AIRBORNE LIDAR TASK ORDER REPORT

NRCS MAINE 0.7M NPS LIDAR
UNITED STATES GEOLOGICAL SURVEY (USGS)

CONTRACT NUMBER: G10PC00057

TASK ORDER NUMBER: G13PD00954

Woolpert Project Number: 73683
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PROJECT REPORT

NRCS MAINE 0.7M NSP LIDAR PROCESSING

WOOLPERT PROJECT #73683

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SECTION 1: OVERVIEW

PROJECT NAME: NRCS MAINE 0.7M NPS LIDAR

WOOLPERT PROJECT #73683

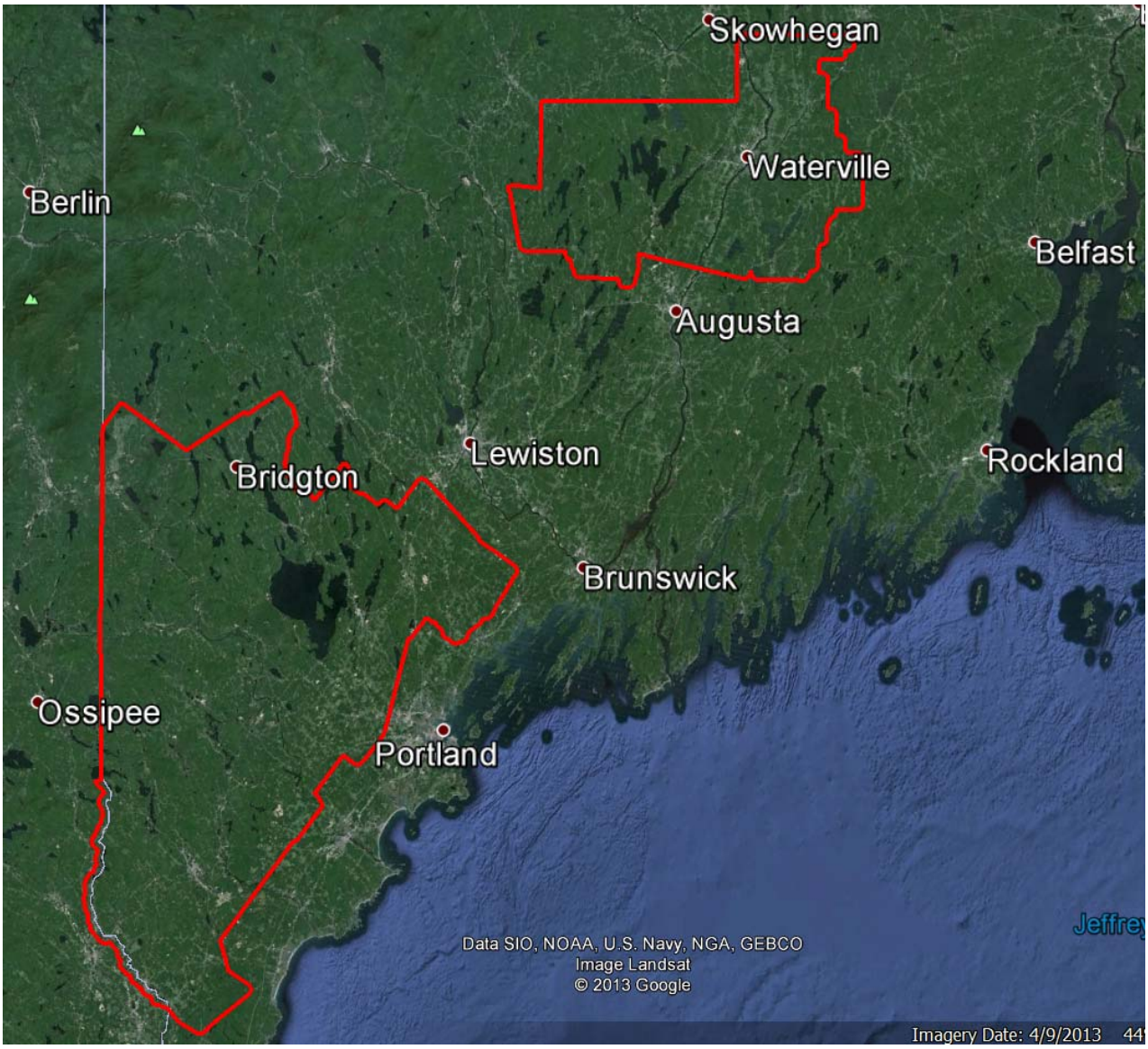
This report contains a comprehensive outline of the Maine 0.7M NPS LiDAR Processing task order for the United States Geological Survey (USGS). This task is issued under Contract Number G10PC00057, as task order number G13PD00954. The project area covers approximately 2,279 square miles in Southern Maine. The LiDAR was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.7 meters. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) LiDAR sensor installed in a Leica gyro-stabilized PAV30 mount. The ALS70 sensor collects up to four returns per pulse, as well as intensity data, for the first three returns. If a fourth return was captured, the system does not record an associated intensity value. The aerial LiDAR was collected at the following sensor specifications:

Post Spacing (Minimum):	2.3 ft / 0.7m
AGL (Above Ground Level) average flying height:	6,500 ft / 1,981 m
MSL (Mean Sea Level) average flying height:	variable
Average Ground Speed:	150 knots / 173 mph
Field of View (full):	40 degrees
Pulse Rate:	272 kHz
Scan Rate:	42.3 Hz
Side Lap (Average):	25%

The LiDAR data was processed and projected in UTM, Zone 19, North American Datum of 1983 (2011) in units of meters. The vertical datum used for the task order was referenced to NAVD 1988, GEOID12A, in units of meters.

Figure 1.1 LiDAR Task Order AOI



SECTION 2: ACQUISITION

The existing LiDAR data was acquired with a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) LiDAR sensor system, on board a Cessna 402. The ALS70 LiDAR system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The system software is operated on an OC50 Operation Controller aboard the aircraft.

Table 2.1: ALS70 LiDAR System Specifications

The ALS70 500 kHz Multiple Pulses in Air (MPiA) LiDAR System has the following specifications:

Specification	
Operating Altitude	200 – 3,500 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	500 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	7 - 16 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 38 cm (one standard deviation)
Number of Returns per Pulse	7 (infinite)
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

Prior to mobilizing to the project site, Woolpert flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support.

The LiDAR data was collected in eleven (11) separate missions, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area.

An initial quality control process was performed immediately on the LiDAR data to review the data coverage, airborne GPS data, and trajectory solution. Any gaps found in the LiDAR data were relayed to the flight crew, and the area was re-flown.

