Airborne Lidar Report

WOOLPERT

USGS
science for a changing world

AZ Fredonia Safford Lidar 2016 D16

Contract Number: G16PC00022
Task Number: G16PD01250

Contractor: Woolpert, Inc.
Woolpert Project # 75926

January 2018

Table of Contents

List of Figures

List of Tables

Section 1: Overview

TASK ORDER NAME: AZ Fredonia Safford Lidar 2016 D16

Project: # 77025

This report contains a comprehensive outline of the AZ Fredonia Safford Lidar 2016 D16 task order. Processing task order for the United States Geological Survey (USGS). This task is issued under USGS Contract No. G16PC00022, Task Order No. G16PD01250. This task consists of lidar data acquisition, and processing over Fredonia QL1 (+/- 516 sq. mi) and Safford QL2 (+/- 771 sq. mi) USGS V.1.2 lidar in Northern and Southeastern Arizona. The data were acquired at a NPS of no greater than 0.35 meters for the Fredonia (Northern) AOI and no greater than 0.7 meters for the Safford (Southern) AOI. 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 three Leica ALS80 HP 1000 kHz Multiple Pulses in Air (MPiA) lidar systems on board Woolpert aircraft. The ALS80 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:

Table 1.1: ALS80 Specifications – Fredonia QL1	
Post Spacing	0.35 m
AGL (Above Ground Level) average flying height	1,524 m
Average Ground Speed:	130 knots
Field of View (full)	20 degrees
Pulse Rate	371 kHz
Scan Rate	50 Hz
Side Lap	25%

Table 1.2: ALS80 Specifications – Safford QL2	
Post Spacing	0.7 m
AGL (Above Ground Level) average flying height	1,981 m
Average Ground Speed:	150 knots
Field of View (full)	40 degrees
Pulse Rate	272 kHz
Scan Rate	42.9 Hz
Side Lap	25%

The horizontal datum used for the task order was referenced to NAD83 (2011), Zone 12, Meters. The vertical datum used for the task order was referenced to NAVD 1988, Meters, GEOID12B.

Figure 1.1: AZ Fredonia Safford Lidar 2016 D16 - Fredonia Task Order AOI

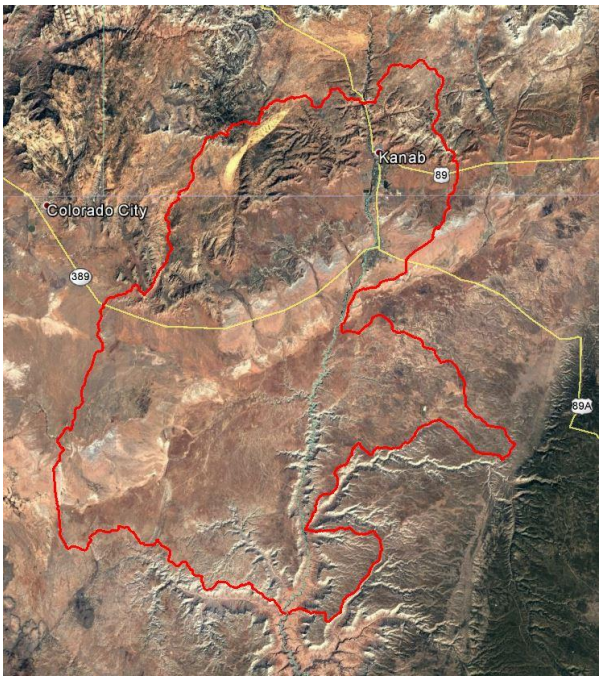
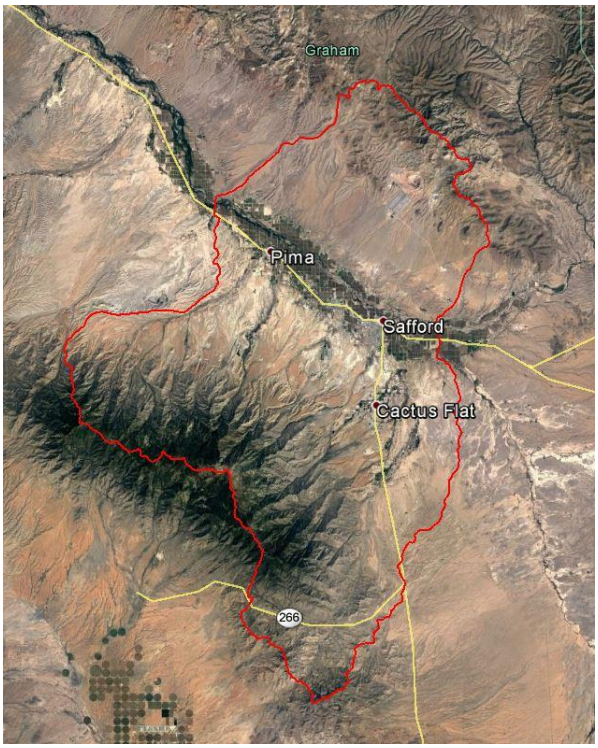


Figure 1.2: AZ Fredonia Safford Lidar 2016 D16 – Safford Task Order AOI



Section 2: Acquisition

The lidar data was acquired with three Leica ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar Sensor Systems. The ALS80 HP 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 ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Table 2.1: ALS80 HP Lidar System Specifications	
Operating Altitude	100 – 7,620 meters
Scan Angle	0 to 72° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	1000 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	6 - 19 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 43 cm (one standard deviation)
Number of Returns per Pulse	Unlimited
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, flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

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

The Lidar data was collected in 16 (sixteen) missions for Fredonia and 5 (five) missions for Safford, 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. Collection of lidar data took place from October 15, 2016 through December 10, 2017.

Figure 2.1: Lidar Flight Layout, AZ Fredonia Lidar QL1

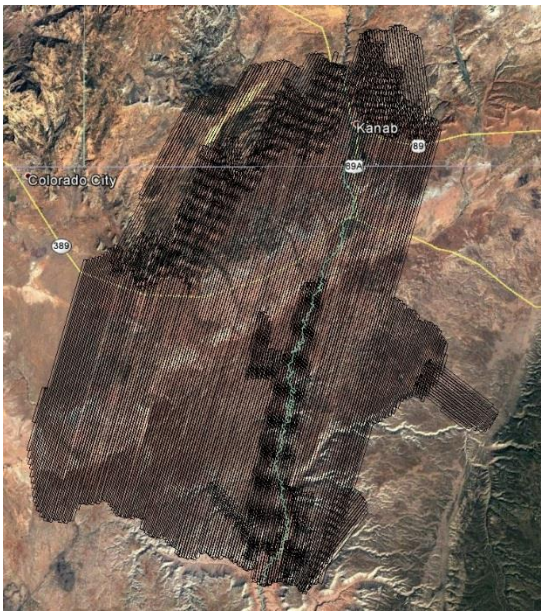


Figure 2.2: Lidar Flight Layout, AZ Safford Lidar QL2

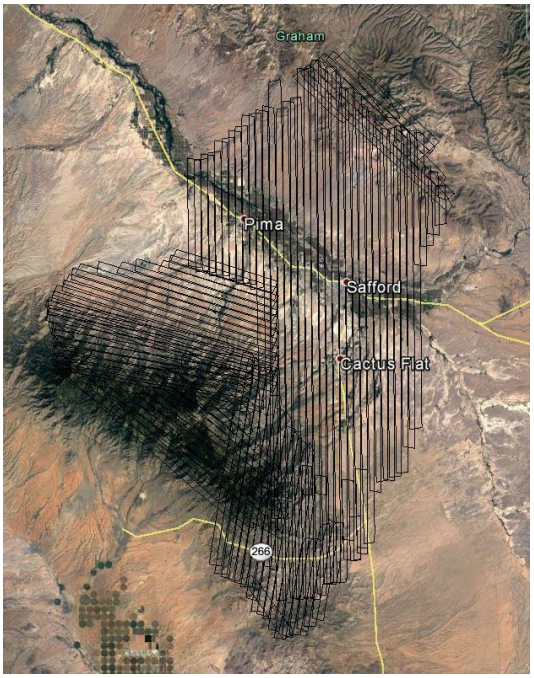


Table 2.3: Airborne Lidar Acquisition Flight Summary

Date of Acquisition	Lines Flown	Acquisition Time (UTC)
October 15, 2016_SH8170_A	**02058-02066, 02086-02112**	**15:56 – 19:35**
October 15, 2016_SH8170_B	**02050-02057, 02067-02085**	**21:09 – 23:55**
October 16, 2016_SH8170_A	**02001-02020**	**15:13 – 18:50**
October 16, 2016_SH8170_B	**02021-02039**	**20:05 – 23:15**
October 17, 2016_SH8170_A	**02040-02049**	**18:14 – 19:11**
October 17, 2016_SH8170_B	**03001-03005**	**22:14 – 22:33**
December 8, 2016_SH8191	**01127-01150**	**19:46 – 22:07**
December 9, 2016_SH8191	**01001-01018**	**19:43 – 23:02**
December 11, 2016_SH8191	**00001-00011, 00018-00044, 10024, 20026, 30026, 40026**	**17:34 – 22:28**
December 13, 2016_SH8191	**00012-00017, 01111-01126, 10017**	**16:36 – 22:04**
December 14, 2016_SH8191	**01019-01030, 01103-01110**	**17:08 – 22:04**
December 17, 2016_SH8191	**01031-01035, 01060-01072**	**18:31 – 23:17**
December 18, 2016_SH8191	**01085-01102, 11103**	**16:44 – 22:24**
December 19, 2016_SH8191	**01052-01059, 01073-01084, 11076**	**17:07 – 22:51**
December 20, 2016_SH8191	**01036-01051, 10019, 10023, 10025-10028, 10030-10032, 11045**	**17:43 – 22:49**
February 15, 2017_SH8194	**04001-04005**	**17:45 – 18:26**
December 10. 2017_SH8191	**1151**	**21:49 – 21:53**
October 18, 2016_SH8170_A	**01001-01007, 02001-02018, 03001-03009**	**16:47 – 20:59**
October 18, 2016_SH8170_B	**01008-01035**	**22:08 – 1:25**
December 6, 2016_SH8191	**00001-00011, 00031-00052**	**19:35 – 23:14**
December 7, 2016_SH8191	**00012-00030, 10017, 10019, 10023-10025**	**16:51 – 21:54**
February 15, 2017_SH8194	**00020**	**22:37 – 22:50**

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: Novatel Inertial Explorer v8.60
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:TerraMatch v. 17., Add Leica Cloud Pro v1.2.3
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.17
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.17.

Global Navigation Satellite System (GNSS)–Inertial Measurement Unit (IMU) Trajectory Processing

Equipment

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.

Base stations were set by acquisition staff and were used to support the Lidar data acquisition. 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)
KKNB Airport	37°00'39.73362"	112°31'47.96481"	1454.16
KKNB Airport-2	37°00'35.62302"	112°31'51.27367"	1452.775

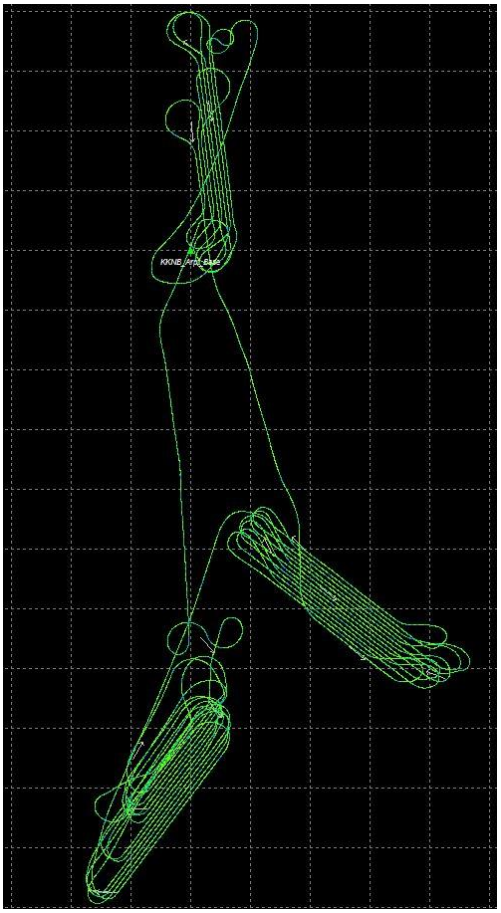
Data Processing

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).

