Control, Acquisition, and Post-Processing of LiDAR Data for Corridor Work -Utility and Transportation-

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Control

- What is required by the scope of work?

1. Specifications of required accuracy (H & V)
2. What datum is required for final delivery
3. Who is to provide the control and their experience performing the task

Specifications of required accuracy

- Accuracy and point density determines the system to be utilized in most cases (terrestrial, mobile, airborne).
- Most requirements are specified as points per square meter (ppsm) and a value horizontally and vertically.
- As few as 2-3 ppsm for flood studies to 50+ ppsm for power line location for definition of objects
- Horizontal accuracy rarely defined in RFP. Easier to verify the higher the point density. Horizontal accuracy is usually a component of vertical accuracy requirement.
- Vertical accuracy may be specified as an absolute value (1.5cm to 1m) for airborne systems.
- Accuracy may also be required to meet a set of standards such as USGS, ASPRS, etc. Especially true when providing data to federal and state agencies

Specifications (cont.)

- Control for the purpose of absolute calibration of LiDAR data should be located on hard level surfaces.
- If used for evaluating the horizontal accuracy then distinct objects such as painted aerial targets or photo identifiable objects should be located. As most of our LiDAR projects have an orthomosaic component the control serves a dual purpose.
- Control for validation of the final LiDAR dataset will normally be collected on different surfaces (pavement, bare ground, grass, kudzu, open woods, etc.).

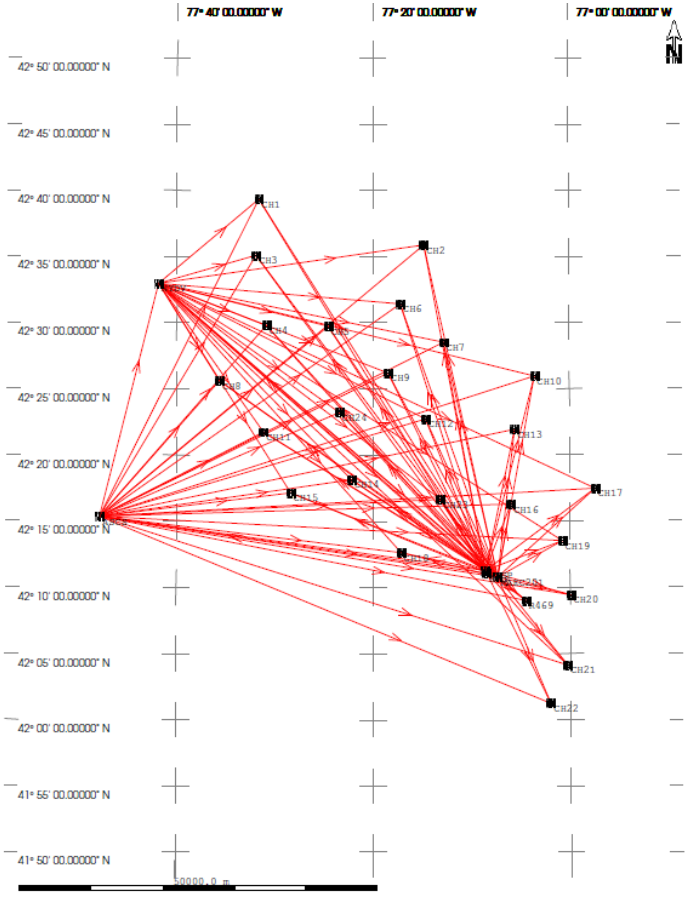
Datum required for delivery

1. As a contractor we have to assume the client is always right! Whatever datum the client requests the contractor is obligated to provide. We deal with this on a daily basis. If you think NAD27 and NGVD29 are dead, think again.
2. Most vertical control is required to be in NAVD88 in either meters or feet (US or International). But there are areas where this is not the case.
3. The higher the vertical accuracy required, the more control required, and the method to produce the control must exceed the vertical accuracy (if 2cm is required, control can't be 5cm). Roadways usually require spirit leveling while power line control usually can be acquired with GPS in various forms (RTK (base and network), static, OPUS, OPUS-RS).
4. Horizontal datum is across the spectrum from NAD27 to NAD83(XX) to UTM zones to project coordinates.

Providing Control

1. Know your limitations and work within them. If you have never provided control to 1cm accuracy maybe this one project is not for you.
2. Know the limitations of your personnel and equipment. Even if the control is to the CM if the panel is painted 0.5m off it will make the data appear off.
3. Know the requirements of reporting (they can be more demanding than acquiring the control).

CORS, BM's, Will it fit ?



- If using CORS are they Height Modernization stations. What is the spacing?
- If using BM's are they on the datum required (most USGS and TVA BM's are on NGVD29 for instance).
- If relative to tidal datum (MLLW = 0) BM's associated with tide gages are referenced to the tidal epoch, some may have NGVD29 elevations, and some may have NAVD88 elevations.

