AIRBORNE LIDAR TASK ORDER REPORT

GRAND TETON AND NATIONAL ELK REFUGE LIDAR
UNITED STATES GEOLOGICAL SURVEY (USGS)

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WOOLPERT
DESIGN | GEOSPATIAL | INFRASTRUCTURE

PROJECT REPORT

USGS GRAND TETON AND NATIONAL ELK REFUGE LIDAR PROCESSING

WOOLPERT PROJECT #74714

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SECTION 1: OVERVIEW

PROJECT NAME: GRAND TETON AND NATIONAL ELK REFUGE LIDAR

WOOLPERT PROJECT #74714

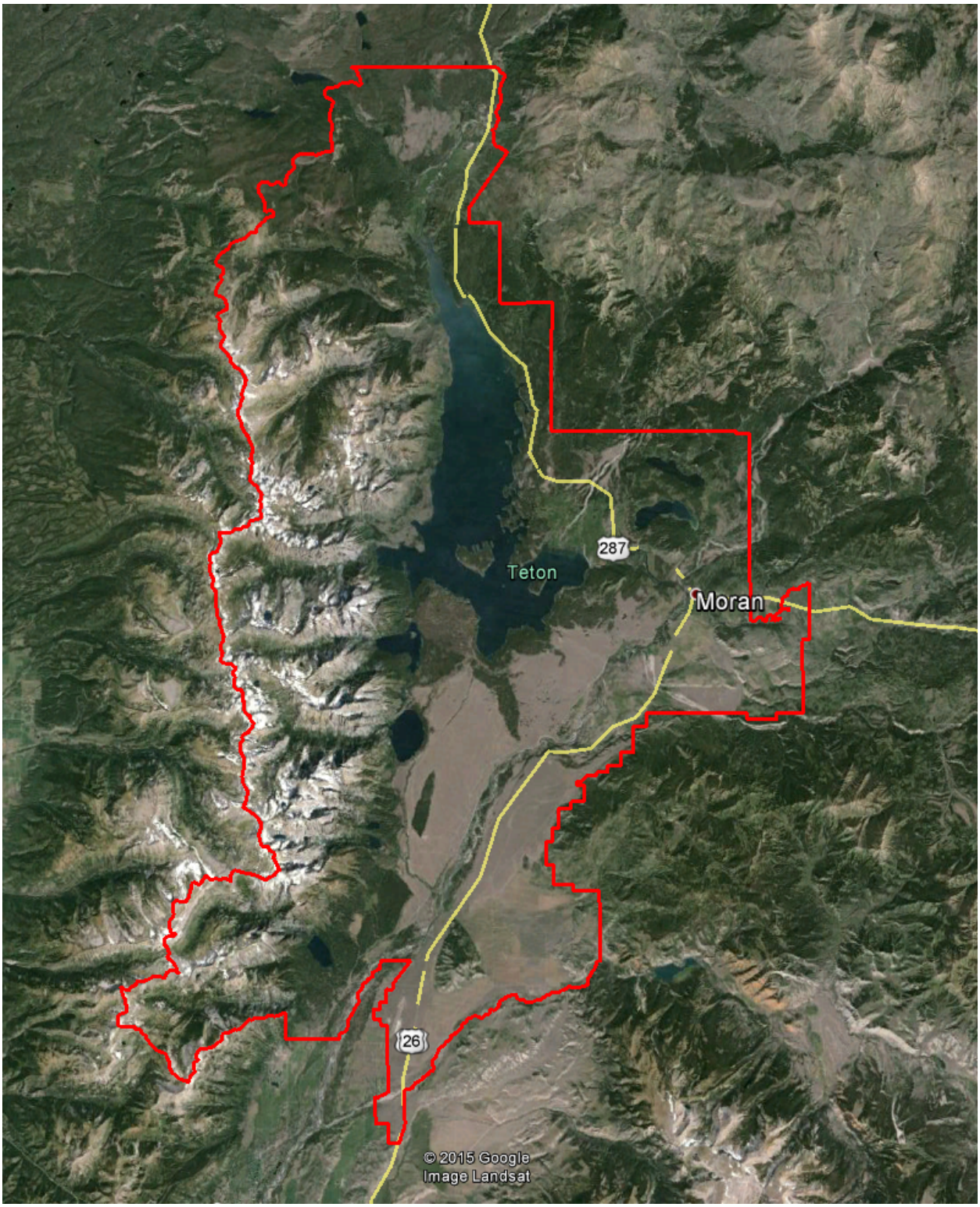
This report contains a comprehensive outline of the Grand Teton and National Elk Refuge Lidar Processing task order for the United States Geological Survey (USGS). This task is issued under Contract Number G10PC00057, as task order number G14PD00775. This task order requires lidar data to be acquired over several areas in Wyoming including Grand Teton National Park and National Elk Refuge as part of the Wyoming area of interest (AOI), and will be acquired as part of this task order. The total area of the Grand Teton and National Elk Refuge Lidar AOI is approximately 559 square miles. 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:	7,500 ft / 2,286 m
MSL (Mean Sea Level) average flying height:	variable
Average Ground Speed:	150 knots / 173 mph
Field of View (full):	32 degrees
Pulse Rate:	239 kHz
Scan Rate:	41.6 Hz
Side Lap (Average):	25%

The lidar data was processed and projected in UTM, Zone 12, 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 Woolpert Cessna aircraft. 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, 2015 Grand Teton and National Elk Refuge Task Order

