Airborne Topographic LiDAR Report

Wisconsin WROC - 3DEP

Sawyer County LiDAR 2017

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

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1. Summary / Scope

1.1. Summary

This report contains a summary of the Wisconsin WROC Sawyer 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 1,360 square miles over Sawyer 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 1,360 square miles and encompasses the entirety of Saywer County in 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 April 21, 2017 to April 22, 2017 in seven total lifts. See “Section: 2.5. Time Period” for more details.

1.5. Issues

There were no issues to report with this project.

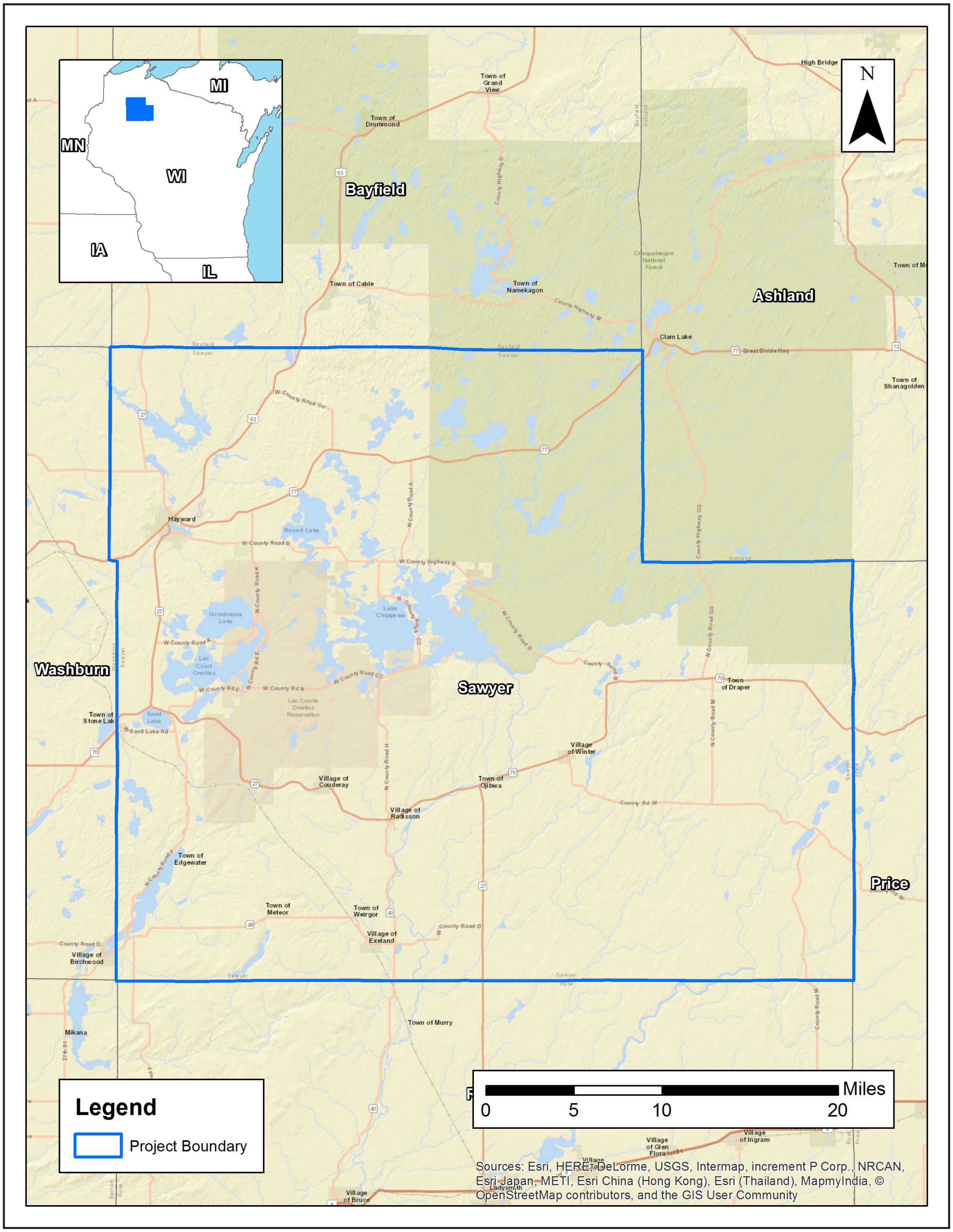
1.6. Deliverables

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) WISCRS Sawyer County Coordinate System, US survey feet; NAVD88 (GEOID12B), US survey feet. All tiled deliverables have a tile size of 4,500-feet x 4,500-feet. Tile names follow a sequential naming schema.

