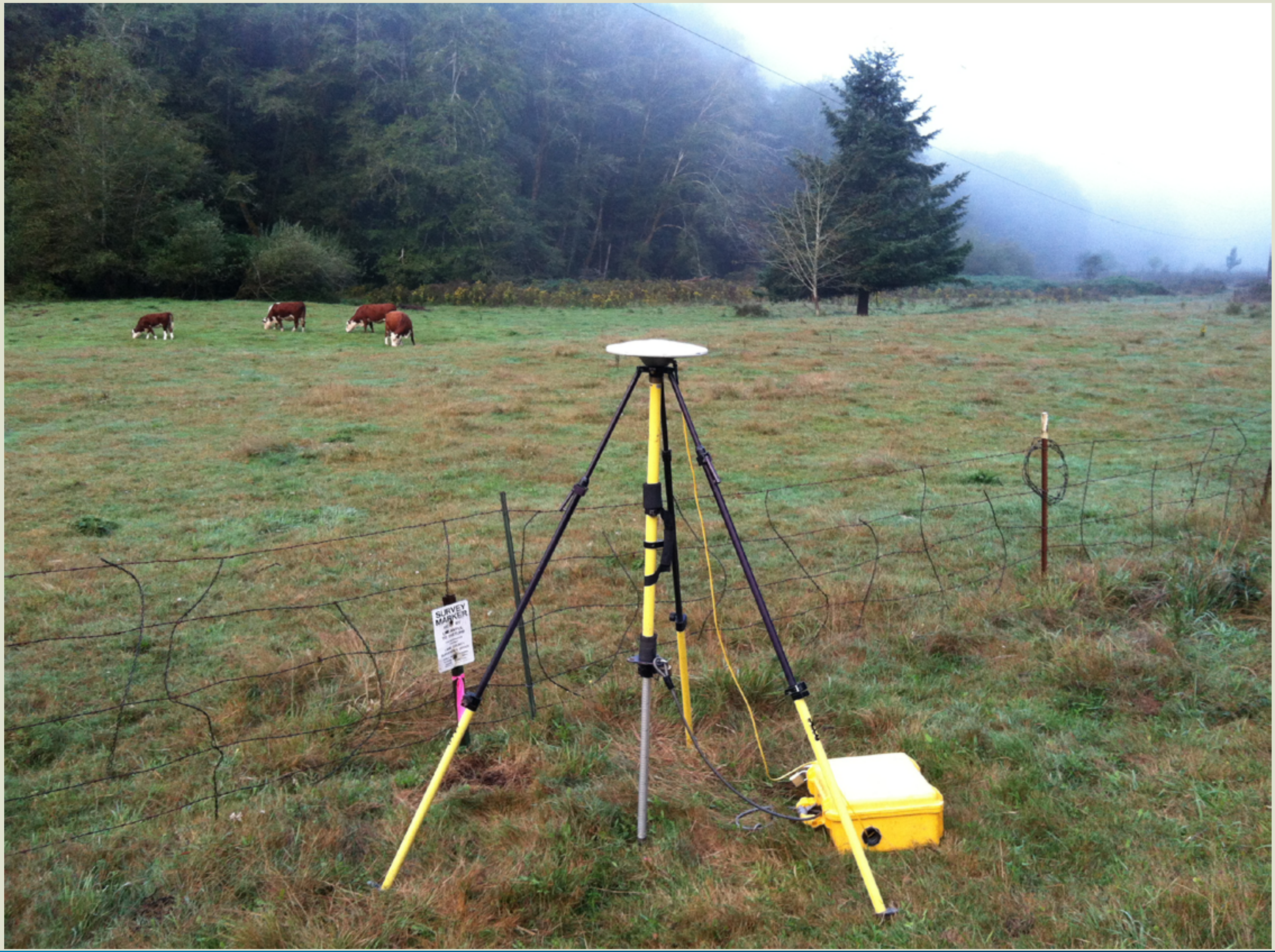
WSI Applied Remote Sensing and Analysis

OLC Lane County: Delivery 10



December 28 , 2015

GPS Monument Lane_06 with Trimble R7 and R8.

Data collected for:
Oregon Department of Geology and Mineral Industries

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GPS Monument “Lane_05”

Project Overview

WSI has completed the acquisition and processing of Light Detection and Ranging (LiDAR) data and Four-Band Radiometric Image Enhanced Survey (FRIES) of the OLC Lane County Delivery Area Ten (final delivery), for the Oregon Department of Geology and Mineral Industries (DOGAMI). The Oregon LiDAR Consortium's Lane County project area of interest (AOI) encompasses 2,030,099 acres. Delivery Area Ten encompasses 548,022 acres.

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.

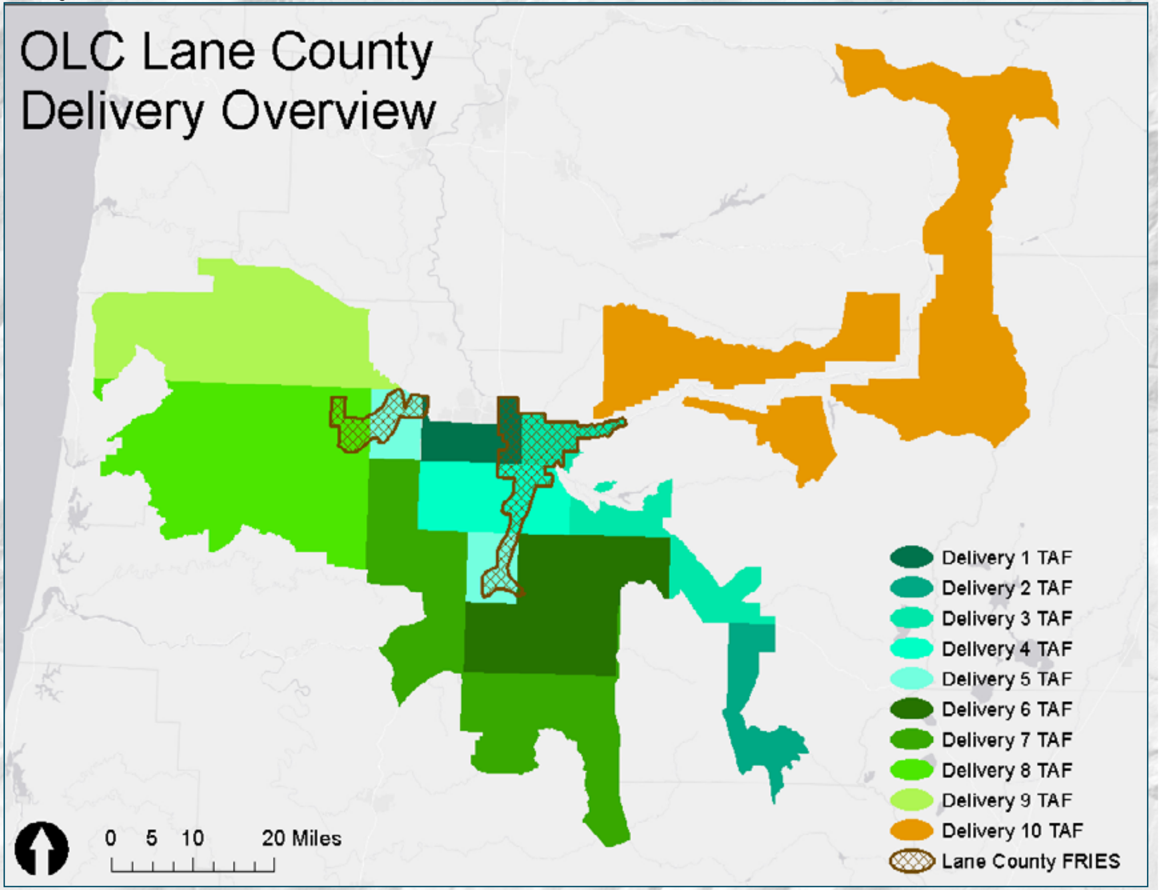
WSI began data collection on September 5, 2013 and was completed on June 8, 2015. Delivery Area Ten was acquired between July 7, 2014 and June 8, 2015. Settings for LiDAR data capture produced an average resolution of at least eight pulses per square meter.

