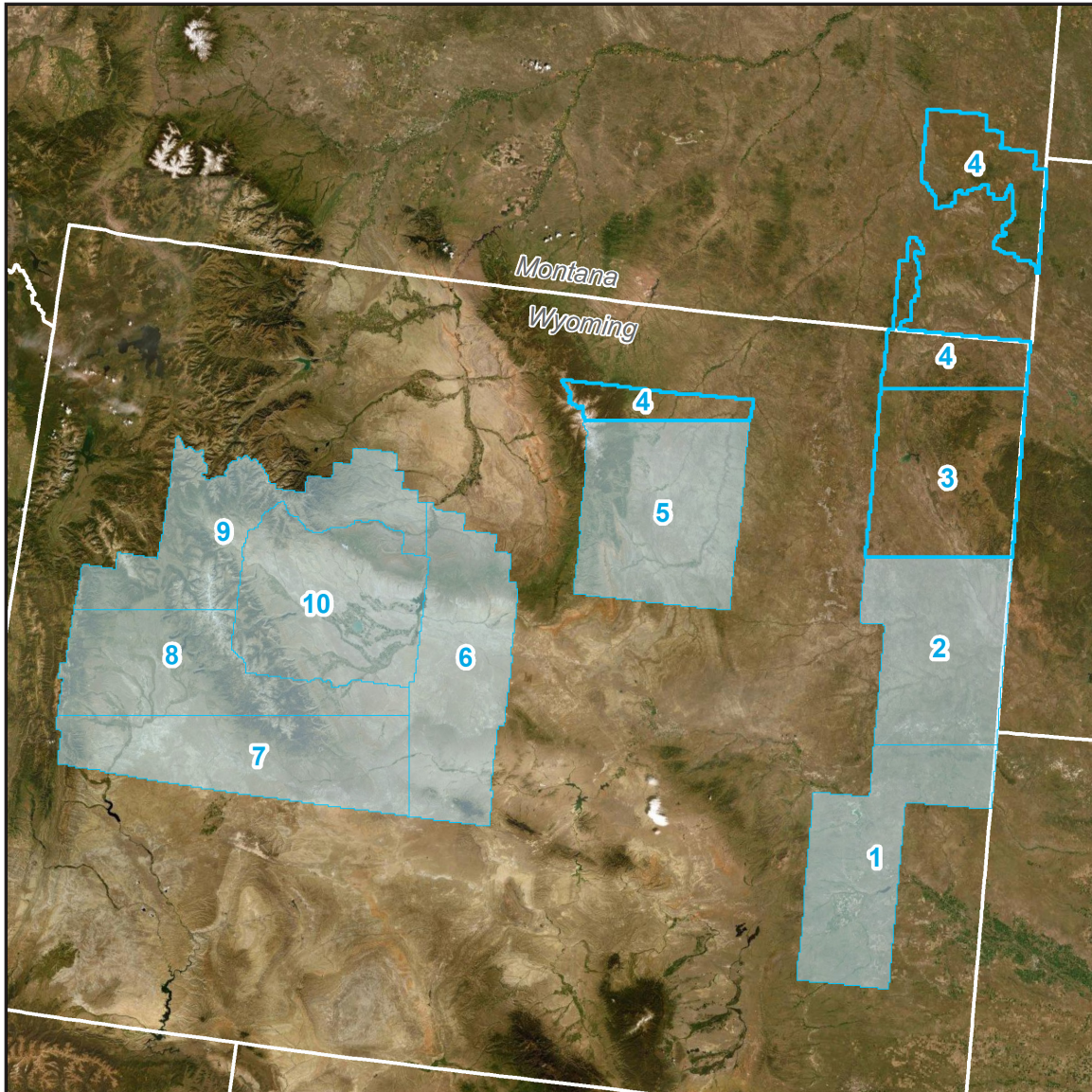


WY FEMA East 2019 D19

Lot 6 Blocks 3 and 4 Airborne Lidar Report

May 2020



Contract # G16PC00022
Task Order # 140G0219F0127



Contractor Woolpert
Project # 79935

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1. Overview

About

This project contains a comprehensive outline of the 140G0219F0127 WY FEMA East 2019 D19 task order issued by the United States Geological Survey's National Geospatial Technical Operations Center (USGS-NGTOC). This task order called for the acquisition and processing of QL2 data over 10 blocks that total approximately 32,466 square miles in Wyoming and Montana.

This report encompasses the Lot 6 Blocks 3 and 4 areas of interest. This AOI totals approximately 6,185 square miles and includes the following counties:

- Carter
- Crook
- Johnson
- Weston

Purpose

This project will support the 3DEP mission, and the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment and Planning (MAP) program.

Specifications

Data for this task order was acquired and produced to meet USGS Lidar Base Specification v1.3 standards and the American Society of Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data (Edition 1, Version 1.0).

Spatial Reference

Geospatial data products were produced using the following horizontal and vertical spatial data reference system.

Table 1-1. Spatial Reference System

Area of Interest		
Horizontal	EPSG Code	6350
	Datum	NAD83 (2011)
	Projection	Albers Equal Area
	Units	Meters
Vertical	Datum	NAVD88
	Geoid	GEOID12B
	Units	Meters
	Height Type	Orthometric

Task Order Deliverables

All data products produced as part of this task order are listed below. All tiled deliverables had a tile size of 1,000-meters x 1,000-meters. Tile names are derived from the coordinates of the lower left corner of each tile.

Table 1-2. Deliverables

Lidar Data	
Classified lidar point cloud data	Tiles in .las v1.4 format Classes <ul style="list-style-type: none"> • 1 – Processed, not Classified • 2 – Ground • 7 – Noise • 9 – Water • 17 – Bridge Decks • 18 – High Noise • 20 – Ignored Ground • 21 – Snow
Breaklines used for hydro-flattening	<ul style="list-style-type: none"> • Lake and River features as feature classes in an Esri file geodatabase <ul style="list-style-type: none"> • Water bodies greater than 2 acres as polygon features • Rivers 30.5 meters / 100 feet and greater in width as polyline features • Bridges used in DEM generation as point features in Esri shapefile format
Hydro-flattened bare earth digital elevation model (DEM)	1-meter pixel size, 32-bit floating-point; no bridges or overpass structures ERDAS .img format
Intensity Imagery	1-meter pixel size, 8-bit gray-scale (linear rescaling from 16-bit intensity) GeoTIFF format
Flight Line Index	Polygon features in an Esri file geodatabase
Control Data	
Lidar calibration points	Esri shapefile format
Lidar NVA checkpoints	Esri shapefile format
Lidar VVA checkpoints	Esri shapefile format
Other Data	
Tile Index	Esri shapefile format
Snow Polygons	Esri shapefile format
Metadata and Reports	
Metadata	Deliverable-level FGDC CSDGM/USGS MetaParser Compliant metadata in .xml format
Lidar Project Report	Project report with flight logs in .pdf format
Survey Report	Survey report in .pdf format

