GROUND CONTROL SURVEY REPORT
ROAD 46N02 - MODOC

GPS SURVEY FOR LIDAR CONTROL

CONTENTS

1. ABSTRACT

This report documents the GPS ground surveys conducted in support of LIDAR data collection for the Road 46N02-Modoc area. The surveyed ground control was established on October 4, 5, 2013. The aerial collection was performed with the Optech ALTM Gemini LiDAR. The ground control stations were established utilizing the **Leica RX1205 XC** Survey receiver. There were no problems encountered during this survey. The ground survey was conducted at 21 sites utilizing the CORS stations identified on the *OPUS* Data sheets. These surveys established "Ground Truth" data at each site.

A Beechcraft Bonanza A36TC, based out of Chino Airport, CA was utilized on this project for the LiDAR Mission. This aircraft was outfitted with an Optech Gemini ALTM 167kHZ system (s/n 07SEN204).

Mission planning parameters for the LiDAR noted below. These lines would be flown using the following settings:

Altitude: **800 m**
Overlap: **60 %**
Speed: **120 kts**
System PRF: **70 kHz**
Scan Freq: **64 Hz**
Scan Half Angle: **10°**
Cross Track Res.: **0.491 m**
Down Track Res.:   **0.482 m**

The actual local flight times and duration of flights were controlled by fuel consumption of the aircraft, safety of flight operations in the particular airspace and during times when the GPS constellation was most favorable, producing the highest number of satellites visible in the best geometric configuration relative to the GPS receivers onboard the aircraft as well as at the master stations on the ground. A standard of flying with no less than 6 satellites visible and a PDOP (position dilution of precision) of less than 3.0 was adopted.

Statistical comparisons were made between ground truth points collected in the survey and airborne LIDAR points.

Comparisons were also made between the survey points and the LIDAR derived terrain surface. These comparisons provide an additional verification of the LIDAR data against the survey data.

The horizontal and vertical datum used for this project are listed below:

Vertical Datum: **NAVD88, Geoid12A**

Horizontal Datum: **NAD83**

Projection: **UTM Zone 10**

Units: **METERS**

LiDAR MISSION PARAMETERS

DMI always checked PDOP before commencing flight (weather permitting) – *next page* shows data collection and dates with PDOP report October 4 and 5 (Road 46N02-MODOC)
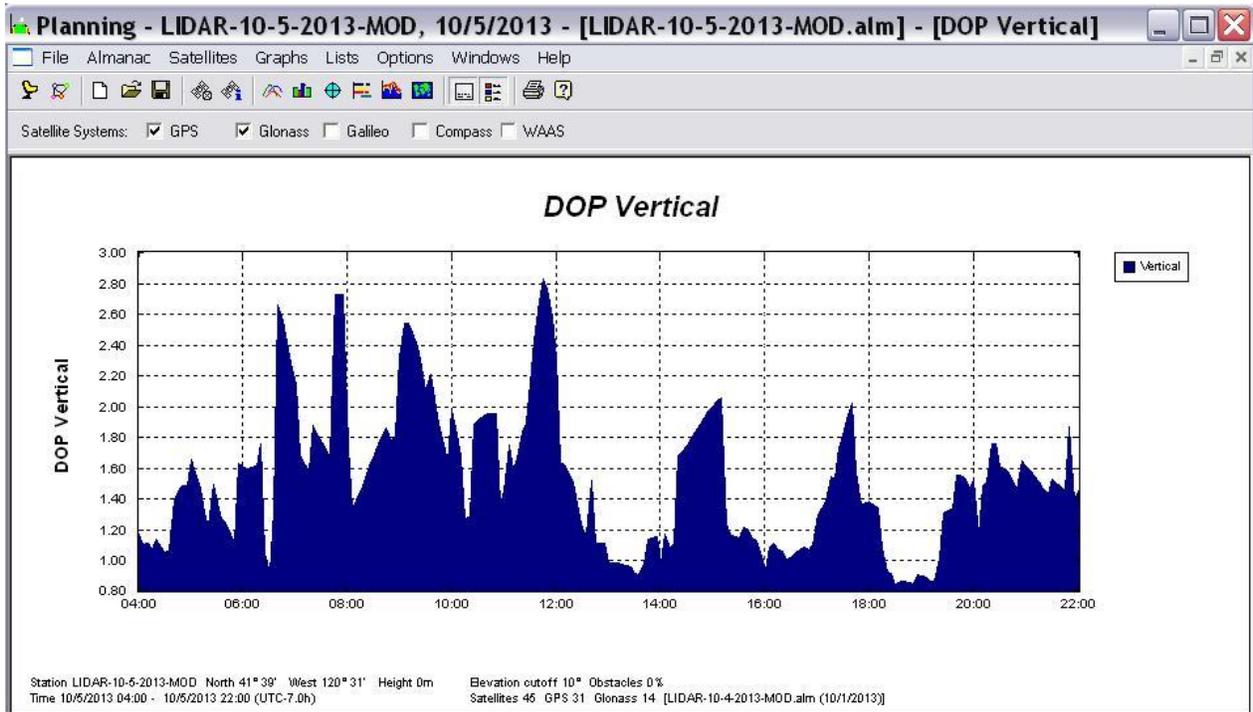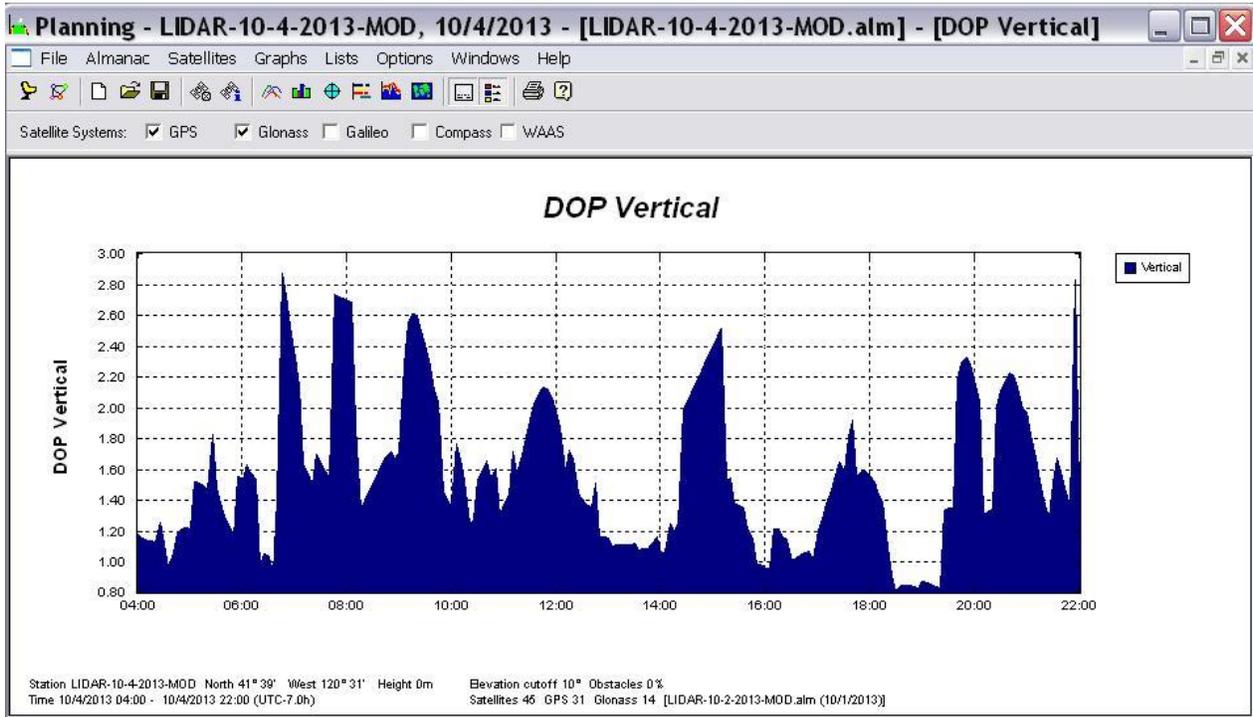
SBET IMAGES and FLIGHT LINES (ROAD 46N02-MODOC)

