2015 Big Windy

Data collected for:

Department of Geology and Mineral Industries

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Prepared by:

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WSI Applied Remote Sensing and Analysis

Contents

Project Overview

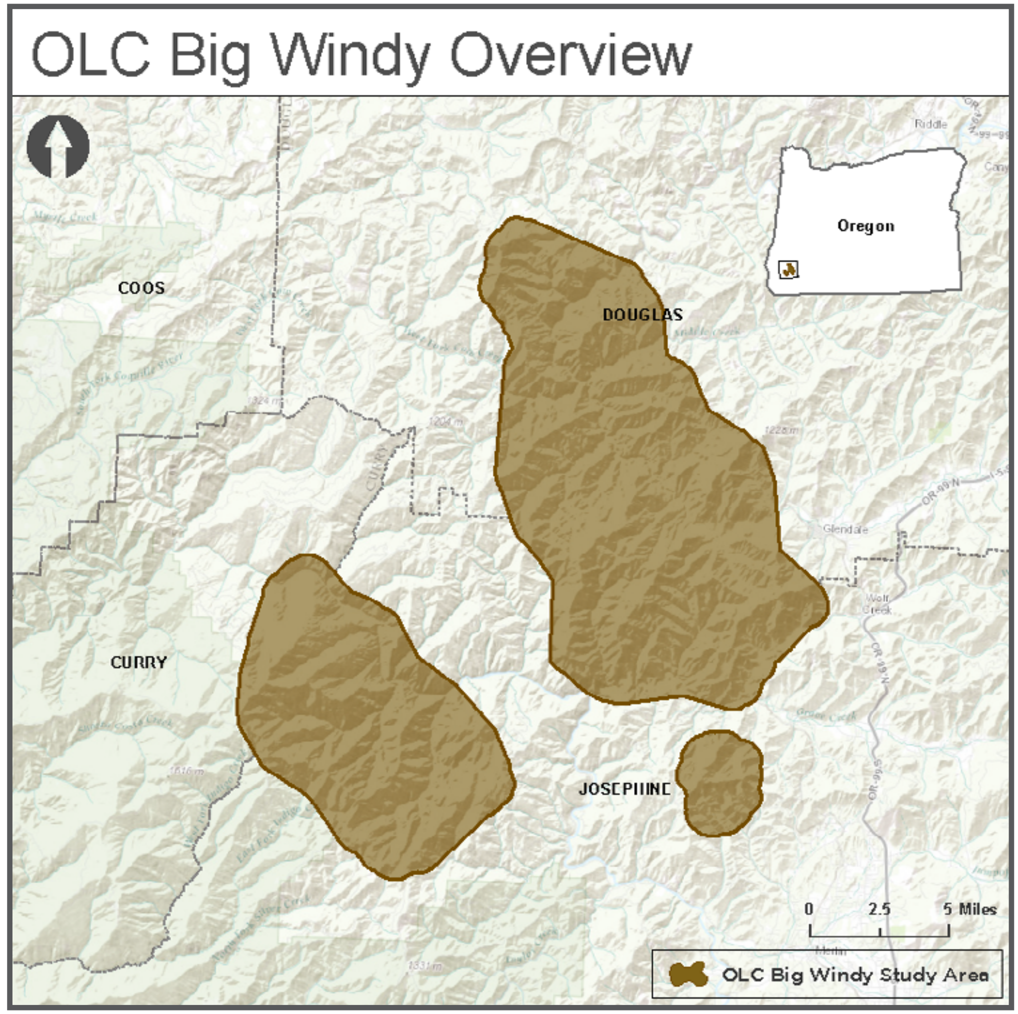
Quantum Spatial has collected Light Detection and Ranging (LiDAR) data for the Oregon LiDAR Consortium (OLC) Big Windy 2015 study area. This study area is located near Glendale, Oregon.

The collection of high resolution geographic data is part of an ongoing pursuit to amass a library of information accessible to government agencies as well as the general public.

In June 2015 QSI employed remote-sensing lasers in order to obtain a total area flown of acres. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

Final products created include 3-inch orthophotos, RGB extracted (from NAIP imagery) LiDAR point cloud data, three foot digital elevation models of highest hit and bare earth ground models, 1.5 foot intensity rasters, study area vector shapes, and corresponding statistical data. Final deliverables are projected in Oregon Statewide Lambert Conformal Conic.

OLC Big Windy Data	
LiDAR Acquisition Dates	6/26/2015 - 7/3/2015
Area of Interest	131,357 acres
Bufered Area of Interest	135,195 acres
Projection	Oregon Statewide Lambert Conformal Conic
Horizontal Datum Vertical Datum	NAD83 (2011) Epoch 2010.00 NAVD88 (Geoid 12A)
Units	International Feet



Study area overview map.