Figure 2.1: LiDAR Flight Layout, Northern AOI

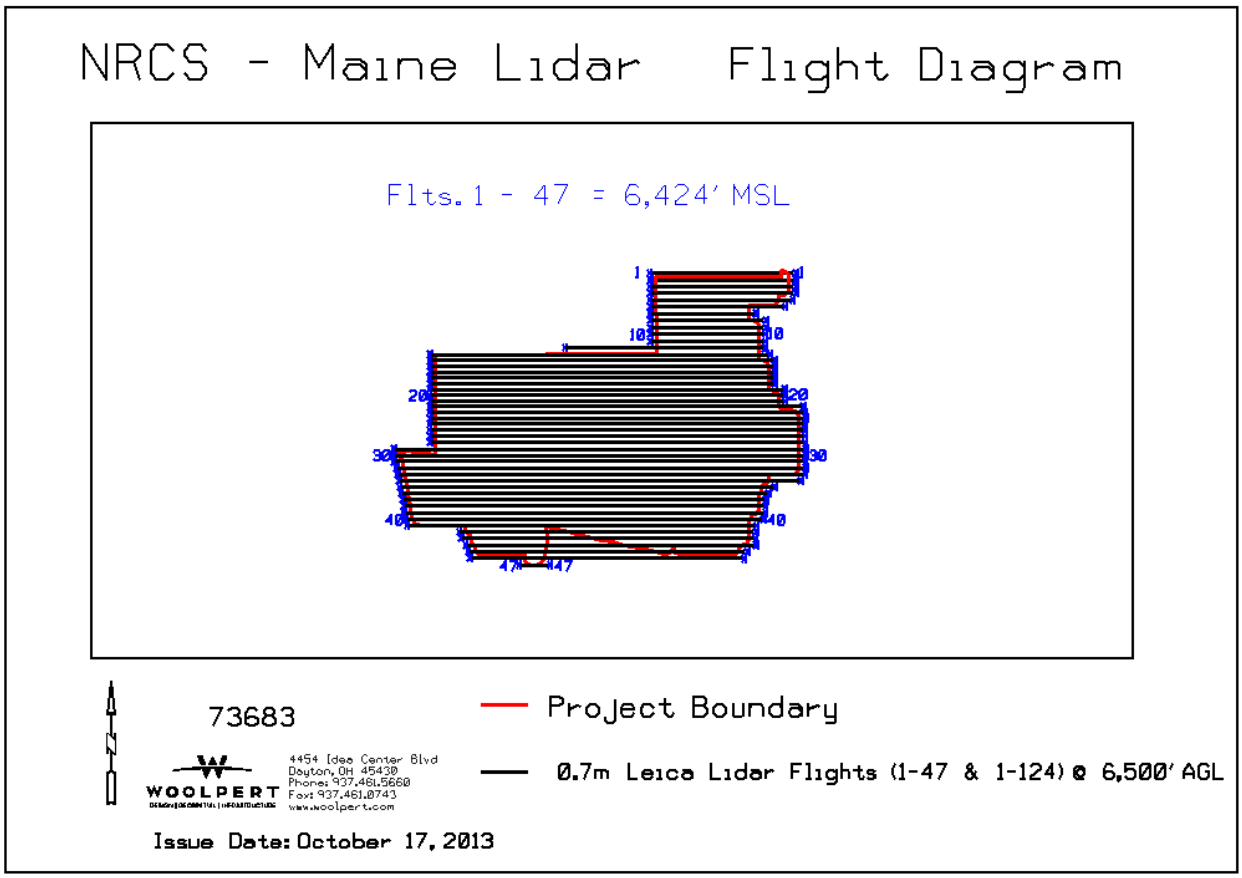


Figure 2.2 LiDAR Flight Layout – Southern AOI

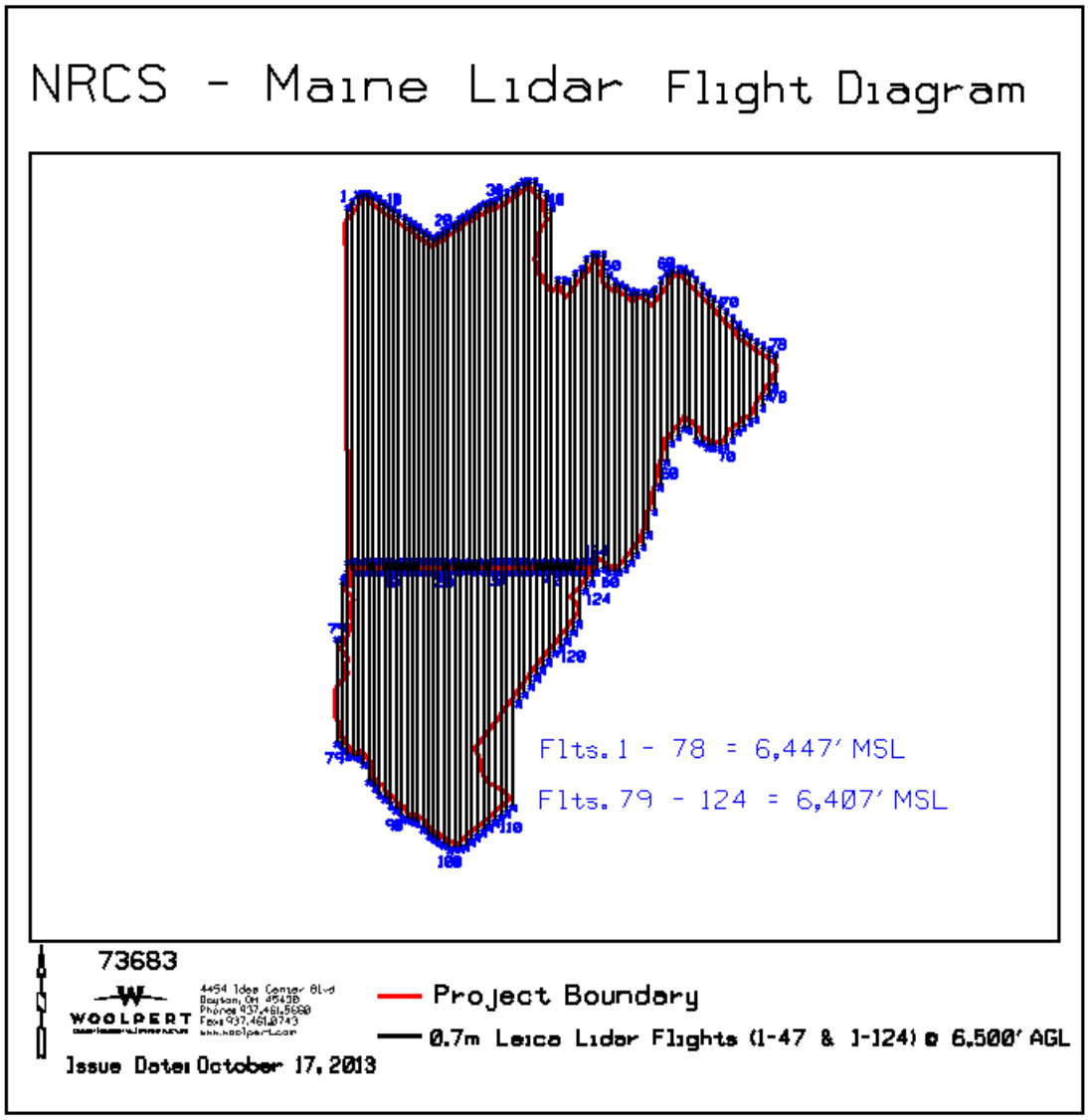


Table 2.2: Airborne LiDAR Acquisition Flight Summary

Airborne LiDAR Acquisition Flight Summary			
Date of Mission	**Lines Flown**	**Mission Time (UTC)** **Wheels Up/** **Wheels Down**	**Mission Time (Local = EDT)** **Wheels Up/** **Wheels Down**
November 5, 2013 – Sensor 7108	1-20	19:21 – 22:55	02:21PM – 05:55PM
November 6, 2013 – Sensor 7108	21-38	14:23 - 18:44	09:23AM – 01:44PM
November 9, 2013 – Sensor 7108	30-34, 39-47	16:59 – 20:21	11:59AM – 03:21PM
November 16, 2013 – Sensor 7108 A	33, 34, 39-43	14:36 – 16:30	09:36AM – 11:30AM
November 16, 2013 – Sensor 7108 B	1-13	18:43 – 22:30	01:43PM – 05:30PM
November 20, 2013 – Sensor 7108	14-25, 79-94	14:24 – 20:39	09:24AM – 03:39PM
November 23, 2013 – Sensor 7177	48-78	14:27 – 20:51	09:27AM – 03:51PM
November 25, 2013 – Sensor 7177	26-44, 117-124	17:06 – 23:22	12:06PM – 07:22PM
November 29, 2013 – Sensor 7177	10-13, 18-25, 45, 79-80	01:49 – 04:37	08:49AM – 11:27AM
November 30, 2013 – Sensor 7177	81-102	13:50 – 18:20	08:50AM – 01:20PM
December 4, 2013 – Sensor 7177	96-116	14:22 – 18:03	09:22AM – 01:03PM

SECTION 3: LIDAR DATA PROCESSING

APPLICATIONS AND WORK FLOW OVERVIEW

1. Resolved kinematic corrections for three subsystems: inertial measurement unit (IMU), sensor orientation information and airborne GPS data. Developed a blending post-processed aircraft position with attitude data using Kalman filtering technology or the smoothed best estimate trajectory (SBET).
   Software: POSPac Software v. 5.3, IPAS Pro v.1.35.

2. Calculated laser point position by associating the SBET position to each laser point return time, scan angle, intensity, etc. Created raw laser point cloud data for the entire survey in LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift.
   Software: ALS Post Processing Software v.2.75 build #25, Proprietary Software, TerraMatch v. 14.01.

3. Imported processed LAS point cloud data into the task order tiles. Resulting data were classified as ground and non-ground points with additional filters created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the LiDAR data was then adjusted to reduce the vertical bias when compared to the survey ground control.
   Software: TerraScan v.14.011.

4. The LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts from the ground class.
   Software: TerraScan v.14.011.

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)-INERTIAL MEASUREMENT UNIT (IMU) TRAJECTORY PROCESSING

EQUIPMENT

Flight navigation during the LiDAR data acquisition mission is performed using IGI CCNS (Computer Controlled Navigation System). The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

The aircraft are all configured with a NovAtel Millennium 12-channel, L1/L2 dual frequency Global Navigation Satellite System (GNSS) receivers collecting at 2 Hz.

All Woolpert aerial sensors are equipped with a Litton LN200 series Inertial Measurement Unit (IMU) operating at 200 Hz.

A base-station unit was mobilized for each acquisition mission, and was operated by a member of the Woolpert acquisition team. Each base-station setup consisted of one Trimble 4000 – 5000 series dual frequency receiver, one Trimble Compact L1/L2 dual frequency antenna, one 2-meter fixed-height tripod, and essential battery power and cabling. Ground planes were used on the base-station

antennas. Data was collected at 1 or 2 Hz.

Woolpert's acquisition team was on site, operating GNSS base stations at the Portland International Jetport and Waterville Robert LaFleur Airport, along with utilizing the MEGO CORS station.

The GNSS base station operated during the LiDAR acquisition missions are listed below:

Table 3.1: GNSS Base Station

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
Waterville Robert LaFleur Airport	44°32'00.56967"	69°40'45.78962"	67.576
Portland International Jetport	43°38'56.50237"	70°17'57.77437"	-15.485
MEGO CORS	43°40'52.06780"	70°27'03.72438"	90.028

DATA PROCESSING

All airborne GNSS and IMU data was post-processed and quality controlled using Applanix MMS software. GNSS data was processed at a 1 and 2 Hz data capture rate and the IMU data was processed at 200 Hz.

