Greene County, Missouri
2011 Digital Mapping Project

LiDAR & Survey Report

2011

EXECUTIVE SUMMARY

USACE contracted with Sanborn to provide LiDAR mapping services for Greene Co. Missouri. Utilizing a multi-return LiDAR system, data in the form of 3-dimensional positions of a dense set of mass points was collected for approximately 678 square miles. The system includes geodetic GPS positioning, orientation derived from high-end inertial sensors and high-accuracy lasers. The sensor is attached to the aircraft's underside and emits rapid pulses of light that are used to determine distances between the plane and near-ground surface features.

For Green Co., the Leica ALS-60 LiDAR system was used to collect data for the survey. The LiDAR system is calibrated by conducting flight passes over a known ground surface before and after each LiDAR mission. During final data processing, the calibration parameters are inserted into post-processing software.

A GPS control network survey was designed to provide ground control for high-accuracy LiDAR data collection of Greene Co MO project. AGPS stations were strategically situated to ensure LiDAR collection occurred within 40km of any base station. Multiple receivers were used to achieve this requirement. The GPS control network consisted of four (4) control stations. The network included NGS monuments: AC7221, AI4215, AC7184 and HD1507. Springfield Regional Airport (SGF) was used as base for all LiDAR operations.

The checkpoint survey was designed to provide quality control points throughout project area. Seventeen (17) evenly distributed checkpoints were collected throughout project area. Checkpoints were chosen in bare earth class areas.

The acquired LiDAR data was processed to obtain first and last return point data. The last return data was further filtered to yield a LiDAR surface representing the bare earth.

The contents of this report summarize the methods used to establish the base station coordinate check, perform the LiDAR data collection and post-processing as well as the results of these methods.

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LIST OF TABLES & FIGURES

1.0 INTRODUCTION

This document contains the technical write-up of the LiDAR campaign, including grounds control and checkpoint surveys, the collection and post-processing of the LiDAR data.

1.1 Contact Information

Questions regarding the technical aspects of this report should be addressed to:

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1.2 Purpose of the LiDAR Acquisition

As stated in the statement of work for acquisition and production of the standard FEMA data for Greene Co. This LiDAR operation was designed to create data sets that will establish an authoritative source for elevation information for Greene Co.