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 numbers 7161 and 7178, 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

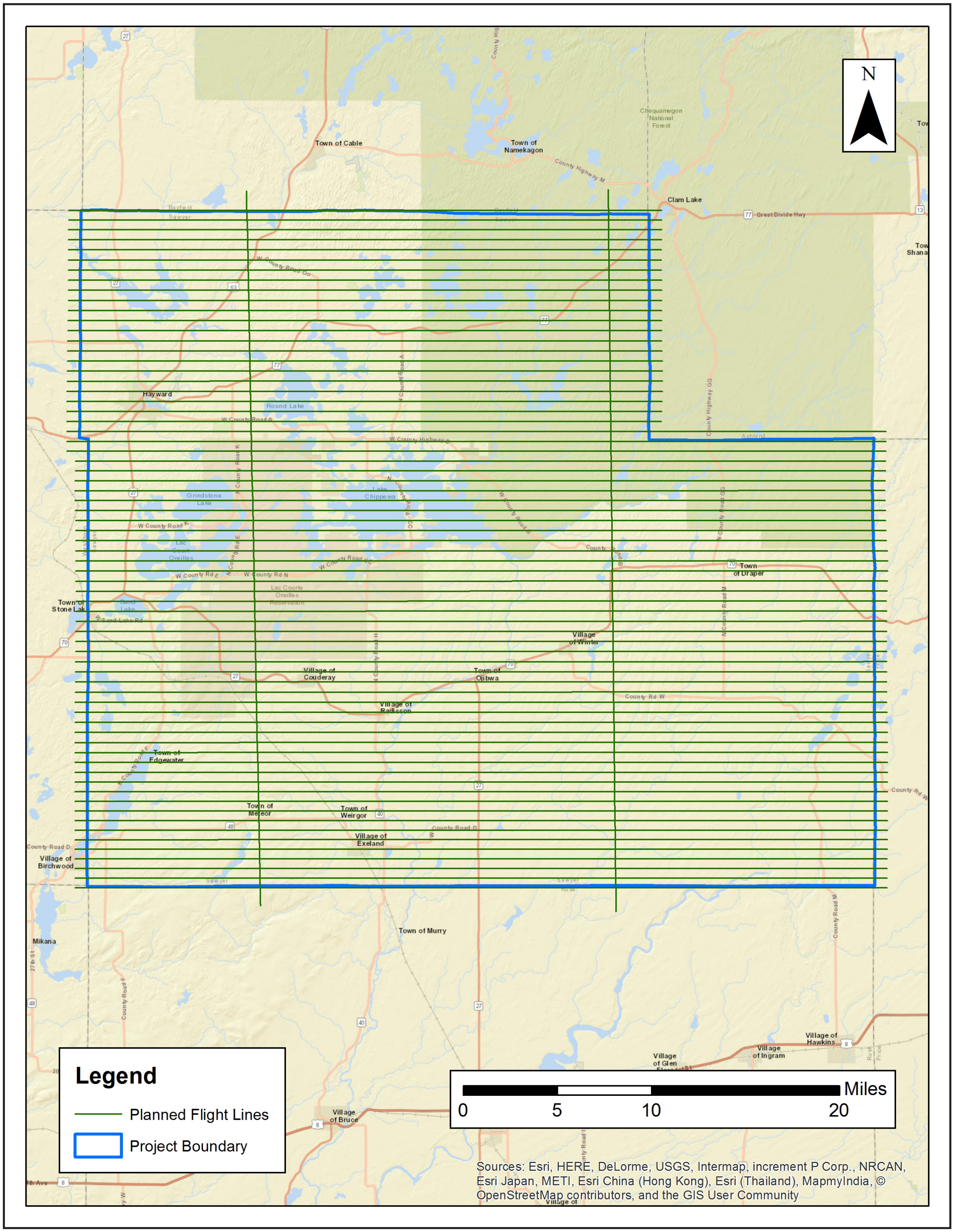
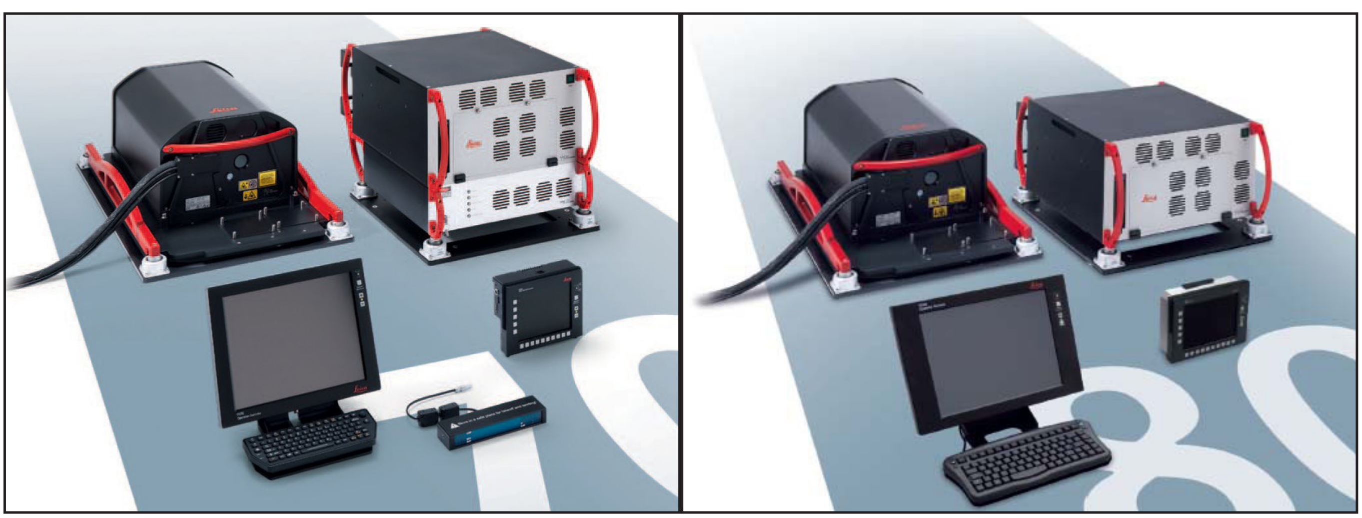


