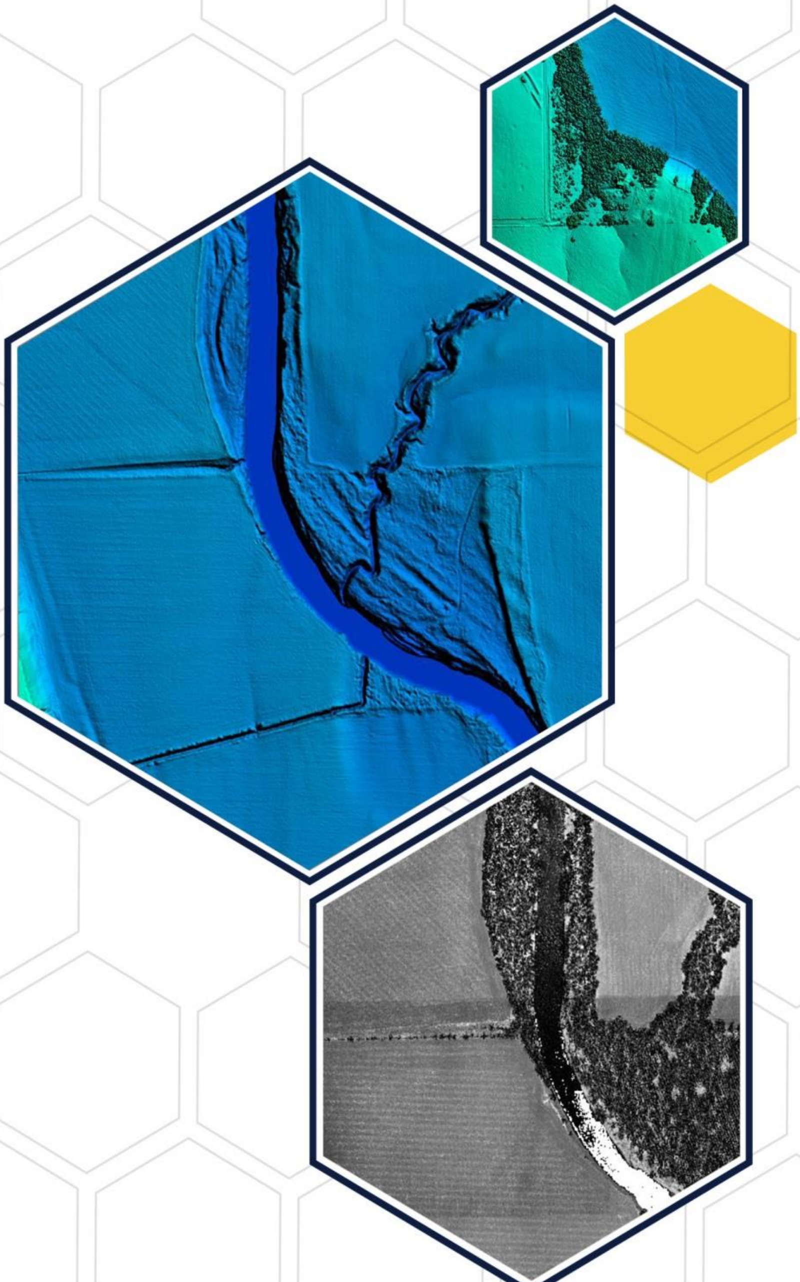

Final Survey Report

Alabama ADECA 6 County Lidar 2016 B16

October 2016

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Executive Summary

1.1 Introduction

In support of the *2017 AL AGIO & ADECA 12 County LIDAR 2017 B16 Light Detection and Ranging (LiDAR)* project a Real-Time Network – Real-Time Kinematic (RTN-RTK) survey was utilized for the collection of quality assurance and quality control (QA/QC) verification points. The importance of this survey was twofold; to ensure a homogenous project meeting defined project accuracies and to "tie" the mapping to the existing Alabama Department of Transportation (ALDOT) Continually Operating Reference Stations (CORS) framework used for aerial acquisition. This allows for repeatable accuracies for current and future surveying and mapping needs.

The project consisted of twelve (12) contiguous Alabama counties which due to geographic proximity were combined into one Area of Interest (AOI). A total of four hundred eighty-three (483) QA/QC points were subdivided into 3 main categories: non-vegetated, vegetated checkpoints, and LiDAR calibration points. The survey crew mobilized to the AOI to perform the RTN –RTK survey to support the aerial LiDAR collection October 20^{th} through November $19^{th,}$ 2016.