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, 3-inch orthophotos, ground density rasters, study area vector shapes, acquisition shapes, and corresponding statistical data.

WSI acquires and processes data in the most current, NGS-approved datums and geoid. For OLC Lane county, 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 Lane County Delivery 10 Data Delivered December 28, 2015	
Acquisition Dates	7/7/2014 - 6/8/2015
Delivery Area Ten Area of Interest	548,022 acres
Projection	Oregon Lambert
Datum: horizontal & vertical	NAD83 (2011) NAVD88 (Geoid 12A)
Units	International Feet

Study Area



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

Aerial Acquisition

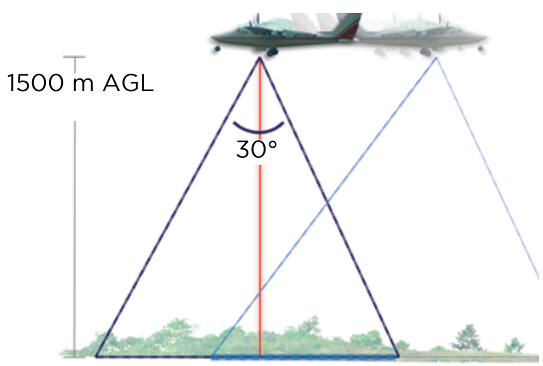
Cessna Caravan

LiDAR Survey

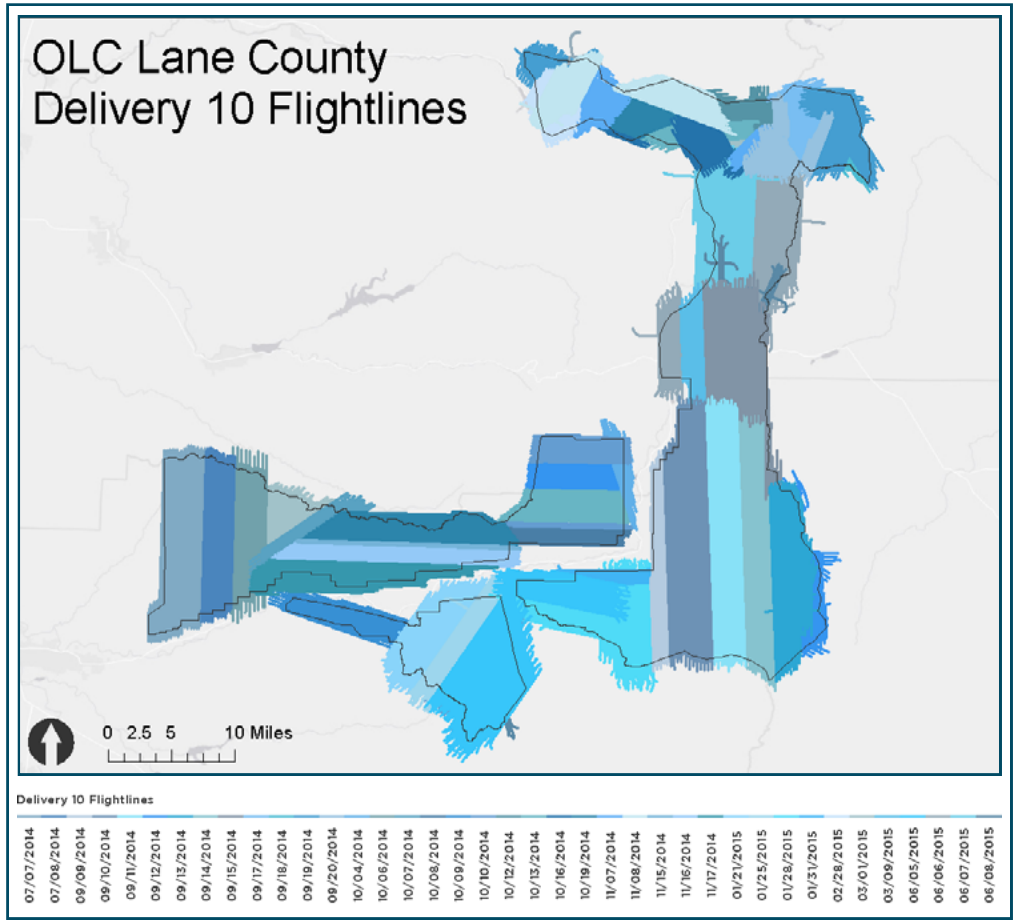
The OLC Lane County Delivery 10 LiDAR survey utilized the Leica ALS80 sensor mounted in a Cessna Caravan 208. The system was programmed to emit single pulses at a rate of 350 kilohertz and flown at 1,500 meters above ground level (AGL), capturing a scan angle of +/-15 degrees from nadir (field of view 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, 1,460 full and partial flightlines provide coverage of the study area.



Project Flightlines



Lane County Delivery 10 Acquisition Specifications	
Sensors Deployed	Leica ALS 80
Aircraft	Cessna Caravan 208B
Survey Altitude (AGL)	1,500 m
Pulse Rate	350 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

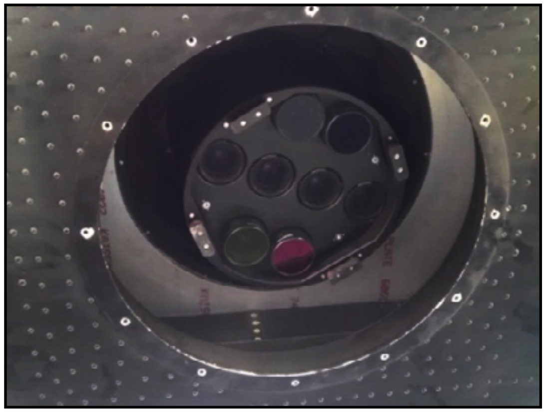
Aerial Acquisition

Photography

The photography or Four-Band Radiometric Image Enhanced Survey (FRIES) utilized an UltraCam Eagle 260 megapixel camera mounted in a Cessna 208B Caravan. 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.



