Airborne Topographic LiDAR Report

Wisconsin WROC - 3DEP

La Crosse County LiDAR 2017

Prime contractor: Ayres Associates
Airborne LiDAR acquisition completed by Quantum Spatial

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1.1. Summary

This report contains a summary of the Wisconsin WROC La Crosse QL2 2017 LiDAR acquisition task order, issued by Ayres under their Task Order # 24 on March 3, 2017. The task order yielded a project area covering 486 square miles over La Crosse County, Wisconsin. The intent of this document is only to provide specific validation information for the data acquisition/collection work 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

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
2 pts / m^2	1,800 m	40°	30%	≤ 10 cm

1.3. Coverage

The project boundary covers 486 square miles and encompasses the entirety of La Crosse County in western Wisconsin. A buffer of 100 meters was created to meet task order specifications. LiDAR extents are shown in Figure 1.

1.4. Duration

LiDAR data was acquired from March 10, 2017 to March 11, 2017 in three total lifts. See "Section: 2.5. Time Period" for more details.

1.5. Issues

There were no issues to report with this project.

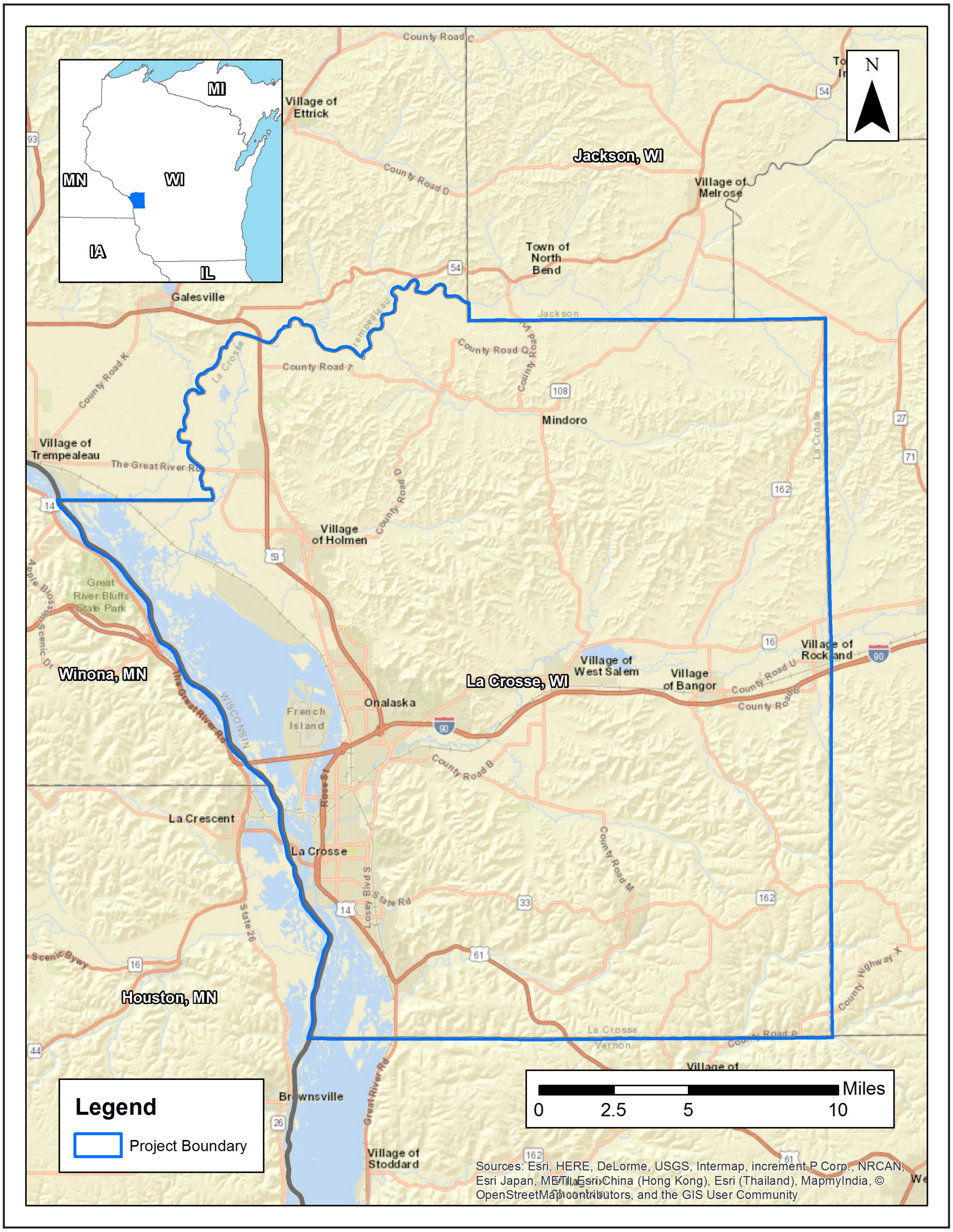
1.6. Deliverables

The following products were produced and delivered:

- Raw LiDAR point cloud data swaths in LAS 1.4 format
- LiDAR point cloud data, tiled, in LAS 1.4 format
- SBETs in .SOL format
- Trajectories in .TRJ format
- Flight logs and GPS/IMU statistics in .PDF format
- Lift-level metadata in .XML format

All geospatial deliverables were produced in NAD83 (2011) State Plane Wisconsin South Zone, US survey feet; NAVD88 (GEOID12B), US survey feet. All tiled deliverables have a tile size of 4,500 feet x 4,500 feet.

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 Leica MissionPro planning software. The entire target area was comprised of 54 planned flight lines measuring approximately 1,140 total flight line miles (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized a Leica ALS 70 LiDAR sensor (Figure 3), serial number 7161, during the project. The Leica ALS 70 system is capable of collecting data at a maximum frequency of 500 kHz, which affords elevation data collection of up to 500,000 points per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd and last returns. The intensity of the 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

