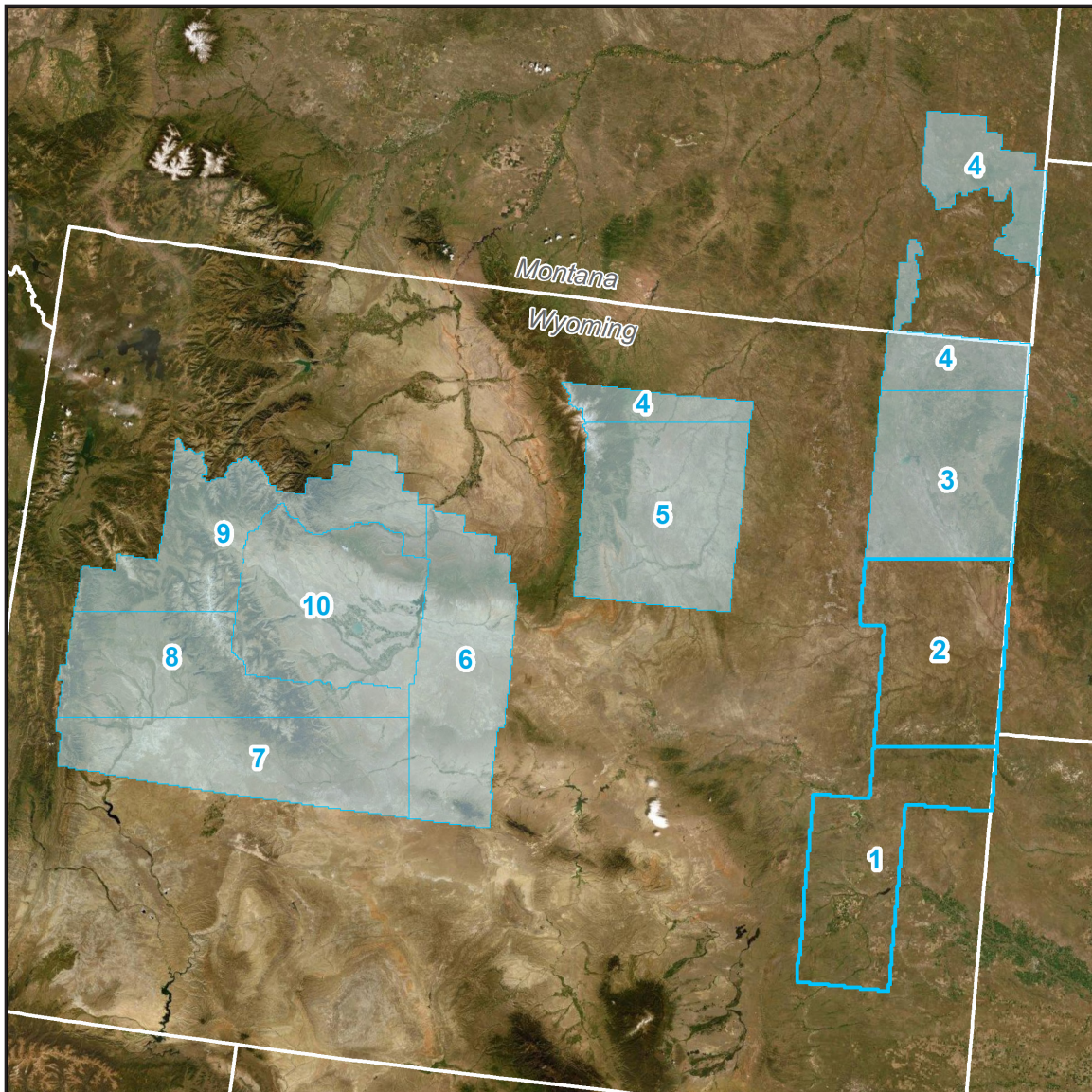


# WY FEMA East 2019 D19

## Lot 5 Blocks 1 and 2 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 5 Blocks 1 and 2 areas of interest. This AOI totals approximately 6,180 square miles and includes the following counties:

- Platte
- Niobrara
- 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		
<b>Horizontal</b>	<b>EPSG Code</b>	6350
	<b>Datum</b>	NAD83 (2011)
	<b>Projection</b>	Albers Equal Area
	<b>Units</b>	Meters
<b>Vertical</b>	<b>Datum</b>	NAVD88
	<b>Geoid</b>	GEOID12B
	<b>Units</b>	Meters
	<b>Height Type</b>	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

<b>Lidar Data</b>	
Classified lidar point cloud data	Tiles in .las v1.4 format Classes <ul style="list-style-type: none"> <li>• 1 – Processed, not Classified</li> <li>• 2 – Ground</li> <li>• 7 – Noise</li> <li>• 9 – Water</li> <li>• 17 – Bridge Decks</li> <li>• 18 – High Noise</li> <li>• 20 – Ignored Ground</li> <li>• 21 – Snow</li> </ul>
Breaklines used for hydro-flattening	<ul style="list-style-type: none"> <li>• Lake and River features as feature classes in an Esri file geodatabase               <ul style="list-style-type: none"> <li>• Water bodies greater than 2 acres as polygon features</li> <li>• Rivers 30.5 meters / 100 feet and greater in width as polyline features</li> </ul> </li> <li>• Bridges used in DEM generation as point features in Esri shapefile format</li> </ul>
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
<b>Control Data</b>	
Lidar calibration points	Esri shapefile format
Lidar NVA checkpoints	Esri shapefile format
Lidar VVA checkpoints	Esri shapefile format
<b>Other Data</b>	
Tile Index	Esri shapefile format
Snow Polygons	Esri shapefile format
<b>Metadata and Reports</b>	
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