TRAJECTORY QUALITY

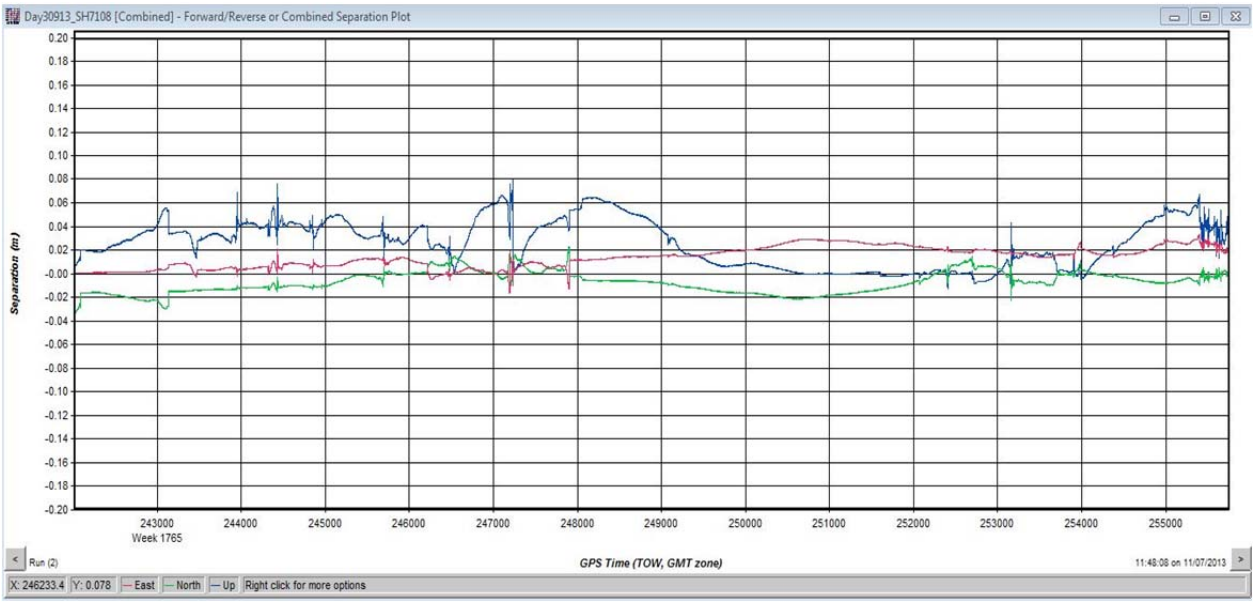
The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

Combined Separation

The Combined Separation is a measure of the difference between the forward run and the backward run solution of the trajectory. The Kalman filter is processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate reliable solution is achieved.

Woolpert's goal is to maintain a Combined Separation Difference of less than ten (10) centimeters. In most cases we achieve results below this threshold.

Figure 3.1: Combined Separation, Day30913 SH7108

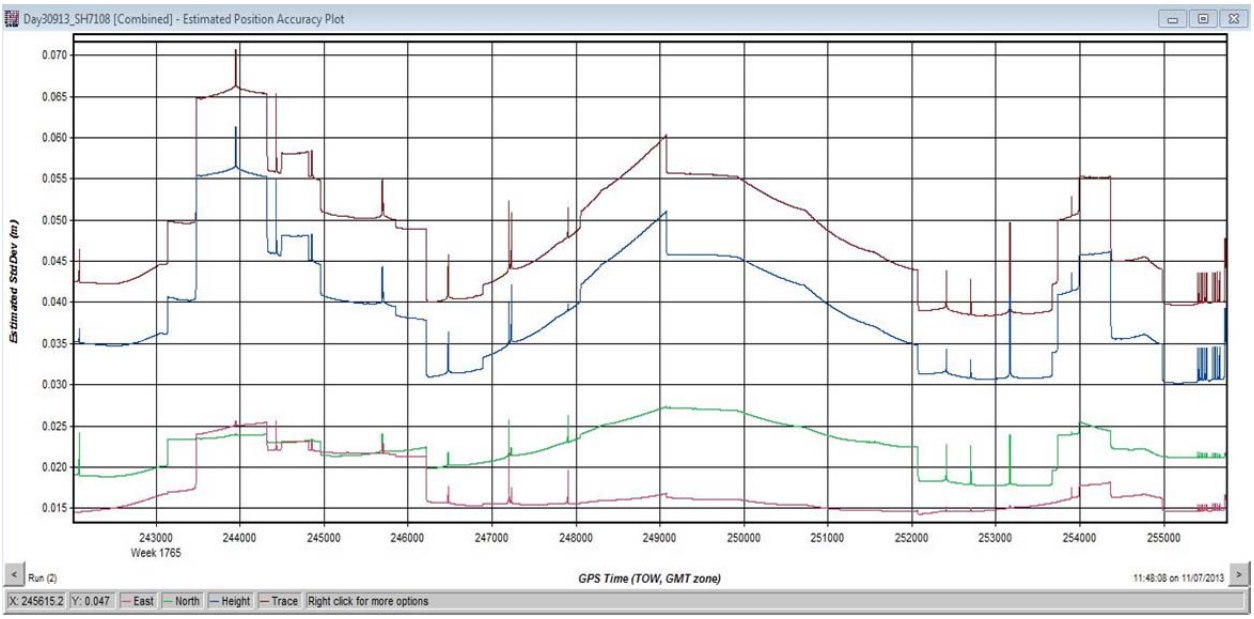


Estimated Positional Accuracy

The Estimated Positional Accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

Woolpert's goal is to maintain an Estimated Positional Accuracy of less than ten (10) centimeters, often achieving results well below this threshold.

Figure 3.2: Estimated Positional Accuracy, Day30913 SH7108

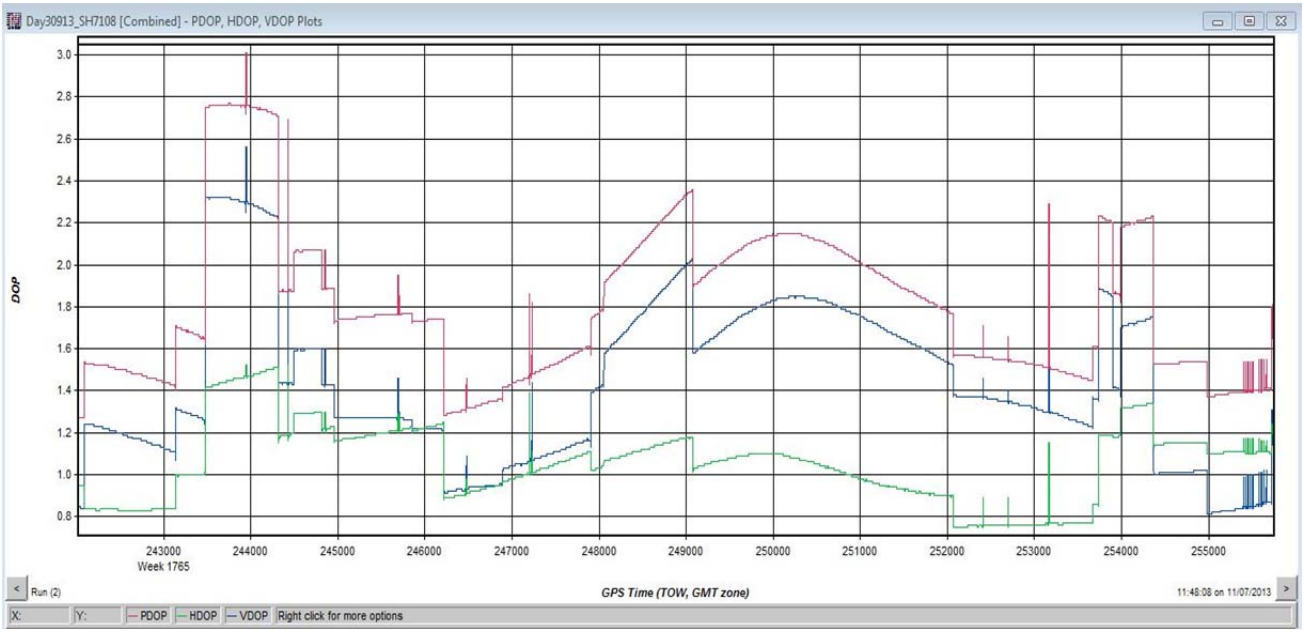


PDOP

The PDOP measures the precision of the GPS solution in regards to the geometry of the satellites acquired and used for the solution.

Woolpert's goal is to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Figure 3.3: PDOP, Day30913 SH7108



LIDAR DATA PROCESSING

When the sensor calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert LiDAR specialists included:

- Processed individual flight lines to derive a raw "Point Cloud" LAS file. Matched overlapping flight lines, generated statistics for evaluation comparisons, and made the necessary adjustments to remove any residual systematic error.

- Calibrated LAS files were imported into the task order tiles and initially filtered to create a ground and non-ground class. Then additional classes were filtered as necessary to meet client specified classes.

- Once all project data was imported and classified, survey ground control data was imported and calculated for an accuracy assessment. As a QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparisons against the TIN and the DEM using surveyed ground control of higher accuracy. The LiDAR is adjusted accordingly to meet or exceed the vertical accuracy requirements.

- The LiDAR tiles were reviewed using a series of proprietary QA/QC procedures to ensure it fulfills the task order requirements. A portion of this requires a manual step to ensure anomalies have been removed from the ground class.