The final required accuracy of the Lidar calibration points (LCP's) and the checkpoints, is defined by the specified Lidar accuracy. For this project, the Lidar vertical accuracy is to meet a Root Mean Square Error ($RMSE_Z$) of 10 cm required by the United States Geological survey (USGS) Quality Level Two (QL2) specification. Typically, QA/QC surveys should be at least three times as accurate as the final products being tested, therefore a $RMSE_Z$ of 3.3 cm or less is required. Based on the analysis of the RTN-RTK checkpoints, this verification data meets this projects requirement for calibrating and testing the vertical accuracy of the Lidar.

ction 2:

Standards and Equipment

2.1 Project Accuracy Standards

The accuracy standards for the QA/QC survey is to be approximately three times as accurate as the Lidar which required a vertical $RMSE_Z$ of 10 cm in non-vegetated areas. Although not specifically tested, the Lidar horizontal accuracy is defined to comply with the "compiled to meet" statement of having a $RMSE_R$ of 60cm or less. Therefore, the accuracy for the QA/QC survey was defined to have a horizontal $RMSE_R$ of <2cm and a $RMSE_Z$ of <3cm to meet and exceed project requirements.

2.2 Datum and Coordinate Systems

Horizontal: Universal Transverse Mercator (UTM) Zone 16N NAD83-2011 Meters.
Vertical: North American Vertical Datum 88 (NAVD88) Geoid12B Meters.

2.3 Survey Equipment

The following survey equipment was utilized to collect the survey coordinates:

- Topcon HiPer V GPS Receiver S/N 1132-10004 (Dual Frequency)
- Topcon HiPer V GPS Receiver S/N 1132-10738 (Dual Frequency)
- Topcon Tesla Data Collector S/N 163110
- Topcon Tesla Data Collector S/N 163462

- ALDOT RTN (Leica LEICA GRX1200GGPRO (Dual Frequency)

Survey Methodology

3.1 Real Time Network Survey – Real Time Kinematic

RTN-RTK use is a standard throughout the Geo-Spatial industry and was chosen to be the most efficient way to execute this survey when cell phone coverage was available. The ALDOT RTN is a system of established Global Navigation Satellite Survey System (GNSS) receivers that transmits real-time corrections which are sent to the GNSS rover receiver via cellular connections. The internal accuracy for the fixed ambiguity solutions pertaining to the RTN-RTK network results in a repeatable accuracy of <2cm horizontally and <3cm vertically at the 95% confidence level. All QA/QC points were surveyed utilizing a 2-meter rod leveled over each point coupled with a GNSS receiver using the ALDOT RTN. The GNSS receiver is configured to log data at 1 Hz with an update rate of 10Hz, and at 10° degrees' mask at a collection rate of 180 seconds or better. During collection, the field technician monitored standard field criteria to optimize each observation. These field criteria include but is not limited to: number of SV's, PDOP, RMS, and status of ambiguity i.e. "fixed" or "float". RTN-RTK Root Mean Square values and digital field notes can be found in a separate appendix document - *16079_Survey_Report_Appendix.pdf*

3.2 QA/QC Survey Points

To initially control the Lidar during the calibration phase of production, calibration survey points were required. The LCP's were strategically positioned throughout the project area of interest. These LCP's are located on hard to semi-hard relatively surfaces with flat or moderate slope to allow for a good sampling of ground surface types where the Lidar reflectivity would yield a good range.

To test the vertical accuracy of the Lidar point cloud, Lidar checkpoints were surveyed and used in an independent verification process, post calibration. These check points were collected in two different categories: Non-Vegetated Accuracy (NVA) and Vegetated Vertical Accuracy (VVA). Checkpoints serve to analyze or "ground truth" the accuracy of the LIDAR return with respect to surfaces types found within the project area of interest.

Error! Reference source not found. displays the QA/QC survey collection of eighty-eight (88) Lidar calibration points, two hundred twenty-seven (227) NVA, and one hundred sixty-eight (168) VVA checkpoints. Final point coordinates summary, photographs of the LCP's & checkpoints, observation digital Field notes, and static session forms can be found in the separate appendix document.