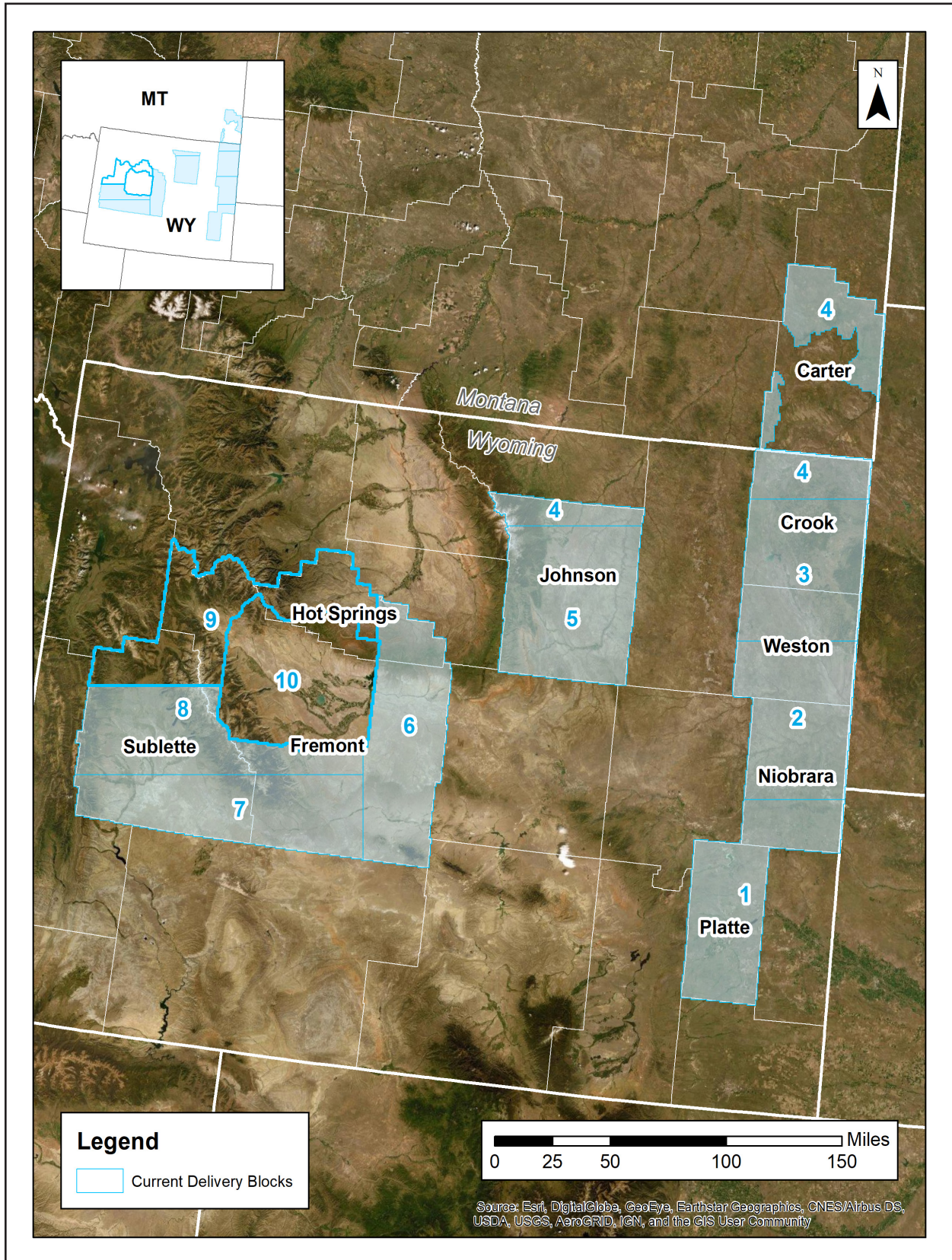
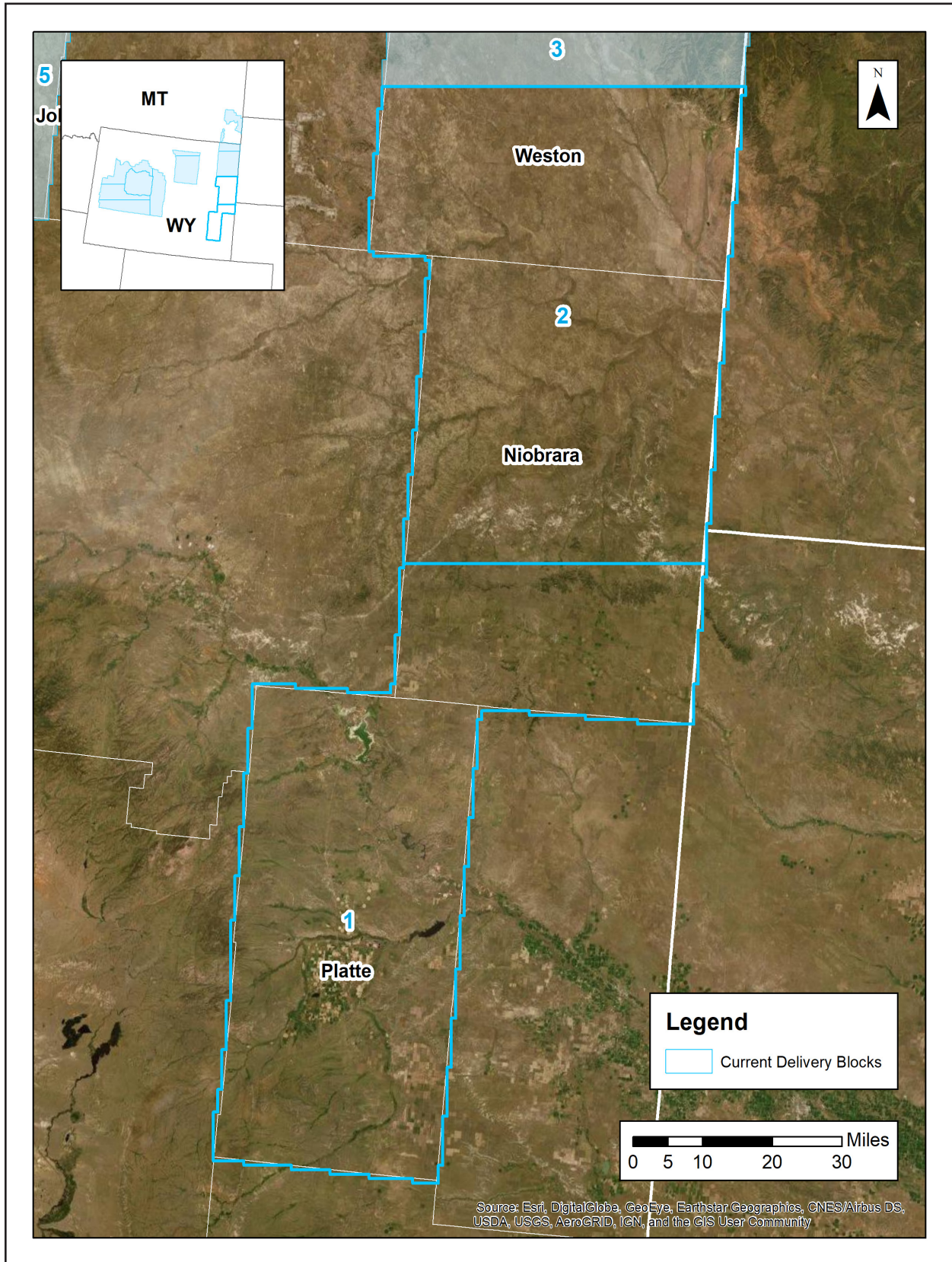