- The LiDAR LAS files are classified into the Default (Class 1), Ground (Class 2), Noise (Class 7), Water (Class 9), Ignored Ground (Class 10), Overlap default (Class 17), and Overlap Ground (Class 18) classifications.

- FGDC Compliant metadata was developed for the task order in .xml format for the final data products.

- The horizontal datum used for the task order was referenced to UTM19N American Datum of 1983 (2011). The vertical datum used for the task order was referenced to NAVD 1988, meters, GEOID12A. Coordinate positions were specified in units of meters.

SECTION 4: HYDROLOGIC FLATTENING

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

NRCS Maine 0.7m NPS LiDAR Processing task order required the compilation of breaklines defining water bodies and rivers. The breaklines were used to perform the hydrologic flattening of water bodies, and gradient hydrologic flattening of double line streams and rivers. Lakes, reservoirs and ponds, at a minimum size of 2-acres or greater, were compiled as closed polygons. The closed water bodies were collected at a constant elevation. Rivers and streams, at a nominal minimum width of 30.5 meters (100 feet), were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation.

LIDAR DATA REVIEW AND PROCESSING

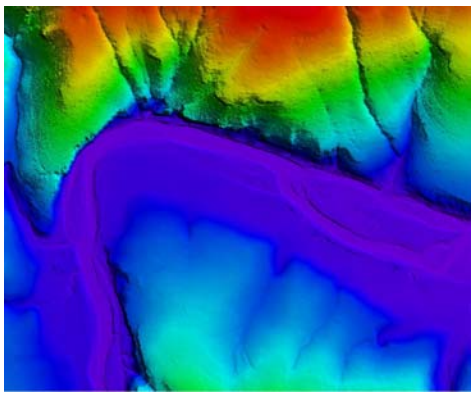
Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing LiDAR data.

1. Woolpert used the newly acquired LiDAR data to manually draw the hydrologic features in a 2D environment using the LiDAR intensity and bare earth surface. Open Source imagery was used as reference when necessary.

2. Woolpert utilizes an integrated software approach to combine the LiDAR data and 2D breaklines. This process "drapes" the 2D breaklines onto the 3D LiDAR surface model to assign an elevation. A monotonic process is performed to ensure the streams are consistently flowing in a gradient manner. A secondary step within the program verifies an equally matching elevation of both stream edges. The breaklines that characterize the closed water bodies are draped onto the 3D LiDAR surface and assigned a constant elevation at or just below ground elevation.

3. The lakes, reservoirs and ponds, at a minimum size of 2-acres or greater, were compiled as closed polygons. **Figure 4.1** illustrates a good example of 2-acre lakes and 30.5 meters (100 feet) nominal streams identified and defined with hydrologic breaklines. The breaklines defining rivers and streams, at a nominal minimum width of 30.5 meters (100 feet), were draped with both sides of the stream maintaining an equal gradient elevation.

Figure 4.1



4. All ground points were reclassified from inside the hydrologic feature polygons to water, class

nine (9).

5. All ground points were reclassified from within a buffer along the hydrologic feature breaklines to buffered ground, class ten (10).

6. The LiDAR ground points and hydrologic feature breaklines were used to generate a new digital elevation model (DEM).

Figure 4.2 **Figure 4.3**

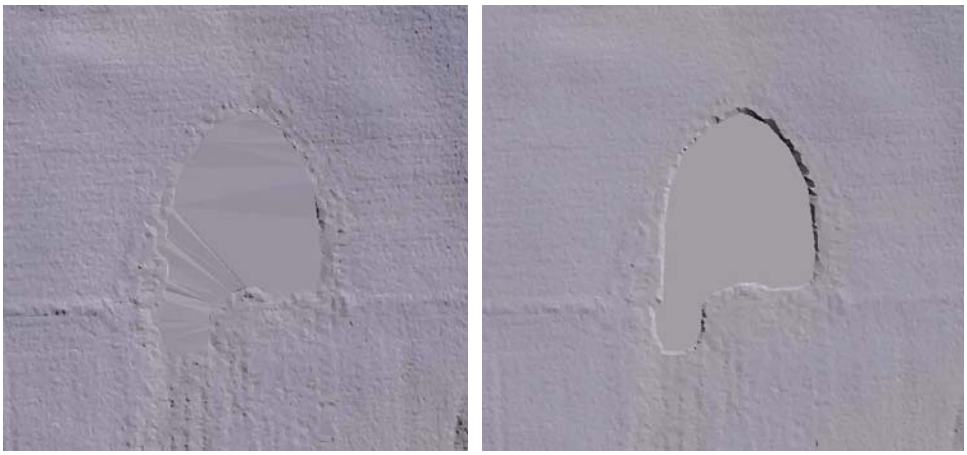


Figure 4.2 reflects a DEM generated from original LiDAR bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

Figure 4.3 reflects a DEM generated from LiDAR with breaklines compiled to define the hydrologic features. This figure illustrates the results of adding the breaklines to hydrologically flatten the DEM data. Note the smooth appearance of the lake surface in the DEM.

Terrascan was used to add the hydrologic breakline vertices and export the lattice models. The hydrologically flattened DEM data was provided to USGS in ERDAS .IMG format at a 1-meter cell size.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS as an ESRI shapefile. The breaklines defining the water bodies greater than 2-acres were provided as a PolygonZ file. The breaklines compiled for the gradient flattening of all rivers and streams at a nominal minimum width of 30.5 meters (100 feet) were provided as a PolylineZ file.

DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v15, by reviewing the grids and hydrologic breakline features. Additionally, ESRI software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

Edits and corrections were addressed individually by tile. If a water body breakline needed to be adjusted to improve the flattening of the DEM data, the area was cross referenced by tile number, corrected accordingly, a new DEM file was regenerated and reviewed.

SECTION 5: FINAL ACCURACY ASSESSMENT

FINAL VERTICAL ACCURACY ASSESSMENT

The vertical accuracy statistics were calculated by comparison of the LiDAR bare earth points to the ground surveyed quality check points.

Table 5.1: Overall Vertical Accuracy Statistics

Average error	0.001	meters
Minimum error	-0.139	meters
Maximum error	0.165	meters
Root mean square	0.064	meters
Standard deviation	0.065	meters

Table 5.2: Swath Quality Check Point Analysis, FVA, UTM 19N, NAD83, NAVD88 GEOID12A

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Dz (meters)
2000	353163.02	4788256.291	34.199	-0.009
2001	349308.612	4794402.071	116.99	-0.02
2002	358094.498	4796152.233	45.62	-0.03
2003	361799.645	4806957.053	73.276	-0.006
2004	348260.095	4808827.298	117.829	-0.049
2005	338597.414	4806640.88	104.41	-0.06
2006	345098.044	4821851.163	232.108	0.012
2007	360709.635	4821414.201	80.211	0.019
2008	372417.627	4821667.891	60.804	-0.034
2009	380233.257	4828863.986	51.765	0.025
2010	364167.046	4831644.601	108.824	-0.024
2011	347256.261	4834287.461	135.873	-0.073
2012	339953.74	4850861.066	121.079	-0.069
2013	364965.189	4851477.523	94.219	0.011
2014	386258.584	4849669.081	81.132	0.068
2015	399455.262	4854109.393	72.683	-0.003

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Dz (meters)
2016	409546.382	4861528.688	47.209	-0.139
2017	394220.53	4863561.031	60.15	-0.05
2018	378316.138	4871154.142	138.039	-0.029
2019	363902.842	4876046.386	139.299	-0.069
2020	347562.012	4877006.277	114.697	-0.027
2021	418402.711	4937637.735	136.352	-0.012
2022	430078.293	4910930.688	104.388	0.122
2023	453668.024	4913498.172	101.43	0.13
2024	458717.942	4922318.02	76.45	0.06
2025	460258.005	4942795.617	38.362	0.008
2026	453987.921	4952786.431	48.115	0.165
2027	447220.503	4939676.133	71.84	0
2028	449410.437	4935305.716	55.557	0.013
2029	437576.369	4928731.689	99.206	-0.016
2030	436713.363	4920461.835	147.666	0.104

VERTICAL ACCURACY CONCLUSIONS

LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.125 meters fundamental vertical accuracy at 95 percent confidence level, derived according to NSSDA, in open terrain in open using (RMSEz) x 1.9600, tested against the TIN.

Bare-Earth DEM Fundamental Vertical Accuracy (FVA) Tested 0.122 meters fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 Tested against the DEM.

