GROUND CONTROL SURVEY REPORT MEDICINE LAKE - Trout Annex

GPS SURVEY FOR LIDAR CONTROL

CONTENTS

1. ABSTRACT

This report documents the GPS ground surveys conducted in support of LIDAR data collection for the Modoc Forest area. The surveyed ground control was established on September 7 - 11 (TROUT) and September 11-13 (Medicine Lake and Harris), 2013 . The aerial collection was performed with the Optech ALTM Gemini LiDAR Sensor on September 7 and 8 (Trout Annex)) and October 6, 7, 8, 16, 17, and 18(Medicine Lake and Harris), 2013 . 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 24(Medicine Lake and Harris) and 10 (Trout Annex) 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**

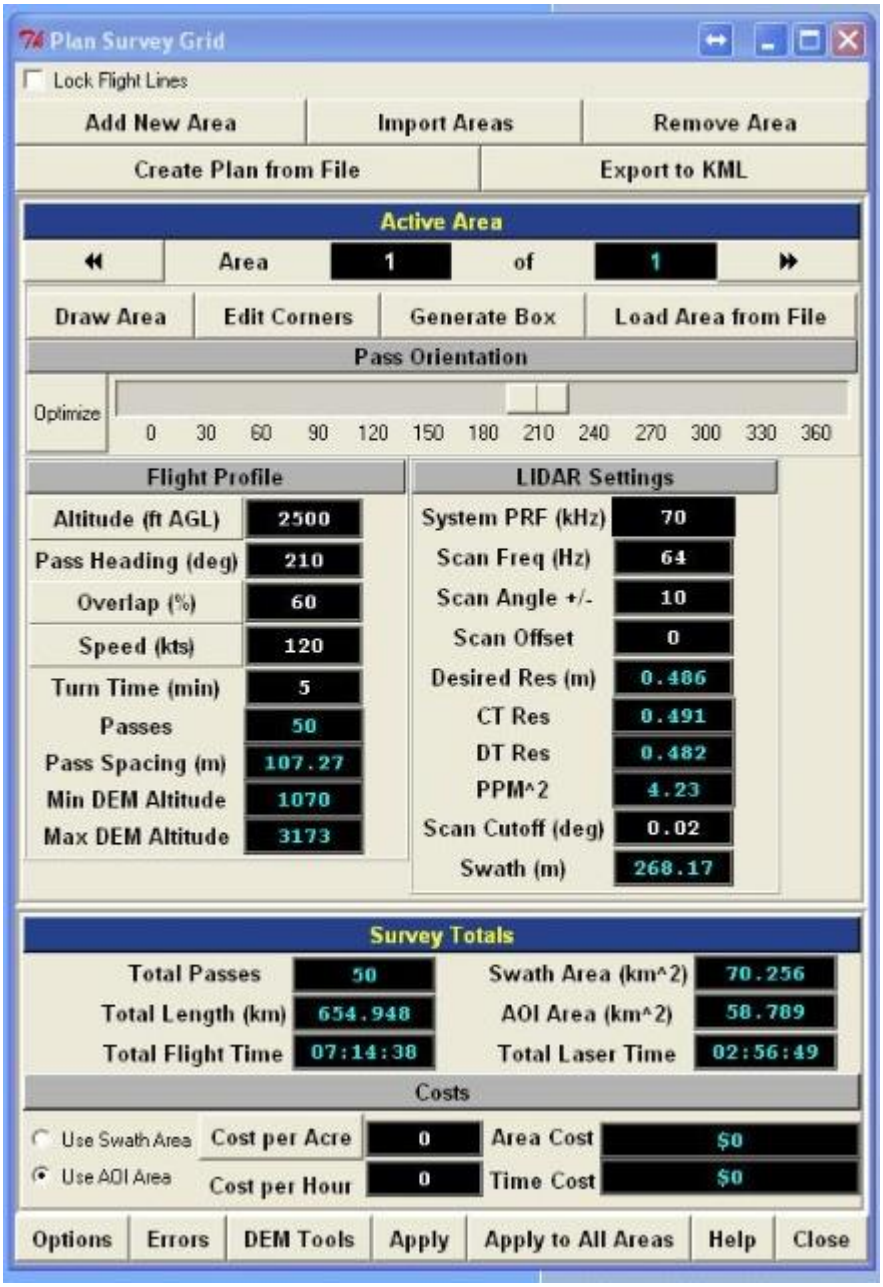
The actual local flight times and duration of flights were controlled by fuel consumption of the aircraft, safety of flight operations in the particular airspace and during times when the GPS constellation was most favorable, producing the highest number of satellites visible in the best geometric configuration 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.

