483	4737056.461	339.657	339.76	0.103	0.103	BARE EARTH
53010	453135.765	4737014.431	339.68	339.76	0.079	0.079	BARE EARTH
53011	453159.096	4737002.183	340.222	340.28	0.058	0.058	BARE EARTH
54006	429067.181	4705562.11	488.636	488.67	0.034	0.034	BARE EARTH

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
54015	429208.502	4705548.837	488.972	489.04	0.068	0.068	BARE EARTH
54016	429164.097	4705601.807	488.683	488.74	0.057	0.057	BARE EARTH
1090	439452.759	4778372.168	118.751	118.71	-0.041	0.041	URBAN
1095	439487.347	4778347.635	119.701	119.69	-0.011	0.011	URBAN
2013	449256.926	4771633.522	135.631	135.61	-0.021	0.021	URBAN
2014	449257.158	4771626.417	135.882	135.88	-0.002	0.002	URBAN
2015	449258.272	4771626.494	135.909	135.88	-0.029	0.029	URBAN
2016	449260.536	4771623.792	135.958	135.95	-0.008	0.008	URBAN
2017	449262.402	4771621.549	135.976	135.96	-0.016	0.016	URBAN
2018	449262.271	4771620.372	135.977	135.96	-0.017	0.017	URBAN
2019	449259.928	4771618.377	135.93	135.91	-0.02	0.02	URBAN
2020	449256.852	4771616.001	135.939	135.92	-0.019	0.019	URBAN
2021	449252.289	4771621.279	135.815	135.85	0.035	0.035	URBAN
2022	449252.419	4771622.437	135.823	135.79	-0.033	0.033	URBAN
2023	449254.839	4771624.517	135.843	135.84	-0.003	0.003	URBAN
2042	449292.685	4771722.079	136.382	136.36	-0.022	0.022	URBAN
3013	455927.343	4759411.395	443.815	443.82	0.005	0.005	URBAN
3023	455985.569	4759414.586	440.927	440.93	0.003	0.003	URBAN
3026	455946.325	4759414.455	442.803	442.82	0.017	0.017	URBAN
3027	455946.145	4759408.405	442.86	slope	*	*	URBAN
3028	455927.667	4759402.423	443.556	slope	*	*	URBAN
3029	455931.36	4759420.251	443.321	443.32	-0.001	0.001	URBAN
3030	455906.945	4759414.323	444.588	444.61	0.022	0.022	URBAN
3031	455907.21	4759408.156	444.685	444.66	-0.025	0.025	URBAN
3032	455876.176	4759408.084	446.099	446.09	-0.009	0.009	URBAN
3033	455875.461	4759414.277	446.089	446.09	0.001	0.001	URBAN
3037	455839.005	4759414.17	447.813	447.81	-0.002	0.002	URBAN
3038	455838.502	4759408.077	447.903	447.85	-0.053	0.053	URBAN
4006	444485.972	4759385.672	411.201	411.2	-0.001	0.001	URBAN
4007	444489.425	4759385.667	411.129	411.14	0.011	0.011	URBAN
4019	444483.426	4759305.021	409.908	409.9	-0.008	0.008	URBAN
4022	444499.225	4759385.741	411.032	411.05	0.018	0.018	URBAN
4023	444519.871	4759385.293	410.492	410.5	0.008	0.008	URBAN
4024	444537.776	4759384.951	409.977	410	0.023	0.023	URBAN
4025	444558.911	4759384.887	409.565	409.58	0.015	0.015	URBAN
4026	444577.055	4759384.092	409.281	409.29	0.009	0.009	URBAN
5073	425141.636	4761218.325	367.611	367.58	-0.031	0.031	URBAN
5074	425146.413	4761220.44	368.318	368.27	-0.048	0.048	URBAN
5075	425144.316	4761227.616	368.601	368.58	-0.021	0.021	URBAN
6026	431753.931	4758746.656	286.692	286.67	-0.022	0.022	URBAN