Table 2. LiDAR System Specifications

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	1,010.3 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 and 80 LiDAR Sensors



2.3. Aircraft

All flights for the project were accomplished through the use of a customized Piper Navajo (twin-piston), Tail #s N262AS and N73TM. These aircraft provided an ideal, stable aerial base for LiDAR acquisition. These aerial platforms have 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

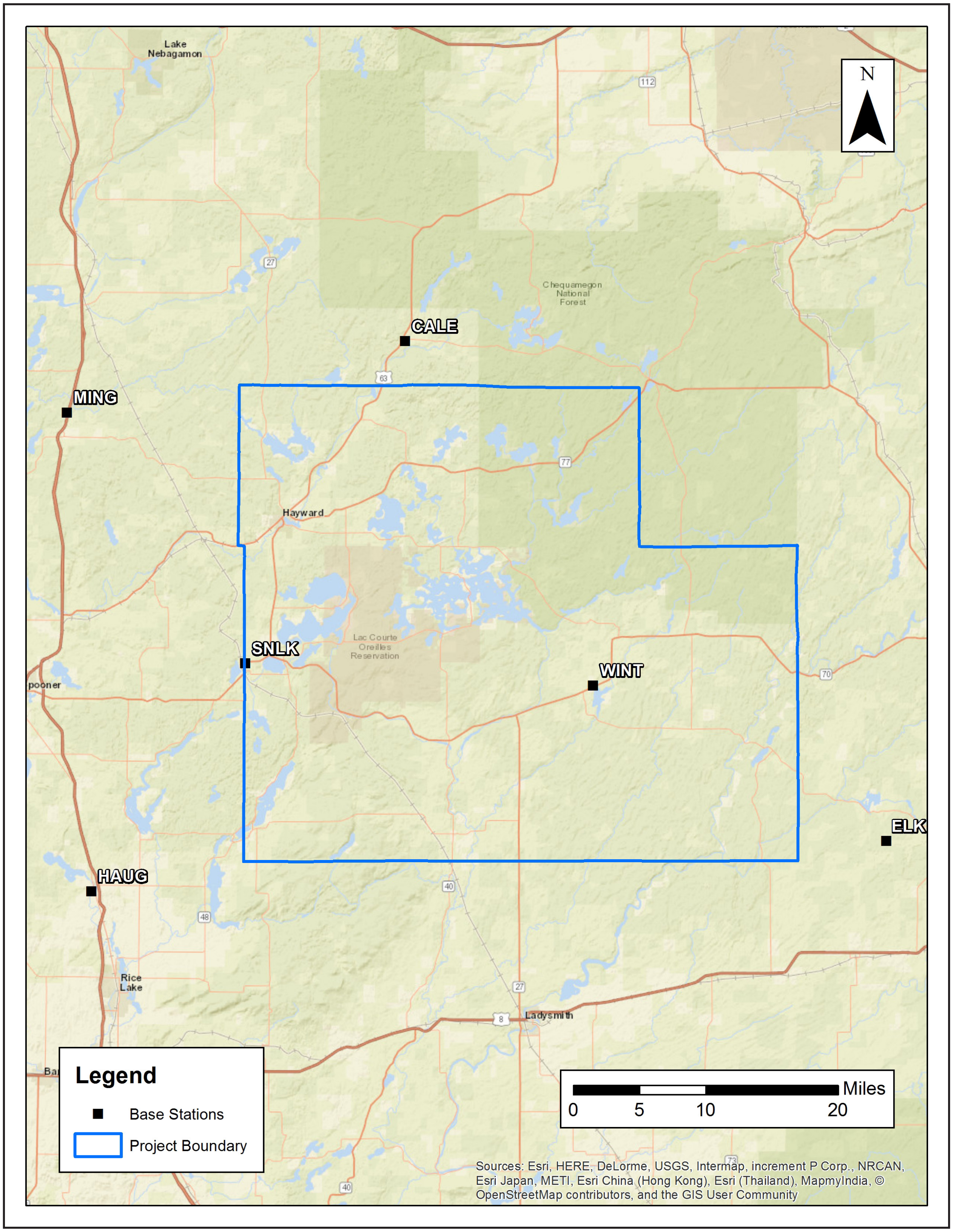
Base Station	Longitude	Latitude	Ellipsoid Height (m)
CALE	91° 17′ 29.90351″	46° 12′ 23.7286″	390.901
ELK	90° 32′ 22.47381″	45° 39′ 31.13763″	419.362
HAUG	91° 46′ 43.73887″	45° 36′ 11.81386″	344.14
MING	91° 49′ 22.94854″	46° 7′ 35.14154″	299.827
SNLK	91° 32′ 26.06716″	45° 51′ 12.6551″	387.702
WINT	90° 59′ 46.00929″	45° 49′ 48.92889″	383.306

2.5. Time Period

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

- April 21, 2017-A (N262AS, SN7161)
- April 21, 2017-B (N262AS, SN7161)
- April 21, 2017-B (N73TM, SN7178)
- April 21, 2017-C (N262AS, SN7161)
- April 22, 2017-A (N262AS, SN7161)
- April 22, 2017-A (N73TM, SN7178)
- April 22, 2017-B (N73TM, SN7178)

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.