Platforms Available for LiDAR Missions

Bell 407 N196TA

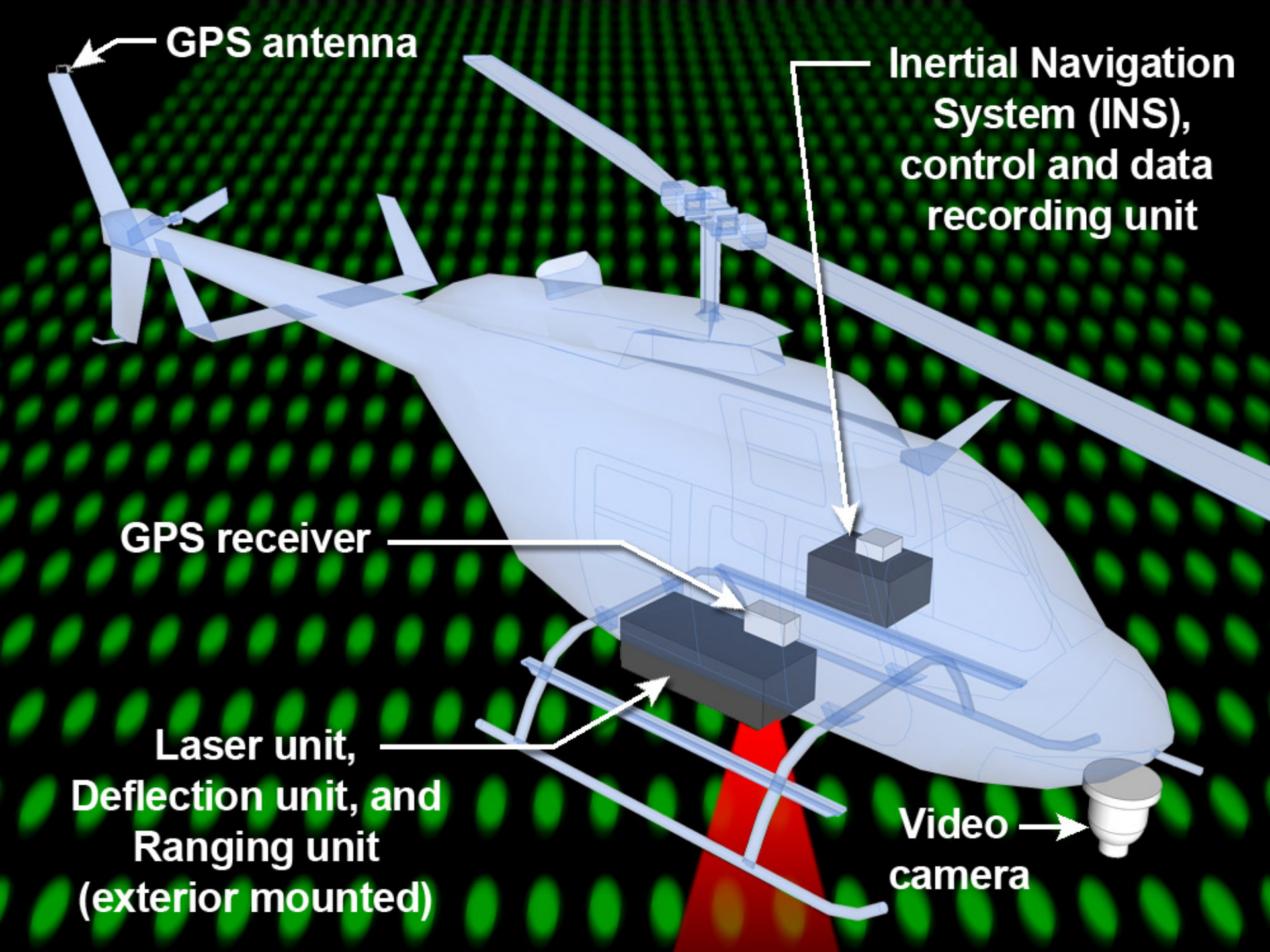
Bell LongRanger 206LIII N194TA

LiDAR System

Bell JetRanger 206BIII N192TA

Cessna 206 – N193TA

Tuck Mapping Solutions, Inc.
LiDAR Platform

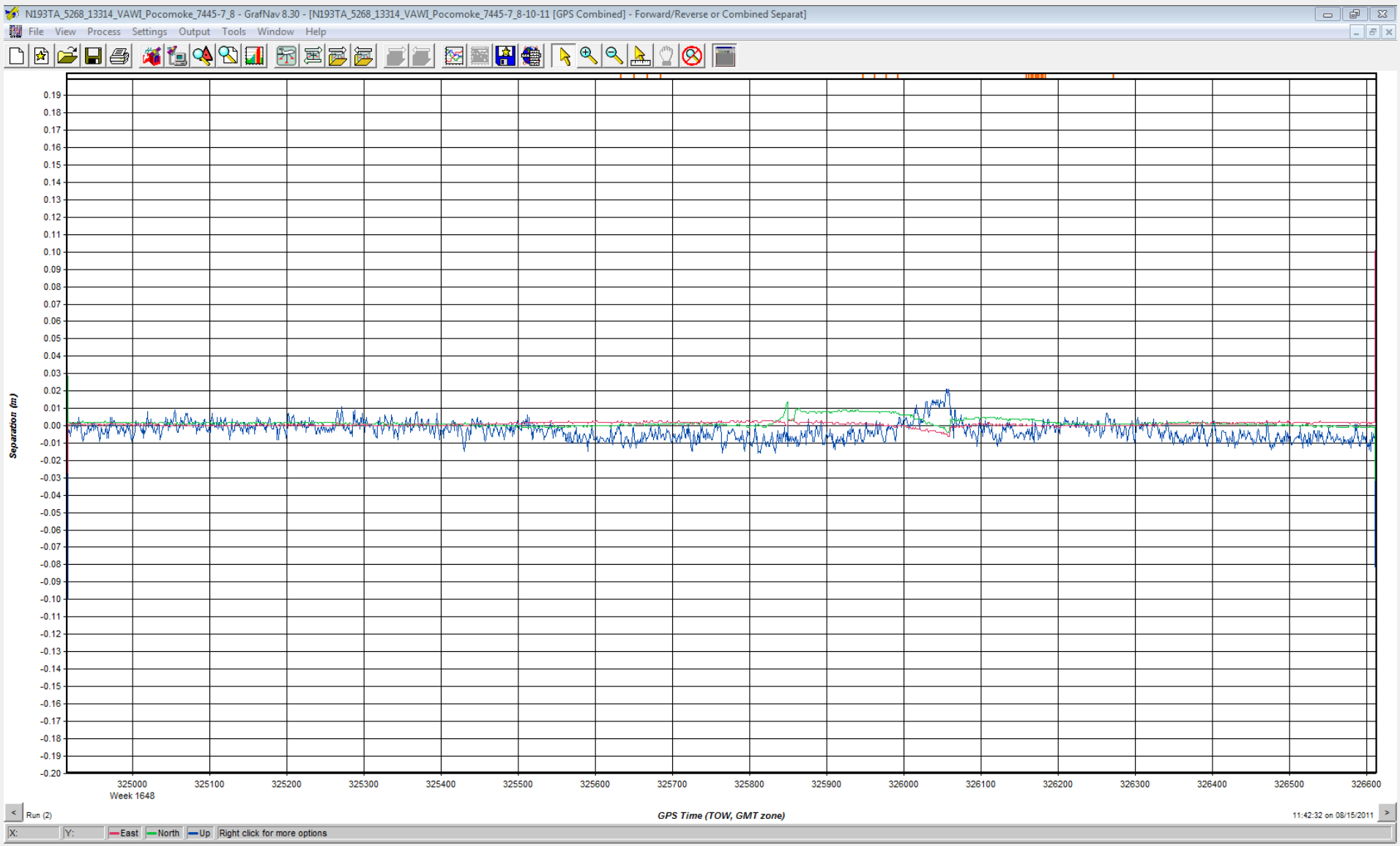

GPS antenna
Inertial Navigation System (INS), control and data recording unit
GPS receiver
Laser unit, Deflection unit, and Ranging unit (exterior mounted)
Video camera

Acquiring Airborne LiDAR Data

- As the trajectory is the single component driving the accuracy of the LiDAR data, mission planning is critical.
- The better the satellite geometry the better the chance of acquiring suitable data. There are sometimes when it is counterproductive to fly (yes really!).
- With the upcoming geomagnetic storms due to Solar Cycle 24, even more emphasis on mission planning will be required.
- Weather, restricted airspace (you want to do what where?), aircraft support staff required and available, etc. affect flight schedules.
- We have utilized both ground stations and CORS on projects in combination. The ground control must be relative to whatever we use.
- We usually initialize on the ground but regularly do so on the fly as well. Both require 10 minutes of data but on the fly requires a fairly straight line when approaching and leaving the base station.
- Communication between aircraft and ground crew is desirable especially where cell phone coverage is minimal.
- Current flight plans and suitable data storage capacity are part of the preflight review. Our LiDAR systems produce from 250 gigabytes to 1 terabyte of data during a three hour mission.

Post-processing of LiDAR Data

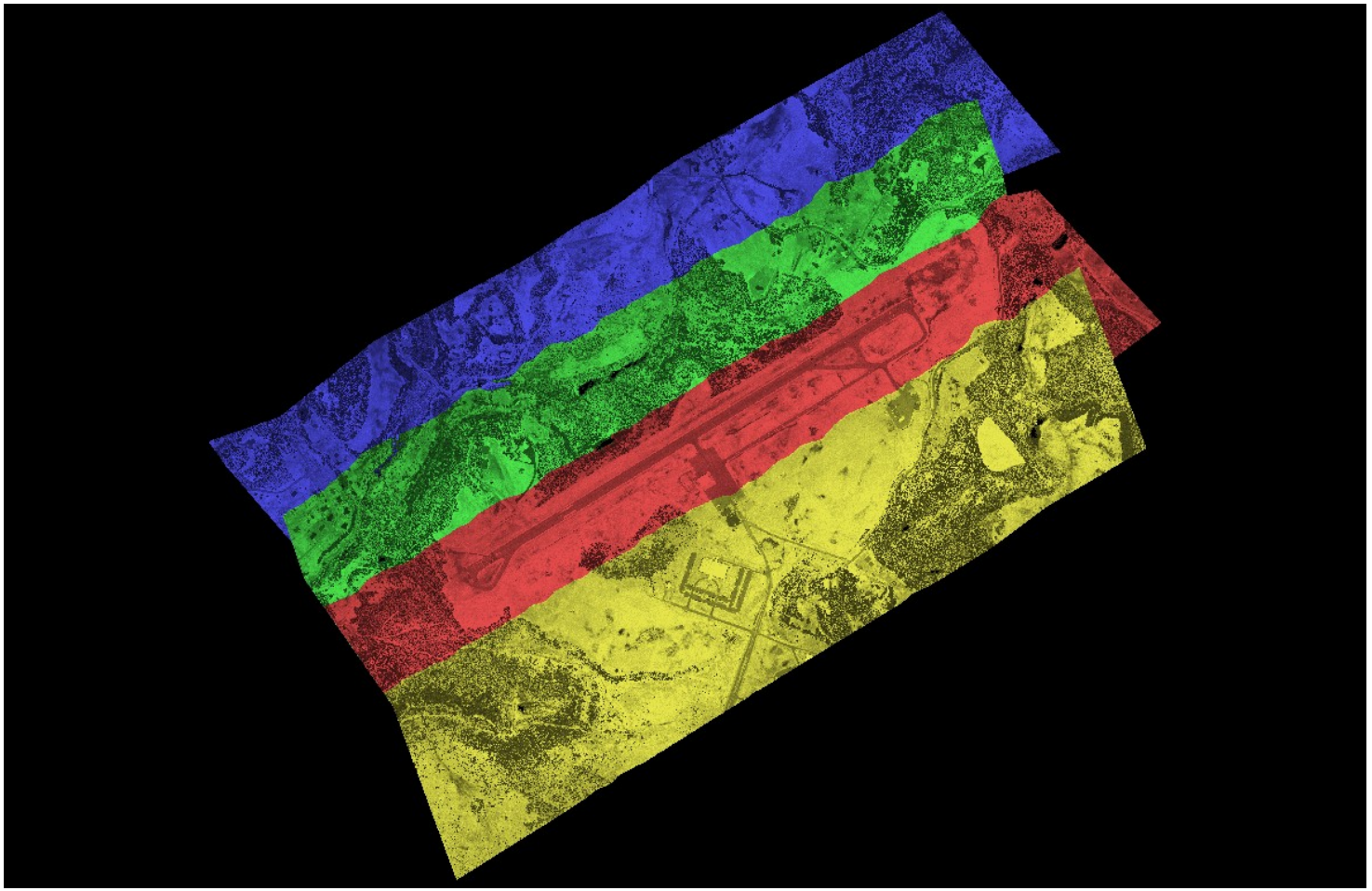
- Aircraft data is downloaded and backed up after each flight.
- Flight crew has the capability to review the data set for coverage and determine if any gaps exist due to terrain primarily.
- The base station data is downloaded and backed up by day regardless of the number of flights.
- The aircraft trajectory is computed by combining base station and aircraft data. One second epoch data is required on the base station. The aircraft is capable of collecting data at 0.2 second intervals.
- The trajectory should look like the following:


N193TA_5268_13314_VAWI_Pocomoke_7445-7_8 - GrafNav 8.30 - [N193TA_5268_13314_VAWI_Pocomoke_7445-7_8-10-11 [GPS Combined] - Forward/Reverse or Combined Separat]
File View Process Settings Output Tools Window Help
Separation (m)
0.19 0.18 0.17 0.16 0.15 0.14 0.13 0.12 0.11 0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02 0.01 0.00 -0.01 -0.02 -0.03 -0.04 -0.05 -0.06 -0.07 -0.08 -0.09 -0.10 -0.11 -0.12 -0.13 -0.14 -0.15 -0.16 -0.17 -0.18 -0.19 -0.20
325000 Week 1648
325100 325200 325300 325400 325500 325600 325700 325800 325900 326000 326100 326200 326300 326400 326500 326600
Run (2)
GPS Time (TOW, GMT zone)
11:42:32 on 08/15/2011
X: Y: East North Up Right click for more options

Post-processing (cont.)