Figure 1-2. Project Area - Blocks 1 and 2



## 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"> <li>• 2 points per square meter</li> <li>• 0.71-meter nominal point spacing</li> </ul>
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"> <li>• Cloud and fog-free between the aircraft and ground</li> <li>• Ground is snow free</li> <li>• Ground has no unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation</li> <li>• Preference of vegetation is leaf-off</li> </ul>
Data Voids	Not allowed except <ul style="list-style-type: none"> <li>• Where caused by water bodies</li> <li>• Where caused by areas of low near infra-red (NIR) reflectivity (i.e. asphalt or composition roofing)</li> <li>• Where caused by lidar shadowing from buildings or other features; or</li> <li>• Where appropriately filled-in by another swath</li> </ul>
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

<b>Sensor Specifications</b>	
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
<b>Laser Specifications</b>	
Laser Beam Divergence	0.25 mrad (1/e)
Laser Classification	Class 4 laser product
<b>Accuracy</b>	
Range Resolution	< 1 cm RMS
Elevation Accuracy	< 5 cm 1 $\sigma$
Horizontal Accuracy	< 13 cm 1 $\sigma$
<b>Physical Specifications</b>	
Size (cm), Weight (kg) • Scanner • Control Electronics	<ul style="list-style-type: none"> <li>• 37 W x 68 L x 26 H cm, 47 kg</li> <li>• 45 W x 47 D x 25 H cm, 33 kg</li> </ul>
Operating Temperature • Scanner • Control Electronics	<ul style="list-style-type: none"> <li>• 0 - 40°C cabin-side temperature</li> <li>• 0 - 40°C</li> </ul>
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

