## Airborne Topographic LiDAR Report

# Wisconsin WROC / 3DEP 2016 LiDAR Project Report: Bayfield County (Southern Project)

**October 31, 2016**


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

AYRES ASSOCIATES quantum SPATIAL

## 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 2016 Wisconsin WROC / 3DEP LiDAR data collection issued for Bayfield County (Southern Project Area). The task orders (in conjunction with the Northern Project Area) yielded a project area covering approximately 1,681 total square miles over Bayfield 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 1,681 square miles, which includes the Northern Project Area (flown fall 2015) and the Southern Project Area (flown spring 2016). LiDAR extents for the Southern Project Area are shown in Figure 1 on the following page. A buffer of 100 meters was created to meet task order specifications.

## 1.4. Duration

LiDAR data was acquired from on April 15, 2016 in two total lifts. See “Section: 2.5. Time Period” for more details.

## 1.5. Issues

There were no issues to report with this project.

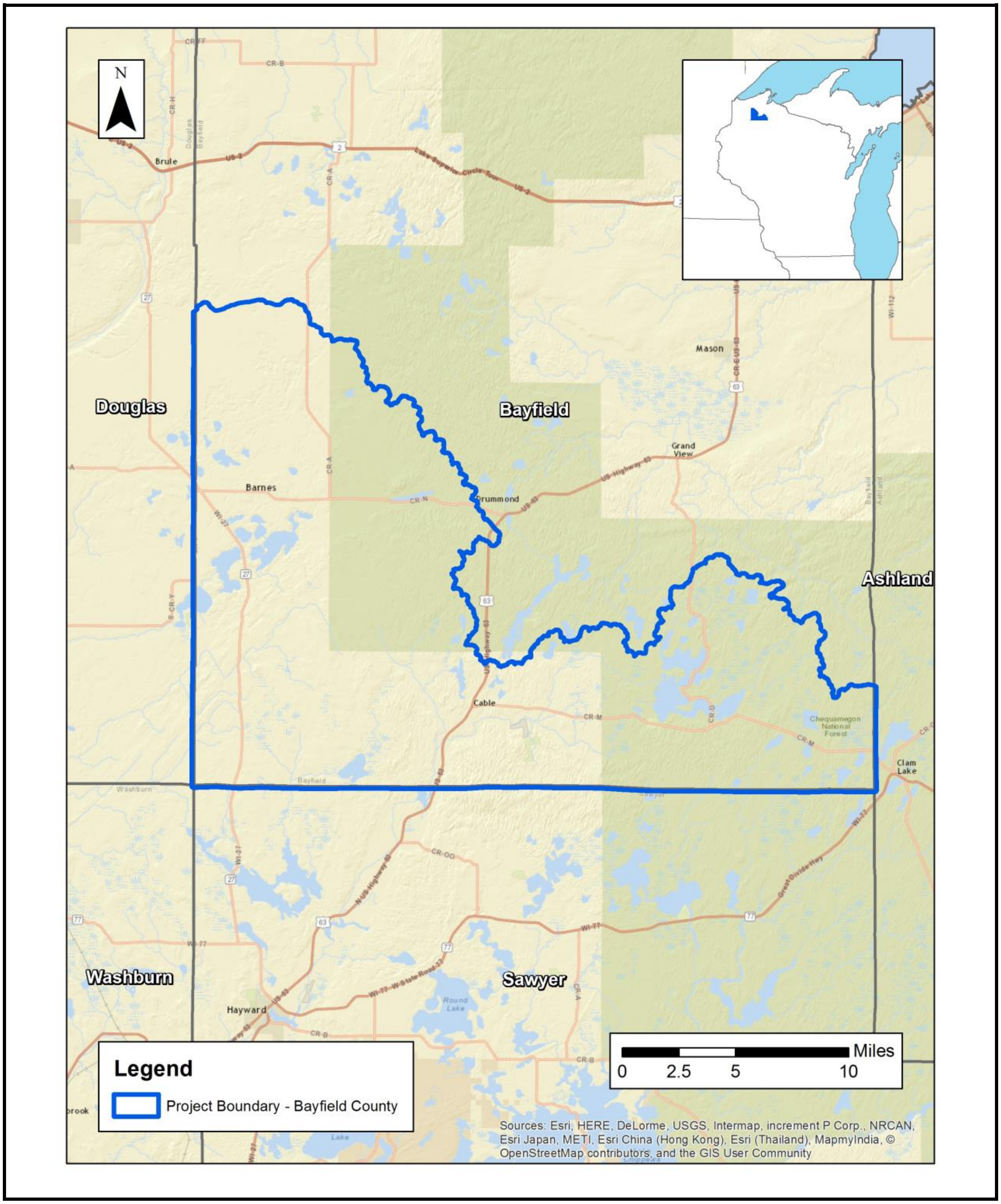
## 1.6. Deliverables

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 1.2 format
- LiDAR point cloud data, in raw swaths, in LAS 1.2 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) WISCRS Bayfield County, US survey feet; NAVD88 (Geoid 12A), 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 Optech MissionNAV planning software. The entire target area was comprised of 46 planned flight lines measuring approximately 993.19 total flight line miles (Figure 2).

## 2.2. LiDAR Sensor

Quantum Spatial utilized two Optech Orion H300 LiDAR sensors (Figure 3), serial numbers 324 and 329, during the project. These systems are capable of collecting data at a maximum frequency of 300 kHz, which affords elevation data collection of up to 300,000 points per second. These systems utilize a Multi-Pulse in the Air option (MPIA). These sensors are 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**