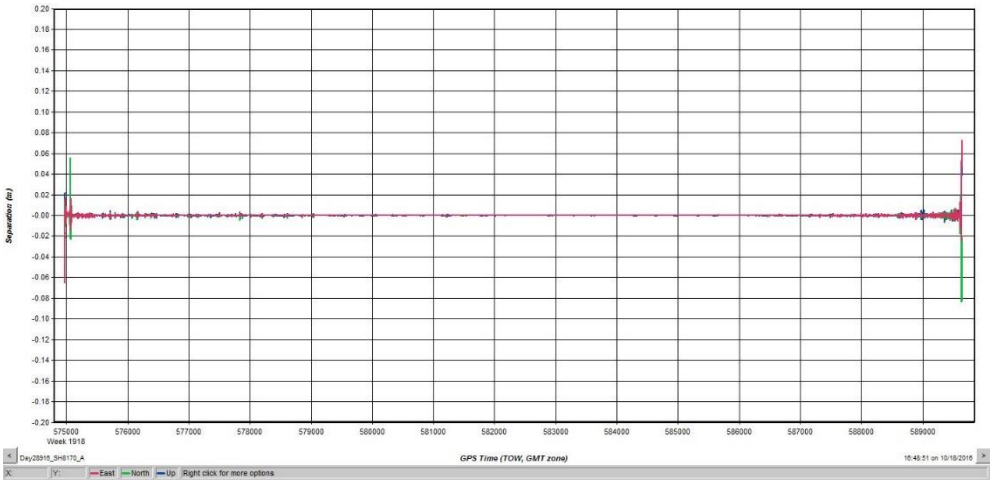
Figure 3.1: Trajectory, Day28916_SH8170_A



Combination 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 3.2: Combined Separation, Day28916_SH8170_A

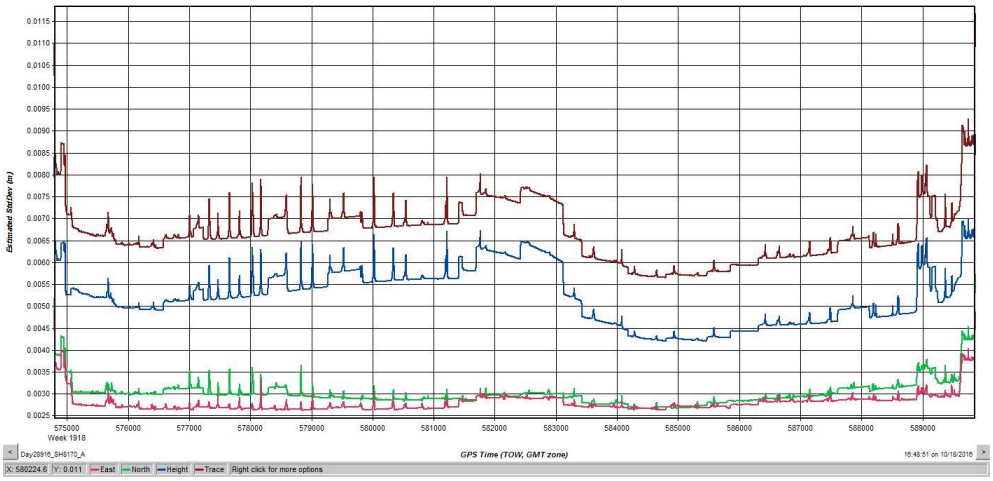


Estimated Positional Accuracy

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 3.3: Estimated Positional Accuracy, Day28916_SH8170_A



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 3.4: PDOP, Day28916_SH8170_A

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/Processed but not classified (Class 1), Bare earth ground (Class 2), Low Vegetation (Class 3), Medium Vegetation (Class 4), High Vegetation (Class 5), Low Noise (Class 7), Water (Class 9), Ignored ground (Class10), Bridge Decks (Class 17), High Noise (Class 18) classifications.
- FGDC Compliant metadata was developed for the task order in .xml format per product.
- The horizontal datum used for the task order was referenced to NAD83 (2011), Zone 12, Meters. The vertical datum used for the task order was referenced to NAVD 1988, Meters, GEOID12B

Section 4: Hydrologic Flattening

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

AZ Fredonia Safford Lidar 2016 D16 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-acre 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 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-acre or greater and streams at a minimum size of 30 meters (100 feet) nominal width, were compiled to meet task order requirements. **Figure 4.1** illustrates an example of 30 meters (100 feet) nominal streams identified and defined with hydrologic breaklines. The breaklines defining rivers and streams, at a nominal minimum width of 30 meters (100 feet), were draped with both sides of the stream maintaining an equal gradient elevation.
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 4.1: Example Hydrologic Breaklines

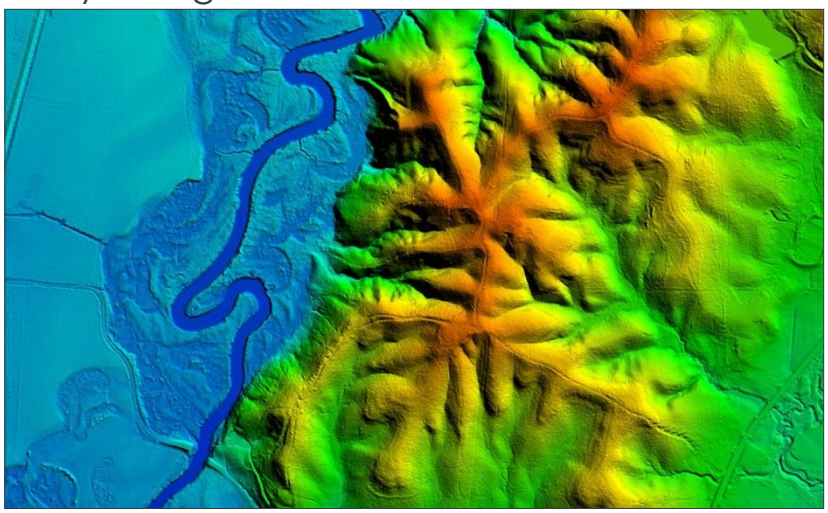


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

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.

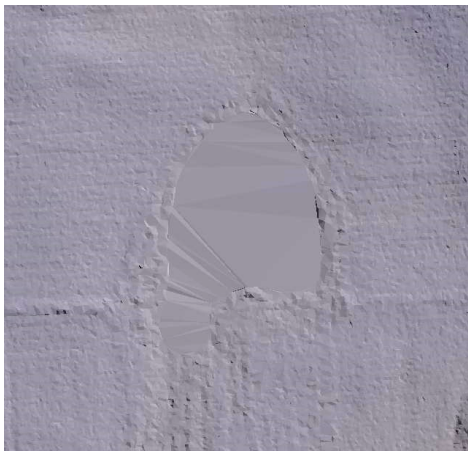


Figure 4.2

Figure 4.3

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.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS in ESRI shapefile format. The breaklines defining the water bodies greater than 2-acre and for the gradient flattening of all rivers and streams at a nominal minimum width of 30 meters (100 feet) were provided in geodatabase as a Polygon-Z and Polyline-Z shape file, respectively.

DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v17, 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: ACCURACY ASSESSMENT

Accuracy Assessment for Fredonia (QL1):

The vertical accuracy statistics were calculated by comparison of all lidar points to the ground surveyed QC points.

Table 5.1: Overall Vertical Accuracy Statistics		
Average error	0.010	Meter
Minimum error	-0.110	Meter
Maximum error	0.233	Meter
Average magnitude	0.029	Meter
Root mean square	0.042	Meter
Standard deviation	0.041	Meter

Table 5.2: RAW Swath Quality Check Point Analysis NVA

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	TIN Elevation (Meter)	Dz (Meter)
2000	363256.880	4104736.338	1536.186	1536.170	-0.016
2000A	363245.971	4104735.471	1536.304	1536.300	-0.004
2001	364348.418	4100771.132	1506.940	1506.960	0.020
2001A	364345.665	4100754.092	1506.803	1506.820	0.017
2002	368043.564	4099102.943	1548.786	1548.800	0.014
2002A	368069.662	4099096.995	1548.642	1548.640	-0.002
2003	372705.313	4098912.519	1579.852	1579.890	0.038
2003A	372682.547	4098913.043	1580.040	1580.100	0.060
2004	363783.346	4095246.997	1474.525	1474.550	0.025
2004A	363771.115	4095120.432	1477.439	1477.420	-0.019
2005	363260.340	4087279.907	1416.116	1416.160	0.044
2005A	363252.098	4087262.642	1417.008	1417.040	0.032
2006	346072.020	4069554.018	1426.202	1426.180	-0.022
2006A	346087.937	4069575.769	1425.852	1425.840	-0.012
2007	339136.422	4061491.375	1494.246	1494.280	0.034
2007A	339106.968	4061473.477	1494.774	1494.820	0.046
2008	335950.670	4081671.336	1513.043	1513.060	0.017
2008A	335947.124	4081661.532	1513.032	1513.050	0.018
2009	344136.076	4099769.643	1772.992	1772.990	-0.002
2010	343402.987	4062061.460	1489.960	1489.940	-0.020
2010A	343393.984	4062087.093	1489.904	1489.880	-0.024
2011	337990.002	4061454.629	1495.956	1495.900	-0.056
2011A	337969.892	4061451.202	1495.051	1495.020	-0.031
2012	336613.367	4056625.846	1519.189	1519.150	-0.039
2012A	336620.114	4056648.808	1519.026	1518.990	-0.036
2013	342820.039	4053140.840	1562.608	1562.650	0.042

2013A	342831.766	4053159.246	1562.185	1562.210	0.025
2014	348298.002	4049641.522	1582.154	1582.210	0.056
2014A	348330.065	4049629.842	1579.402	1579.400	-0.002
2015	331936.716	4059308.174	1507.602	1507.630	0.028
2015A	331936.115	4059286.912	1507.849	1507.890	0.041
2017	366980.818	4067895.555	1678.841	1678.840	-0.001
2018	371884.152	4070823.379	1700.702	1700.750	0.048
2018A	371867.422	4070800.836	1701.095	1701.130	0.035
2019	367077.941	4088186.740	1466.892	1466.900	0.008
2019A	367053.473	4088196.153	1466.650	1466.690	0.040
2020	337209.640	4058929.515	1501.280	1501.270	-0.010
2020A	337202.642	4058902.622	1501.736	1501.720	-0.016
2021	360782.382	4098440.465	1568.768	1568.830	0.062
2021A	360779.106	4098417.324	1568.165	1568.190	0.025
2022	346528.780	4096680.213	1674.397	1674.630	0.233
2023	353819.862	4107030.462	1834.020	1834.010	-0.010
2023A	353813.445	4107016.533	1834.130	1834.110	-0.020
2024	350086.994	4075927.745	1380.353	1380.350	-0.003
2024A	350090.918	4075939.571	1380.730	1380.620	-0.110
2025	348060.379	4071319.947	1409.694	1409.660	-0.034
2025A	348068.127	4071288.878	1410.317	1410.290	-0.027
2026	352959.250	4061449.934	1537.998	1537.990	-0.008
2026A	352953.267	4061439.111	1538.096	1538.100	0.004
2027	328894.291	4060776.618	1519.393	1519.430	0.037
2027A	328903.144	4060791.373	1519.135	1519.160	0.025
2028	343292.504	4066412.527	1450.958	1450.980	0.022
2028A	343273.147	4066411.090	1450.819	1450.820	0.001
2029	377398.758	4068023.268	1833.742	1833.730	-0.012
2029A	377409.349	4068014.766	1833.727	1833.730	0.003
2030	361391.221	4066669.556	1616.199	1616.210	0.011
2030A	361377.773	4066671.942	1616.278	1616.310	0.032
2031	365158.844	4105660.960	1579.637	1579.600	-0.037
2031A	365224.651	4105723.803	1582.019	1581.980	-0.039
2032	364505.796	4090519.250	1427.745	1427.800	0.055
2032A	364530.172	4090519.628	1427.726	1427.760	0.034
2033	363528.735	4092419.564	1438.892	1438.950	0.058
2033A	363568.114	4092432.355	1434.373	1434.410	0.037
2034	331330.847	4083290.025	1577.705	1577.680	-0.025
2034A	331316.999	4083281.303	1577.867	1577.900	0.033
2035	349495.365	4066470.729	1473.661	1473.620	-0.041
2035A	349492.772	4066490.553	1473.328	1473.320	-0.008
2036	366812.566	4092696.521	1494.410	1494.430	0.020
2036A	366792.479	4092686.198	1494.094	1494.090	-0.004
2037	359670.272	4072060.849	1508.467	1508.460	-0.007
2037A	359643.756	4072076.487	1507.513	1507.490	-0.023

2038	351805.209	4058908.628	1575.245	1575.260	0.015
2038A	351790.679	4058915.288	1575.459	1575.510	0.051
2039	348650.479	4104699.455	1889.439	1889.470	0.031
2039A	348658.737	4104698.309	1889.533	1889.530	-0.003
2040	378983.185	4064764.618	1947.351	1947.360	0.009
2040A	378960.797	4064754.586	1946.519	1946.520	0.001

VERTICAL ACCURACY CONCLUSIONS

Raw Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.082 Meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) 0.042 x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all lidar points against 77 NVA points.