<b>Sensor Performance</b>	
Performance envelope <sup>1, 2, 3, 4</sup>	150-6000 m AGL, nominal
Absolute horizontal accuracy <sup>2, 3</sup>	1/10,000 × altitude; 1 $\sigma$
Absolute elevation accuracy <sup>2, 3</sup>	< 0.03-0.25 m RMSE from 150-6000 m AGL
<b>Laser Configuration</b>	
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 <sup>5</sup>	< 0.008 m, 1 $\sigma$
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)
<b>Sensor Configuration</b>	
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 5 Blocks 1 and 2 was collected from June 14, 2019 through July 10, 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 2-4. 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<sub>x</sub> / RMSE<sub>y</sub> 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<sub>z</sub> 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<sub>z</sub> 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				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
79935	Wyoming FEMA East	Day166_90513_A	06/15/2019	166	A	

Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing		
Larocque	Cessna 404 Titan - N7079F	2164.1	09:35:00	15:35:00	CYS		
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving		
DeHart	Leica Terrain Mapper - 90513	2168.5	12:41:00	18:41:00	CYS		

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
20	9	10	12,500	Clear	17	6	3010
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	13,000	13,000	6,047				

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
52	E	15:35:00	15:51:00	00:16:00	22	1.1	Area 3
51	W	15:55:00	16:11:00	00:16:00	21	1.2	
50	E	16:14:00	16:29:00	00:15:00	21	1.2	
49	W	16:33:00	16:49:00	00:16:00	22	1.2	
48	E	16:52:00	17:07:00	00:15:00	22	1.1	
47	W	17:10:00	17:28:00	00:18:00	24	1	
46	E	17:31:00	17:44:00	00:13:00	22	1.1	
45	W	17:47:00	18:03:00	00:16:00	23	1.1	
44	E	18:06:00	18:22:00	00:16:00	19	1.1	
43	W	18:25:00	18:41:00	00:16:00	19	1.1	

Additional Comments

# Woolpert Lidar Acquisition Log

Project Info			Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
79935	Wyoming Block 4	Day166_90515	06/15/2019	166	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Finn	Cessna 404 Titan - N475RC	1705.4	08:50:00	14:50:00	KCYS
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90515	1706.8	10:16:00	15:16:00	KCYS

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
330	7	10	41,100	Broken	10.6	-2	29.88
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		9,842		12,940		6,100	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	40	82	600	100

							Verify S-Turns Before Mission
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
69	W	15:19:00	15:31:00	00:12:00	16	1.4	Clouds 35-55 KM in

**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	Day171_90513_A	06/20/2019	171	A

Crew	Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Larocque	Cessna 404 Titan - N7079F		2172.4	09:01:00	15:01:00	CPR
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
DeHart	Leica Terrain Mapper - 90513		2178.4	02:02:00	20:02:00	CPR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
60	6	10	10,000	Broken	11	7	29.87
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		13,000		13,000		6,047	

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
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
59	E	15:01:00	15:12:00	00:11:00	24	1.1	Area 3
60	W	15:16:00	15:31:00	00:15:00	23	1.1	
61	E	15:34:00	15:37:00	00:03:00	25	1.1	Had to abort due to ground speed
61	E	15:46:00	15:57:00	00:11:00	24	1.2	Reached speed of 172
62	W	16:01:00	16:15:00	00:14:00	23	1.2	
63	E	16:19:00	16:30:00	00:11:00	22	1.2	Reached speed of 173
64	W	16:34:00	16:49:00	00:15:00	25	1	
65	E	16:52:00	17:03:00	00:11:00	24	1.1	
66	W	17:06:00	17:21:00	00:15:00	22	1	
42	E	17:30:00	17:45:00	00:15:00	24	0.9	
41	W	17:49:00	18:07:00	00:18:00	20	1.1	
40	E	18:10:00	18:24:00	00:14:00	16	1.1	Possible holiday 13.5 miles in
39	W	18:28:00	18:46:00	00:18:00	15	1.2	
38	E	18:49:00	19:03:00	00:14:00	16	1.2	
37	W	19:07:00	19:25:00	00:18:00	15	1.2	
36	E	19:28:00	19:42:00	00:14:00	16	1.2	
35	W	19:45:00	20:02:00	00:17:00	17	1.1	

							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	Wyoming Block 4	Day171_90515	06/20/2019	171		

Crew	Equipment	Time			Airports
<b>Pilot</b>	<b>Aircraft Make / Model / Tail #</b>	<b>Hobbs Start</b>	<b>Local Start</b>	<b>UTC Start</b>	<b>Departing</b>
Finn	Cessna 404 Titan - N475RC	1711.5	08:30:00	14:30:00	KCYS
<b>Operator</b>	<b>Sensor Make / Model / Serial #</b>	<b>Hobbs End</b>	<b>Local End</b>	<b>UTC End</b>	<b>Arriving</b>
Nardone	Leica Terrain Mapper - 90515	1715.5	12:35:00	18:35:00	KCYS

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
110	5	10		Clear	12	2	29.95
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		9,842		12,940		6,100	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	40	82	600	100

**Verify S-Turns Before Mission**

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
65	W	15:01:00	15:15:00	00:14:00	18	1.6	W Bound Lines good, E Bound race track
64	E	15:28:00	15:38:00	00:10:00	18	1.4	Flew as fast as possible, Race Tracking
64	W	15:43:00	15:56:00	00:13:00	17	1.6	
63	E	15:59:00	16:07:00	00:08:00	17	1.6	Flew as fast as possible, Race Tracking
63	W	16:15:00	16:28:00	00:13:00	16	1.8	
62	E	16:42:00	16:50:00	00:08:00	18	1.3	Flew as fast as possible, Race Tracking
62	W	16:54:00	17:07:00	00:13:00	17	1.4	
61	E	17:13:00	17:21:00	00:08:00	18	1.3	Flew as fast as possible, Race Tracking
61	W	17:25:00	17:38:00	00:13:00	20	1.2	
59	E	17:46:00	17:55:00	00:09:00	19	1.1	Flew as fast as possible, Race Tracking
59	W	18:02:00	18:16:00	00:14:00	15	1.2	

**Page 1**

**Verify S-Turns After Mission**

**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	Day172_90513_A	06/21/2019	172	A	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Larocque	Cessna 404 Titan - N7079F	2178.4	10:19:00	16:19:00	CPR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
DeHart	Leica Terrain Mapper - 90513	2180.5	11:33:00	17:33:00	CPR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
250	19	10	10,000	Broken	10	-2	29.91
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	13,000	13,000	6,047				

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

	<b>Verify S-Turns Before Mission</b>	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
34	E	16:19:00	16:35:00	00:16:00	21	1.2	Area 3
33	W	16:38:00	16:55:00	00:17:00	23	1	
32	E	16:58:00	17:13:00	00:15:00	22	1	
31	W	17:16:00	17:33:00	00:17:00	24	1	Light cloud layer at end of line

Page 1	<b>Verify S-Turns After Mission</b>	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	Wyoming Block 4	Day175_90515	06/24/2019	175		

Crew		Equipment		Time			Airports
Pilot		Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Finn		Cessna 404 Titan - N475RC		1715.5	09:01:00	15:01:00	KCYS
Operator		Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Nardone		Leica Terrain Mapper - 90515		1719.9	01:30:00	19:29:00	KCYS

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
270	15	10		Clear	19	5	30.01
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		9,842	12,940	6,100			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	40	82	600	100

**Verify S-Turns Before Mission**

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
58	W	15:23:00	15:37:00	00:14:00	18	1.4	
57	E	15:42:00	15:54:00	00:12:00	18	1.3	
56	W	15:58:00	16:11:00	00:13:00	16	1.7	
54	E	16:18:00	16:30:00	00:12:00	17	1.4	
53	W	16:34:00	16:47:00	00:13:00	19	1.2	
52	E	16:53:00	17:07:00	00:14:00	19	1.1	
51	W	17:10:00	17:24:00	00:14:00	20	1	
50	E	17:34:00	17:48:00	00:14:00	19	1.1	
49	W	17:51:00	18:03:00	00:12:00	16	1.3	
48	E	18:06:00	18:18:00	00:12:00	15	1.4	
47	W	18:23:00	18:36:00	00:13:00	17	1.5	
46	E	18:39:00	18:51:00	00:12:00	15	1.6	
45	W	18:55:00	19:08:00	00:13:00	15	1.5	

**Verify S-Turns After Mission**

**Additional Comments**

# Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
79935	Wyoming Block 4	Day176_90515	06/25/2019	176		

Crew	Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Finn	Cessna 404 Titan - N475RC		1719.9	09:20:00	15:20:00	KCYS
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90515		1724.9	02:24:00	20:24:00	KCYS

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
280	10	10		Clear	17	5	30.11
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		9,842		12,940		6,100	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	40	82	600	100

**Verify S-Turns Before Mission**

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
42	W	15:42:00	15:55:00	00:13:00	15	1.5	
41	E	16:00:00	16:12:00	00:12:00	15	1.7	
40	W	16:18:00	16:31:00	00:13:00	18	1.4	
39	E	16:37:00	16:50:00	00:13:00	17	1.3	
38	W	16:54:00	17:07:00	00:13:00	17	1.4	
37	E	17:11:00	17:22:00	00:11:00	18	1.1	
36	W	17:26:00	17:39:00	00:13:00	15	1.2	
35	E	17:44:00	17:56:00	00:12:00	15	1.3	
34	W	17:59:00	18:12:00	00:13:00	15	1.4	
33	E	18:16:00	18:27:00	00:11:00	14	1.6	
32	W	18:33:00	18:45:00	00:12:00	14	1.9	
31	E	18:50:00	19:02:00	00:12:00	15	1.9	
30	W	19:07:00	19:19:00	00:12:00	16	1.6	
29	E	19:25:00	19:37:00	00:12:00	19	1.4	
28	W	19:44:00	19:56:00	00:12:00	19	1.7	

**Page 1** **Verify S-Turns After Mission**

**Additional Comments**



# Woolpert Lidar Acquisition Log

Project Info			Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
79935	Wyoming Block 4	Day179_90515	06/28/2019	179	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Finn	Cessna 404 Titan - N475RC	1726.2	11:30:00	17:30:00	KCYS
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90515	1730	03:20:00	21:20:00	KCYS

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
280	10	10		Clear	29	3	30.11
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	9,842	12,940	6,100				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	40	82	600	100

**Verify S-Turns Before Mission**

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
71	N	17:51:00	17:59:00	00:08:00	15	1.5	
27	W	18:08:00	18:20:00	00:12:00	15	1.6	
26	E	18:24:00	18:35:00	00:11:00	14	1.7	
25	W	18:40:00	18:53:00	00:13:00	14	1.8	
24	E	18:59:00	19:11:00	00:12:00	16	1.7	
23	W	19:20:00	19:32:00	00:12:00	15	1.6	
22	E	19:36:00	19:48:00	00:12:00	12	1.7	
21	W	19:52:00	20:04:00	00:12:00	14	1.5	
20	E	20:08:00	20:20:00	00:12:00	14	1.5	
19	W	20:25:00	20:37:00	00:12:00	14	1.3	
18	E	20:42:00	20:53:00	00:11:00	12	1.9	

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**Verify S-Turns After Mission**

**Additional Comments**



# Woolpert Lidar Acquisition Log

Project Info				Date			
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #		
79935	FEMA Wyoming	Day183_90513_A	07/02/2019	183	A		
Crew		Equipment		Time		Airports	
Pilot		Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
LaRocque		Cessna 404 Titan - N7079F		2205.7	08:53:00	14:53:00	CPR
Operator		Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90513		2210.8	14:09:00	20:09:00	CPR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
0	0	10	25,000	Scattered	17	11	30.07
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		7,500		12,900		5,300	

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	
80	E	15:27:00	15:39:00	00:12:00	19	1.2	clear	
79	W	15:42:00	15:54:00	00:12:00	19	1.1		
78	E	15:57:00	16:08:00	00:11:00	21	1		
77	W	16:11:00	16:22:00	00:11:00	20	1.1		
76	E	16:25:00	16:37:00	00:12:00	21	1		
75	W	16:40:00	16:51:00	00:11:00	22	0.9		
74	E	16:54:00	17:06:00	00:12:00	21	1		
73	W	17:09:00	17:21:00	00:12:00	22	1		
72	E	17:24:00	17:36:00	00:12:00	20	1.1		
71	W	17:38:00	17:50:00	00:12:00	18	1.2		
70	E	17:53:00	18:05:00	00:12:00	18	1.3		
69	W	18:07:00	18:19:00	00:12:00	19	1.3		
68	E	18:22:00	18:33:00	00:11:00	20	1.1		
67	W	18:36:00	18:48:00	00:12:00	19	1.2		
62	E	18:51:00	19:03:00	00:12:00	22	1.1	reflight of line 62	
82	N	19:11:00	19:22:00	00:11:00	22	1.2	cross strip line	
58	W	19:30:00	19:41:00	00:11:00	23	1.2	reflight of line 58	
							end mission for clouds	
							Block 3 fully captured	

Page 1	Verify S-Turns After Mission	Yes
<b>Additional Comments</b>		





# Woolpert Lidar Acquisition Log

Project Info					Date		
Project #	Project Name		Unique ID		Flight Date (UTC)	Day of Year	Flight #
79325	WY_FEMA		Day183_90511_B		07/02/2019	183	B
Crew		Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start		Local Start	UTC Start	Departing
Operator	Sensor Make / Model / Serial #		Hobbs End		Local End	UTC End	Arriving
Finn	Cessna 404 Titan - N475RC		1735		10:24:00	16:24:00	KCYS
Galambos	Leica Terrain Mapper - 90511		1738		12:53:00	18:53:00	KCYS
Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
Air Speed (kts)	Altitude AGL (ft)		Altitude MSL (ft)	Airfield Elevation (ft)			
260	6	10	12,000		22	12	30.23
150	9,842		12,940	3,091			
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
8	E	16:24:03	16:35:30	00:11:27	19	1.1	
9	W	16:39:03	16:50:21	00:11:18	19	1.1	
10	E	16:54:30	17:06:30	00:12:00	19	1.1	
11	W	17:10:23	17:21:31	00:11:08	19	1.1	
12	E	17:25:22	17:37:12	00:11:50	18	1.3	
13	W	17:40:44	17:52:27	00:11:43	18	1.3	
14	E	17:55:28	18:07:14	00:11:46	16	1.5	
15	W	18:10:51	18:22:49	00:11:58	16	1.6	
16	E	18:25:49	18:37:20	00:11:31	16	1.8	
17	W	18:40:30	18:52:31	00:12:01	16	1.6	
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			Day191_90515_B		07/10/2019	191	B	
Crew		Equipment			Time			Airports	
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gibiarlo		Cessna 404 Titan - N475RC			1756.6	09:17:00	15:17:00	KGCC	
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Galambos		Leica Terrain Mapper - 90515			1761.3	13:16:00	19:16:00	KGCC	
Conditions									
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)		
250	9	10	12,000		13	10	30.3		
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 4/GPS 13:05:42		
							ROLL MOUNT ISSUE		
							Reboot in flight		
							Circles		
60	W	15:17:05	15:29:17	00:12:12	18	1.4	Reflight		
19	E	15:40:22	15:52:11	00:11:49	19	1.2			
16	W	15:54:49	16:06:45	00:11:56	19	1.1			
43	N	16:53:02	17:06:08	00:13:06	14	1.3	Block 7 - - 13,533 FE 3,691		
42	S	17:09:05	17:22:13	00:13:08	13	1.4			
41	N	17:25:15	17:38:22	00:13:07	12	1.5			
40	S	17:41:38	17:54:30	00:12:52	11	1.6			
39	N	17:57:45	18:10:43	00:12:58	11	1.7			
38	S	18:13:53	18:26:37	00:12:44	12	1.5			
37	N	18:30:00	18:43:00	00:13:00	12	2.2			
36	S	18:46:00	18:58:56	00:12:56	12	1.7			
35	N	19:02:28	19:15:45	00:13:17	14	1.8			

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	Day175_90513_A	06/24/2019	175	A		
Crew		Equipment		Time		Airports	
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing	
Larocque	Cessna 404 Titan - N7079F		2181.5	09:10:00	15:10:00	CPR	
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving	
DeHart	Leica Terrain Mapper - 90513		2184.9	11:37:00	17:37:00	CPR	

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
240	7	10	12,000	Clear	16	4	29.91
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		13,000	13,000	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	
30	E	15:10:00	15:27:00	00:17:00	23	1.1	Area 3	
29	W	15:29:00	15:45:00	00:16:00	22	1.3		
28	E	15:48:00	16:04:00	00:16:00	22	1.1		
27	W	16:07:00	16:23:00	00:16:00	23	1		
26	E	16:26:00	16:41:00	00:15:00	21	1.1		
25	W	16:44:00	17:00:00	00:16:00	22	1		
24	E	17:03:00	17:19:00	00:16:00	22	1		
23	W	17:22:00	17:37:00	00:15:00	22	1	Clouds on line	

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	Wyoming FEMA East	Day176_90513_A	06/25/2019	176	A	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Larocque	Cessna 404 Titan - N7079F	2184.9	10:03:00	16:03:00	CPR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
DeHart	Leica Terrain Mapper - 90513	2189.6	12:23:00	18:23:00	CPR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
249	4	10	12,000	Clear	14	8	30.02
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		13,000		13,000		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

<b>Verify S-Turns Before Mission</b>	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
23	E	16:03:00	16:19:00	00:16:00	20	1.2	Area 3
22	W	16:22:00	16:38:00	00:16:00	23	1	
21	E	16:41:00	16:56:00	00:15:00	22	1	
20	W	16:59:00	17:15:00	00:16:00	24	0.9	
19	E	17:18:00	17:33:00	00:15:00	21	1	
18	W	17:36:00	17:52:00	00:16:00	19	1.1	
17	E	17:55:00	18:10:00	00:15:00	19	1.2	
16	W	18:12:00	18:23:00	00:11:00	19	1.2	Error"number of TO's without TO increase, Emergency button pressed, PAV error." Rebooted system, emergency breaker had not been pushed.

Page 1	<b>Verify S-Turns After Mission</b>	Yes
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<b>Additional Comments</b>





# Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
79935	Wyoming FEMA East			Day177_90513_A		06/26/2019	177	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Larocque		Cessna 404 Titan - N7079F			2189.6	08:48:00	14:48:00	CPR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
DeHart		Leica Terrain Mapper - 90513			2195.1	01:19:00	19:19:00	CPR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
0	0	10	12,000	Clear	12	9	30.07	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		13,000	13,000	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	
12	E	14:48:00	15:02:00	00:14:00	23	1.1	Area 3	
11	W	15:05:00	15:21:00	00:16:00	24	1.1		
10	E	15:23:00	15:39:00	00:16:00	24	1.1		
9	W	15:42:00	15:58:00	00:16:00	22	1.3		
8	E	16:01:00	16:16:00	00:15:00	23	1.1		
7	W	16:19:00	16:34:00	00:15:00	23	1.1		
6	E	16:37:00	16:53:00	00:16:00	22	1.2		
81	S	17:05:00	17:17:00	00:12:00	24	0.9	Xcheck	
80	E	17:32:00	17:47:00	00:15:00	18	1.1	Area 2	
79	W	17:50:00	18:05:00	00:15:00	15	1.3		
78	E	18:08:00	18:24:00	00:16:00	15	1.3		
77	W	18:27:00	18:42:00	00:15:00	16	1.2		
76	E	18:45:00	19:01:00	00:16:00	15	1.3		
75	W	19:04:00	19:19:00	00:15:00	16	1.3		
							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	Day178_90513_A	06/27/2019	178	A	
Crew		Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing	
Larocque	Cessna 404 Titan - N7079F	2195.1	09:30:00	15:30:00	CPR	
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving	
DeHart	Leica Terrain Mapper - 90513	2199.8	01:07:00	19:07:00	CPR	

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
140	3	10	12,000	Broken	14	12	30.11
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		13,000	13,000	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

<b>Verify S-Turns Before Mission</b>	<b>Yes</b>
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
74	E	15:30:00	15:45:00	00:15:00	24	1.2	Area 2
73	W	15:48:00	16:03:00	00:15:00	22	1.3	
72	E	16:06:00	16:22:00	00:16:00	23	1	
71	W	16:25:00	16:41:00	00:16:00	22	1.1	
70	E	16:43:00	16:58:00	00:15:00	22	1	
69	W	17:01:00	17:17:00	00:16:00	22	1	
68	E	17:20:00	17:35:00	00:15:00	21	1	
67	W	17:39:00	17:55:00	00:16:00	16	1.2	
66	E	17:57:00	18:12:00	00:15:00	15	1.3	Exceeded roll limit
65	W	18:15:00	18:31:00	00:16:00	16	1.2	
64	E	18:34:00	18:49:00	00:15:00	15	1.2	
63	W	18:51:00	19:07:00	00:16:00	16	1.2	

Page 1	<b>Verify S-Turns After Mission</b>	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			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	FEMA Wyoming Block 6 and 2		Day188_90513_A		07/07/2019	188	A	
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Swain		Cessna 404 Titan - N7079F			2216.7	07:13:00	13:13:00	GCC
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90513			2223.5	14:15:00	20:15:00	GCC
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
130	4	10	25,000	Clear	16	13	30.06	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		8,000	14,340	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 6								
9a	S	13:54:00			24	1.1	Clear, patch for line 9	
10a	N	14:03:00	14:08:00	00:05:00	25	1.1	patch	
11a	S	14:12:00	14:16:00	00:04:00	25	1.1	patch	
12a	N	14:21:00	14:29:00	00:08:00	25	1.1	patch	
13a	S	14:31:00	14:39:00	00:08:00	24	1.2	patch	
14a	N	14:45:00	14:51:00	00:06:00	25	1.1	patch, Auto IT adjusted for dark shadow	
15a	S	14:55:00	14:58:00	00:03:00	24	1.2	patch, Auto IT adjusted for dark shadow	
16a	N	15:01:00	15:03:00	00:02:00	24	1.1	patch	
17a	S	15:06:00	15:08:00	00:02:00	23	1.2	patch	
18a	N	15:11:00	15:14:00	00:03:00	22	1.2	fly patch for 475RC possible? Cloud	
Block 2								
48		15:49:00	16:08:00	00:19:00	21	1.1	clear all	
47		16:10:00	16:28:00	00:18:00	23	1		
46		16:30:00	16:48:00	00:18:00	22	1		
45		16:50:00	17:08:00	00:18:00	19	1.1		
44		17:11:00	17:29:00	00:18:00	20	1.1		
43		17:31:00	17:50:00	00:19:00	20	1.2		
42		17:52:00	18:10:00	00:18:00	15	1.4		
41		18:12:00	18:30:00	00:18:00	18	1.1		
40		18:32:00	18:50:00	00:18:00	19	1.1		
39		18:53:00	19:11:00	00:18:00	19	1.2		
38		19:13:00	19:31:00	00:18:00	19	1.2		
37		19:33:00	19:51:00	00:18:00	18	1.2		
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	FEMA Wyoming Block 2			Day188_90513_B	07/07/2019	188	B	
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Swain	Cessna 404 Titan - N7079F			2223.5	15:20:00	21:20:00	GCC	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Stanton	Leica Terrain Mapper - 90513			2225.7	17:47:00	23:47:00	GCC	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
130	18	10	25,000	Clear	29	14	29.93	
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 2								
36	E	21:51:00	22:09:00	00:18:00	20	1.2	Clear, roll out of limit error 12 nmi from W	
35	W	22:11:00	22:30:00	00:19:00	21	1.2		
34	E	22:32:00	22:50:00	00:18:00	22	1.3		
33	W	22:53:00	23:11:00	00:18:00	22	1.2		
36a	E	23:15:00	23:19:00	00:04:00	21	1.2	patch for roll error on line 36 end for rain moving onto block	
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	FEMA Wyoming East Lidar Block 1	Day189_90511_1	07/08/2019	189	1	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7211.1	08:45:00	14:45:00	GTF
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Kennedy	Leica Terrain Mapper - 90511	7217.1	14:46:00	20:43:00	GCC

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
330	5	10		Few	17	13	29.9
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	9,842	12,940	4,364				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.7	2	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
40	E	16:55:00	17:13:00	00:18:00	22	1.1	Airfield elevation based on KGCC
41	W	17:16:00	17:35:00	00:19:00	22	1.1	Base overflight at 16:36z Reposition for clouds
50	E	17:39:00	17:57:00	00:18:00	24	1.2	
51	W	18:00:00	18:19:00	00:19:00	22	1.2	
52	E	18:22:00	18:40:00	00:18:00	25	1.1	
53	W	18:43:00	19:01:00	00:18:00	21	1.3	
54	E	19:04:00	19:22:00	00:18:00	22	1.2	
55	W	19:25:00	19:44:00	00:19:00	22	1.2	
56	E	19:47:00	20:05:00	00:18:00	22	1.1	overexposure, clouds on last 2 miles
62	W	20:08:00	20:26:00	00:18:00	23	1.2	Reposition for clouds

**Page 1** **Verify S-Turns After Mission**  Yes

**Additional Comments**