Airborne Topographic LiDAR Report

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

October 31, 2016

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

Contact: Ayres Associates, Geospatial Division
5201 East Terrace Drive, Suite 200, Madison, WI, 53718
(608) 443-1200

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. Section 1 Heading

1.1. Summary

This report contains a summary of the Portage County portion of the Wisconsin WROC / 3DEP LiDAR 2016-17 acquisition task order, issued by Ayres under their Task Order 20 dated March 7, 2016. The task order yielded a project area covering approximately 830 total square miles over Portage 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
≥ 2 pts / m^2	1,700 m	38°	30%	≤ 10 cm

1.3. Coverage

The LiDAR project boundary covers approximately 830 square miles over Portage County in central 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 April 5, 2016 to April 14, 2016 in five total lifts. See “Section: 2.5. Time Period” for more details.

1.5. Issues

There were no issues to report with this project.

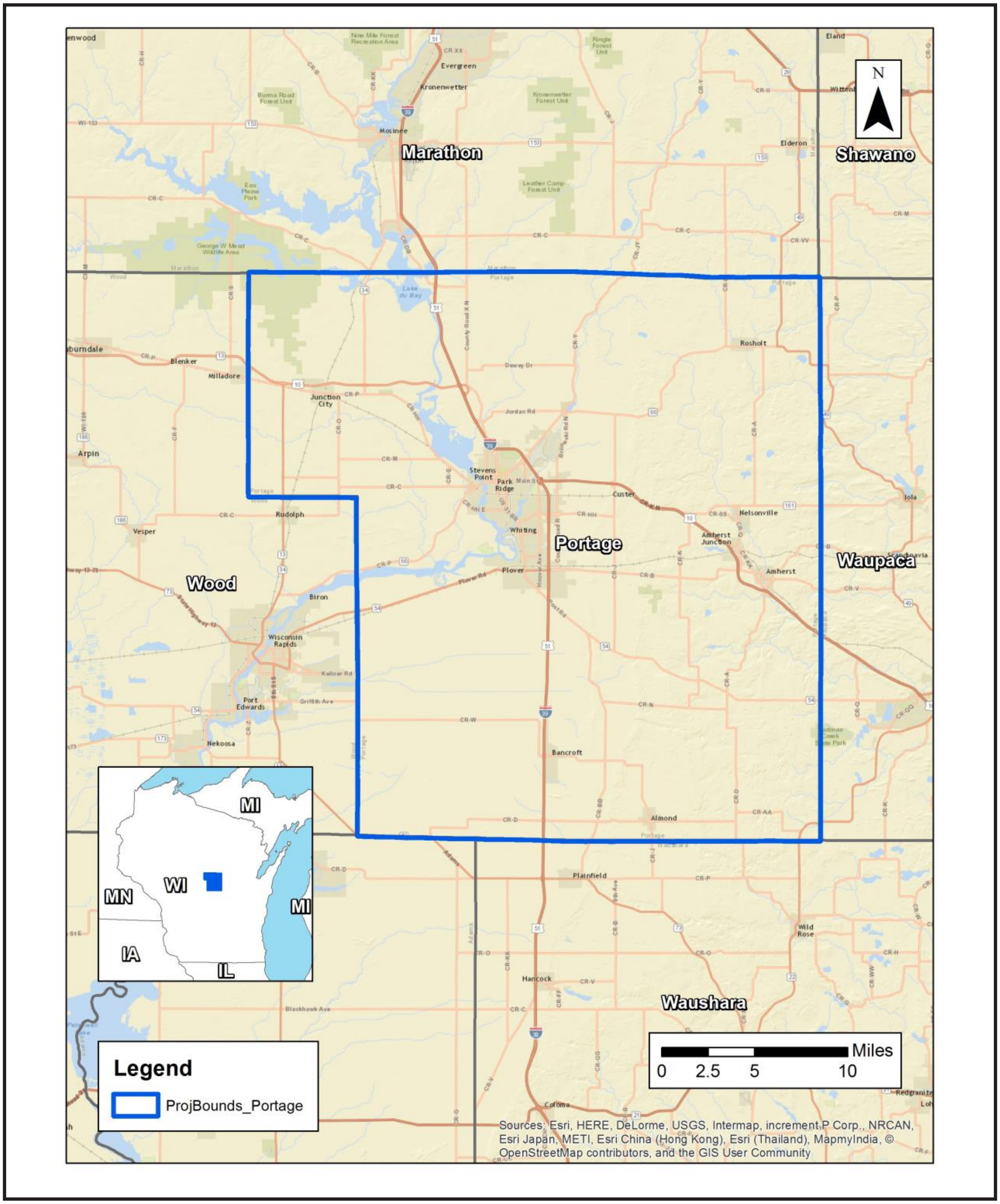
1.6. Deliverables