LAS Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.082 Meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) 0.042 x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using lidar ground points against 77 NVA points.

Table 5.3: NVA Check Point Analysis DEM

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	DEM Elevation (Meter)	Dz (Meter)
2000	363256.880	4104736.338	1536.186	1536.160	-0.026
2000A	363245.971	4104735.471	1536.304	1536.330	0.026
2001	364348.418	4100771.132	1506.940	1506.950	0.010
2001A	364345.665	4100754.092	1506.803	1506.830	0.027
2002	368043.564	4099102.943	1548.786	1548.810	0.024
2002A	368069.662	4099096.995	1548.642	1548.670	0.028
2003	372705.313	4098912.519	1579.852	1579.930	0.078
2003A	372682.547	4098913.043	1580.040	1580.110	0.070
2004	363783.346	4095246.997	1474.525	1474.530	0.005
2004A	363771.115	4095120.432	1477.439	1477.400	-0.039
2005	363260.340	4087279.907	1416.116	1416.170	0.054
2005A	363252.098	4087262.642	1417.008	1417.050	0.042
2006	346072.020	4069554.018	1426.202	1426.150	-0.052
2006A	346087.937	4069575.769	1425.852	1425.840	-0.012
2007	339136.422	4061491.375	1494.246	1494.280	0.034
2007A	339106.968	4061473.477	1494.774	1494.830	0.056
2008	335950.670	4081671.336	1513.043	1513.040	-0.003
2008A	335947.124	4081661.532	1513.032	1513.050	0.018
2009	344136.076	4099769.643	1772.992	1772.980	-0.012
2010	343402.987	4062061.460	1489.960	1489.930	-0.030

2010A	343393.984	4062087.093	1489.904	1489.880	-0.024
2011	337990.002	4061454.629	1495.956	1495.890	-0.066
2011A	337969.892	4061451.202	1495.051	1495.010	-0.041
2012	336613.367	4056625.846	1519.189	1519.150	-0.039
2012A	336620.114	4056648.808	1519.026	1518.990	-0.036
2013	342820.039	4053140.840	1562.608	1562.630	0.022
2013A	342831.766	4053159.246	1562.185	1562.200	0.015
2014	348298.002	4049641.522	1582.154	1582.140	-0.014
2014A	348330.065	4049629.842	1579.402	1579.380	-0.022
2015	331936.716	4059308.174	1507.602	1507.600	-0.002
2015A	331936.115	4059286.912	1507.849	1507.940	0.091
2017	366980.818	4067895.555	1678.841	1678.830	-0.011
2018	371884.152	4070823.379	1700.702	1700.750	0.048
2018A	371867.422	4070800.836	1701.095	1701.140	0.045
2019	367077.941	4088186.740	1466.892	1466.880	-0.012
2019A	367053.473	4088196.153	1466.650	1466.720	0.070
2020	337209.640	4058929.515	1501.280	1501.250	-0.030
2020A	337202.642	4058902.622	1501.736	1501.720	-0.016
2021	360782.382	4098440.465	1568.768	1568.820	0.052
2021A	360779.106	4098417.324	1568.165	1568.180	0.015
2022	346528.780	4096680.213	1674.397	1674.670	0.273
2023	353819.862	4107030.462	1834.020	1833.990	-0.030
2023A	353813.445	4107016.533	1834.130	1834.080	-0.050
2024	350086.994	4075927.745	1380.353	1380.330	-0.023
2024A	350090.918	4075939.571	1380.730	1380.590	-0.140
2025	348060.379	4071319.947	1409.694	1409.670	-0.024
2025A	348068.127	4071288.878	1410.317	1410.300	-0.017
2026	352959.250	4061449.934	1537.998	1537.930	-0.068
2026A	352953.267	4061439.111	1538.096	1538.080	-0.016
2027	328894.291	4060776.618	1519.393	1519.440	0.047
2027A	328903.144	4060791.373	1519.135	1519.180	0.045
2028	343292.504	4066412.527	1450.958	1450.980	0.022
2028A	343273.147	4066411.090	1450.819	1450.820	0.001
2029	377398.758	4068023.268	1833.742	1833.750	0.008
2029A	377409.349	4068014.766	1833.727	1833.720	-0.007
2030	361391.221	4066669.556	1616.199	1616.200	0.001
2030A	361377.773	4066671.942	1616.278	1616.270	-0.008
2031	365158.844	4105660.960	1579.637	1579.570	-0.067
2031A	365224.651	4105723.803	1582.019	1581.980	-0.039
2032	364505.796	4090519.250	1427.745	1427.780	0.035
2032A	364530.172	4090519.628	1427.726	1427.760	0.034

2033	363528.735	4092419.564	1438.892	1438.960	0.068
2033A	363568.114	4092432.355	1434.373	1434.430	0.057
2034	331330.847	4083290.025	1577.705	1577.630	-0.075
2034A	331316.999	4083281.303	1577.867	1577.900	0.033
2035	349495.365	4066470.729	1473.661	1473.620	-0.041
2035A	349492.772	4066490.553	1473.328	1473.310	-0.018
2036	366812.566	4092696.521	1494.410	1494.410	0.000
2036A	366792.479	4092686.198	1494.094	1494.090	-0.004
2037	359670.272	4072060.849	1508.467	1508.490	0.023
2037A	359643.756	4072076.487	1507.513	1507.490	-0.023
2038	351805.209	4058908.628	1575.245	1575.260	0.015
2038A	351790.679	4058915.288	1575.459	1575.500	0.041
2039	348650.479	4104699.455	1889.439	1889.450	0.011
2039A	348658.737	4104698.309	1889.533	1889.540	0.007
2040	378983.185	4064764.618	1947.351	1947.370	0.019
2040A	378960.797	4064754.586	1946.519	1946.530	0.011

VERTICAL ACCURACY CONCLUSIONS

Bare-Earth DEM Non-Vegetated Vertical Accuracy (NVA) Tested 0.099 Meters Non-Vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM against 77 NVA points

Table 5.4: VVA Quality Check Point Analysis DEM

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	DEM Elevation (Meter)	Dz (Meter)
3000	364473.146	4105232.673	1563.202	1563.280	0.078
3000A	364450.250	4105221.521	1562.712	1562.760	0.048
3001	366502.961	4101034.636	1539.644	1539.670	0.026
3001A	366480.447	4101033.789	1539.227	1539.220	-0.007
3002	372723.221	4098867.887	1578.540	1578.830	0.290
3002A	372722.675	4098902.807	1579.333	1579.480	0.147
3003	360866.307	4098361.966	1560.116	1560.210	0.094
3003A	360848.855	4098370.050	1562.504	1562.570	0.066
3004	363810.008	4094980.793	1477.353	1477.250	-0.103
3004A	363815.150	4094951.205	1476.162	1476.300	0.138
3005	364127.167	4089817.632	1423.802	1424.170	0.368
3005A	364124.824	4089793.869	1423.583	1423.720	0.137
3006	348855.883	4068925.335	1435.019	1435.080	0.061

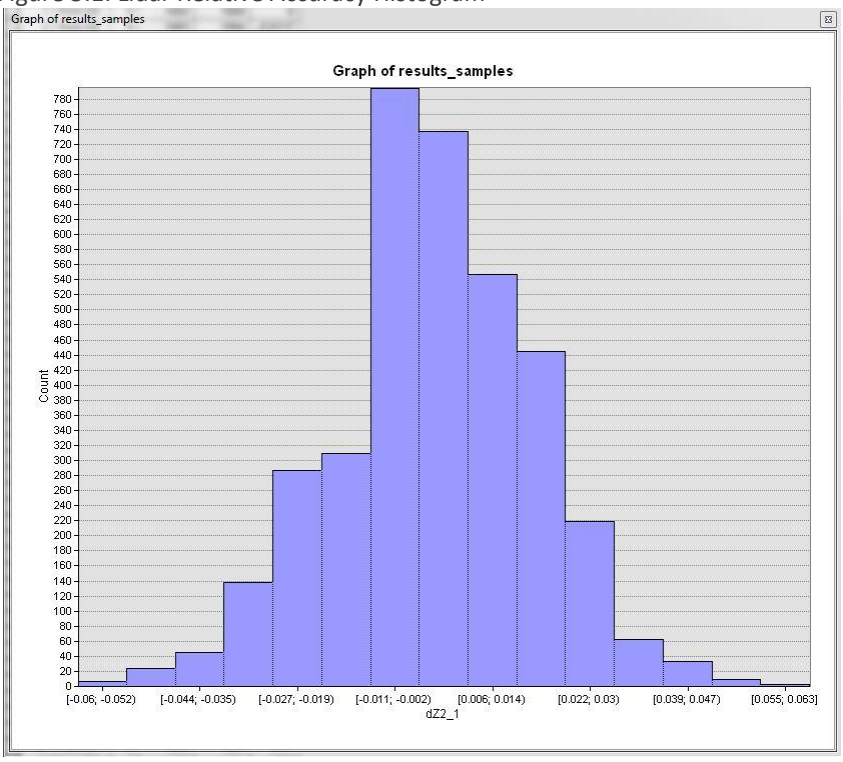
3006A	348867.852	4068920.563	1435.265	1435.290	0.025
3007	350111.042	4075874.384	1379.909	1379.950	0.041
3007A	350121.170	4075872.207	1379.891	1379.920	0.029
3008	336510.817	4081496.338	1508.081	1508.160	0.079
3008A	336510.374	4081481.873	1508.250	1508.520	0.270
3009	331565.939	4083227.146	1561.871	1561.640	-0.231
3009A	331549.546	4083237.537	1561.189	1561.140	-0.049
3010	348064.222	4071240.324	1410.734	1410.780	0.046
3010A	348060.901	4071227.520	1411.029	1411.090	0.061
3011	342365.923	4063601.703	1473.080	1473.090	0.010
3011A	342356.293	4063585.851	1473.377	1473.510	0.133
3012	328865.350	4060787.170	1519.695	1519.640	-0.055
3012A	328861.037	4060764.654	1519.462	1519.420	-0.042
3013	331834.615	4058542.938	1511.923	1511.950	0.027
3013A	331820.164	4058549.056	1511.656	1511.670	0.014
3014	373930.676	4071198.152	1747.324	1747.410	0.086
3014A	373938.483	4071210.736	1747.542	1747.540	-0.002
3015	342694.523	4054045.768	1540.890	1540.940	0.050
3015A	342673.106	4054018.864	1540.055	1540.140	0.085
3016	345374.044	4050187.595	1597.567	1597.720	0.153
3016A	345388.773	4050182.796	1597.780	1597.880	0.100
3017	352935.883	4061466.281	1538.768	1538.800	0.032
3018	352946.545	4061489.345	1538.407	1538.420	0.013
3019	379385.895	4065437.435	1949.249	1949.270	0.021
3019A	379391.119	4065415.519	1948.688	1948.780	0.092
3020	371042.601	4070551.358	1706.602	1706.580	-0.022
3020A	371017.473	4070548.898	1706.054	1706.070	0.016
3021	344364.913	4099839.853	1778.482	1778.490	0.008
3022	353920.823	4107379.747	1821.284	1821.330	0.046
3022A	353929.890	4107341.546	1822.574	1822.580	0.006
3023	359637.780	4072136.465	1506.854	1506.900	0.046
3023A	359623.815	4072113.428	1506.551	1506.620	0.069
3024	365168.750	4102263.162	1546.400	1546.430	0.030
3024A	365176.579	4102264.495	1546.499	1546.690	0.191
3025	366995.130	4092637.772	1493.918	1493.960	0.042
3025A	366997.974	4092663.568	1494.343	1494.410	0.067
3026	336636.038	4056609.929	1520.491	1520.580	0.089
3026A	336619.896	4056619.458	1519.826	1519.780	-0.046
3027	351825.592	4058887.365	1575.263	1575.330	0.067
3027A	351817.979	4058899.168	1575.313	1575.330	0.017
3028	349107.347	4049143.086	1595.083	1595.060	-0.023