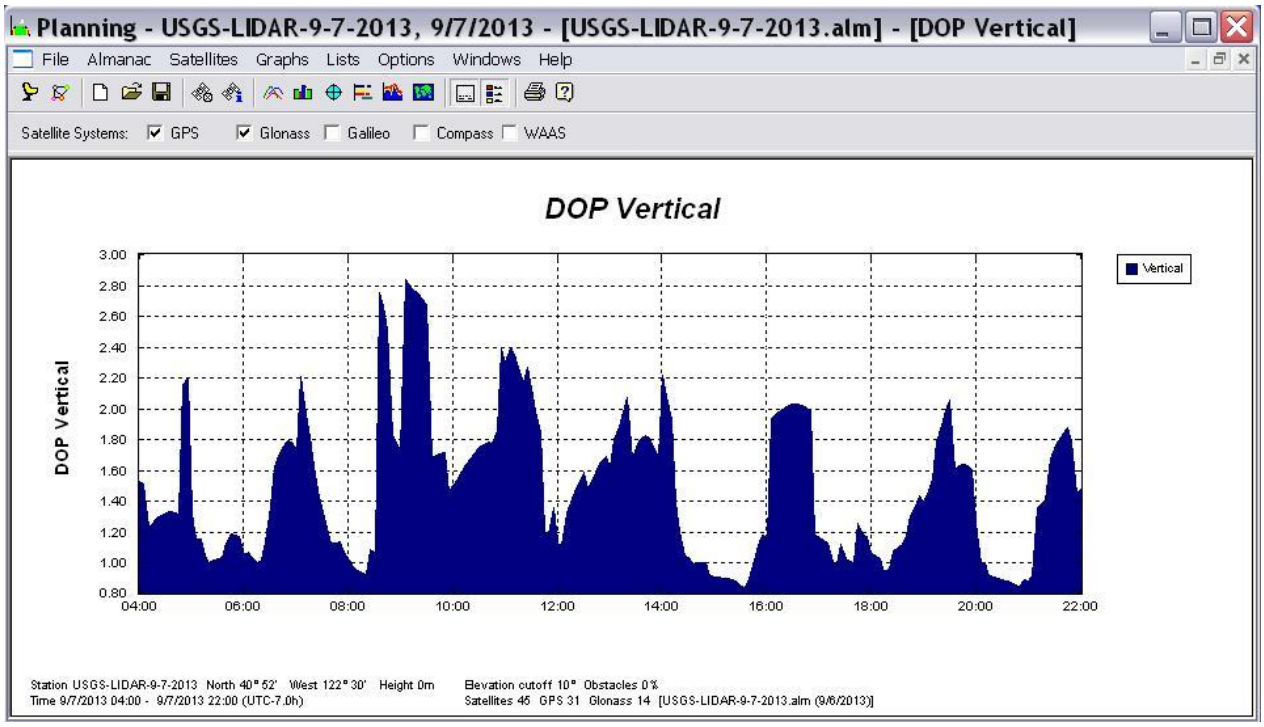
The horizontal and vertical datum used for this project are listed below:

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 September 7 and 8 (TROUT) and October 6, 7, 8, 16, 17, and 18(Medicine Lake and Harris)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File Almanac Satellites Graphs Lists Options Windows Help
Satellite Systems: GPS Glonass Galileo Compass WAAS
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DOP Vertical
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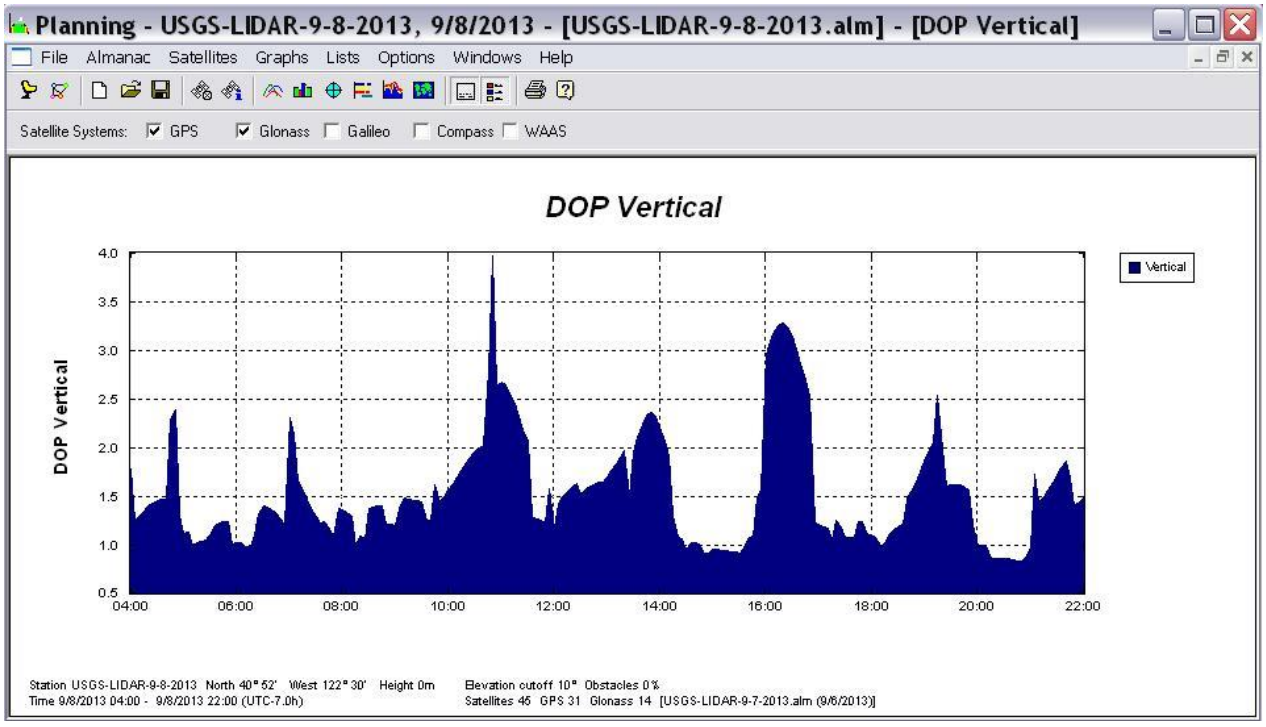
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Vertical
Station USGS-LIDAR-9-7-2013 North 40° 52' West 122° 30' Height 0m
Time 9/7/2013 04:00 - 9/7/2013 22:00 (UTC-7.0h)
Elevation cutoff 10° Obstacles 0%
Satellites 46 GPS 31 Glonass 14 [USGS-LIDAR-9-7-2013.alm (9/6/2013)]