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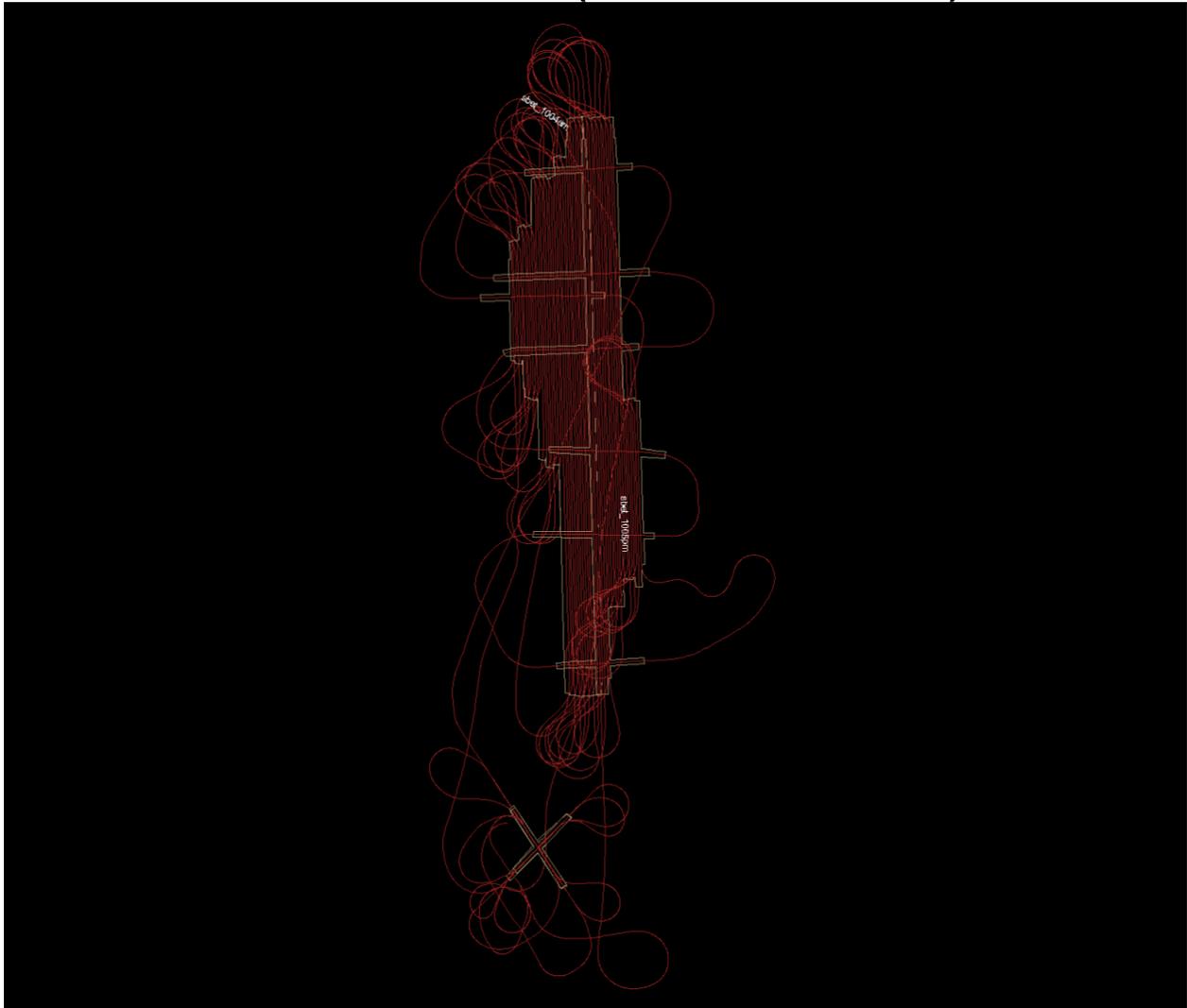
OPUS: Online Positioning User Service – Solution Report
@ ½ Second

Ground Receiver UNIT 1   - 10/04/2013

```
START: 2013/10/04  14:16:00
 STOP: 2013/10/04  19:17:00


ANT NAME: LEIAX1202 NONE # FIXED AMB:    67 /    67   : 100%


ARP HEIGHT: 1.6698   OVERALL RMS: 0.011(m)
```