Table 5.3: Quality Check Point Analysis, Bare Earth and Open Terrain, UTM 19N, NAD83, NAVD88 GEOID12A, NRCS Maine

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Dz (meters)
2000	353163.02	4788256.291	34.199	0.001
2001	349308.612	4794402.071	116.99	0.03
2002	358094.498	4796152.233	45.62	0.03
2003	361799.645	4806957.053	73.276	0.024
2004	348260.095	4808827.298	117.829	0.039
2005	338597.414	4806640.88	104.41	0.09
2006	345098.044	4821851.163	232.108	0.002
2007	360709.635	4821414.201	80.211	0.019
2008	372417.627	4821667.891	60.804	0.024
2009	380233.257	4828863.986	51.765	0.025
2010	364167.046	4831644.601	108.824	0.044
2011	347256.261	4834287.461	135.873	0.063
2012	339953.74	4850861.066	121.079	0.049
2013	364965.189	4851477.523	94.219	0.001
2014	386258.584	4849669.081	81.132	0.058
2015	399455.262	4854109.393	72.683	0.003
2016	409546.382	4861528.688	47.209	0.149
2017	394220.53	4863561.031	60.15	0.06
2018	378316.138	4871154.142	138.039	0.031
2019	363902.842	4876046.386	139.299	0.049
2020	347562.012	4877006.277	114.697	0.017
2021	418402.711	4937637.735	136.352	0.032
2022	430078.293	4910930.688	104.388	0.122
2023	453668.024	4913498.172	101.43	0.12

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Dz (meters)
2024	458717.942	4922318.02	76.45	0.03
2025	460258.005	4942795.617	38.362	0.018
2026	453987.921	4952786.431	48.115	0.155
2027	447220.503	4939676.133	71.84	0
2028	449410.437	4935305.716	55.557	0.003
2029	437576.369	4928731.689	99.206	0.016
2030	436713.363	4920461.835	147.666	0.094

ACCURACY CONCLUSIONS

Bare Earth/Open Terrain Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.151 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Errors larger than 95th percentile include:

- Point 2026, Easting 453987.921, Northing 4952786.431, Z-Error 0.155 meters

Table 5.4: Quality Check Point Analysis, Urban, UTM 19N, NAD83, NAVD88 GEOID12A, NRCS Maine

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
3000	352545.239	4789522.349	46.116	0.016
3001	348700.731	4791603.278	60.485	0.005
3002	359144.641	4796312.633	39.419	0.039
3003	356418.869	4811268.113	86.542	0.002
3004	339954.201	4800764.558	74.656	0.004
3005	339029.09	4808048.821	125.14	0.05
3006	345704.291	4821904.45	218.131	0.111
3007	361616.317	4821736.404	82.666	0.014
3008	371701.944	4828855.76	52.205	0.025
3009	384130.294	4837328.672	61.608	0.032

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
3010	355279.842	4838814.879	173.582	0.122
3011	346630.487	4833749.369	147.992	0.062
3012	344015.4	4850938.679	124.37	0.02
3013	367226.862	4850317.428	90.528	0.008
3014	384597.461	4854550.121	94.676	0.044
3015	399727.138	4854176.443	65.79	0.02
3016	397352.157	4868701.102	85.794	0.114
3017	393119.415	4860194.084	92.642	0.022
3018	377976.871	4873349.435	142.215	0.085
3019	363565.723	4879345.649	123.395	0.065
3020	341199.303	4875681.109	130.326	0.096
3021	414700.273	4941075.066	107.43	0.03
3022	422986.952	4915357.667	84.966	0.124
3023	454819.96	4915941.899	75.062	0.118
3024	464853.879	4931134.691	90.894	0.026
3025	460152.293	4942825.886	39.889	0.079
3026	452448.616	4938380.848	38.289	0.071
3027	447245.987	4939676.468	70.431	0.031
3028	449437.229	4935196.81	55.588	0.022
3029	443053.773	4933030.881	76.516	0.016
30271	447324.446	4939687.015	66.142	0.088

ACCURACY CONCLUSIONS

Urban Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.123 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Urban Errors larger than 95th percentile include:

- Point 3022, Easting 422986.952, Northing 4915357.667, Z-Error 0.124 meters

Table 5.5: Quality Check Point Analysis, Tall Weeds and Crops, UTM 19N, NAD83, NAVD88 GEOID12A

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
4000	351537.539	4789859.364	40.178	0.142
4001	348669.685	4793805.478	100.384	0.066
4002	358087.025	4796101.529	44.551	0.059
4003	362692.696	4806535.546	70.38	0.04
4004	353768.321	4812463.15	170.575	0.035
4005	338976.37	4807373.928	108.821	0.029
4006	345126.696	4822067.974	227.209	0.061
4007	363577.655	4820914.117	115.392	0.068
4008	373348.151	4822011.615	49.607	0.023
4009	380236.357	4828841.105	51.312	0.102
4010	362977.097	4828630.818	120.725	0.065
4011	346659.722	4833791.552	147.771	0.051
4012	341253.542	4850230.938	117.054	0.066
4013	365755.335	4850848.505	89.794	0.016
4014	387079.803	4849124.094	63.403	0.023
4015	399373.892	4854078.337	74.408	0.0116
4016	410123.946	4861239.124	53.992	0.172
4017	394130.379	4863855.298	62.737	0.077
4018	378210.373	4871023.864	135.977	0.073
4019	364020.432	4876003.148	140.031	0.071
4020	342026.589	4876058.981	128.727	0.037
4005	338795.118	4806416.465	92.155	0.0153
4021	418428.248	4937573.083	137.643	0.033
4022	429089.127	4911771.698	144.063	0.147
4023	454640.675	4915153.999	70.408	0.052

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
4024	458044.812	4921013.706	102.876	0.184
4025	459922.403	4943559.494	41.729	0.079
4026	454062.306	4952815.936	48.023	0.247
4027	447286.659	4939458.151	64.312	0.038
4028	449476.296	4935250.215	53.782	0.078
4029	437765.258	4928884.496	104.422	0.002
4030	436437.53	4919847.783	125.158	0.172

ACCURACY CONCLUSIONS

Tall Weeds and Crops Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.206 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Tall Weeds and Crops Errors larger than 95th percentile include:

- Point 4026, Easting 454062.306, Northing 4952815.936, Z-Error 0.247 meters

Table 5.6: Quality Check Point Analysis, Brush Lands and Trees, UTM 19N, NAD83, NAVD88 GEOID12A, NRCS Maine

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
5000	349194.698	4794238.117	113.767	0.183
5001	358412.025	4795629.513	42.524	0.076
5002	362560.782	4806715.978	73.033	0.057
5003	348869.868	4808409.803	94.277	0.073
5004	338775.141	4805709.339	92.539	0.051
5005	360773.013	4821610.206	78.971	0.169
5006	372885.171	4822136.817	58.535	0.245
5007	362716.42	4829054.53	105.33	0.11
5008	342121.868	4833946.856	191.35	0.1
5009	340127.257	4850930.196	114.978	0.262

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
5010	366833.502	4850971.274	93.782	0.088
5011	387057.655	4849337.878	62.089	0.191
5012	399163.735	4854499.456	82.614	0.176
5013	410385.69	4861902.123	65.72	0.16
5014	378181.112	4871102.903	135.754	0.166
5015	363981.26	4876592.987	124.825	0.105
5016	340924.476	4875637.288	123.143	0.137
5017	418074.214	4937903.025	108.685	0.035
5019	460041.589	4925401.969	66.898	0.212
5020	460049.836	4944321.37	43.181	0.179
5021	447244.353	4939662.425	70.346	0.224
5022	444278.72	4922805.369	53.2	0.02
5023	426152.355	4929506.997	98.169	0.211
5024	413851.536	4917938.043	198.841	0.199
5025	449480.131	4935280.892	54.536	0.204

ACCURACY CONCLUSIONS

Brush Lands and Trees Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.257 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Brush Lands and Trees Errors larger than 95th percentile include:

- Point 5009, Easting 340127.257, Northing 4850930.196, Z-Error 0.262 meters

Table 5.7: Quality Check Point Analysis, Forested and Fully Grown, UTM 19N, NAD83, NAVD88 GEOID12A

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
6000	352411.756	4789753.213	44.535	0.0453
6001	349351.009	4794361.944	114.469	0.0094

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
6002	358867.861	4795600.867	37.303	0.0529
6003	361746.633	4806971.384	72.031	0.0312
6004	348250.094	4808878.608	118.454	0.0037
6005	338699.33	4806447.184	94.552	0.0018
6006	345608.114	4822275.267	217.444	0.1064
6007	360775.26	4821400.979	79.61	0.0095
6008	372284.525	4821599.642	62.887	0.0527
6009	380059.696	4828562.669	52.157	0.053
6010	364209.885	4831570.433	106.878	0.0483
6011	346727.595	4833942.404	148.96	0.0201
6012	340141.866	4850994.208	118.594	0.1564
6013	364858.698	4851542.492	95.38	0.06
6014	387095.892	4849229.583	64.54	0.0598
6015	399589.999	4854108.72	69.614	0.0242
6016	410186.191	4861260.82	52.903	0.1931
6017	394263.091	4863498.14	59.201	0.0089
6018	378132.472	4871072.18	136.459	0.0187
6019	364033.941	4876387.626	131.031	0.071
6020	348310.919	4876629.294	133.232	0.1185
6021	418301.969	4937725.315	127.811	0.011
6022	429043.086	4911699.447	142.936	0.164
6023	454512.098	4915258.424	70.403	0.127
6024	459148.325	4922979.854	63.786	0.006
6025	460008.383	4944416.321	44.302	0.002
6026	453939.009	4952827.776	47.128	0.172
6027	447195.117	4939633.979	71.566	0.114
6029	439395.521	4929863.173	80.925	0.115

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Abs. Dz (meters)
6028	449459.813	4935140.771	55.647	0.093
6030	436546.598	4919852.081	129.208	0.012

ACCURACY CONCLUSIONS

Forested and Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.180 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Forested and Fully Grown Errors larger than 95th percentile include:

- Point 6016, Easting 410186.1908, Northing 4861260.8198 Z-Error 0.193 meters

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT

ACCURACY CONCLUSIONS

Consolidated Vertical Accuracy (CVA) Tested 0.201 meters consolidated vertical accuracy at the 95th percentile level, tested against the DEM. Consolidated errors larger than 95th percentile include:

- Point 5025, Easting 449480.131, Northing 4935280.892, Z-Error 0.204 meters
- Point 5023, Easting 426152.355, Northing 4929506.997 Z-Error 0.211 meters
- Point 5019, Easting 460041.589, Northing 4925401.969, Z-Error 0.212 meters
- Point 5021, Easting 447244.353, Northing 4939662.425, Z-Error 0.224 meters
- Point 5006, Easting 372885.171, Northing 4822136.817, Z-Error 0.245 meters
- Point 4026, Easting 454062.306, Northing 4952815.936, Z-Error 0.247 meters
- Point 5009, Easting 340127.257, Northing, 4850930.196 Z-Error 0.262 meters

Approved By:			
Title	Name	Signature	Date
Associate LiDAR Specialist Certified Photogrammetrist #1281	Qian Xiao		May 2014

SECTION 6: FLIGHT LOGS

FLIGHT LOGS

Flight logs for the project are shown on the following pages.