Figure 1-1. Project Area

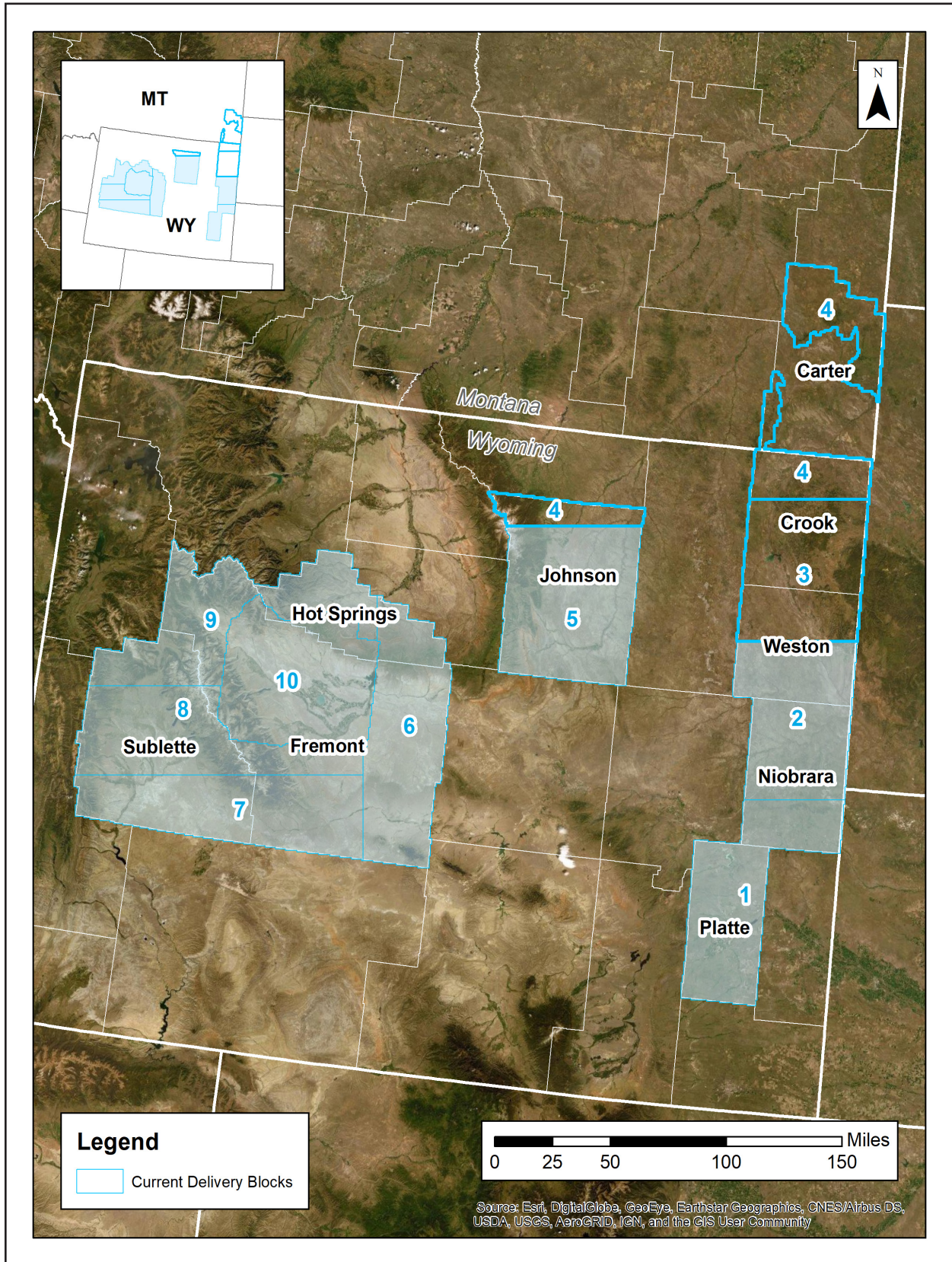
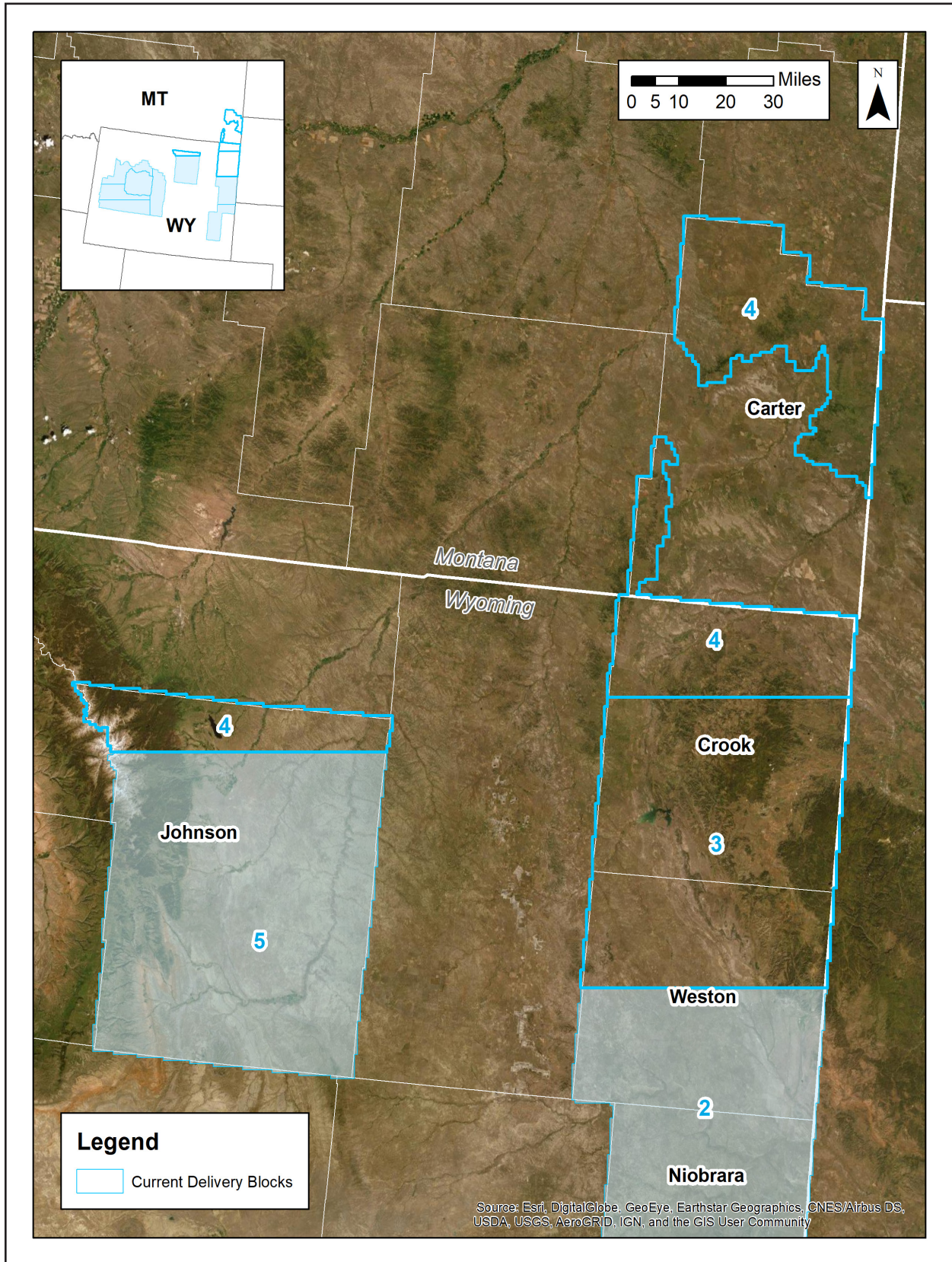


Figure 1-2. Project Area - Blocks 3 and 4



2. Acquisition

Flight Planning

Aerial lidar data was collected using the specifications listed below.