1.3 Project Location

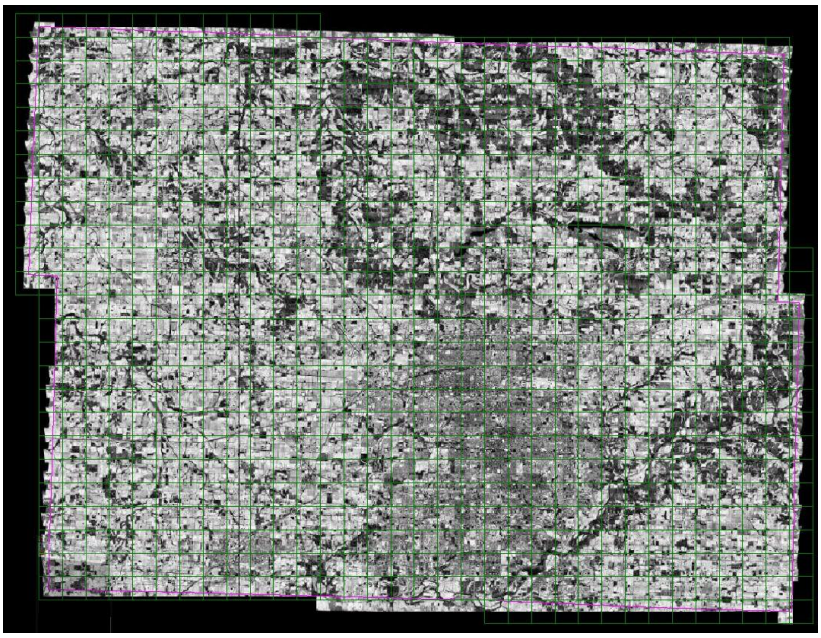

Figure 1: Area of Collection

1.4 Standard Specifications for LiDAR

Table 2: Project Specifications

Area (sq. mi)	678	**Product type**	FEMA	**Projection**	Missouri State Central Zone State Plane Survey Feet
Vertical Accuracy (CM)	Bare Earth 15 cm	**Check Points required**	Yes	**Horizontal Datum / Vertical Datum**	NAD 83/NAVD 88
Horizontal accuracy (M)	0.5 meter	**Number Collected**	17	**Units**	US Survey Feet

Final Product DELIVERIES in both:

- UTM Zone 15 (meters) &
- MO SPCS Central Zone (US Svy Feet)

2.0 FINAL LIDAR PROCESSING

The post-processing of LiDAR data involves several steps. The airborne GPS data was post-processed using Waypoint's GravNAV™ software (version 7.5). A fixed-bias carrier phase solution was computed in both the forward and reverse chronological directions. The data was processed for both base stations and combined. In the event that the solution degraded as a result of the combination of both solutions, the best of either solution was used to yield more accurate data. LiDAR acquisition was limited to periods when the PDOP was less than 3.2.

The GPS trajectory was combined with the raw IMU data and post-processed using Applanix Inc.'s POSPROC (version 4.3) Kalman Filtering software. This results in a two-fold improvement in the attitude accuracies over the real-time INS data. The best-estimated trajectory (BET) and refined attitude data are then re-introduced into the LEICA ALS post processor for the Leica system to compute the laser point-positions. The trajectory is then combined with the attitude data and laser range measurements to produce the 3-dimensional coordinates of the mass points.

All return values are produced within ALS Post processing software for the Leica system. The multi-return information is processed to obtain the "Bare Earth Dataset" as a deliverable. All LiDAR data is processed using the binary LAS format 1.2 file format.

LiDAR filtering was accomplished using TerraSolid, TerraScan LiDAR processing and modeling software. The filtering process reclassifies all the data into classes with in the LAS formatted file based scheme set using the LAS format 1.2 specifications or by the client. Once the data is classified, the entire data set is reviewed and manually edited for anomalies that are outside the required guidelines of the product specification or contract guidelines, whichever apply. Table 3 indicates the required product specifications.

The coordinate and datum transformations are then applied to the data set to reflect the required deliverable projection, coordinate and datum systems as provided in the contract.

The Greene Co. deliverables are then generated. At this time, a final QC process is undertaken to validate all deliverables for the project. Prior to release of data for delivery, Sanborn's quality control/quality assurance department reviews the data and then releases it for delivery.

Table 3: Processing Accuracies and Requirements

Accuracy of LiDAR Data (H)	0.5 m RMSE
Accuracy of LiDAR data in bare areas	15 cm RMSE
Accuracy of LiDAR data in vegetated areas	27 cm RMSE
Percent of artifacts removed (terrain and vegetation dependent)	95%
Percent of all outliers removed	98%
Percent of all vegetation removed	97%
Percent of all buildings removed	99%

3.0 GEODETIC BASE NETWORK

3.1 Network Scope

During the LiDAR campaign, the Sanborn field crew conducted a GPS field survey to establish final coordinates of the ground base stations for final processing of the base-remote GPS solutions. NGS points AI4215, AC7184, AC7221 and HD1507 were used for the LiDAR missions. See table 5 for station names, orders and constraints.

3.2 Data Processing and Network Adjustment

The static baselines created between points AI4215, AC7184, AC7221 and HD1507 were processed using Trimble Geomatics Office ™ (Ver. 1.62) software. Fixed bias solution was obtained for the baselines. The broadcast ephemeris was used, since the accuracy and extent of the network does not warrant the use of the precise ephemeris. The results were satisfactory; therefore, fulfilling project specifications for first order control network. See Table 6 for loop closure summary.