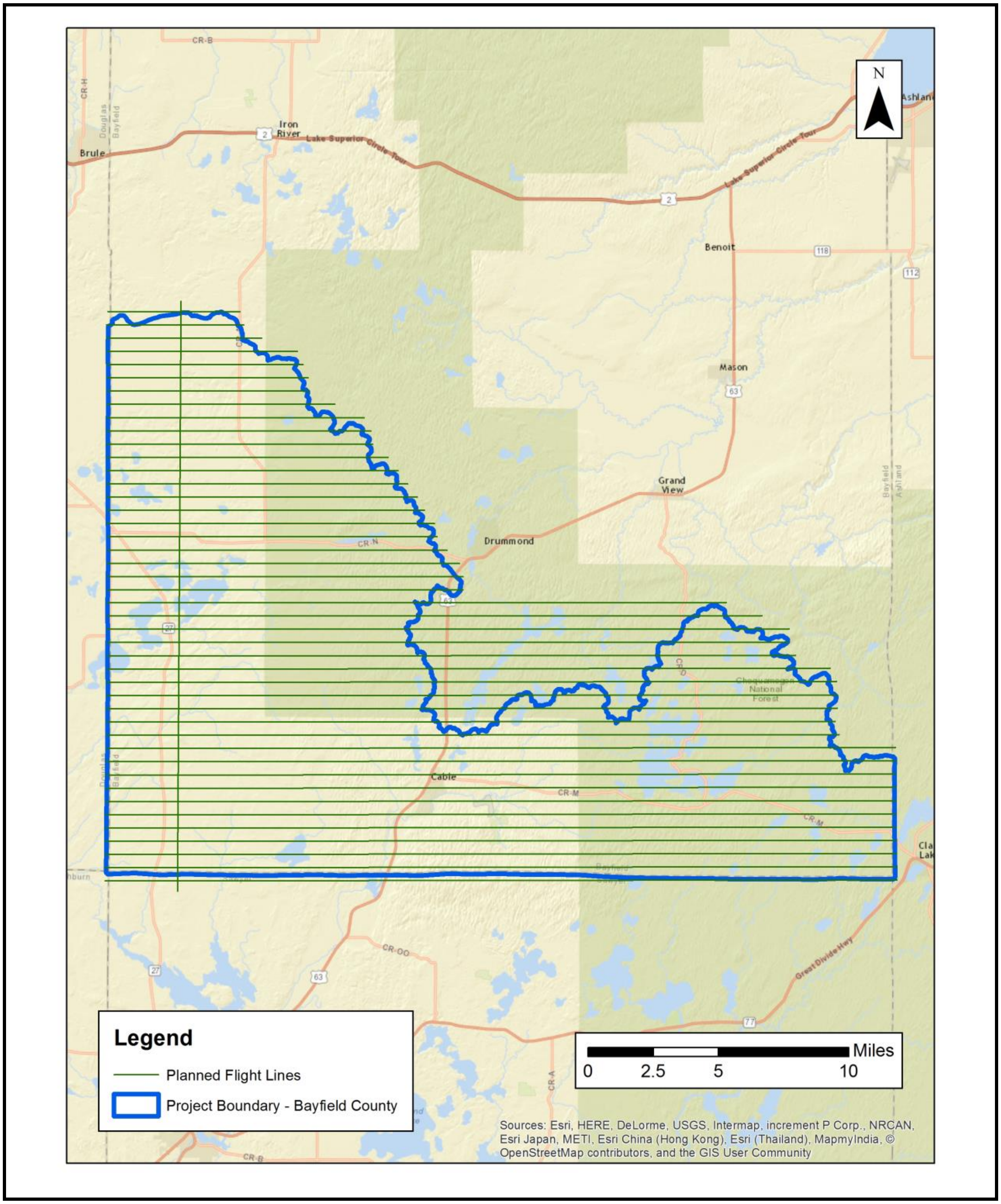
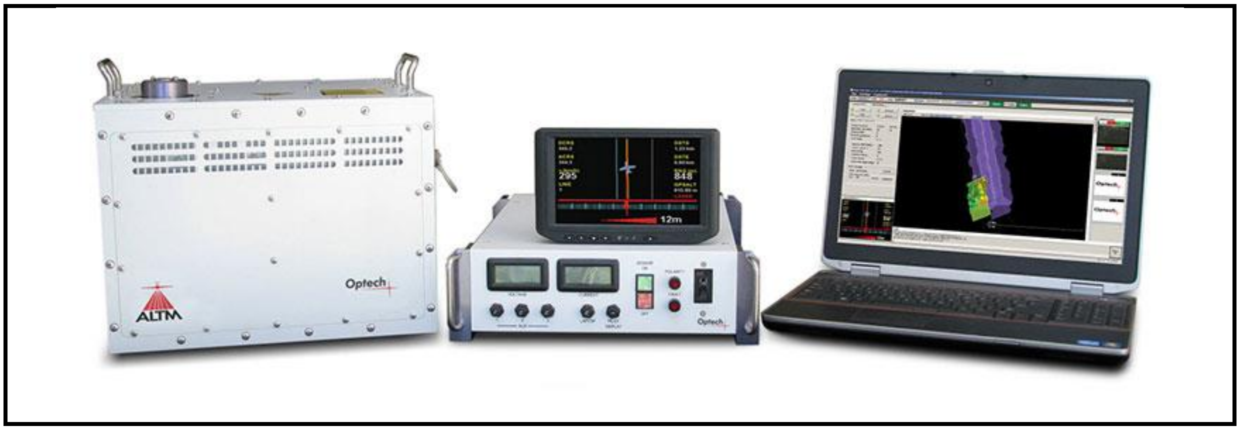


**Table 2: LiDAR System Specifications**

| | | |
|---|---|---|
| **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 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 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**