- Trajectory fixes the position and elevation of the GPS antenna. Offsets to the IMU, scanner, and cameras are surveyed. Software georeferences data to compute position and elevation of LiDAR returns.
- The software defaults to WGS84 latitude and longitude and ellipsoid heights in GEOID09.
- Software analyzes data to locate overlapping datasets (planar surfaces) and computes the angular misalignment between the IMU and the LiDAR scanner to align the data. This is where you find out how good your equipment and calibration is. Note that control is not being utilized during this process. It may take more than 8 hours for the initial calibration results (waveform processed) from a single 3 hour lift and multiple runs may be necessary but requiring less time.

Example of flight lines and sidelap used to calibrate datasets



Calibration Report

RiPROCESS Scan Data Adjustment Protocol

Project:	8247-Detroit Light Rail Line LiDAR 06-06-11
Protocol date:	2011-07-14 14:36
Operator:	MJD
Comments:	
Program version:	RiPROCESS v1.4.8 (2010-11-15)
Computer:	TUCK144
Physical units:	ft, deg

Observation parameters

Calculation parameters

Calculation mode:	Adjustment
Calculation time:	45 mins, 24 secs, 901 msecs
Calculation mode:	Robust
Tolerance:	0.000000
Search corresp. planes:	True
Search radius [ft]:	3.281
Angular tolerance [deg]:	5.000
Max. normal dist. [ft]:	3.281
Observations active:	True
Observations count:	4841

Calculation results

Number of free parameters:	18
Number of observations:	4841
Error (Std. deviation) [ft]:	0.0580

Laser data

Name	Roll	Pitch	Yaw	East	North	Height	Time
110606_100613	0.000	-0.014	0.004	0.401	-0.446	-0.074	0.0000
- Confidence	0.000021	0.000143	0.000129	0.000000	0.000000	0.000000	0.0000000
110606_102715	-0.002	-0.013	-0.012	0.360	-0.421	-0.016	0.0000
- Confidence	0.000057	0.000146	0.000227	0.000000	0.000000	0.000000	0.0000000
110606_103755	0.000	-0.002	-0.006	-0.075	0.358	0.003	0.0000
- Confidence	0.000174	0.000136	0.000513	0.000000	0.000000	0.000000	0.0000000
110606_105327	-0.001	-0.003	-0.005	-0.069	0.397	0.016	0.0000
- Confidence	0.000208	0.000170	0.000465	0.000000	0.000000	0.000000	0.0000000
110606_105812	0.002	-0.007	0.008	-0.023	0.178	0.031	0.0000
- Confidence	0.000103	0.000205	0.000414	0.000000	0.000000	0.000000	0.0000000
110606_110053	0.002	-0.008	0.000	0.080	0.021	0.027	0.0000
- Confidence	0.000128	0.000213	0.000202	0.000000	0.000000	0.000000	0.0000000

Tilt mounts

Name	Roll	Pitch	Yaw

Laser devices

Name	Roll	Pitch	Yaw	X	Y	Z	Range Shift
Scanner 1 (Q680i, 9998212)	0.00047	0.45160	-0.41530	0.000	0.000	0.000	0.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000

Navigation devices

Name	Roll	Pitch	Yaw	East	North	Height	Time
INS-GPS 1 (INS Type 01, 9998212)	0.000	0.000	0.000	0.000	0.000	0.000	15.0000
- Confidence	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000000

Observations

Best 15 observations

#	Object 1	Object 2	Deviation	Description
1	110606_102715	110606_110053	0.000	
2	110606_100613	110606_105812	0.000	
3	110606_105812	110606_110053	0.000	
4	110606_100613	110606_102715	0.000	
5	110606_103755	110606_105327	0.000	
6	110606_103755	110606_105327	0.000	
7	110606_100613	110606_105812	0.000	
8	110606_100613	110606_102715	0.000	
9	110606_102715	110606_110053	0.000	
10	110606_100613	110606_102715	0.000	
11	110606_100613	110606_102715	0.000	
12	110606_100613	110606_102715	0.000	
13	110606_103755	110606_105327	0.000	
14	110606_103755	110606_105327	0.000	
15	110606_100613	110606_102715	0.000	

Calibration Report

Worst 15 observations

#	Object 1	Object 2	Deviation	Description
1	110606_103755	110606_105327	0.197	
2	110606_105812	110606_110053	0.181	
3	110606_100613	110606_102715	-0.181	
4	110606_100613	110606_102715	-0.180	
5	110606_105812	110606_110053	-0.177	
6	110606_103755	110606_105327	-0.177	
7	110606_103755	110606_105327	0.176	
8	110606_105812	110606_110053	0.176	
9	110606_100613	110606_102715	-0.175	
10	110606_103755	110606_105327	-0.174	
11	110606_105812	110606_110053	0.173	
12	110606_105812	110606_110053	-0.173	
13	110606_100613	110606_102715	0.172	
14	110606_103755	110606_105327	-0.171	
15	110606_100613	110606_102715	0.171	

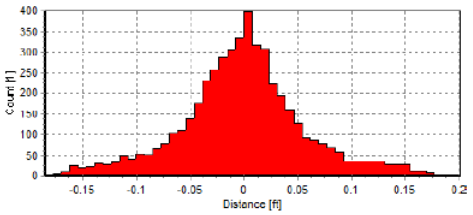
Best 6 scans

Name	Objects	Std. dev.
110606_102715	3789	0.054
110606_100613	3790	0.055
110606_105812	679	0.067
110606_110053	653	0.067
110606_103755	386	0.072
110606_105327	385	0.072

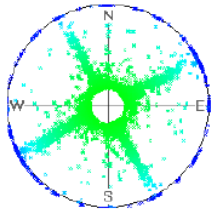
Worst 6 scans

Name	Objects	Std. dev.
110606_105327	385	0.072
110606_103755	386	0.072
110606_110053	653	0.067
110606_105812	679	0.067
110606_100613	3790	0.055
110606_102715	3789	0.054

Histogram of residues



Orientation chart



Verification of post-processed data

- Control data is compared to a LiDAR derived surface.
- Most of the datasets we have collected check to the control ≤3 cm due to multiple factors as noted. Control and base station data are the same and are of excellent quality. Flight planning is critical. Calibration of the system is survey quality.
- Data can be raised or lowered to a base to match the control if necessary. Our systems produce data that is normally 1.5-3cm high compared to control. We have multiple systems and all are within the same tolerance.

LiDAR absolute control check

L:\8247 Detroit\Ground Control\8247-GC_PENZ.txt

Number	Easting	Northing	Known Z	Laser Z	Dz
CP100	13458651.330	347311.094	639.906	outside	*
CP101	13459130.506	346188.028	639.943	outside	*
CP102	13459382.577	345478.059	640.129	640.120	-0.009
CP103	13459913.648	344630.316	640.527	640.490	-0.037
CP104	13461064.312	342254.932	638.906	638.930	+0.024
CP105	13461481.213	341616.393	640.270	640.220	-0.050
CP106	13462411.613	339895.061	640.547	640.560	+0.013
CP107	13462932.921	339073.444	640.127	640.240	+0.113
CP108	13463142.538	338481.399	638.531	638.620	+0.089
CP109	13463457.271	337856.158	637.868	637.870	+0.002
CP110	13464031.899	336974.577	637.520	outside	*
CP111	13464291.833	336261.131	636.056	636.120	+0.064
CP112	13464717.177	335633.404	635.731	635.710	-0.021
CP113	13464804.427	335252.928	635.273	635.200	-0.073
CP114	13465492.623	333870.074	634.847	634.810	-0.037
CP115	13466027.982	333105.810	635.468	635.510	+0.042
CP116	13466132.792	332701.710	636.198	636.150	-0.048
CP117	13466431.896	332331.309	637.856	637.890	+0.034
CP118	13466544.461	331877.723	639.101	639.100	-0.001
CP119	13466883.637	331257.210	639.821	639.800	-0.021
CP120	13467303.495	330649.365	641.352	641.430	+0.078
CP121	13467438.053	330164.476	641.872	641.870	-0.002
CP122	13468251.532	328813.606	635.804	635.830	+0.026
CP123	13468440.493	328230.732	633.923	634.060	+0.137
CP124	13468853.173	327650.565	633.509	633.500	-0.009
CP125	13469332.240	326745.984	634.796	634.870	+0.074
CP126	13469887.241	325641.134	634.427	634.470	+0.043
CP127	13470113.846	325017.423	632.068	632.120	+0.052
CP128	13470426.816	324624.855	632.240	632.340	+0.100
CP129	13470587.380	324104.788	631.080	631.070	-0.010
CP130	13471416.189	322702.189	631.801	631.860	+0.059
CP131	13471543.481	322269.798	630.784	slope	*
CP132	13471884.910	321785.046	630.630	630.690	+0.060
CP133	13472397.867	320806.146	630.600	630.630	+0.030
CP134	13472555.399	320309.166	630.660	630.690	+0.030
CP135	13472887.719	319859.605	630.956	630.990	+0.034
CP136	13473124.703	319162.170	630.781	630.830	+0.049
CP137	13473447.069	318754.301	630.491	630.530	+0.039
CP138	13473889.942	317900.716	632.039	632.050	+0.011
CP139	13474158.158	317214.995	631.418	631.450	+0.032
CP140	13474736.318	316055.008	631.398	631.410	+0.012
CP141	13475327.600	314901.133	628.179	628.210	+0.031
CP142	13475743.498	314287.568	626.475	626.500	+0.025
CP143	13476086.484	313486.380	623.597	623.640	+0.043
CP144	13476380.321	313173.250	623.130	623.190	+0.060
CP145	13476465.456	312747.393	621.834	621.850	+0.016
CP146	13476977.516	312003.637	619.082	619.130	+0.048
CP147	13477119.785	311492.086	617.851	617.870	+0.019
CP148	13477546.923	310922.217	615.943	616.020	+0.077
CP149	13477759.815	310240.629	615.386	615.420	+0.034
CP150	13478503.110	309043.790	609.362	609.430	+0.068
CP151	13478811.909	308463.173	603.460	603.480	+0.020
CP152	13479008.563	308116.277	603.751	603.750	-0.001
CP153	13479201.934	307488.138	600.821	600.790	-0.031
CP154	13479451.906	307067.097	597.017	596.990	-0.027
CP155	13479638.317	306758.616	598.634	598.620	-0.014
CP156	13479888.422	306347.237	600.742	600.710	-0.032
CP157	13480117.980	305942.767	599.486	599.450	-0.036
CP158	13480223.277	305670.480	601.382	601.330	-0.052
CP159	13480777.045	305090.272	598.614	outside	*
CP160	13480969.078	304749.401	600.138	outside	*
CP161	13480280.273	304340.297	602.544	outside	*
CP162	13479434.761	305196.688	607.806	607.810	+0.004
CP163	13479183.791	305476.521	604.823	604.790	-0.033
CP164	13479093.999	305812.165	599.335	599.360	+0.025
CP165	13478999.479	306532.438	598.004	outside	*
CP601	13457958.695	348156.081	642.133	outside	*
CP602	13458270.266	348357.796	640.133	outside	*