Aerial Acquisition

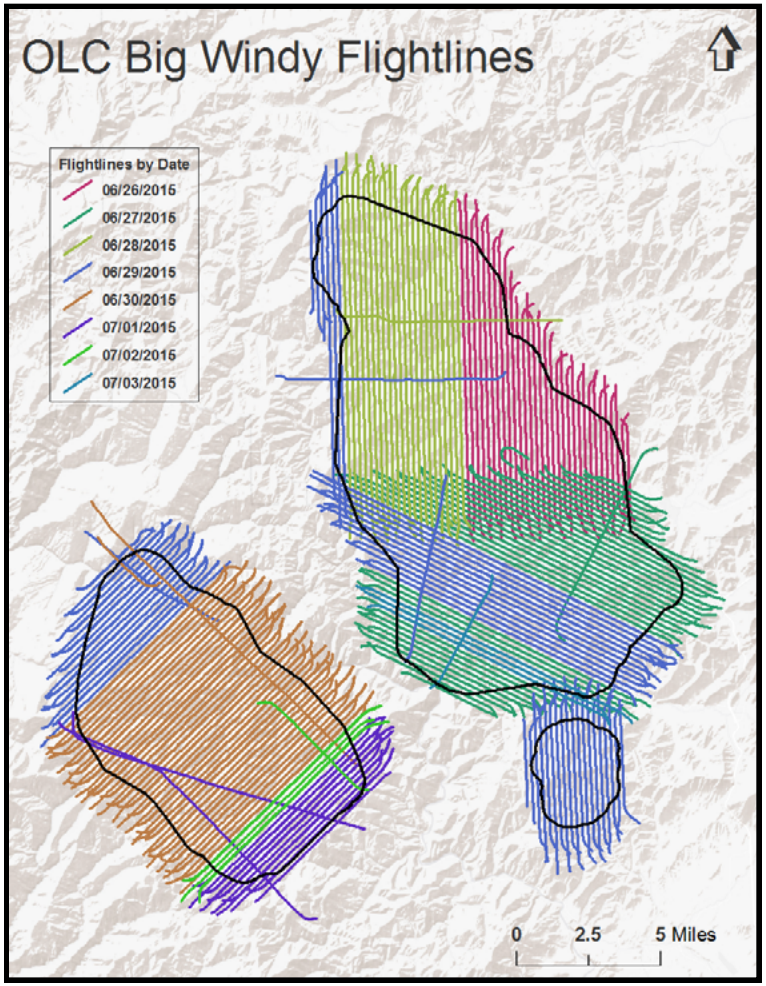
LiDAR Survey

The LiDAR survey occurred between June 26, 2015 and July 3, 2015 utilizing a Leica ALS70 mounted in a Cessna Grand Caravan. The systems were programmed to emit single pulses at around 198 kHz and flown at 1,400 m AGL, capturing a scan angle of 15 degrees from nadir. These settings were developed to yield points with an average native density of greater than eight pulses per square meter over terrestrial surfaces.

To solve for laser point position, an accurate description of aircraft position and attitude is vital. Aircraft position is described as x, y, and z and was measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is described as pitch, roll, and yaw (heading) and was measured 200 times per second (200 hertz) from an onboard inertial measurement unit (IMU).

The LiDAR sensor operators constantly monitored the data collection settings during acquisition of the data, including pulse rate, power setting, scan rate, gain, field of view, and pulse mode. For each flight, the crew performed airborne calibration maneuvers designed to improve the calibration results during the data processing stage. They were also in constant communication with the ground crew to ensure proper ground GPS coverage for data quality. The LiDAR coverage was completed with no data gaps or voids, barring non-reflective surfaces (e.g., open water, wet asphalt). All necessary measures were taken to acquire data under good conditions (e.g., minimum cloud decks) and in a manner (e.g., adherence to flight plans) that prevented the possibility of data gaps. All QSI LiDAR systems are calibrated per the manufacturer and our own specifications, and tested by QSI for internal consistency for every mission using proprietary methods.

OLC Big Windy LiDAR Acquisition Specs	
Sensor	Leica ALS70
Aircraft	Cessna Grand Caravan
Acquisition Date Range	6/26/2015 - 7/3/2015
Coverage	100% Overlap with 60% Sidelap
Field of View (FOV)	30 degrees
Targeted Pulse Density	≥8 PPSM
Pulse Rate	198 kHz
Speed	110 kts



Project Flightlines

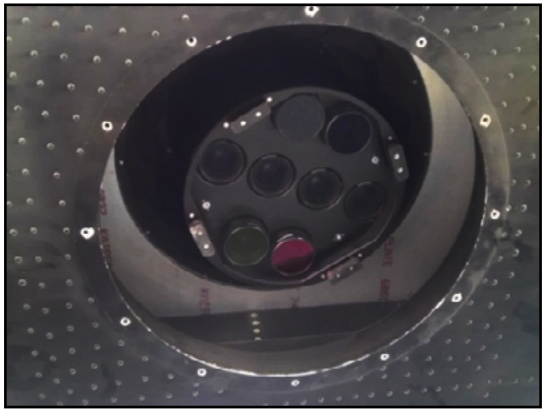
Aerial Acquisition

Photography

The photography or Four-Band Radiometric Image Enhanced Survey (FRIES) utilized an UltraCam Eagle 260 megapixel camera mounted in a Piper Navajo. The UltraCam Eagle is an 80 mm, 260 megapixel large format digital aerial camera manufactured by the Microsoft Corporation. The system is gyro-stabilized and contains a fully integrated UltraNav flight management system with a POS-AV 510 IMU embedded within the body of the camera unit.