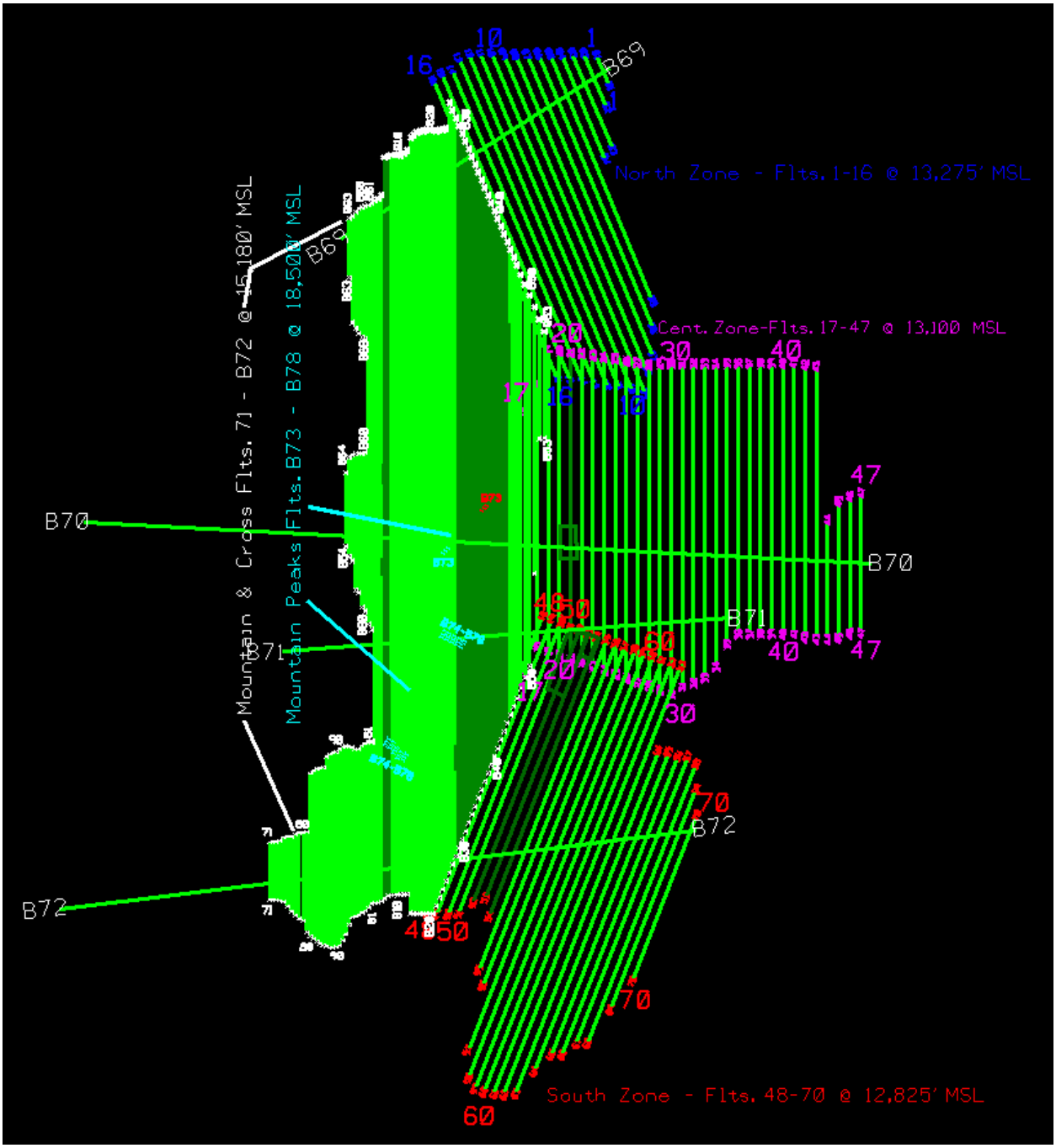


Table 2.2: Airborne Lidar Acquisition Flight Summary

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
August 27, 2014 – Sensor 7177	51-70	16:32 – 20:10	10:32AM – 02:10PM
August 29, 2014 - Sensor 7177	18-51	14:53 – 20:30	08:53AM - 02:30PM
September 2, 2014 – Sensor 7177	A1-A16,A54-A54,A71-A80,B63-B67	15:25 – 20:40	09:25AM – 02:40PM
September 3, 2014 – Sensor 7177	B46-B52	14:12 – 16:32	08:12AM – 10:32AM
September 5, 2014 – Sensor 7177_A	B30-B45	13:00 – 17:40	07:00AM – 11:40AM
September 5, 2014 – Sensor 7177_B	B03-B06,B28-B29,B54-B62,A80-A82	00:00 – 20:00	02:00PM – 06:00PM
September 6, 2014 – Sensor 7177	B7-B27	13:45 – 19:35	07:45AM – 01:35PM
September 7, 2014 – Sensor 7177	A82-A89	14:10 – 15:45	08:10AM – 09:45AM
September 8, 2014 – Sensor 7177	A21,A88-A99,B1-B4,B6-B7,B23,B29,B30-B44,B73-B78	13:30 – 19:40	07:30AM – 01:40PM
September 10, 2014 – Sensor 7177	B70,B72	13:45 – 15:15	07:45AM – 09:15AM
September 12, 2014 – Sensor 7177	B6,B69-B71	01:14 – 03:09	07:14PM – 09:09PM

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 a GNSS base station at the Jackson Hole Airport (KJAC).

The GNSS base station operated during the Lidar acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
KJAC Airport Base	43°35'52.23860"	-110°40'20.88187"	1944.008

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

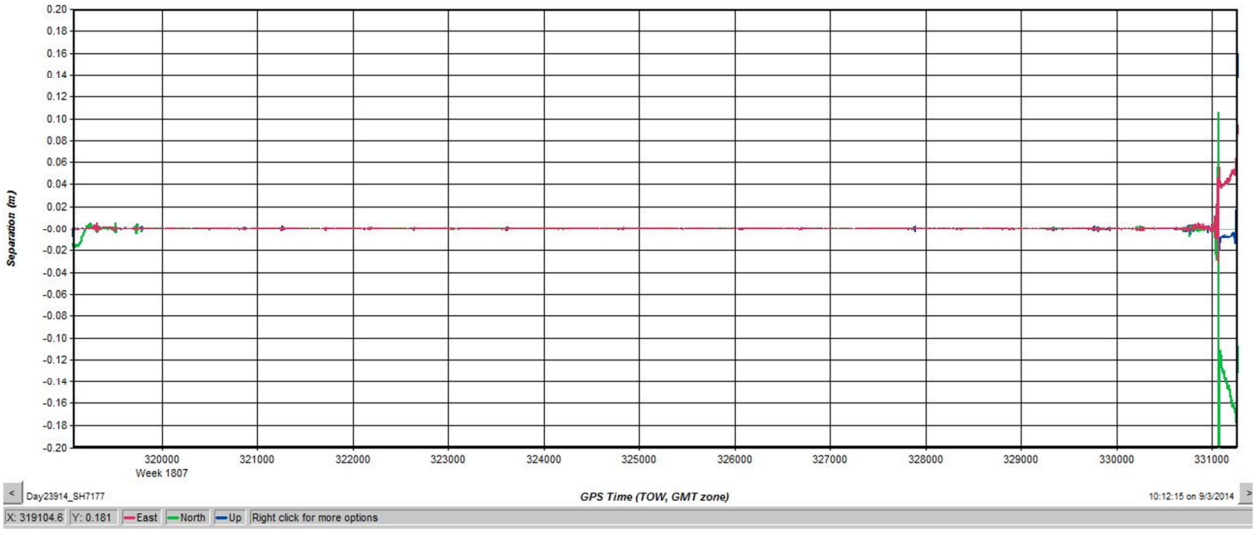
The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional 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, Day23914 SH7177

