Airborne Topographic LiDAR Report

Wisconsin WROC / 3DEP 2016-17 LiDAR Project Report – Buffalo County

October 31, 2016

Prime contractor: Ayres Associates Inc
Airborne LiDAR Acquisition Completed by Quantum Spatial, Inc.

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1. Section 1 Heading

1.1. Summary

This report contains a summary of the Buffalo County portion of the Wisconsin WROC / 3DEP LiDAR 2016-17 - acquisition task order, issued by Ayres Associates under their Task Order 20 dated March 7, 2016. The task order yielded a project area covering approximately 717 total square miles over Buffalo County, Wisconsin. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

1.2. Scope

Aerial topographic LiDAR was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned LiDAR Specifications

Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
$\geq$ 2 pts / m^2	1,700 m	38°	30%	$\leq$ 10 cm

1.3. Coverage

The LiDAR project boundary covers approximately 717 square miles over Buffalo County in western Wisconsin. LiDAR extents are shown in Figure 1. A buffer of 100 meters was created to meet task order specifications.

1.4. Duration

LiDAR data was acquired from March 21, 2016 to March 22, 2016 in four total lifts. See "Section: 2.5. Time Period" for more details.

1.5. Issues

There were no issues to report with this project.

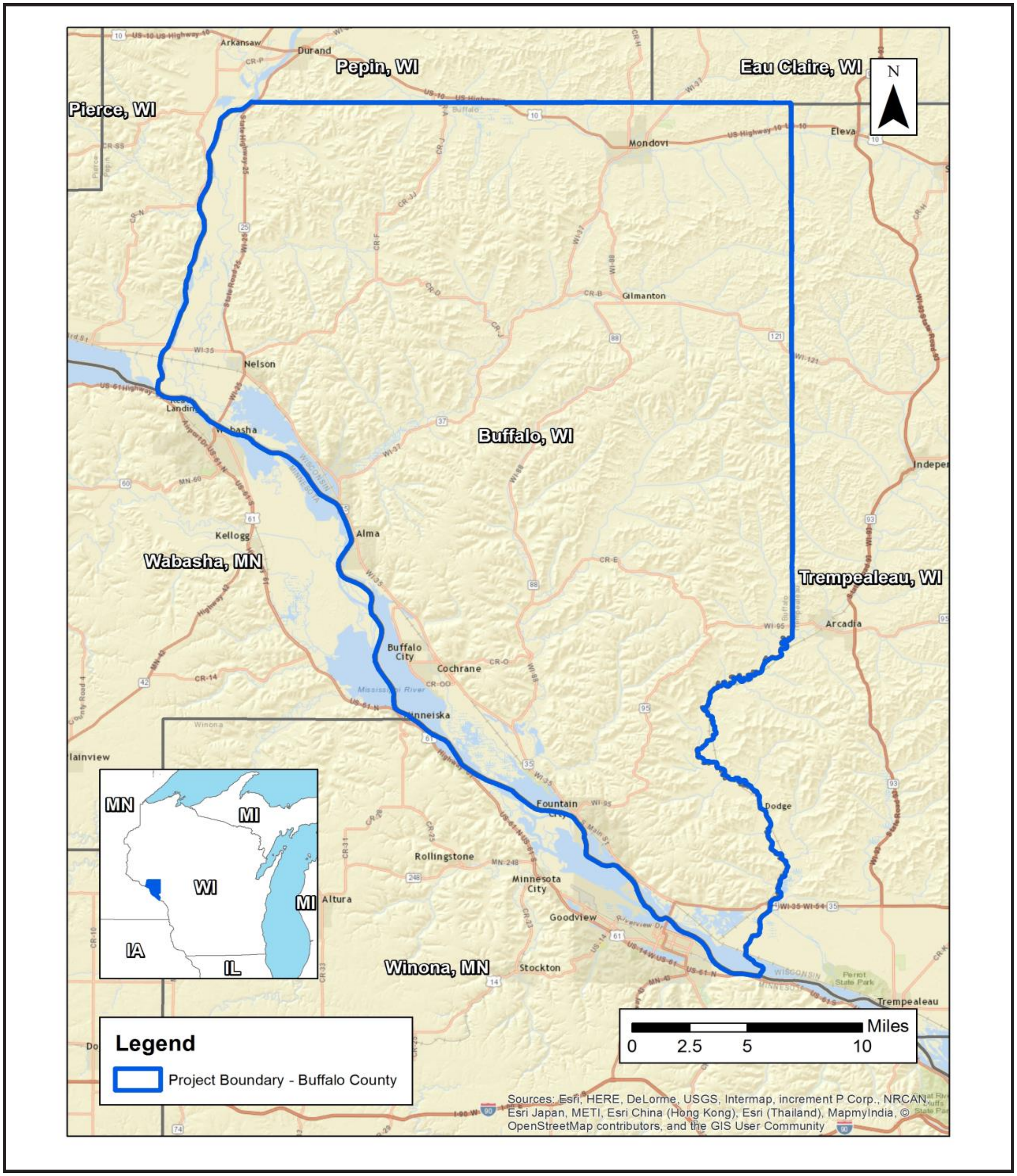
1.6. Deliverables

The following products were produced and delivered:

- Flight plans in digital format
- As-flown flight lines in Esri shapefile format
- Flight logs and notes
- Flight Quality Control Report
- WISCORS and supplemental base station data and OPUS reports
- LiDAR point cloud data, tiled, in LAS 1.4 format
- LiDAR point cloud data, in raw swaths, in LAS 1.4 format
- SBET/ABGPS/IMU materials and documentation
- Trajectories in .TRJ format
- All Flight mission parameters appropriate for inclusion in FGDC/USGS compliant metadata

All geospatial deliverables were produced in NAD83 (2011) Buffalo County Coordinate System (WISCRS), US survey feet; NAVD88 (Geoid 12A), US survey feet. All tiled deliverables were produced with a tile size of 4,500 feet x 4,500 feet. The tile index consists of 1,044 tiles.

Figure 1. Project Boundary



2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using Optech MissionNAV planning software. The entire target area was comprised of 58 planned flight lines measuring approximately 1,722.03 total flight line miles (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized one Optech Orion H300 LiDAR sensor (Figure 3), serial number 309, during the project. This system is capable of collecting data at a maximum frequency of 300 kHz, which affords elevation data collection of up to 300,000 points per second. This system utilize a Multi-Pulse in the Air option (MPIA). This sensor is also equipped with the ability to measure up to 5 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd, 4th, and last returns. The intensity of the first four returns is also captured during aerial acquisition.

A brief summary of the aerial acquisition parameters for the project are shown in the LiDAR System Specifications in Table 2.

Figure 2. Planned Flight Lines

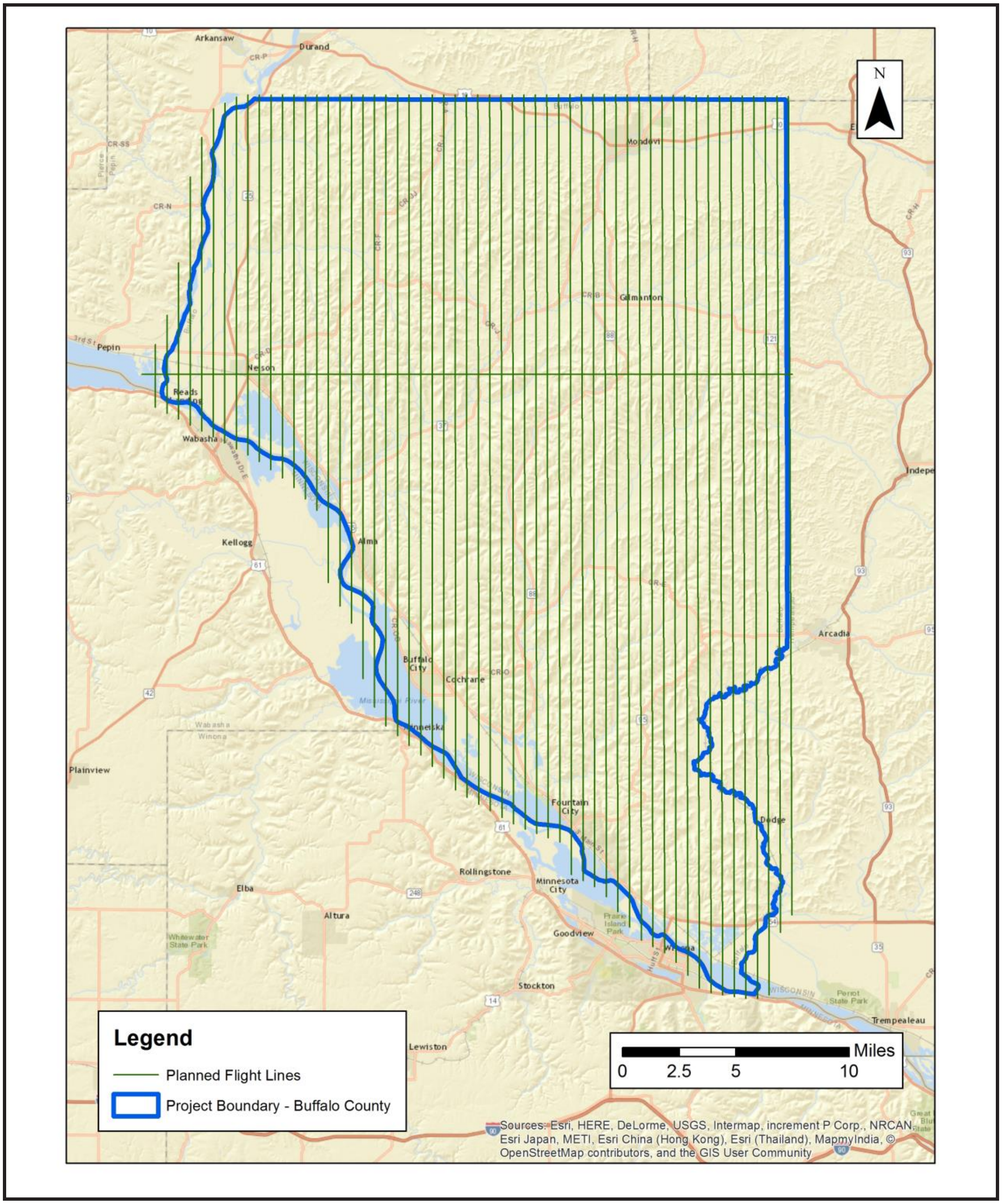
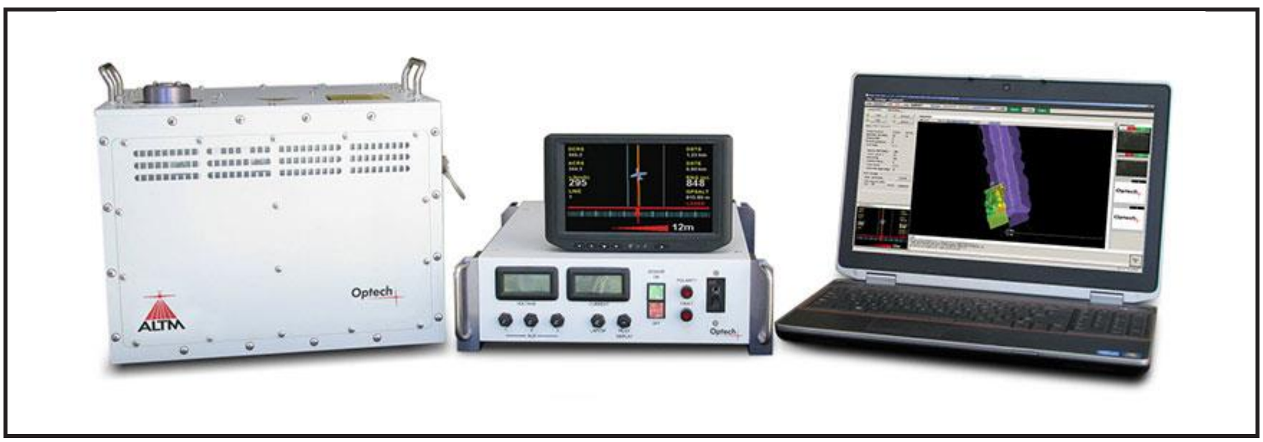


Table 2: LiDAR System Specifications

Terrain and Aircraft Scanner	Flying Height	1,700 m
	Recommended Ground Speed	140 kts
Scanner	Field of View	38°
	Scan Rate Setting Used	52 Hz
Laser	Laser Pulse Rate Used	225 kHz
	Multi Pulse in Air Mode	Enabled
Coverage	Full Swath Width	1,170.71 m
	Line Spacing	816 m
Point Spacing and Density	Average Point Density	2.19 pts / m2

Figure 3. Optech Orion H300 LiDAR Sensor



2.3. Aircraft

All flights for the project were accomplished through the use of a customized Cessna 402 (twin-piston), Tail Number N2JJ. This aircraft provided an ideal, stable aerial base for LiDAR and orthoimagery acquisition. This aerial platform has relatively fast cruise speeds which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which proved ideal for collection of high-density, consistent data posting using state-of-the-art Optech LiDAR systems. Some of Quantum Spatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of Quantum Spatial's Aircraft

2.4. Base Stations

GPS base stations were utilized during all phases of flight (Table 3). The base station locations were verified using NGS OPUS service and subsequent surveys. Base station locations are depicted in Figure 5. Data sheets, graphical depiction of base station locations or log sheets used during station occupation are available in Appendix A.

Table 3. Base Station Locations

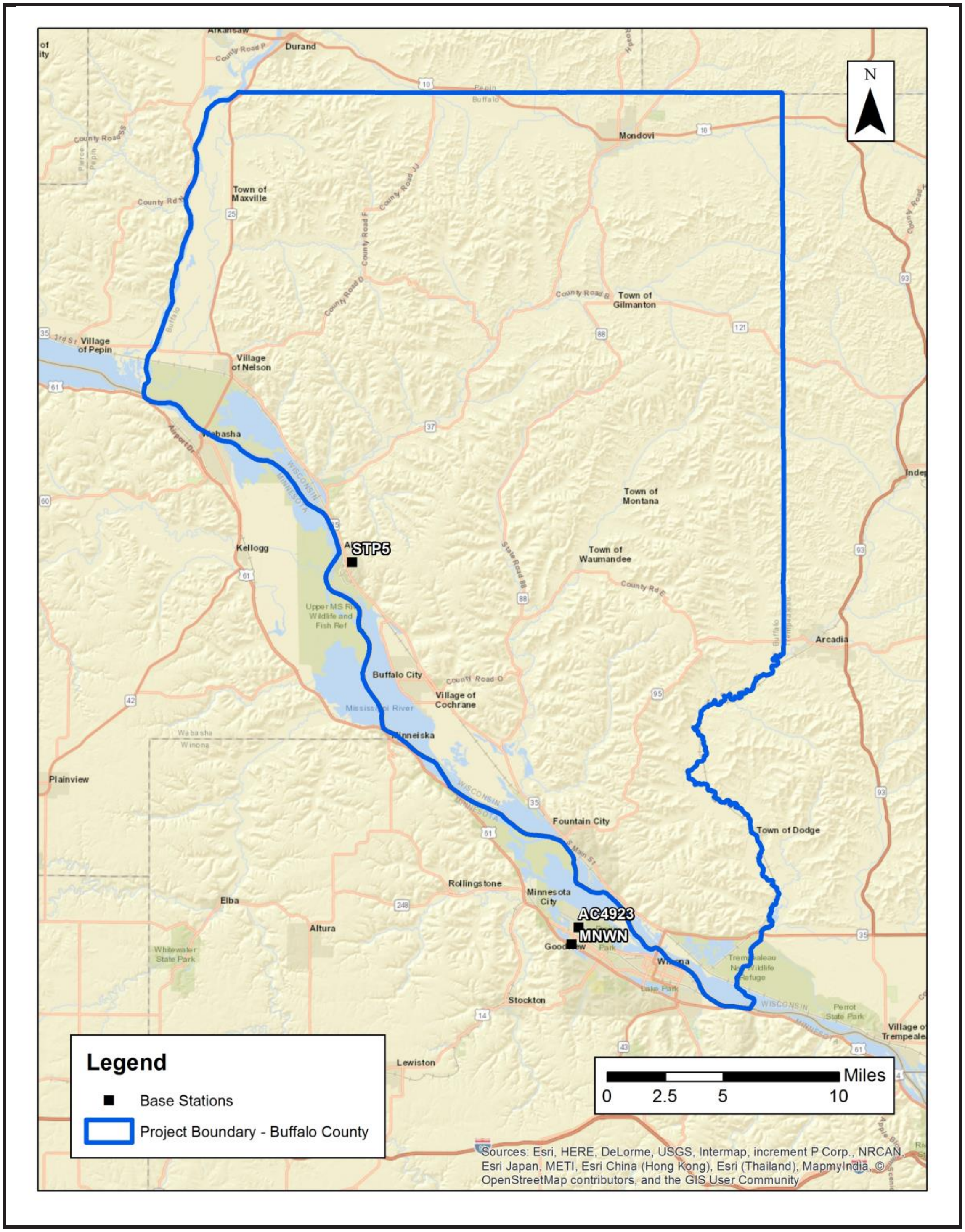
Base Station	Latitude	Longitude	Ellipsoid Height (m)
STP5	44° 18' 14.18818"	91° 54' 11.87112"	354.887
MNWN	44° 3' 54.00852"	91° 42' 45.48033"	179.648
AC4923	44° 4' 32.23381"	91° 42' 24.16622"	168.901

2.5. Time Period

Project specific flights were conducted over two days. Four sorties, or aircraft lifts were completed. Accomplished sorties are listed below.

- Mar 21, 2016-A (N2JJ, SN309)
- Mar 21, 2016-A (N2JJ, SN309)
- Mar 22, 2016-A (N2JJ, SN309)
- Mar 22, 2016-B (N2JJ, SN309)

Figure 5. Base Station Locations



3. Processing Summary

3.1. Flight Logs

Flight logs were completed by LIDAR sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.

3.2. LiDAR Processing

Applanix + POSPac Mobile Mapping Suite software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the LiDAR sensor during all flights. POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a “Smoothed Best Estimate Trajectory (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: Max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory. All relevant graphs produced in the POSPac processing environment for each sortie during the project mobilization are available in Appendix A.

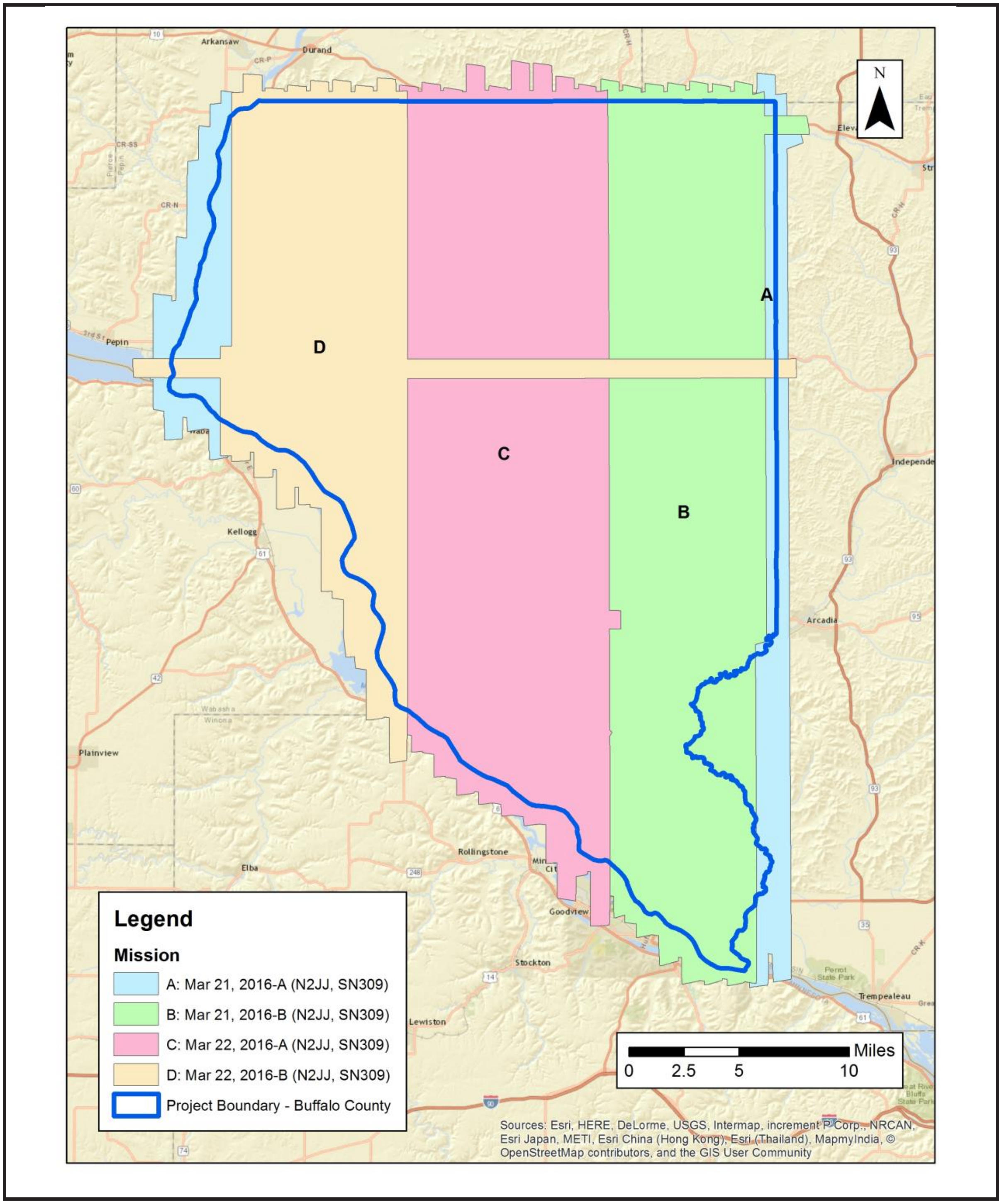
The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set. Point clouds were created using the Optech DashMap Post Processor software. GeoCue distributive processing software was used in the creation of some files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. TerraScan and TerraModeler software packages were then used for the automated data classification, manual cleanup, and bare earth generation. Project specific macros were developed to classify the ground and remove side overlap between parallel flight lines.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper was used as a final check of the dataset. GeoCue was used to create the deliverable industry-standard LAS files for the All Point Cloud Data.

4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 6.

Figure 6. Flightline Swath LAS File Coverage



5. Ground Control and Checkpoint Collection

Quantum Spatial utilized 11 ground control (calibration) points collected by Ayres Associates, Inc. as an independent test of the accuracy of this project. In this document, horizontal coordinates for ground control and QA points for all LiDAR classes are reported in NAD83 (2011) Buffalo County Coordinate System (WISCRS), US survey feet; NAVD88 (Geoid 12A), US survey feet.

5.1. Calibration Control Points

TerraScan was used to perform a quality assurance check for each of the LiDAR bare earth calibration points. Note that these results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface. See Figure 7 and Table 4.

Figure 7. Calibration Point Locations

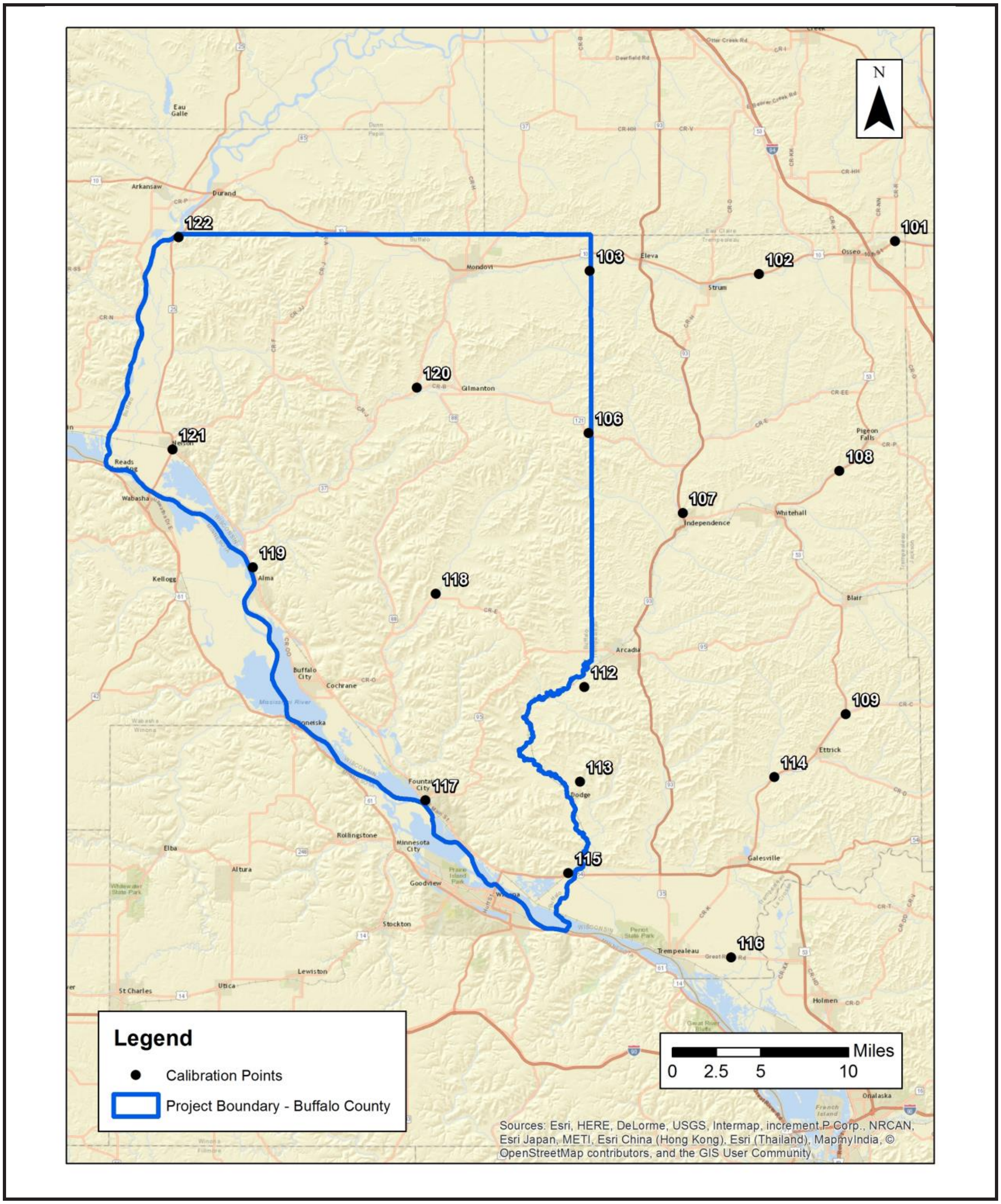


Table 4. Calibration Point Report
Units = US Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
118	598657.126	299032.378	771.022	771.230	+0.208
117	595622.580	237069.619	662.492	662.690	+0.198
122	521479.143	405977.284	736.957	737.110	+0.153
121	519755.536	342287.740	690.012	690.100	+0.088
106	644547.533	347225.665	957.482	957.560	+0.078
112	643216.769	271082.179	881.391	881.400	+0.009
119	543778.075	307007.367	680.954	680.940	-0.014
113	641955.615	242691.643	745.785	745.720	-0.065
120	592970.706	360860.413	743.187	743.040	-0.147
103	644916.874	395879.665	893.594	893.410	-0.184
115	638490.729	215210.058	667.754	667.440	-0.314

Average Dz	+0.001 ft
Minimum Dz	-0.314 ft
Maximum Dz	+0.208 ft
Average Magnitude	0.133 ft
Root Mean Square	0.159 ft