The Eagle was designed with high efficiency, high resolution, and high accuracy in mind. With a physical pixel size of 5.2 microns, the Eagle captures a 6.5 cm ground sample distance (GSD) at a flying height of 1,000 meters AGL. This sensor size of the camera is 20,010 x 13,080 pixels in size, which allows for total ground coverage of 1300 x 850 meters within a single captured image frame at 1,000 meters AGL. This large footprint coupled with a fast frame rate (1.8 seconds per frame) allows for highly efficient acquisition. The precise integrated UltraNav system is accurate enough for direct georeferencing in many applications.

The UltraCam Eagle simultaneously collects panchromatic and multispectral (RGB, NIR) imagery in 14 bit format. The spectral sensitivity of the panchromatic charged coupled device (CCD) array ranges from 400-720 nm, with 16,000 grey values per pixel. Four separate 27 mm lenses collect red (590-720 nm), green (490-660 nm), blue (410-590 nm) and near infrared (690-990 nm) light. Panchromatic lenses collect high resolution imagery by illuminating nine CCD arrays, writing nine raw image files. RGB and NIR lenses collect lower resolution imagery, written as four individual raw image files. Level 2 images are created by stitching together raw image data from the nine panchromatic CCDs, and ultimately combined with the multispectral image data to yield Level 3 pan-sharpened TIFFs in either 8 bit format.



UltraCam Eagle lens configuration as viewed from the Piper Navajo.

UltraCam Eagle installed in the aircraft.

Digital Orthophotography Survey Specifications	
Aircraft	Piper Navajo
Sensor	UltraCam Eagle
Altitude	1,200 m AGL
GPS Satellite Constellation	6
GPS PDOP	3.0
GPS Baselines	≤ 13 nm
Image	8-bit GeoTIFF
Along Track Overlap	60%
Spectral Bands	Red, Green, Blue, NIR
Resolution	3 in. pixel size

Ground Survey

Ground control surveys, including monumentation, aerial targets, and ground survey points (GSPs) were conducted to support the airborne acquisition. Ground control data are used to geospatially correct the aircraft positional coordinate data and to perform quality assurance checks on final LiDAR data products. See the table to the right for specifications of equipment used.

Monumentation

Ground control surveys, including monumentation, and ground survey points (GSPs), were conducted to support the airborne acquisition. Ground control data were used to geospatially correct the aircraft positional coordinate data and to perform quality assurance checks on final LiDAR data.

The spatial configuration of ground survey monuments provided redundant control within 13 nautical miles of the mission areas for LiDAR flights. Monuments were also used for collection of ground survey points using real time kinematic (RTK), post processed kinematic (PPK), and fast static (FS) survey techninques. Monument locations were selected with consideration for satellite visibility, field crew safety, and optimal location for GSP coverage. QSI utilized six existing monument and established three new monuments for the OLC Big Windy LiDAR project. New monumentation was set using 5/8" x 30" rebar topped with stamped 2-1/2" aluminum caps. QSI's professional land surveyor, Christopher Glantz (OR PLS #83648) oversaw and certified the establishment of all monuments.

Monument cap "BW_06"

Base station set up over monument "BW_06" within the OLC Big Windy study area.

Monument Accuracy	
FGDC-STD-007.2-1998 Rating	
St Dev NE	0.020 m
St Dev z	0.050 m

Ground survey map of the 2015 OLC Big Windy study area.

PID	Lattitude	Longitude	Ellipsoid (m)	NAVD88 Height (m)
BW_01	42° 52' 16.18629"	-123° 36' 40.48339"	843.486	867.562
BW_04	42° 44' 31.35062"	-123° 28' 50.74246"	390.363	414.267
BW_05	42° 36' 15.95668"	-123° 46' 30.78800"	1132.792	1157.094
BW_06	42° 36' 43.47390"	-123° 45' 59.37129"	984.428	1008.747
BW_07	42° 36' 21.06403"	-123° 29' 56.66432"	938.421	962.484
BW_08	42° 39' 48.32561"	-123° 31' 04.21966"	338.882	362.965
BW_09	42° 44' 25.60821"	-123° 30' 37.12892"	400.618	424.576
BW_10	42° 41' 10.72442"	-123° 39' 21.24672"	773.015	797.176
ROGUE_15_RESET	42° 41' 08.89031"	-123° 37' 37.94635"	428.227	452.387