Table 2-1. Acquisition Requirements

Specification	Target
Resolution	<ul style="list-style-type: none"> • 2 points per square meter • 0.71-meter nominal point spacing
Overlap	At contractor's discretion, but enough to ensure there are no data gaps between usable portions of the swath and nominal point density is achieved
Acquisition Window	Fall 2019 leaf off window running through September 15, 2019
Acquisition Conditions	<ul style="list-style-type: none"> • Cloud and fog-free between the aircraft and ground • Ground is snow free • Ground has no unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation • Preference of vegetation is leaf-off
Data Voids	Not allowed except <ul style="list-style-type: none"> • Where caused by water bodies • Where caused by areas of low near infra-red (NIR) reflectivity (i.e. asphalt or composition roofing) • Where caused by lidar shadowing from buildings or other features; or • Where appropriately filled-in by another swath
Control	Airborne Global Positioning System (ABGPS) and Inertial Measurement Unit (IMU) data to be used along with differentially-corrected GPS ground control points

Lidar Sensor Information

Aerial lidar data was acquired for this project using the Leica Terrain Mapper and Optech Galaxy PRIME lidar sensor systems. A total of 1,197 flight lines were collected for this project.

Table 2-2. Leica Terrain Mapper Sensor Info

Sensor Specifications	
Operating Altitude (m AGL)	300 - 5,500 at 10% reflective target
Maximum Measurement Rate (kHz)	2,000
Scan Angle	20 - 40
Scan Width	Up to 70% of flight altitude
Scan Frequency	Programmable up to 125 Hz (7,500 RPM), 250 scan lines per second
Number of Returns	15
Number of intensity measurements	15
Pulse Mode(s)	Up to 35 pulses in air
Laser Specifications	
Laser Beam Divergence	0.25 mrad (1/e)
Laser Classification	Class 4 laser product
Accuracy	
Range Resolution	< 1 cm RMS
Elevation Accuracy	< 5 cm 1 σ
Horizontal Accuracy	< 13 cm 1 σ
Physical Specifications	
Size (cm), Weight (kg) • Scanner • Control Electronics	<ul style="list-style-type: none"> • 37 W x 68 L x 26 H cm, 47 kg • 45 W x 47 D x 25 H cm, 33 kg
Operating Temperature • Scanner • Control Electronics	<ul style="list-style-type: none"> • 0 - 40°C cabin-side temperature • 0 - 40°C
Flight Management	Leica FlightPro
Power Consumption	922 W @ 22.0 – 30.3 VDC

Source: Leica TerrainMapper Data Sheet

<https://leica-geosystems.com/en-US/products/airborne-systems/topographic-lidar-sensors/leica-terrainmapper>

Table 2-3. Optech Galaxy PRIME Sensor Info

Sensor Performance	
Performance envelope ^{1, 2, 3, 4}	150-6000 m AGL, nominal
Absolute horizontal accuracy ^{2, 3}	1/10,000 × altitude; 1 σ
Absolute elevation accuracy ^{2, 3}	< 0.03-0.25 m RMSE from 150-6000 m AGL
Laser Configuration	
Topographic laser	1064-nm near-infrared
Laser classification	Class IV (US FDA 21 CFR 1040.10 and 1040.11; IEC/EN 60825-1)
Pulse repetition frequency (effective)	Programmable, 50-1000 kHz
Beam divergence	0.25 mrad (1/e)
Laser range precision ⁵	< 0.008 m, 1 σ
Minimum target separation distance	< 0.7 m (discrete)
Range capture	Up to 8 range measurements, including last
Intensity capture	Up to 8 intensity measurements, including last (12-bit)
Sensor Configuration	
Position and orientation system	POS AV™ AP60 (OEM); 220-channel dual frequency GNSS receiver; GNSS airborne antenna with Iridium filters; high-accuracy AIMU (Type 57); non-ITAR
Scan angle (FOV)	10-60°
Swath width	10-115% of altitude AGL
Scan frequency	0-120 Hz advertised (0-240 scan lines/sec)
Scan product	2000 maximum
Flight management system	Optech FMS (Airborne Mission Manager and Nav) with operator console
SwathTRAK™	Dynamic FOV for fixed-width data swaths in variable terrain
PulseTRAK™	Multipulse tracking algorithm with no density loss across PIA transition zones
Roll compensation	±5° minimum
Data storage	Removable SSD (primary); internal SSD (spare)
Power requirements	28 V; 400 W
Dimensions and weight	Sensor: 0.34 × 0.34 × 0.25 m, 27 kg PDU: 0.42 × 0.33 × 0.10 m, 6.5 kg
Operating temperature	0 to +35°C

1. Target reflectivity $\geq 20\%$; 99% detection probability
2. Dependent on selected operational parameters; assumes nominal FOV of up to 40° in standard atmospheric conditions (i.e. 23-km visibility) and use of Optech LMS Professional software suite
3. Angle of incidence $\leq 20^\circ$
4. Target size \geq laser footprint
5. Under Teledyne Optech test conditions, 1 sigma

Source: Optech Galaxy PRIME Airborne Lidar Terrain Mapper Specification Sheet
<http://info.teledyneoptech.com/acton/attachment/19958/f-0278/1/-/-/-/Galaxy%20PRIME%20Brochure.pdf>

GNSS and IMU Equipment

Prior to mobilizing to the project site, flight crews coordinated with the necessary air traffic control personnel to ensure airspace access. Crews were on-site, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support.

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

Base stations were set by acquisition staff and was used to support the aerial data acquisition. See the table below for stations operated during acquisition for the whole project.

Table 2-4. GNSS Base Stations

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height L1 Phase Center (Meters)
Base2	42° 50' 00.77963	104° 24' 50.76535	1550.411
Base1	43° 19' 21.88533"	105° 02' 43.56787"	1514.653
WYRF_CORS	42° 49' 50.36453"	106° 19' 38.49771"	1634.444
WYLC_CORS	41° 06' 16.29488"	104° 46' 31.29307"	1824.826
P042_CORS	42° 03' 05.40043"	104° 54' 38.09615"	1423.359
KGCC_Airport	44° 20' 55.78123"	105° 32' 00.99884"	1306.038
AutoAnt	44° 20' 55.78123"	105° 32' 00.99884"	1306.038
P033_CORS	43° 57' 10.41596"	107° 23' 15.12165"	1376.681
KRIW_Airport	43° 03' 37.92270"	108° 27' 18.25590"	1648.117
P715_CORS	43° 30' 02.74785"	109° 41' 23.41714"	2988.93
BLW2_CORS	42° 46' 01.63709"	109° 33' 28.03604"	2216.398
TSWY_CORS	43° 40' 26.70325"	110° 35' 50.86433"	2191.496
AHID_CORS	42° 46' 23.20961"	111° 03' 49.41574"	1976.311

Timeline

Lidar data for Lot 6 Blocks 3 and 4 was collected from July 5, 2019 through August 8, 2019. Acquisition specifications are listed in the table below. An initial quality control process was immediately performed on to review the data coverage, airborne GPS data, and trajectory solution.

Table 2-5. Project Acquisition Specifications

Settings	Leica TerrainMapper Acq. Blocks 1-4, 6-8	Leica TerrainMapper Acq. Block 5	Leica TerrainMapper Acq. Blocks 9, 12-13, 17-19	Leica TerrainMapper Acq. Blocks 10-11, 14-16, 20-21	Optech Galaxy PRIME Acq. Blocks 23 -24
Max. Number of Returns	15	15	15	15	8
Nominal Point Spacing	0.71 m	0.71 m	0.71 m	0.71 m	0.7 m
Nominal Point Density	2 ppsm	2 ppsm	2 ppsm	2 ppsm	2.73 ppsm
Flying Height Above Ground Level	3,000 m	3,200 m	3,250 m	3,500 m	1,600 m
Flight Speed	150 knots	150 knots	150 knots	150 knots	120 knots
Scan Angle	40°	40°	40°	40°	46°
Scan Rate Used	82 Hz	82 Hz	82 Hz	80 Hz	51 Hz
Pulse Rate Used	600 kHz	650 kHz	650 kHz	670 kHz	250 kHz
Multi-Pulse in Air	Enabled	Enabled	Enabled	Enabled	Enabled
Swath Width	2,184 m	2,329 m	2,366 m	2,548 m	1,358 m
Swath Overlap	25%	25%	25%	25%	20%

For more information, see the Flight Logs in Appendix 1.