Woolpert

Leica LIDAR					
	11/5/2013	309	73683		maine

Operator	Aircraft		Local Start Time	Local End Time	Base
SMITH	N7079F	2828.8	2:21:00	19:21:00	
Pilot	**Sensor Type**	**Flight Line**	**Local End Time**	**Data End Time**	**POC**
ALBERS	ALS-7108	2832.3	5:55:00	22:55:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Haz/Cloud		
210/7	10			8				Departing	wvl
								Arriving	wvl

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up		Single		A	135
				Gain - Fine/Down		Multi	x	B	140

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	19:13:00
		↑ Times entered are Zulu / GMT ↑						Verify 2 Turns before Mission	Yes x No
1	w	19:32:00	19:36:00	15:23:00	16	0.6	1		
2	e	19:39:00	19:44:00	0:00:00	18	0.6	1		
3	w	19:47:00	19:51:00	0:00:00	18	0.6	1		
4	e	19:54:00	19:59:00	0:00:00	17	0.6	1		
5	w	20:02:00	20:06:00	0:00:00	17	0.6	1.1		
6	e	20:09:00	20:13:00	0:00:00	19	0.6	1		
7	w	20:17:00	20:20:00	0:00:00	17	0.6	1.1		
8	e	20:22:00	20:26:00	0:00:00	17	0.6	1.1		
9	w	20:29:00	20:33:00	0:00:00	17	0.6	1.2		
10	e	20:35:00	20:39:00	0:00:00	18	0.6	1.2		
11	w	20:41:00	20:45:00	0:00:00	18	0.6	1.2		
12	e	20:50:00	20:56:00	0:00:00	19	0.6	1.1		
13	w	20:59:00	21:10:00	0:00:00	19	0.6	1.1		
14	e	21:12:00	21:23:00	0:00:00	19	0.6	1.1		
15	w	21:26:00	21:37:00	0:00:00	18	0.6	1.3		
16	e	21:39:00	21:51:00	0:00:00	17	0.6	1.3		
17	w	21:53:00	22:04:00	0:00:00	19	0.6	1.1		
18	e	22:07:00	22:18:00	0:00:00	19	0.6	1.1		
19	w	22:20:00	22:31:00	0:00:00	20	0.6	1.1		
20	e	22:34:00	22:45:00	0:00:00	21	0.6	1		
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments:	Drive #

Woolpert

Leica LIDAR					
	11/6/2013	330	73683		maine

Operator	Aircraft	Flight #	Local Start Time	Local End Time	Base
SMITH	N7079F	2832.3	9:23:00	14:23:00	
Pilot	**Sensor Type**	**Flight Min**	**Local End Time**	**Daily End Time**	**POC**
ALBERS	ALS-7108	2836.7	1:44:00	18:44:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
	10			3	0	3034		Departing	wvl
								Arriving	wvl

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up		Single		A	135
				Gain - Fine/Down		Multi	x	B	140

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	14:15:00
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns Before Mission	Yes x No
21	w	14:35:00	14:47:00	5:50:00	17	0.8	1.5		
22	e	14:49:00	15:01:00	0:00:00	15	0.7	1.4		
23	w	15:04:00	15:16:00	0:00:00	18	0.6	1.1		
24	e	15:19:00	15:31:00	0:00:00	19	0.6	1.1		
25	w	15:34:00	15:46:00	0:00:00	20	0.6	1		
26	e	15:49:00	16:00:00	0:00:00	19	0.6	1		
27	w	16:03:00	16:15:00	0:00:00	16	0.6	1.2		
28	e	16:17:00	16:29:00	0:00:00	18	0.6	1		
29	w	16:32:00	16:46:00	0:00:00	19	0.6	1.1		
30	e	16:48:00	17:01:00	0:00:00	19	0.6	1.1		
35	w	17:04:00	17:16:00	0:00:00	18	0.6	1.1		
36	e	17:18:00	17:30:00	0:00:00	17	0.6	1.2		
37	w	17:32:00	17:44:00	0:00:00	17	0.6	1.2		
38	e	17:47:00	17:59:00	0:00:00	17	0.6	1.1	clouds wp 51	
31	w	18:02:00	18:16:00	0:00:00	18	0.6	1.1	clouds wp 51	
32	e	18:18:00	18:31:00	0:00:00	17	0.6	1.1	clouds wp 55,60-end	
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments:

Drive #

Woolpert

Leica LIDAR					
	11/9/2013	313	73683		maine

Operator	Aircraft	Aircraft Hobbs	Local Start Time	Local End Time	Base
SMITH	N7079F	2836.7	11:59:00	16:59:00	
Pilot	**Sensor Type**	**Flight Hobbs**	**Local End Time**	**Daily End Time**	**POC**
ALBERS	ALS-7108	2840.0	3:21:00	20:21:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
270/6	10			4	-8	3003		Departing	wvl
								Arriving	wvl

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up		Single		A	135
				Gain - Fine/Down		Multi	x	B	140

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	16:50:00
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns before Mission	Yes x No
32	e	17:09:00	17:14:00	10:35:00	17	0.7	1.2	refit clouds	
30	w	17:17:00	17:18:00	0:00:00	17	0.7	1.2	refit	
47	w	17:25:00	17:26:00	0:00:00	16	0.7	1.2		
46	e	17:31:00	17:39:00	0:00:00	17	0.7	1.1	clouds 33,34	
45	w	17:42:00	17:51:00	0:00:00	20	0.7	1		
44	e	17:54:00	18:04:00	0:00:00	19	0.7	1		
43	w	18:07:00	18:16:00	0:00:00	17	0.7	1.1		
42	e	18:19:00	18:28:00	0:00:00	17	0.7	1.1	clouds 28,29	
41	w	18:32:00	18:43:00	0:00:00	15	0.7	1.3		
40	e	18:46:00	18:57:00	0:00:00	15	0.7	1.3		
39	w	19:00:00	19:12:00	0:00:00	16	0.7	1.1	****	
34	e	19:15:00	19:27:00	0:00:00	17	0.7	1	****	
33	w	19:30:00	19:43:00	0:00:00	21	0.7	1	****	
32	e	19:53:00	19:58:00	0:00:00	18	0.7	1	****	
31	w	20:01:00	20:04:00	0:00:00	18	0.7	1.1	****	
42	e	20:09:00	20:10:00	0:00:00	18	0.7	1.2	****	
46	e	20:12:00	20:13:00		18	0.7	1.2	****	
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
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				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments: Drive #

****– bg% returns less than 80%– various % on each line–warning stayed on throughout lines

Woolpert

Leica LIDAR					
	11/16/2013	329	73683		maine

Operator	Aircraft		Local Start Time	Local End Time	Base
SMITH	N7079F	2844.1	9:36:00	14:36:00	
Pilot	**Sensor Type**	**Flight Log #**	**Local End Time**	**Daily End Time**	**PIC**
ALBERS	ALS-7108	2846.0	11:30:00	16:30:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
calm	10			2	-2	3026		Departing	wvl
								Arriving	wvl

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up		Single		A	135
				Gain - Fine/Down		Multi	x	B	135

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	14:20:00
		↑ Times entered are Zulu / GMT ↑						Verify 2 Turns before Mission	Yes x No
33	w	14:45:00	14:59:00	6:15:00	19	0.6	1.1		
34	e	15:01:00	15:14:00	0:00:00	20	0.6	1		
39	w	15:17:00	15:29:00	0:00:00	17	0.6	1.2		
40	e	15:31:00	15:43:00	0:00:00	18	0.6	1.1		
41	w	15:46:00	15:57:00	0:00:00	16	0.6	1.2		
42	e	16:00:00	16:10:00	0:00:00	19	0.6	1		
43	w	16:13:00	16:22:00	0:00:00	18	0.6	1.1		
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	Date (mm/dd/yyyy)	Julian Date	Project #	Flight #	Project Name
	11/16/2013	320	73683		maine

Operator	Aircraft #	Aircraft Start	Local Start Time	Local End Time	Base
SMITH	N7079F	2846.4	1:43:00	18:43:00	
Pilot	**Sensor Type**	**Aircraft End**	**Local End Time**	**Daily End Time**	**POC**
ALBERS	ALS-7108	2850.2	5:30:00	22:30:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
calm	10							Departing	pwm
								Arriving	pwm