3028A	349091.815	4049146.057	1595.721	1595.740	0.019
3029	337969.478	4061438.663	1496.369	1496.340	-0.029
3029A	338002.392	4061435.144	1497.417	1497.410	-0.007
3030	337338.697	4059164.292	1501.707	1501.680	-0.027
3030A	337306.833	4059165.413	1499.910	1499.920	0.010
3031	367926.470	4099070.096	1547.451	1547.460	0.009
3031A	367894.728	4099085.052	1547.429	1547.420	-0.009
3032	348592.419	4104614.538	1888.191	1888.240	0.049
3032A	348604.248	4104605.357	1886.796	1887.690	0.894

VERTICAL ACCURACY CONCLUSIONS

Vegetated Vertical Accuracy (VVA) Tested 0.286 Meters at the 95th percentile reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM against 63 VVA points. VVA Errors larger than 95th percentile include:
Point 3002, Easting 372723.221, Northing 4098867.887, Z-Error 0.290 Meters
Point 3005, Easting 364127.167, Northing 4089817.632, Z-Error 0.368 Meters

Figure 5.1: Lidar Relative Accuracy Histogram



RELATIVE ACCURACY ASSESSMENT AND CONCLUSION

Relative accuracy also known as "between swath" accuracy was tested through a series of well distributed flight line overlap locations. The relative accuracy for the Fredonia (QL1) Lidar measured at 0.017 Meters RMSDz.

Accuracy Assessment for Safford (QL2):

The vertical accuracy statistics were calculated by comparison of all lidar points to the ground surveyed QC points.

Table 5.5: Overall Vertical Accuracy Statistics		
Average error	-0.002	Meter
Minimum error	-0.127	Meter
Maximum error	+0.076	Meter
Average magnitude	0.043	Meter
Root mean square	0.052	Meter
Standard deviation	0.053	Meter

Table 5.6: RAW Swath Quality Check Point Analysis NVA

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	TIN Elevation (Meter)	Dz (Meter)
2100	589334.416	3630810.972	1339.157	1339.060	-0.097
2100A	589360.152	3630877.930	1335.257	1335.160	-0.097
2101	592755.065	3634149.250	1108.458	1108.380	-0.078
2101A	592704.925	3634133.601	1109.445	1109.360	-0.085
2102	604530.610	3643797.493	853.293	853.300	0.007
2102A	604524.215	3643830.209	852.663	852.680	0.017
2103	615304.876	3652062.838	1175.560	1175.610	0.050
2103A	615318.167	3652042.115	1175.306	1175.360	0.054
2104	608895.419	3639595.864	882.015	882.050	0.035
2104A	608883.887	3639621.558	881.552	881.580	0.028
2105	611843.597	3647051.052	973.225	973.270	0.045
2105A	611819.146	3647032.978	972.189	972.220	0.031
2106	608219.640	3634009.414	919.765	919.740	-0.025
2106A	608211.355	3634043.830	919.133	919.150	0.017
2107	601678.546	3634060.377	962.705	962.690	-0.015
2107A	601679.613	3634142.162	961.264	961.240	-0.024
2108	623390.269	3638664.693	953.119	953.150	0.031
2108A	623402.773	3638684.790	953.215	953.220	0.005
2109	607323.384	3627696.145	1192.542	1192.540	-0.002
2109A	607305.183	3627653.663	1197.103	1197.070	-0.033
2110	616077.909	3601077.402	1389.772	1389.700	-0.072
2110A	616095.990	3601095.292	1390.733	1390.630	-0.103
2111	615476.203	3639998.884	879.491	879.530	0.039
2111A	615491.745	3640013.858	880.588	880.620	0.032

2112	618521.738	3633834.884	888.531	888.560	0.029
2112A	618506.037	3633845.936	888.490	888.510	0.020
2113	624774.981	3641371.919	1021.179	1021.220	0.041
2113A	624758.949	3641331.774	1019.817	1019.880	0.063
2114	626819.189	3635721.926	961.435	961.460	0.025
2114A	626790.658	3635727.340	961.374	961.410	0.036
2115	614578.862	3616020.700	1409.720	1409.670	-0.050
2115A	614567.419	3616032.322	1409.752	1409.730	-0.022
2116	629954.399	3640396.744	1058.380	1058.440	0.060
2116A	629969.671	3640391.656	1057.054	1057.130	0.076
2116B	629969.674	3640391.649	1057.076	1057.130	0.054
2117	620288.429	3625322.164	951.511	951.560	0.049
2117A	620289.457	3625292.969	952.185	952.210	0.025
2118	624995.185	3630137.341	907.907	907.940	0.033
2118A	624992.572	3630147.092	907.751	907.780	0.029
2119	626624.705	3626244.544	936.353	936.380	0.027
2119A	626650.478	3626255.458	936.320	936.360	0.040
2120	625279.823	3617000.704	1041.165	1041.200	0.035
2120A	625204.119	3616996.563	1040.550	1040.570	0.020
2121	611687.317	3604164.445	1481.806	1481.690	-0.116
2121A	611722.207	3604139.824	1480.217	1480.090	-0.127
2122	621104.062	3619180.174	999.329	999.340	0.011
2122A	621111.362	3619145.482	998.749	998.760	0.011
2123	622743.693	3611120.412	1155.398	1155.390	-0.008
2123A	622753.484	3611122.105	1155.437	1155.420	-0.017
2124	621423.779	3605661.720	1242.629	1242.600	-0.029
2124A	621411.714	3605645.043	1242.814	1242.760	-0.054
2125	608103.008	3605063.061	1683.253	1683.170	-0.083
2125A	608135.629	3605047.098	1681.116	1681.010	-0.106
2126	619582.537	3642185.942	976.301	976.330	0.029
2126A	619610.734	3642182.337	976.785	976.790	0.005

VERTICAL ACCURACY CONCLUSIONS

Raw Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.102 Meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) 0.052 x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all lidar points against 55 NVA points.

LAS Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.099 Meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) 0.05 x 1.96000 as defined by the National Standards for Spatial

Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using lidar ground points against 55 NVA points.

Table 5.7: NVA Check Point Analysis DEM

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	DEM Elevation (Meter)	Dz (Meter)
2100	589334.416	3630810.972	1339.157	1339.080	-0.077
2100A	589360.152	3630877.930	1335.257	1335.160	-0.097
2101	592755.065	3634149.250	1108.458	1108.420	-0.038
2101A	592704.925	3634133.601	1109.445	1109.380	-0.065
2102	604530.610	3643797.493	853.293	853.320	0.027
2102A	604524.215	3643830.209	852.663	852.650	-0.013
2103	615304.876	3652062.838	1175.560	1175.590	0.030
2103A	615318.167	3652042.115	1175.306	1175.390	0.084
2104	608895.419	3639595.864	882.015	882.030	0.015
2104A	608883.887	3639621.558	881.552	881.570	0.018
2105	611843.597	3647051.052	973.225	973.230	0.005
2105A	611819.146	3647032.978	972.189	972.200	0.011
2106	608219.640	3634009.414	919.765	919.790	0.025
2106A	608211.355	3634043.830	919.133	919.160	0.027
2107	601678.546	3634060.377	962.705	962.690	-0.015
2107A	601679.613	3634142.162	961.264	961.240	-0.024
2108	623390.269	3638664.693	953.119	953.160	0.041
2108A	623402.773	3638684.790	953.215	953.230	0.015
2109	607323.384	3627696.145	1192.542	1192.510	-0.032
2109A	607305.183	3627653.663	1197.103	1197.070	-0.033
2110	616077.909	3601077.402	1389.772	1389.680	-0.092
2110A	616095.990	3601095.292	1390.733	1390.610	-0.123
2111	615476.203	3639998.884	879.491	879.540	0.049
2111A	615491.745	3640013.858	880.588	880.570	-0.018
2112	618521.738	3633834.884	888.531	888.500	-0.031
2112A	618506.037	3633845.936	888.490	888.470	-0.020
2113	624774.981	3641371.919	1021.179	1021.170	-0.009
2113A	624758.949	3641331.774	1019.817	1019.840	0.023
2114	626819.189	3635721.926	961.435	961.450	0.015
2114A	626790.658	3635727.340	961.374	961.410	0.036
2115	614578.862	3616020.700	1409.720	1409.730	0.010
2115A	614567.419	3616032.322	1409.752	1409.720	-0.032
2116	629954.399	3640396.744	1058.380	1058.420	0.040
2116A	629969.671	3640391.656	1057.054	1057.110	0.056
2116B	629969.674	3640391.649	1057.076	1057.110	0.034

2117	620288.429	3625322.164	951.511	951.540	0.029
2117A	620289.457	3625292.969	952.185	952.240	0.055
2118	624995.185	3630137.341	907.907	907.940	0.033
2118A	624992.572	3630147.092	907.751	907.750	-0.001
2119	626624.705	3626244.544	936.353	936.370	0.017
2119A	626650.478	3626255.458	936.320	936.340	0.020
2120	625279.823	3617000.704	1041.165	1041.210	0.045
2120A	625204.119	3616996.563	1040.550	1040.620	0.070
2121	611687.317	3604164.445	1481.806	1481.690	-0.116
2121A	611722.207	3604139.824	1480.217	1480.070	-0.147
2122	621104.062	3619180.174	999.329	999.290	-0.039
2122A	621111.362	3619145.482	998.749	998.770	0.021
2123	622743.693	3611120.412	1155.398	1155.380	-0.018
2123A	622753.484	3611122.105	1155.437	1155.390	-0.047
2124	621423.779	3605661.720	1242.629	1242.590	-0.039
2124A	621411.714	3605645.043	1242.814	1242.770	-0.044
2125	608103.008	3605063.061	1683.253	1683.120	-0.133
2125A	608135.629	3605047.098	1681.116	1681.010	-0.106
2126	619582.537	3642185.942	976.301	976.350	0.049
2126A	619610.734	3642182.337	976.785	976.810	0.025

VERTICAL ACCURACY CONCLUSIONS

Bare-Earth DEM Non-Vegetated Vertical Accuracy (NVA) Tested 0.105 Meters Non-Vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM against 55 NVA points.