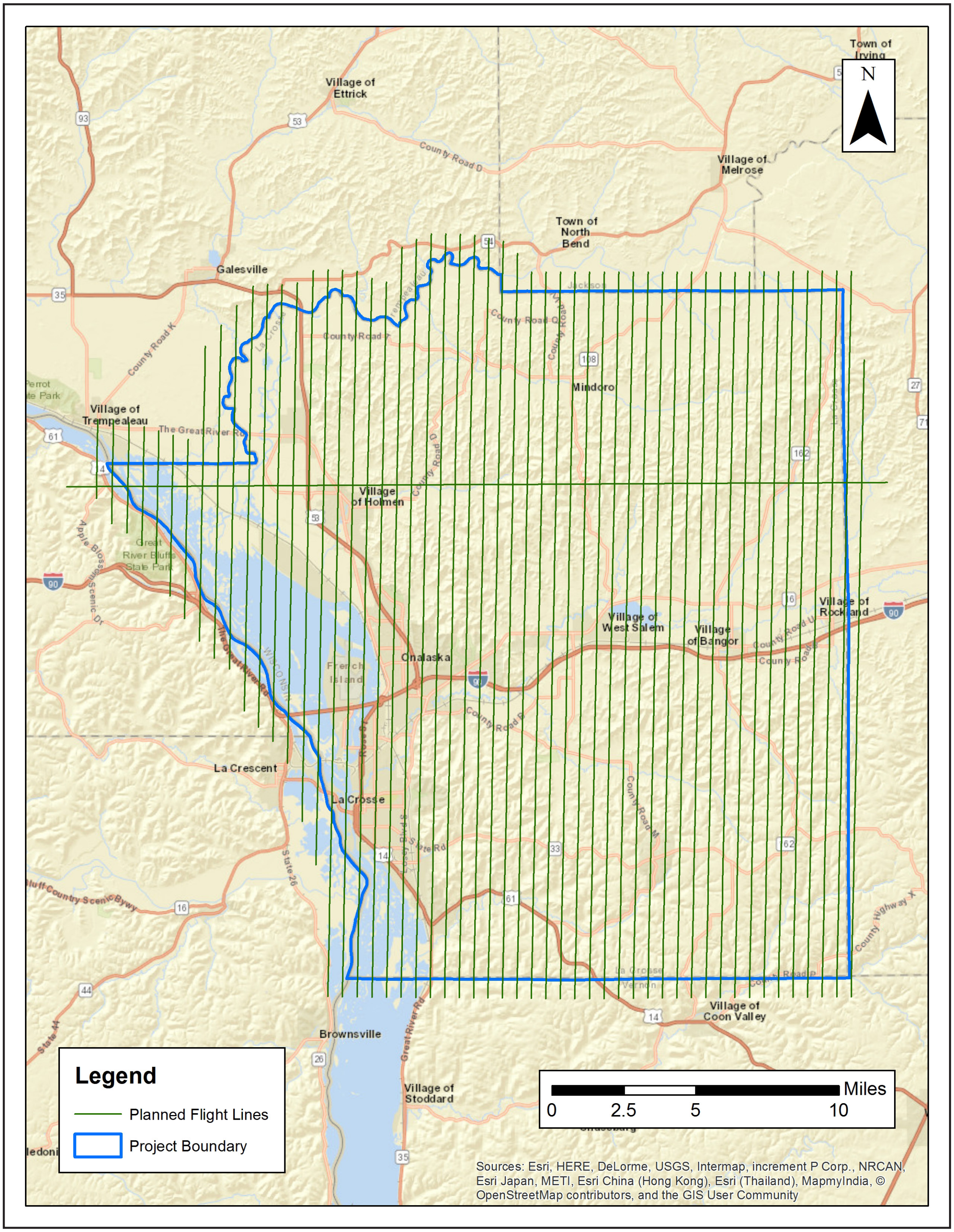


Table 2. Lidar System Specifications

Terrain and Aircraft Scanner	Flying Height	1,800 m
	Recommended Ground Speed	150 kts
Scanner	Field of View	40°
	Scan Rate Setting Used	53.4 Hz
Laser	Laser Pulse Rate Used	302.6 kHz
	Multi Pulse in Air Mode	Enabled
Coverage	Full Swath Width	1,310.29 m
	Line Spacing	12.50 m
Point Spacing and Density	Maximum Point Spacing Across Track	1.01 m
	Maximum Point Spacing Along Track (in phase)	1.44 m
	Maximum Point Spacing Along Track (out of phase)	0.72 m
	Average Point Density	2.99 pts / m^2

Figure 3. Leica ALS 70 LiDAR Sensor

2.3. Aircraft

All flights for the project were accomplished through the use of a customized Piper Navajo (twin-piston), Tail # N262AS. This aircraft provided an ideal, stable aerial base for LiDAR 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 a state-of-the-art Leica LiDAR systems. Some of Quantum Spatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of Quantum Spatial's Planes

2.4. Base Station Information

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	WGS 84		Ellipsoid Height (m)
	Longitude	Latitude	
MESE	-91.0097385	44.11772963	208.129
LACR	-91.16365052	43.88482269	198.569
V114	-91.08825285	43.71604167	99.995
V115	-90.94645561	43.71856111	99.995

2.5. Time Period

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

- Mar 10, 2017-A (N262AS, SN7161)
- Mar 11, 2017-A (N262AS, SN7161)
- Mar 11, 2017-B (N262AS, SN7161)

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

Inertial Explorer 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. Inertial Explorer 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 Inertial Explorer 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 Inertial Explorer processing environment for each sortie during the project mobilization are available in Appendix A.