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
6027	431748.8	4758750.125	286.514	286.46	-0.054	0.054	URBAN
6028	431744.49	4758754.944	286.366	286.39	0.024	0.024	URBAN
6051	431766.153	4758751.126	287.397	287.41	0.013	0.013	URBAN
6059	431754.729	4758706.605	285.394	285.32	-0.074	0.074	URBAN
6084	431739.194	4758909.895	286.547	286.53	-0.017	0.017	URBAN
6085	431736.558	4758909.422	286.518	286.52	0.002	0.002	URBAN
6086	431730.529	4758909.409	286.111	286.11	-0.001	0.001	URBAN
6087	431735.382	4758904.407	286.334	286.32	-0.014	0.014	URBAN
6088	431734.639	4758913.534	286.571	286.59	0.019	0.019	URBAN
7025	429115.834	4777299.24	118.97	119	0.03	0.03	URBAN
7026	429114.515	4777298.26	118.915	118.91	-0.005	0.005	URBAN
7032	429098.955	4777358.944	119.591	119.61	0.019	0.019	URBAN
7033	429051.389	4777348.795	119.667	119.68	0.013	0.013	URBAN
8003	421246.624	4778548.899	119.874	119.84	-0.034	0.034	URBAN
8004	421243.308	4778549.61	119.907	119.88	-0.027	0.027	URBAN
8005	421244.035	4778556.139	120.066	120.04	-0.026	0.026	URBAN
8006	421247.553	4778555.816	120.055	120.03	-0.025	0.025	URBAN
8007	421245.431	4778553.067	119.955	119.94	-0.015	0.015	URBAN
8008	421241.516	4778555.17	120.053	120.02	-0.033	0.033	URBAN
8009	421239.831	4778555.194	120.039	120.01	-0.029	0.029	URBAN
8010	421239.719	4778550.321	119.907	119.89	-0.017	0.017	URBAN
8011	421241.357	4778550.406	119.925	119.9	-0.025	0.025	URBAN
8012	421240.555	4778552.646	119.981	119.96	-0.021	0.021	URBAN
9040	438907.647	4768849.638	149.687	149.67	-0.017	0.017	URBAN
9052	438933.375	4768759.362	149.958	149.97	0.012	0.012	URBAN
9053	438929.314	4768758.777	149.927	149.94	0.013	0.013	URBAN
9054	438931.289	4768747.339	149.889	149.91	0.021	0.021	URBAN
9055	438935.237	4768747.998	149.897	149.9	0.003	0.003	URBAN
9056	438932.766	4768752.324	149.928	149.93	0.002	0.002	URBAN
9057	438928.429	4768735.199	149.559	149.57	0.011	0.011	URBAN
9058	438933.241	4768736.037	149.74	149.72	-0.02	0.02	URBAN
9059	438934.68	4768727.529	149.544	149.55	0.006	0.006	URBAN
9060	438929.712	4768726.77	149.379	149.39	0.012	0.012	URBAN
9061	438931.684	4768731.027	149.582	149.57	-0.012	0.012	URBAN
10014	527895.911	4719290.37	445.61	445.72	0.111	0.111	URBAN
10015	527907.667	4719312.663	445.32	445.37	0.05	0.05	URBAN
11009	509588.111	4696824.105	421.053	421.08	0.027	0.027	URBAN
11010	509610.195	4696829.066	421.204	421.25	0.046	0.046	URBAN
11013	509601.334	4696849.558	421.245	421.33	0.085	0.085	URBAN
11014	509587.239	4696846.414	421.039	421.11	0.071	0.071	URBAN