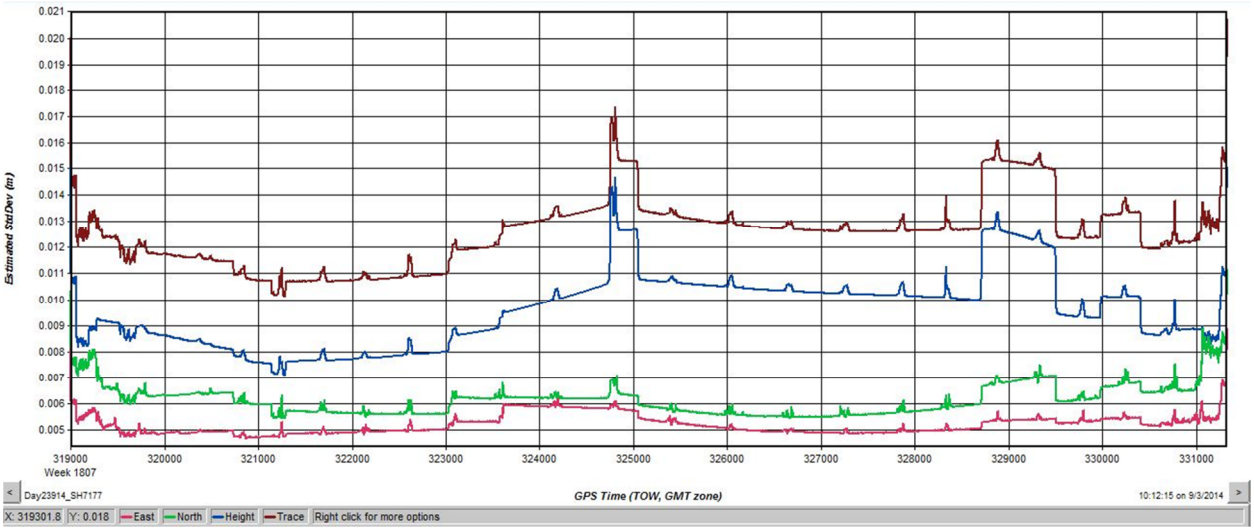


Estimated Positional Accuracy

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, Day23914 SH7177

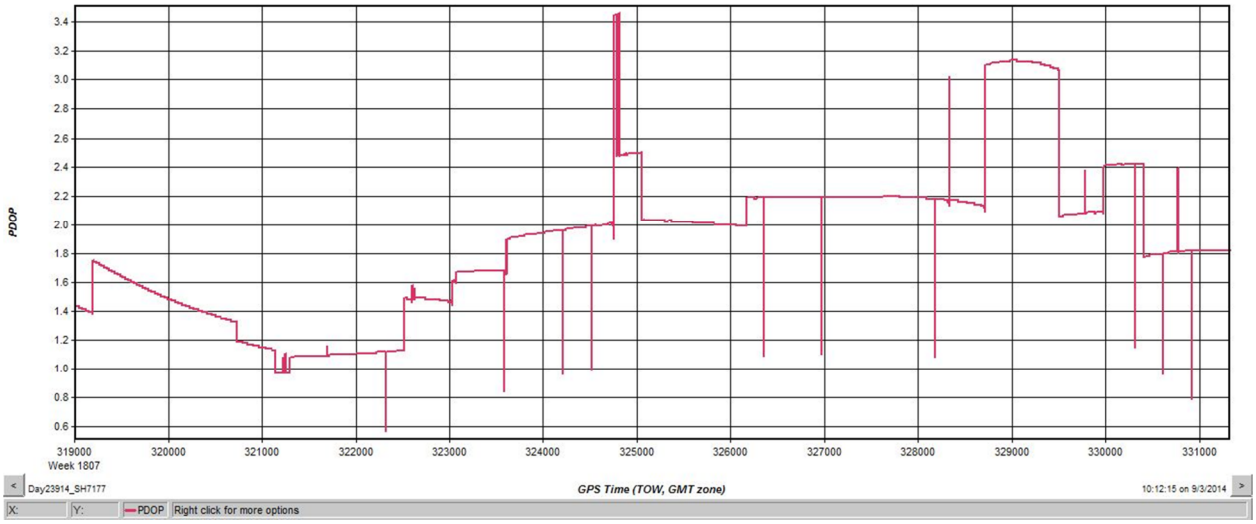


PDOP

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, Day23914 SH7177



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), Low Vegetation (Class 3), Buildings (Class 6), 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 UTM12N 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

Grand Teton and National Elk Refuge 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

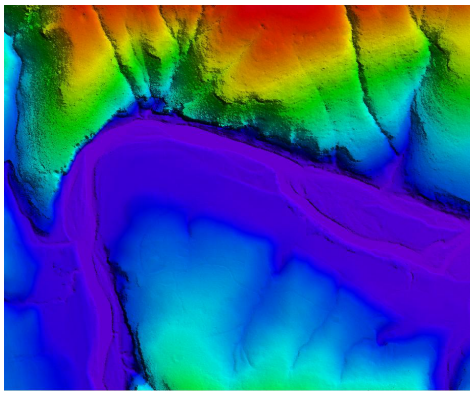
Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing lidar data.

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**

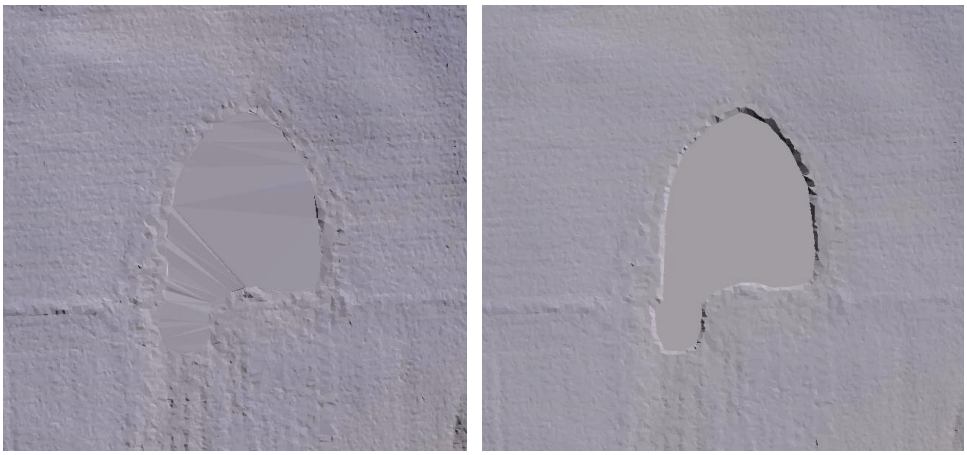


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

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	0.027	meters
Minimum error	-0.194	meters
Maximum error	0.135	meters
Root mean square	0.074	meters
Standard deviation	0.069	meters

Table 5.2: Swath Quality Check Point Analysis, FVA, UTM 12N, NAD83, NAVD88 GEOID12A, Grand Teton and National Elk Refuge Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2002	531033.4	4829949	2032.63	-0.045
2002A	531039	4829941	2033.09	0.005
2003	532965.7	4843396	2141.21	0.043
2003A	532965.1	4843401	2140.65	0.022
2004	524437.3	4834912	1988.24	0.075
2004A	524419.7	4834904	1988.05	0.046
2005	530925.4	4852282	2101.65	0.079
2005A	530910.1	4852294	2101.88	0.054
2006	539633.6	4854377	2057.38	0.006
2006A	539644.6	4854377	2057.37	0.033
2007	528971.3	4864258	2073.51	0.044
2007A	528966.4	4864264	2074	-0.008
2008	526066.6	4881967	2084.34	-0.035
2008A	526058.2	4881970	2084.16	-0.03

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2009	526816.3	4886725	2099.66	-0.074
2010A	517447.9	4885433	2205.09	0.072
2011	521722.5	4848328	2097.68	0.104
2011A	521734.2	4848304	2097.68	0.058
2012	517192.4	4830062	1966.09	0.069
2012A	517188.3	4830070	1966.65	0.079
2013	515614.9	4826997	1934.05	0.033
2013A	515611.9	4827000	1933.67	-0.028
2014	510067	4826905	3131.14	0.028
2014A	510066.3	4826876	3126.89	0.103
2015	523497	4846240	2086.25	0.037
2015A	523504.7	4846208	2086.86	0.06
2016	524930	4878863	2188.92	0.13
2016A	524933.1	4878872	2188.52	0.106
2017	524473.3	4849067	2128.85	0.009
2017A	524455.3	4849081	2128.76	0.079
2018	526853.3	4829353	2004.68	0.068
2018A	526841.7	4829361	2004.36	0.097
2019	522255.1	4844163	2069.54	0.015
2019A	522267.8	4844184	2069.77	0.006
2020	546039.5	4853582	2069.91	0.003
2020A	546048	4853577	2069.92	0.033
2101	521546.1	4823665	1948.37	0.135
2101A	521545.9	4823640	1948.36	0.094
2102	521577.6	4822842	1952.14	0.103
2102A	521597	4822839	1952.63	0.083
2103	521389	4821148	1949.11	0.11