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) Portage 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 1,189 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 64 planned flight lines measuring approximately 1,851.32 total flight line miles (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized one Optech Orion H300 LiDAR sensor (Figure 3), serial number 324, 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 utilizes 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

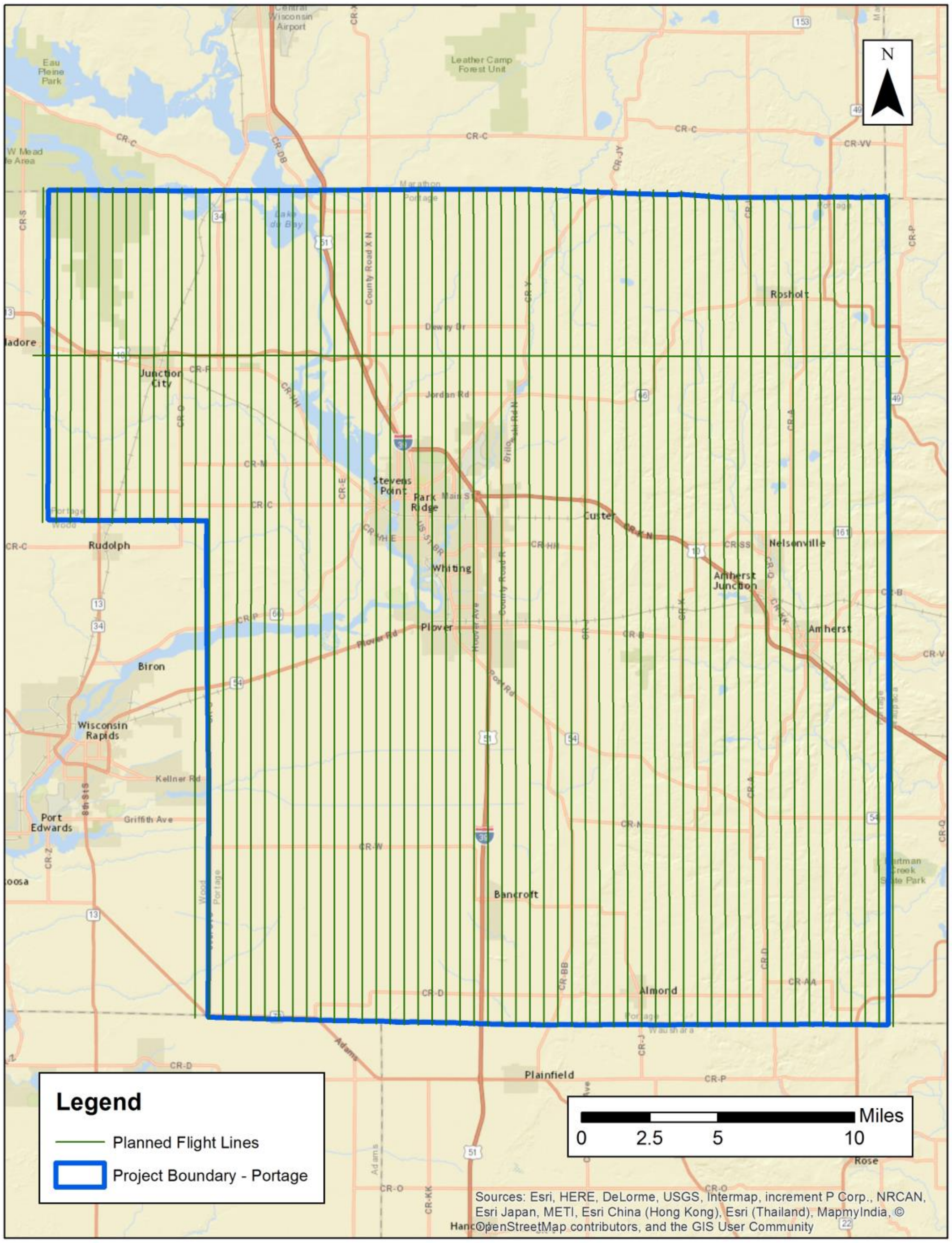
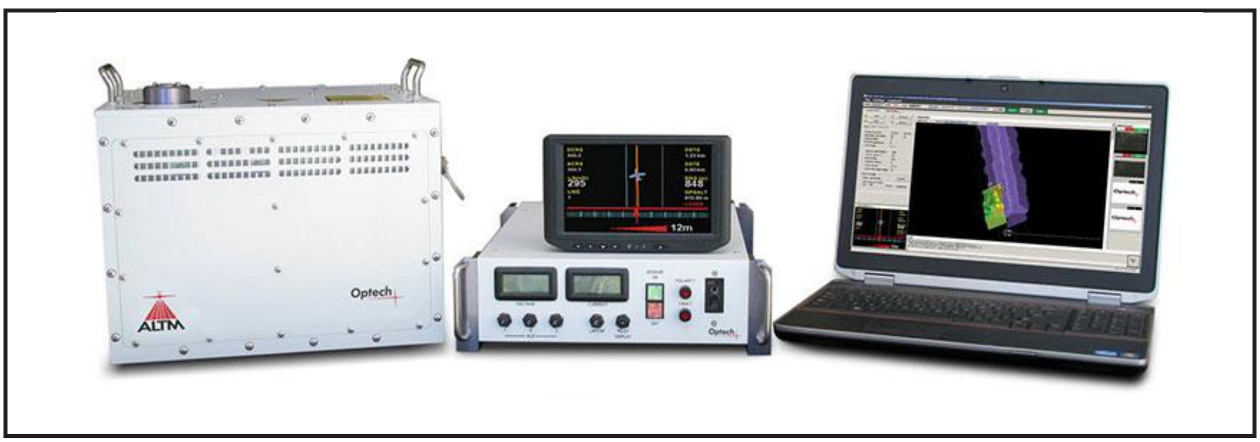


