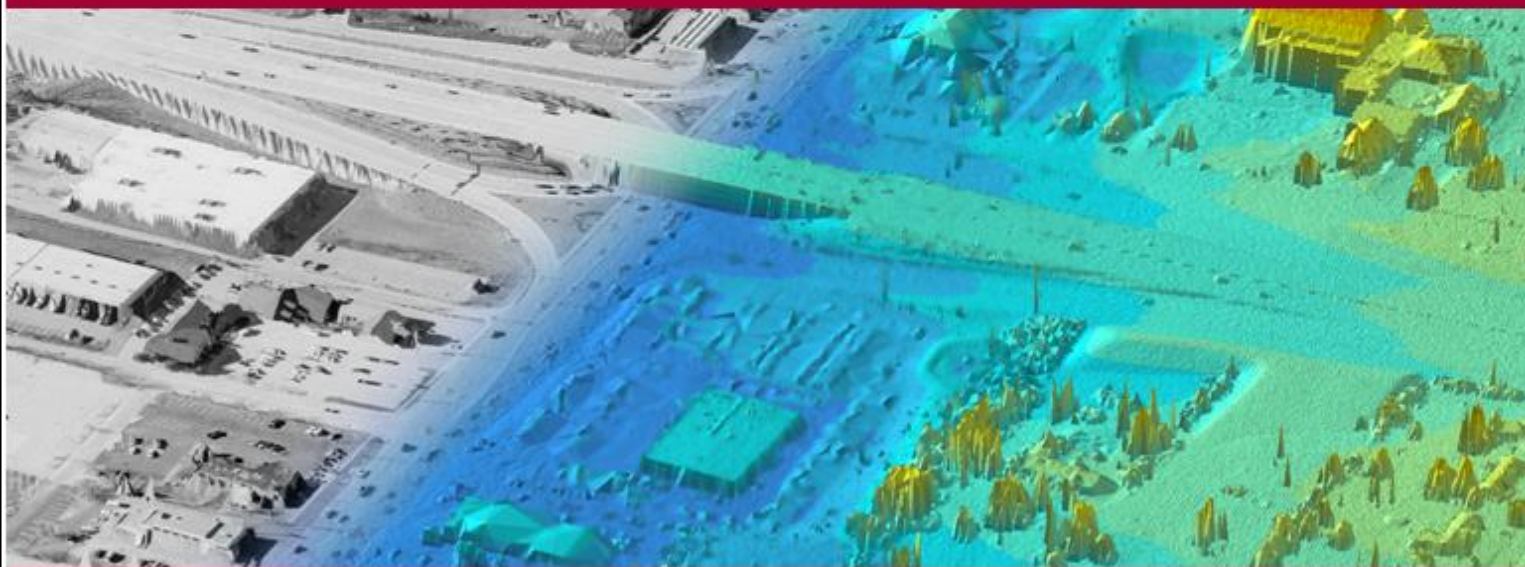


LiDAR ACCURACY REPORT

Project: MO/AR Counties LiDAR Project
Report Area: Ray County, MO
Delivery Order No.: 0018
Contract No.: W912P9-10D-0538
Date: 23-December-2016
Submitted by: Wade Williams, Project Manager



US Army Corps of Engineers, St. Louis District

Project Overview

The St. Louis District of the United States Army Corps of Engineers (USACE) contracted with Surdex Corporation in the fall of 2013 to collect high resolution LiDAR elevation data over multiple counties as part of the Missouri & Arkansas Counties Lidar Project. The project combines the varied interests of the MO-NRCS, MO-DNR, USGS, USACE and Arkansas Game & Fish totaling over 20,200 square miles of coverage. Processing of the LiDAR data and bare-earth model followed USGS Base LiDAR Specifications V1.0 standards. Surdex tested that the deliverables meet or exceed accuracy as stated in NDEP Guidelines for digital elevation data, Version 1.0 for NSSDA of 95% confidence for 2' contours and ASPRS Class I Standards. Hard surface (bare earth) survey control points were collected by Surdex in order to calibrate the swath LAS data, these values are listed in the table on page 3. In addition independent survey check points were collected on hard surface features, in urban areas, in grass & under trees for each delivery area as specified by the USACE. The survey check points were compared to both the Classified LAS LiDAR data & bare-earth Imagine DEM and the differences have been outlined on page 6.

In order to meet the USACE project specifications the FVA of bare-earth points for swath and the DEM will meet or exceed 15.0 centimeters RMSEz or less. The RMSEz was calculated as the square root of the average of the set of squared differences between the bare-earth and the survey points collected for the bare-eath (hard surface) features. Also, 95 percent of the feature should be $\leq 1.96 \times \text{RMSEz}$, which equals 29.4 centimeters or less NSSDA. The SVA's for each land cover of grass, trees & urban features will be $\leq 36.3\text{cm}$ @ the 95th percentile. The overall (CVA) vertical accuracy for all classes will be $\leq 36.3\text{cm}$ @ the 95th percentile. The final results for this delivery area are listed on the last page of this report.