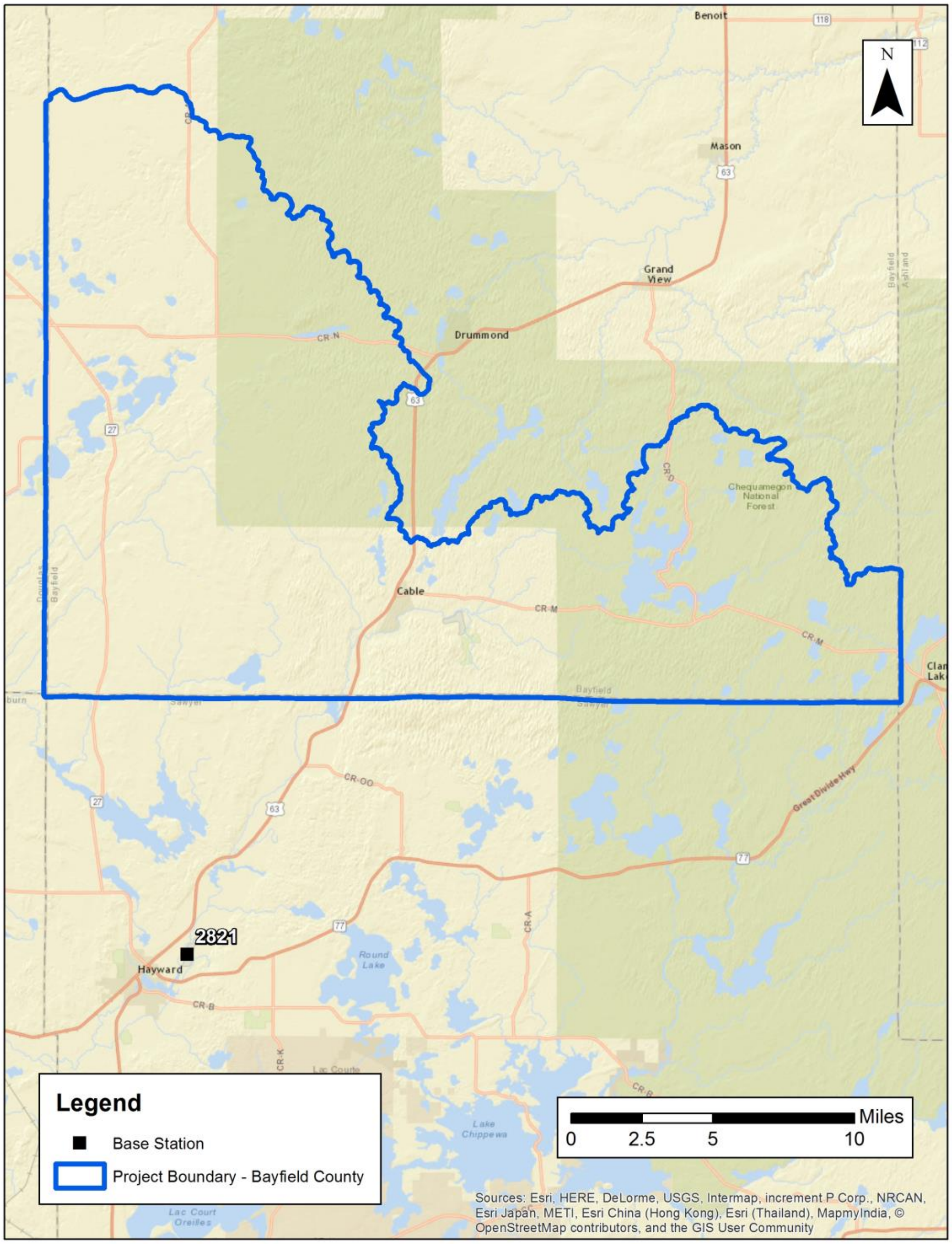
| Base Station | Latitude | Longitude | Ellipsoid Height (m) |
|---|---|---|---|
| 2821 | 46° 1' 28.26036" | 91° 26' 48.97963" | 339.262 |

## 2.5. Time Period

Project specific flights were conducted over one day. Two sorties, or aircraft lifts were completed. Accomplished sorties are listed below.

- Apr 15, 2016-A (N2JJ, SN309)
- Apr 15, 2016-A (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.