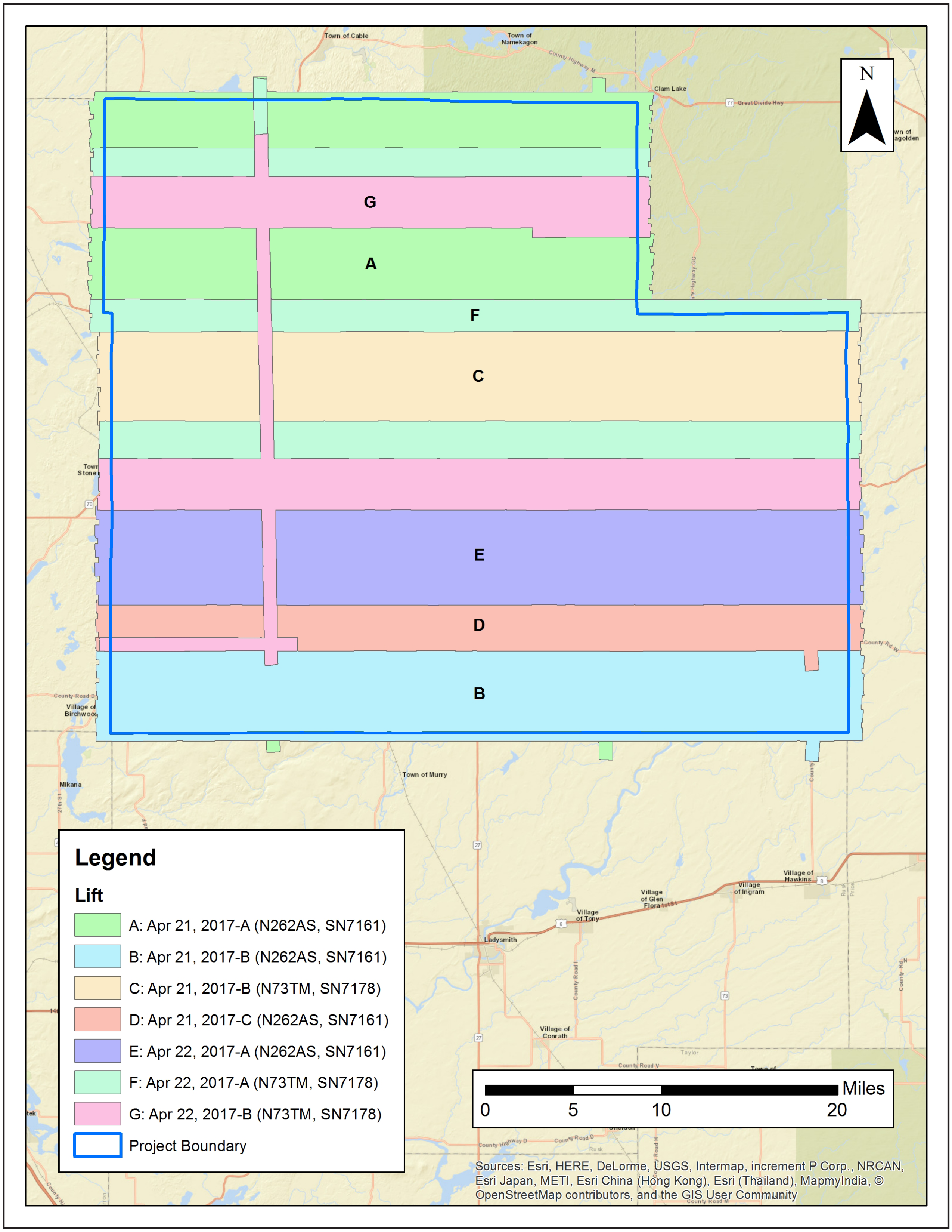
The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At 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 15 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) WISCRS Sawyer County Coordinate System, 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