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2103A	521389.6	4821170	1949.5	0.126
2104	520486.7	4818530	1899.67	0.062
2104A	520477.6	4818535	1900.06	0.08
2105	519275.6	4814685	1896.5	0.105
2105A	519276.9	4814676	1896.63	0.132
2106	520776.3	4814131	1916.46	0.046
2106A	520781.2	4814145	1916.16	0.065
2107	521527.9	4815541	1905.1	0.031
2107A	521536.1	4815535	1905.24	0.075
2108A	522521.8	4816840	1923.37	0.053
2109	524798	4819159	1934.59	0.048
2109A	524798.2	4819171	1934.69	-0.008
2110	526827.8	4819789	1972.2	0.01
2110A	526817.8	4819789	1972.07	-0.021
2111A	527193.3	4821718	1992.8	-0.073
2112	530212.9	4822883	2069.37	-0.194
2112A	530211.1	4822892	2069.32	-0.134
2113	531132.6	4826261	2059.24	-0.05
2113A	531124.3	4826256	2058.82	-0.078
2114	530471	4829281	2030.01	-0.005
2114A	530463.9	4829277	2029.87	-0.033
2115	533680.8	4832077	2057.79	-0.137
2115A	533651.8	4832060	2056.86	-0.144
2116	528613.3	4828965	2061.82	0.021
2116A	528620.9	4828963	2062.2	0.007
2117	527207.7	4827939	2017.6	0.04
2117A	527203.5	4827937	2017.46	0.036

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2118	526014.1	4827516	2014.86	0.054
2118A	526007.8	4827524	2014.95	0.064
2119	524822.6	4825910	1976.18	0.071
2119A	524829.8	4825927	1976.34	0.074
2120	524678.4	4826133	1976.66	0.049
2120A	524679.5	4826128	1976.56	0.022
2121	524795.3	4822221	1941.94	0.013
2121A	524794.9	4822230	1942.03	0.032
2122	529467.7	4826071	2031.26	-0.1
2122A	529473	4826076	2031.23	-0.139

VERTICAL ACCURACY CONCLUSIONS

LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.141 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 0.152 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.

SUPPLEMENTAL VERTICAL ACCURACY ASSESSMENTS

Table 5.3: Quality Check Point Analysis, Sage and Steppe, UTM 12N, NAD83, NAVD88 GEOID12A, Grand Teton and National Elk Refuge Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4002	531171.084	4830069.272	2032.099	-0.089
4002A	531168.495	4830074.955	2032.220	-0.13
4003	532141.767	4843607.541	2130.880	0.015
4003A	532147.884	4843609.591	2130.860	0.017

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4004	524405.477	4834850.205	1988.319	0.042
4004A	524401.445	4834824.386	1988.260	-0.043
4005	530986.483	4852261.208	2101.389	0.186
4005A	530995.072	4852290.731	2101.500	0.084
4006	539668.479	4854320.607	2055.389	0.035
4006A	539671.899	4854325.62	2055.440	0.003
4007	528927.456	4864342.103	2082.380	0.141
4007A	528923.159	4864352.858	2082.980	-0.011
4008	526326.057	4882148.92	2090.010	0.011
4008A	526307.566	4882140.621	2089.829	0.038
4009	526840.835	4886689.521	2100.040	-0.03
4009A	526854.142	4886686.864	2100.079	-0.035
4010	517838.448	4884931.316	2187.340	0.263
4010A	517824.475	4884936.505	2187.119	0.081
4011	522245.894	4848159.782	2102.480	0.046
4011A	522224.009	4848153.564	2102.199	-0.013
4012	517262.394	4829851.89	1958.270	0.04
4012A	517268.046	4829852.756	1958.150	0.003
4013	515739.25	4827047.782	1933.940	0.113
4013A	515748.35	4827050.771	1934.030	0.093
4014	510080.758	4826871.753	3125.360	0.034
4014A	510054.584	4826859.506	3124.820	0.087
4015	546046.342	4853615.818	2069.400	0.039
4015A	546051.897	4853624.735	2069.460	-0.031
4016	522687.017	4844477.277	2072.719	0.199
4016A	522669.597	4844489.573	2072.540	0.086
4017	526834.049	4829443.288	2004.770	0.16

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4017A	526814.773	4829428.332	2004.500	0.135
4018	522089.364	4881921.189	2141.559	0.079
4018A	522067.549	4881925.274	2141.420	0.118
4019	534142.445	4858842.516	2098.290	0.009
4019A	534138.953	4858832.623	2097.480	0.014
4020	536785.785	4847737.15	2079.309	0.044
4020A	536782.562	4847731.482	2079.219	0.067
4101	521503.103	4823606.356	1944.849	0.081
4101A	521488.145	4823601.626	1945.150	0.16
4102	521585.641	4822852.589	1951.900	0.157
4102A	521607.322	4822848.811	1952.069	0.147
4103	521415.566	4821157.31	1949.930	0.192
4103A	521409.679	4821135.689	1949.740	0.224
4104	520517.735	4818535.495	1897.819	0.13
4104A	520526.838	4818548.893	1897.980	0.149
4105	519760.287	4817142.628	1895.119	0.23
4105A	519770.601	4817150.383	1895.150	0.251
4106	520798.427	4814126.234	1920.210	0.151
4106A	520806.414	4814133.8	1922.079	0.191
4107	521530.044	4815572.704	1902.750	0.122
4107A	521530.983	4815579.18	1902.309	-0.032
4108	522573.943	4816819.929	1925.200	0.147
4108A	522582.278	4816808.174	1925.579	0.035
4109	523816.157	4818723.328	1918.339	0.06
4109A	523813.808	4818713.835	1918.319	0.131
4110	526995.872	4820011.472	1977.480	-0.058
4110A	526998.053	4820000.548	1977.390	-0.009

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4111	527067.845	4821706.783	1988.520	-0.024
4111A	527075.635	4821712.735	1989.569	-0.053
4112	530192.063	4822907.752	2068.840	-0.124
4112A	530184.825	4822914.111	2068.449	-0.189
4113	531152.418	4826258.592	2060.219	-0.054
4113A	531142.535	4826252.871	2059.550	-0.001
4114	530457.653	4829260.087	2029.819	-0.027
4114A	530457.44	4829248.26	2029.930	-0.022
4115	533603.15	4832063.762	2058.329	-0.003
4115A	533599.721	4832068.652	2058.809	-0.09
4116	528467.921	4828903.652	2050.719	-0.04
4116A	528475.642	4828907.389	2051.210	-0.012
4117	527222.251	4827939.984	2017.240	0.004
4117A	527230.798	4827944.025	2016.700	0.045
4118	525984.525	4827506.051	2015.569	0.021
4118A	525993.82	4827498.191	2016.000	0.082
4119	524811.119	4825918.827	1976.059	0.035
4119A	524801.265	4825897.151	1976.059	0.001
4120	524668.576	4826123.543	1976.720	0.121
4120A	524668.086	4826133.677	1976.770	0.161
4121	524811.803	4822197.269	1941.510	0.007
4121A	524818.895	4822201.248	1941.579	0.004
4122	529472.109	4826049.512	2031.010	0.04
4122A	529464.275	4826041.966	2030.230	0.064

ACCURACY CONCLUSIONS

Sage and Steppe Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.198 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Sage and Steppe Errors larger than 95th percentile include:

- Point 4010, Easting 517838.448, Northing 4884931.316, Z-Error 0.263 meters
- Point 4016, Easting 522687.017, Northing 4844477.277, Z-Error 0.199 meters
- Point 4103A, Easting 521409.679, Northing 4821135.689, Z-Error 0.224 meters
- Point 4105, Easting 519760.287, Northing 4817142.628, Z-Error 0.230 meters
- Point 4105A, Easting 519770.601, Northing 4817150.383, Z-Error 0.251 meters