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up		Single		A	135
				Gain - Fine/Down		Multi	x	B	135

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	18:30:00
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns before Mission	Yes x No
1	s	19:02:00	19:15:00	14:47:00	20	0.6	0.9		
2	n	19:17:00	19:30:00	0:00:00	20	0.6	0.9		
3	s	19:33:00	19:46:00	0:00:00	18	0.6	1.1		
4	n	19:49:00	20:02:00	0:00:00	18	0.6	1.2		
5	s	20:05:00	20:18:00	0:00:00	19	0.6	1.1		
6	n	20:21:00	20:34:00	0:00:00	19	0.6	1.1		
7	s	20:36:00	20:49:00	0:00:00	19	0.6	1.1		
8	n	20:52:00	21:05:00		17	0.6	1.3		
9	s	21:07:00	21:20:00		20	0.6	1.1		
10	n	21:23:00	21:36:00		19	0.6	1.1		
11	s	21:38:00	21:51:00		20	0.6	1.1		
12	n	21:54:00	22:06:00		21	0.6	1		
13	s	22:09:00	22:21:00		16	0.6	1.3		
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments:

Drive #

Woolpert

Leica LIDAR					
	11/20/2013	324	73683		maine south

Operator	Aircraft		Local Start Time	Local End Time	Base
SMITH	N7079F	2850.2	9:24:00	14:24:00	
Pilot	**Sensor Type**	**Flight Hrs**	**Local End Time**	**Daily End Time**	**POC**
ALBERS	ALS-710B	2856.4	3:39:00	20:39:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
330/11	10			1	-12	3047		Departing	pwm
								Arriving	pwm

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	135
				Gain - Fine/Down	12	Multi	x	B	135

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No	x	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	8:30:00
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns Before Mission	Yes x No
14	n	14:36:00	14:49:00	5:56:00	20	0.6	1		
15	s	14:52:00	15:04:00	0:00:00	20	0.6	1		
16	n	15:07:00	15:20:00	0:00:00	17	0.6	1.2		
17	s	15:23:00	15:35:00	0:00:00	18	0.6	1.1		
18	n	15:38:00	15:51:00	0:00:00	19	0.6	1		
19	s	15:53:00	16:05:00	0:00:00	19	0.6	1.1		
20	n	16:08:00	16:20:00	0:00:00	17	0.6	1.2		
21	s	16:22:00	16:35:00		17	0.6	1.2		
22	n	16:38:00	16:50:00		17	0.6	1.1		
23	s	16:53:00	17:05:00		19	0.6	1		
24	n	17:09:00	17:21:00		17	0.6	1.1		
25	s	17:24:00	17:36:00		17	0.6	1.1		
79	s	17:43:00	17:47:00		15	0.6	1.3		
80	n	17:49:00	17:56:00		15	0.6	1.3		
81	s	17:59:00	18:05:00		15	0.6	1.3		
82	n	18:09:00	18:16:00		15	0.6	1.2		
83	s	18:19:00	18:25:00		16	0.6	1.2		
84	n	18:28:00	18:36:00		17	0.6	1		
85	s	18:39:00	18:46:00		19	0.6	1		
86	n	18:49:00	18:57:00		17	0.6	1		
87	s	18:59:00	19:08:00	0:00:00	19	0.6	0.9		
88	n	19:11:00	19:19:00	0:00:00	18	0.6	1		
89	s	19:21:00	19:30:00	0:00:00	18	0.6	1.1		
90	n	19:33:00	19:42:00	0:00:00	18	0.6	1.2		
91	s	19:44:00	19:53:00	0:00:00	18	0.6	1.3		
92	n	19:56:00	20:05:00	0:00:00	19	0.6	1.1		
93	s	20:08:00	20:17:00	0:00:00	18	0.6	1.2		
94	n	20:20:00	20:30:00	0:00:00	18	0.6	1.2		
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes x No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	Mission Date/UTC	Julian Date	Project #	Flight #	Project Name
	11/23/2013	327	73683	2	Maine Lidar NRCS

Operator	Aircraft	Aircraft Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N404CP	4525.5	9:27:00	14:27:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Aircraft End**	**Local End Time**	**Zulu End Time**	**POC**
GEBHART	ALS-7177	4532.,4	3:51:00	20:51:00	Near Fed Ex (8:23L)

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
320 15 28	10	Clear		3	-6	2982		Departing	KPWM
								Arriving	KPWM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	6447	Ft	Yes		No	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a	14:26:26	14:26:38	n/a	n/a	n/a	n/a	GPS Began Logging At:	14:02:35
		↑ Times entered are Zulu / GMT ↑						Verify 2 Turns before Mission	Yes X No
78	N	14:27:11	14:28:26	#VALUE!	20	0.6	1.1	Takeoff at:14:11	
77	S	14:32:26	14:34:10	0:00:00	20	0.6	1.1		
76	N	14:38:50	14:41:22	0:00:00	19	0.6	1.1		
75	S	14:45:23	14:48:18	0:00:00	18	0.6	1.2		
74	N	14:52:38	14:55:56	0:00:00	16	0.6	1.2		
73	S	14:59:52	15:03:32	0:00:00	18	0.6	1.2	River	
72	N	15:08:01	15:12:36	0:00:00	18	0.6	1		
71	S	15:16:42	15:21:27	0:00:00	18	0.7	1		
70	N	15:26:17	15:31:50	0:00:00	19	0.6	1		
69	S	15:35:41	15:40:52	0:00:00	19	0.6	1		
68	N	15:45:28	15:51:23	0:00:00	19	0.6	1		
67	S	15:56:00	16:01:42	0:00:00	18	0.6	1.1		
66	N	16:05:51	16:12:16	0:00:00	17	0.7	1.2		
65	S	16:15:01	16:21:58	0:00:00	17	0.7	1.2		
64	N	16:25:58	16:32:55	0:00:00	17	0.7	1.2		
63	S	16:36:42	16:42:37	0:00:00	17	0.7	1.1		
62	N	16:47:32	16:54:46	0:00:00	19	0.6	0.9		
61	S	16:58:23	17:04:41	0:00:00	17	0.6	1.1		
60	N	17:09:50	17:17:37	0:00:00	17	0.6	1.1		
59	S	17:21:09	17:28:35	0:00:00	17	0.6	1.1		
58	N	17:34:07	17:42:50	0:00:00	15	0.7	1.1		
57	S	17:46:18	17:55:09	0:00:00	15	0.7	1.3		
56	N	17:58:44	18:08:25	0:00:00	15	0.7	1.2		
55	S	18:12:15	18:21:38	0:00:00	16	0.7	1.1		
54	N	18:25:29	18:35:54	0:00:00	20	0.6	0.9		
53	S	18:39:19	18:49:34	0:00:00	20	0.6	1		
52	N	18:54:00	19:05:06	0:00:00	19	0.6	1		
51	S	19:09:00	19:19:45	0:00:00	18	0.7	1.1		
50	N	19:23:58	19:35:10	0:00:00	18	0.7	1.3		
49	S	19:39:15	19:51:00	0:00:00	19	0.6	1.2		
48	N	19:55:09	20:06:40	0:00:00	19	0.6	1.2		
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes X No

Additional Comments:	Drive #
	ALS 70 #4

Woolpert

Leica LIDAR					
	11/25/2013	329	73683	2	Maine Lidar NRCS

Operator	Aircraft				
GALAMBOS	N404CP	4532.4	12:06:00	17:06:00	WOOLPERT PIN
Pilot	Sensor Type				
GEBHART	ALS-7177	4539.1	7:22:00	23:22:00	Near Fed Ex (8:00L)

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Haz/Cloud		
330 14	10	Clear		-2	-21	3021		Departing	KPWM
								Arriving	KPWM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	6447	Ft	Yes		No	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a	17:04:48	17:05:03	n/a	n/a	n/a	n/a	GPS Began Logging At:	16:45:02
		* Times entered are Zulu / GMT *						Verify 2-Turns Before Mission	Yes x No
44	N	17:06:18	17:17:57	10:52:36	17	0.7	1	Takeoff at: 16:53	
43	S	17:21:10	17:31:26	0:00:00	16	0.7	1.3	Large long lake	
42	N	17:35:09	17:46:40	0:00:00	15	0.7	1.3	Light dusting of snow north end	
41	S	17:50:09	18:00:30	0:00:00	16	0.7	1.1		
40	N	18:04:09	18:18:38	0:00:00	16	0.7	1.2		
39	S	18:22:25	18:35:53	0:00:00	20	0.6	0.9		
38	N	18:40:22	18:55:02	0:00:00	18	0.6	1		
37	S	18:59:03	19:13:15	0:00:00	18	0.7	1.1		
36	N	19:17:29	19:32:32	0:00:00	18	0.7	1.2		
35	S	19:36:14	19:50:22	0:00:00	19	0.6	1.1		
34	N	19:54:33	20:08:32	0:00:00	18	0.7	1.2		
33	S	20:12:12	20:26:25	0:00:00	17	0.7	1.3		
32	N	20:30:39	20:44:09	0:00:00	20	0.6	1		
31	S	20:49:52	21:01:16	0:00:00	19	0.6	1.1		
30	N	21:05:30	21:18:42	0:00:00	21	0.5	1		
29	S	21:22:34	21:36:08	0:00:00	21	0.7	1		
28	N	21:29:58	21:53:03	0:00:00	18	0.6	1.1		
27	S	21:56:56	22:10:32	0:00:00	19	0.6	1.1		
26	N	22:14:25	22:36:58	0:00:00	18	0.6	1.1		
124	S	22:40:33	22:41:12	0:00:00	19	0.7	1.2		
123	N	22:45:09	22:46:11	0:00:00	18	0.8	1.2		
122	S	22:49:50	22:52:04	0:00:00	16	0.9	1.2		
121	N	22:55:30	22:58:00	0:00:00	16	0.9	1.7		
120	S	23:01:38	23:04:32	0:00:00	16	0.8	1.7		
119	N	23:06:56	23:10:00	0:00:00	16	0.7	1.2		
118	S	23:12:36	23:16:00	0:00:00	16	0.7	1.2		
117	N	23:18:55	23:22:17	0:00:00	16	0.7	1.2	Landing: 23:34	
				0:00:00				Static: 23:38:15	
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes x No