Above: UltraCam Eagle lens configuration as viewed from the Cessna Caravan.

Above: A Cessna Grand Caravan 208B was employed in the collection of all orthoimagery.

Below: UltraCam Eagle installed in the aircraft.

Orthophoto Processing

Within the UltraMap software suite, raw acquired images are radiometrically and geometrically corrected using the camera's calibration files and output as Level 2 images. The resulting radiometry is then manually edited to ensure each image has the appropriate tone, no pixels are clipped, and to blend each image with its neighbors. Once radiometry has been edited, separate RGBI and panchromatic images are blended together to form single level 3 pan-sharpened 4 band TIFF images.

The kinematic GPS positional data is post-processed in office, using static monument coordinates from base stations that were occupied for a minimum of 6 hours and were running during the time of acquisition. Photo position and orientation are calculated by linking the time of image capture, the corresponding aircraft position and attitude, and the smoothed best estimate of trajectory (SBET) data in POSPac MMS, and outputting an initial Exterior Orientations (EO) file.

The EO file is combined with level 3 TIFFs within the Inpho software suite to place the images frames spatially. Aerial triangulation is performed to tie the image frames to each other, and to align them with surveyed ground control coordinates. A point cloud ground model is generated from the image frames by finding matching pixels between images and calculating the coordinates of each extracted point. Triangulated image frames are then draped onto a DEM, derived from the extracted point cloud and orthorectified. Individual orthorectified tiffs are blended together to remove seams and corrected for any remaining radiometric differences between images using Inpho's OrthoVista. The 4-Band image mosaic is tiled to create a usable GeoTIFF raster product.

The 4-band GeoTIFF format allows for flexibility in image analysis and display. By adjusting the image band setup to display the near infrared spectral band as red (this display is known as color-infrared), vegetation stands out extremely vividly in the orthophoto mosaic.

Digital Orthophotography Survey Specifications	
Aircraft	Cessna 208-B Grand Caravan
Sensor	UltraCam Eagle
Altitude	1,846 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

Below: Trimble R7 set up over monument "AI1995".

Aerial Targets

Prior to photo acquisition, permanent and temporary aerial photo targets were located and installed throughout the study area. The air targets were set within two miles of a GPS base location and target control points (TCPs) were collected at each corner of the target, as well as the center point, for utilization in the processing and quality control of the orthophoto deliverables.

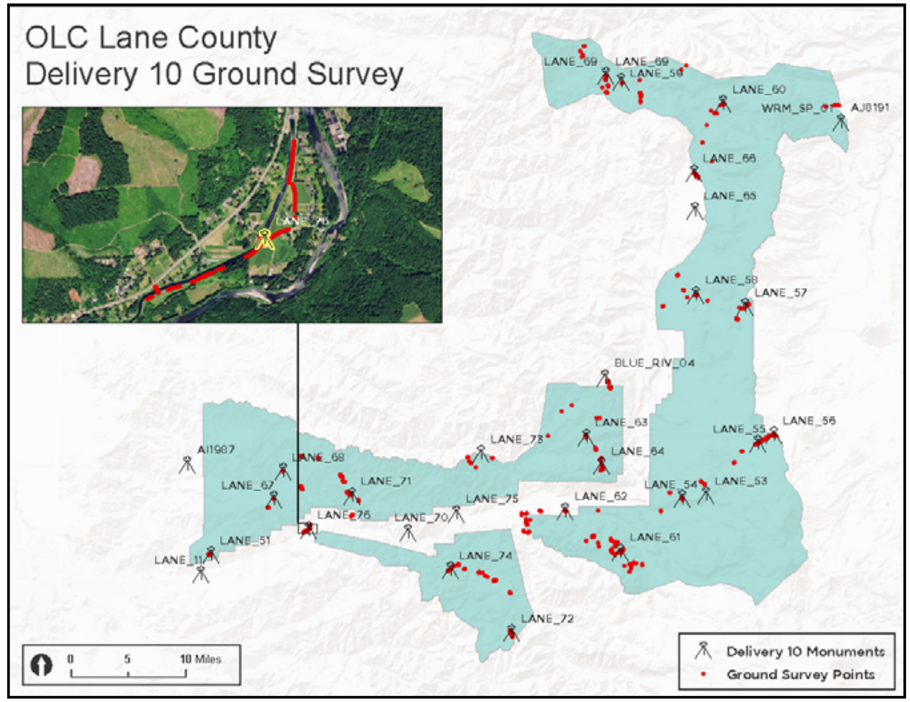
Because temporary air targets are subject to possible outside influences (e.g., weather, curious public, wildlife), WSI identifies locations adequate for collection of TCPs that are on permanent features. Selected locations include existing aerial targets, turn-arrows, STOP bars, etc. that are visible from the aircraft. WSI also paints permanent targets in appropriate locations when necessary. Additional permanent air targets were identified in the field and used for processing orthophotos.

All TCPs were acquired using one of two methods. The air targets that were set within two miles of a GPS base location had TCPs collected at each corner of the target as well as the center point. In order to increase TCP sample size for data quality, WSI also used a Fast-Static (FS) survey technique by baseline post-processing. For the air targets that were set this way, WSI collected a single static session with the R8 rover set over the center point of the target. The FS sessions lasted 15-30 minutes, depending on the distance from the air target to the base station. The static sessions and the concurrent R7 base session data were later processed in Trimble Business Center software. The use of post processing eliminates the need to deal with radio link issues, and fast static methodology generally results in precision equal to or better than full RTK collection on each target.

Examples of permanent air targets.

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 R6, Trimble R8, and Trimble R10 GNSS receivers.

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).

Monument locations were selected with consideration for satellite visibility, field crew safety, and optimal location for GSP coverage. QSI utilized 26 new monuments and four existing monuments for the OLC Lane County project. New monumentation was set using 5/8” x 30” rebar topped with stamped 2” aluminum caps. QSI’s professional land surveyor, Christopher Glantz (OR PLS #83648) oversaw and certified the establishment of all monuments.

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 page nine provides the list of monuments used in Delivery Area Ten. See Appendix B for a complete list of monuments placed within the OLC Lane County Study Area.

Methodology

Ground survey points (GSPs) are collected using Real Time Kinematic (RTK) and Post Processed Kinematic (PPK) survey techniques. For RTK surveys, a Trimble R7 base unit was set up over an appropriate monument to broadcast a real-time correction to a roving R6, R8, or R10 unit. This RTK rover survey allows for precise location measurement (2.0 centimeter). All RTK measurements were made during periods with a Position Dilution of Precision (PDOP) of less than 3.0 and in view of at least six satellites by the stationary reference and roving receiver. For RTK data, the collector recorded at least a five-second stationary observation, and then calculated the pseudorange position from three one-second epochs with relative error less than 1.5 centimeter horizontal and 2.0 centimeter vertical.