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
12003	528508.599	4699406.64	589.651	589.74	0.089	0.089	URBAN
12004	528500.878	4699440.615	591.74	591.81	0.07	0.07	URBAN
12015	528530.843	4699543.82	593.152	593.3	0.148	0.148	URBAN
12016	528546.679	4699555.351	593.366	593.53	0.164	0.164	URBAN
13004	521118.371	4707457.178	432.465	432.5	0.035	0.035	URBAN
13005	521096.119	4707432.795	431.617	431.64	0.023	0.023	URBAN
14007	508133.302	4708996.631	376.856	376.83	-0.026	0.026	URBAN
14012	508169.84	4708956.247	373.655	373.67	0.015	0.015	URBAN
14013	508200.294	4708965.064	371.879	371.88	0.001	0.001	URBAN
15004	520027.629	4752497.731	190.82	190.83	0.01	0.01	URBAN
15005	519988.901	4752481.651	190.266	190.33	0.064	0.064	URBAN
15012	519865.301	4752430.662	192.145	192.22	0.075	0.075	URBAN
15013	519863.156	4752452.035	192.394	192.44	0.046	0.046	URBAN
16003	525363.394	4744897.202	227.022	227.02	-0.002	0.002	URBAN
16004	525391.531	4744913.827	227.414	227.44	0.026	0.026	URBAN
16013	525428.355	4744936.108	227.926	slope	*	*	URBAN
16014	525430.07	4744946.897	228.199	228.19	-0.009	0.009	URBAN
16015	525418.317	4744970.968	228.353	228.32	-0.033	0.033	URBAN
17013	512246.597	4726837.334	393.832	393.89	0.058	0.058	URBAN
18003	515584.559	4720869.037	452.568	452.55	-0.017	0.017	URBAN
18004	515612.669	4720911.372	454.24	454.23	-0.01	0.01	URBAN
18013	515656.15	4720998.879	458.83	458.85	0.021	0.021	URBAN
18014	515680.407	4721004.216	457.586	457.61	0.024	0.024	URBAN
19003	521912.214	4727143.71	593.962	594.01	0.048	0.048	URBAN
19004	521910.475	4727186.426	593.234	593.28	0.046	0.046	URBAN
19009	521842.634	4727269.924	600.972	601	0.028	0.028	URBAN
19011	521894.236	4727275.86	596.331	596.34	0.009	0.009	URBAN
19016	521917.669	4727282.525	594.691	594.7	0.009	0.009	URBAN
20005	504486.615	4715186.73	364.981	365.01	0.029	0.029	URBAN
20008	504533.356	4715221.023	365.482	365.51	0.028	0.028	URBAN
20009	504543.748	4715251.755	365.654	365.64	-0.014	0.014	URBAN
21003	498329.151	4755418.878	437.923	437.87	-0.053	0.053	URBAN
21009	498132.629	4755428.174	436.788	slope	*	*	URBAN
21011	498166.356	4755477.872	436.112	436.06	-0.052	0.052	URBAN
21014	498208.362	4755496.363	435.635	435.65	0.015	0.015	URBAN
22003	504832.644	4751410.5	465.717	465.77	0.053	0.053	URBAN
22004	504846.66	4751430.569	466.57	466.65	0.08	0.08	URBAN
23003	512968.51	4758874.269	214.829	214.89	0.061	0.061	URBAN
23004	513000.484	4758864.169	215.79	215.89	0.1	0.1	URBAN
24014	511619.46	4737363.191	384.767	384.79	0.024	0.024	URBAN