CP603	13458184.558	347239.821	640.498	outside	*
CP604	13458745.359	347541.248	639.446	outside	*
CP605	13459267.406	347691.482	637.881	outside	*
CP606	13458897.224	346401.698	638.679	outside	*
CP607	13459235.496	346516.297	636.691	outside	*
CP608	13459548.519	347281.353	636.518	outside	*
CP609	13459088.679	345448.837	637.487	outside	*
CP610	13459750.602	345760.517	639.816	outside	*
CP611	13460226.679	343854.685	638.706	638.620	-0.086
CP612	13460660.088	344059.337	637.442	outside	*
CP613	13460634.922	342525.274	638.915	outside	*
CP614	13461068.613	342636.707	639.204	639.170	-0.034
CP615	13461808.469	340807.645	640.902	640.830	-0.072
CP616	13462161.214	341053.437	639.534	outside	*
CP617	13462486.909	339528.747	640.891	640.840	-0.051
CP618	13462874.372	339731.326	638.572	outside	*
CP619	13463093.795	338115.887	639.177	639.150	-0.027
CP620	13463527.712	338309.733	636.093	outside	*
CP621	13463723.487	337110.638	639.063	639.070	+0.007
CP622	13464218.796	337251.169	637.548	outside	*
CP623	13464346.073	335784.451	635.897	outside	*
CP624	13464713.043	336071.450	635.053	outside	*
CP625	13464708.623	334663.785	636.097	outside	*
CP626	13465320.427	334912.739	634.840	outside	*
CP627	13466103.811	334842.487	635.807	outside	*
CP628	13466196.591	335396.606	634.146	outside	*
CP629	13466586.368	334626.488	635.873	outside	*
CP630	13467432.837	336051.692	634.242	outside	*
CP631	13467674.737	335605.678	634.627	outside	*
CP632	13467913.907	335241.674	635.282	outside	*
CP633	13465324.492	333592.580	638.815	outside	*
CP634	13465959.161	333929.309	637.952	outside	*
CP635	13466073.918	332294.413	636.400	outside	*
CP636	13466528.250	332497.311	637.463	outside	*
CP637	13466770.644	331016.801	639.849	outside	*
CP638	13467232.637	331239.446	642.016	outside	*
CP639	13467475.432	329734.914	641.329	outside	*
CP640	13467740.275	329824.812	639.694	639.670	-0.024
CP641	13468071.073	328379.887	635.562	outside	*
CP642	13468549.035	328651.445	635.256	outside	*
CP643	13468992.140	327194.157	634.584	634.570	-0.014
CP644	13469224.206	327384.974	634.004	outside	*
CP645	13469664.172	325899.394	634.101	634.050	-0.051
CP646	13469920.527	326037.736	633.731	outside	*
CP647	13470279.289	324592.790	632.111	632.090	-0.021
CP648	13470698.736	324826.192	630.920	outside	*
CP649	13471008.925	323301.864	630.215	630.170	-0.045
CP650	13471293.038	323437.594	631.027	outside	*
CP651	13471478.182	321886.071	630.743	outside	*
CP652	13471890.936	322125.374	630.709	outside	*
CP653	13472132.399	320633.770	631.131	outside	*
CP654	13472647.272	320832.658	630.992	outside	*
CP655	13472887.551	319302.175	630.160	outside	*
CP656	13473307.999	319535.314	629.821	outside	*
CP657	13473669.329	318078.221	631.906	631.910	+0.004
CP658	13473958.108	318132.209	631.419	outside	*
CP659	13474194.761	316668.559	631.863	outside	*
CP660	13474473.701	316828.773	631.282	631.280	-0.002
CP661	13474861.694	315382.455	631.613	outside	*
CP662	13475122.372	315559.656	630.585	630.560	-0.025
CP663	13475496.882	314295.137	627.389	outside	*
CP664	13475932.539	314510.570	626.864	outside	*
CP665	13476235.355	312839.440	624.401	outside	*
CP666	13476673.514	313109.208	625.459	outside	*
CP667	13476933.314	311489.109	618.493	outside	*
CP668	13477289.579	311753.195	619.757	outside	*
CP669	13477520.839	310213.800	617.454	outside	*
CP670	13477996.125	310452.561	617.743	outside	*
CP671	13478301.665	308854.112	609.232	outside	*
CP672	13478605.159	309147.191	610.211	outside	*
CP673	13478978.695	307409.288	599.495	outside	*

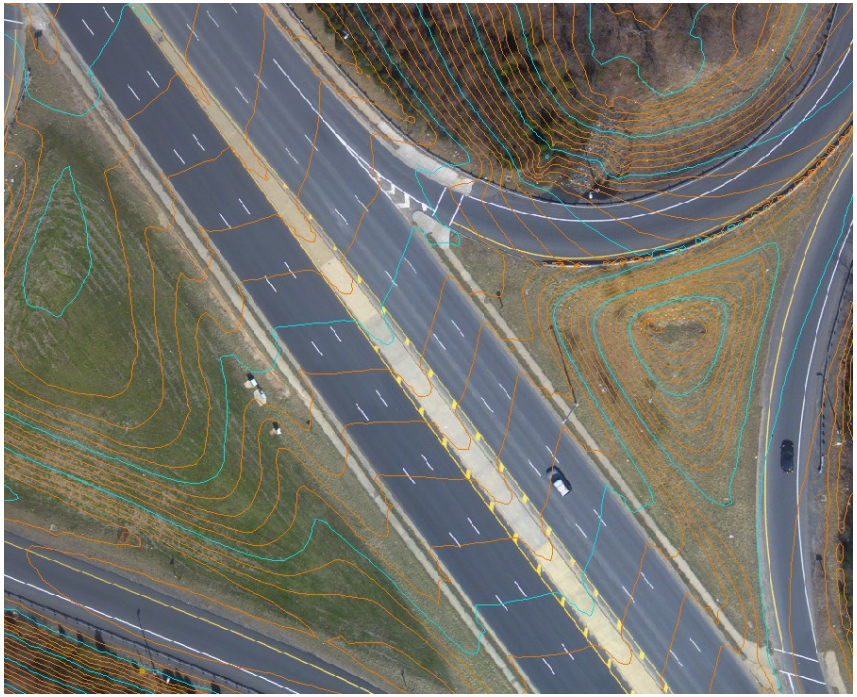
LiDAR absolute control check (cont.)