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

GSP positions were collected on bare earth locations such as paved, gravel or stable dirt roads, and other locations where the ground was clearly visible (and was likely to remain visible) from the sky during the data acquisition and GSP measurement periods. In order to facilitate comparisons with LiDAR data, GSP measurements were not taken on highly reflective surfaces such as center line stripes or lane markings on roads. The planned locations for control points were determined prior to field deployment, and the suitability of these locations was verified on site. The distribution of ground survey points 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 R6	Integrated GNSS Antenna R6	TRM_R6	Rover
Trimble R8	Integrated Antenna R8 Model 2	TRM_R8_GNSS	Static, Rover
Trimble R10	Integrated Antenna R10	TRMR10	Rover

PID	Latitude	Longitude	Ellipsoid Height (m)	Othometric Height (m)
AI1987	44° 12' 27.42931"	-122° 49' 49.03656"	157.321	180.547
AJ8191	44° 39' 23.18028"	-121° 41' 33.57573"	1983.063	2004.142
BLUE_RIV_04	44° 19' 45.50913"	-122° 06' 01.51323"	1412.718	1434.494
LANE_11	44° 04' 08.74341"	-122° 48' 06.59661"	161.587	184.843
LANE_51	44° 05' 39.63958"	-122° 47' 04.98635"	545.973	569.170
LANE_53	44° 11' 00.46734"	-121° 55' 12.33453"	1466.849	1487.977
LANE_54	44° 10' 41.98041"	-121° 57' 40.08010"	1208.453	1229.835
LANE_55	44° 14' 58.44023"	-121° 49' 52.63978"	1558.758	1579.651
LANE_56	44° 15' 38.38604"	-121° 48' 09.68817"	1601.779	1622.656
LANE_57	44° 25' 19.90234"	-121° 51' 23.67546"	1434.237	1455.411
LANE_58	44° 26' 11.01683"	-121° 56' 36.51882"	1117.648	1139.020
LANE_59	44° 42' 09.70199"	-122° 04' 57.99867"	497.773	519.608
LANE_60	44° 40' 38.57139"	-121° 54' 04.98722"	1281.918	1303.188
LANE_61	44° 06' 36.49027"	-122° 04' 04.83173"	1438.496	1460.115
LANE_62	44° 09' 36.54184"	-122° 09' 57.92458"	418.342	440.548
LANE_63	44° 15' 13.30087"	-122° 07' 55.02809"	1377.917	1399.839
LANE_64	44° 13' 05.95603"	-122° 06' 13.58282"	1482.944	1504.845
LANE_65	44° 32' 32.44739"	-121° 56' 55.23407"	1309.719	1331.132
LANE_66	44° 35' 22.26603"	-121° 57' 03.82977"	1007.465	1028.968
LANE_67	44° 09' 58.41010"	-122° 40' 34.96786"	736.802	759.768
LANE_68	44° 12' 06.66895"	-122° 39' 43.82798"	699.408	722.356
LANE_69	44° 42' 36.07454"	-122° 06' 34.98350"	463.910	485.791
LANE_70	44° 07' 45.63642"	-122° 26' 24.72517"	543.955	566.617
LANE_71	44° 10' 24.58901"	-122° 32' 25.77843"	536.990	559.796
LANE_72	44° 00' 18.08908"	-122° 15' 17.28580"	1623.222	1645.274
LANE_73	44° 13' 48.46606"	-122° 18' 56.85686"	1319.790	1341.995
LANE_74	44° 04' 58.19343"	-122° 21' 53.66019"	715.086	737.581
LANE_75	44° 09' 14.03758"	-122° 21' 22.49449"	302.432	324.989
LANE_76	44° 07' 45.92618"	-122° 36' 53.81440"	205.074	227.969
WRM_SP_01	44° 39' 22.75371"	-121° 41' 33.13407"	1981.876	2002.956

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

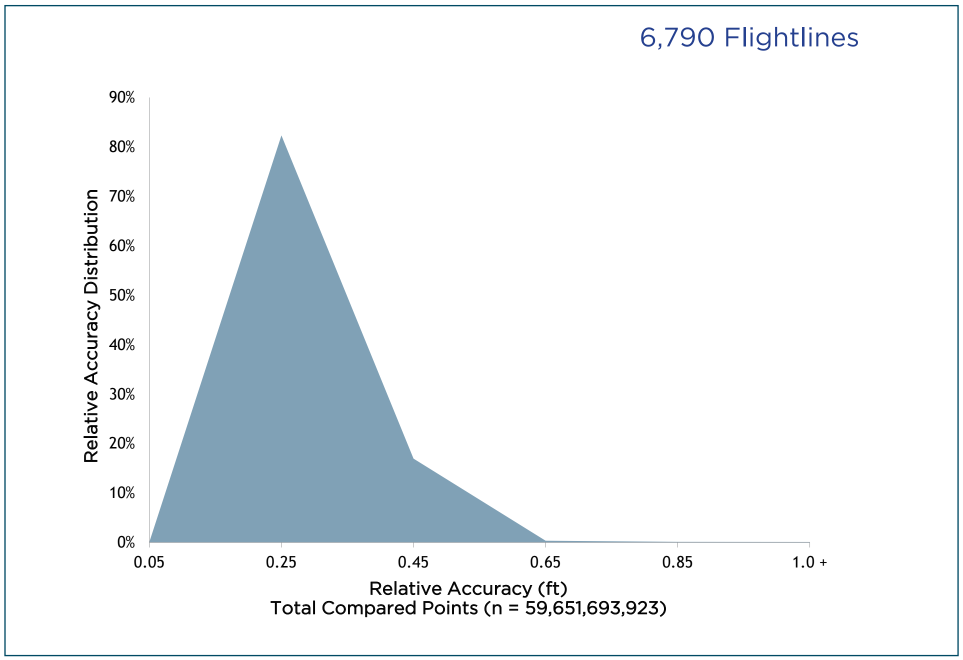
LiDAR Accuracy

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 6,790 full and partial flightlines (1,460 full and partial flightlines from Delivery Area Ten) and over 59 billion points. Relative accuracy is reported for the cumulative delivered portions of the study area.