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)   IGS08 (EPOCH:2013.7581)

```
        X:    -2424751.361(m)   0.013(m)      -2424752.218(m)   0.013(m)
        Y:    -4109565.969(m)   0.007(m)      -4109564.714(m)   0.007(m)
        Z:     4220400.224(m)   0.007(m)       4220400.210(m)   0.007(m)
      LAT:  41 41  0.13506      0.003(m)     41 41  0.14863      0.003(m)
    E LON: 239 27 29.82249      0.010(m)    239 27 29.76302      0.010(m)
    W LON: 120 32 30.17751      0.010(m)    120 32 30.23698      0.010(m)
   EL HGT:        1498.078(m)   0.012(m)           1497.587(m)   0.012(m)
ORTHO HGT:        1519.846(m)   0.030(m) [NAVD88 (Computed using GEOID12A)]
```

UTM COORDINATES STATE PLANE COORDINATES

	UTM (Zone 10)	**SPC (0401 CA 1)**
Northing (Y) [meters]	4617542.095	761963.790
Easting (X) [meters]	704602.741	2121411.950
Convergence [degrees]	1.63535835	0.95354904
Point Scale	1.00011518	1.00000429
Combined Factor	0.99988024	0.99976937

US NATIONAL GRID DESIGNATOR: 10TGM0460217542(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK6408	P347 ADINCTYARDCN2007 CORS ARP	N411100.021	w1205654.407	65127.6
DN7467	P731 LILJUNIPERCN2007 CORS ARP	N411957.039	w1202821.887	39399.9
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	w1212923.893	79364.3

```
             NEAREST NGS PUBLISHED CONTROL POINT
MW0807       LOGAN                      N414024.505 w1203711.148   6582.0
```

Ground Receiver UNIT 2 - 10/04/2013

```
START: 2013/10/04  14:10:00
 STOP: 2013/10/04  19:21:00


ANT NAME: LEIAX1202 NONE # FIXED AMB: 51 / 55 : 93%


ARP HEIGHT: 1.6298 OVERALL RMS: 0.013(m)
```

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)   IGS08 (EPOCH:2013.7581)

```
        X:    -2424907.264(m)   0.008(m)      -2424908.121(m)   0.008(m)
        Y:    -4109669.357(m)   0.007(m)      -4109668.102(m)   0.007(m)
        Z:     4220210.779(m)   0.011(m)       4220210.765(m)   0.011(m)
      LAT:   41 40 51.92408     0.007(m)      41 40 51.93765    0.007(m)
    E LON:  239 27 26.28941     0.010(m)     239 27 26.22993    0.010(m)
    W LON:  120 32 33.71059     0.010(m)     120 32 33.77007    0.010(m)
   EL HGT:        1497.768(m)   0.009(m)           1497.277(m)  0.009(m)
ORTHO HGT:        1519.540(m)   0.027(m) [NAVD88 (Computed using GEOID12A)]
```

UTM COORDINATES STATE PLANE COORDINATES

	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4617286.512	761709.139
Easting (X) [meters]	704528.280	2121334.462
Convergence [degrees]	1.63463198	0.95290731
Point Scale	1.00011480	1.00000370
Combined Factor	0.99987991	0.99976883

US NATIONAL GRID DESIGNATOR: 10TGM0452817286(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK6408	P347 ADINCTYARDCN2007 CORS ARP	N411100.021	w1205654.407	64869.0
DK6484	MODB MODOC PLATEAU CORS ARP	N415408.355	w1201810.137	31651.7
DN7467	P731 LILJUNIPERCN2007 CORS ARP	N411957.039	w1202821.887	39161.5

NEAREST NGS PUBLISHED CONTROL POINT
| MW0807 | LOGAN | N414024.505 | w1203711.148 | 6463.5 |

Ground Receiver UNIT 1 - 10/05/2013

```
START: 2013/10/05  20:02:00
 STOP: 2013/10/05  23:52:00


ANT NAME: LEIAX1202 NONE # FIXED AMB: 47 / 48 : 98%


ARP HEIGHT: 1.6088 OVERALL RMS: 0.011(m)
```

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)   IGS08 (EPOCH:2013.7614)