Planning - USGS-LIDAR-9-8-2013, 9/8/2013 - [USGS-LIDAR-9-8-2013.alm] - [DOP Vertical]
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Satellite Systems: GPS Glonass Galileo Compass WAAS
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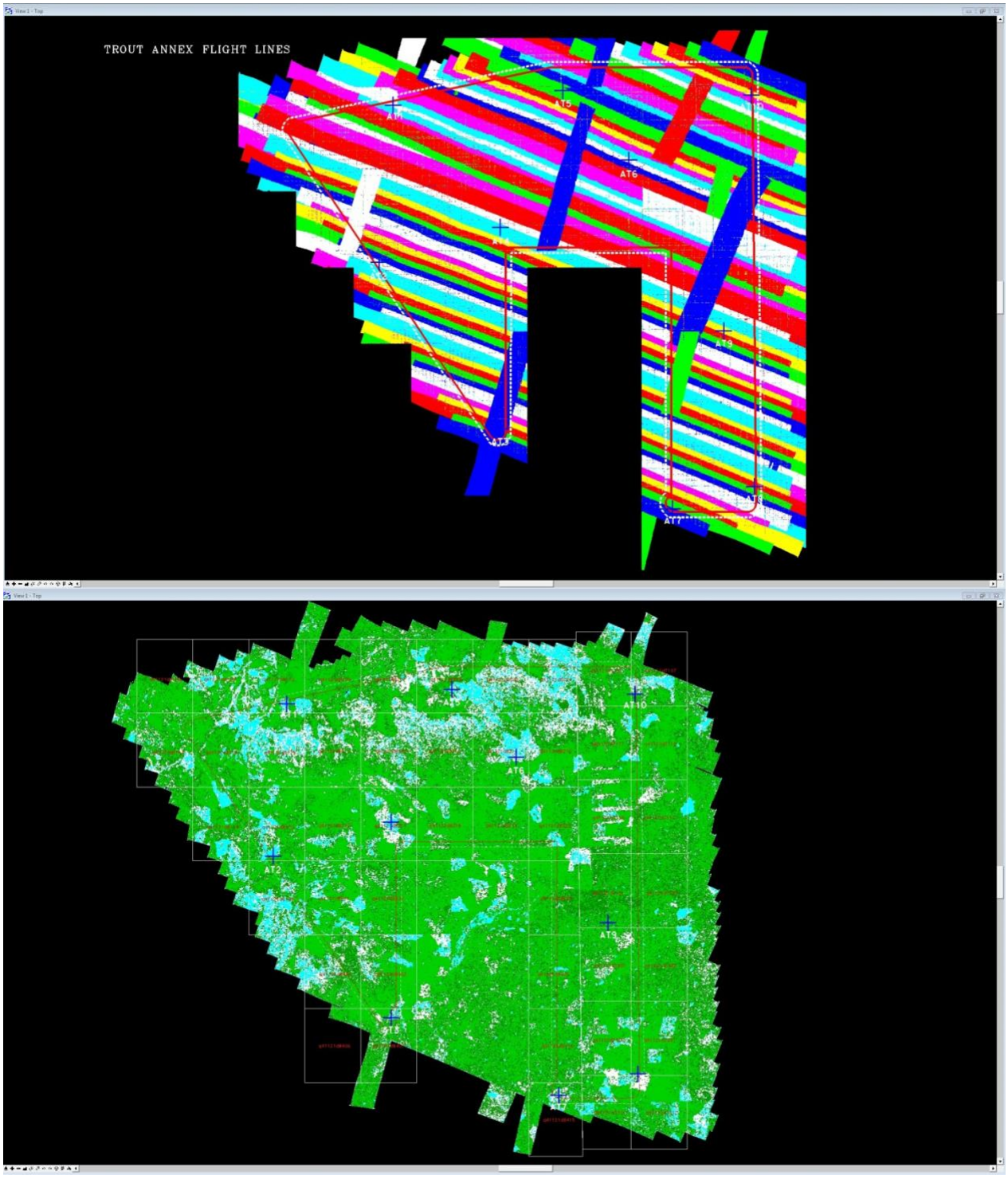
DOP Vertical
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Vertical
Station USGS-LIDAR-9-8-2013 North 40° 52' West 122° 30' Height 0m
Time 9/8/2013 04:00 - 9/8/2013 22:00 (UTC-7.0h)
Elevation cutoff 10° Obstacles 0%
Satellites 46 GPS 31 Glonass 14 [USGS-LIDAR-9-7-2013.alm (9/6/2013)]