Table 5.4: Quality Check Point Analysis, Brushlands and Trees, UTM 12N, NAD83, NAVD88 GEOID12A, Grand Teton and National Elk Refuge Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
5002	531022.058	4829960.944	2032.349	-0.047
5002A	531004.636	4829958.793	2032.730	0.074
5003	532408.229	4843643.875	2132.239	0.234
5003A	532409.971	4843648.727	2129.500	0.256
5004	524342.47	4834742.278	1976.589	-0.03
5004A	524376.016	4834732.938	1977.240	0.089
5005	531004.749	4852304.051	2100.790	0.01
5005A	531012.625	4852331.577	2101.090	0.044
5006	539642.499	4854290.553	2054.170	-0.063
5006A	539634.092	4854288.262	2054.139	0.288
5007	528949.923	4864256.774	2074.360	0.016
5007A	528938.359	4864266.357	2074.469	0.124
5008	526146.651	4881921.618	2086.940	0.053
5008A	526152	4881913.153	2086.840	-0.086
5009	526871.707	4886666.178	2099.949	-0.02
5009A	526852.74	4886655.67	2099.869	-0.004
5010	517825.732	4884947.806	2187.309	-0.059

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
5010A	517807.375	4884954.717	2187.369	0.028
5011	521778.326	4848258.427	2097.840	0.047
5011A	521743.202	4848263.408	2097.550	-0.007
5012	517307.166	4829830.702	1953.380	-0.039
5012A	517306.506	4829825.249	1953.420	-0.015
5013	516713.423	4827019.831	1927.829	0.07
5013A	516723.408	4827025.014	1927.740	0.072
5014	510028.056	4826852.236	3123.510	0.127
5014A	510013.191	4826844.183	3121.389	0.09
5015	524913.036	4878915.372	2178.770	0.085
5015A	524916.142	4878922.437	2178.650	0.119
5016	522892.626	4881644.228	2098.909	0.086
5016A	522928.407	4881653.627	2097.570	0.104
5017	528276.78	4861767.017	2069.210	-0.063
5017A	528280.039	4861769.828	2068.969	0.113
5018	527071.47	4829388.648	2004.260	0.075
5018A	527046.577	4829382.995	2003.829	0.131
5019	522408.751	4844470.123	2074.489	-0.066
5019A	522387.725	4844430.519	2073.489	-0.054
5020	546185.603	4853544.281	2068.309	0.148
5020A	546192.291	4853540.169	2068.590	0.293
5101	521494.304	4823643.311	1944.470	0.108
5101A	521520.037	4823660.71	1945.069	0.05
5102	520984.781	4820431.048	1991.579	0.027
5102A	520902.794	4820499.019	1981.280	-0.002
5104	519903.521	4817359.396	1894.780	0.212
5104A	519910.5	4817369.168	1894.670	0.197

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
5105	521084.596	4814283.474	1972.280	0.109
5105A	521075.493	4814281.678	1972.010	0.224
5106	521202.957	4814085.398	1978.569	0.012
5106A	521213.305	4814090.112	1981.920	0.106
5107	521775.724	4815374.24	1941.859	0.014
5107A	521784.446	4815378.43	1944.470	0.1
5108	522921.954	4816514.188	1984.470	0.036
5108A	522930.214	4816503.644	1988.000	0.246
5109	527013.342	4818591.543	2012.950	0.139
5109A	527019.273	4818597.511	2012.839	0.097
5110	526929.404	4819634.727	2000.809	0.073
5110A	526928.758	4819628.002	2002.710	-0.175
5111	527059.55	4821686.486	1988.020	0.187
5111A	527053.125	4821680.071	1987.480	0.167
5112	530194.981	4822824.592	2055.420	-0.082
5112A	530180.237	4822821.276	2054.920	0.004
5113	531301.709	4826642.943	2072.949	0.186
5113A	531307.601	4826643.236	2072.460	-0.199
5114	530435.515	4829227.206	2029.980	-0.025
5114A	530445.384	4829223.288	2032.920	0.111
5115	533642.413	4832006.965	2052.840	-0.161
5115A	533649.89	4832024.677	2053.159	-0.036
5116	528228.533	4829029.144	2017.88	0.07
5116A	528224.804	4829025.563	2018.21	0.149
5117	527217.419	4828162.739	2029.02	0.022
5117A	527212.228	4828174.285	2028.23	0.165
5118	526083.641	4827731.112	2008.42	0.124

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
5118A	526091.651	4827739.576	2008.25	0.219
5119	524970.891	4826028.197	2001.8	-0.01
5119A	524978.259	4826023.334	2002.14	-0.01
5120	524646.505	4826146.516	1977.829	0.184
5121	524116.579	4822135.073	1930.24	0.163
5121A	524122.049	4822130.558	1930.55	0.317
5122	529426.821	4827088.115	2069.44	-0.071
5122A	529434.632	4827088.118	2070.44	0.056

ACCURACY CONCLUSIONS

Brushlands and Trees Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.247 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Brushlands and Trees Errors larger than 95th percentile include:

- Point 5003A, Easting 532409.971, Northing 4843648.727, Z-Error 0.256 meters
- Point 5006A, Easting 539634.092, Northing 4854288.262, Z-Error 0.288 meters
- Point 5020A, Easting 546192.291, Northing 4853540.169, Z-Error 0.293 meters
- Point 5121A, Easting 524122.049, Northing 4822130.558, Z-Error 0.317 meters

Table 5.5: Quality Check Point Analysis, Forested and Fully Grown, UTM 12N, NAD83, NAVD88 GEOID12A, Grand Teton and National Elk Refuge Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
6001	526661.405	4883778.919	2087.059	0.045
6001A	526657.79	4883771.907	2086.94	0.009
6002	521711.295	4881872.031	2148.969	0.009
6002A	521720.3	4881884.925	2147.909	0.056
6003	524584.06	4876716.548	2242.159	0.239

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
6003A	524594.856	4876735.842	2242.449	0.019
6003B	524553.571	4876700.324	2241.29	0.103
6003C	524560.104	4876711.594	2241.429	0.117
6004	525296.253	4872643.953	2073.57	-0.029
6004A	525296.278	4872628.51	2073.29	0.049
6005	529108.799	4867264.926	2088.04	0.073
6005A	529128.152	4867253.162	2090.92	0.071
6006	528306.907	4861790.637	2069.079	-0.098
6006A	528318.745	4861788.453	2069.73	-0.076
6007	538046.686	4856145.749	2065.09	-0.006
6007A	538063.549	4856141.326	2064.98	0.078
6008	539483.04	4854853.432	2085.25	0.041
6008A	539490.632	4854870.747	2085.869	0.23
6009	536928.819	4848141.936	2077.949	0.23
6009A	536929.289	4848147.046	2077.869	0.004
6010	517449.515	4885456.376	2205.409	0.282
6010A	517469.123	4885427.621	2204.9	0.261
6011	521512.886	4848196.492	2094.329	0.119
6011A	521598.441	4848184.487	2095.28	-0.063
6012	530999.536	4852433.466	2103.219	0.095
6012A	530976.19	4852429.014	2101.42	-0.011
6013	516978.715	4827006.256	1927.559	0.007
6013A	516980.5	4826989.817	1928.079	-0.055
6013B	534144.22	4858809.725	2095.09	-0.155
6013C	534132.148	4858789.604	2094.619	-0.041
6014	529049.192	4864159.89	2068.36	0.131
6014A	529057.805	4864147.875	2070.73	-0.104

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Abs. Dz (meters)
6015	527120.861	4886370.902	2099.21	-0.018
6015A	527132.888	4886367.501	2099.26	0.01
6016	518749.139	4834711.406	2045.22	-0.021
6016A	518763.322	4834707.394	2044.5	-0.03
6017	517311.646	4829808.742	1953.119	0.178
6017A	517320.863	4829806.754	1952.869	-0.117
6019	531319.56	4830087.36	2030.41	-0.131
6020	542597.685	4854172.9	2080.469	-0.152
6020A	542585.663	4854168.739	2080.26	0.031
6110	530407.409	4844665.036	2107.079	-0.025
6110A	530433.335	4844636.718	2107.429	-0.026