Table 2: LiDAR System Specifications

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	818 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 N246MP. 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

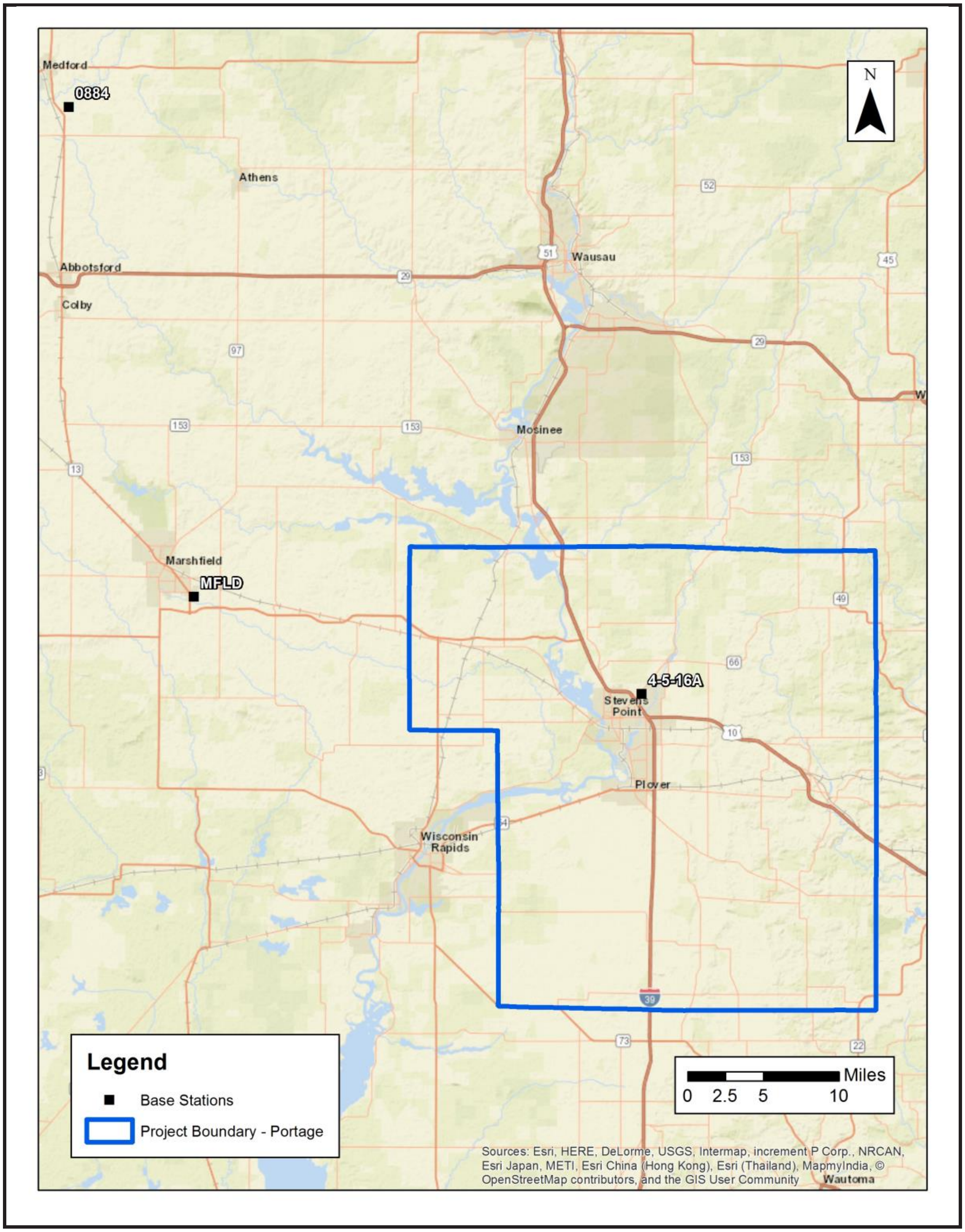
Base Station	Latitude	Longitude	Ellipsoid Height (m)
4-5-16A	44° 32' 43.97813"	89° 32' 7.26649"	300.603
MFLD	44° 38' 12.60353"	90° 8' 5.88277"	342.717
0884	45° 6' 14.7859"	90° 18' 32.40171"	412.820

2.5. Time Period

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

- Apr 5, 2016-A (N246MP, SN324)
- Apr 12, 2016-A (N246MP, SN324)
- Apr 13, 2016-B (N246MP, SN324)
- Apr 14, 2016-A (N246MP, SN324)
- Apr 14, 2016-B (N246MP, SN324)

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.