Table 5.8 VVA Quality Check Point Analysis DEM

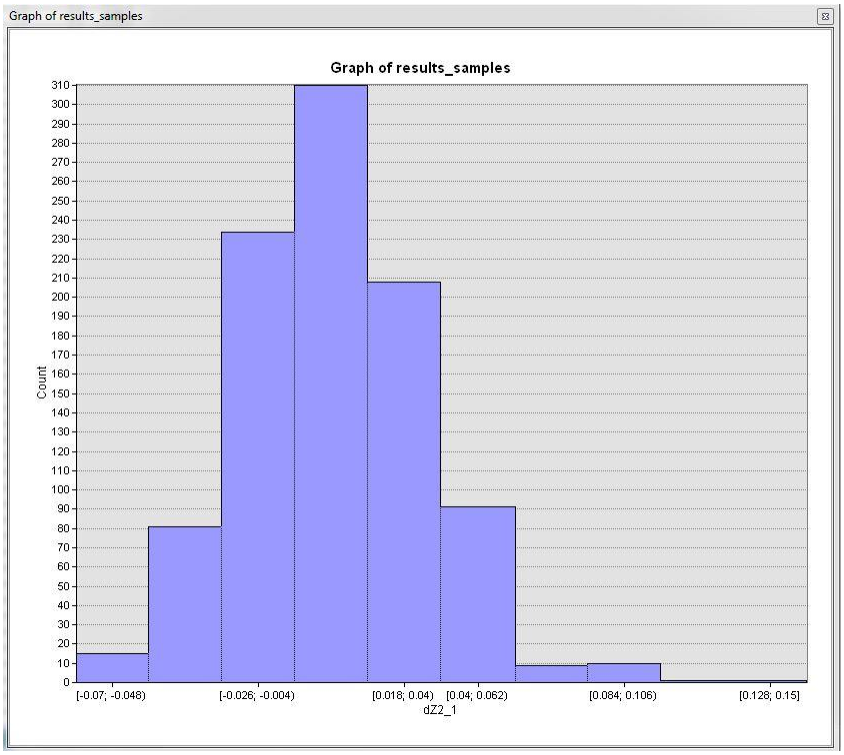
Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)	DEM Elevation (Meter)	Dz (Meter)
3100	589397.754	3630890.989	1333.798	1333.740	-0.058
3100A	589362.972	3630803.420	1338.852	1338.820	-0.032
3101	601744.758	3634123.260	965.305	965.340	0.035
3101A	601765.311	3634062.993	967.159	967.110	-0.049
3102	607286.150	3641891.820	862.269	862.310	0.041
3102A	607269.201	3641907.677	862.105	862.140	0.035
3103	611878.197	3647068.373	973.519	973.560	0.041
3103A	611842.872	3647040.173	974.319	974.350	0.031
3104	615161.915	3652025.665	1165.887	1165.990	0.103

3105	617671.285	3654346.390	1282.286	1282.290	0.004
3105A	617645.891	3654269.532	1279.588	1279.800	0.212
3106	619447.261	3642152.460	970.563	970.600	0.037
3106A	619484.809	3642186.816	972.203	972.240	0.037
3107	630045.397	3640594.360	1062.919	1062.940	0.021
3107A	630068.730	3640605.536	1063.419	1063.560	0.141
3108	624936.480	3629823.801	911.330	911.430	0.100
3108A	624956.467	3629828.315	911.561	911.620	0.059
3109	621317.625	3626876.080	932.223	932.310	0.087
3109A	621343.017	3626863.973	932.108	932.370	0.262
3110	617937.435	3624442.741	988.802	988.910	0.108
3110A	617925.991	3624447.142	989.553	989.730	0.177
3111	614393.419	3616148.499	1430.234	1430.330	0.096
3111A	614382.275	3616137.800	1428.380	1428.300	-0.080
3112	622135.126	3613422.598	1096.938	1097.200	0.262
3112A	622105.086	3613418.537	1096.372	1096.470	0.098
3113	619649.220	3603832.088	1295.838	1296.000	0.162
3113A	619654.848	3603856.252	1295.760	1295.890	0.130
3114	626893.669	3635614.843	960.390	960.490	0.100
3114A	626868.784	3635580.542	959.678	959.900	0.222
3115	616049.319	3600875.219	1396.774	1396.800	0.026
3115A	616054.223	3600848.742	1397.599	1397.600	0.001
3116	606793.893	3626803.715	1283.461	1283.560	0.099
3116A	606782.843	3626832.854	1279.371	1279.470	0.099
3117	608027.683	3605095.187	1687.370	1687.270	-0.100
3117A	608039.073	3605073.919	1689.050	1689.060	0.010
3118	608990.647	3634032.326	915.900	915.950	0.050
3118A	609023.830	3634022.172	915.782	915.890	0.108
3119	614785.157	3635245.702	884.578	884.670	0.092
3119A	614804.742	3635237.475	884.919	885.000	0.081
3120	625596.693	3617119.349	1039.424	1039.450	0.026
3120A	625585.613	3617076.065	1040.178	1040.220	0.042

VERTICAL ACCURACY CONCLUSIONS

Vegetated Vertical Accuracy (VVA) Tested 0.256 Meters at the 95th percentile reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM against 42 VVA points. VVA Errors larger than 95th percentile include:
Point 3109A, Easting 621343.017, Northing 3626863.973, Z-Error 0.262 Meters
Point 3112, Easting 622135.126, Northing 3613422.598, Z-Error 0.262 Meters

Figure 5.2: Lidar Relative Accuracy Histogram



RELATIVE ACCURACY ASSESSMENT AND CONCLUSION

Relative accuracy also known as "between swath" accuracy was tested through a series of well distributed flight line overlap locations. The relative accuracy for the Safford QL2 Lidar measured at 0.027 Meters RMSDz.

Approved by:	Name	Signature	Date
Associate Member, Lidar Specialist Certified Photogrammetrist #1381	Qian Xiao		January 2018

Section 6: 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
	2/15/2017	46	77025	2	USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Denham	N475RC	778.1	10:12:00	17:12:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
Rader	ALS-8194	779.3	11:38:00	18:38:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
030 / 4	10	12000	CLEAR	10	-5	30.33		Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	Varies	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	10:03:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes: x No:
				0:00:00					Take Off: 10:22	
1	SE	17:40:00	17:40:00	0:00:00		1.2			ALS Error at end of line.	
1	NW	17:43:00	x	0:00:00		x			ALS Error	
1	SE	17:47:00	17:47:00	0:00:00		1.2			Manual Stop	
2	NW	17:50:00	X	0:00:00		X			ALS Error	
2	SE	17:53:00	17:54:00	0:00:00		1.2			Manual Stop	
3	SE	18:06:00	18:06:00	0:00:00		1.2				
2	SE	18:10:00	18:10:00	0:00:00		1.2			Manual Stop	
4	NW	18:22:00	18:22:00	0:00:00		1.1				
5	SE	18:25:00	18:25:00	0:00:00		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						
				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: Drive #

BLOCK E ALS Error range measurement - eye safe shutoff distance. Had to manually stop lines for succesful collection.

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/15/2016	289	77025	2	Fredonia_AZ

Operator	Aircraft	HOBBS Start	Local Start Time IMU	ZULU Start Time IMU	Base
Linville	N111SD	186.8	9:35:00	15:35:00	WOOLPERT PIN
Pilot	**Sensor Type**				**PID**
LaROCQUE	OTHER	190.8	1:52:00	19:52:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	kknb
calm	10	clr	0	18	0	30.1		Arriving	kknb

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
20	50	344	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed	AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	5000	agl	10700	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	Base GPS Began Logging At: 9:23:00
		↕ Times entered are Zulu / GMT ↕						Figure 8-Turns Before Mission Yes x No
100	206.3	15:59:05	15:59:40		21	0.6	1.2	
101	026.2	16:03:28	16:04:20		22	0.6	1.1	wind at altitude 233@34 cause pitch
102	206.3	16:08:25	16:09:40		22	0.6	1.1	to exceed 5 degree on line 101
103	206.3	16:14:35	16:16:03		21	0.6	1.3	
104	206.3	16:19:43	16:21:23		21	0.6	1.3	
105	206.3	16:25:17	16:26:57		21	0.6	1.3	
106	206.3	16:31:32	16:33:16		23	0.6	1.1	
107	206.3	16:36:51	16:39:25		21	0.6	1.1	
108	206.3	16:44:00	16:46:34		20	0.6	1.1	
109	206.3	16:51:09	16:54:30		21	0.6	1.1	
110	206.3	16:59:34	17:02:52		20	0.6	1.2	
111	206.3	17:08:03	17:11:21		21	0.6	1.2	
112	206.3	17:16:26	17:19:34		20	0.7	1.3	
86	116.3	17:27:30	17:29:49		20	0.7	1.3	
87	296.4	17:32:40	17:35:24		20	0.7	1.3	
88	116.3	17:38:18	17:40:54		22	0.6	1.1	
89	296.4	17:44:14	17:47:08		22	0.6	1.1	
90	116.3	17:50:13	17:52:54		22	0.6	1.1	
91	296.4	17:56:43	17:59:23		23	0.6	1.1	
92	116.3	18:02:36	18:05:09		23	0.6	1.1	
93	296.4	18:08:14	18:10:54		22	0.6	1.1	
94	116.3	18:14:03	18:16:37		22	0.6	1.1	
95	296.4	18:19:26	18:22:00		22	0.6	1.1	
96	116.3	18:25:02	18:27:32		22	0.6	1.1	
97	296.4	18:30:45	18:33:02		22	0.6	1.1	
98	116.3	18:36:15	18:38:25		22	0.6	1.1	
99	296.3	18:41:39	18:42:33		22	0.6	1.1	
58	341.2	18:50:54	18:51:39		21	0.6	1.1	
59	161.2	18:54:38	18:55:34		21	0.6	1.1	
60	341.2	18:58:06	18:59:00		19	0.6	1.1	
61	161.2	19:02:35	19:03:46		19	0.6	1.1	
62	341.3	19:06:37	19:09:22		19	0.6	1.1	
63	161.2	19:12:29	19:15:25		17	0.7	1.1	
64	341.3	19:18:38	19:21:32		17	0.7	1.1	
65	161.2	19:24:36	19:27:54		18	0.7	1.1	
66	341.3	19:31:10	19:34:20		17	0.7	1.1	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/15/2016	289	77025	2	Fredonia_AZ

Operator	Aircraft	HOBBS Start	Local Start Time IMU	ZULU Start Time IMU	Base
Linville	N111SD	190.8	2:49:00	20:49:00	WOOLPERT PIN
Pilot	**Sensor Type**				**PID**
LaROCQUE	OTHER	194.0	6:09:00	20:09:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	kknb
220@19g24	10	clr	0	27	-1	29.99		Arriving	kknb

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
20	50	344	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed	AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	5000	agl	10700	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	Base GPS Began Logging At: 9:23:00
								Figure 8-Turns Before Mission Yes X No
67	161.2	21:10:56	21:14:10		19	0.6	1.1	
68	341.3	21:17:14	21:20:42		19	0.6	1	
69	161.2	21:23:59	21:27:29		19	0.6	1	
70	341.3	21:30:05	21:33:27		17	0.7	1.1	
71	161.2	21:36:46	21:40:12		18	0.7	1.1	
72	341.3	21:42:57	21:46:22		18	0.6	1.1	
73	161.3	21:49:52	21:53:13		17	0.6	1.1	
74	341.3	21:55:50	21:59:01		18	0.6	1.1	
75	161.3	22:02:05	22:05:29		18	0.6	1.1	
76	341.3	22:08:11	22:11:46		18	0.6	1.1	
77	161.3	22:14:30	22:17:50		18	0.6	1.2	
78	341.3	22:23:44	22:33:44		18	0.7	1.2	
79	161.3	22:26:31	22:30:22		18	0.7	1.2	
80	341.3	22:33:05	22:36:45		18	0.7	1.2	
81	161.3	22:39:35	22:43:11		19	0.7	1.2	
82	341.3	22:45:41	22:48:57		18	0.7	1.3	
83	161.3	22:51:48	22:55:15		17	0.7	1.4	
84	341.3	22:57:32	23:00:51		17	0.7	1.4	
85	161.3	23:03:30	23:06:51		18	0.7	1.4	
57	196.5	23:11:01	23:12:20		18	0.7	1.4	
56	016.5	23:16:40	23:18:01		20	0.6	1.2	
55	196.5	23:22:05	23:25:22		20	0.6	1.1	
54	016.5	23:28:33	23:31:44		20	,6	1.1	
53	196.5	23:34:53	23:37:19		21	0.6	1	
52	016.5	23:40:24	23:43;00		21	0.6	1.1	
51	196.5	23:45:50	23:48:37		21	0.6	1.1	
50	016.5	23:51:32	23:54:15		22	0.5	1	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/16/2016	290	77025	2	Fredonia_AZ

Operator	Aircraft	Hobbs Start	Local Start Time (MST)	Zulu Start Time (MST)	Base
Linville	N111SD	194.7	8:53:00	14:53:00	WOOLPERT PIN
Pilot	**Sensor Type**				**PID**
LaROCQUE	OTHER	198.8	1:07:00	19:07:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
calm	10	clr	0	15	3	30.04		Departing	kknb
								Arriving	kknb