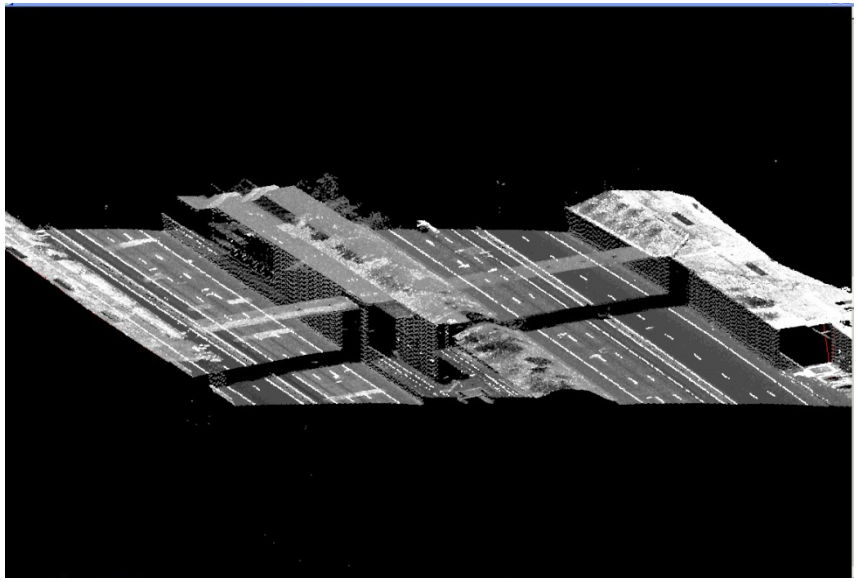
CP674	13479455.816	307663.692	600.092	outside		*
CP675	13478526.702	306007.606	597.072	outside		*
CP676	13479059.496	306319.656	597.991	outside		*
CP677	13479583.049	306242.608	599.901	outside		*
CP678	13480286.851	306530.603	603.122	outside		*
CP679	13479258.825	305086.891	607.905	outside		*
CP680	13480584.261	305884.215	598.262	outside		*
CP681	13479878.161	304986.916	594.891	594.970	+0.079	
CP682	13480600.465	305368.847	594.683	594.660	-0.023	
CP683	13479653.424	304629.954	590.444	590.420	-0.024	
CP684	13480405.076	304935.737	594.861	outside		*
CP685	13479977.318	304156.405	601.540	outside		*
CP686	13481142.776	304859.227	600.803	outside		*
CP901	13458922.671	346756.637	637.561	outside		*
CP901A	13458828.152	346729.232	637.435	outside		*
CP901B	13458762.807	346654.109	638.103	outside		*
CP902	13460708.880	343119.993	639.187	639.120	-0.067	
CP902A	13460636.957	343067.901	639.624	639.540	-0.084	
CP902B	13460810.524	343150.175	640.270	640.220	-0.050	
CP903	13462109.860	340447.210	641.857	641.800	-0.057	
CP903A	13462045.698	340351.721	641.863	641.830	-0.033	
CP903B	13462200.230	340473.725	641.516	641.440	-0.076	
CP904	13463714.371	337444.592	637.555	637.520	-0.035	
CP904A	13463656.851	337373.181	637.878	637.840	-0.038	
CP904B	13463825.706	337428.689	638.117	638.060	-0.057	
CP905	13465192.669	334367.299	632.757	632.660	-0.097	
CP905A	13465065.841	334302.600	634.449	outside		*
CP905B	13465301.727	334491.009	634.081	634.040	-0.041	
CP906	13465909.198	334438.170	636.029	outside		*
CP906A	13465809.184	335000.619	636.193	outside		*
CP906B	13466064.313	334302.053	636.884	outside		*
CP907	13466841.932	335693.306	634.355	outside		*
CP907A	13466769.910	335768.150	634.776	outside		*
CP907B	13467014.841	334857.422	635.742	outside		*
CP908	13466723.970	331643.618	639.551	639.470	-0.081	
CP908A	13466765.740	331668.105	639.076	639.060	-0.016	
CP908B	13466670.063	331615.438	639.048	639.030	-0.018	
CP909	13468003.994	329271.527	635.929	635.920	-0.009	
CP909A	13467944.069	329210.047	636.277	636.230	-0.047	
CP909B	13468219.289	329341.441	635.158	outside		*
CP910	13469513.212	326356.405	635.093	635.150	+0.057	
CP910A	13469446.110	326320.553	635.145	635.140	-0.005	
CP910B	13469855.382	326629.863	634.977	outside		*
CP911	13470726.754	323786.909	630.527	outside		*
CP911A	13470580.349	323663.339	629.833	outside		*
CP911B	13470844.914	323793.814	630.516	outside		*
CP912	13472170.696	321252.093	630.194	630.210	+0.016	
CP912A	13472090.587	321185.326	630.214	630.220	+0.006	
CP912B	13472332.707	321298.807	629.613	outside		*
CP913	13473450.632	318487.847	631.441	631.420	-0.021	
CP913A	13473285.723	318401.809	630.550	outside		*
CP913B	13473624.349	318510.235	631.071	631.050	-0.021	
CP914	13475442.264	314951.501	628.608	628.700	+0.092	
CP914A	13474995.007	314743.961	626.949	outside		*
CP914B	13475745.313	315101.220	630.724	outside		*
CP915	13476698.801	312297.711	620.615	620.610	-0.005	
CP915A	13476516.238	312192.946	621.227	outside		*
CP915B	13477009.044	312461.364	622.487	outside		*
CP916	13478117.405	309685.440	612.892	612.900	+0.008	
CP916A	13478066.272	309658.692	612.328	612.310	-0.018	
CP916B	13478154.610	309733.858	612.754	612.830	+0.076	
CP917	13479737.176	306749.894	598.994	599.020	+0.026	
CP917A	13479481.797	306659.176	599.803	outside		*
CP917B	13479943.799	306880.520	600.471	outside		*
CP918	13479143.865	305605.401	602.908	602.900	-0.008	
CP918A	13479469.541	305748.866	602.746	outside		*
CP918B	13479714.948	305163.749	604.607	outside		*
CP919	13480183.212	305907.585	599.320	599.260	-0.060	
CP919A	13479745.117	305931.305	600.831	outside		*
CP919B	13480378.050	306065.298	600.472	600.540	+0.068	
CP920	13480115.480	305139.020	592.691	592.640	-0.051	

CP920A	13479907.558	305011.785	594.699	594.730	+0.031	
CP920B	13480233.869	305226.694	592.652	592.610	-0.042	
CP921	13479968.799	304679.559	593.993	594.020	+0.027	
CP921A	13479710.981	304534.246	590.034	590.030	-0.004	
CP921B	13480076.131	304752.760	594.668	removed		*
CP922	13480798.764	305004.043	598.524	outside		*
CP922A	13480632.889	304773.144	601.473	outside		*
CP922B	13480998.489	304993.115	600.891	outside		*
CP9000	13467103.860	324196.447	637.425	outside		*
CP9001	13480495.216	303782.978	580.347	outside		*
CP9002	13473011.636	313820.195	625.083	outside		*
CP9003	13477574.513	318085.480	634.934	outside		*
CP9004	13467826.800	337231.079	633.582	outside		*
CP9005	13459409.494	336803.371	649.495	outside		*
CP63684	13456711.822	347445.536	647.810	outside		*
CP63685	13463813.228	347792.004	634.910	outside		*
CP82663	13470281.582	326903.027	633.276	outside		*
CPSEMEN	13486012.973	306344.412	580.020	outside		*

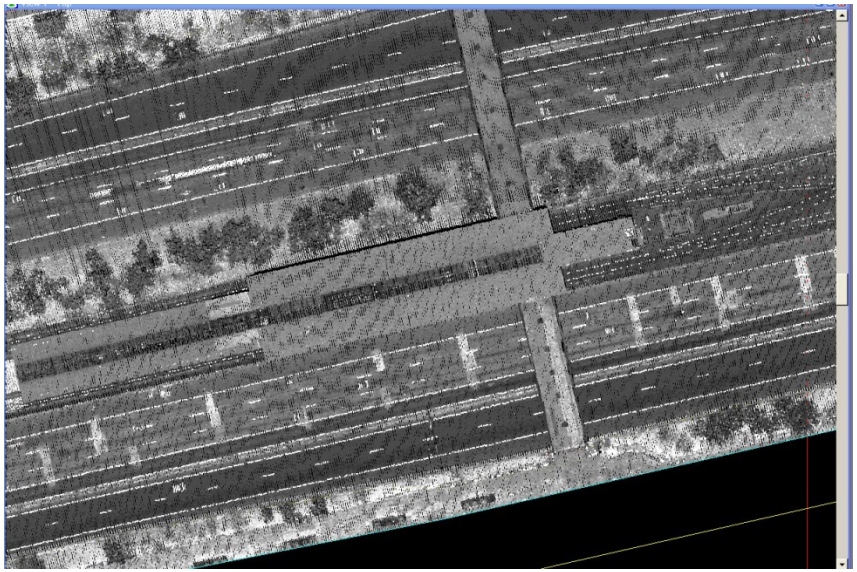
Average dz	+0.001'
Minimum dz	-0.097'
Maximum dz	+0.137'
Average magnitude	0.039'
Root mean square	0.047'
Std deviation	0.048'