Acquisition Quality Assurance

Woolpert developed a quality assurance and validation plan to ensure the acquired lidar data meets the USGS Base Specification Version 1.3. For quality assurance purposes, the lidar data was processed immediately following acquisition to verify the coverage has appropriate density, distribution, and no unacceptable data voids. Accompanying GPS data was post processed using differential and Kalman filter algorithms to derive a best estimate of trajectory. The quality of the solution was verified to be consistent with the accuracy requirements of the task order. Any required re-flights were scheduled at the earliest opportunity.

The spatial distribution of the geometrically usable first return lidar points was reviewed for density requirements as well as regular and uniform point distribution - verifying the lidar data is spaced so that 90% of the cells in a 2*NPS grid placed over the data contain at least one lidar point. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath. Additionally, the data was reviewed for unacceptable data voids – verifying no area greater than or equal to $(4 \times \text{ANPS})^2$ exhibited data coverage gaps.

3. Processing

Processing Summary

Once the lidar data passed initial QC, the dataset was corrected for aircraft orientation and movement. This process used airborne inertial, orientation, and GPS data collected during acquisition along with ground-based GPS data. The data went through a geometric calibration that further corrected each laser point. This calibrated data set was used to create the LAS point cloud. The LAS point data was initially classified into “ground” and “non-ground”, then further refined using the classes specified in this task order. Breaklines were drawn to denote hydrological features. After the hydro-flattening process, the final deliverables products were created.

GNSS-IMU Trajectory Processing

Kinematic corrections for the aircraft position were resolved using aircraft GPS and static ground GPS (1-Hz) for each geodetic control (base station) for three subsystems: inertial measurement unit (IMU), sensor orientation information, and airborne GPS data.

Post-processing of the IMU system data and aircraft position with attitude data was completed to compute an optimally accurate, blended navigation solution based on Kalman filtering technology, or the smoothed best estimate of trajectory (SBET).

Software: POSPac Software v. 5.3, IPAS Pro v.1.35., Novatel Inertial Explorer v8.60.6129

Trajectory Quality

The GNSS trajectory and 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).

Combination Separation

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

The data for this task order was processed with a goal to maintain a combined separation difference of less than ten (10) centimeters.

Estimated Positional Accuracy

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.

PDOP

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

The data for this task order was processed with a goal 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.

Geometric Calibration

After the initial phase was complete, a formal reduction process was performed on the data. Laser point position was calculated by associating the SBET position to each laser point return time, scan angle, intensity, etc. Raw laser point cloud data was created for the whole project area 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. Statistical reports were generated for comparison and used to make the necessary adjustments to remove any residual systematic error.

Software: Proprietary Software, TerraMatch v18, Leica CloudPro 1.2.4

Lidar Data Classification

LAS data was 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 of higher accuracy.

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 the following client-specified classes:

- Class 1 – Default / Processed, but not Classified
- Class 2 – Bare Earth Ground
- Class 7 – Low Noise
- Class 9 – Water
- Class 17 – Bridge Decks
- Class 18 – High Noise
- Class 20 – Ignored Ground
- Class 21 – Snow

Classified LAS files were evaluated through a series of manual QA/QC steps as well as a peer-based review to eliminate remaining artifacts from the ground class. This included a review of the DEM surface to remove artifacts and ensure topographic quality.

Software: Proprietary Software, TerraScan v18

Hydrologic Flattening

The lidar task order required compilation of breaklines defining the following types of water body features:

Lakes, reservoirs, ponds	Minimum of 2-acres or greater Compiled as closed polygons, collected at a constant elevation
Rivers, streams	Nominal width of 30.5 meters / 100 feet Compiled in direction of flow, with both sides maintaining an equal elevation gradient
Bridge breaklines	Breaklines used to enforce a logical terrain surface below a bridge

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. The newly acquired lidar data was utilized to manually compile 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. An integrated software approach was applied 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. All classified ground points from inside the hydrologic feature polygons were reclassified to water, class nine (9).
4. All classified ground points were reclassified from within a buffer along the hydrologic feature breaklines to buffered ground, class twenty (20). The buffer distance was approximately the task order designed nominal pulse spacing distance.
5. Breaklines used for bridge removal during the hydrologic flattening were included with the hydrologic breakline geodatabase deliverable. The purpose of these breaklines is for a more aesthetically pleasing DEM appearance.
6. The lidar ground points and breaklines were used to generate a digital elevation model (DEM).
7. QA/QC for this task was performed by reviewing the hydrologically flattened DEM and hydrologic breakline features. Additionally, a combined approach utilizing commercial off the shelf software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

TerraScan was used to add the hydrologic breakline vertices and export the lattice models.

Breaklines defining the water bodies greater than 2-acres were provided as polygon features. Rivers and streams with a nominal minimum width of 30.5 meters (100 feet) were provided as polyline features. All lake and river breaklines compiled as part of the flattening process were provided in an Esri file geodatabase.

Breaklines used for DEM generation were provided as point features in Esri shapefile format.

Software: TerraScan v18, TerraModeler v18, Esri ArcMap v10.4, LP360 v2018.1.57.4

Digital Elevation Model

TerraScan was used to add the hydrologic breakline vertices and export the lattice models. Class 2 (ground) lidar points in conjunction with the hydro breaklines and bridge breaklines were used to create 1-meter hydro-flattened bare-earth raster DEM files. Using automated scripting routines within ArcMap, an 32-bit floating point raster ERDAS .img file was created for each tile. Files were produced to the full extents of the tile boundaries. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

Intensity Imagery

Lidar intensity data derived from the acquired lidar data was linearly rescaled from 16-bit intensity and provided as 1-meter pixel, 8-bit, 256 gray scale GeoTIFF format intensity imagery files. Files were produced to the full extents of the tile boundaries.

Software: TerraScan v18

Metadata

FGDC CSDGM/USGS MetaParser-compliant metadata was produced in XML format. The metadata includes a complete description of the task order client information, contractor information, project purpose, lidar acquisition and ground survey collection parameters, lidar acquisition and ground survey collection dates, spatial reference system information, data processing including acquisition quality assurance procedures, GPS and base station processing, geometric calibration, lidar classification, hydrologic flattening, intensity imagery development, and final product development.

Other metadata deliverables included Esri shapefiles of the ground control and QA/QC points and delivery tile index. A georeferenced, polygonal representation of the detailed extents of each acquired lidar swath was produced as a polygon feature class in an Esri file geodatabase.

4. Accuracy Statement

Horizontal Accuracy

The data sets was produced to meet ASPRS “Positional Accuracy Standards for Digital Geospatial Data” (2014) for a 25.9 cm RMSE_x / RMSE_y Horizontal Accuracy Class which equates to Positional Horizontal Accuracy = +/- 63.6 cm at a 95% confidence level.

Raw Lidar Swath Testing

This project required the lidar point cloud swath to be produced to meet a Non-Vegetated Vertical Accuracy (NVA) value of 19.6 cm at a 95% confidence level using an RMSE_z target value of 10 cm x 1.9600.