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
20	50	344	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
130		5000	agl	10700	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	Base GPS Began Logging At: 8:40:00
↕ Times entered are Zulu / GMT ↕								Figure 8-Turns Before Mission Yes X No
1	196.3	15:15:08	15:17:25		18	0.6	1.1	
2	016.2	15:21:21	15:24:42		18	0.6	1.1	wind at altitude 224@46
3	196.3	15:28:50	15:34:42		18	0.6	1.1	
4	196.3	15:40:58	15:46:45		18	0.6	1.1	
5	196.3	15:54:22	16:00:20		17	0.6	1.2	
6	016.2	16:03:26	16:09:02		18	0.6	1.1	
7	196.3	16:12:49	16:19:21		18	0.6	1.3	
8	196.3	16:26:50	16:33:29		20	0.6	1.1	
9	196.3	16:41:56	16:48:31		19	0.6	1.1	
10	196.3	16:57:14	17:03:24		18	0.6	1.2	
11	016.3	17:10:18	17:16:15		19	0.6	1.1	
12	196.3	17:19:58	17:26:16		18	0.6	1.2	
13	016.3	17;30:39	17:37:16		19	0.6	1.2	
14	196.3	17:41:46	17:48:26		18	0.7	1.2	
15	016.3	17:51:11	17:58:30		20	0.6	1.1	
16	196.3	18:01:23	18:09:00		21	0.6	1.1	
17	016.3	18:11:08	18:18:49		21	0.6	1.1	
18	196.3	18:22:02	18:29:58		21	0.6	1.1	
19	016.3	18:32:24	18:40:10		21	0.6	1.1	
20	196.3	18:42:40	18:50:28		22	0.6	1.1	
21	196.4	20:06:27	20:14:35		17	0.7	1.3	start 2nd flight
22	016.3	20:17:35	20:25:22		17	0.8	1.4	wind at altitude 217@30
23	196.4	20:28:05	20:36:04		17	0.7	1.4	
24	016.3	20:39:33	20:47:00		17	0.7	1.3	
25	196.4	20:49:37	20:57:03		19	0.6	1.1	
26	061.3	21:00:28	21:07:40		19	0.6	1.1	
27	196.4	21:11:22	21:18:44		19	0.6	1.1	
28	016.3	21:22:00	21:29:21		19	0.6	1.1	
29	196.4	21:32:15	21:39:37		18	0.6	1	
30	016.3	21:41:54	21:49:28		18	0.6	1	
31	196.4	21:52:43	22:00:22		17	0.7	1.1	
32	016.3	22:02:41	22:09:47		18	0.6	1.1	
33	196.4	22:12:26	22:20:06		18	0.7	1.2	
34	016.3	22:22:21	22:29:53		18	0.7	1.2	
35	196.4	22:33:13	22:41:28		19	0.7	1.2	
36	016.3	22:43:10	22:52:00		17	0.7	1.4	
37	196.4	22:55:09	23:00:00		17	0.7	1.4	
38	016.4	23:02:07	23:07:07		17	0.7	1.4	
39	196.4	23:09:32	23:14:25		20	0.6	1.2	
↑ Times entered are Zulu / GMT ↑				Page	1			Figure 8-Turns After Mission Yes X No

Additional Comments: Drive #

Aircraft tail # is N6255Q 2nd flight hobbs start 198.9 hobbs stop 202.3. system start local 1:45:00 Zulu 19:45:00. system stop local 5:30:00 Zulu 23:30:00 weather: 210@20 CLR 25/1 29.98

156

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/17/2016	291	77025	2	Fredonia_AZ

Operator	Aircraft	Hobbs Start	Local Start Time MST	Local Stop Time MST	Base
Linville	N111SD	203.4	11:59:00	17:59:00	WOOLPERT PIN
Pilot	**Sensor Type**				**PID**
LaROCQUE	OTHER	204.7	1:30:00	19:30:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
230@12	10	clr	0	21	3	29.98		Departing	kknb
								Arriving	kknb

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
20	50	344	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed	AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	5000	agl	10700	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	Base GPS Began Logging At: 9:56:00
		↕ Times entered are Zulu / GMT ↕						Figure 8-Turns Before Mission Yes X No
40	016.4	18:15:20	18:18:47		19	0.6	1.1	flight is right under base of clouds
41	196.5	18:21:21	18:24:44		19	0.6	1.1	
42	016.4	18:27:34	18:30:27		19	0.6	1.1	
43	196..5	18:33:15	18:36:10		19	0.6	1.1	
44	016.4	18:38:59	18:41:40		19	0.6	1.1	
45	196.5	18:44:55	18:47:28		19	0.6	1	
46	016.4	18:50:17	18:52:50		18	0.6	1.1	
47	196.5	18:55:21	18:58:12		18	0.6	1.1	
48	016.4	19:01:04	19:04:11		17	0.6	1.2	
49	196.5	19:06:53	19:09:57		18	0.6	1.1	
1	171.8	22:15:07	22:16:39		18	0.8	1.2	D flights, 11900msl, 5000 agl
2	351.8	22:19:18	22:20:46		18	0.7	1.2	Line 1 starts 2nd flight
3	171.8	22:23:17	22:24:40		19	0.7	1.3	
4	351.8	22:27:14	22:28:17		19	0.7	1.2	
5	171.8	22:30:47	22:31:34		19	0.7	1.2	

↑ Times entered are Zulu / GMT ↑				1	Figure 8-Turns After Mission	Yes	X	No	

Additional Comments: Drive #

Aircraft tail # 6255Q. 2nd flight system start L 3:57:00 Z 21:57:00 hobbs start 204.7 wx:250@13g20 CLR 22/4 29.94 205.4 system stop L 4:48:00 Z 22:48:00 hobbs stop

132

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/8/2016	343	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
DENHAM	N404CP	5764.6	12:25:00	19:25:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5767.3	3:20:00	22:20:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KNB
CALM	10	10000	BKN	6	-12	30.29		Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	12:15:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 12:35	
150	S	19:49:00	19:50:00	0:00:00		1				
149	N	19:53:00	19:54:00	0:00:00		1.1				
148	S	19:56:00	19:58:00	0:00:00		1.1				
147	N	20:01:00	20:03:00	0:00:00		1.1				
146	S	20:06:00	20:08:00	0:00:00		1				
145	N	20:10:00	20:12:00	0:00:00		1				
144	S	20:15:00	20:17:00	0:00:00		1.1				
143	N	20:19:00	20:21:00	0:00:00		1.1				
142	S	20:23:00	20:25:00	0:00:00		1.1				
141	N	20:28:00	20:30:00	0:00:00		1.1				
140	S	20:32:00	20:35:00	0:00:00		1.1				
139	N	20:37:00	20:39:00	0:00:00		1.1				
138	S	20:42:00	20:44:00	0:00:00		1.2				
137	N	20:46:00	20:49:00	0:00:00		1.1				
136	S	20:52:00	20:55:00	0:00:00		1.3				
135	N	20:57:00	21:01:00	0:00:00		1.3				
134	S	21:03:00	21:06:00	0:00:00		1.3				
133	N	21:09:00	21:12:00	0:00:00		1.2				
132	S	21:14:00	21:18:00	0:00:00		1.3				
131	N	21:20:00	21:23:00	0:00:00		1.2				
130	S	21:26:00	21:33:00	0:00:00		1.1				
129	N	21:36:00	21:44:00	0:00:00		1.1				
128	S	21:47:00	21:55:00	0:00:00		1.2				
127	N	21:58:00	22:06:00	0:00:00		1.1				
				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: Drive #

BLOCK B

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/9/2016	344	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5768.0	12:21:00	19:21:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5771.8	16:23:00 PM	23:23:00 PM	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	10000	BKN	8	-3	30.3		Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode			Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	215	
				Gain - Fine/Down		Multi	X	B	195	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	12:18:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 12:35; Landing: 16:17	
1	S	19:45:00	19:46:00	0:00:00		1.1				
2	N	19:49:00	19:52:00	0:00:00		1.1				
3	S	19:57:00	20:04:00	0:00:00		1.1				
4	N	20:06:00	20:12:00	0:00:00		1.1				
5	S	20:15:00	20:21:00	0:00:00		1.1				
6	N	20:23:00	20:30:00	0:00:00		1.1				
8	S	20:40:00	20:47:00	0:00:00		1.1				
9	N	20:49:00	20:56:00	0:00:00		1.3				
10	S	21:02:00	21:10:00	0:00:00		1.3				
7	N	21:13:00	21:20:00	0:00:00		1.2				
11	S	21:22:00	21:30:00	0:00:00		1.1				
12	N	21:32:00	21:40:00	0:00:00		1.1				
13	S	21:42:00	21:51:00	0:00:00		1.1				
14	N	21:53:00	22:03:00	0:00:00		1.2				
15	S	22:04:00	22:12:00	0:00:00		1				
16	N	22:14:00	22:36:00	0:00:00		1.2				
17	S	22:43:00	22:51:00	0:00:00		1.2				
18	N	22:53:00	23:06:00	0:00:00		1.2				
				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 S-Turns After Mission	Yes X No

Additional Comments:	Drive #
BLOCK B. Reflew Lines 7, 14, 16 & 18 due to unsafe eye altitude due to range perameters, Lidar stopped capturing and had to refly lines at higher altitude JOY	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/11/2016	346	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	Zulu Start Time	Base
Other	N404CP	5772.5	10:17:00	17:17:00 PM	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5777.7	15:43:00 PM	22:243:00 PM	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	10	-4	30.19		Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	215
				Gain - Fine/Down		Multi	X	B	195

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
130	Kts	5000	Ft	8300	Ft	Yes		No		@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At: 10:06:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission Yes X No
									Take Off: 10:27; Landing: 15:37
1	S	17:37:00	17:39:00	0:00:00		1.1			
2	N	17:41:00	17:43:00	0:00:00		1.1			
3	S	17:45:00	17:47:00	0:00:00		1.1			
4	N	17:49:00	17:51:00	0:00:00		1.1			
5	S	17:53:00	17:56:00	0:00:00		1			
6	N	17:58:00	18:00:00	0:00:00		1			
7	S	18:02:00	18:03:00	0:00:00		1.1			
8	N	18:05:00	18:06:00	0:00:00		1.1			
9	S	18:08:00	18:09:00	0:00:00		1.2			
10	N	18:12:00	18:13:00	0:00:00		1.2			
11	S	18:15:00	18:16:00	0:00:00		1.1			
40	NW	18:29:00	18:31:00	0:00:00		1.2			
38	N	18:46:00	18:47:00	0:00:00		1.3			
37	S	18:50:00	18:51:00	0:00:00		1.3			
36	N	18:54:00	18:56:00	0:00:00		1.3			
35	S	18:59:00	19:05:00	0:00:00		1.4			
34	N	19:09:00	19:11:00	0:00:00		1.4			
33	S	19:14:00	19:17:00	0:00:00		1.4			
32	N	19:22:00	19:24:00	0:00:00		1.3			
31	S	19:27:00	19:30:00	0:00:00		1.1			
30	N	19:32:00	19:35:00	0:00:00		1.1			
29	S	19:37:00	19:40:00	0:00:00		1			
28	N	19:43:00	19:46:00	0:00:00		1.1			
27	S	19:52:00	19:55:00	0:00:00		1.1			
26	N	20:11:00	20:14:00	0:00:00		1.1			
25	S	20:19:00	20:26:00	0:00:00		1			
44	NW	20:29:00	20:31:00	0:00:00		1.1			
43	SE	20:33:00	20:35:00	0:00:00		1.1			
42	NW	20:37:00	20:40:00	0:00:00		1.2			
41	SE	20:42:00	20:44:00	0:00:00		1.3			
39	SE	20:46:00	20:48:00	0:00:00		1.3			
24	N	20:58:00	21:07:00	0:00:00		1.2			
23	S	21:09:00	21:19:00	0:00:00		1.1			
22	N	21:21:00	21:31:00	0:00:00		1.1			
21	S	21:33:00	21:43:00	0:00:00		1.1			
20	N	21:45:00	21:55:00	0:00:00		1.2			
19	S	21:57:00	22:17:00	0:00:00		1.1			
18	N	22:19:00	22:28:00	0:00:00		1.2			
				Page		1			Verify S-Turns After Mission Yes X No
									Drive #

A Block, ALS did not start recording on line 19 when manually tried to record, Sensor shut off on lines 38-27 and had to refly many of them.