SBET IMAGES and FLIGHT LINES (Trout Annex)


TROUT ANNEX FLIGHT LINES

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

Ground Receiver UNIT 1 - 9/07/2013

START: 2013/09/07 23:14:00
STOP: 2013/09/08 02:10:00

ANT NAME: LEIAX1202 NONE # FIXED AMB: 40 / 49 : 82%

ARP HEIGHT: 1.8128 OVERALL RMS: 0.016(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)			IGS08 (EPOCH:2013.6850)	
X:	-2538280.326(m)	0.008(m)	-2538281.181(m)	0.008(m)
Y:	-4068356.551(m)	0.013(m)	-4068355.295(m)	0.013(m)
Z:	4193221.018(m)	0.019(m)	4193221.013(m)	0.019(m)
LAT:	41 21 32.19986	0.016(m)	41 21 32.21287	0.016(m)
E LON:	238 2 22.66649	0.003(m)	238 2 22.60669	0.003(m)
W LON:	121 57 37.33351	0.003(m)	121 57 37.39331	0.003(m)
EL HGT:	1202.569(m)	0.018(m)	1202.105(m)	0.018(m)
ORTHO HGT:	1226.472(m)	0.038(m)	[NAVD88 (Computed using GEOID12A)]	

UTM COORDINATES STATE PLANE COORDINATES

	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4579125.879	724923.282
Easting (X) [meters]	586958.997	2003315.877
Convergence [degrees]	0.68700337	0.02591316
Point Scale	0.99969306	0.99993638
Combined Factor	0.99950453	0.99974780

US NATIONAL GRID DESIGNATOR: 10TEL8695879125(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN7470	P784 YORKMN040GCN2008 CORS ARP	N414950.922	W1222513.585	64956.7
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	W1212923.893	48599.8
DN7398	P348 HATCHETMTNCN2005 CORS ARP	N405419.951	W1214940.756	51579.2

NEAREST NGS PUBLISHED CONTROL POINT

MW0387	K 499	N412114.	W1215731.	581.7

Ground Receiver UNIT 2 - 09/07/2013

START: 2013/09/07 23:11:00
STOP: 2013/09/08 02:12:00

ANT NAME: LEIAX1202 NONE # FIXED AMB: 45 / 49 : 92%

ARP HEIGHT: 1.7048 OVERALL RMS: 0.014(m)

REF FRAME:	NAD_83(2011)(EPOCH:2010.0000)		IGS08 (EPOCH:2013.6850)	
X:	-2538360.758(m)	0.009(m)	-2538361.613(m)	0.009(m)
Y:	-4068356.266(m)	0.008(m)	-4068355.010(m)	0.008(m)
Z:	4193171.757(m)	0.013(m)	4193171.752(m)	0.013(m)
LAT:	41 21 30.09500	0.015(m)	41 21 30.10801	0.015(m)
E LON:	238 2 19.72474	0.005(m)	238 2 19.66494	0.005(m)
W LON:	121 57 40.27526	0.005(m)	121 57 40.33506	0.005(m)
EL HGT:	1201.794(m)	0.009(m)	1201.331(m)	0.009(m)
ORTHO HGT:	1225.699(m)	0.027(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4579060.149	724858.320
Easting (X) [meters]	586891.424	2003247.533
Convergence [degrees]	0.68645535	0.02537884
Point Scale	0.99969292	0.99993629
Combined Factor	0.99950451	0.99974783