Digital Elevation Model Testing

This project required DEM data to be produced to meet a Non-Vegetated Vertical Accuracy (NVA) value of 19.6 cm at a 95% confidence level using an RMSE_z target value of 10 cm x 1.9600 and a Vegetated Vertical Accuracy (VVA) value of 0.30 cm at the 95th percentile error.

Appendix 1: Flight Logs

Woolpert Lidar Acquisition Log

Project Info

Project Info			Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
79935	FEMA Wyoming Block 2 and 1	Day186_90513_A	07/05/2019	186	A

Crew

Equipment

Time

Airports

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing		
Swain	Cessna 404 Titan - N7079F	2211.4	08:12:00	14:12:00	GCC		
Operator		Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving	
Stanton		Leica Terrain Mapper - 90513	2213.4	10:34:00	16:34:00	GCC	

Conditions

Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
100	6	10	14,000	Scattered	15	13	30.16
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		8,000	12,900	4,364			

Settings

Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35	10	40	81	600	100

Verify S-Turns Before Mission

Yes

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
1	E	14:45:00	15:03:00	00:18:00	23	1.1	Block 2, cloud 23 nmi from W end
2	W	15:06:00	15:25:00	00:19:00	22	1.2	clouds 16-19, 23-24 from W end
Block 1							move to Block 1 due to clouds
70	E	15:36:00	15:54:00	00:18:00	23	1.1	clear
69	W	15:57:00	16:15:00	00:18:00	23	1.1	clouds 12?-16, 19-22 fr W, 21-20 from E end
							end mission due to clouds

Verify S-Turns After Mission

Yes

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
79935	WY_FEMA			Day187_90515_A		07/06/2019	187	A
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gibilaro	Cessna 404 Titan - N475RC			1742.4	08:01:00	14:01:00	KGCC	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Galambos	Leica Terrain Mapper - 90515			1748.1	12:46:00	18:46:18	KGCC	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
130	4	10	12,000		15	13	30.06	
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)					
150	9,842	12,940	4,405					
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)			
0.7		40	82	600	100			
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
							Block 6/ STATIC 13:14:04	
1	S	14:01:54	14:15:25	00:13:31	18	1.4	Takeoff: 1323z	
2	N	14:18:18	14:31:32	00:13:14	18	1.4	Failed to initialize in time	
3	S	14:34:25	14:47:41	00:13:16	19	1.5	GPS Altitude 14,347 feet block 6	
4	N	14:50:26	15:03:29	00:13:03	20	1.5		
5	S	15:06:35	15:19:32	00:12:57	18	1.6		
6	N	15:22:23	15:35:32	00:13:09	17	1.5		
7	S	15:38:27	15:51:41	00:13:14	19	1.3		
8	N	15:54:02	16:07:00	00:12:58	19	1.2		
							Block 2 Flight Line 24	
							12,940 GPS MSL'	
24	E	16:40:15	16:58:14	00:17:59	17	1.3		
23	W	17:01:15	17:20:25	00:19:10	16	1.2		
22	E	17:23:14	17:41:17	00:18:03	15	1.5		
21	W	17:44:27	18:03:25	00:18:58	13	1.5		
20	E	18:06:24	18:24:44	00:18:20	11	1.7		
19	W	18:27:22	18:46:18	00:18:56	11	2.1		
							Verify S-Turns After Mission	Yes

Additional Comments

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
79935	WY_FEMA	Day189_90515_A	07/08/2019	189	A	

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing	
Gibilaro	Cessna 404 Titan - N475RC		1748.1	08:05:00	14:05:00	KGCC	
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving	
Galambos	Leica Terrain Mapper - 90515		1754.9	14:04:00	20:04:00	KGCC	

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
		10		Clear	15	13	29.9
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		9,842	12,940	3,097			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7		40	82	600	100

	Verify S-Turns Before Mission	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
							Block 6
18	E	14:05:03	14:23:02	00:17:59	13	1.5	Roll Mount Issue
17	W	14:26:05	14:44:46	00:18:41	13	1.7	
16	E	14:47:37	15:06:02	00:18:25	13	1.7	
15	W	15:08:50	15:27:53	00:19:03	13	1.7	
14	E	15:30:54	15:49:08	00:18:14	18	1.2	
13	W	15:52:08	16:10:36	00:18:28	18	1.2	
12	E	16:13:27	16:31:33	00:18:06	18	1.2	
11	W	16:34:27	16:53:11	00:18:44	19	1.1	
10	E	16:55:58	17:14:05	00:18:07	18	1.4	
9	W	17:16:56	17:36:02	00:19:06	17	1.5	
8	E	17:39:07	17:57:24	00:18:17	17	1.5	
7	W	18:00:28	18:19:00	00:18:32	17	1.6	
6	E	18:22:00	18:39:44	00:17:44	19	1.5	
5	W	18:42:25	19:00:29	00:18:04	15	1.2	
4	E	19:03:27	19:21:21	00:17:54	15	1.8	
3	W	19:24:20	19:42:36	00:18:16	16	1.5	
81	S	19:54:18	20:04:20	00:10:02	17	1.3	
							Descending circles due to fuel load

Page 5	Verify S-Turns After Mission	Yes
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Additional Comments

Woolpert Lidar Acquisition Log

Project Info							Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #	
79935	FEMA Wyoming Block 1			Day191_90513_A		07/10/2019	191	A	
Crew		Equipment			Time			Airports	
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gebhart		Cessna 404 Titan - N7079F			2230.3	10:09:00	16:09:00	GCC	
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Stanton		Leica Terrain Mapper - 90513			2237.1	17:17:00	23:17:00	GCC	
Conditions									
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)		
190	7	10	25,000	Clear	19	8	30.31		
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)					
150		8,000	12,940	4,364					
Settings									
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)				
0.35	10	40	81	600	100				
							Verify S-Turns Before Mission	Yes	
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments		
Block 1									
80	E	16:36:00	16:54:00	00:18:00	19	1.1	Clear		
79	W	16:58:00	17:17:00	00:19:00	17	1.2			
78	E	17:20:00	17:38:00	00:18:00	17	1.2			
77	W	17:41:00	18:01:00	00:20:00	16	1.1			
76	E	18:03:00	18:23:00	00:20:00	17	1.2			
75	W	18:26:00	18:45:00	00:19:00	19	1.1			
74	E	18:48:00	19:07:00	00:19:00	18	1.2			
73	W	19:12:00	19:31:00	00:19:00	20	1.1			
72	E	19:34:00	19:53:00	00:19:00	19	1.2			
71	W	19:56:00	20:16:00	00:20:00	22	1.1	roll mount limit error 22 nmi from W end		
69a	E	20:19:00	20:38:00	00:19:00	23	1.1	patch line for previous mission clouds		
68	W	20:41:00	21:00:00	00:19:00	20	1.4			
67	E	21:03:00	21:22:00	00:19:00	20	1.1			
66	W	21:25:00			22	1.2	power to sensor interrupted		
							reboot, airstart at 21:34 UTC, 360 turns		
66	W						failed to activate laser aborted line		
66	W	21:48:00	22:07:00	00:19:00	21	1.1	roll mount limit error 23 nmi from W end		
49	E	22:12:00	22:31:00	00:19:00	20	1.2			
48	W	22:34:00	22:53:00	00:19:00	20	1.1	auto IT adjusts shutter speed for shadows		
							Verify S-Turns After Mission	Yes	
Additional Comments									

Woolpert Lidar Acquisition Log

Project Info			Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
79935	FEMA Wyoming Block 1	Day194_90513_A	07/13/2019	194	A