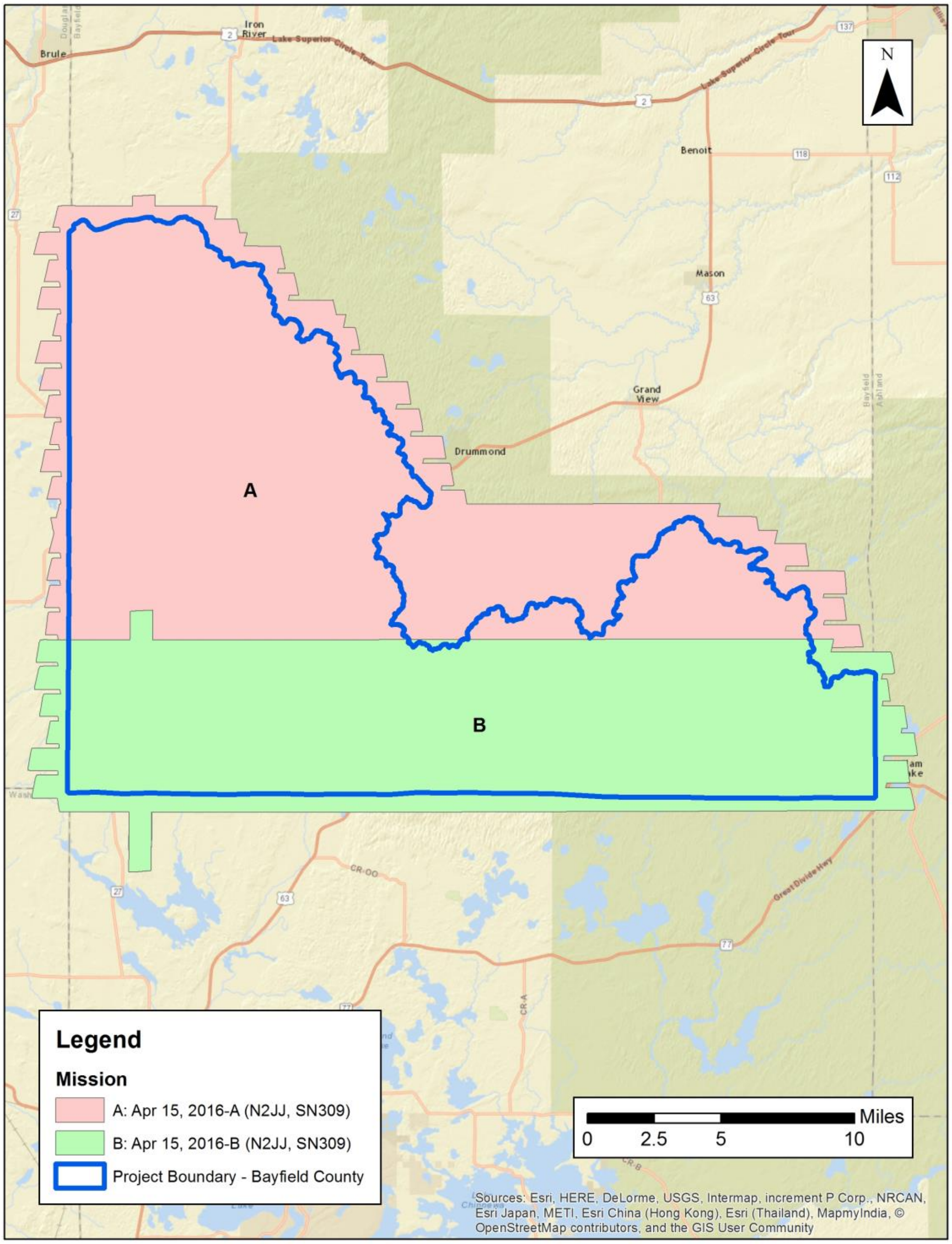
The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At 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**