X:	-2424751.358(m)	0.007(m)	-2424752.215(m)	0.007(m)
Y:	-4109565.969(m)	0.001(m)	-4109564.714(m)	0.001(m)
Z:	4220400.215(m)	0.005(m)	4220400.201(m)	0.005(m)
LAT:	41 41 0.13488	0.005(m)	41 41 0.14845	0.005(m)
E LON:	239 27 29.82260	0.005(m)	239 27 29.76313	0.005(m)
W LON:	120 32 30.17740	0.005(m)	120 32 30.23687	0.005(m)
EL HGT:	1498.071(m)	0.004(m)	1497.580(m)	0.004(m)
ORTHO HGT:	1519.839(m)	0.023(m)	[NAVD88 (Computed using GEOID12A)]	

UTM COORDINATES STATE PLANE COORDINATES

	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4617542.089	761963.784
Easting (X) [meters]	704602.744	2121411.953
Convergence [degrees]	1.63535837	0.95354906
Point Scale	1.00011518	1.00000429
Combined Factor	0.99988024	0.99976938

US NATIONAL GRID DESIGNATOR: 10TGM0452817286(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	w1212923.893	79364.3
DN7464	P730 BALLARDRDGCN2007 CORS ARP	N412133.095	w1204941.645	43235.8
DK6408	P347 ADINCTYARDCN2007 CORS ARP	N411100.021	w1205654.407	65127.6

NEAREST NGS PUBLISHED CONTROL POINT

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
MW0807	LOGAN	N414024.505	w1203711.148	6582.0

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Ground Receiver UNIT 2   - 10/05/2013

```
START: 2013/10/05  19:56:00
 STOP: 2013/10/05  23:55:00


ANT NAME: LEIAX1202 NONE # FIXED AMB: 46 / 46 : 100%


ARP HEIGHT: 1.6158 OVERALL RMS: 0.010(m)
```

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)   IGS08 (EPOCH:2013.7614)

X:	-2424907.252(m)	0.006(m)	-2424908.109(m)	0.006(m)
Y:	-4109669.349(m)	0.001(m)	-4109668.094(m)	0.001(m)
Z:	4220210.777(m)	0.004(m)	4220210.763(m)	0.004(m)
LAT:	41 40 51.92431	0.004(m)	41 40 51.93788	0.004(m)
E LON:	239 27 26.28968	0.005(m)	239 27 26.23020	0.005(m)
W LON:	120 32 33.71032	0.005(m)	120 32 33.76980	0.005(m)
EL HGT:	1497.757(m)	0.003(m)	1497.266(m)	0.003(m)
ORTHO HGT:	1519.529(m)	0.023(m)	[NAVD88 (Computed using GEOID12A)]	

UTM COORDINATES STATE PLANE COORDINATES

	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4617286.519	761709.147
Easting (X) [meters]	704528.286	2121334.468
Convergence [degrees]	1.63463203	0.95290736
Point Scale	1.00011480	1.00000370
Combined Factor	0.99987991	0.99976883

US NATIONAL GRID DESIGNATOR: 10TGM0452817286(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK6408	P347 ADINCTYARDCN2007 CORS ARP	N411100.021	w1205654.407	64869.0
DN7464	P730 BALLARDRDGCN2007 CORS ARP	N412133.095	w1204941.645	42979.7
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	w1212923.893	79260.9

NEAREST NGS PUBLISHED CONTROL POINT

MW0807	LOGAN	N414024.505	w1203711.148	6463.5

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2. GROUND TRUTH SUMMARY

Surveys were conducted to establish ground truth data at representative sites throughout the project area. These sites were selected on the basis of the optimizing visibility needed for the LIDAR survey over the area.