Cumulative Relative Accuracy Distribution



Relative Accuracy Results	Delivery 10	Cumulative
Sample Size (N)	1,460 flightlines	6,790 flightlines
Project Average	0.201 ft. (0.061 m)	0.196 ft. (0.057 m)
Median Relative Accuracy	0.197 ft. (0.060 m)	0.190 ft. (0.058 m)
1σ Relative Accuracy	0.223 ft. (0.068 m)	0.217 ft. (0.066 m)
2σ Relative Accuracy	0.274 ft. (0.083 m)	0.313 ft. (0.096 m)

R7 Receiver

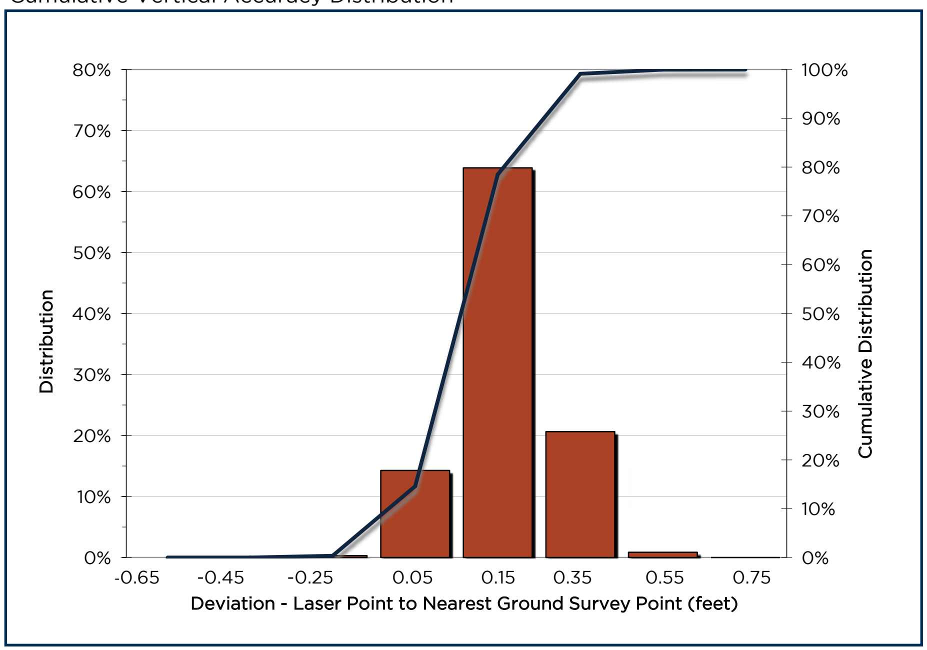
Vertical Accuracy

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 Lane County Delivery Ten study area, 5,535 GSPs were collected. Statistics are shown for Delivery Area Ten and cumulative (right).

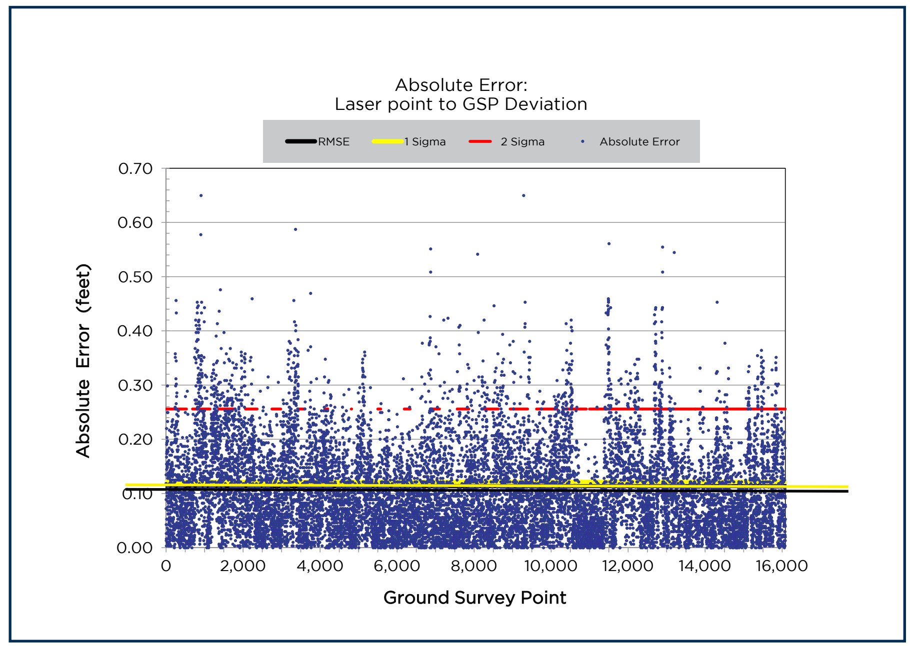
For this project, no independent survey data were collected, nor were reserved points collected for testing. As such, vertical accuracy statistics are reported as "Compiled to Meet." Vertical Accuracy is reported for the entire study area and reported in the table below. Histogram and absolute deviation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

Vertical Accuracy Results		
	Delivery Area Ten	Cumulative
Sample Size (n)	5,535 Ground survey points	16,085 Ground survey points
Root Mean Square Error	0.10 ft. (0.03 m)	0.11 ft. (0.03 m)
1 Standard Deviation	0.11 ft. (0.04 m)	0.12 ft. (0.04 m)
2 Standard Deviation	0.25 ft. (0.08 m)	0.26 ft. (0.08 m)
Average Deviation	0.10 ft. (0.03 m)	0.10 ft. (0.03 m)
Minimum Deviation	-0.54 ft. (-0.17 m)	-0.65 ft. (-0.20 m)
Maximum Deviation	0.56 ft. (0.17 m)	0.65 ft. (0.20 m)