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
24015	511631.487	4737328.996	385.071	385.09	0.019	0.019	URBAN
25004	498617.252	4731494.264	399.087	399.09	0.003	0.003	URBAN
25005	498627.646	4731469.807	399.327	399.35	0.023	0.023	URBAN
25007	498630.302	4731407.958	402.68	402.68	0	0	URBAN
25010	498697.771	4731415.281	398.986	398.98	-0.006	0.006	URBAN
26010	490683.567	4737656.747	464.712	464.71	-0.002	0.002	URBAN
26011	490729.745	4737728.809	472.009	472.02	0.011	0.011	URBAN
26012	490723.303	4737742.492	473.323	473.33	0.007	0.007	URBAN
26017	490768.017	4737718.141	470.678	470.77	0.092	0.092	URBAN
27003	479444.236	4739953.7	350.142	350.18	0.038	0.038	URBAN
27004	479411.867	4739952.937	350.52	350.61	0.09	0.09	URBAN
27006	479375.633	4739935.474	351.435	351.59	0.155	0.155	URBAN
27008	479340.381	4739950.252	353.291	353.41	0.119	0.119	URBAN
29005	492309.581	4717829.096	486.242	486.28	0.038	0.038	URBAN
29006	492269.682	4717824.474	488.424	488.46	0.036	0.036	URBAN
29014	492178.116	4717813.515	492.163	492.22	0.057	0.057	URBAN
31011	473760.33	4727827.089	376.623	376.66	0.037	0.037	URBAN
31012	473768.353	4727860.947	377.004	377.04	0.036	0.036	URBAN
31014	473775.435	4727891.388	377.386	377.42	0.034	0.034	URBAN
31015	473779.15	4727923.921	377.947	377.97	0.023	0.023	URBAN
32008	480768.962	4753327.336	383.031	383.06	0.029	0.029	URBAN
32009	480733.755	4753329.283	383.103	383.09	-0.013	0.013	URBAN
32010	480664.176	4753332.943	383.219	383.22	0.001	0.001	URBAN
32018	480594.503	4753336.819	383.519	383.56	0.041	0.041	URBAN
33003	485877.405	4762725.12	403.766	403.85	0.084	0.084	URBAN
33010	485741.603	4762805.996	401.529	401.65	0.121	0.121	URBAN
33011	485698.152	4762832.672	400.496	400.61	0.114	0.114	URBAN
33017	485820.579	4762759.362	403.916	403.99	0.075	0.075	URBAN
34012	491230.612	4753857.826	381.429	381.46	0.031	0.031	URBAN
34016	491162.777	4753755.362	378.918	378.94	0.022	0.022	URBAN
36003	504411.935	4741448.019	497.59	497.61	0.02	0.02	URBAN
36009	504309.067	4741534.674	500.467	500.5	0.033	0.033	URBAN
36010	504273.461	4741497.241	498.792	498.83	0.038	0.038	URBAN
37008	465675.747	4753204.735	419.204	419.25	0.046	0.046	URBAN
37011	465676.66	4753287.054	418.056	418.03	-0.026	0.026	URBAN
37012	465723.335	4753285.805	419.154	419.24	0.086	0.086	URBAN
38013	466397.46	4744648.465	363.704	363.71	0.006	0.006	URBAN
38014	466363.808	4744654.199	363.606	363.58	-0.026	0.026	URBAN
38015	466320.911	4744664.619	363.291	363.3	0.009	0.009	URBAN
38016	466296.134	4744665.79	363.274	363.27	-0.004	0.004	URBAN

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
39008	464451.68	4736804.04	440.851	440.9	0.049	0.049	URBAN
39013	464534.246	4736876.899	439.39	439.41	0.02	0.02	URBAN
39015	464492.053	4736839.049	439.612	439.6	-0.012	0.012	URBAN
41003	479829.43	4747383.744	362.306	362.35	0.044	0.044	URBAN
41004	479828.218	4747376.869	362.323	362.34	0.017	0.017	URBAN
41005	479850.547	4747377.124	362.156	362.18	0.024	0.024	URBAN
41011	479975.286	4747356.22	361.945	362.02	0.075	0.075	URBAN
41020	479840.284	4747455.817	362.664	362.74	0.076	0.076	URBAN
42003	474003.43	4739775.897	410.456	410.44	-0.016	0.016	URBAN
42006	473966.596	4739837.131	410.823	410.84	0.017	0.017	URBAN
42014	474063.307	4739889.649	412.144	412.22	0.076	0.076	URBAN
42019	474040.897	4739841.512	411.013	411.03	0.017	0.017	URBAN
42020	474023.403	4739836.211	411.192	411.22	0.028	0.028	URBAN
43008	464562.564	4732385.259	396.646	396.68	0.034	0.034	URBAN
43011	464457.519	4732343.314	396.576	396.58	0.004	0.004	URBAN
44003	453712.257	4748076.716	361.893	361.89	-0.003	0.003	URBAN
44009	453705.141	4748277.834	363.41	363.43	0.02	0.02	URBAN
44010	453709.704	4748268.155	363.328	363.32	-0.008	0.008	URBAN
44013	453766.825	4748293.442	363.176	363.21	0.034	0.034	URBAN
44017	453709.779	4748140.327	362.65	362.65	0	0	URBAN
45009	442014.532	4752437.496	438.441	438.43	-0.011	0.011	URBAN
45010	442016.469	4752400.523	439.181	439.15	-0.031	0.031	URBAN
45017	442008.452	4752547.084	437.179	437.13	-0.049	0.049	URBAN
45018	442006.444	4752583.755	437.182	437.13	-0.052	0.052	URBAN
45019	442002.233	4752608.775	437.2	437.15	-0.049	0.049	URBAN
46006	433889.673	4727886.989	488.057	488.02	-0.037	0.037	URBAN
46007	433861.52	4727880.21	489.308	489.29	-0.018	0.018	URBAN
46008	433825.245	4727877.847	491.85	491.85	0	0	URBAN
46013	433868.206	4727961.373	489.628	489.64	0.012	0.012	URBAN
48004	442262.918	4735475.182	519.758	519.67	-0.088	0.088	URBAN
48006	442214.477	4735461.697	518.944	518.83	-0.114	0.114	URBAN
48009	442183.349	4735384.301	511.487	511.35	-0.137	0.137	URBAN
48013	442085.914	4735442.277	515.805	515.75	-0.055	0.055	URBAN
48022	442182.452	4735453.352	518.017	517.91	-0.107	0.107	URBAN
49003	426925.832	4744561.037	396.603	396.57	-0.033	0.033	URBAN
49010	427002.797	4744405.093	397.584	397.51	-0.074	0.074	URBAN
49011	427000.341	4744399.275	397.374	397.34	-0.034	0.034	URBAN
49012	427011.69	4744364.751	397.258	397.21	-0.048	0.048	URBAN
49019	426917.382	4744421.214	397.54	397.5	-0.04	0.04	URBAN
50003	444694.962	4745746.651	433.391	433.45	0.059	0.059	URBAN