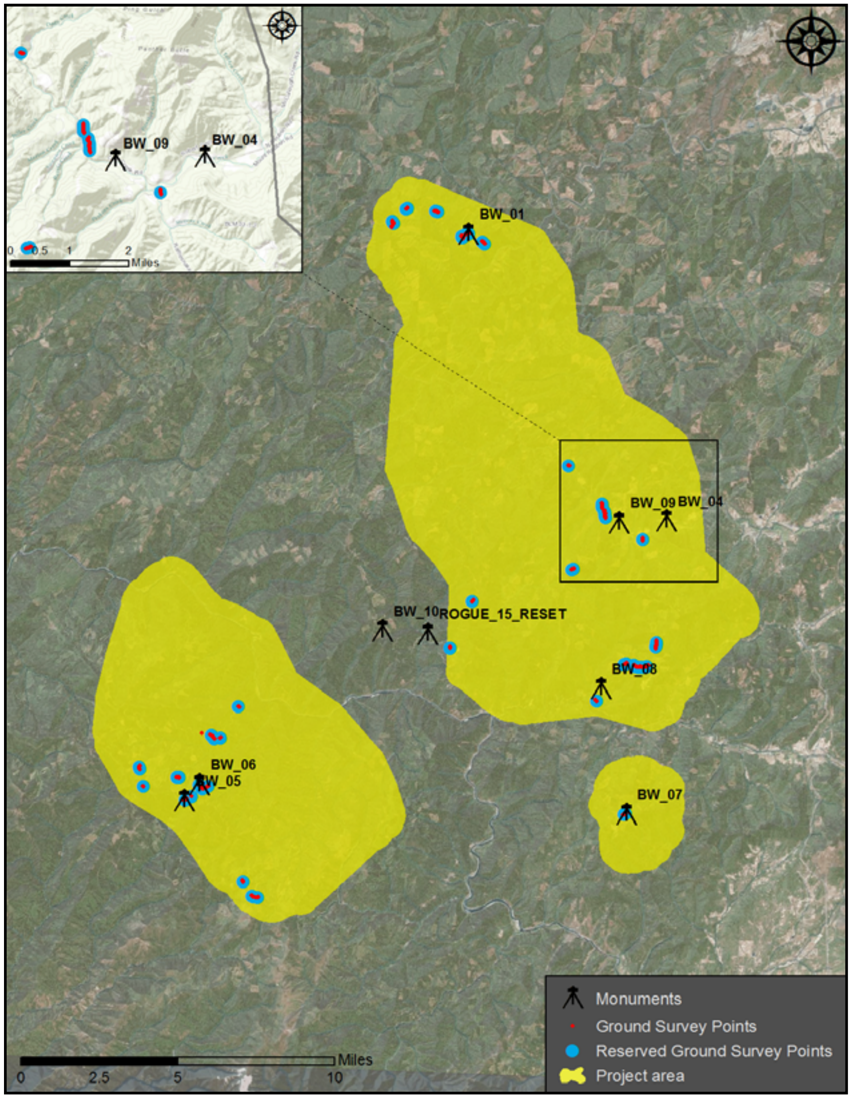
Coordinates are on the NAD83 (2011) datum, epoch 2010.00. NAVD88 height referenced to Geoid12A.

To correct the continuously recorded onboard measurements of the aircraft position, QSI concurrently conducted multiple static Global Navigation Satellite System (GNSS) ground surveys (1 Hz recording frequency) over each monument. During post-processing, the static GPS data were triangulated with nearby Continuously Operating Reference Stations (CORS) using the Online Positioning User Service (OPUS) for precise positioning. Multiple independent sessions over the same monument were processed to confirm antenna height measurements and to refine position accuracy. The table on the previous page provides the list of monuments used.

Ground Survey Points (GSPs)

Ground Survey Points (GSPs) are collected using Real Time Kinematic (RTK) survey techniques. For RTK surveys, a base receiver is positioned at a nearby monument to broadcast a kinematic correction to a roving receiver. All GSP measurements are made during periods with a Position Dilution of Precision (PDOP) no greater than 3.0 and in view of at least six satellites for both receivers. Relative errors for the position must be less than 1.5 centimeters horizontal and 2.0 centimeters vertical in order to be accepted.

In order to facilitate comparisons with high quality LiDAR data, GSP measurements are not taken on highly reflective surfaces such as center line stripes or lane markings on roads. GSPs are taken no closer than one meter to any nearby terrain breaks such as road edges or drop offs. GSPs were collected within as many flight lines as possible; however, the distribution depended on ground access constraints and may not be equitably distributed throughout the study area.



Ground survey map.

Ground survey instrumentation

Instrumentation			
Receiver Model	Antenna	OPUS Antenna ID	Use
Trimble R7	Zephyr GNSS Geodetic Model 2 RoHS	TRM57971.00	Static
Trimble R6	Integrated GNSS Antenna R6	TRM_R6	Rover