Additional Comments:	Drive #
File_20131125_164136	ALS 70 #4

Woolpert

Leica LIDAR					
	11/29/2013	333	73683	2	Maine Lidar NRCS

GALAMBOS	N7079F	2860.7	8:49:00	1:49:00	WOOLPERT PIN
RADER	ALS-7177	2871.9	11:27:00	4:37:00	Near Fed Ex (8:23L)

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
360 10	10	Clear		-7	-14	30.69		Departing	KPWM
								Arriving	KPWM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	6447	Ft	Yes		No	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments
Test	n/a	1:45:11	1:46:00	n/a	n/a	n/a	n/a	GPS Began Logging At: 1:20:51
		↑ Times entered are Zulu / GMT ↑						Verify 2 Turns Before Mission Yes X No
45	N	1:48:43	1:53:04	4:04:59	14	0.8	1.3	Takeoff at:01:21 WPTS 50-40
21	N	1:58:52	2:06:07	0:00:00	15	0.7	1.1	WPTS 51-20
20	S	2:09:00	2:16:41	0:00:00	17	0.6	1	WPTS 15-50 RIVER
19	S	2:19:02	2:25:17	0:00:00	16	0.7	1.1	WPTS 48-22
13	N	2:28:04	2:29:52	0:00:00	16	0.7	1.1	Wpts 31-37
12	S	2:32:10	2:33:56	0:00:00	16	0.7	1.1	Wpts 38-32
11	N	2:36:14	2:39:48	0:00:00	16	0.7	1.1	Wpts 34-44, 50 ACTUAL
10	N	2:45:30	2:51:49	0:00:00	17	0.6	1.1	Wpts 60-32
18	S	3:00:13	3:12:06	0:00:00	17	0.6	1.1	Entire Line
22	N	3:14:17	3:26:41	0:00:00	15	0.7	1.3	Entire Line
23	S	3:29:00	3:41:32	0:00:00	16	0.7	1.3	Entire Line
24	N	3:43:54	3:56:30	0:00:00	16	0.7	1.4	Entire Line
25	S	3:58:39	4:11:20	0:00:00	16	0.7	1.6	Entire Line
79	S	4:17:34	4:20:32	0:00:00	18	0.6	1.3	Wpts 7-17
80	N	4:23:21	4:27:32	0:00:00	18	0.6	1.3	Wpts 28-10
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				Landing 04:42 (11:42)
				0:00:00				Static 04:44:47
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments:

FILE # 20131130_011719

Drive #

ALS#1

Woolpert

Leica LIDAR					
	11/30/2013	334	73683		73683 Maine

Operator	Aircraft	Aircraft Start	Local Start Time	Local End Time	Base
SIMMONS	N7079F	2871.9	8:50:00	13:50:00	WOOLPERT FIN
Pilot	**Sensor Type**	**Aircraft End**	**Local End Time**	**Daily End Time**	**FBO**
SWAIN	ALS-7177	2876.2	13:20:00	18:20:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
CALM	10 SM	CLR		8	-13	3081		Departing	KPWN
								Arriving	KPWN

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft		Ft	Yes		No	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:
		↑ Times entered are Zulu / GMT ↑						Verify 2 Turns Before Mission: Yes X No
81	N	14:08:00	14:13:00					REFLIGHT - PARTIAL
82	S	14:18:00	14:25:00					
83	N	14:28:00	14:35:00					
84	S	14:38:00	14:46:00					
85	N	14:49:00	14:57:00					
86	S	15:01:00	15:09:00					
87	N	15:12:00	15:20:00					
88	S	15:24:00	15:32:00					
89	N	15:35:00	15:44:00					
90	S	15:47:00	15:57:00					
91	N	15:59:00	16:08:00					
92	S	16:12:00	16:21:00					
93	N	16:24:00	16:33:00					
94	S	16:37:00	16:47:00					CLOUDS W/P 32, 36, 37---TO THE EN
95	N	16:49:00	16:59:00					CLOUDS W/P 44-29
96	S	17:02:00	17:09:00					CLOUDS W/P 26-29 STOPPED LASER
97	N	17:15:00	17:20:00					MANUAL START AT W/P 23; CLOUD
98	S	17:23:00	17:27:00					STOPPED AT W/P 18
99	N	17:30:00	17:34:00					STARTED AT W/P 18
100	S	17:37:00	17:42:00					STOPPED AT W/P 18
101	N	17:45:00	17:49:00					STARTED AT W/P 18; CLOUD AT W/P
102	S	17:52:00	17:54:00					STOPPED AT W/P 13; CLOUDS ON W

↑ Times entered are Zulu / GMT ↑		Page	1	Verify S-Turns After Mission: Yes X No	
Additional Comments:					Drive #

Woolpert

Leica LIDAR	Mission Date	Day of Year	Project #	Flight #	Project Name
	12/4/2013	338	73683	2	Maine Lidar NRCS

Operator	Aircraft	Aircraft Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N7079F	2880.1	9:22:00	14:22:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Aircraft End**	**Local End Time**	**Zulu End Time**	**Pilot**
RADER	ALS-7177	2884.9	1:03:00	18:03:00	Near Fed Ex (7:45L)

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
260 4	10	Clear	0	-2	-5	3003		Departing	KPWM
								Arriving	KPWM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used			Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	6447	Ft	Yes		No	X	@ NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	15:58:36
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission	Yes X No
96	S	14:22:10	14:28:32	5:08:51	18	0.6	1.2	Takeoff:14:07 WPTS 20-45	
97	N	14:31:11	14:37:40	0:00:00	17	0.6	1.1	wpts 46-19	
98	S	14:40:30	14:47:26	0:00:00	18	0.6	1.1	wpts 16-46	
99	N	14:50:10	14:57:39	0:00:00	19	0.6	1.1	wpts 47-15	
100	S	15:00:08	15:20:53	0:00:00	19	0.6	1.1	wpts 14-47	
101	N	15:10:16	15:33:25	0:00:00	17	0.7	1.2	wpts 47-14	
102	S	15:23:28	15:46:42	0:00:00	17	0.7	1.2	Entire Line end of reflights	
103	N	15:36:08	15:59:20	0:00:00	17	0.7	1.2	fresh lines	
104	S	15:49:33	15:59:20	0:00:00	16	0.7	1.3		
105	N	16:02:07	16:12:05	0:00:00	19	0.6	1.1		
106	S	16:14:43	16:24:05	0:00:00	18	0.6	1.1		
107	N	16:26:45	16:36:19	0:00:00	17	0.6	1.1		
108	S	16:38:38	16:47:42	0:00:00	17	0.6	1.1		
109	N	16:50:10	16:59:15	0:00:00	15	0.7	1.3		
110	S	17:01:33	17:10:21	0:00:00	15	0.7	1.3		
111	N	17:12:55	17:21:33	0:00:00	15	0.7	1.2		
112	S	17:23:37	17:28:29	0:00:00	15	0.7	1.2		
113	N	17:30:51	17:35:33	0:00:00	16	0.7	1.1	MM diskspace is low 68%	
114	S	17:37:45	17:42:01	0:00:00	16	0.7	1.2		
115	N	17:44:38	17:48:42	0:00:00	17	0.7	1.1		
116	S	17:50:58	17:54:40	0:00:00	19	0.7	1		
96	S	18:00:19	18:02:48	0:00:00	18	0.6	1	REFLIGHT NORTH END WPT 20-30	
				0:00:00				Landing: 18:14	
				0:00:00				Base Station File # 32983380.to1	
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00				ALS File #20131204_135508	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes X No

Additional Comments:	Drive #
	ALS#1

SECTION 7: FINAL DELIVERABLES

FINAL DELIVERABLES

The final LiDAR deliverables are listed below.

- LAS v1.2 classified point cloud
- LAS v1.2 raw unclassified point cloud flight line strips no greater than 2GB. Long swaths greater than 2GB will be split into segments)
- Hydrologically flattened Polygon z and Polyline z shapefiles
- Hydrologically flattened bare earth 1-meter DEM in ERDAS .IMG format
- 8-bit gray scale intensity images
- Tile Layout and data extent provided as ESRI shapefile
- Control points provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- LiDAR processing report in pdf format
- Survey report in pdf format

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