Cumulative Vertical Accuracy Distribution



Cumulative GSP Absolute Error



Density

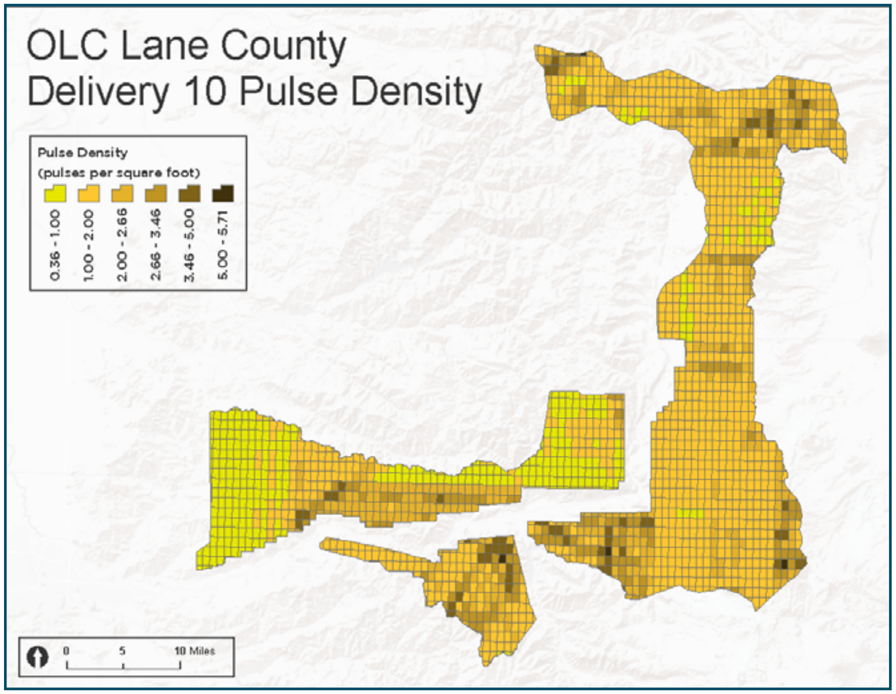
Pulse Density

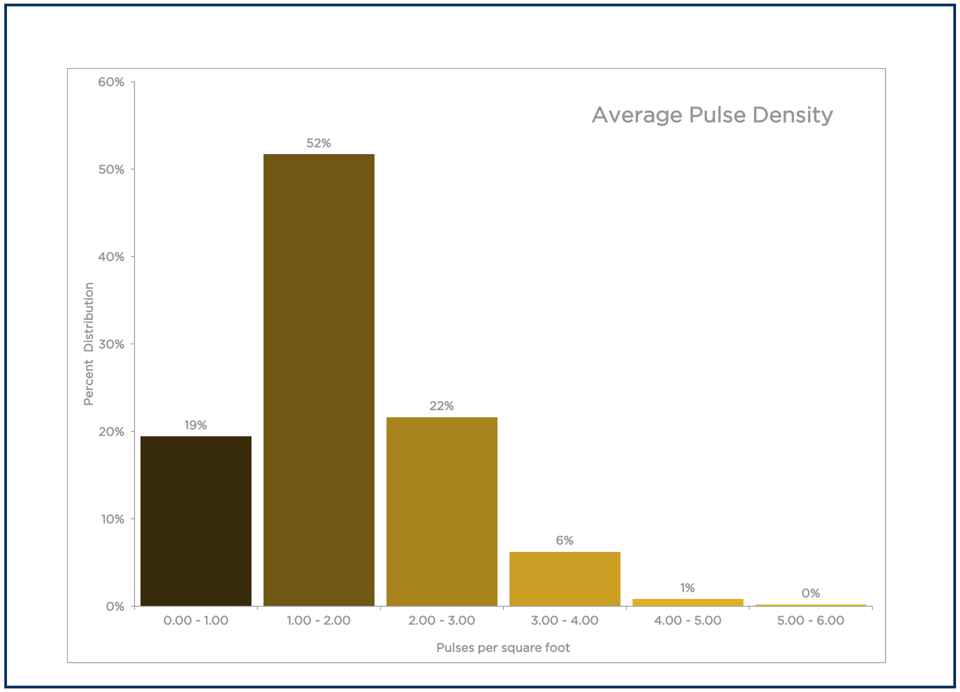
Final pulse density is calculated after processing and is a measure of first returns per sampled area. Some types of surfaces (e.g., dense vegetation, water) may return fewer pulses than the laser originally emitted. Therefore, the delivered density can be less than the native density and vary according 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.

Delivery 10 Average Pulse Density	pulses per square meter	pulses per square foot
	18.08	1.68

Cumulative Average Pulse Density	pulses per square meter	pulses per square foot
	12.44	1.16

Average Pulse Density per 0.75' USGS Quad (color scheme aligns with density chart). Below left, note area of minimal pulse density over water body.





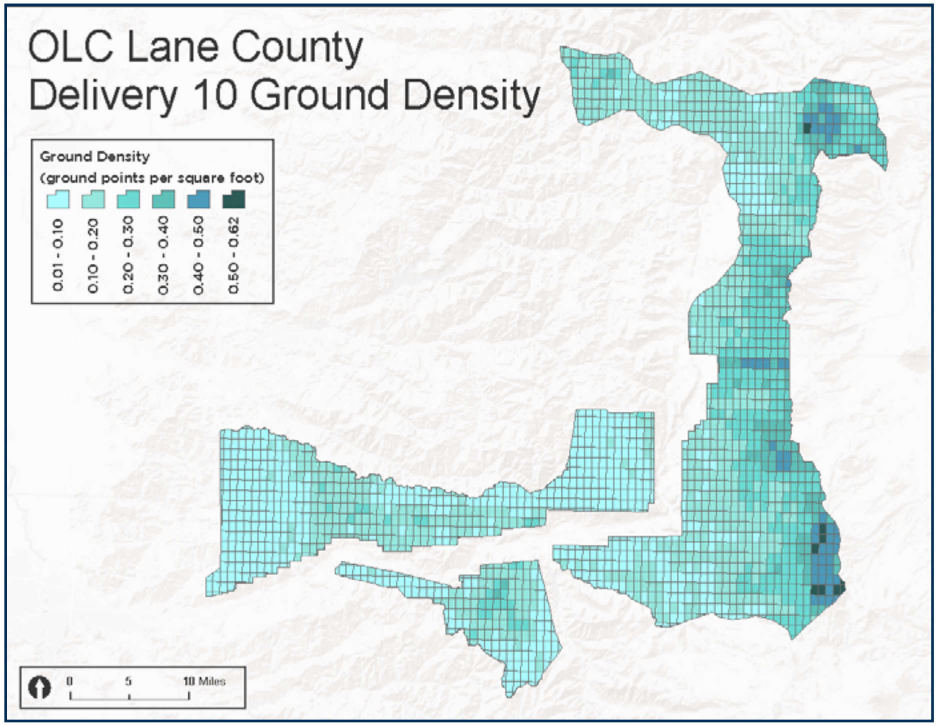
Ground Density

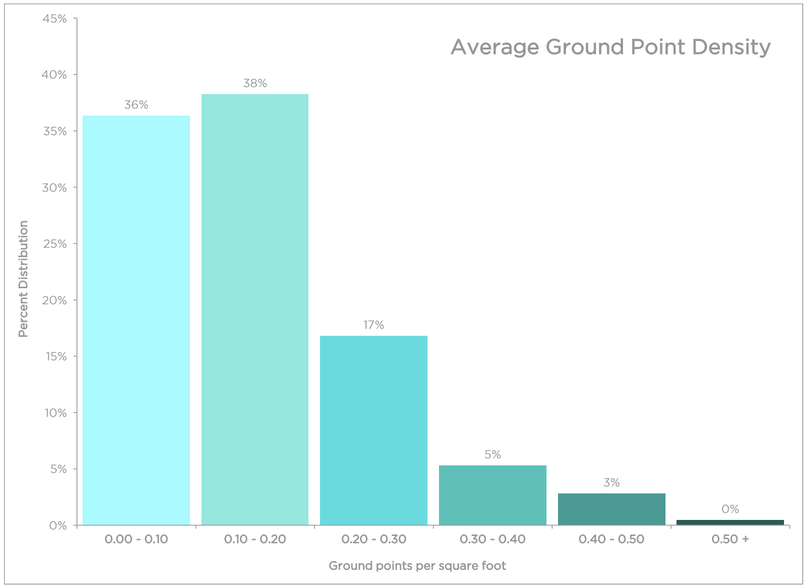
Ground classifications were derived from ground surface modeling. Further classifications were performed by reseeding of the ground model where it was determined that the ground model failed, usually under dense vegetation and/or at breaks in terrain, steep slopes, and at tile boundaries. The classifications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

Delivery 10 Average Ground Density	ground points per square meter	ground points per square foot
	1.67	0.16

Cumulative Average Ground Density	ground points per square meter	ground points per square foot
	0.99	0.09

Average Ground 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. Thirteen 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 Lane County project area.