Delivery Area

This report covers the collection and processing of LiDAR elevation data over Ray County MO. The project limits are presented in the graphics below. The project area consisted of approximately 450 square miles of elevation data.

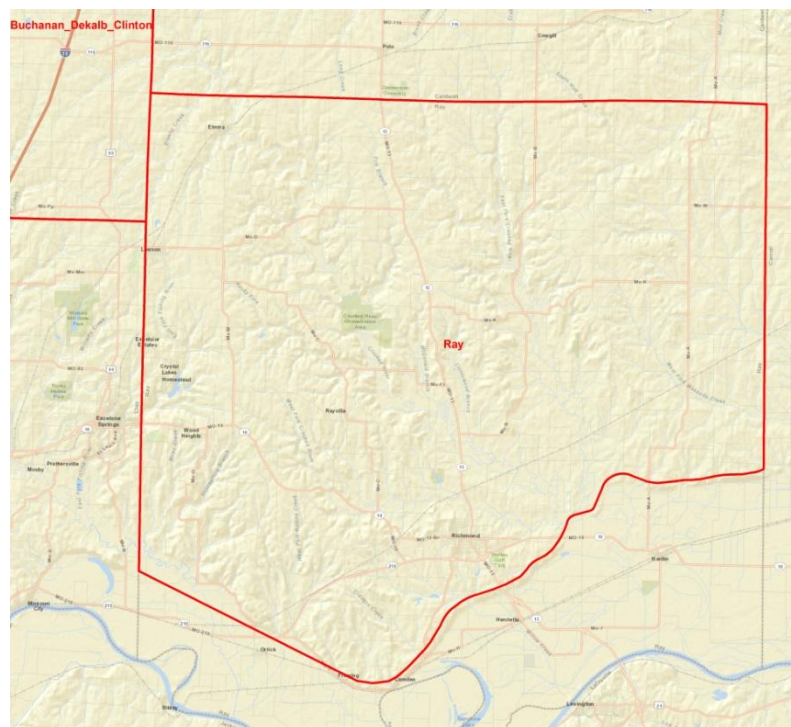


Figure 1 Ray Co. Project Area

LiDAR Data Collection

The LiDAR elevation data for this project was collected with a Leica ALS70HP Aerial LiDAR sensor system. The project design called for acquisition of LiDAR data with lines flown east-west. The nominal collection scenario called for the acquisition of nominal point spacing of 1 meter on the ground.

Ray Co. Swath LiDAR Control

The field survey control for this delivery consisted of 20 hard surface (bare-earth) control points used for calibrating the unclassified LiDAR swath data. The graphic below presents these control points on the delivery area map.

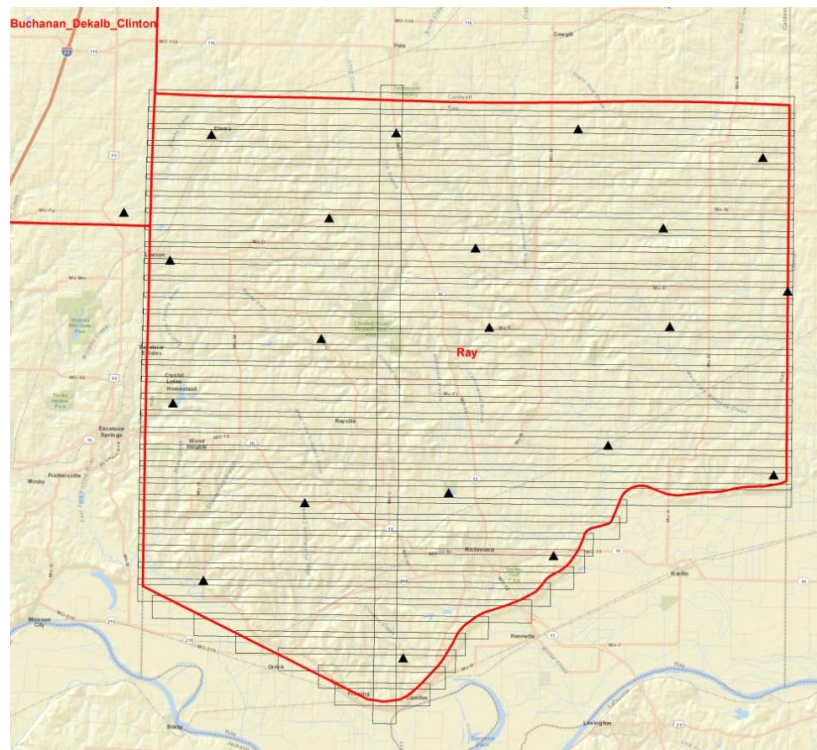


Figure 2 Ray Co. Swath LiDAR Control

Swath LiDAR Control Accuracy Results

The table below presents the results of the control accuracy analysis for the Ray Co., MO unclassified swath LAS data. All values are in meters.