Crew		Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Gebhart	Cessna 404 Titan - N7079F		2246	08:53:00	14:53:00	GCC
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Stanton	Leica Terrain Mapper - 90513		2250.7	13:54:00	19:54:00	GCC

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
170	11	10	25,000	Clear	24	14	30.1

Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)
150	8,000	12,940	4,364

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35	10	40	81	600	100

							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
Block 1								
27	E	15:21:00	15:40:00		26	1.1	Clear	
26	W	15:43:00	16:01:00	00:18:00	25	1	Auto IT adjust for underexposure	
25	E	16:04:00	16:24:00	00:20:00	23	1		
24	W	16:26:00	16:45:00	00:19:00	19	1.1		
23	E	16:48:00	17:06:00	00:18:00	20	1.1		
22	W	17:09:00	17:28:00	00:19:00	17	1.2		
21	E	17:31:00	17:49:00	00:18:00	18	1.1		
20	W	17:52:00	18:11:00	00:19:00	17	1.2		
19	E	18:13:00	18:32:00	00:19:00	18	1.1	Clouds 12- 14 nmi from E end, 103-106 fram	
18	W	18:34:00	18:52:00	00:18:00	17	1.2	flight pro froze during line select, then clear	
17a	E	18:55:00	19:14:00	00:19:00	18	1.1	reflight of all line 17 for previous clouds	
19a	W	19:16:00	19:22:00	00:06:00	17	1.1	patch for cloud on line 19	
							finished all of Block 1 lines	

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
79935	WY_FEMA			Day187_90515_A		07/06/2019	187	A
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gibilaro	Cessna 404 Titan - N475RC			1742.4	08:01:00	14:01:00	KGCC	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Galambos	Leica Terrain Mapper - 90515			1748.1	12:46:00	18:46:18	KGCC	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
130	4	10	12,000		15	13	30.06	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		9,842	12,940	4,405				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.7		40		82	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
							Block 6/ STATIC 13:14:04	
1	S	14:01:54	14:15:25	00:13:31	18	1.4	Takeoff: 1323z	
2	N	14:18:18	14:31:32	00:13:14	18	1.4	Failed to initialize in time	
3	S	14:34:25	14:47:41	00:13:16	19	1.5	GPS Altitude 14,347 feet block 6	
4	N	14:50:26	15:03:29	00:13:03	20	1.5		
5	S	15:06:35	15:19:32	00:12:57	18	1.6		
6	N	15:22:23	15:35:32	00:13:09	17	1.5		
7	S	15:38:27	15:51:41	00:13:14	19	1.3		
8	N	15:54:02	16:07:00	00:12:58	19	1.2		
							Block 2 Flight Line 24 12,940 GPS MSL'	
24	E	16:40:15	16:58:14	00:17:59	17	1.3		
23	W	17:01:15	17:20:25	00:19:10	16	1.2		
22	E	17:23:14	17:41:17	00:18:03	15	1.5		
21	W	17:44:27	18:03:25	00:18:58	13	1.5		
20	E	18:06:24	18:24:44	00:18:20	11	1.7		
19	W	18:27:22	18:46:18	00:18:56	11	2.1		
						Page 1	Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
79935	WY_FEMA		Day192_90515_A			07/11/2019	192	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gibiarlo		Cessna 404 Titan - N475RC			1761.3	09:03:00	15:03:00	KGCC
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Galambos		Leica Terrain Mapper - 90515			14:24	14:36:00	20:36:00	KGCC
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
160	16	10	12,000		19.4	12.2	30.1	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		9,842	13,533	3,691				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.7		40		82	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
							Block 1/ static 14:22:04	
1	E	15:03:00	15:20:05	00:17:05	14	1.7		
2	W	15:23:15	15:41:14	00:17:59	19	1.2	Takeoff: 14:37	
3	E	15:44:15	16:02:23	00:18:08	19	1.2		
4	W	16:05:44	16:23:52	00:18:08	21	1.1		
5	E	16:26:38	16:44:46	00:18:08	13	1.3		
6	W	16:47:45	17:05:39	00:17:54	13	1.4		
7	E	17:08:29	17:26:09	00:17:40	11	1.6		
8	W	17:29:36	17:47:39	00:18:03	11	1.7		
9	E	17:50:31	18:08:26	00:17:55	10	1.9		
10	W	18:11:46	18:29:47	00:18:01	14	1.3		
11	E	18:32:41	18:50:32	00:17:51	13	1.6		
12	W	18:53:34	19:12:11	00:18:37	13	1.6		
13	E	19:14:56	19:32:51	00:17:55	16	1.5		
14	W	19:36:10	19:54:22	00:18:12	17	1.4		
15	E	19:57:16	20:14:52	00:17:36	17	1.3		
16	W	20:18:15	20:36:33	00:18:18	14	2.1		
							Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info

Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
79935	FEMA Wyoming Block 1	Day193_90513_A	07/12/2019	193	A

Date

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing		
Gebhart	Cessna 404 Titan - N7079F	2244.3	08:28:00	14:28:00	GCC		
Operator		Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90513		2244.3	10:21:00	16:21:00	GCC

Conditions

Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
150	9	10	25,000	Clear	23	13	30.11
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		8,000		12,940		4,364	

Settings

Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35	10	40	81	600	100

Verify S-Turns Before Mission Yes

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
Block 1							
82	N						Abort line, laser not activated
82	N	16:06:00	16:25:00	00:19:00	25	0.9	Clear
81	N	16:28:00	16:46:00	00:18:00	21	1	
17	W	16:49:00	17:08:00	00:19:00	19	1.1	Clouds 15 nmi to W end clouds forming at our altitude all lines end mission for clouds

Page 1 Verify S-Turns After Mission Yes

Additional Comments

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
79935	WY_FEMA	Day193_90515_A	07/12/2019	193	A	

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing	
Gibiarlo	Cessna 404 Titan - N475RC		1767.6	09:59:00	14:59:00	KGCC	
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving	
Galambos	Leica Terrain Mapper - 90515		1772.7	13:18:00	19:18:00	KGCC	

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
180	9	10	12,000	Clear	22	13	30.1
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	9,842	13,533	3,691				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7		40	82	600	100

					Verify S-Turns Before Mission	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
							Block 7/ gps 14:27:00/ T/O: 1436Z
34	S	14:59:45	15:12:43	00:12:58	18	1.7	
33	N	15:15:55	15:29:06	00:13:11	18	1.3	
32	S	15:32:10	15:45:20	00:13:10	16	1.6	
31	N	15:48:20	16:01:14	00:12:54	17	1.7	
30	S	16:04:12	16:17:12	00:13:00	17	1.7	
29	N	16:20:20	16:32:32	00:12:12	17	1.2	
28	S	16:36:21	16:49:30	00:13:09	18	1.2	
27	N	16:53:00	17:06:06	00:13:06	17	1.3	
26	S	17:09:17	17:22:16	00:12:59	15	1.5	
25	N	17:25:57	17:39:10	00:13:13	14	1.5	
24	S	17:42:41	17:55:33	00:12:52	13	1.7	
23	N	17:58:43	18:11:56	00:13:13	16	1.4	
22	S	18:15:20	18:28:26	00:13:06	16	1.3	
21	N	18:32:05	18:45:20	00:13:15	14	1.5	
20	S	18:49:08	19:02:06	00:12:58	17	1.4	
19	N	19:05:18	19:18:26	00:13:08	18	1.5	