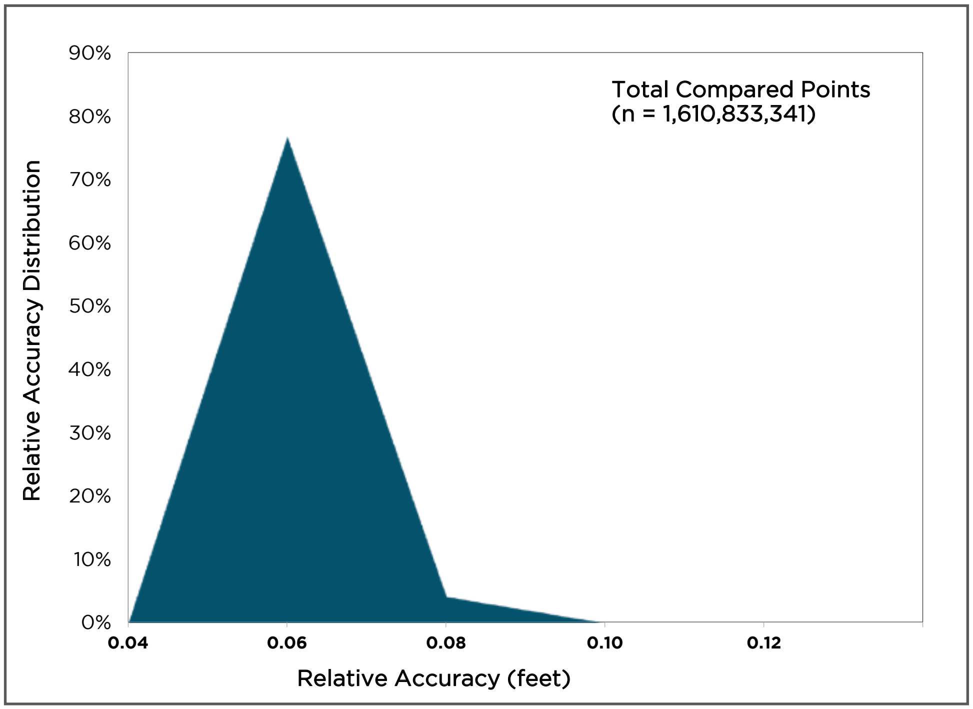
Accuracy

Relative Accuracy

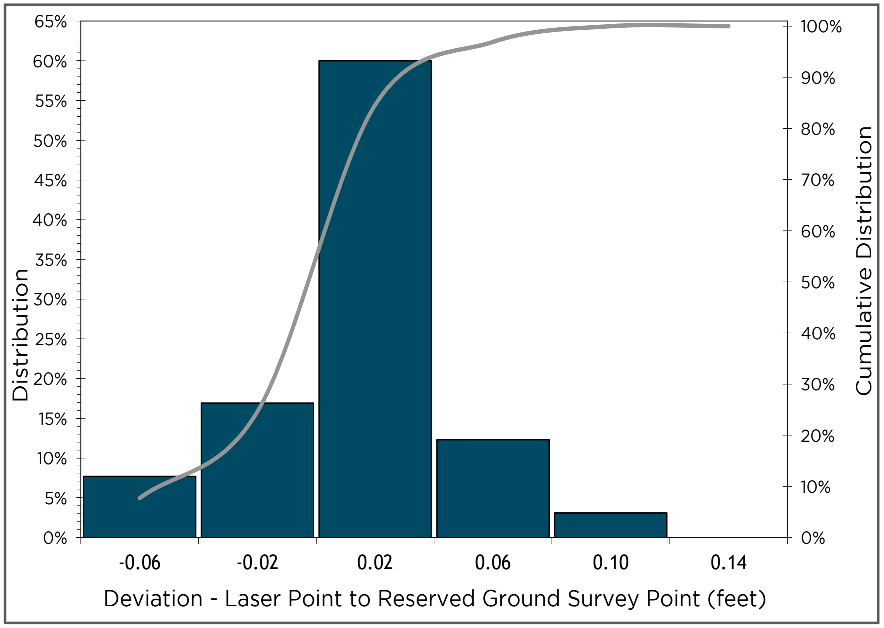
Relative accuracy refers to the internal consistency of the data set and is measured as the divergence between points from different flightlines within an overlapping area. Divergence is most apparent when flightlines are opposing. When the LiDAR system is well calibrated the line to line divergence is low (<10 centimeters). Internal consistency is affected by system attitude offsets (pitch, roll, and heading), mirror flex (scale), and GPS/IMU drift.

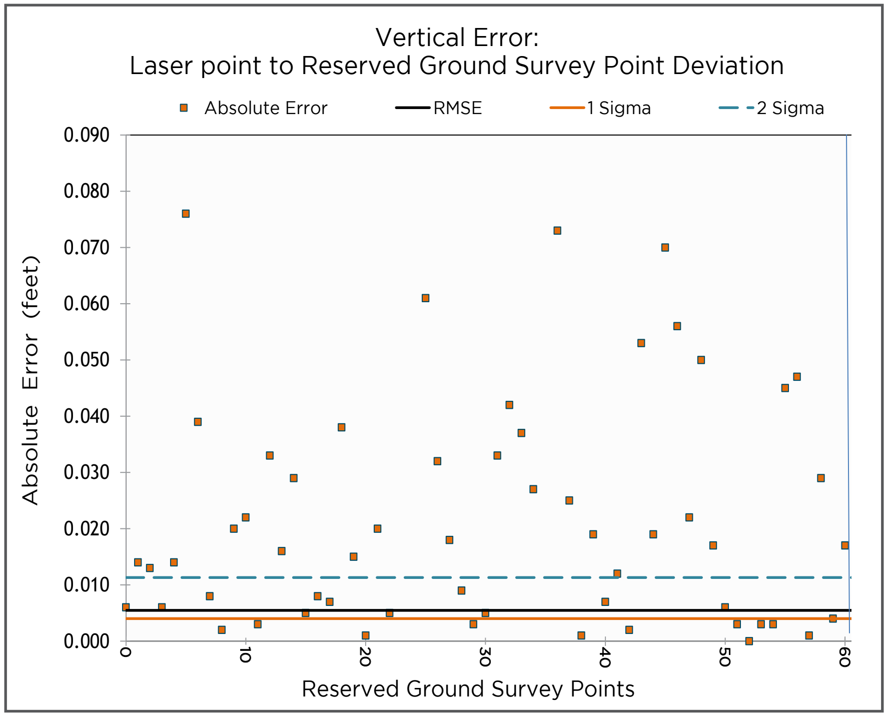
Relative accuracy statistics are based on the comparison of 215 flightlines and over 1,610,833,341 LiDAR points. Relative accuracy is reported for the entire study area.