ACCURACY CONCLUSIONS

Forested and Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.24 meters supplemental vertical accuracy at the 95th percentile, tested against the DEM. Forested and Fully Grown Errors larger than 95th percentile include:

- Point 6010, Easting 517449.515, Northing 4885456.376, Z-Error 0.282 meters
- Point 6010A, Easting 517469.123, Northing 4885427.621, Z-Error 0.261 meters

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT

ACCURACY CONCLUSIONS

Consolidated Vertical Accuracy (CVA) Tested 0.227 meters consolidated vertical accuracy at the 95th percentile level, tested against the DEM. Consolidated errors larger than 95th percentile include:

- Point 4010, Easting 517838.448, Northing 4884931.316, Z-Error 0.263 meters
- Point 4105, Easting 519760.287, Northing 4817142.628, Z-Error 0.230 meters
- Point 4105A, Easting 519770.601, Northing 4817150.383, Z-Error 0.251 meters

- Point 5003, Easting 532408.229, Northing 4843643.875, Z-Error 0.234 meters
- Point 5003A, Easting 532409.971, Northing 4843648.727, Z-Error 0.256 meters
- Point 5006A, Easting 539634.092, Northing 4854288.262, Z-Error 0.288 meters
- Point 5020A, Easting 546192.291, Northing 4853540.169, Z-Error 0.293 meters
- Point 5108A, Easting 522930.214, Northing 4816503.644, Z-Error 0.246 meters
- Point 5121A, Easting 524122.049, Northing 4822130.558, Z-Error 0.317 meters
- Point 6003, Easting 524584.060, Northing 4876716.548, Z-Error 0.239 meters
- Point 6008A, Easting 539490.632, Northing 4854870.747, Z-Error 0.230 meters
- Point 6009, Easting 536928.819, Northing 4848141.936, Z-Error 0.230 meters
- Point 6010, Easting 517449.515, Northing 4885456.376, Z-Error 0.282 meters
- Point 6010A, Easting 517469.123, Northing 4885427.621, Z-Error 0.261 meters

Approved By:			
Title	Name	Signature	Date
Associate LiDAR Specialist Certified Photogrammetrist #1281	Qian Xiao		January 2015

SECTION 6: FLIGHT LOGS

FLIGHT LOGS

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

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	8/27/2014	239	74714	2	GRAND TRETON & ELK REFUGE

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5126.6	10:32:00	16:32:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5129.7	14:10:00	20:10:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	BKN140		11	7			Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	41.5	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	X	B	150

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 S-Turns Before Mission	Yes	No
70	S	17:01:00	17:05:00	10:20:00						
69	N	17:08:00	17:12:00	0:00:00						
68	S	17:15:00	17:19:00	0:00:00						
67	N	17:22:00	17:27:00	0:00:00						
66	S	17:30:00	17:35:00	0:00:00						
65	N	17:38:00	17:43:00	0:00:00						
64	S	17:45:00	17:51:00	0:00:00						
63	N	17:54:00	18:01:00	0:00:00						
62	S	18:04:00	18:11:00	0:00:00						
61	N	18:14:00	18:21:00	0:00:00						
60	S	18:24:00	18:32:00	0:00:00						
59	N	18:35:00	18:42:00	0:00:00						
58	S	18:45:00	18:52:00	0:00:00						
57	N	18:55:00	19:03:00	0:00:00				CLOUDS ON VERY NORTHERN END		
56	S	19:05:00	19:11:00	0:00:00				CLOUDS ON VERY NORTHERN END		
55	N	19:14:00	19:19:00	0:00:00				POSSIBLE CLOUD ON NORTH END		
54	S	19:22:00	19:27:00	0:00:00				POSSIBLE CLOUD ON NORTH END		
53	N	19:30:00	19:33:00	0:00:00				CLOUDS ON VERY NORTHERN END		
52	S	19:37:00	19:42:00	0:00:00				CLOUDS ON VERY NORTHERN END		
51	N	19:44:00	19:47:00	0:00:00				ABORT ON W/P14 DUE TO CLOUDS		
				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	No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	8/29/2014	241	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5135.2	8:53:00	14:53:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5140.1	2:30:00	20:30:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		11	7	3025		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40			100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	X	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts		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 S-Turns Before Mission	Yes	X	No
51	N	15:30:00	15:35:00	7:21:00							
50	S	15:38:00	15:43:00	0:00:00							
49	N	15:46:00	15:51:00	0:00:00							
48	S	15:54:00	16:00:00	0:00:00							
17	N	16:12:00	16:16:00	0:00:00							
47	S	16:23:00	16:25:00	0:00:00							
46	N	16:29:00	16:31:00	0:00:00							
45	S	16:33:00	16:36:00	0:00:00							
44	N	16:39:00	16:41:00	0:00:00							
43	S	16:46:00	16:51:00	0:00:00							
42	N	16:54:00	16:58:00	0:00:00							
41	S	17:01:00	17:05:00	0:00:00							
40	N	17:08:00	17:12:00	0:00:00							
39	S	17:15:00	17:19:00	0:00:00							
38	N	17:22:00	17:26:00	0:00:00							
37	S	17:29:00	17:33:00	0:00:00							
36	N	17:36:00	17:41:00	0:00:00							
35	S	17:43:00	17:48:00	0:00:00							
34	N	17:51:00	17:55:00	0:00:00							
33	S	17:58:00	18:03:00	0:00:00							
32	N	18:06:00	18:11:00	0:00:00							
31	S	18:13:00	18:16:00	0:00:00				ABORT DUE TO ATC			
31	S	18:23:00	18:26:00	0:00:00				PICKED UP REMAINING PORTION			
30	N	18:29:00	18:34:00	0:00:00							
29	S	18:36:00	18:42:00	0:00:00							
28	N	18:44:00	18:49:00	0:00:00							
27	S	18:52:00	18:57:00	0:00:00							
26	N	18;59	19:05:00	0:00:00							
25	S	19:07:00	19:12:00	0:00:00							
24	N	19:15:00	19:20:00	0:00:00							
23	S	19:22:00	19:27:00	0:00:00				POSSIBLE CLOUD OVER WATER W/P 13			
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes	X	No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	8/29/2014	241	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base

Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	
								Arriving	

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

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
	Kts		Ft		Ft	Yes		No		@ 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 S-Turns Before Mission Yes No
22	N	19:30:00	0:00:00	15:19:00				
21	S	19:37:00	19:42:00	0:00:00				CLOUD W/P 14-16
20	N	19:45:00	19:50:00	0:00:00				
19	S	19:52:00	19:57:00	0:00:00				
18	N	19:59:00	20:04:00	0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
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↑ Times entered are Zulu / GMT ↑				Page		2		Verify S-Turns After Mission Yes No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/2/2014	245	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5140.1	9:25:00	15:25:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5145.2	14:40:00	20:40:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		6	3	3017		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
	Kts		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 S-Turns Before Mission	Yes X No
A52	S	15:37:00	15:40:00	7:27:00				REFLIGHT W/P 1-10	
A53	N	15:42:00	15:45:00	0:00:00				REFLIGHT W/P 10-1	
A54	S	15:48:00	15:50:00	0:00:00				REFLIGHT W/P 1-7	
A16	N	16:00:00	16:05:00	0:00:00				SPEED 164 AT START	
A15	S	16:12:00	16:17:00	0:00:00				CLOUD W/P 3	
A14	N	16:21:00	16:27:00	0:00:00				HIGH PITCH; VERY SLOW AT START	
A13	S	16:30:00	16:35:00	0:00:00					
A12	N	16:39:00	16:45:00	0:00:00					
A11	S	16:48:00	16:54:00	0:00:00					
A10	N	16:58:00	17:05:00	0:00:00					
A9	S	17:07:00	17:13:00	0:00:00					
A8	N	17:16:00	17:22:00	0:00:00					
A7	S	17:25:00	17:31:00	0:00:00					
A6	N	17:34:00	17:39:00	0:00:00				CLOUD W/P 1	
A5	S	17:43:00	17:47:00	0:00:00				CLOUD W/P 1	
A4	N	17:51:00	17:53:00	0:00:00					
A3	S	17:56:00	17:58:00	0:00:00					
A2	N	18:02:00	18:03:00	0:00:00					
A1	S	18:08:00	18:09:00	0:00:00					
B63	S	18:17:00	18:18:00	0:00:00				CLOUD W/P 2	
B64	N	18:22:00	18:24:00	0:00:00				CLOUD W/P 8	
B65	S	18:27:00	18:29:00	0:00:00				CLOUD W/P 3	
B66	N	18:33:00	18:36:00	0:00:00				CLOUD W/P 4-6	
B67	S	18:39:00	18:41:00	0:00:00					
A71	S	18:50:00	18:51:00	0:00:00					
A72	N	18:55:00	18:56:00	0:00:00					
A73	S	18:59:00	19:00:00	0:00:00					
A74	N	19:04:00	19:05:00	0:00:00					
A75	S	19:08:00	19:10:00	0:00:00					
A76	N	9:13:00	19:14:00	0:00:00					
A77	S	9:18:00	19:19:00	0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/2/2014	245	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	
								Arriving	

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

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
	Kts		Ft		Ft	Yes		No		@	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 S-Turns Before Mission	Yes	No
A78	N	19:22:00	19:23:00	14:55:00						
A79	S	19:27:00	19:28:00	0:00:00				CLOUD W/P 2		
A80	N	19:32:00	19:33:00	0:00:00				CLOUD W/P 2-4		
A81	S	?	?	0:00:00				ACCIDENTAL START		
B20	N	19:42:00	19:48:00	0:00:00				SHUTTER CLOSED; ABORTED		
A17	S	19:55:00	19:56:00	0:00:00				TEST; SHUTTER OPENED		
B53	S	20:02:00	20:04:00	0:00:00				TEST; SHUTTER OPENED		
B47	S	20:10:00	20:13:00	0:00:00				TEST; SHUTTER OPENED		
B20	S	20:16:00	20:17:00	0:00:00				TEST OVER PEAKS; SHUTTER CLOSED		
				0:00:00						
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↑ Times entered are Zulu / GMT ↑				Page		2		Verify S-Turns After Mission	Yes	No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/3/2014	246	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5145.2	8:12:00	14:12:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5146.9	10:32:00	16:32:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		6	3	2991		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.	
	Kts		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 S-Turns Before Mission	Yes X	No
B52	N	14:57:00	15:00:00	6:11:00						
B51	S	15:03:00	15:08:00	0:00:00						
B50	N	15:13:00	15:20:00	0:00:00				HIGH PITCH -12		
B49	S	15:23:00	15:31:00	0:00:00						
B48	N	15:34:00	15:42:00	0:00:00				HIGH PITCH -12		
B47	S	15:46:00	15:54:00	0:00:00						
B46	N	15:57:00	16:04:00	0:00:00						
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↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X	No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/5/2014	248	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5147.1	7:00:00	13:00:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5151.2	11:40:00	17:40:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		1	-1	3028		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments	
Test	n/a			n/a	n/a	n/a		GPS Began Logging At:	
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission	Yes X No
B45	S	13:39:00	13:47:00	3:48:00					
B44	N	13:51:00	13:57:00	0:00:00			STOP	WP26	
B44	N	13:57:00	13:59:00	0:00:00			START	WP30	
B43	S	14:02:00	14:05:00	0:00:00			STOP	WP26	
B43	S	14:06:00	14:11:00	0:00:00			START	WP21	
B42	N	14:14:00	14:20:00	0:00:00			STOP	WP20	
B42	N	14:21:00	14:23:00	0:00:00			START	WP31	
B41	S	14:38:00	14:41:00	0:00:00			STOP	WP24	
B41	S	14:42:00	14:48:00	0:00:00			START	WP21	
B40	N	14:51:00	14:56:00	0:00:00			STOP	WP25	
B40	N	14:58:00	15:00:00	0:00:00			START	WP32	
B39	S	15:03:00	15:06:00	0:00:00			STOP	WP28	
B39	S	15:07:00	15:12:00	0:00:00			START	WP22	
B38	N	15:15:00	15:21:00	0:00:00			STOP	WP26	
B38	N	15:23:00	15:25:00	0:00:00			START	WP34	
B37	S	15:28:00	15:32:00	0:00:00			STOP	WP28	
B37	S	15:36:00	15:38:00	0:00:00			START	WP8	
B36	N	15:40:00	15:43:00	0:00:00			STOP	WP14	
B36	N	15:47:00	15:50:00	0:00:00			START	WP35	
B35	S	15:53:00	15:56:00	0:00:00			STOP	WP32	
B35	S	16:01:00	16:03:00	0:00:00			START	WP9	
B34	N	16:06:00	16:09:00	0:00:00			STOP	WP12	
B34	N	16:14:00	16:16:00	0:00:00			START	WP35	
B33	S	16:19:00	16:23:00	0:00:00			STOP	WP31	
B33	S	16:28:00	16:30:00	0:00:00			START	WP9	
B32	N	16:32:00	16:35:00	0:00:00			STOP	WP12	
B32	N	16:40:00	16:43:00	0:00:00			START	WP37	
B31	S	16:46:00	16:50:00	0:00:00			STOP	WP33	
B31	S	16:55:00	16:58:00	0:00:00			START	WP9	
B30	N	17:01:00	17:03:00	0:00:00			STOP	WP14	
B30	N	17:09:00	17:12:00	0:00:00			START	WP44	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/5/2014	248	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5151.2	14:00:00	20:00:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5155.0	18:00:00	0:00:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		17	2	3027		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments	
Test	n/a			n/a	n/a	n/a		GPS Began Logging At:	
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission	Yes X No
A80	S	20:54:00	20:56:00	17:58:00					
A81	N	20:58:00	21:00:00	0:00:00					
A82	S	21:04:00	21:06:00	0:00:00					
B54	N	21:14:00	21:15:00	0:00:00					
B55	S	21:18:00	21:20:00	0:00:00					
B56	N	21:23:00	21:25:00	0:00:00					
B57	S	21:28:00	21:30:00	0:00:00					
B58	N	21:33:00	21:36:00	0:00:00					
B59	S	21:39:00	21:42:00	0:00:00					
B60	N	21:45:00	21:47:00	0:00:00					
B68	N	21:49:00	21:51:00	0:00:00					
B61	S	21:54:00	22:02:00	0:00:00					
B62	N	22:05:00	22:12:00	0:00:00					
B03	S	22:15:00	22:27:00	0:00:00				CLOUD W/P 1	
B04	N	22:31:00	22:43:00	0:00:00				CLOUD W/P 1-2	
B05	S	22:47:00	22:58:00	0:00:00					
B06	N	23:01:00	23:13:00	0:00:00				CLOUD W/P 25	
B29	S	23:18:00	23:31:00	0:00:00				CLOUD W/P 7	
B28	N	23:34:00	23:45:00	0:00:00					
				0:00:00					
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↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/6/2014	249	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5155.0	7:45:00	13:45:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5160.6	13:35:00	19:35:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		2	1	3038		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments	
Test	n/a			n/a	n/a	n/a		GPS Began Logging At:	
↕ Times entered are Zulu / GMT ↕								Verify S-Turns Before Mission	Yes X No
B27	S	14:06:00	14:20:00	4:57:00					
B26	N	14:22:00	14:35:00	0:00:00					
B25	S	14:37:00	14:49:00	0:00:00					
B24	N	14:52:00	15:04:00	0:00:00					
B23	S	15:07:00	15:19:00	0:00:00				CLOUD W/P 17-16	
B22	N	15:22:00	15:34:00	0:00:00					
B21	S	15:37:00	15:49:00	0:00:00					
B20	N	15:52:00	16:05:00	0:00:00					
B19	S	16:07:00	16:20:00	0:00:00					
B18	N	16:22:00	16:34:00	0:00:00					
B17	S	16:37:00	16:49:00	0:00:00					
B16	N	16:52:00	17:04:00	0:00:00					
B15	S	17:07:00	17:19:00	0:00:00					
B14	N	17:22:00	17:34:00	0:00:00					
B13	S	17:37:00	17:49:00	0:00:00					
B12	N	17:52:00	18:04:00	0:00:00					
B11	S	18:06:00	18:18:00	0:00:00					
B10	N	18:21:00	18:33:00	0:00:00					
B9	S	18:35:00	18:47:00	0:00:00					
B8	N	18:50:00	19:01:00	0:00:00					
B7	S	19:04:00	19:13:00	0:00:00				SHUTTER CLOSED DUE TO CLOUD W/P	
				0:00:00					
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↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/7/2014	250	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5160.6	8:10:00	14:10:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5161.9	9:45:00	15:45:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		2	1	3024		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments
Test	n/a			n/a	n/a	n/a		GPS Began Logging At:
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission Yes X No
A82	S	14:35:00	14:38:00	5:23:00				
A83	N	14:40:00	14:43:00	0:00:00				
A85	N	14:51:00	14:54:00	0:00:00				
A84	S	14:56:00	14:59:00	0:00:00				
A87	N	15:02:00	15:05:00	0:00:00				
A86	S	15:07:00	15:10:00	0:00:00				
A89	N	15:14:00	15:16:00	0:00:00				CLOUDS W/P 10; STOPPED LASER
				0:00:00				
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↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/8/2014	251	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5161.9	7:30:00	13:30:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5167.7	13:40:00	19:40:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		2	1	3015		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments		
Test	n/a		14:57:00	n/a	n/a	n/a		GPS Began Logging At:		
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission	Yes X	No
B73	NE	14:07:00	14:08:00	4:32:00						
B74	S	14:15:00	14:17:00	0:00:00						
B75	N	14:20:00	14:22:00	0:00:00						
B76	S	14:25:00	14:27:00	0:00:00						
B77	N	14:30:00	14:32:00	0:00:00						
B78	S	14:36:00	14:38:00	0:00:00						
A88	S	14:48:00	14:51:00	0:00:00						
A89	N	14:54:00	14:57:00	0:00:00						
A90	S	15:00:00	15:03:00	0:00:00						
A91	N	15:06:00	15:09:00	0:00:00						
A92	S	15:12:00	15:15:00	0:00:00						
A93	N	15:17:00	15:21:00	0:00:00						
A94	S	15:24:00	15:27:00	0:00:00						
A95	N	15:30:00	15:32:00	0:00:00						
A96	S	15:36:00	15:39:00	0:00:00						
A97	N	15:42:00	15:45:00	0:00:00						
A98	S	15:48:00	15:51:00	0:00:00						
A99	N	15:53:00	15:56:00	0:00:00						
B1	S	15:59:00	16:02:00	0:00:00						
B2	N	16:05:00	16:07:00	0:00:00						
B30	N	16:13:00	16:21:00	0:00:00				wp 8-42		
B31	S	16:24:00	16:32:00	0:00:00				wp 5-38		
B32	N	16:34:00	16:42:00	0:00:00				wp 6-38		
B33	S	16:52:00	17:00:00	0:00:00				wp6-38		
B34	N	17:02:00	17:09:00	0:00:00				wp7-36		
B35	S	17:12:00	17:20:00	0:00:00				wp5-37		
B36	N	17:22:00	17:30:00	0:00:00				wp10-38		
B37	S	17:33:00	17:40:00	0:00:00				wp6-36		
B38	N	17:45:00	17:49:00	0:00:00				wp20-37		
B39	S	17:52:00	17:57:00	0:00:00				wp18-33		
B40	N	17:59:00	18:03:00	0:00:00				wp20-36		
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X	No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/8/2014	251	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base

Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	
								Arriving	

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

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
	Kts		Ft		Ft	Yes		No		@	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 S-Turns Before Mission	Yes	No
B41	S	18:06:00	18:10:00	12:29:00				wp19-32		
B42	N	18:13:00	18:16:00	0:00:00				wp22-34		
B43	S	18:19:00	18:23:00	0:00:00				wp17-30		
B44	N	18:26:00	18:29:00	0:00:00				wp21-33		
B23	S	18:35:00	18:37:00	0:00:00				wp14-19		
B6	N	18:39:00	18:41:00	0:00:00				wp23-27		
B7	S	18:45:00	18:50:00	0:00:00				17-1		
B4	N	18:52:00	18:53:00	0:00:00				wp1-4		
B3	S	18:56:00	18:57:00	0:00:00				wp1-4		
B29	N	19:01:00	19:03:00	0:00:00				wp5-9		
A21	NW	19:09:00	19:10:00	0:00:00				wrong waypoints		
A21	NW	19:16:00	19:18:00	0:00:00				wp 10-18		
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Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/10/2014	253	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SIMMONS	N475RC	5167.7	7:45:00	13:45:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5168.7	9:15:00	15:15:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	CLR		6	-1	3009		Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
				Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP		Line Notes/Comments	
Test	n/a		14:57:00	n/a	n/a	n/a		GPS Began Logging At:	
↕ Times entered are Zulu / GMT ↕								Verify S-Turns Before Mission	Yes X No
B70	W	14:19:00	14:32:00	5:32:00				CLOUDED THROUGHOUT	
B72	E	14:41:00	14:51:00	0:00:00				CLOUDS W/P 5-1	
				0:00:00					
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Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	9/12/2014	255	74714	2	Grand Teton & Elk Refuge

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
BURKE	N475RC	5168.7	19:14:00	1:14:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
SWAIN	ALS-7177	5170.1	21:09:00	3:09:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
040/8	10	CLR		8	-8	30.33	N/A	Departing	KJAC
								Arriving	KJAC

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
26	25.8	102.5	100	Gain - Course/Up	255	Single	X	A	170
				Gain - Fine/Down	255	Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
140	Kts	8850	Ft	15185	Ft	Yes		No	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	ALT MSL	Line Notes/Comments
Test	n/a		14:57:00	n/a	n/a	n/a		GPS Began Logging At:
↕ Times entered are Zulu / GMT ↕								Verify S-Turns Before Mission: Yes X No
B69	226	1:52:48	1:58:38	0:05:50	17	1	15197	No Clouds
B6	168	2:03:13	2:06:00	0:02:47	14	1.3	15213	No Clouds
B70	81	2:14:21	2:27:28	0:13:07	14	1.4	15154	No Clouds
B71	254	2:31:15	2:39:00	0:07:45	14	1.4	15165	No Clouds
				0:00:00				
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Additional Comments:

Drive #

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
- 1st Return 1-meter DSM 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