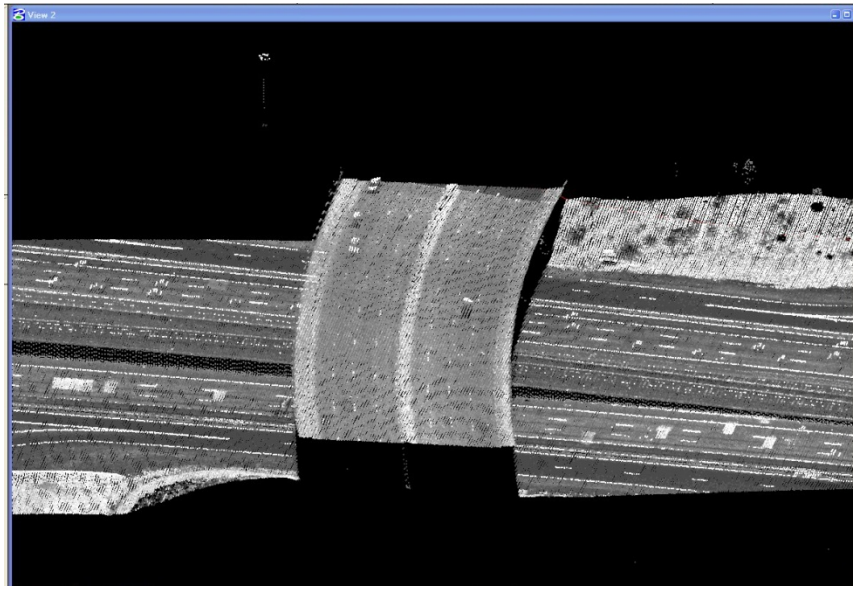
Transportation



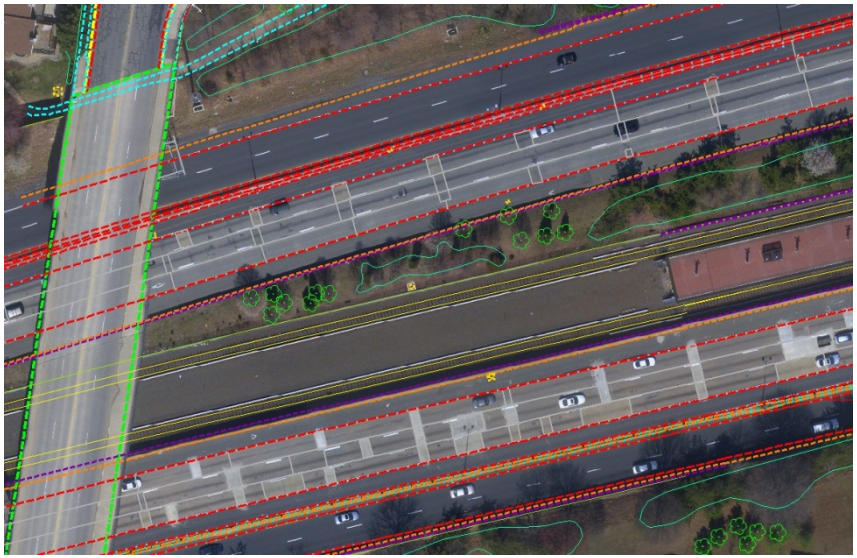


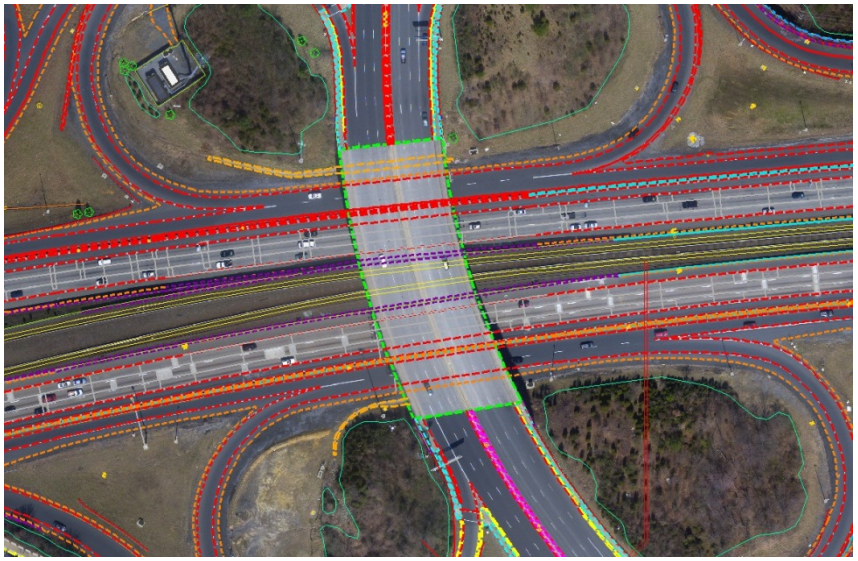
Transportation



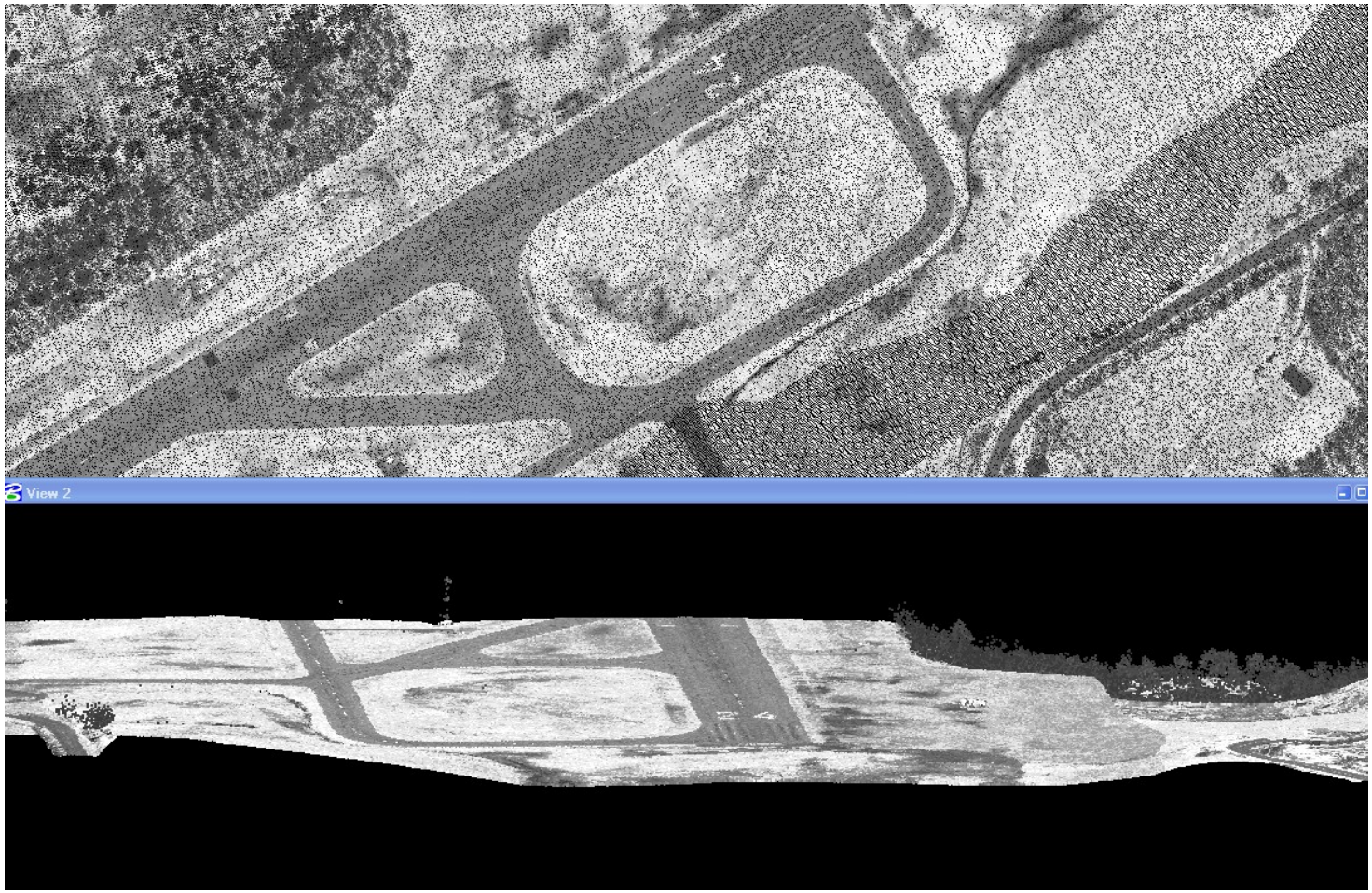