US NATIONAL GRID DESIGNATOR: 10TEL8689179060(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN7398	P348 HATCHETMTNCN2005 CORS ARP	N405419.951	W1214940.756	51530.6
DN7515	P060 POLLARDFLTCN2005 CORS ARP	N405951.462	W1222453.528	55276.0
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	W1212923.893	48693.3

NEAREST NGS PUBLISHED CONTROL POINT

MW0387	K 499	N412114.	W1215731.	542.3

Ground Receiver UNIT 1 - 09/08/2013

START: 2013/09/08 13:32:00
STOP: 2013/09/08 19:13:30

ANT NAME: LEIAX1202 NONE # FIXED AMB: 82 /92 : 89%

ARP HEIGHT: 1.6418 OVERALL RMS: 0.015(m)

REF FRAME:	NAD_83(2011)(EPOCH:2010.0000)		IGS08 (EPOCH:2013.6868)	
X:	-2538360.755(m)	0.008(m)	-2538361.610(m)	0.008(m)
Y:	-4068356.276(m)	0.009(m)	-4068355.020(m)	0.009(m)
Z:	4193171.772(m)	0.011(m)	4193171.767(m)	0.011(m)
LAT:	41 21 30.09522	0.012(m)	41 21 30.10822	0.012(m)
E LON:	238 2 19.72508	0.003(m)	238 2 19.66528	0.003(m)
W LON:	121 57 40.27492	0.003(m)	121 57 40.33472	0.003(m)
EL HGT:	1201.809(m)	0.011(m)	1201.346(m)	0.011(m)
ORTHO HGT:	1225.714(m)	0.028(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4579060.156	724858.327
Easting (X) [meters]	586891.432	2003247.541
Convergence [degrees]	0.68645542	0.02537890
Point Scale	0.99969292	0.99993629
Combined Factor	0.99950451	0.99974783

US NATIONAL GRID DESIGNATOR: 10TEL8689179060(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN5668	P663 SHWHALEBAKCN2007 CORS ARP	N413154.969	W1220910.465	25094.4
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	W1212923.893	48693.3
DN7398	P348 HATCHETMTNCN2005 CORS ARP	N405419.951	W1214940.756	51530.6

NEAREST NGS PUBLISHED CONTROL POINT

MW0387	K 499	N412114.	W1215731.	542.3

Ground Receiver UNIT 2 - 09/08/2013

START: 2013/09/08 13:37:00
STOP: 2013/09/08 19:10:00

ANT NAME: LEIAX1202 NONE # FIXED AMB: 87 / 102 : 85%
ARP HEIGHT: 1.6298 OVERALL RMS: 0.016(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2013.6868)

X:	-2538280.350(m)	0.019(m)	-2538281.205(m)	0.019(m)
Y:	-4068356.579(m)	0.033(m)	-4068355.323(m)	0.033(m)
Z:	4193221.033(m)	0.022(m)	4193221.028(m)	0.022(m)
LAT:	41 21 32.19945	0.008(m)	41 21 32.21245	0.008(m)
E LON:	238 2 22.66625	0.009(m)	238 2 22.60645	0.009(m)
W LON:	121 57 37.33375	0.009(m)	121 57 37.39355	0.009(m)
EL HGT:	1202.606(m)	0.043(m)	1202.143(m)	0.043(m)
ORTHO HGT:	1226.509(m)	0.075(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 10)	SPC (0401 CA 1)
Northing (Y) [meters]	4579125.866	724923.269
Easting (X) [meters]	586958.992	2003315.871
Convergence [degrees]	0.68700332	0.02591312
Point Scale	0.99969306	0.99993638
Combined Factor	0.99950452	0.99974779

US NATIONAL GRID DESIGNATOR: 10TEL8695879125(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DN7470	P784 YORKMN040GCN2008 CORS ARP	N414950.922	W1222513.585	64956.7
DN7398	P348 HATCHETMTNCN2005 CORS ARP	N405419.951	W1214940.756	51579.2
DN7461	P674 GLASSMTN__CN2006 CORS ARP	N413658.746	W1212923.893	48599.8

NEAREST NGS PUBLISHED CONTROL POINT

MW0387	K 499	N412114.	W1215731.	581.6

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.