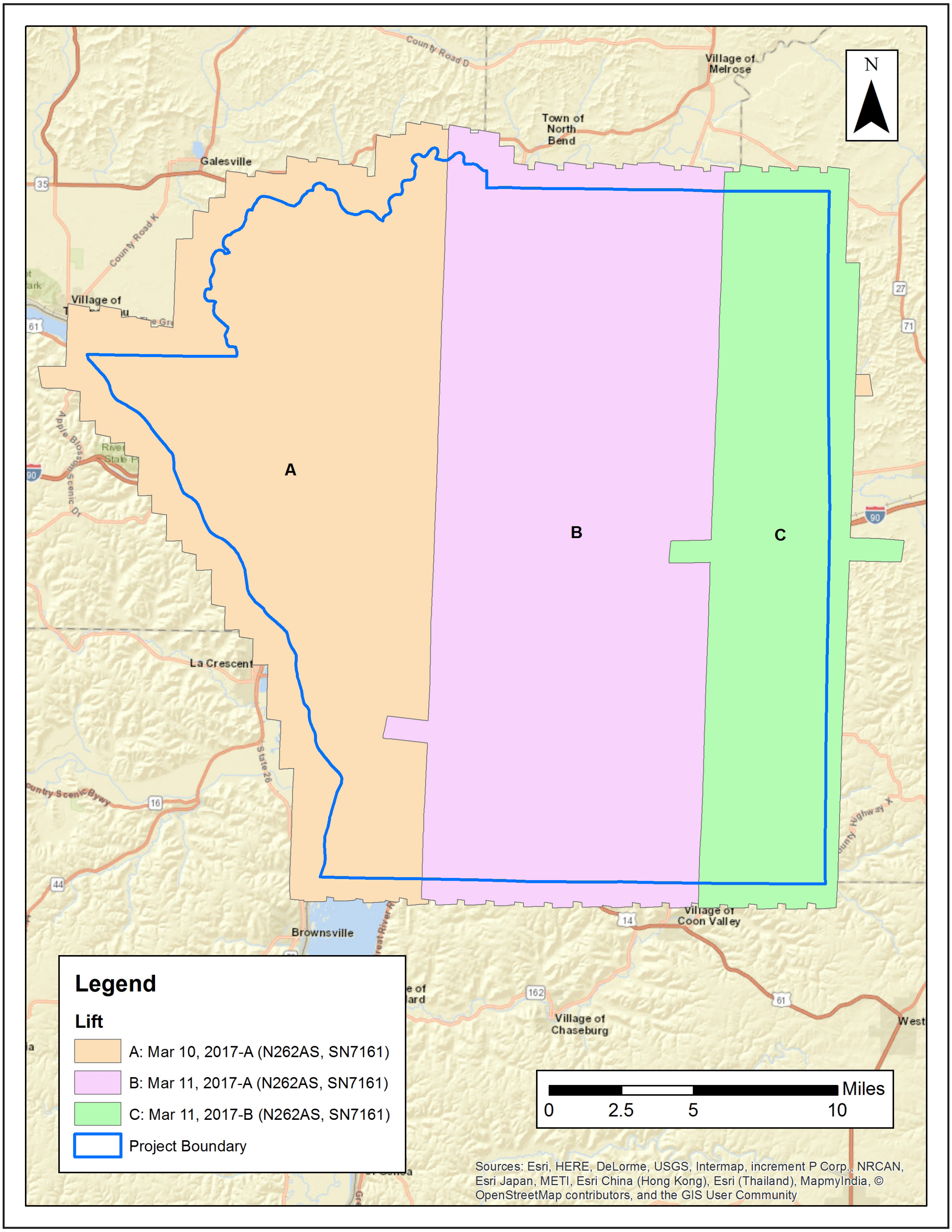
The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At 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 Leica CloudPro 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 bare earth dataset. GeoCue was used to create the deliverable industry-standard LAS files for both 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 Check Point Collection

Quantum Spatial utilized 12 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) State Plane Wisconsin South Zone, US survey feet; NAVD88 (GEOID12B), US survey feet.

5.1. Calibration Control Point Testing

Figure 7 shows the location of each bare earth calibration point for the project area. Table 4 depicts the Control Report for the LiDAR bare earth calibration points, as computed in TerraScan as a quality assurance check. 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.