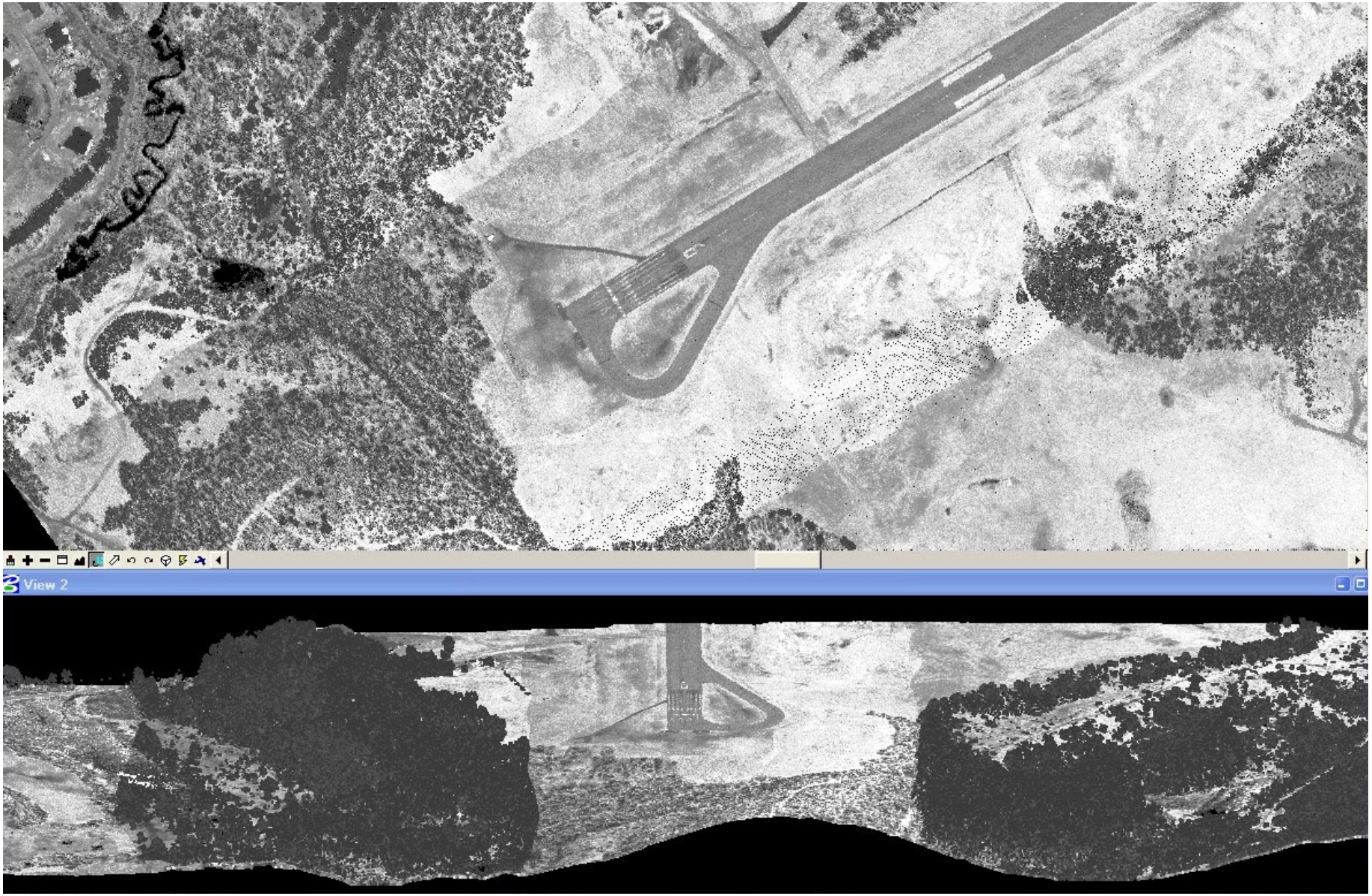
Transportation

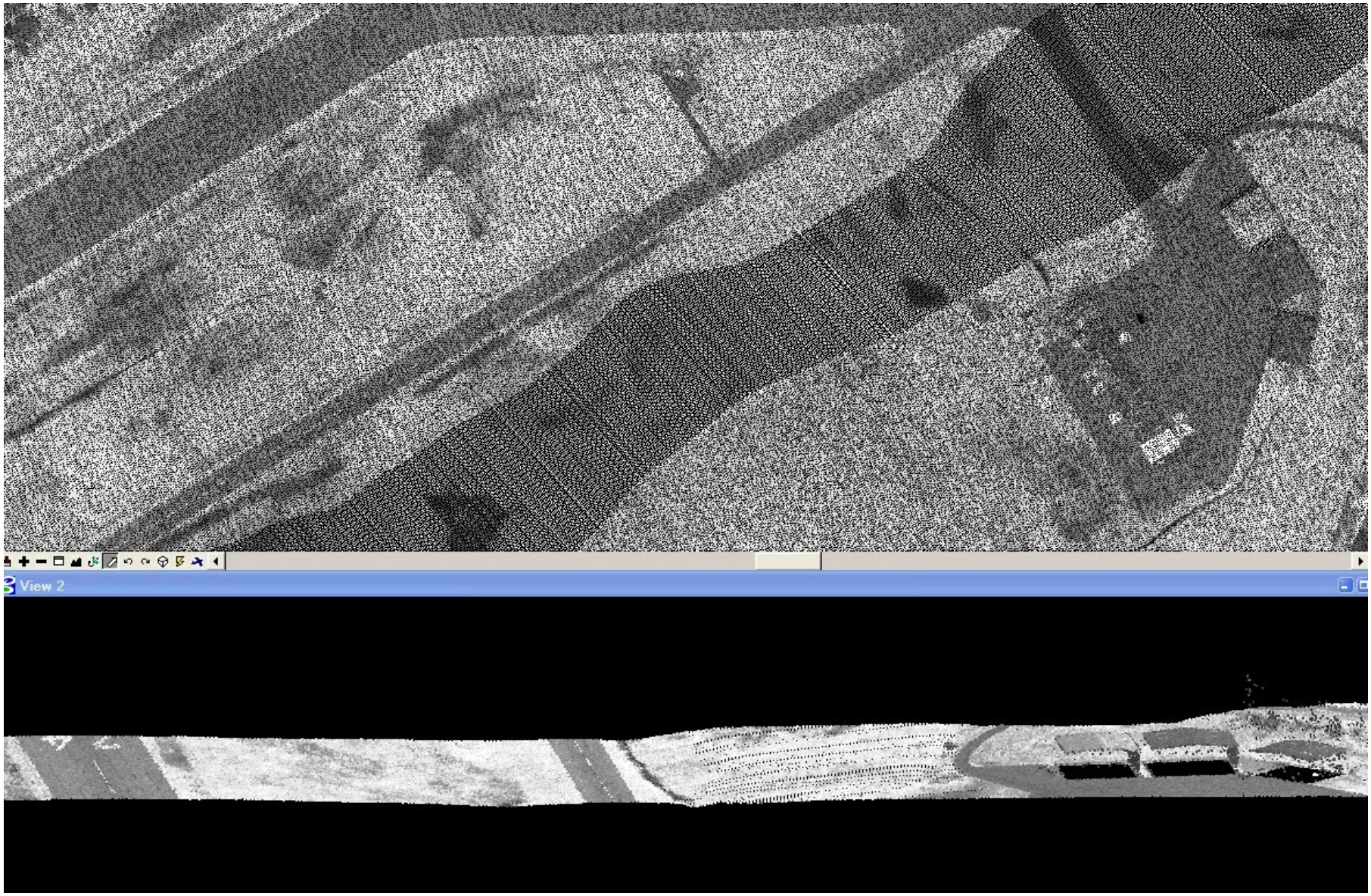


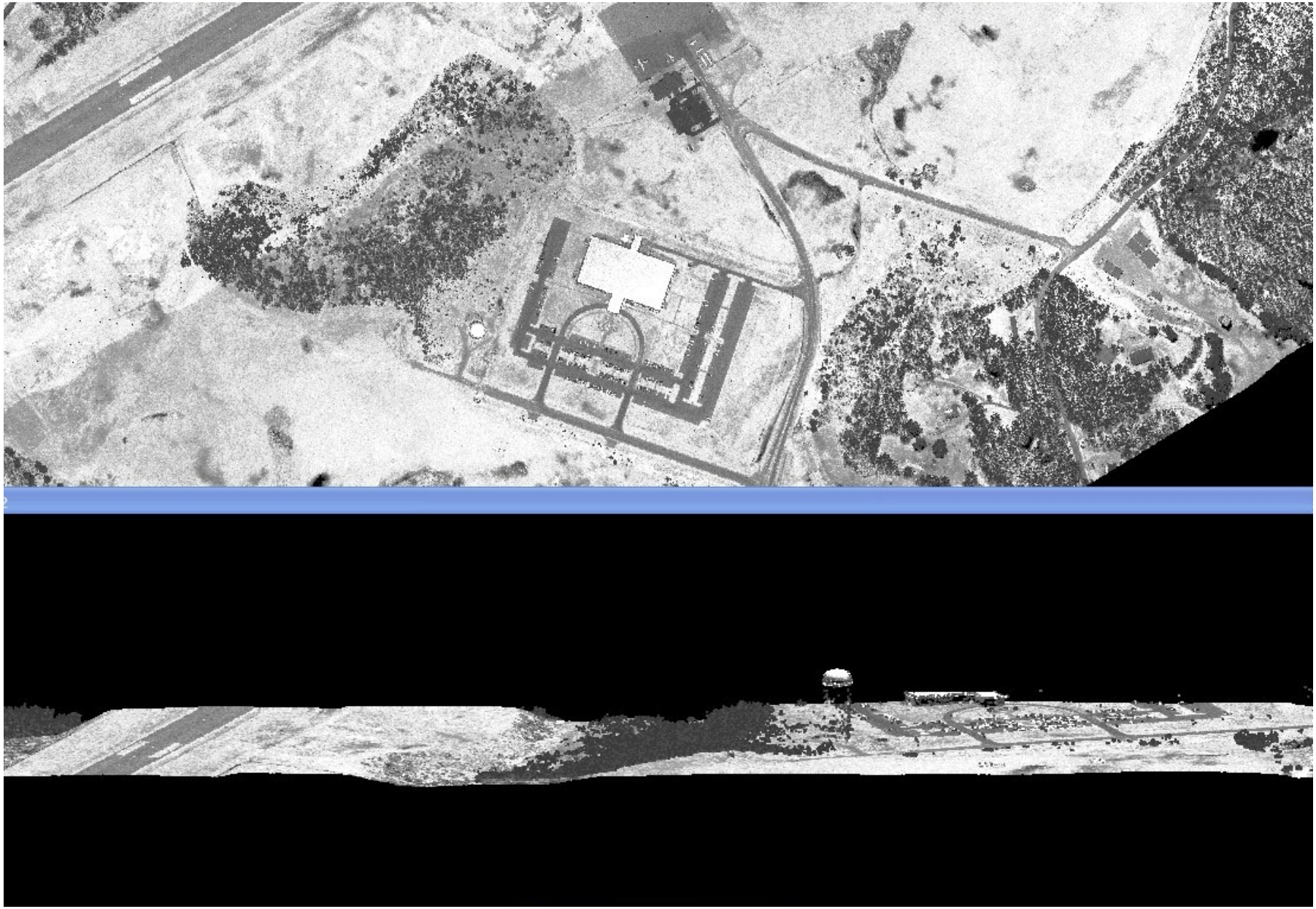


Airport obstruction surveys

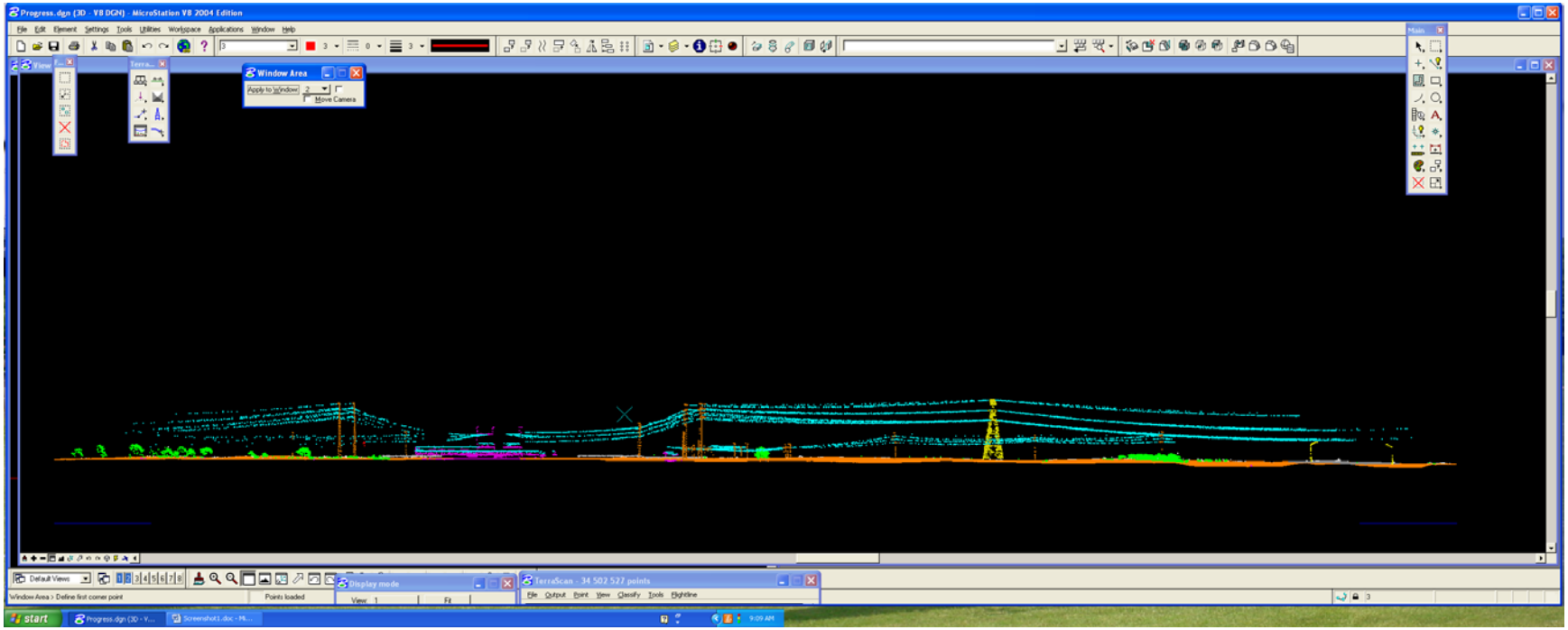