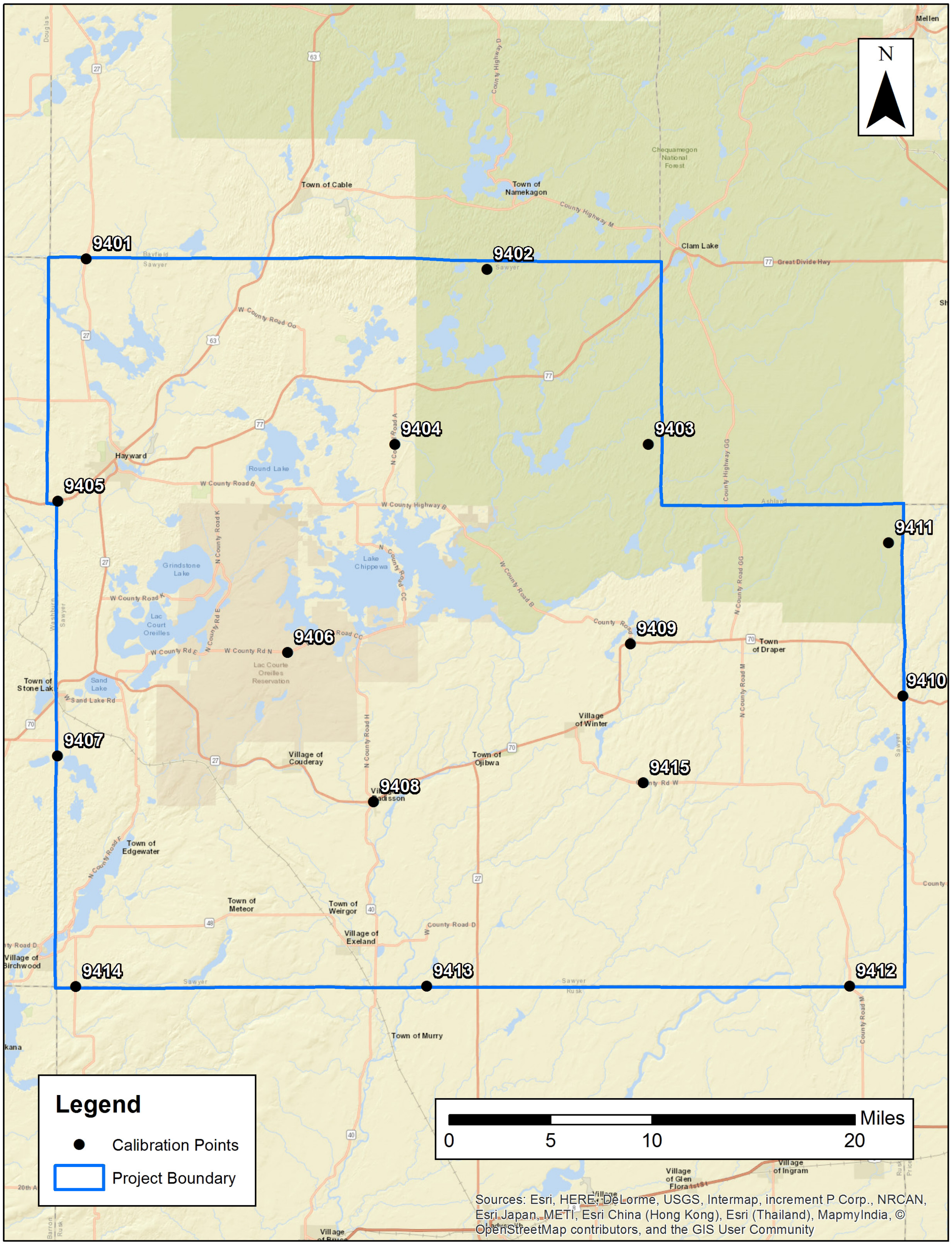


Table 4. Calibration Control Point Report
Units = US survey feet

Number	Easting	Northing	Known Z	Laser Z	Dz
9401	610329.233	490024.297	1322.86	1322.77	-0.09
9402	714596.197	487226.117	1451.26	1451.05	-0.21
9403	756537.436	441759.764	1438.91	1438.90	-0.01
9404	690612.801	441760.752	1386.47	1386.17	-0.30
9405	602916.486	426980.645	1174.90	1175.05	0.15
9406	662723.578	387672.368	1343.67	1343.79	0.12
9407	602860.483	360693.866	1322.50	1322.49	-0.01
9408	685042.165	348785.845	1245.21	1245.24	0.03
9409	751886.962	389911.003	1363.42	1363.39	-0.03
9410	822869.191	376275.987	1395.07	1395.22	0.15
9411	819063.486	416149.346	1548.96	1549.31	0.35
9412	809003.954	300861.044	1388.85	1388.74	-0.11
9413	698959.464	300826.998	1190.90	1190.97	0.07
9414	607555.307	300710.777	1271.54	1271.54	0.00
9415	755266.657	353773.380	1490.19	1490.05	-0.14

Average Dz	-0.006
Minimum Dz	-0.299
Maximum Dz	+0.301
Average Magnitude	0.115
Root Mean Square	0.147
Std Deviation	0.152