TROUT LIDAR 2013 / DIGITAL MAPPING INC./ UTM 10

AERIAL POINT#	LATITUDE	LONGITUDE	NORTH (M)	EAST (M)	TARGET ELEV.	DESCRIPTION
AT 1	41°28'37.21251" N	121°56'27.09634" W	4592252.546	588430.644	1968.194	SET 60D SPIKE
AT 2	41°27'03.70643" N	121°56'39.84763" W	4589365.286	588170.088	1909.425	SET 60D SPIKE
AT 3	41°25'23.25261" N	121°55'05.15966" W	4586294.521	590405.762	1435.590	SET 60D SPIKE
AT 4	41°27'23.59255" N	121°55'03.14794" W	4590006.271	590406.049	1689.251	SET 60D SPIKE
AT 5	41°28'44.69194" N	121°54'12.14703" W	4592522.209	591557.574	1889.772	SET 60D SPIKE
AT 6	41°28'02.69530" N	121°53'20.29320" W	4591242.412	592776.807	1548.377	SET 60D SPIKE
AT 7	41°24'34.28235" N	121°52'49.20159" W	4584824.449	593581.152	1447.471	SET 60D SPIKE
AT 8	41°24'47.04558" N	121°51'44.12419" W	4585237.744	595086.877	1485.421	SET 60D SPIKE
AT 9	41°26'20.19379" N	121°52'06.85718" W	4588103.429	594521.579	1505.124	SET 60D SPIKE
AT 10	41°28'40.46572" N	121°51'42.51704" W	4592436.707	595029.524	1580.387	SET 60D SPIKE

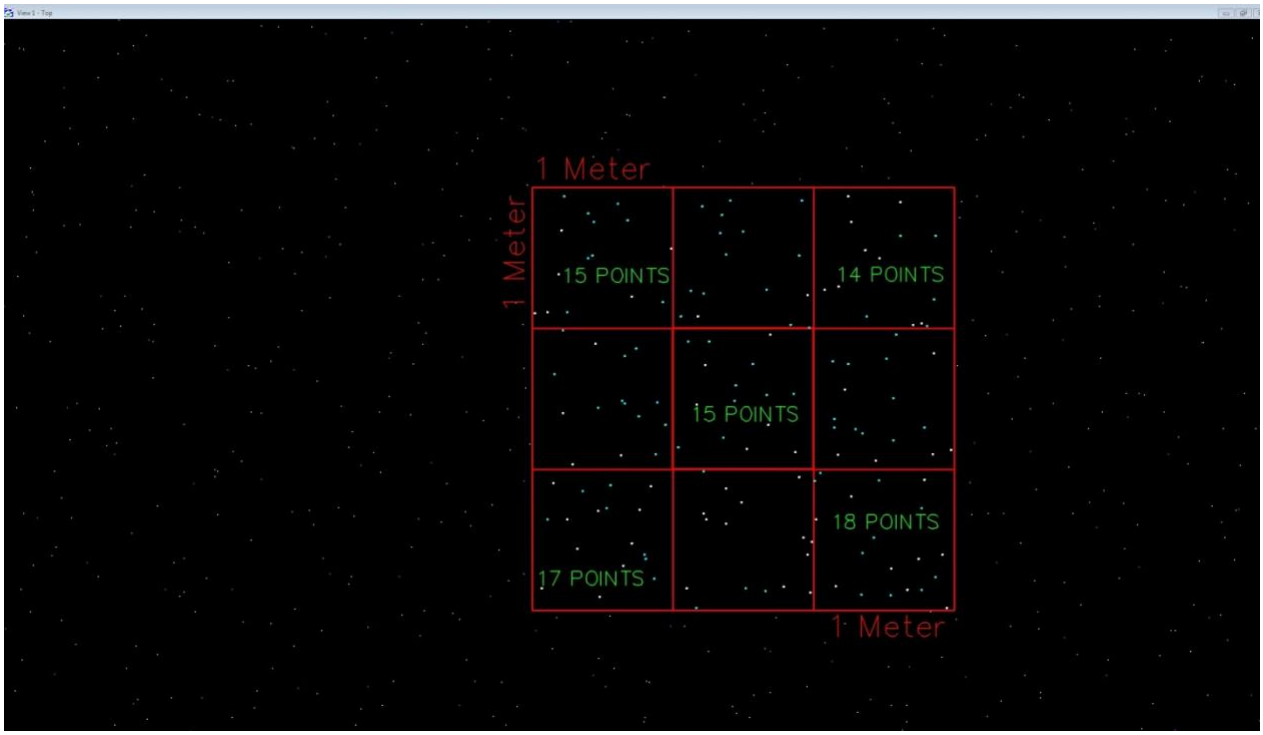
CORS SITES USED (PLEASE REFER TO OPUS DATA SHEETS)

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.