Stat	Hard Surface (HS)
Count	20
RMSEz (FVA)	0.031
95% Confidence Level (FVA)	0.061

Ray Co. LiDAR QC Check

An additional set of survey check points were collected for an independent QC of the Classified LAS & Imagine DEM deliverable tiles. The points were collected over the following feature types: 20 hard surface (HS), 20 grass (G) points, 20 tree (TR) & 21 urban (U) points for a total of 81 qc check points. The graphic below presents these QC check points on the delivery area map.

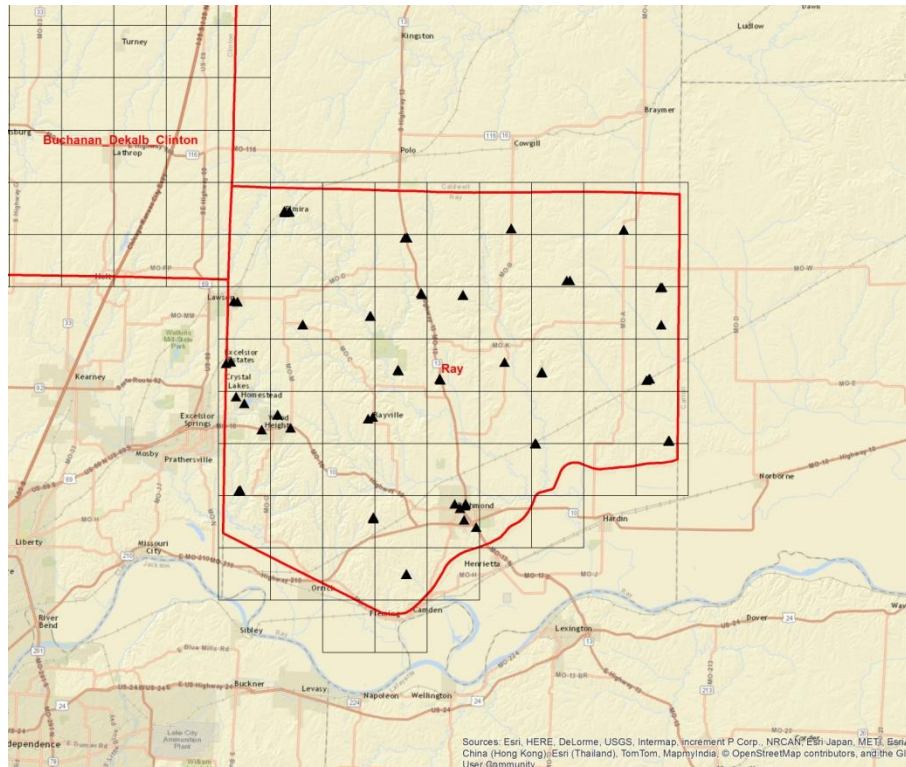


Figure 3 Ray Co. LiDAR QC Check

These points consisted of various types of ground cover including asphalt, gravel, short grass, tall grass and trees. Examples to the types of points surveyed are included below.





The required LiDAR elevation data values were derived within ArcGIS from the bare earth LAS files. For each control point location a LiDAR elevation value was derived and exported and the surface value subtracted from the survey elevation. These derived values were imported into Excel and comparisons were performed to generate statistics by ground cover type and for the overall dataset.

Swath LiDAR Check Accuracy Results

The table below presents the results of the check accuracy analysis for the Ray Co., MO unclassified swath LAS data. All values are in meters.

Stat	Hard Surface (HS)
Count	20
RMSEz (FVA)	0.043
95% Confidence Level (FVA)	0.085

As indicated above the LAS LiDAR surface meets hard surface Fundamental Vertical Accuracy (FVA) project specifications of RMSEz less than or equal to 15.0 cm, with an RMSEz of 4.3 cm. The FVA 95% confidence level of 29.4 cm or less was also met with a value of 8.5 cm.

Classified LAS QC Accuracy Results

The table below presents the results of the QC accuracy analysis for the Ray Co., MO classified LAS tile data. All values are in meters.

Stat	Overall	Hard Surface (HS)	Grass (G)	Trees (TR)	Urban (U)
Count	81	20	20	20	21
RMSEz (FVA)	0.067	0.045	0.078	0.082	0.058
95% Confidence Level (FVA)	0.132	0.088	0.153	0.160	0.113
95 th Percentile (CVA & SVA)	0.120	0.068	0.121	0.149	0.097

DEM QC Accuracy Results

The table below presents the results of the QC accuracy analysis for the Ray Co., MO derived bare-earth Imagine DEM tile data. All values are in meters.

Stat	Overall	Hard Surface (HS)	Grass (G)	Trees (TR)	Urban (U)
Count	80	20	20	20	20
RMSEz (FVA)	0.064	0.042	0.076	0.078	0.055
95% Confidence Level (FVA)	0.126	0.082	0.149	0.153	0.108
95 th Percentile (CVA & SVA)	0.132	0.070	0.118	0.145	0.095

As indicated above the derived DEM LiDAR surface meets both Supplemental & Consolidated Vertical Accuracy (SVA & CVA) project specifications of 95th Percentile less than or equal to 36.3 cm.