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/13/2016	348	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5778.3	9:20:00	16:20:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5784.1	15:19:00	22:19:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	2	0	30.2	NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	8300/9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At: 9:10:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission Yes X No
A	Blk								Take Off: 9:31 Land: 15:12
17	S	16:38:00	16:50:00	0:00:00	1.4				
16	N	16:52:00	17:00:00	0:00:00	1.1				
15	S	17:03:00	17:11:00	0:00:00	1.1				
14	N	17:13:00	17:19:00	0:00:00	1				
13	S	17:21:00	17:27:00	0:00:00	1				
12	N	17:29:00	17:35:00	0:00:00	1.1				
B	Blk								
124	S	17:44:00	17:59:00	0:00:00	1				
125	N	18:01:00	18:10:00	0:00:00	1.2				
126	S	18:12:00	18:21:00	0:00:00	1.1				
123	N	18:23:00	18:37:00	0:00:00	1.2				
122	S	18:39:00	18:54:00	0:00:00	1.3				
121	N	18:56:00	19:11:00	0:00:00	1.4				
120	S	19:13:00	19:27:00	0:00:00	1.4				
119	N	19:30:00	19:44:00	0:00:00	1.2				
118	S	19:49:00	20:04:00	0:00:00	1.2				
117	N	20:07:00	20:21:00	0:00:00	1.2				
116	S	20:23:00	20:38:00	0:00:00	1.2				
115	N	20:41:00	20:55:00	0:00:00	1.3				
114	S	20:57:00	21:13:00	0:00:00	1.2				
113	N	21:15:00	21:29:00	0:00:00	1.1				
112	S	21:32:00	21:47:00	0:00:00	1.3				
111	N	21:51:00	22:03:00	0:00:00	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					
↑ Times entered are Zulu / GMT ↑				Page	1				Verify S-Turns After Mission Yes X No

Additional Comments: **A BLOCK & BLOCK B**

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/14/2016	349	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	Zulu Start Time	Base
Other	N404CP	5784.8	9:50:00	16:50:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5790.2	15:30:00	22:30:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	6	1	30.24	NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At: 9:35:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission Yes X No
									Take Off: 10:00 Land: 15:23
110	S	17:11:00	17:24:00	0:00:00	1.1				
109	N	17:27:00	17:39:00	0:00:00	1.2				
108	S	17:42:00	17:55:00	0:00:00	1				
107	N	17:59:00	18:13:00	0:00:00	1.2				
106	S	18:15:00	18:30:00	0:00:00	1.2				
105	N	18:32:00	18:46:00	0:00:00	1.3				
104	S	18:49:00	19:04:00	0:00:00	1.4				
103	N	19:07:00	19:22:00	0:00:00	1.4				Clouds cut off sensor with 3 Points left
19	S	19:32:00	19:41:00	0:00:00	1.2				
20	N	19:43:00	19:52:00	0:00:00	1.1				
21	S	19:55:00	20:04:00	0:00:00	1.1				
22	N	20:07:00	20:16:00	0:00:00	1.1				
23	S	20:22:00	20:31:00	0:00:00	1.2				
24	N	20:33:00	20:42:00	0:00:00	1.4				
25	S	20:45:00	20:54:00	0:00:00	1.2				
26	N	20:56:00	21:05:00	0:00:00	1.2				
27	S	21:08:00	21:22:00	0:00:00	1.2				
28	N	21:25:00	21:37:00	0:00:00	1.2				
29	S	21:40:00	21:49:00	0:00:00	1.2				
30	N	21:55:00	22:03:00	0:00:00	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					
↑ Times entered are Zulu / GMT ↑				Page		1			Verify S-Turns After Mission Yes X No

Additional Comments: Drive #

BLOCK B

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/17/2016	352	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5794.1	11:13:00	18:13:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5799.3	16:25:00	23:25:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	0	-12	30.05	NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode			Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A		
				Gain - Fine/Down		Multi	X	B		

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	11:05:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 11:23 Land: 16:27	
31	S	18:33:00	18:41:00	0:00:00		1.5				
32	N	18:43:00	18:52:00	0:00:00		1.5				
33	S	18:56:00	19:06:00	0:00:00		1.2				
34	N	19:08:00	19:18:00	0:00:00		1				
35	S	19:22:00	19:33:00	0:00:00		1.1				
60	N	19:36:00	19:51:00	0:00:00		1.1				
61	S	19:54:00	20:07:00	0:00:00		1.1				
62	N	20:10:00	20:24:00	0:00:00		1.2				
63	S	20:26:00	20:41:00	0:00:00		1.3				
64	N	20:44:00	20:57:00	0:00:00		1.1				
65	S	21:00:00	21:14:00	0:00:00		1.1				
66	N	21:17:00	21:32:00	0:00:00		1.2				
67	S	21:34:00	21:48:00	0:00:00		1				
68	N	21:51:00	22:05:00	0:00:00		1.2				
69	S	22:08:00	22:22:00	0:00:00		1.2				
70	N	22:25:00	22:40:00	0:00:00		1.1				
71	S	22:43:00	22:58:00	0:00:00		1.1				
72	N	23:01:00	23:17:00	0:00:00		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 S-Turns After Mission	Yes X No

Additional Comments: Drive #

BLOCK B

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/18/2016	353	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5800.0	9:25:00	16:25:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5806.0	15:42:00	22:42:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	-3	-14	30.37	HAZE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	9:19:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 9:35 Land: 15:36	
102	S	16:45:00	17:00:00	0:00:00		1.1				
101	N	17:03:00	17:19:00	17:19:00		1.2				
100	S	17:21:00	17:37:00	0:00:00		1.1				
99	N	17:39:00	17:55:00	0:00:00		1.1				
98	S	18:01:00	18:16:00	0:00:00		1.2				
97	N	18:19:00	18:35:00	0:00:00		1.3				
96	S	18:37:00	18:53:00	0:00:00		1.2				
95	N	18:55:00	19:11:00	0:00:00		1				
94	S	19:14:00	19:30:00	0:00:00		1				
93	N	19:33:00	19:49:00	0:00:00		1				
92	S	19:52:00	20:08:00	0:00:00		1.2				
91	N	20:11:00	20:27:00	0:00:00		1.2				
90	S	20:29:00	20:46:00	0:00:00		1.1				
89	N	20:48:00	21:04:00	0:00:00		1.2				
88	S	21:07:00	21:23:00	0:00:00		1.1				
87	N	21:25:00	21:41:00	0:00:00		1				
86	S	21:44:00	22:01:00	0:00:00		1.2				
85	N	22:03:00	22:20:00	0:00:00		1.1				
103	S	22:22:00	22:24:00	0:00:00		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						
↑ Times entered are Zulu / GMT ↑				Page		1			Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

B Block

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/19/2016	354	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5806.7	9:51:00	16:51:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5790.2	16:07:00	23:07:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	1	-17	30.55	NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	9:45:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 9:59 Land: 15:59	
73	S	17:08:00	17:24:00	0:00:00		1.1				
74	N	17:26:00	17:42:00	0:00:00		1				
75	S	17:44:00	18:00:00	0:00:00		1.1				
76	N	18:02:00	18:22:00	0:00:00		1.2				
77	S	18:24:00	18:40:00	0:00:00		1.3				
78	N	18:43:00	18:58:00	0:00:00		1.4				
79	S	19:01:00	19:16:00	0:00:00		1				
80	N	19:19:00	19:34:00	0:00:00		1.1				
81	S	19:37:00	19:53:00	0:00:00		1.1				
82	N	19:56:00	20:12:00	0:00:00		1.1				
83	S	20:14:00	20:30:00	0:00:00		1.2				
84	N	20:32:00	20:49:00	0:00:00		1.1				
59	S	20:53:00	21:07:00	0:00:00		1				
58	N	21:10:00	21:24:00	0:00:00		1.2				
57	S	21:26:00	21:40:00	0:00:00		1.1				
56	N	21:43:00	21:55:00	0:00:00		1.2				
55	S	21:57:00	22:10:00	0:00:00		1.2				
54	N	22:12:00	22:24:00	0:00:00		1.1				
53	S	22:26:00	22:37:00	0:00:00		1.2				
52	N	22:39:00	22:50:00	0:00:00		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						
↑ Times entered are Zulu / GMT ↑				Page		1			Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

B BLOCK

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/20/2016	355	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Other	N404CP	5813.4	10:25:00	17:25:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5818.8	16:03:00	23:03:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10	12000	BKN	4	-11	30.54	NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	10:18:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 10:35 Land: 15:56	
B36	S	17:46:00	17:57:00	0:00:00		1.2				
B37	N	18:00:00	18:11:00	0:00:00		1.2				
B38	S	18:14:00	18:25:00	0:00:00		1.3				
B39	N	18:27:00	18:39:00	0:00:00		1.4				
B40	S	18:42:00	18:54:00	0:00:00		1.2				
B41	N	18:56:00	19:08:00	0:00:00		1				
B42	S	19:10:00	19:23:00	0:00:00		1				
B43	N	19:25:00	19:37:00	0:00:00		1.1				
B44	S	19:40:00	19:51:00	0:00:00		1.1				
B45	N	19:53:00	20:08:00	0:00:00		1.2				
B46	S	20:14:00	20:27:00	0:00:00		1.2				
B47	N	20:29:00	20:40:00	0:00:00		1.1				
B48	S	20:42:00	20:56:00	0:00:00		1.2				
B49	N	20:59:00	21:10:00	0:00:00		1.1				
B50	S	21:13:00	21:24:00	0:00:00		1.1				
A19	N	21:29:00	21:30:00	0:00:00		1.1				
A23	N	21:34:00	21:35:00	0:00:00		1.2				
A25	N	21:39:00	21:41:00	0:00:00		1.2				
A26	N	21:43:00	21:48:00	0:00:00		1.2				
A27	N	21:51:00	21:55:00	0:00:00		1.2				
A30	S	22:03:00	22:06:00	0:00:00		1.1				
A28	N	22:08:00	22:11:00	0:00:00		1.1				
A29	S	22:14:00	22:16:00	0:00:00		1.1				
A31	N	22:18:00	22:21:00	0:00:00		1				
A32	S	22:23:00	22:25:00	0:00:00		1				
A33	N	22:28:00	22:30:00	0:00:00		1.1				
B51	N	22:35:00	22:46:00	0:00:00		1.1				
				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: Drive #

A BLOCK (REFLIGHTS) & BLOCK B

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/10/2017	345	77025		USGS Fredonia AZ

Operator	Aircraft	HOBBS Start	Local Start Time	Zulu Start Time	Base
Other	N404CP			21:49:00	WOOLPERT PIN

Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID
Other	ALS-8191			21:53:00	KNB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
CALM	10						NONE	Departing	KNB
								Arriving	KNB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
20	50	371	99	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
130	Kts	5000	Ft	9500	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments
Test	n/a			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
B1151	S	21:49:00	21:53:00	0:00:00		1.2			

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

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	2/15/2017	46	77025	2	USGS Safford AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
Denham	N475RC	781.2	2:55:00	21:55:00	WOOLPERT PIN
Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID
Rader	ALS-8194	782.1	4:05:00	23:05:00	KSAD

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KSAD
110 / 10	10		CLEAR	16	-1	30.14		Arriving	KSAD

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used			Waveform Mode	Pre-Trigger Dist.
150	Kts	6500	Ft	9240	Ft	Yes		No	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	2:35:00
↕ Times entered are Zulu / GMT ↕									Verify S-Turns Before Mission	Yes X No
									Take Off: 3:03	
20	S	22:16:00	X	0:00:00	19	1.2	152	9199	ALS Error	
				0:00:00					Shut Down/ Refly Base Station	
20	S	22:37:00	22:50:00	0:00:00	19	1.2	157	9230		
				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						
				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						
				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:	Drive #
BLOCK A ALS Error - System Controller has not received a proper time recovery message from INS/GNSS Module. {SOW not Updating}	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/18/2016	292	77025	2	Safford_AZ

Operator	Aircraft	HOBBS Start	Local Start Time IMU	ZULU Start Time IMU	Base
Linville	N111SD	207.0	9:21:00	16:21:00	WOOLPERT PIN

Pilot	Sensor Type				PID
LaROCQUE	OTHER	211.7	2:16:00	21:16:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
calm	10	clr	0	21	3	30.03		Departing	ksad
								Arriving	ksad