Relative Accuracy Calibration Results	
Project Average	0.047 m 0.153 ft.
Median Relative Accuracy	0.048 m 0.157 ft.
1σ Relative Accuracy	0.051 m 0.167 ft.
2σ Relative Accuracy	0.058 m 0.189 ft.



Vertical Accuracy Distribution





Vertical Accuracy

Vertical Accuracy reporting is designed to meet guidelines presented in the National Standard for Spatial Data Accuracy (NSSDA) (FGDC, 1998) and the ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data V1.0 (ASPRS, 2004). The statistical model compares known ground survey points (GSPs) to the closest laser point. Vertical accuracy statistical analysis uses ground survey points in open areas where the LiDAR system has a “very high probability” that the sensor will measure the ground surface and is evaluated at the 95th percentile.

For the OLC Big Windy study area, a total of 1,228 GSPs were collected. An additional 65 reserved ground survey points were collected for independent verification, resulting in a fundamental vertical accuracy (FVA) of 0.022 meters.

Vertical Accuracy Results	Hard Surface
Sample Size (n)	n = 65 GSPs
FVA (RMSE*1.96)	0.022 m (0.071 ft.)
Root Mean Square Error	0.011 m (0.036 ft.)
1 Standard Deviation	0.008 m (0.027 ft.)
2 Standard Deviations	0.023 m (0.075 ft.)
Average Deviation	-0.002 m (-0.007 ft.)
Minimum Deviation	-0.044 m (-0.145 ft.)
Maximum Deviation	0.030 m (0.099 ft.)

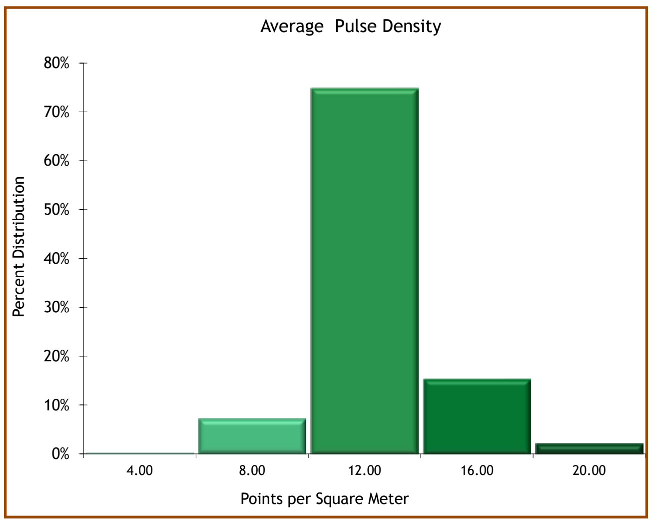
Density

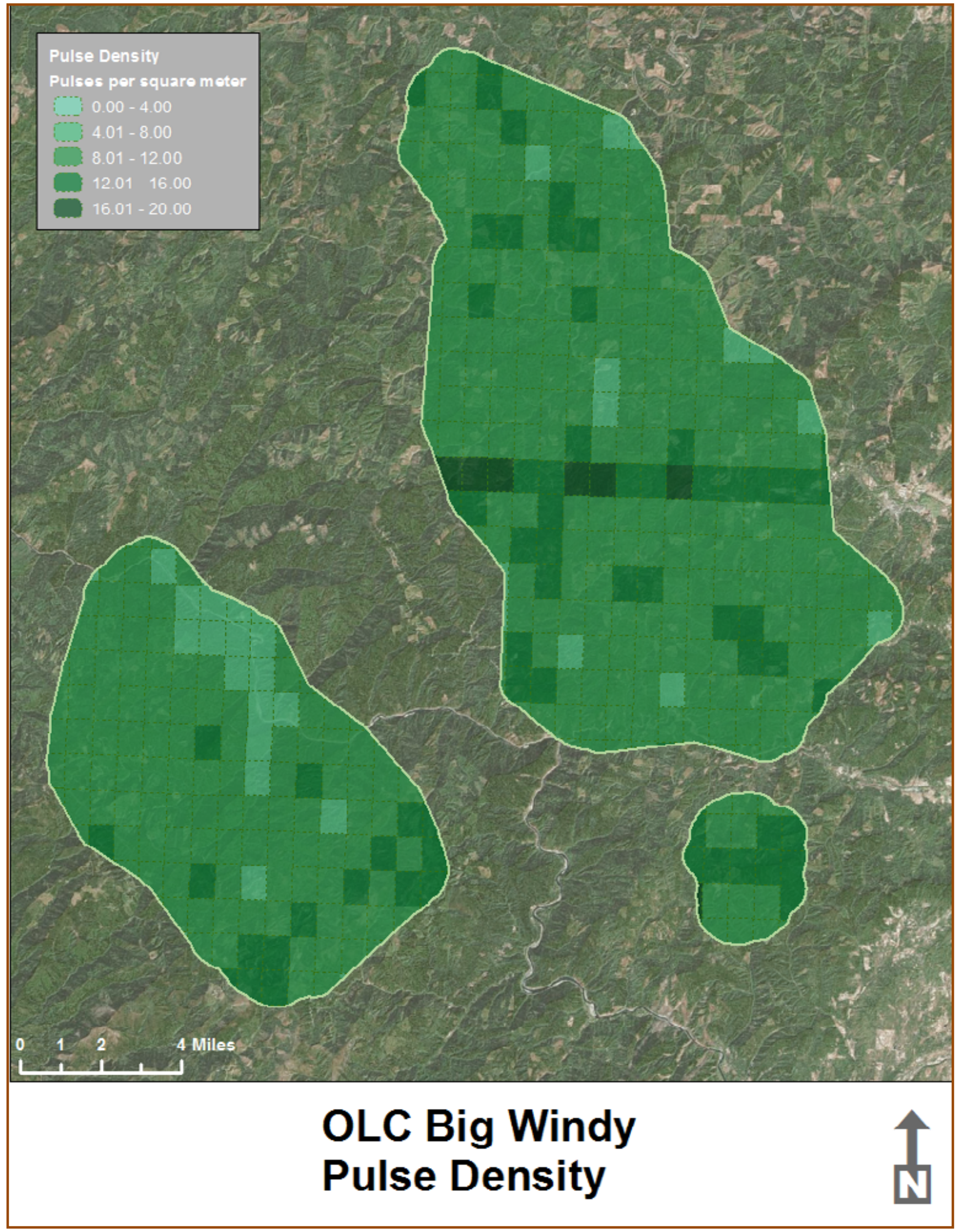
Pulse Density

Some types of surfaces (e.g., dense vegetation, water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according to terrain, land cover, and water bodies. Density histograms and maps have been calculated based on first return laser pulse density and ground-classified laser point density.

Average Point Densities			
Pulses per square meter	Pulses per square foot	Ground points per square meter	Ground points per square foot
10.20	0.95	1.52	0.14