Orthophoto horizontal accuracy results.

Orthophoto Horizontal Accuracy (n=13)	WSI Achieved (m)	WSI Achieved (ft.)
RMSE	0.110	0.360
1 Sigma	0.118	0.388
2 Sigma	0.187	0.612

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Appendix A : PLS Certification

WSI, a Quantum Spatial company, provided LiDAR Services for OLC Lane County LiDAR project Delivery 10 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.

12/23/2015

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 July 7, 2014 and March 1, 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".

12/23/2015

Christopher Glantz, PLS
Land Survey Manager
WSI, a Quantum Spatial Company

Appendix B : GPS Monument Table

List of GPS monuments used in OLC Lane County Survey Area. Coordinates are on the NAD83 (2011) datum, epoch 2010.00. NAVD88 height referenced to Geoid12A.

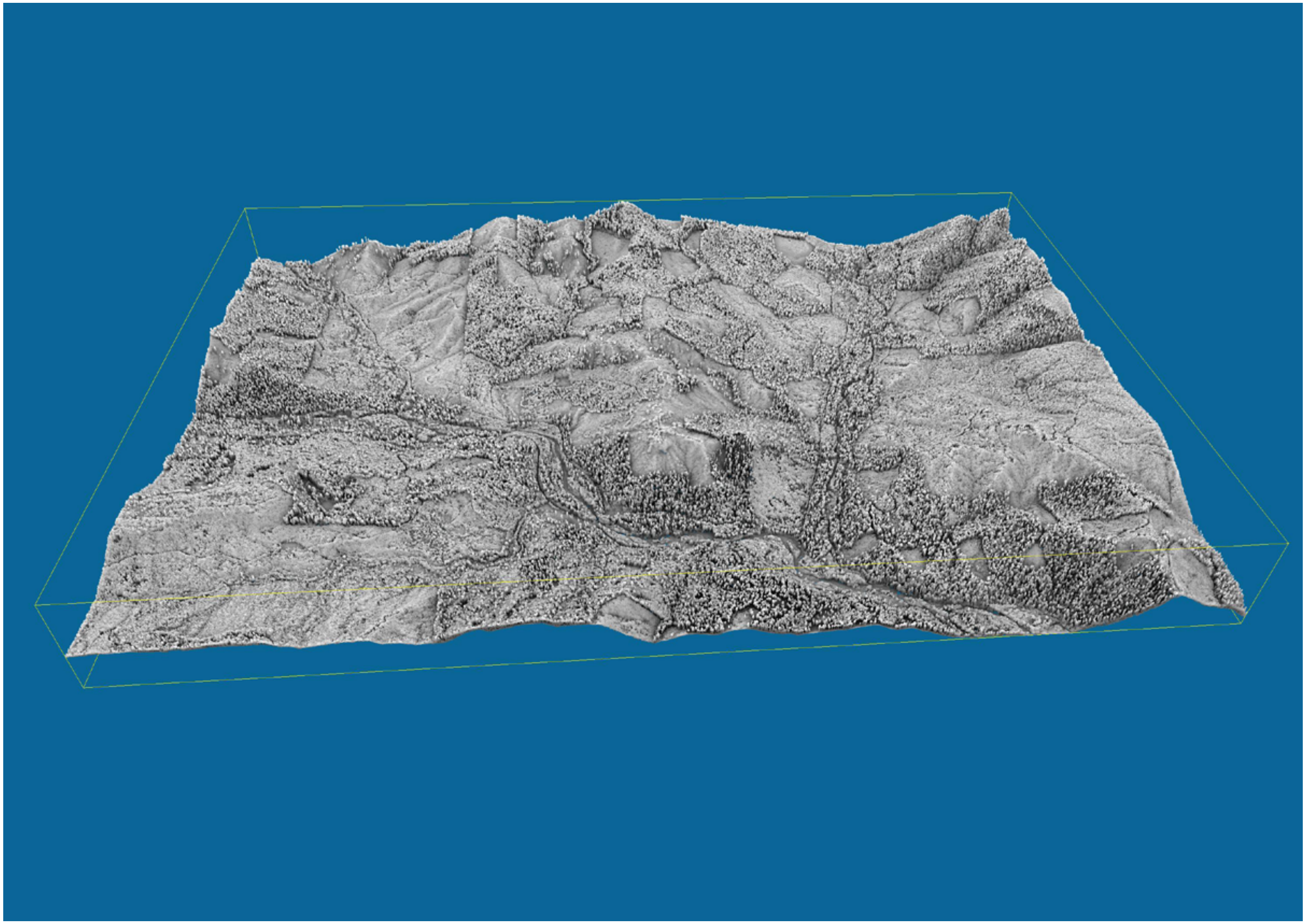
PID	Latitude	Longitude	Ellipsoid Height (m)	NAVD 88 Height (m)
AI1987	44° 12' 27.42931"	-122° 49' 49.03656"	157.321	180.547
AI1995	44° 01' 06.96543"	-123° 51' 37.53642"	-15.700	7.830
AI2001	43° 55' 19.20493"	-122° 47' 41.08223"	195.963	219.207
AJ8191	44° 39' 23.18028"	-121° 41' 33.57573"	1983.063	2004.142
BLUE_RIV_04	44° 19' 45.50913"	-122° 06' 01.51323"	1412.718	1434.494
LANE_01	44° 13' 34.22103"	-123° 55' 25.99216"	487.832	510.916
LANE_02	44° 11' 04.59366"	-123° 51' 03.90195"	104.844	127.923
LANE_03	44° 17' 35.16542"	-123° 41' 42.13047"	69.602	92.380
LANE_04	44° 19' 30.86443"	-123° 39' 58.03953"	230.843	253.546
LANE_05	44° 16' 43.86859"	-124° 02' 41.13217"	458.248	481.771
LANE_06	44° 12' 10.80761"	-123° 30' 31.42667"	196.503	219.151
LANE_06	44° 12' 10.80764"	-123° 30' 31.42667"	196.522	219.169
LANE_06A	44° 14' 32.55999"	-123° 24' 47.48386"	336.456	359.076
LANE_07	43° 59' 52.25896"	-123° 22' 23.48186"	143.322	166.275
LANE_08	44° 08' 23.10388"	-123° 35' 55.56664"	168.733	191.568
LANE_09	44° 04' 26.42150"	-123° 30' 21.24330"	133.059	155.944
LANE_10	44° 00' 11.70302"	-123° 59' 45.31927"	-21.486	2.572
LANE_11	44° 04' 08.74341"	-122° 48' 06.59661"	161.587	184.843
LANE_12	44° 05' 44.71178"	-123° 43' 49.91180"	63.439	86.487
LANE_13	44° 00' 41.08475"	-122° 59' 27.48519"	119.047	142.488
LANE_14	43° 50' 13.64839"	-123° 14' 03.11154"	175.699	198.720
LANE_15	43° 59' 28.97732"	-122° 56' 10.19436"	139.378	162.854
LANE_16	43° 49' 45.78726"	-123° 07' 47.74145"	212.747	235.886
LANE_17	43° 59' 22.07068"	-123° 11' 07.80197"	111.693	134.821
LANE_18	43° 55' 40.86962"	-123° 37' 20.35729"	178.186	201.375
LANE_19	44° 00' 01.44296"	-123° 13' 56.62771"	104.781	127.866
LANE_20	43° 53' 27.38516"	-123° 28' 30.83622"	153.934	176.937
LANE_22	43° 52' 51.72856"	-123° 13' 33.92296"	147.785	170.814