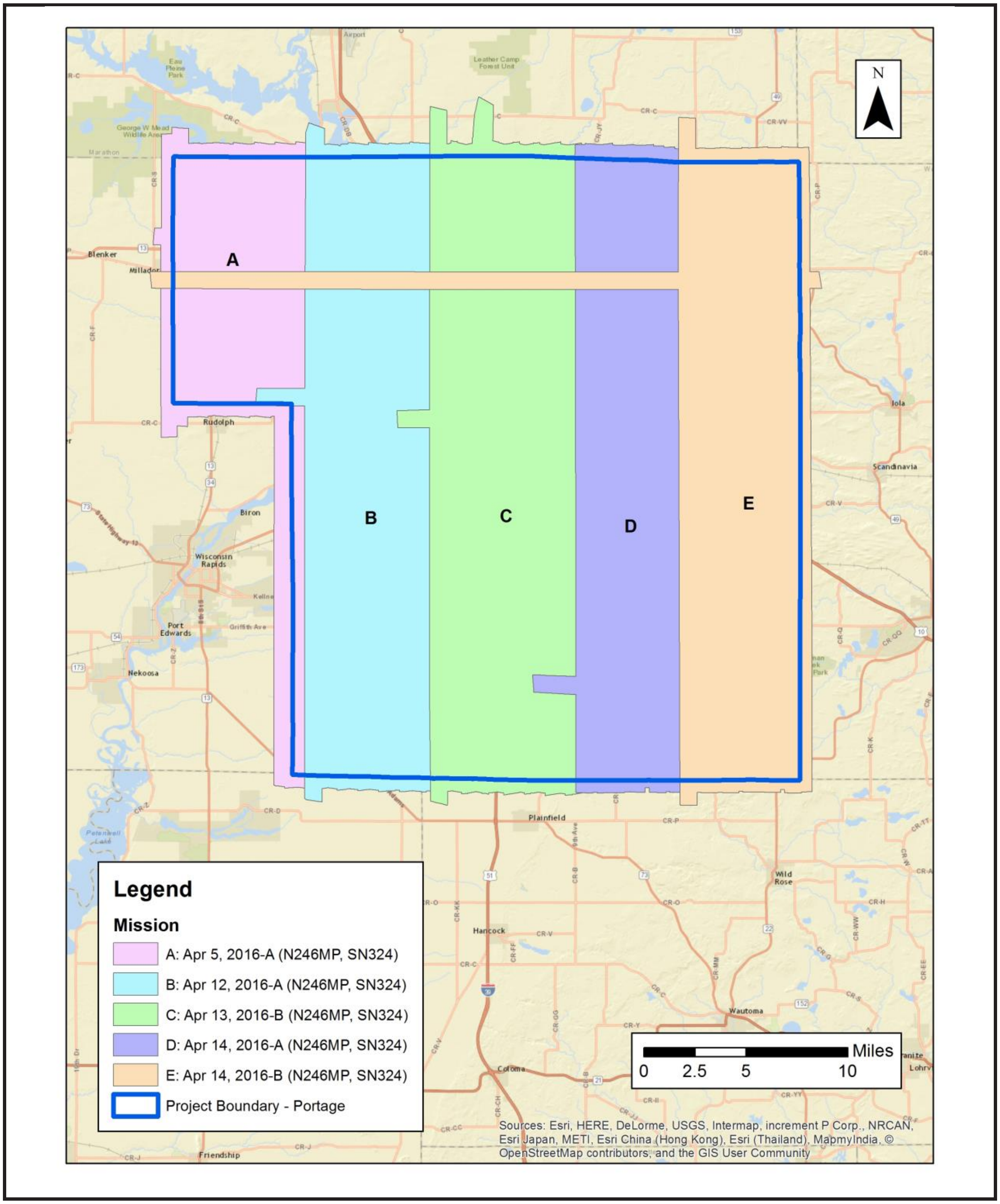
The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At 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 18 ground control (calibration) points collected by Ayres Associates 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) Portage 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