Number	Easting	Northing	Known Z	Laser Z	Dz	Magnitude	CATEGORY
50004	444691.654	4745727.227	432.012	432.07	0.058	0.058	URBAN
50013	444667.988	4745601.592	426.11	426.2	0.09	0.09	URBAN
51016	426884.035	4730237.661	395.818	395.81	-0.008	0.008	URBAN
51017	426839.832	4730249.371	395.756	395.73	-0.026	0.026	URBAN
52011	435921.224	4714632.085	471.295	471.24	-0.055	0.055	URBAN
52012	435922.091	4714643.529	471.813	471.75	-0.063	0.063	URBAN
52014	435896.719	4714674.766	471.638	471.58	-0.058	0.058	URBAN
52016	435928.027	4714665.623	472.199	472.15	-0.049	0.049	URBAN
52017	435945.846	4714685.966	472.913	472.85	-0.063	0.063	URBAN
52018	435898.466	4714621.02	471.416	471.39	-0.026	0.026	URBAN
52020	435820.237	4714496.912	470.043	470.01	-0.033	0.033	URBAN
52021	435806.748	4714476.611	469.806	469.75	-0.056	0.056	URBAN
53007	453081.305	4737040.737	340.134	340.17	0.036	0.036	URBAN
53016	453161.038	4737055.131	340.454	340.45	-0.004	0.004	URBAN
53018	453155.587	4737121.189	340.617	340.62	0.003	0.003	URBAN
54007	429078.791	4705593.135	489.384	489.39	0.006	0.006	URBAN
54008	429147.911	4705597.367	488.998	489.02	0.022	0.022	URBAN
54012	429232.813	4705634.27	488.027	488.09	0.063	0.063	URBAN
54013	429228.591	4705598.918	488.828	488.89	0.062	0.062	URBAN
54014	429236.92	4705565.127	488.941	488.96	0.019	0.019	URBAN

Table 8 LiDAR Point Cloud Swath NVA Check Point Assessment

2.10 Vertical Accuracy Results

An overall statistical assessment of the check points can be found in Tables 9, 10, 11, 12, and 13 below. The values provided are in meters. Table 13 is a tabulation of checkpoints that could not be assessed due to slope > 10 degrees or abrupt elevation changes in nearby lidar point returns.

Check Point Error Statistics								
Category	Amount	Min	Max	Mean	Median	Skewness	Std Dev	RMSEz
Open Terrain/Bare Earth	159	-0.1590	0.1790	0.0393	0.0380	-4427	0.0578	0.0699
URBAN	214	-0.1370	0.1640	0.0094	0.0065	0.3866	0.0456	0.0465

Table 9 Check Point Error Statistics

Check Points Vertical Accuracy Assessment			
Land Cover Category	**# of Checkpoints**	**FVA-Fundamental Vertical Accuracy (RMSE$_z$ x 1.9600)**	**SVA — Supplemental Vertical Accuracy (95th Percentile)**
Open Terrain/Bare Earth	159	0.137	
Urban Terrain	214		0.117