ROAD 46N02-MODOC 2013 / DIGITAL MAPPING INC./ UTM 10

| AERIAL POINT#	LATITUDE	LONGITUDE	NORTH (M)	EAST (M)	TARGET ELEV.	DESCRIPTION
AT 1	41°33'29.51506"N	120°32'39.70350"W	4603637.478	704778.375	1412.972	SET 60D SPIKE
AT 2	41°33'29.69131"N	120°31'28.16103"W	4603690.256	706435.568	1393.470	SET 60D SPIKE
AT 3	41°34'57.46137"N	120°32'11.36845"W	4606368.665	705357.349	1497.176	SET 60D SPIKE
AT 4	41°35'00.57000"N	120°31'32.13906"W	4606490.541	706263.042	1496.576	SET 60D SPIKE
AT 5	41°36'10.23943"N	120°32'32.68085"W	4608599.252	704799.860	1494.164	SET 60D SPIKE
AT 6	41°36'23.68224"N	120°31'28.21075"W	4609056.551	706280.438	1502.267	SET 60D SPIKE
AT 7	41°36'25.88655"N	120°30'16.50124"W	4609172.383	707938.450	1506.565	SET 60D SPIKE
AT 8	41°37'47.94835"N	120°30'51.00392"W	4611680.327	707066.788	1517.263	SET 60D SPIKE
AT 9	41°38'05.48702"N	120°31'54.38917"W	4612179.116	705584.546	1513.328	SET 60D SPIKE
AT 10	41°39'24.58914"N	120°32'52.07294"W	4614580.746	704180.400	1512.472	SET 60D SPIKE
AT 11	41°39'05.58723"N	120°30'23.43851"W	4614093.358	707635.370	1525.191	SET 60D SPIKE
AT 12	41°41'00.13498"N	120°32'30.17745"W	4617542.092	704602.743	1519.844	SET 60D SPIKE
AT 13	41°43'07.43797"N	120°33'34.63625"W	4621426.103	703001.066	1560.577	SET 60D SPIKE
AT 14	41°41'30.12277"N	120°31'08.16463"W	4618521.396	706472.316	1535.952	SET 60D SPIKE
AT 15	41°41'26.46287"N	120°33'58.85067"W	4618295.881	702529.572	1535.046	SET 60D SPIKE
AT 16	41°43'06.66718"N	120°32'25.90882"W	4621447.550	704589.925	1559.502	SET 60D SPIKE
AT 17	41°44'11.31393"N	120°32'55.27661"W	4623422.093	703854.467	1582.011	SET 60D SPIKE
AT 18A	41°44'00.16923"N	120°32'25.13402"W	4623098.234	704560.651	1568.173	SET 60D SPIKE
AT 19A	41°44'18.10797"N	120°33'11.31897"W	4623621.090	703477.895	1605.103	SET 60D SPIKE
AT 20	41°45'51.10612"N	120°30'55.25677"W	4626579.573	706538.234	1498.114	SET 60D SPIKE
AT 21	41°46'16.04267"N	120°31'45.99711"W	4627314.931	705344.429	1553.639	SET 60D SPIKE

CORS SITES USED (PLEASE REFER TO OPUS DATA SHEETS)

3. DATA ANALYSIS

Data analysis was accomplished by comparing ground truth checkpoints with LIDAR points from the edited data set. The only exception to this were the ground truth points collected under the tree/forest canopy, where comparisons were made with LIDAR pulses that fell near known positions. This is because fewer LIDAR pulses are able to reach the ground in heavily forested areas, so the point spacing is larger than in cleared areas.

The base stations used to collect survey data were included in the static GPS network, and were selected on the basis of their having an unobstructed view of the sky, as well as being in a location considered favorable for collecting ground truth data. The vertical and horizontal accuracy of each base station was determined by the statistical tests performed in the least squares adjustment process.

Note that the edited LIDAR points are simply a subset of the raw LIDAR points. The points that fell above the ground surface on vegetation canopies, buildings, or other obstructions were removed from the data set. Comparisons were also made between the survey points and the LIDAR derived terrain surface. These comparisons provide an additional verification of the LIDAR data against the survey data.
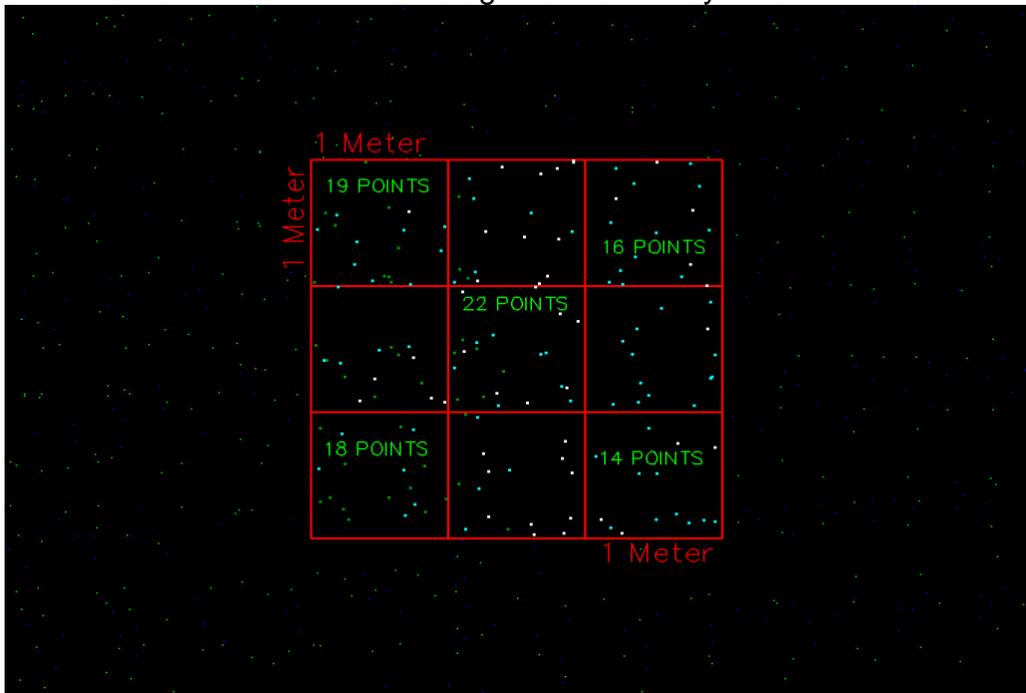
ONE METER SQUARE