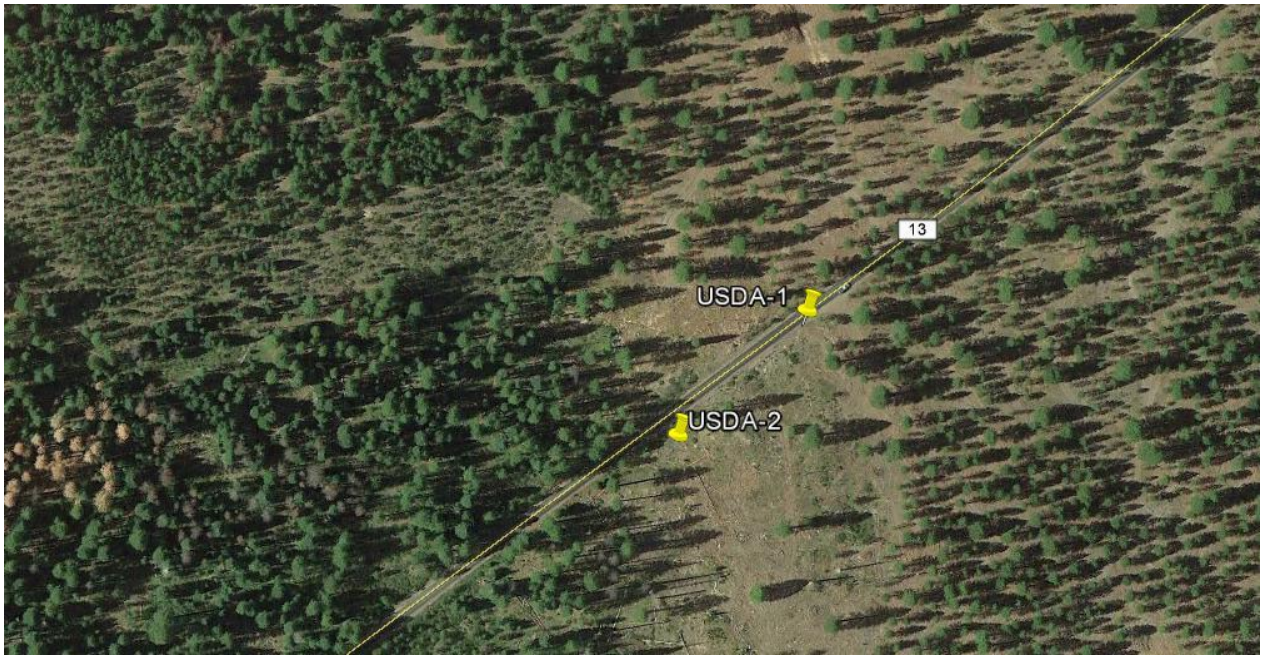
ONE METER SQUARE

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**

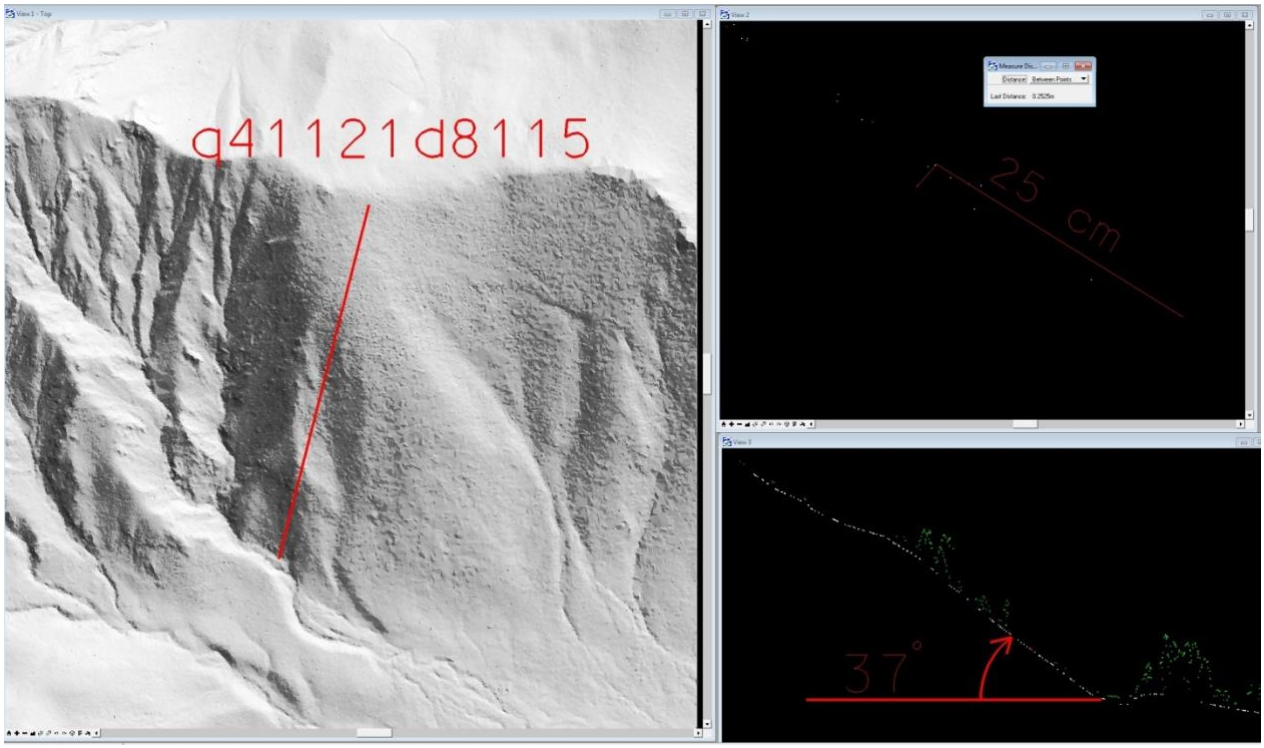
Ground Control Z vs. Aerial Surveyed/ Laser Pointing Z (QA/QC)