Table 10 Check Points Vertical Accuracy Assessment

Non-vegetated Vertical Accuracy (NVA)			
Broad Land Cover Type	# of Points	RMSE$_z$ (m)	95% Confidence Level (m)
NVA of Point Cloud	373	.058	0.113

Table 11 Non-vegetated Vertical Accuracy (NVA)

Comparison of NSSDA, NDEP, and ASPRS Standards					
Land Cover Category	NSSDA Acc. Z at 95% confidence level based on RMSEZ * 1.9600 (m)	NDEP FVA, plus SVAs and CVA based on 95th Percentile (m)	NDEP Accuracy Term	Term ASPRS Vertical Accuracy (m)	ASPRS Accuracy Term
Open Terrain/Bare Earth	0.137	.130	FVA	0.113	NVA
Urban Terrain	.091	.089	SVA		

Table 12 Comparison of NSSDA, NDEP, and ASPRS Standards

5% Outliers > 95th Percentile (0.117 Meters)					
Number	Easting	Northing	Known Z	Laser Z	Dz	CATEGORY
27008	479340.381	4739950.252	353.291	353.41	0.119	URBAN
33010	485741.603	4762805.996	401.529	401.65	0.121	URBAN
36015	504315.867	4741423.887	499.434	499.56	0.126	BARE EARTH
27011	479342.479	4740016.994	354.333	354.46	0.127	BARE EARTH
41013	479947.202	4747373.177	362.082	362.21	0.128	BARE EARTH
24004	511634.492	4737271.12	386.092	386.22	0.129	BARE EARTH
50006	444666.218	4745704.058	428.49	428.62	0.13	BARE EARTH
33006	485818.547	4762716.06	403.038	403.17	0.132	BARE EARTH
48009	442183.349	4735384.301	511.487	511.35	-0.137	URBAN
48010	442176.253	4735422.451	514.729	514.59	-0.139	BARE EARTH
12015	528530.843	4699543.82	593.152	593.3	0.148	URBAN
33004	485866.577	4762710.754	403.86	404.01	0.15	BARE EARTH
15014	519848.499	4752442.809	192.869	193.02	0.151	BARE EARTH
48020	442182.102	4735473.191	519.992	519.84	-0.152	BARE EARTH
8040	421216.833	4778578.387	119.757	119.91	0.153	BARE EARTH
27006	479375.633	4739935.474	351.435	351.59	0.155	URBAN
48005	442238.144	4735463.962	519.249	519.09	-0.159	BARE EARTH
41007	479892.197	4747398.496	362.347	362.51	0.163	BARE EARTH
12016	528546.679	4699555.351	593.366	593.53	0.164	URBAN
12008	528442.862	4699467.68	597.233	597.4	0.167	BARE EARTH
12007	528469.278	4699487.998	596.683	596.86	0.177	BARE EARTH
27007	479357.892	4739943.464	352.341	352.52	0.179	BARE EARTH

Table 13 Outliers greater than the 95th Percentile

Points Removed Due to Slope or Abrupt Elevation Changes					
Number	Easting	Northing	Known Z	Laser Z	Dz	CATEGORY
4048	444475.599	4759444.212	411.781	Removed	*	BARE EARTH

14005	508156.153	4708910.227	373.536	slope	*	BARE EARTH
42017	474066.764	4739814.943	411.644	slope	*	BARE EARTH
3027	455946.145	4759408.405	442.86	slope	*	URBAN
3028	455927.667	4759402.423	443.556	slope	*	URBAN
16013	525428.355	4744936.108	227.926	slope	*	URBAN
21009	498132.629	4755428.174	436.788	slope	*	URBAN

Table 14 Points not Assessed due to slope or other factors

2.11 Limitations of Use

The accuracy assessment confirms that the data may be used for the intended applications stated in **Project Purpose** section of this document. The dataset may also be used as a topographic input for other applications but the user should be aware that this lidar dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of AXIS GeoSpatial, LLC.

It should also be noted that lidar points do not represent a continuous surface model. Lidar points are discrete measurements of the surface and any values derived within a triangle of three lidar points are interpolated. As such, the user should not use the resultant lidar dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated lidar point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this lidar dataset was developed differently and that previous lidar datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer lidar technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

Section 3:   Certification

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.

Brian L Tolley, ASPRS Certified Photogrammetrist #R1391