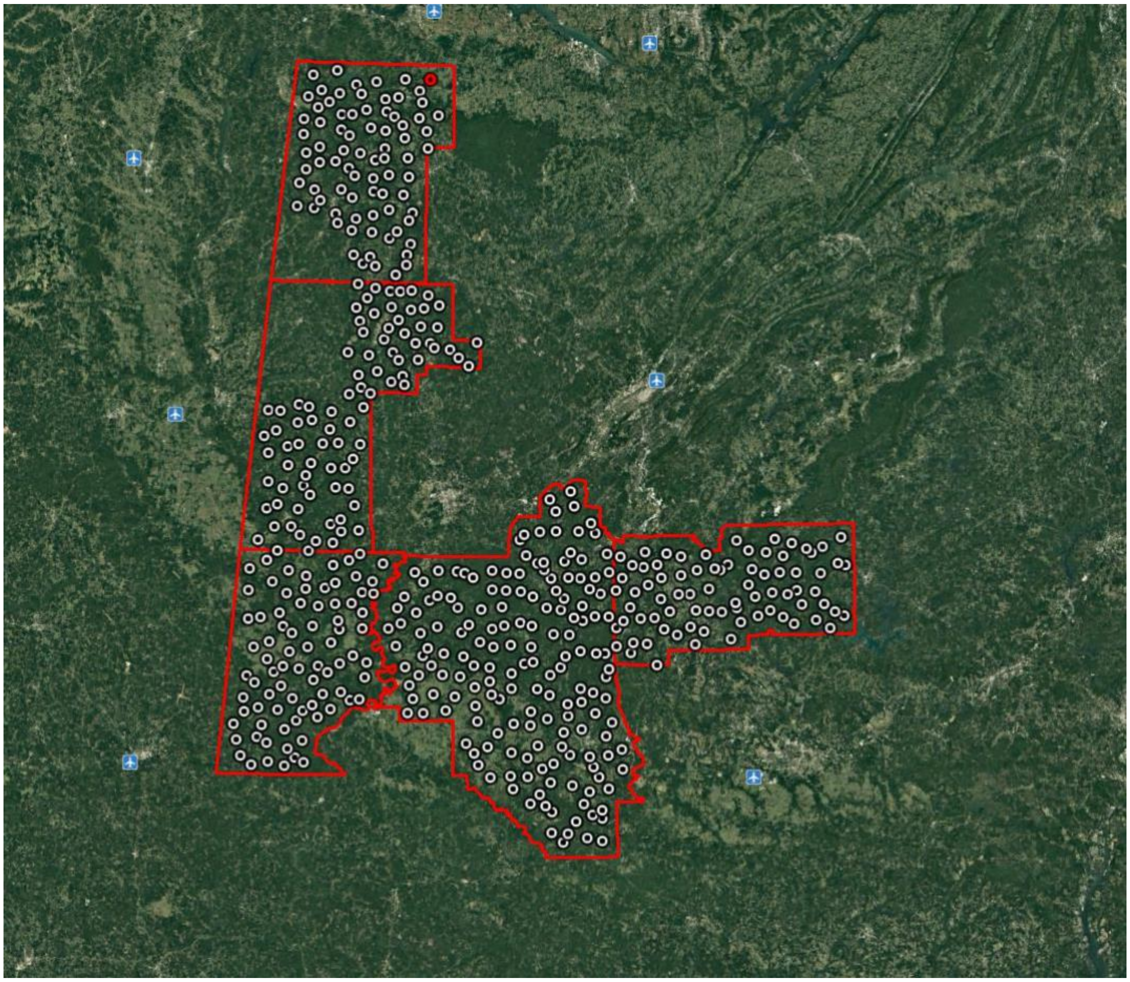

Figure 1 – AGIO-ADEA Checkpoint & LCP Survey

5.1 QA/QC Data Analysis

The advantages of using the RTN-RTK survey methodology is obtaining a real time answer along with an estimate of its accuracy. However, to verify the system integrity and to provide a definitive check, Atlantic performs additional survey processes. Prior to the QA/QC survey, ten (10) NGS control monuments were recovered, statically observed, and processed using the National Geodetic Survey's (NGS) On-Line Positioning User Service (OPUS) service. OPUS uses a robust 3D least squares algorithm utilizing CORS within the vicinity of the survey point to provide a coordinate along with many metrics on the accuracy. The observations purpose is verifying the published NGS coordinates which can be compared to the RTN-RTK coordinates. During each daily survey session, at least one (1) NGS control monument was occupied and compared with the OPUS network adjusted values. If the comparisons were within acceptable tolerances (good repeatability) than the GNSS unit and the system integrity was functioning properly.

To further verify the RTN-RTK data, observed coordinates for each checkpoint & LCP were transferred into Topcon MAGNET Tools software for QA/QC checks. During the analysis, the horizontal and vertical RMS values for each vector line between the RTN base and survey point were reviewed to ensure that they are within acceptable limits.

For all static observations, the processing results and accuracy metrics are reviewed via the OPUS solution report. If the observations were weak and did not compare well with the published NGS coordinate values, the data would have been reobsevered, however no reobservations were required. The OPUS solutions, daily comparisons, and the QC observations can be found in a separate appendix document.

Accuracy

8.1 Summary of Survey Accuracies

The accuracy of this survey can be defined in multiple ways due to the methods for how the set verification monuments, Lidar calibration points, and checkpoints were derived. The accuracy of this survey was based on the analysis of the RTN-RTK final verification point checks at a 95% confidence level which statistically was <2cm horizontally and <3cm vertically. This was confirmed by the daily check measurements on the verification points. The static measurements also met the same accuracy based on the statistical data provided by the OPUS reports which compared favorably to the published NGS monument values. The data easily exceeds the requirements for testing the vertical accuracy of the Lidar data

Custody Transference Assurance

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