TROUT ANNEX

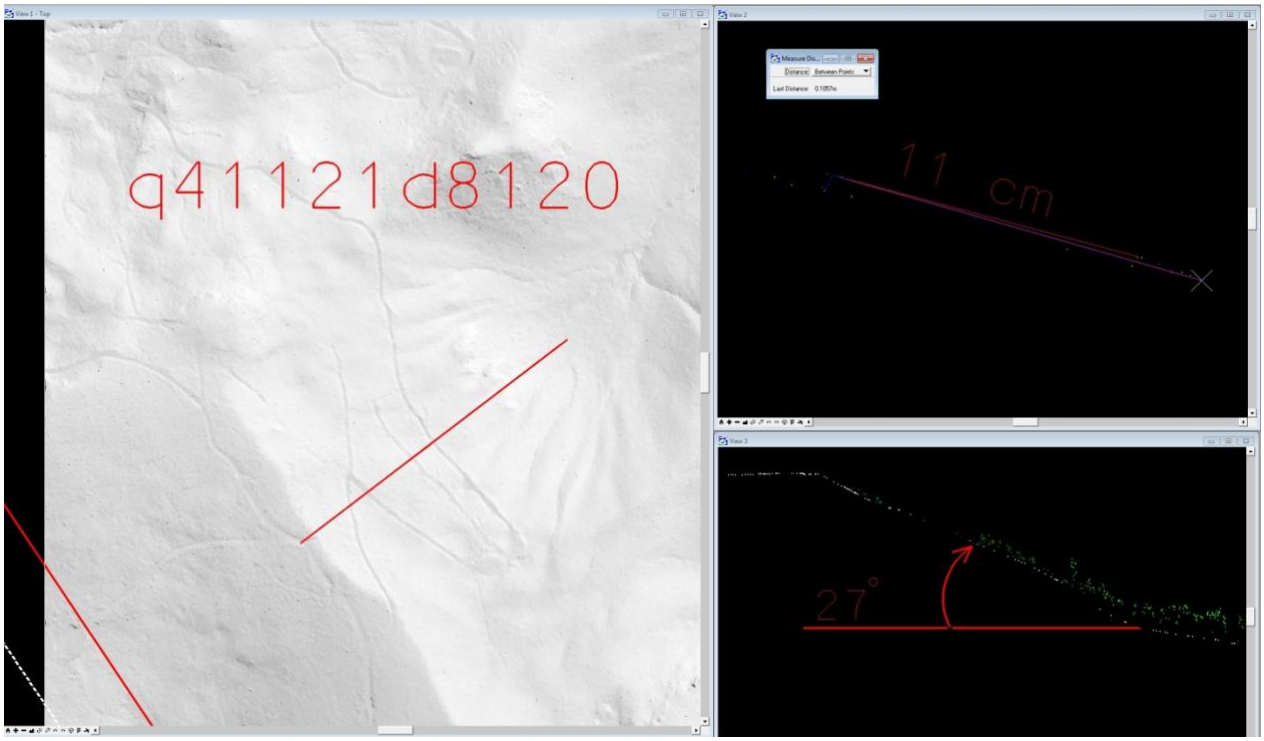
Number	Easting	Northing	Known Z	Laser Z	Dz
AT1	588430.644	4592252.546	1968.194	1968.150	-0.044
AT2	588170.088	4589365.286	1909.425	1909.410	-0.015
AT3	590405.762	4586294.521	1435.590	1435.580	-0.010
AT4	590406.049	4590006.271	1689.251	1689.260	+0.009
AT5	591557.574	4592522.209	1889.772	1889.750	-0.022
AT6	592776.807	4591242.412	1548.377	1548.370	-0.007
AT7	593581.152	4584824.449	1447.471	1447.580	+0.109
AT8	595086.877	4585237.744	1485.421	1485.350	-0.071
AT9	594521.579	4588103.429	1505.124	1505.120	-0.004
AT10	595029.524	4592436.707	1580.387	1580.400	+0.013

Average dz	-0.004
Minimum dz	-0.071
Maximum dz	+0.109
Average magnitude	0.030
Root mean square	0.045
Std deviation	0.047

37 DEGREE SLOPE



27 DEGREE SLOPE



FLAT AREA