Page 5					Verify S-Turns After Mission	Yes
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Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
79935	WY_FEMA			Day194_90515_A		07/13/2019	194	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gibiarlo		Cessna 404 Titan - N475RC			1772.7	09:32:00	15:32:00	KGCC
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Galambos		Leica Terrain Mapper - 90515			1778.6	14:24:00	20:24:00	KGCC
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
170	14	10	12,000	Clear	20	14	30.1	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		9,842	13,533	3,691				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.7		40		82	600	100		
						Verify S-Turns Before Mission	Yes	
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
							Block 7/ gps 14:52:46/ T/O: 14Z	
18	S	15:32:52	15:45:52	00:13:00	21	1.3		
17	N	15:49:10	16:02:16	00:13:06	21	1.2		
16	S	16:05:38	16:18:37	00:12:59	19	1.1		
15	N	16:22:08	16:35:00	00:12:52	17	1.1		
14	S	16:38:13	16:40:16	00:02:03	14	1.4		
13	N	16:54:40	17:07:40	00:13:00	12	1.5		
12	S	17:10:56	17:23:46	00:12:50	11	1.6		
11	N	17:26:46	17:40:17	00:13:31	13	1.5		
10	S	17:43:38	17:56:32	00:12:54	13	1.5		
9	N	18:00:00	18:12:55	00:12:55	14	1.3		
8	S	18:16:24	18:29:23	00:12:59	12	1.4		
7	N	18:32:46	18:46:02	00:13:16	12	1.4		
6	S	18:49:22	19:02:27	00:13:05	12	1.3		
5	N	19:05:48	19:18:46	00:12:58	12	1.3	Nadir Frames underexposed	
4	S	19:22:00	19:35:07	00:13:07	11	1.6	Very Dark Cloud Shadows	
3	N	19:38:48	19:51:14	00:12:26	11	1.6		
2	S	19:54:55	20:07:41	00:12:46	12	1.6		
1	N	20:11:19	20:24:10	00:12:51	12	1.6	Nadir Frames underexposed	

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID		Flight Date (UTC)	Day of Year	Flight #	
79935	Wyoming FEMA East		Day203_90515_A		07/22/2019	203	A	
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Finn		Cessna 404 Titan - N475RC			1795.4	12:50:00	18:50:00	GCC
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
DeHart		Leica Terrain Mapper - 90515			1800	03:48:00	21:48:00	GCC
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
140	19	10	12,000	Clear	23	15	30.31	
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)	Airfield Elevation (ft)			
150		14,000		14,000	5,350			
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	10	40		81	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
53	S	18:50:00	19:04:00	00:14:00	18	1.3	Area 8	
54	N	19:07:00	19:21:00	00:14:00	16	1.6		
55	S	19:24:00	19:38:00	00:14:00	17	1.6		
56	N	19:41:00	19:55:00	00:14:00	14	1.9		
57	S	19:58:00	20:11:00	00:13:00	13	1.8		
58	N	20:14:00	20:28:00	00:14:00	15	1.6		
59	S	20:31:00	20:45:00	00:14:00	13	2.5		
5	E	21:30:00	21:48:00	00:18:00	13	1.7	Area 1	
							Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
79935	Wyoming FEMA East	Day220_90515_A	08/08/2019	220	A	

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing	
Gilbero	Cessna 404 Titan - N475RC		1822.2	08:43:00	14:43:00	RIW	
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving	
DeHart	Leica Terrain Mapper - 90515		1826.9	12:25:00	18:25:00	RIW	

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
280	12	10	12,000	Broken	17	10	30.12
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		14,000		14,000		5,512	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35	10	40	81	600	100

							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
18	N	14:43:00	14:54:00	00:11:00	14	1.5	Area 5	
17	S	14:57:00	15:07:00	00:10:00	14	1.5		
16	N	15:12:00	15:19:00	00:07:00	12	1.7		
15	S	15:22:00	15:28:00	00:06:00	11	1.8		
14	N	15:31:00	15:38:00	00:07:00	11	1.8		
65	S	16:09:00	16:26:00	00:17:00	11	1.5	Area 10	
64	N	16:29:00	16:46:00	00:17:00	11	2		
63	S	16:49:00	17:05:00	00:16:00	14	1.7		
62	N	17:09:00	17:25:00	00:16:00	14	1.7		
61	S	17:29:00	17:46:00	00:17:00	15	1.7		
60	N	17:49:00	18:06:00	00:17:00	16	1.8		
59	S	18:09:00	18:25:00	00:16:00	17	1.6		

Page 1	Verify S-Turns After Mission	Yes
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Additional Comments

Lidar Flight Log	19097 Carter	Drive used: Galaxy 4
	MissionID: 19097	Sensor: Galaxy Prime

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 18
Aircraft Tail # / Pilot: N7269T/McKay	Dew Point (°F): 13
Airport: KMLS	Pressure (inHg): 30.02
Operator:Muncer	Wind Speed (mph): 4kts
HOBBS: 907.1	Wind Direction: 320
Sensor Serial #: 5060410	Clouds: SCT
Optics Cleaned: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Surface Condition (Wet / Dry / Snow): Dry

Pulse Rate (kHz): 500	Scan Rate (Hz): 87	FOV: 26	LASER %: High	Single-Pulse <input type="checkbox"/> Multi-Pulse <input checked="" type="checkbox"/>
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
70		e	1620	1633		0	0.96	30	
26		s	1638	1652		0	1.07	35	
27		n	1655	1713		0	0.91	33	
28		s	1717	1727		0	0.91	33	
29		n	1730	1740		0	0.86	25	
30		s	1743	1753		0	0.89	25	
71		e	1757	1806		0	0.91	20	
1		s	1813	1826		0	1	30	
2		n	1830	1835		0	1.01	15	Line ended / Clouds
89		w	1900	1903		0	0.98	5	
72		s	1909	1910		0	0.88	1	
73		n	1913	1815		0	0.9	1	
74		s	1918	1927		0	0.94	20	
75		n	1843	1847		0	0.93	20	
76		s	1944	1954		0	0.63	22	

Notes:

Lidar Flight Log

12

Area Flown:

MissionID:

Sensor:

Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
77		n	2000	2013		0	1	30	
78		s	2015	2030		0	0.97	30	
88		w	2035	2040		0	1	10	
79		n	2044	2057		0	0.98	30	End
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			
						0			

Notes:

Lidar Flight Log	19097 Carter	Drive used: Galaxy 4
	MissionID: 19097	Sensor: Galaxy Prime

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 18
Aircraft Tail # / Pilot: N7269T/McKay	Dew Point (°F): 07
Airport: KMLS	Pressure (inHg): 30.18
Operator:Muncer	Wind Speed (mph): 4kts
HOBBS: 912.4	Wind Direction:280
Sensor Serial #: 5060410	CLR
Optics Cleaned: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Surface Condition (Wet / Dry / Snow): Dry

Pulse Rate (kHz): 500	Scan Rate (Hz): 87	FOV: 26	LASER %: High	Single-Pulse <input type="checkbox"/> Multi-Pulse <input checked="" type="checkbox"/>
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
80		s	1645	1657		0	0.9	30	
81		n	1700	1712		0	0.84	25	
82		s	1715	1726		0	0.84	25	
83		n	1729	1742		0	0.84	25	
84		s	1745	1756		0	0.82	25	
85		n	1759	1811		0	0.96	25	
86		s	1814	1824		0	0.96	25	
87		n	1827	1829		0	1.07	4	
31		n	1858	1911		0	0.96	30	
32		s	1914	1922		0	0.89	25	
33		n	1925	1938		0	0.89	20	
34		s	1941	1949		0	0.94	20	
35		n	1952	2003		0	0.88	20	
36		s	2008	2020		0	0.89	25	
37		n	2023	2036		0	0.84	25	END

Notes:

Additional Notes on Reverse Side: []