Figure 7. Calibration Control Point Locations

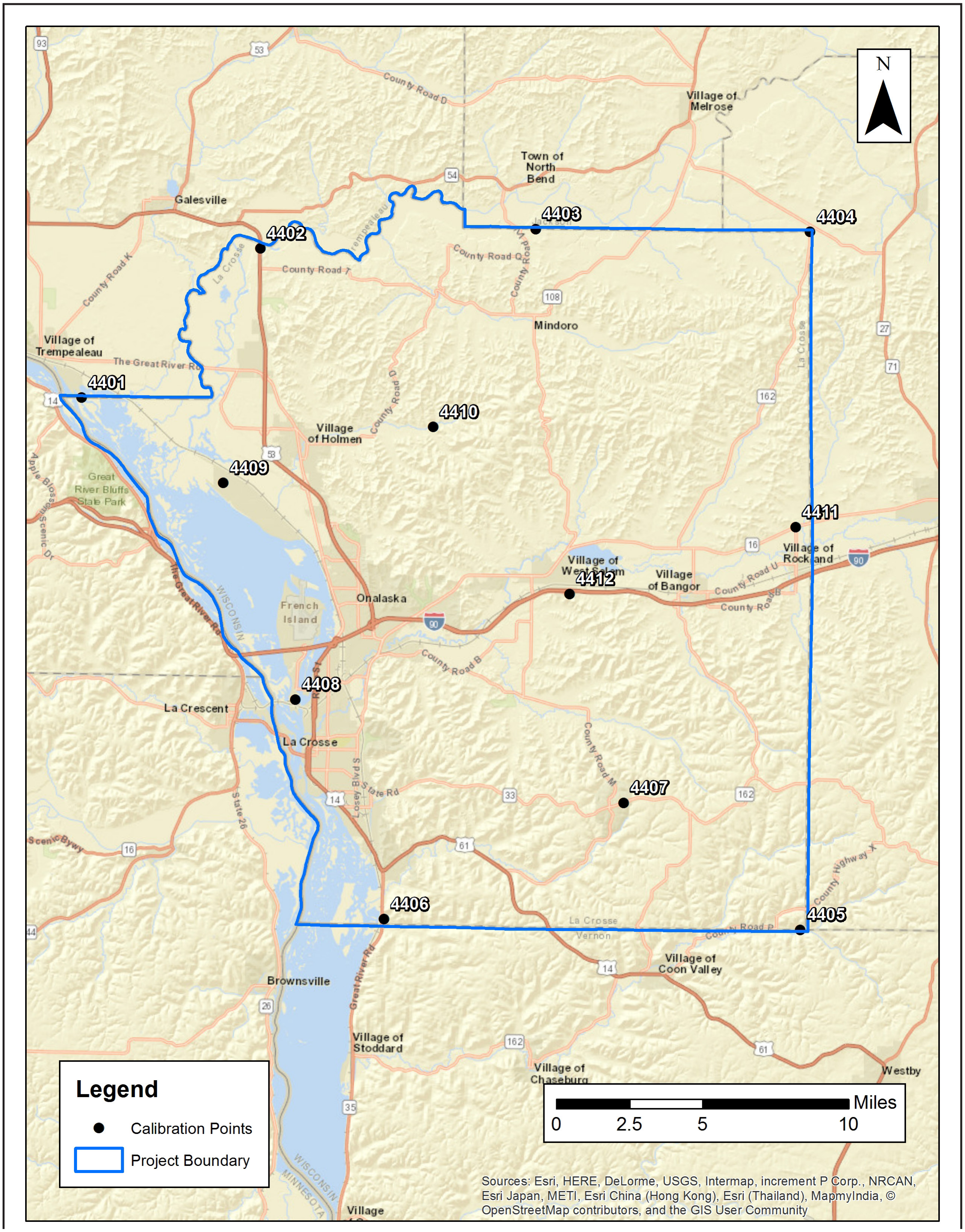


Table 4. Calibration Control Point Report

Units = US survey feet

Number	Easting	Northing	Known Z	Laser Z	Dz
4401	1596861.57	726358.99	644.68	644.79	0.11
4402	1629188.91	753314.19	720.99	720.98	-0.01
4403	1678956.22	756799.32	781.56	781.48	-0.08
4404	1728547.39	756299.05	878.53	878.55	0.02
4405	1726787.19	630170.1	833.03	832.98	-0.05
4406	1651499.47	632110.83	651.75	651.73	-0.02
4407	1694812.71	653131.81	1302.41	1302.52	0.11
4408	1635470.5	671799.76	644.68	644.74	0.06
4409	1622440.21	710932.51	665.62	665.69	0.07
4410	1660422.7	721047.22	777.83	777.8	-0.03
4411	1725941.03	702905.26	781.51	781.49	-0.02
4412	1685058.16	690871.79	808.4	808.2	-0.2

Average Dz	0.065 ft
Minimum Dz	-0.003 ft
Maximum Dz	-0.200 ft
Root Mean Square	0.084 ft
Std. Deviation	0.087 ft