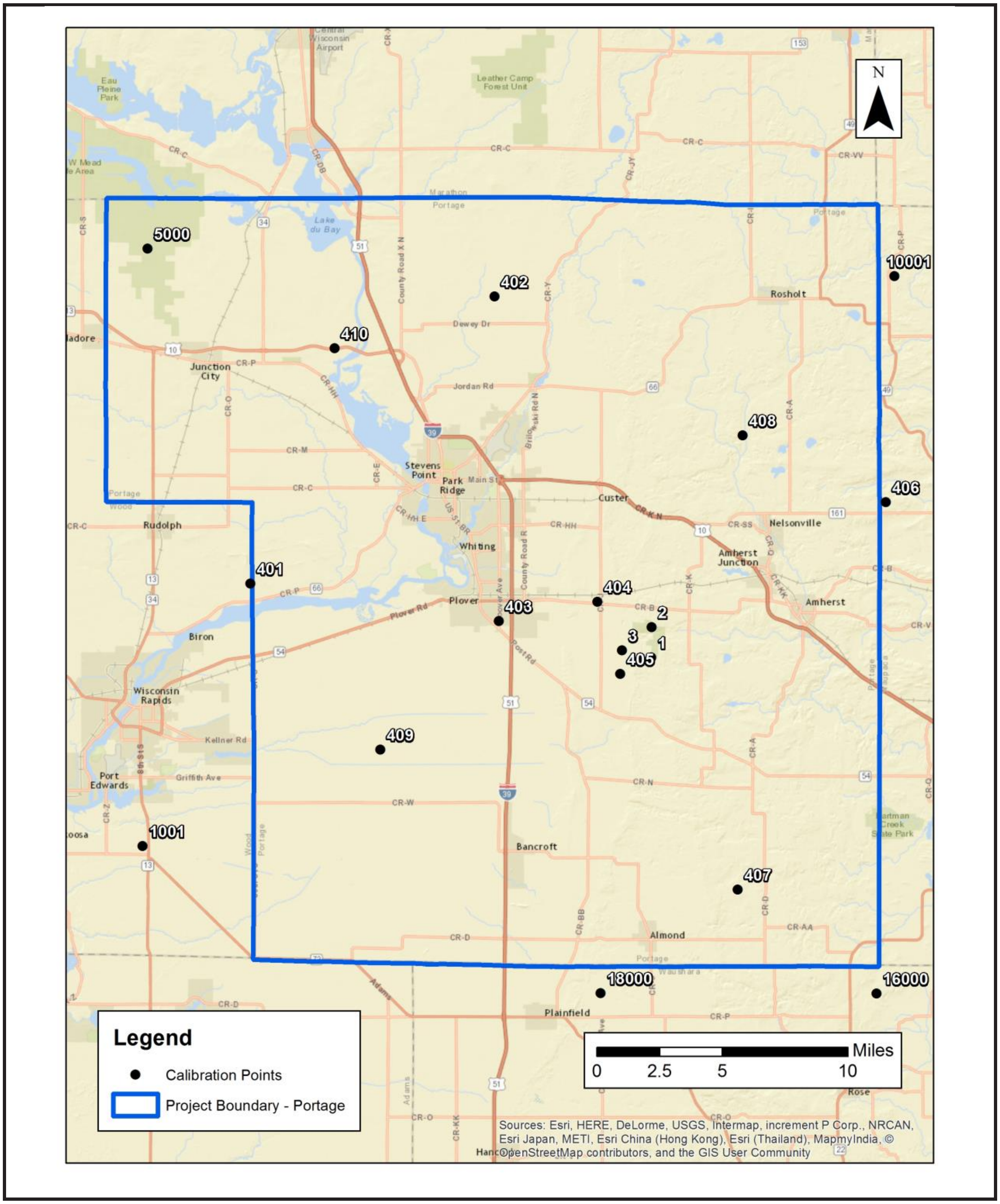


Table 4. Calibration Point Report
Units = US Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
401	125183.230	181273.600	1090.300	1090.670	+0.370
5000	103569.961	251725.026	987.009	987.160	+0.151
410	142875.560	230758.460	1087.490	1087.640	+0.150
403	177442.170	173388.220	1076.550	1076.650	+0.100
406	258793.110	198372.600	1163.820	1163.840	+0.020
10001	260595.409	245936.280	1142.837	1142.840	+0.003
16000	256898.706	95039.959	1172.118	1172.120	+0.002
402	176543.440	241665.190	1039.160	1039.160	+0.000
409	152511.410	146384.750	1056.890	1056.870	-0.020
408	228697.060	212444.760	1209.350	1209.290	-0.060
404	198176.200	177444.490	1094.380	1094.310	-0.070
18000	198821.333	95115.463	1135.596	1135.520	-0.076
1001	102536.381	126070.583	1033.008	1032.930	-0.078
1	209492.352	165736.451	1119.337	1119.240	-0.097
405	202986.960	162282.580	1091.320	1091.220	-0.100
3	203354.938	167203.926	1092.571	1092.440	-0.131
2	209584.926	172085.250	1096.140	1096.000	-0.140
407	227685.750	116906.710	1149.920	1149.770	-0.150

Dz	-0.007 ft
Minimum Dz	-0.150 ft
Maximum Dz	+0.370 ft
Average Magnitude	0.095 ft
Root Mean Square	0.127 ft