9/13/2019	19097	Drive used: 1
	MissionID:	Sensor: Galaxy / Prime

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 11
Aircraft Tail # / Pilot: N72659T/Schupe	Dew Point (°F): 9
Airport: KMLS	Pressure (inHg): 30.08
Operator: Genther	Wind Speed (mph): 8
HOBBS:	Wind Direction: 160
Sensor Serial #: 5060410	Clouds: NO
Optics Cleaned: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Surface Condition (Wet / Dry / Snow): DRY

Pulse Rate (kHz): 250	Scan Rate (Hz): 51	FOV: 46	LASER %: High	Single-Pulse <input type="checkbox"/> Multi-Pulse <input checked="" type="checkbox"/>
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
69		S	15:53	15:59	1620	0	1		
68		N	16:07	16:19	1713	0	1	25.5	
67		s	16:21	16:33	1720	0	1	26.5	
66		N	16:35	16:48	1720	0	1	27.5	
65		S	16:50	17:02	1700	0	1	27	
64		N	17:04	17:17	1700	0	1	28	Altitude spike towards end of line
63		S	17:19	17:33	1700	0	1	29.5	
62		N	17:35	17:42	1710	0	1	29.7	Blown Line
62		N	17:50	18:01	1700	0	1		REFLOWN LINE AROUND 19.4 DSTE
61		S	18:03	18:17		0	1	30.6	
60		N	18:20	18:33	1712	0	1	30	
59		S	18:35	18:51	1700	0	1	34.6	TURBULENCE AROUND 1849
58		N	18:53	19:09	1720	0	1	35	
57		S	19:11	19:28	1700	0	1	35	POSSIBLE SHADOW
56		N	19:30	19:46	1733	0	1	35	MODERATE TURBULANCE

Additional Notes on Reverse Side: []

9/15/2019	19097 - CARTER COUNTY	Drive used: GALAXY 2
	MissionID: 19097	Sensor: Galaxy

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 24
Aircraft Tail # / Pilot: N72659T/Schupe	Dew Point (°F): 11
Airport: KMLS	Pressure (inHg):
Operator: GENTHER	Wind Speed (mph): 11
HOBBS: 9146	Wind Direction: 140
Sensor Serial #: 5060410	Clouds:
Optics Cleaned: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Surface Condition (Wet / Dry / Snow):

Pulse Rate (kHz): 250	Scan Rate (Hz): 51	FOV: 46	LASER %: High	Single-Pulse <input type="checkbox"/> Multi-Pulse <input checked="" type="checkbox"/>
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
38	19097	S	16:01	16:14	1600	0	1.1	26	FIRST LINE ON CARTER OF LIFT 1
39	19097	N	16:16	16:28	1582	0	1	26	
40	19097	S	16:30	16:43	1826	0	1	27	GOT 300 FT ABOVE @ 16:42
41	19097	N	16:50	17:02	1831	0	1	28	
42	19097	S	17:04	17:18	1783	0	1	28	
43	19097	N	17:20	17:33	1641	0	1.1	29	LAST LINE OF LIFT 1
44	19097	S	19:43	19:58	1740	0	1.3	29	FIRST LINE OF 2ND LIFT
45	19097	N	20:00	20:12	1866	0	1	29	
46	19097	S	20:15	20:30	1710	0	1	29	
47	19097	N	20:31	20:44	1827	0	1	29	
48	19097	S	20:46	21:03	1772	0	1	33	
49	19097	N	21:05	21:18	1820	0	1	34	
50	19097	S	21:21	21:38	1700	0	1	34	TURBULENCE
51	19909	n	21:40	21:54	1749	0	1	34	last line of lift 2

Notes:

Additional Notes on Reverse Side: []

9/16/2019	19026 Carter County	Drive used: Galaxy 2
	MissionID:	Sensor: Galaxy

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 17
Aircraft Tail # / Pilot: N72659T/Schupe	Dew Point (°F): 11
Airport: KMLS	Pressure (inHg): 29.72
Operator: GENTHER	Wind Speed (mph): 16
HOBBS: 9153.5	Wind Direction: 140
Sensor Serial #: 5060410	Clouds:
Optics Cleaned: Yes [<input checked="" type="checkbox"/>] No [<input type="checkbox"/>]	Surface Condition (Wet / Dry / Snow):

Pulse Rate (kHz): 250	Scan Rate (Hz): 51	FOV: 46	LASER %: High	Single-Pulse [<input type="checkbox"/>] Multi-Pulse [<input checked="" type="checkbox"/>]
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
52	19097	s	15:38	15:57	1690	0	1.2	34	
53	19097	n	15:59	16:13	1778	0	1.15	34	
54	19097	s	16:16	16:34	16:59	0	1	34	
55	19097	n	16:36	16:51	1663	0	1.1	34	
16	19097	s	17:05	17:25	0:00	0	1.2	37	
17	19097	n	17:27	17:43	1622	0	1.1	38	
18	19097	s	17:45	18:05	1719	0	1	38	
19	19097	N	18:07	1822	1600	0	1.1	37	
20	19097	S	1826	1845	1700	0	1.2	37	
21	19097	N	1847	19:27	1650	0	1.1	37	fms system crash @ 1858 / restarted at 1918
22	19097	s	19:29	19:48	1717	0	1	37	cloud shadows @19:39-19:44
23	19097	N	19:49	20:05	1888	0	1	37.5	Last Line of Lift

Notes:

9/18/2019	19097 CARTER COUNTY	Drive used: GALAXY 3 AND PHASE 3 AND 4
	MissionID:	Sensor: Galaxy AND PHASEONE

MetaData	Weather Conditions
Flight Vendor: Aero-Graphics	Temperature (°F): 11
Aircraft Tail # / Pilot: N72659T/Schupe	Dew Point (°F): 6
Airport: KMLS	Pressure (inHg): 29.95
Operator: GENTHER	Wind Speed (mph):
HOBBS:	Wind Direction:
Sensor Serial #: 5060410	Clouds:
Optics Cleaned: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Surface Condition (Wet / Dry / Snow):

Pulse Rate (kHz): 250	Scan Rate (Hz): 51	FOV: 46	LASER %: High	Single-Pulse <input type="checkbox"/> Multi-Pulse <input checked="" type="checkbox"/>
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Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
24		S	15:09	15:25	1771	0	1	34	FIRST LINE OF LIFT 01
25		N	15:27	15:45	1706	0	1	35	
3		S	15:52	1608	1650	0	1	36	
4		N	1611	1629	1741	0	1	35	
5		S	16:31	16:46	1853	0	1	35	
6		N	1648	1705	1717	0		34	
7		S	1706	1721	1801	0		34	
8		N	1724	1741	1681	0		34	
9		S	1744	1802	1801	0		40	
10		N	1804	1822	1799	0		35	
11		S	1824	1841	1730	0		30	
12		N	1843_	1901	1645	0		40	LAST LINE OF LIFT
13		S	21:21	21:40	1623	0		38	FIRST LINE OF SECOND LIFT
14		N	21:42	21:58	1670	0		38	
15		S	2201	2219	1620	0		38	

Notes:

Additional Notes on Reverse Side: []

Lidar Flight Log	12	Area Flown:
	MissionID:	Sensor:

Line #	Mission ID	Heading (N/S/E/W)	Start Time	End Time	Range (m)	Returns (%)	PDOP	Line [mi] [km]	Comments
22		N	22:22	22:32		0	1		REFLIGHT OF SOUTHERN PORTION FOR CLOUD SHADOWS
2		S	22:39	22:47	1620	0	1	16	UNSURE IF LINE WAS FLOWN BY LAST CREW

Notes: