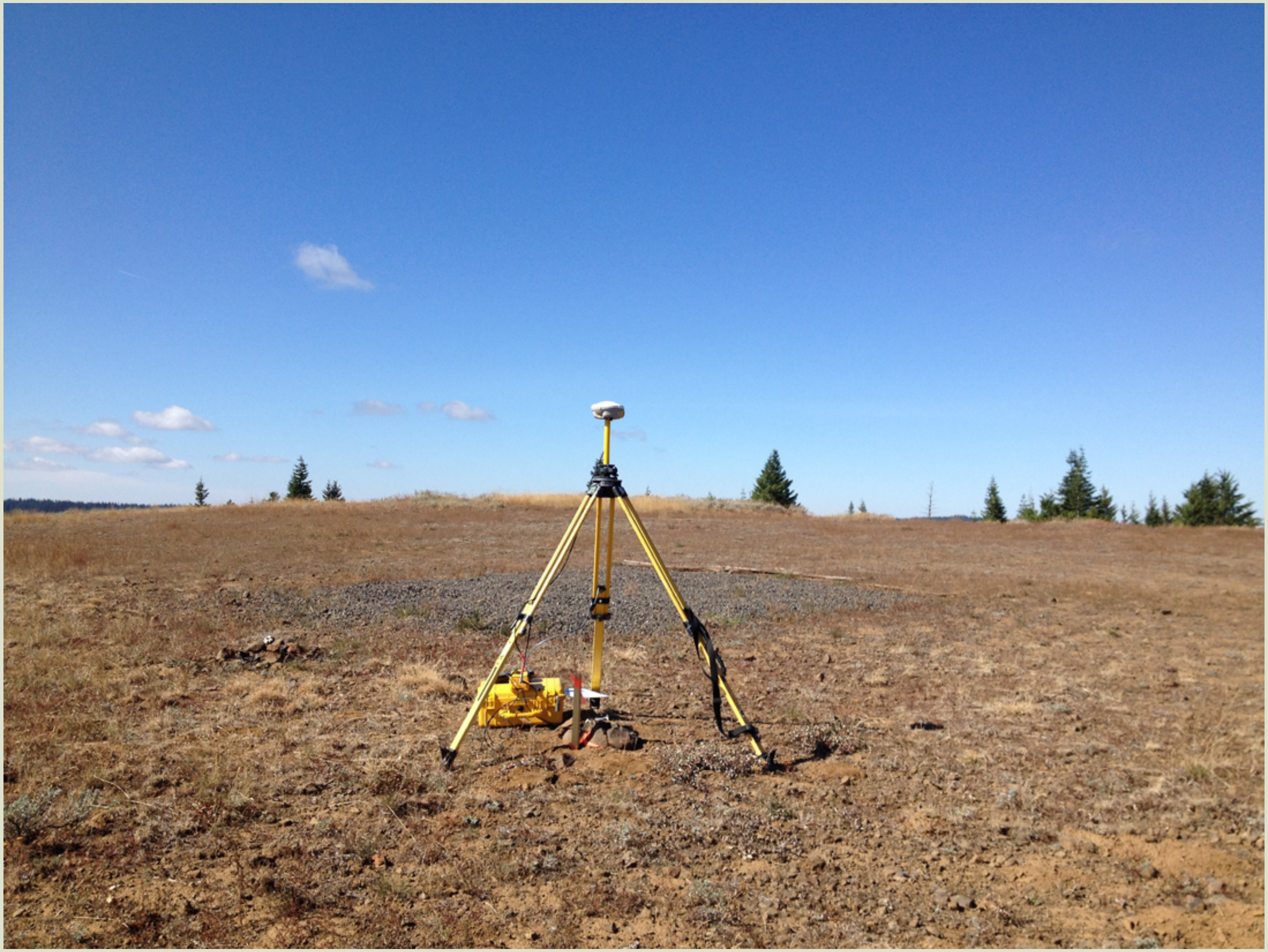
WSI Applied Remote Sensing and Analysis

OLC Umatilla



February 27 , 2015

Trimble R7 set up over GPS Monument "UMA-03"

Data collected for:
Oregon Department of Geology and Mineral Industries

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GPS Monument “UMA-01”

Project Overview

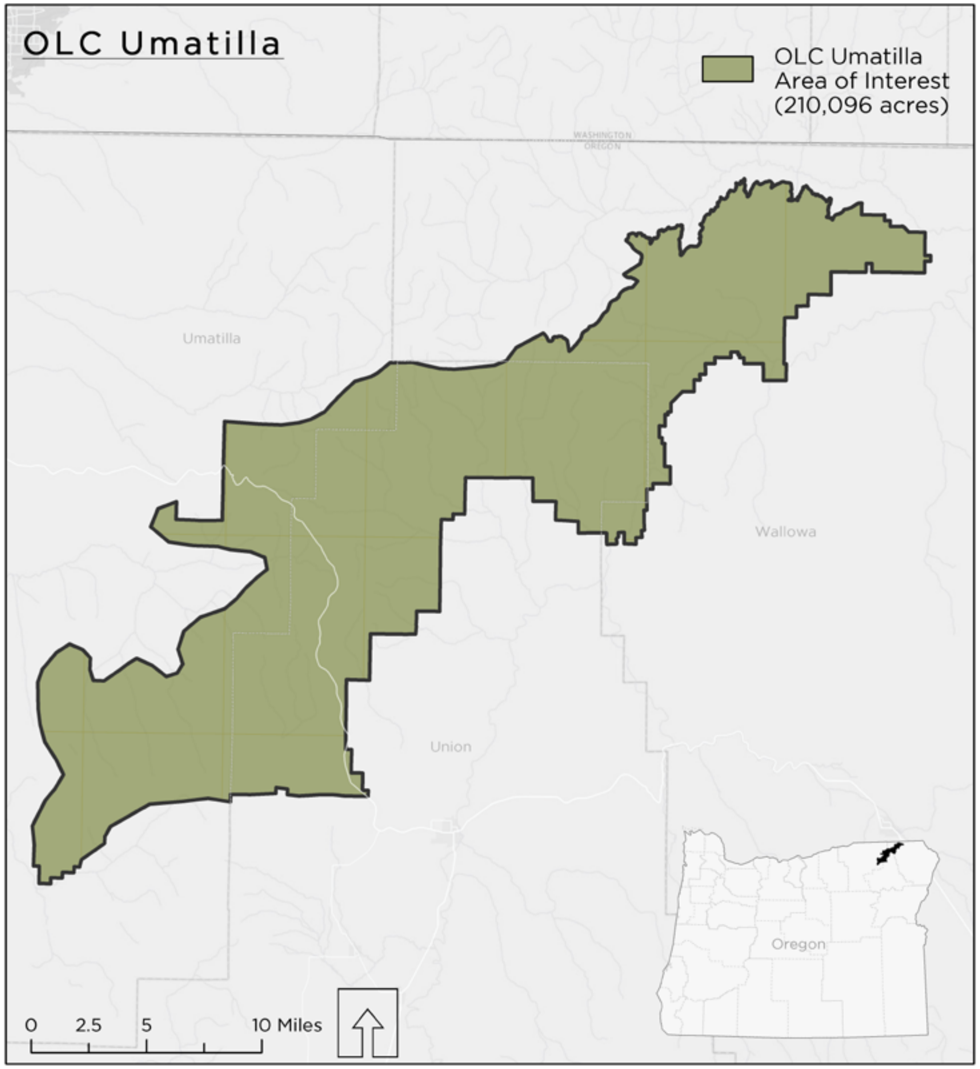
WSI has completed the acquisition and processing of Light Detection and Ranging (LiDAR) data of the OLC Umatilla, for the Oregon Department of Geology and Mineral Industries (DOGAMI). The Oregon LiDAR Consortium's Umatilla project area of interest (AOI) encompasses 210,096 acres in Umatilla, Wallowa, and Union counties

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.

WSI data collection spanned from October 1, 2014 to October 8, 2014. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

Final products created include LiDAR point cloud data, three-foot digital elevation models of bare earth ground model and highest-hit returns, 1.5-foot intensity rasters, ground density rasters, study area vector shapes, and corresponding statistical data.

WSI acquires and processes data in the most current, NGS-approved datums and geoid. For OLC Umatilla, all final deliverables are projected in Oregon Lambert, endorsed by the Oregon Geographic Information Council (OGIC),[1] using the NAD83(2011) horizontal datum and the NAVD88 (Geoid 12A) vertical datum, with units in International Feet.



OLC Umatilla AOI Data Delivered February 27, 2015	
Acquisition Dates	October 1, 2014 - October 8, 2014
Delivery Area Eight Area of Interest	210,096.88 acres
Projection	OREGON STATEWIDE LAMBERT (OGIC)
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	International Feet

1 http://www.oregon.gov/DAS/EISPD/GEO/pages/coordination/projections/projections.aspx

Aerial Acquisition

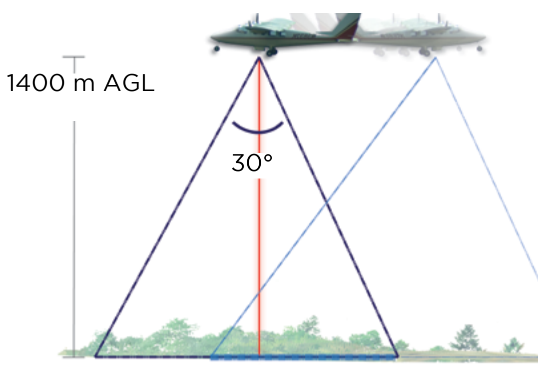
Cessna Caravan

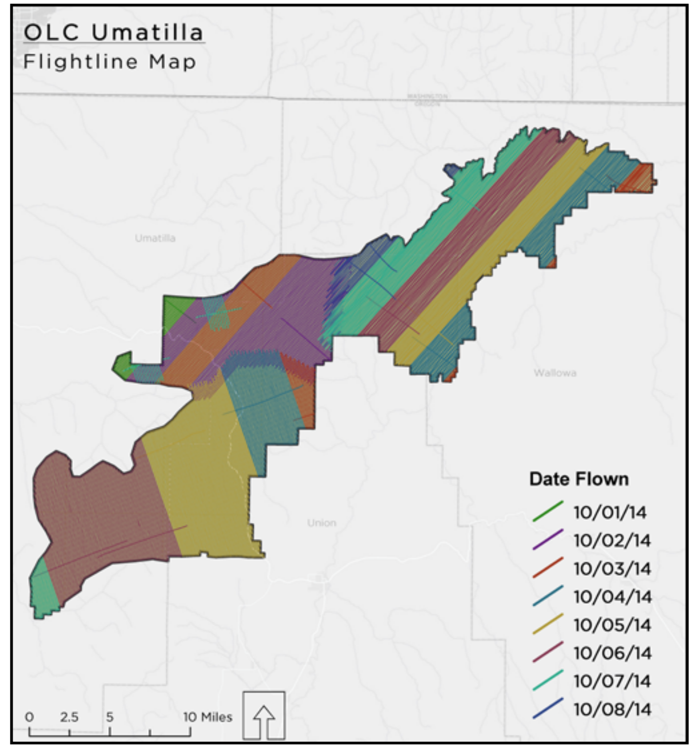
LiDAR Survey

The LiDAR survey utilized both Leica ALS60 and ALS70 sensors mounted in a Cessna Caravan 208B and Piper PA-31 respectively. The systems were programmed to emit single pulses at a rate of 190 to 198 kilohertz and flown at 900 meters above ground level (AGL), capturing a scan angle of +/-15 degrees from nadir (field of view equal to 30 degrees). These settings are developed to yield points with an average native density of greater than eight pulses per square meter over terrestrial surfaces.

The native pulse density is the number of pulses emitted by the LiDAR system. Some types of surfaces such as dense vegetation or water may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and lightly vary according to distributions of terrain, land cover, and water bodies. The study area was surveyed with opposing flight line side-lap of greater than 65 percent with at least 100 percent overlap to reduce laser shadowing and increase surface laser painting. The system allows up to four range measurements per pulse, and all discernible laser returns were processed for the output dataset.

To solve for laser point position, it is vital to have an accurate description of aircraft position and attitude. Aircraft position is described as x, y, and z and measured twice per second (two hertz) by an onboard differential GPS unit. Aircraft attitude is measured 200 times per second (200 hertz) as pitch, roll, and yaw (heading) from an onboard inertial measurement unit (IMU). As illustrated in the accompanying map, 515 full and partial flightlines provide coverage of the study area.





Project Flightlines

OLC Umatilla Acquisition Specifications	
Sensors Deployed	Leica ALS60 and Leica ALS70
Aircraft	Cessna Caravan 208B, Piper PA-31
Survey Altitude (AGL)	900 m
Pulse Rate	190-198 kHz
Pulse Mode	Single (SPiA)
Field of View (FOV)	30°
Roll Compensated	Yes
Overlap	100% overlap with 65% sidelap
Pulse Emission Density	≥ 8 pulses per square meter

Ground Survey

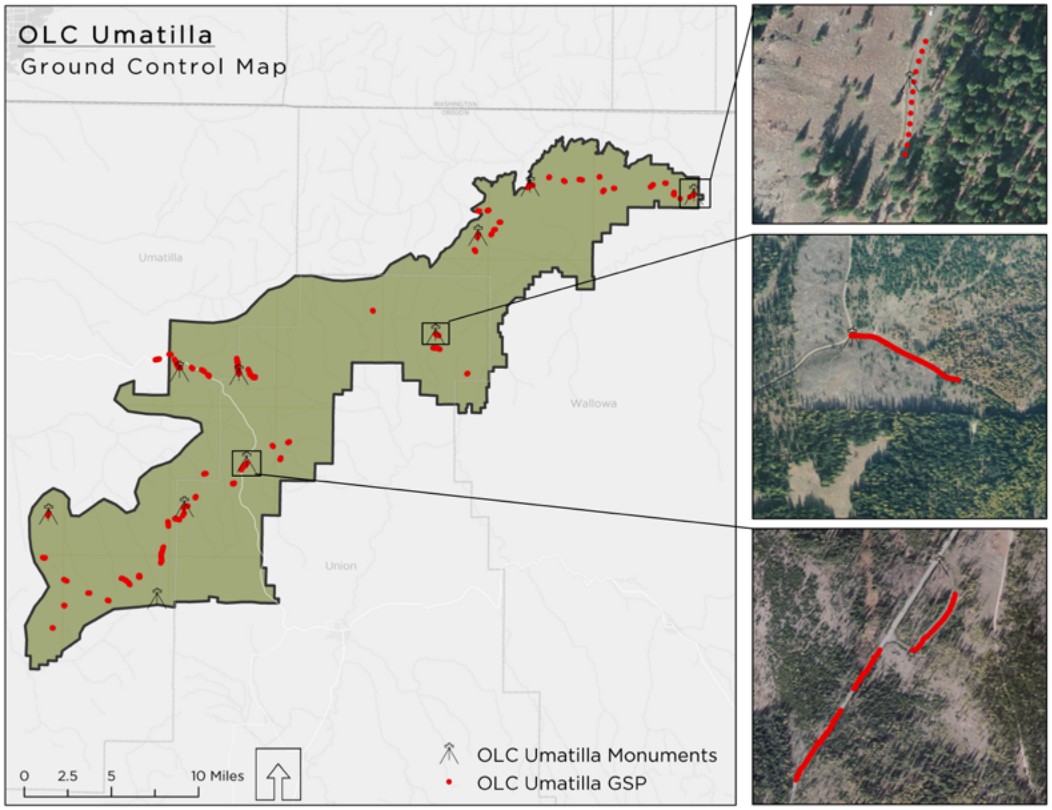
Ground control surveys, including monumentation, aerial targets, and ground survey points (GSPs) were conducted to support the airborne acquisition. Ground control data are used to geospatially correct the aircraft positional coordinate data and to perform quality assurance checks on final LiDAR data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

Instrumentation

All Global Navigation Satellite System (GNSS) static surveys utilized Trimble R7 GNSS receivers with Zephyr Geodetic Model 2 RoHS antennas and Trimble R8 GNSS receivers with internal antennas. Rover surveys for GSP collection were conducted with Trimble R8 and Trimble R10 GNSS receivers. See the table on the following page for specifications of equipment used.

Monumentation

Existing and newly established survey benchmarks serve as control points during LiDAR acquisition. Monument locations were selected with consideration for satellite visibility, field crew safety, and optimal location for GSP coverage. NGS benchmarks are preferred for control points; however, in the absence of NGS benchmarks, WSI produces our own monuments, and every effort is made to keep them within the public right of way or on public lands. If monuments are necessary on private property, consent from the owner is required. All monumentation is done with 5/8” x 30” rebar topped with a two-inch diameter aluminum cap stamped “Watershed Sciences, Inc. Control.” The table at right provides the list of monuments used in the OLC Umatilla study area.



OLC Umatilla Monuments				
PID	Latitude	Longitude	Ellipsoid Height (m)	NAVD 88 Height (m)
UMA_01	45° 46’ 43.89001”	-118° 06’ 55.48650”	1,488.29	1,507.03
UMA_02	45° 46’ 36.71364”	-118° 02’ 41.44847”	1,579.47	1,597.94
UMA_03	45° 35’ 22.56163”	-118° 08’ 18.06418”	1,574.09	1,592.35
UMA_04	45° 39’ 58.11153”	-118° 06’ 26.81714”	1,387.83	1,406.22
UMA_05	45° 48’ 43.88343”	-117° 48’ 41.48025”	1,279.41	1,297.30
UMA_06	45° 53’ 42.09350”	-117° 45’ 43.38273”	1,498.38	1,516.32
UMA_07	45° 56’ 11.05964”	-117° 42’ 01.95532”	1,469.94	1,487.87
UMA_08_RTK	45° 42’ 15.62996”	-118° 02’ 03.31127”	1,516.47	1,534.73
UMA_09_RTK	45° 39’ 30.19656”	-118° 16’ 06.95905”	1,396.81	1,415.73
UMA_10_RTK	45° 55’ 48.64827”	-117° 30’ 18.91194”	966.587	984.332

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

Methodology

To correct the continuously recorded aircraft position, WSI concurrently conducts multiple static GNSS ground surveys over each monument. All control monuments are observed for a minimum of two survey sessions, each lasting no fewer than two hours. Data are collected at a rate of one hertz, using a 10 degree mask on the antenna. The static GPS data are then triangulated with nearby Continuously Operating Reference Stations (CORS) using the Online Positioning User Service (OPUS) for precise positioning.

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

Ground Survey Points (GSPs) are collected using Real Time Kinematic (RTK), Post-Processed Kinematic (PPK), and Fast-Static (FS) survey techniques. For RTK surveys, a base receiver is positioned at a nearby monument to broadcast a kinematic correction to a roving receiver; for PPK and FS surveys, however, these corrections are post-processed. 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 professional collecting RTK

Instrumentation			
Receiver Model	Antenna	OPUS Antenna ID	Use
Trimble R7 GNSS	Zephyr GNSS Geodetic Model 2 RoHS	TRM57971.00	Static
Trimble R8	Integrated Antenna R8 Model 2	TRM_R8_GNSS	Static, Rover
Trimble R10	Integrated Antenna R10	TRMR10	Rover

LiDAR Accuracy

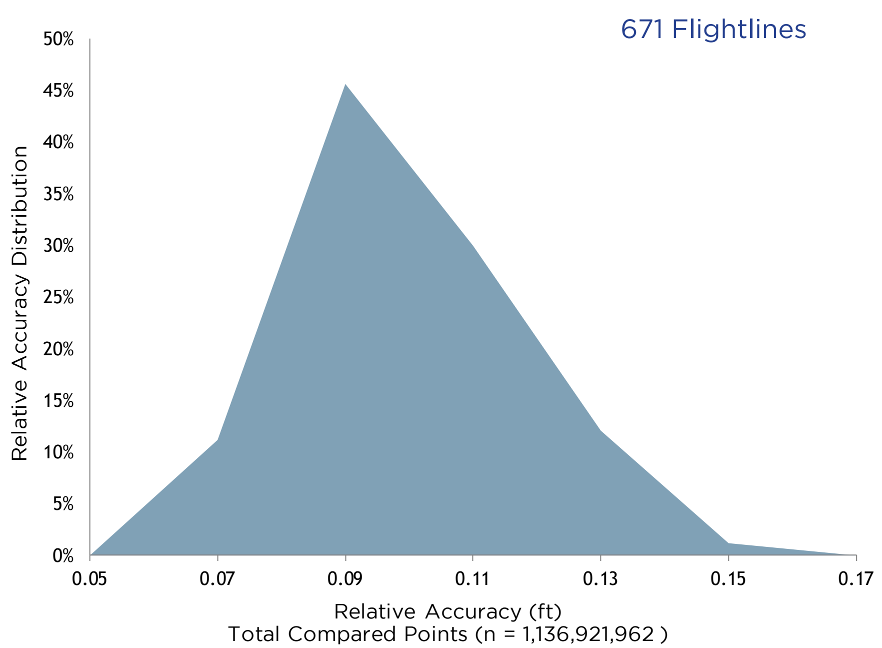
Relative Accuracy

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 671 full and partial flightlines and over 1.1 billion points.

Relative Accuracy Calibration Results N = 671 flightlines	
Project Average	0.09 ft. (0.03 m)
Median Relative Accuracy	0.09 ft. (0.03 m)
1σ Relative Accuracy	0.10 ft. (0.03 m)
2σ Relative Accuracy	0.12 ft. (0.04 m)

Relative Accuracy Distribution



Trimble R7 Receiver set up over GPS monument “UMA_2”

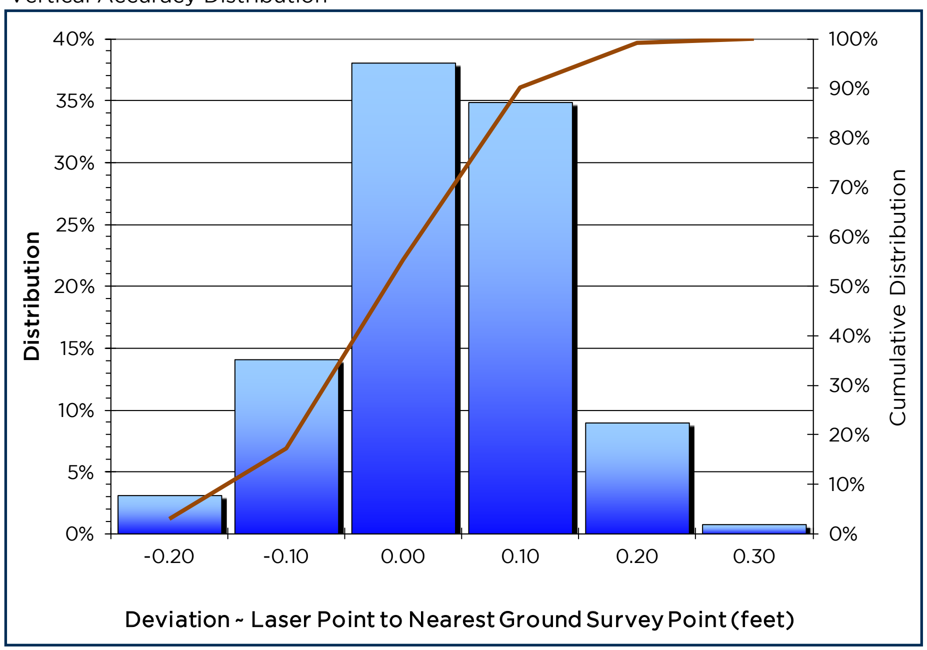
Vertical Accuracy

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 to the triangulated LiDAR surface. Vertical accuracy statistical analysis uses ground control 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 Umatilla study area, 2,903 GSPs were collected.

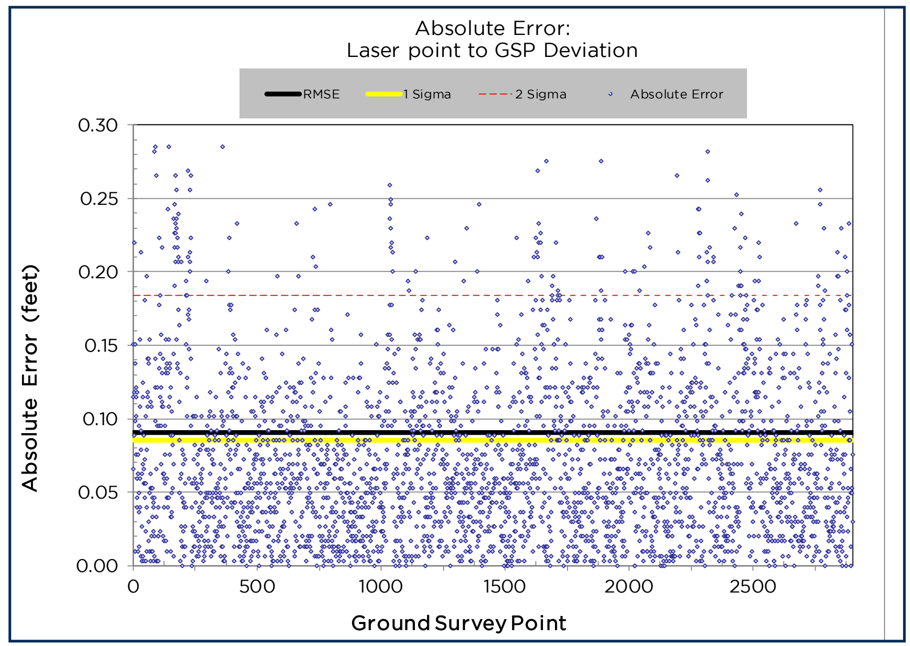
For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as “Compiled to Meet.” Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation statistics displayed below.

Vertical Accuracy Results	
Sample Size (n)	2,903 Ground survey points
FVA (RMSE*1.96)	0.18 ft. (0.05 m)
Root Mean Square Error	0.09 ft. (0.03 m)
1 Standard Deviation	0.09 ft. (0.03 m)
2 Standard Deviation	0.18 ft. (0.06 m)
Average Deviation	0.07 ft. (0.02 m)
Minimum Deviation	-0.29 ft. (-0.09 m)
Maximum Deviation	0.26 ft. (0.08 m)

Vertical Accuracy Distribution



GSP Absolute Error



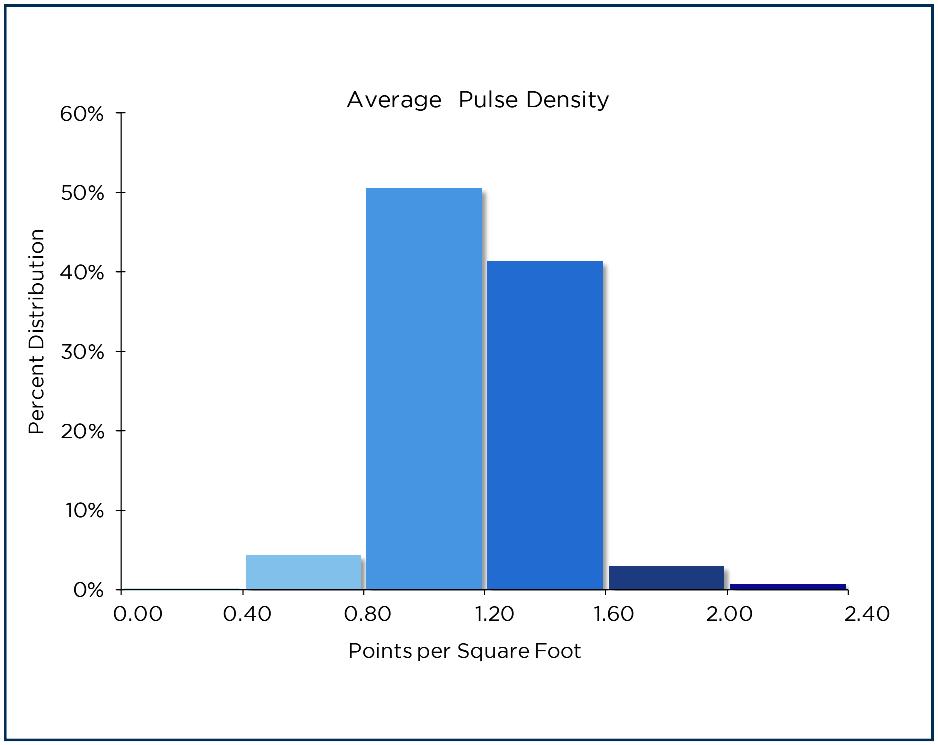
Density

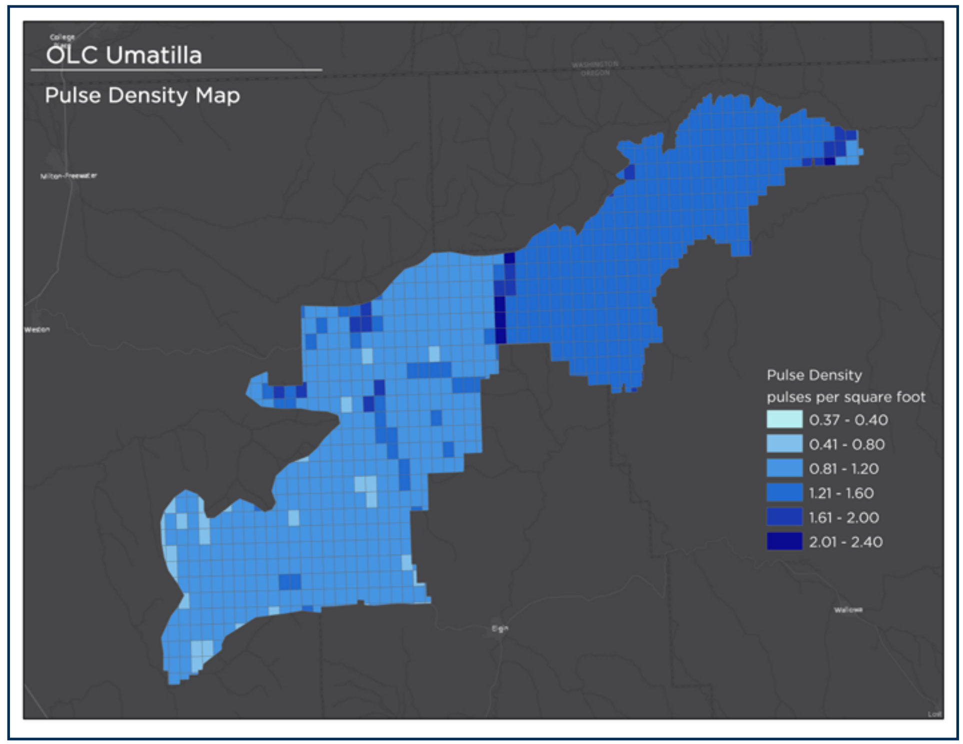
Pulse Density

Final pulse density is calculated after processing and is a measure of first returns per sampled area. 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. Densities are reported for the delivery area.

Average Pulse Density	pulses per square foot	pulses per square meter
	1.14	12.29

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



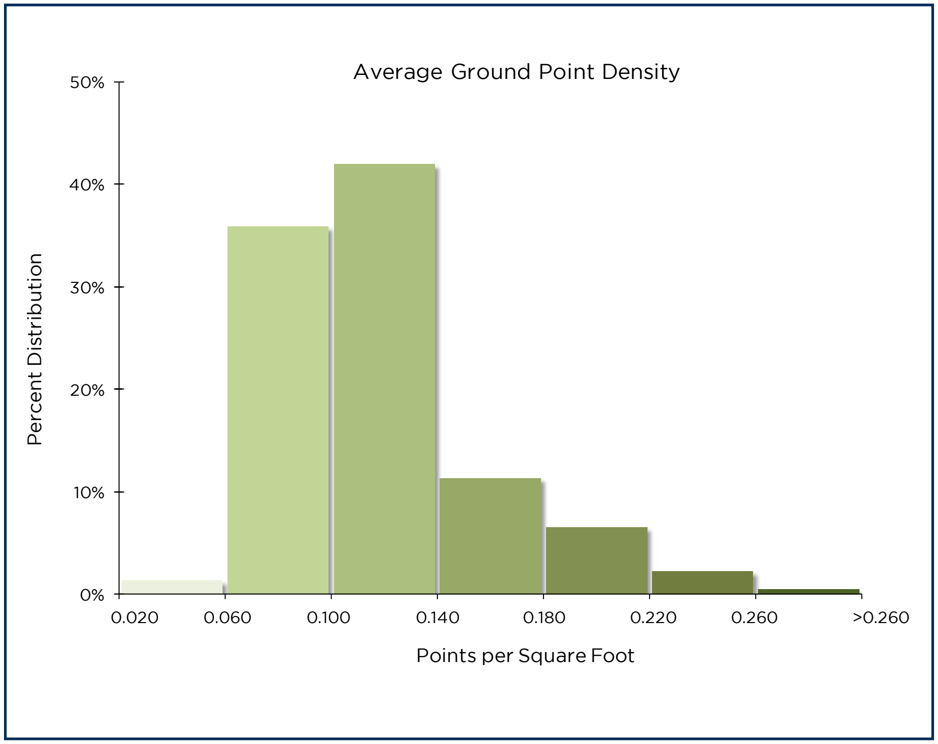


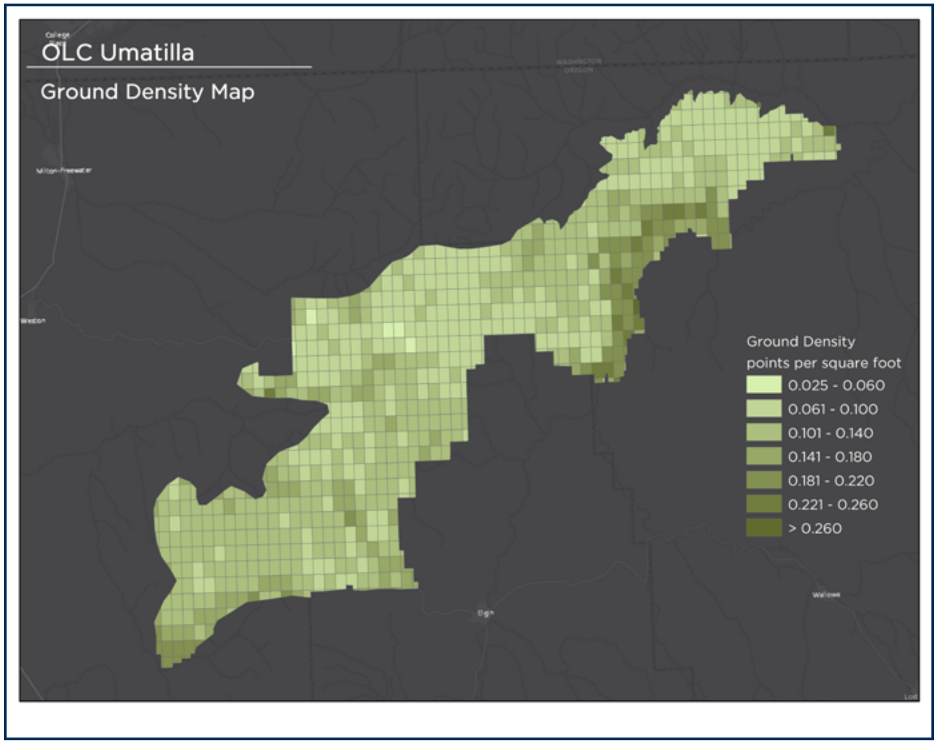
Ground Density

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. The classifications are influenced by terrain and grounding parameters that are adjusted for the dataset. The reported ground density is a measure of ground-classified point data for the delivery area.

Ground Density	points per square foot	points per square meter
	0.12	1.24

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





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Appendix A : PLS Certification

WSI, a Quantum Spatial company, provided LiDAR Services for OLC Lane County LiDAR project Delivery 8 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.

2/20/2015

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 September 7, 2013 and July 6, 2014. 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".

2/20/2015

Christopher Glantz, PLS
Land Surveyor
WSI, a Quantum Spatial Company
Portland, OR 97204

REGISTERED
PROFESSIONAL
LAND SURVEYOR

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