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed	AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	6500	agl	15,240	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	Base GPS Began Logging At: 9:00:00
		↕ Times entered are Zulu / GMT ↕						Figure 8-Turns Before Mission Yes X No
1	115.3	16:52:09	16:53:53		18	0.7	1.3	D flights, wind 240@21
2	295.4	16:57:20	16:59:22		18	0.7	1.3	
3	115.3	17:02:19	17:04:43		18	0.7	1.3	
4	295.4	17:07:31	17:10:15		18	0.7	1.3	
5	115.3	17:13:15	17:16:14		20	0.6	1.2	
6	295.4	17:18:59	17:22:25		20	0.6	1.1	
7	115.3	17:25:35	17:29:10		20	0.6	1.1	
8	295.4	17:32:11	17:36:48		21	0.6	1.1	
9	115.2	17:40:11	17:50:35		20	0.6	1.2	
								C Flights, 13,235 msl
2	301.8	17:52:11	17:53:39		21	0.6	1.1	
3	121.7	17:56:50	17:58:35		21	0.6	1.2	
4	301.7	18:01:47	18:04:14		21	0.6	1.1	
5	121.6	18:07:13	18:09:36		21	0.6	1.1	
6	301.7	18:12:43	18:15:21		21	0.6	1.1	
7	121.6	18:18:20	18:21:07		21	0.6	1.1	
8	301.7	18:25:19	18:29:29		21	0.6	1.1	
9	121.6	18:32:21	18:36:26		21	0.6	1.1	
10	301.8	18:39:25	18:44:39		20	0.6	1.1	
11	121.6	18:47:54	18:53:20		19	0.6	1.1	
12	301.8	18:56:08	19:02:20		18	0.7	1.1	
13	121.6	19:05:27	19:11:02		18	0.6	1.2	
14	301.8	19:14:00	19:21:13		18	0.6	1	
15	121.5	19:24:26	19:31:34		17	0.7	1.1	
16	301.7	19:34:48	19:41:17		17	0.7	1.1	
17	121.5	19:44:23	19:50:26		17	0.7	1.1	
18	135.6	19:54:15	19:55:56		18	0.6	1	
1	308.6	20:08:49	20:10:23		15	0.8	1.5	
1	123.9	20:15:20	20:18:28		16	0.8	1.4	b flights 11,240 msl
2	304.0	20:21:27	20:25:01		17	0.7	1.1	
3	123.9	20:28:15	20:31:39		17	0.7	1.1	
4	304.0	20:34:34	20:38:55		18	0.6	1.1	
5	123.9	20:42:14	20:46:50		18	0.6	1.1	
6	304.0	20:49:34	20:54:30		18	0.6	1.1	
7	123.9	20:57:19	20:58:53		19	0.6	1	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	10/18/2016	292	77025	2	Safford_AZ

Operator	Aircraft	HOBBS Start	Local Start Time IMU	ZULU Start Time IMU	Base
Linville	N111SD	211.7	2:55:00	20:55:00	WOOLPERT PIN
Pilot	**Sensor Type**				**PID**
LaROCQUE	OTHER	215.3	6:43:00	1:43:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
calm	10	clr	0	21	3	30.03		Departing	ksad
								Arriving	ksad

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	PreSet
				Gain - Fine/Down		Multi		B	PreSet

Air Speed	AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	6500	agl	11,240	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	Base GPS Began Logging At:	9:00:00
								Figure 8-Turns Before Mission	Yes X No
8	270.8	22:16:02	22:18:44		19	0.6	1.2		
9	090.6	22:20:45	22:25:15		19	0.6	1.2		
10	270.8	22:27:58	22:33:16		19	0.7	1.2		
11	090.6	22:35:13	22:40:00		17	0.7	1.4		
12	270.8	22:42:31	22:47:28		18	0.7	1.4		
13	090.6	22:49:50	22:54:43		18	0.7	1.5		
14	270.8	22:57:07	23:02:01		19	0.7	1.4		
15	090.6	23:04:19	23:08:55		20	0.6	1.2		
16	270.8	23:11:15	23:15:52		21	0.6	1.1		
17	090.6	23:17:59	23:22:34		22	0.6	1		
18	179.4	23:27:02	23:32:20		21	0.6	1.1		
19	359.4	23:35:11	23:40:24		21	0.6	1.1		
20	179.4	23:43:10	23:48:21		21	0.6	1.1		
21	359.4	23:50:55	23:55:43		21	0.6	1.1		
22	179.4	23:58:08	0:00:23		21	0.6	1.1		
23	359.4	0:05:33	0:10:07		22	0.5	1.1		
24	179.4	0:12:51	0:17:21		22	0.6	1.2		
25	359.4	0:19:37	0:24:21		22	0.6	1.3		
26	179.4	0:27:02	0:31:36		22	0.6	1.1		
27	359.4	0:33:39	0:38:06		23	0.6	1.2		
28	179.4	0:40:24	0:44:58		23	0.6	1.2		
29	359.4	0:47:14	0:51:54		22	0.6	1.2		
30	179.4	0:54:29	0:58:05		21	0.6	1.2		
31	359.4	1:00:25	1:02:18		21	0.6	1.2		
32	179.4	1:04:25	1:06:39		21	0.6	1.2		
33	359.4	1:09:11	1:11:39		23	0.6	1.1		
34	179.5	1:13:50	1:16:12		21	0.6	1.1		
35	359.5	1:19:08	1:20:39		21	0.6	1.1		

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/6/2016	341	77025		USGS SAFFORD AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
DENHAM	N404CP	5753.1	12:10:00	19:10:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5757.2	4:30:00	23:30:00	KSAD

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KSAD
120/4	10		CLEAR	14	-1	29.93		Arriving	KSAD

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	9200	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	11:55:00
		↕ Times entered are Zulu / GMT ↕							Verify S-Turns Before Mission	Yes X No
									Take Off: 12:19	
38	E	19:36:00	19:38:00	0:00:00		1.4				
39	W	19:41:00	19:44:00	0:00:00		1.2				
40	E	19:46:00	19:49:00	0:00:00		1.2				
41	W	19:51:00	19:55:00	0:00:00		1.2				
42	E	19:57:00	20:01:00	0:00:00		1				
43	W	20:03:00	20:08:00	0:00:00		1				
44	E	20:10:00	20:15:00	0:00:00		1.1				
45	W	20:17:00	20:22:00	0:00:00		1.2				
46	E	20:25:00	20:30:00	0:00:00		1.2				
47	W	20:32:00	20:37:00	0:00:00		1.1				
48	E	20:39:00	20:45:00	0:00:00		1.1				
49	W	20:47:00	20:52:00	0:00:00		1.1				
50	E	20:55:00	21:00:00	0:00:00		1.2				
51	W	21:02:00	21:07:00	0:00:00		1.2				
52	E	21:10:00	21:16:00	0:00:00		1.2				
10	N	21:19:00	21:23:00	0:00:00		1.2				
9	S	21:25:00	21:29:00	0:00:00		1.2				
8	N	21:31:00	21:34:00	0:00:00		1.3				
7	S	21:36:00	21:40:00	0:00:00		1.3				
6	N	21:42:00	21:45:00	0:00:00		1.3				
5	S	21:47:00	21:50:00	0:00:00		1.1				
4	N	21:52:00	21:55:00	0:00:00		1.1				
3	S	21:53:00	22:00:00	0:00:00		1.2				
2	N	22:01:00	22:04:00	0:00:00		1.1				
1	S	22:06:00	22:09:00	0:00:00		1.1				
11	S	22:15:00	22:26:00	0:00:00		1.3				
33	N	22:31:00	22:38:00	0:00:00		1.3				
32	S	22:41:00	22:48:00	0:00:00		1.3				
31	N	22:50:00	22:58:00	0:00:00		1.3				
34	S	23:00:00	23:03:00	0:00:00		1.2				
↑ Times entered are Zulu / GMT ↑				Page		1			Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

BLOCK A. Encountered quite a bit of turbulence due to mountains in some areas.

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/6/2016	341	77025		USGS SAFFORD AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
DENHAM	N404CP	5753.1	12:10:00	19:10:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5757.2	4:30:00	23:30:00	KSAD

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
120/4	10		CLEAR	14	-1	29.93		Departing	KSAD
								Arriving	KSAD

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
150	Kts	6500	Ft	9200	Ft	Yes		No		@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At: 11:55:00
↕ Times entered are Zulu / GMT ↕									Verify S-Turns Before Mission Yes X No
									Take Off: 12:19
35	**N**	**23:05:00**	**23:07:00**	**0:00:00**		**1.2**			
36	**S**	**23:09:00**	**23:11:00**	**0:00:00**		**1.2**			
37	**N**	**23:13:00**	**23:14:00**	**0:00:00**		**1.2**			
				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					
				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					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		2			Verify S-Turns After Mission Yes X No

Additional Comments:	Drive #
BLOCK A	

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	12/7/2016	342	77025		USGS SAFFORD AZ

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
DENHAM	N404CP	5757.2	9:15:00	16:15:00	WOOLPERT PIN
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-8191	5762.6	3:06:00	22:06:00	KSAD

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KSAD
CALM	10		CLEAR	11	0	30.05		Arriving	KSAD

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.9	272	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi		B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts		Ft	9300	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	PDOP	Kts	Alt.	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	n/a	GPS Began Logging At:	9:03:00
↕ Times entered are Zulu / GMT ↕									Verify S-Turns Before Mission	Yes X No
									Take Off: 9:40	
12	S	16:52:00	17:03:00	0:00:00		1.5			Cloud Interference	
30	N	17:07:00	17:15:00	0:00:00		1.1				
29	S	17:17:00	17:25:00	0:00:00		1.1				
28	N	17:27:00	17:36:00	0:00:00		1.1				
27	S	17:38:00	17:47:00	0:00:00		1				
26	N	17:50:00	18:00:00	0:00:00		1.3				
25	S	18:02:00	18:13:00	0:00:00		1.3			Cloud Interference	
24	N	18:15:00	18:26:00	0:00:00		1.1			Cloud Interference	
23	S	18:28:00	18:39:00	0:00:00		1.1			Cloud Interference	
22	N	18:41:00	18:53:00	0:00:00		1.2			Cloud Interference	
21	S	18:55:00	19:07:00	0:00:00		1.2				
20	N	19:09:00	19:21:00	0:00:00		1.3				
19	S	19:23:00	19:35:00	0:00:00		1.5			Cloud Interference	
18	N	19:37:00	19:49:00	0:00:00		1.3				
17	S	19:51:00	20:04:00	0:00:00		1.1			Cloud Interference	
16	N	20:06:00	20:17:00	0:00:00		1.1			Cloud Interference	
15	S	20:19:00	20:31:00	0:00:00		1.2			Cloud Interference	
14	N	20:33:00	20:44:00	0:00:00		1.1			Cloud Interference	
13	S	20:49:00	21:01:00	0:00:00		1.2				
12	N	21:03:00	21:05:00	0:00:00		1.2				
11	S	21:07:00	21:10:00	0:00:00		1.2			Patch Reflight	
14	N	21:12:00	21:14:00	0:00:00		1.2			Patch Reflight	
15	S	21:16:00	21:18:00	0:00:00		1.2			Patch Reflight	
16	N	21:21:00	21:22:00	0:00:00		1.2			Patch Reflight	
17	S	21:24:00	21:25:00	0:00:00		1.3			Patch Reflight	
22	N	21:29:00	21:31:00	0:00:00		1.3			Patch Reflight	
19	S	21:33:00	21:34:00	0:00:00		1.3			Patch Reflight	
24	N	21:38:00	21:39:00	0:00:00		1.2			Patch Reflight	
23	S	21:45:00	21:47:00	0:00:00		1.1			Patch Reflight	
25	S	21:51:00	21:53:00	0:00:00		1.2			Patch Reflight	
↑ Times entered are Zulu / GMT ↑				Page		1			Verify S-Turns After Mission	Yes X No

Additional Comments: Drive #

BLOCK A

Section 7: Final Deliverables

The final lidar deliverables are listed below.

- LAS v1.4 classified point cloud
- LAS v1.4 raw unclassified point cloud flight line strips.
- Hydro Breaklines as ESRI shapefile
- Bridge Breaklines as ESRI shapefile
- Digital Elevation Model in ERDAS .IMG format
- Digital Surface Model in ERDAS .IMG format
- 8-bit gray scale intensity images in .TIF format
- Biomass Inventory/Canopy
- Tile layout provided as ESRI shapefile
- Control Points provided as ESRI shapefile
- Flight Lines provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in pdf format