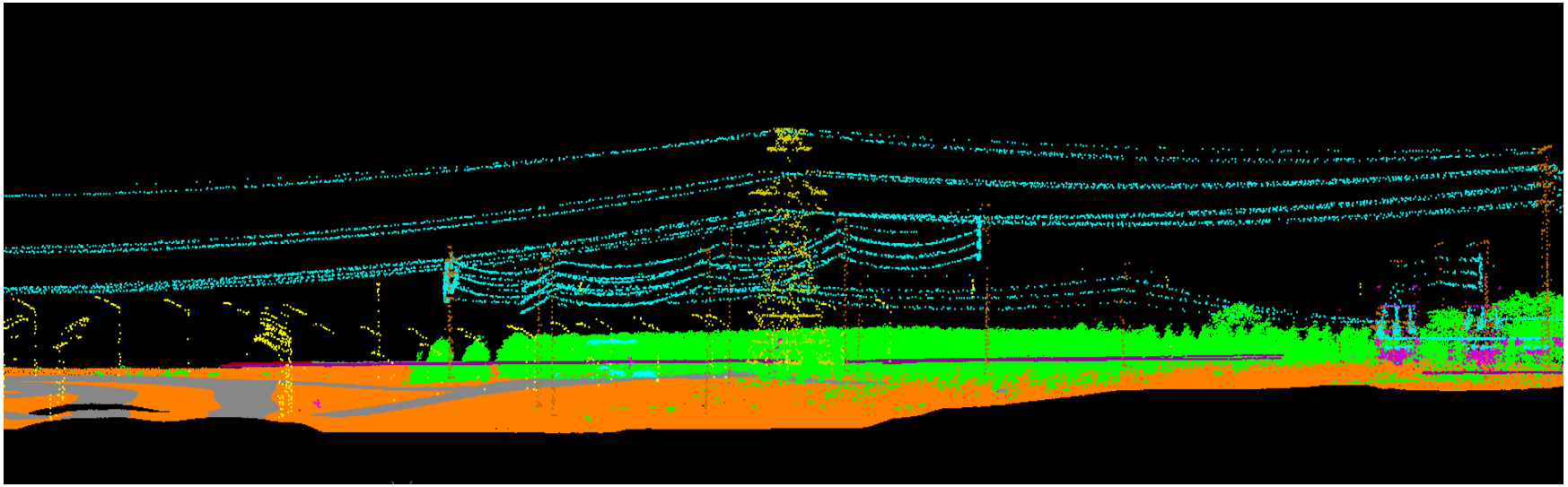

View 2

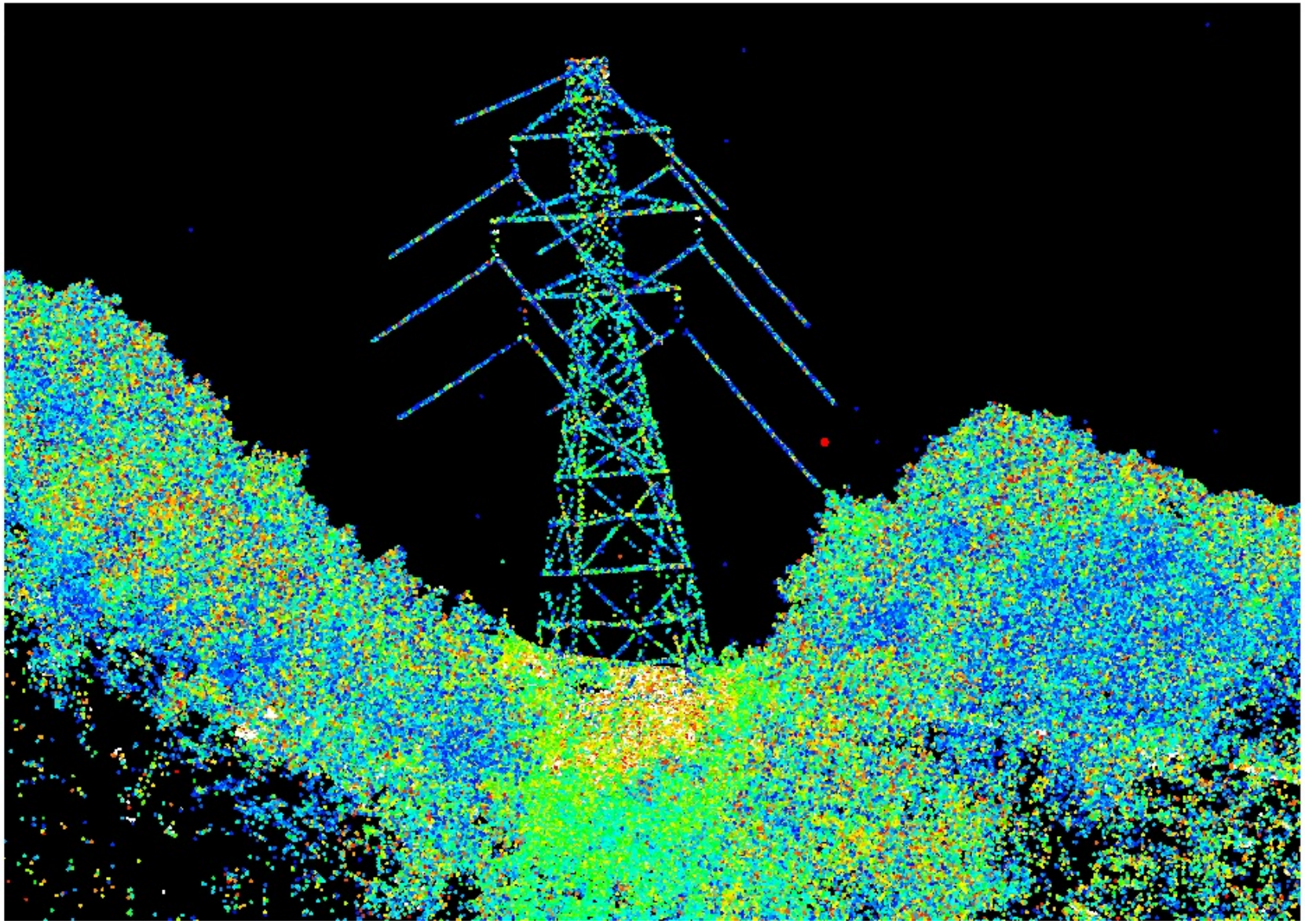

View 2



Utilities


Progress.dgn (3D - V8 DGN) - MicroStation V8 2004 Edition
Window Area





Study of Oxbow Area, White River, AR