LiDAR POINT CHECK

Our ground control check from QA/QC supported in attached documents

4. GROUND TRUTH SURVEY

A. Map of Control Point Locations/ Base Station- Both Days

B. Ground Truth Analysis of LIDAR Points

GROUND TRUTH ANALYSIS

Comparison of LIDAR Points to Ground Truth Points

GeoCue software was used to compare known , position established and occupied for twenty-minutes , control points versus identical position of LiDAR XYZ point data. The intensity image produced from the *LIDAR collection, was used to pick areas where ground and truth data collection could be collected. In areas of flat terrain or areas where detail is important it can be used as areas to collect X,Y,Z ground truth data for accessing the accuracy of the LIDAR data. Ground truth data can be collected using conventional survey techniques or DGPS techniques.*

SPATIAL REFERENCE FRAMEWORK
Vertical Datum **NAVD88, Geoid12A**
Horizontal Datum **NAD83**
Projection **UTM Zone 10**
Units **METERS**
Ground Control Z vs. Aerial Surveyed/ Laser Pointing Z (QA/QC)

ROAD 46N02-MODOC

Number	Easting	Northing	Known Z	Laser Z	Dz
AT-1	704778.375	4603637.478	1412.972	1412.940	-0.032
AT-2	706435.568	4603690.256	1393.470	1393.400	-0.070
AT-3	705357.349	4606368.665	1497.176	1497.160	-0.016
AT-4	706263.042	4606490.541	1496.576	1496.550	-0.026
AT-5	704799.860	4608599.252	1494.164	1494.160	-0.004
AT-6	706280.438	4609056.551	1502.267	1502.390	+0.123
AT-7	707938.450	4609172.383	1506.565	1506.570	+0.005
AT-8	707066.788	4611680.327	1517.263	1517.280	+0.017
AT-9	705584.546	4612179.116	1513.328	1513.300	-0.028
AT-10	704180.400	4614580.746	1512.472	1512.460	-0.012
AT-11	707635.370	4614093.358	1525.191	1525.230	+0.039
AT-12	704602.743	4617542.092	1519.844	1519.850	+0.006
AT-13	703001.066	4621426.103	1560.577	1560.570	-0.007
AT-14	706472.316	4618521.396	1535.952	outside	*
AT-15	702529.572	4618295.881	1535.046	1535.080	+0.034
AT-16	704589.925	4621447.550	1559.502	1559.570	+0.068
AT-17	703854.467	4623422.093	1582.011	1582.040	+0.029
AT-18A	704560.651	4623098.234	1568.173	1568.120	-0.053
AT-19A	703477.895	4623621.090	1605.103	1605.180	+0.077
AT-20	706538.234	4626579.573	1498.114	1498.050	-0.064
AT-21	705344.429	4627314.931	1553.639	1553.640	+0.001

Average dz	+0.004
Minimum dz	-0.070
Maximum dz	+0.123
Average magnitude	0.036
Root mean square	0.047
Std deviation	0.048

16 DEGREE SLOPE

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FLAT AREA