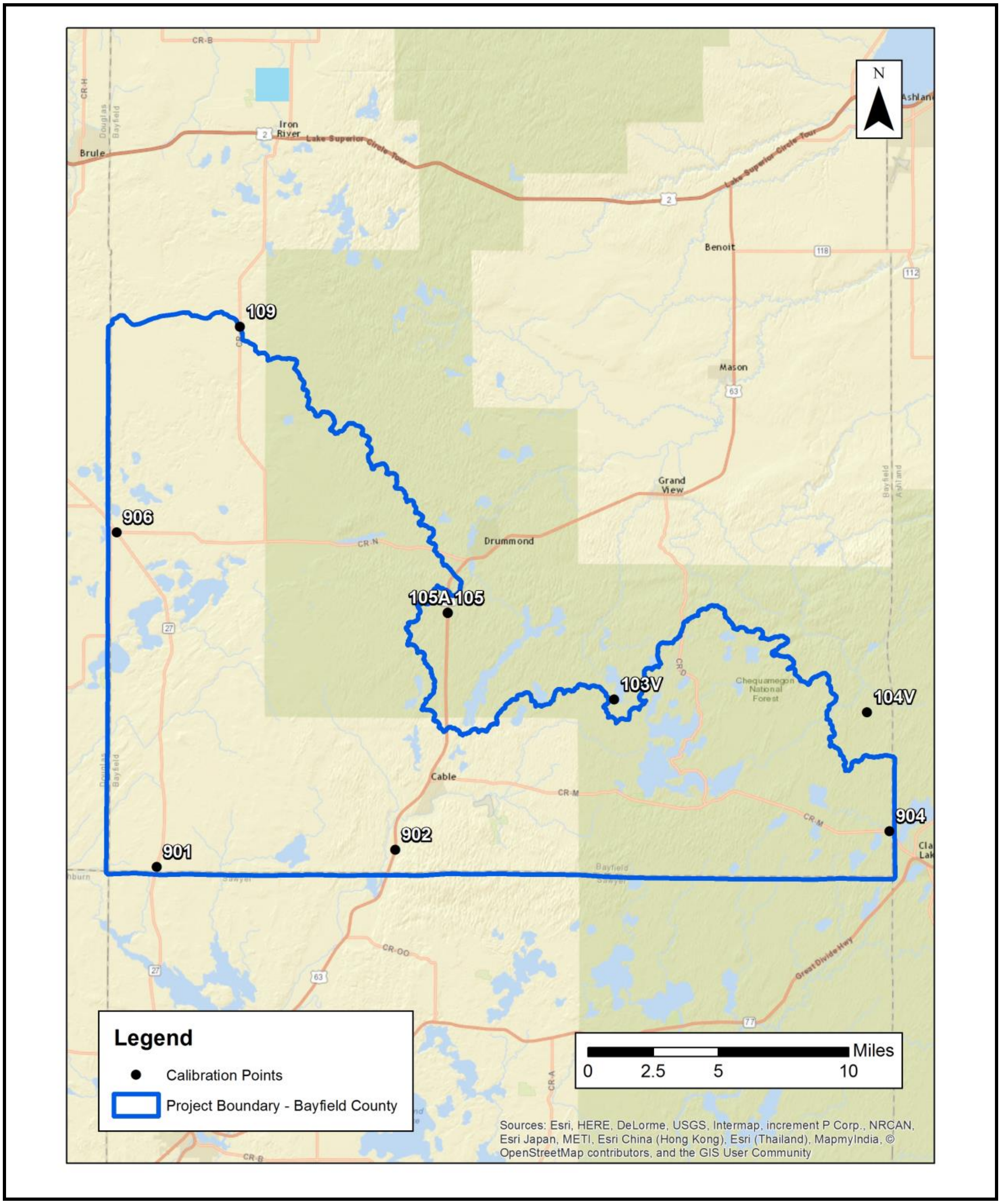
# 5. Ground Control and Checkpoint Collection

Quantum Spatial utilized 9 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) WISCRS Bayfield County, 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**



| Number | Easting | Northing | Known Z | Laser Z | Dz |
|---|---|---|---|---|---|
| 104V | 802689.710 | 332939.720 | 1420.170 | 1420.530 | +0.360 |
| 901 | 658730.040 | 301624.520 | 1330.130 | 1330.420 | +0.290 |
| 904 | 807225.430 | 308809.660 | 1458.960 | 1459.000 | +0.040 |
| 902 | 707104.830 | 305062.520 | 1307.400 | 1307.430 | +0.030 |
| 103V | 751412.450 | 335537.710 | 1443.540 | 1443.540 | +0.000 |
| 906 | 650616.580 | 369383.030 | 1194.630 | 1194.540 | -0.090 |
| 105A | 717731.570 | 353090.800 | 1469.960 | 1469.860 | -0.100 |
| 109 | 675625.640 | 411087.500 | 1285.960 | 1285.760 | -0.200 |
| 105 | 717725.720 | 353038.290 | 1469.590 | 1469.370 | -0.220 |

| | |
|---|---|
| Average Dz | +0.012 ft |
| Minimum Dz | -0.220 ft |
| Maximum Dz | +0.360 ft |
| Average Magnitude | 0.148 ft |
| Root Mean Square | 0.189 ft |