PID	Latitude	Longitude	Ellipsoid Height (m)	NAVD 88 Height (m)
LANE_23	43° 47’ 25.93196”	-123° 01’ 54.25135”	176.209	199.467
LANE_24	43° 42’ 26.18996”	-122° 25’ 40.56001”	450.794	473.495
LANE_25	43° 42’ 51.38283”	-122° 23’ 45.43363”	792.318	814.931
LANE_26	43° 33’ 00.45694”	-122° 28’ 22.66794”	815.341	838.000
LANE_27	43° 31’ 20.08417”	-122° 20’ 15.46234”	1080.075	1102.416
LANE_28	43° 53’ 58.92454”	-122° 48’ 59.17889”	194.478	217.704
LANE_29	43° 52’ 12.08177”	-122° 47’ 18.45224”	420.380	443.439
LANE_29A	43° 52’ 12.08161”	-122° 47’ 18.45256”	420.361	443.420
LANE_30	43° 37’ 14.50986”	-123° 05’ 19.83916”	253.542	276.603
LANE_31	43° 45’ 16.82389”	-122° 26’ 41.15314”	492.053	514.761
LANE_32	43° 47’ 33.82161”	-122° 25’ 40.76291”	677.205	699.811
LANE_33	43° 36’ 30.58173”	-123° 01’ 40.84386”	471.540	494.595
LANE_34	43° 45’ 30.54400”	-122° 29’ 48.47559”	308.081	330.845
LANE_35	43° 48’ 11.57911”	-122° 42’ 37.56859”	1041.596	1064.354
LANE_36	43° 50’ 54.28025”	-123° 21’ 47.73924”	229.292	252.262
LANE_37	43° 51’ 23.46541”	-123° 25’ 02.19196”	197.776	220.754
LANE_38	43° 58’ 54.14928”	-123° 41’ 53.55130”	424.298	447.506
LANE_39	43° 42’ 19.93987”	-122° 57’ 05.04012”	456.450	479.573
LANE_40	43° 35’ 23.35579”	-123° 00’ 04.90380”	479.127	502.200
LANE_41	43° 44’ 45.10607”	-122° 53’ 27.75969”	236.302	259.436
LANE_42	43° 40’ 03.45665”	-122° 48’ 42.76721”	311.004	334.076
LANE_43	43° 21’ 17.49608”	-122° 44’ 41.88280”	524.594	547.828
LANE_45	43° 30’ 26.64379”	-122° 50’ 42.75367”	1160.885	1183.730
LANE_46	43° 38’ 28.84405”	-123° 12’ 52.40829”	104.565	127.600
LANE_47	43° 35’ 46.97747”	-123° 15’ 08.04840”	105.980	129.003
LANE_49	43° 41’ 54.47511”	-122° 46’ 16.97790”	331.018	354.016
LANE_51	44° 05’ 39.63958”	-122° 47’ 04.98635”	545.973	569.170
LANE_53	44° 11’ 00.46734”	-121° 55’ 12.33453”	1466.849	1487.977
LANE_54	44° 10’ 41.98041”	-121° 57’ 40.08010”	1208.453	1229.835
LANE_55	44° 14’ 58.44023”	-121° 49’ 52.63978”	1558.758	1579.651

PID	Latitude	Longitude	Ellipsoid Height (m)	NAVD 88 Height (m)
LANE_56	44° 15' 38.38604"	-121° 48' 09.68817"	1601.779	1622.656
LANE_57	44° 25' 19.90234"	-121° 51' 23.67546"	1434.237	1455.411
LANE_58	44° 26' 11.01683"	-121° 56' 36.51882"	1117.648	1139.020
LANE_59	44° 42' 09.70199"	-122° 04' 57.99867"	497.773	519.608
LANE_60	44° 40' 38.57139"	-121° 54' 04.98722"	1281.918	1303.188
LANE_61	44° 06' 36.49027"	-122° 04' 04.83173"	1438.496	1460.115
LANE_62	44° 09' 36.54184"	-122° 09' 57.92458"	418.342	440.548
LANE_63	44° 15' 13.30087"	-122° 07' 55.02809"	1377.917	1399.839
LANE_64	44° 13' 05.95603"	-122° 06' 13.58282"	1482.944	1504.845
LANE_65	44° 32' 32.44739"	-121° 56' 55.23407"	1309.719	1331.132
LANE_66	44° 35' 22.26603"	-121° 57' 03.82977"	1007.465	1028.968
LANE_67	44° 09' 58.41010"	-122° 40' 34.96786"	736.802	759.768
LANE_68	44° 12' 06.66895"	-122° 39' 43.82798"	699.408	722.356
LANE_69	44° 42' 36.07454"	-122° 06' 34.98350"	463.910	485.791
LANE_70	44° 07' 45.63642"	-122° 26' 24.72517"	543.955	566.617
LANE_71	44° 10' 24.58901"	-122° 32' 25.77843"	536.990	559.796
LANE_72	44° 00' 18.08908"	-122° 15' 17.28580"	1623.222	1645.274
LANE_73	44° 13' 48.46606"	-122° 18' 56.85686"	1319.790	1341.995
LANE_74	44° 04' 58.19343"	-122° 21' 53.66019"	715.086	737.581
LANE_75	44° 09' 14.03758"	-122° 21' 22.49449"	302.432	324.989
LANE_76	44° 07' 45.92618"	-122° 36' 53.81440"	205.074	227.969
RP_265+4988	43° 25' 06.36155"	-123° 09' 01.37675"	201.245	224.527
WRM_SP_01	44° 39' 22.75371"	-121° 41' 33.13407"	1981.876	2002.956

Appendix C : Selected Imagery

Orthophotos: **Top Left:** Main Street Bridge, Springfield, Oregon. **Top Right:** McKenzie View Drive, south of Coburg, Oregon. **Bottom Left:** Kellogg Road, Springfield, Oregon **Bottom Right:** Island Park along the Willamette River, Spring-field, Oregon.



Highest Hit DEM of section of Delivery Area Two.

LiDAR derived DEM's: **Above** highest hit DEM and **Below:** bare earth DEM. Both areas depicted are within delivery area three.