Pulse Density Distribution



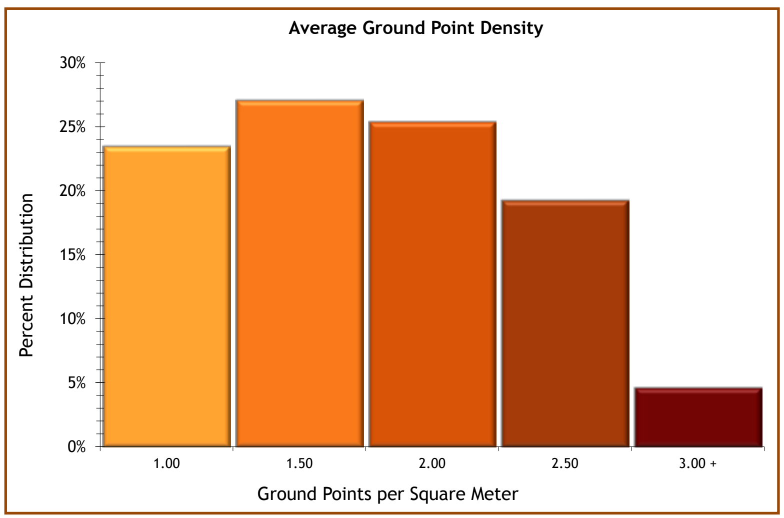


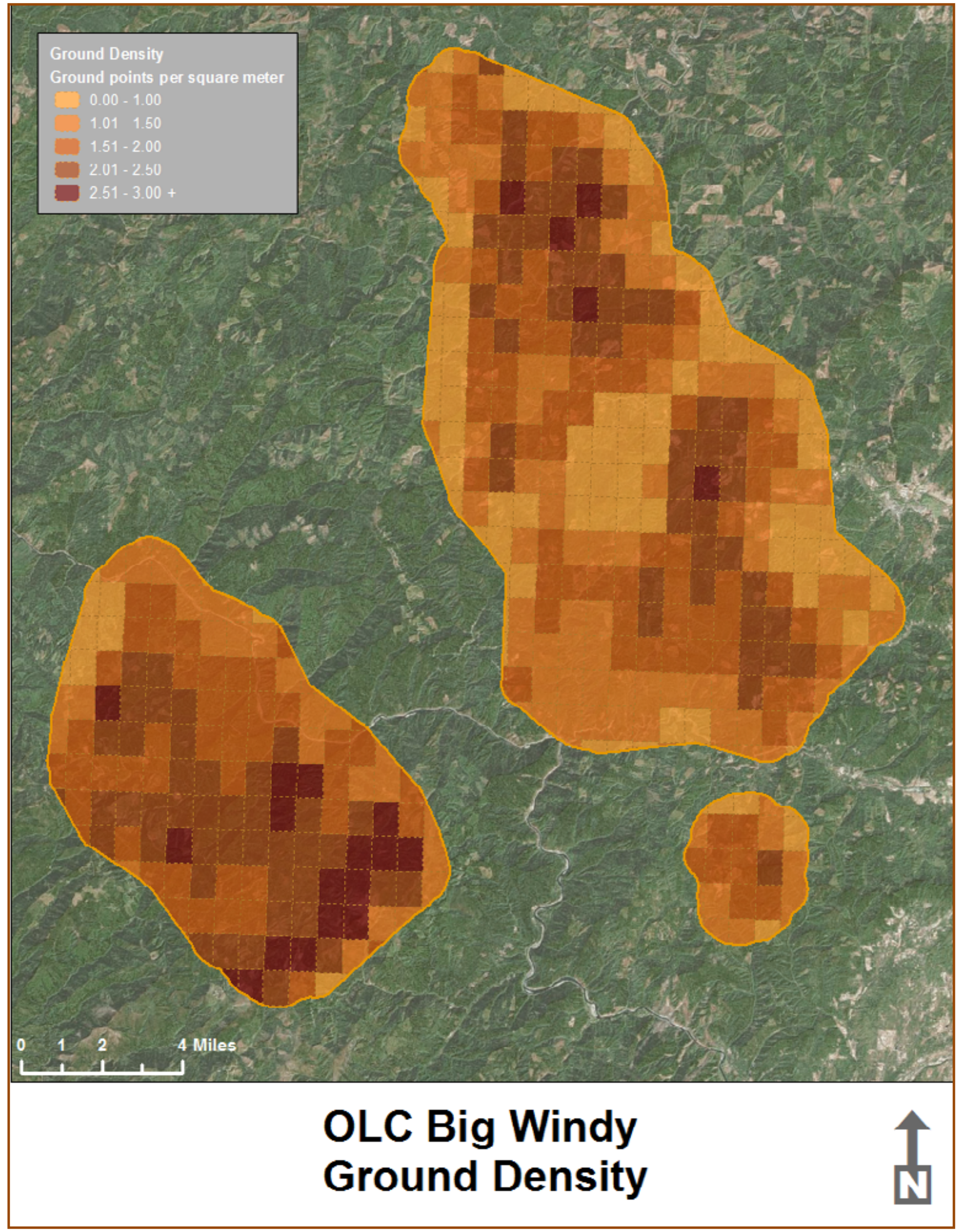
Average Pulse Density per 0.75' USGS Quad (color scheme aligns with density chart).

Ground Density

Ground classifications were derived from ground surface modeling. Further classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes, and at tile boundaries.

Ground Density Distribution





Average Ground Point Density per 0.75' USGS Quad (color scheme aligns with density chart).

Orthophoto Accuracy

Orthophoto Accuracy Assessment

To assess the spatial accuracy of the orthophotographs, artificial check points were established. Nineteen target control points, distributed evenly across the total acquired area, were generated on permanent air target surface features, such as painted road lines and fixed high-contrast objects or on temporary air targets. They were then compared against check points identified from the LiDAR intensity images. The accuracy of the final mosaic was calculated in relation to the LiDAR-derived check points and is listed below. Accuracy statistics are reported for the entire Lane County Orthophoto AOI.

Above: Example of co-registration of color images with LiDAR intensity images. **Below:** Examples of permanent air targets located within the OLC Big Windy project area.

Orthophoto horizontal accuracy results.

Orthophoto Horizontal Accuracy (n=19)	QSI Achieved (m)	QSI Achieved (ft.)
RMSEr	0.712	0.217
1 Sigma	0.746	0.227
2 Sigma	1.086	0.331

Appendix
PLS Certification

WSI, a Quantum Spatial company, provided LiDAR Services for OLC Big Windy LiDAR project as described in this report.

I, John English, have reviewed the attached report for completeness and herby state that it is a complete and accurate report of this project.

1/13/2015

John English
Project Manager
WSI, a Quantum Spatial Company

I, Christopher Glantz, being duly registered as a Professional Land Surveyor in the state of Oregon, say that I hereby certify the methodologies and results of the attached LiDAR project, and that Static GNSS occupations on the Base Stations during airborne flights and RTK survey on hard-surface and GSP's were performed using commonly accepted Standard Practices. Field work conducted for this report was conducted between June 20, 2015 and July 11, 2015. Accuracy statistics shown in the Accuracy Section of this Report have been review by me and found to meet the "National Standard for Spatial Data Accuracy".

1/13/2016

Christopher Glantz, PLS
Land Survey Manager
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