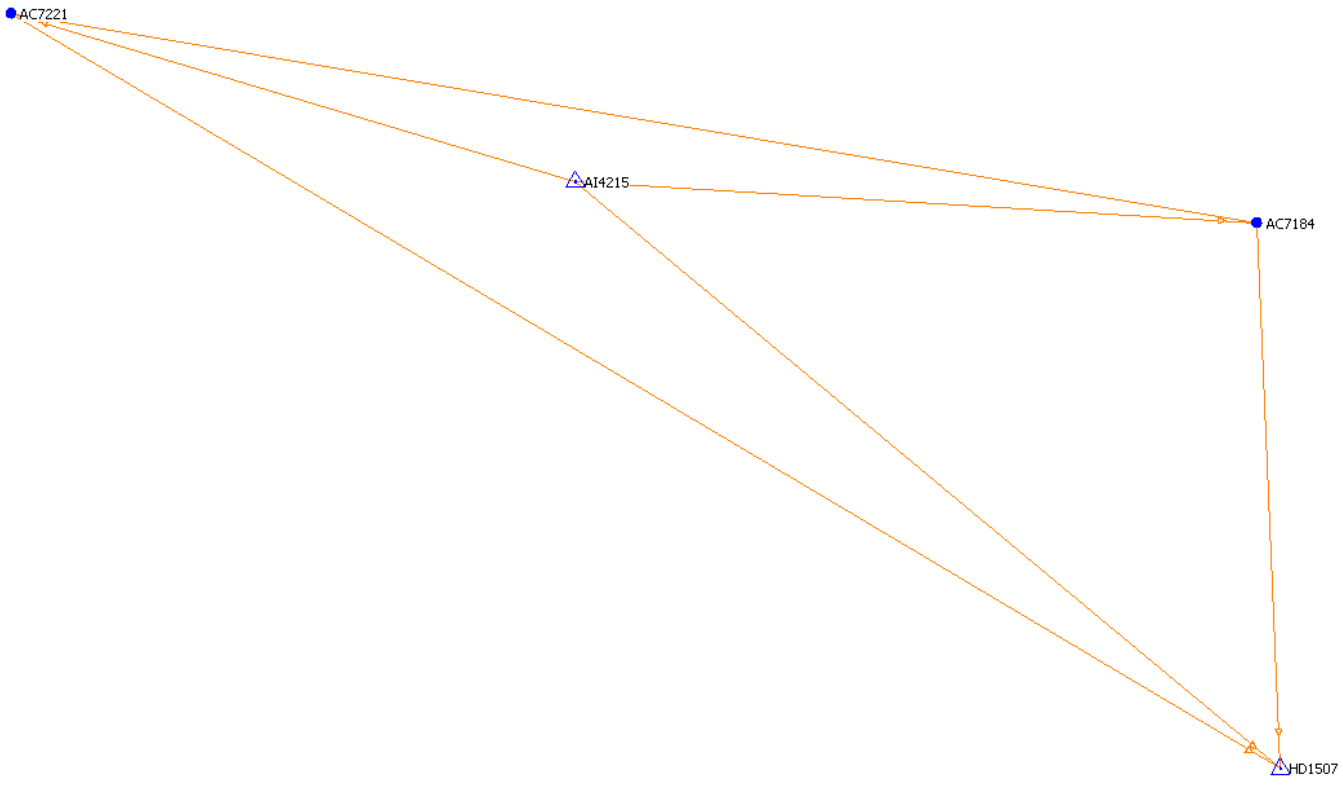

Figure 4: Survey Network Diagram

Table 5: NGS Control Constraints

Horizontal

Code	NGS Station Name	PID	Constrain
AI4215	SGF D	AI4215	Constrained
AC7184	GR 38	AC7184	Checkpoint
AC7221	GR 82	AC7221	Checkpoint
HD1507	WILLIS RESET	HD1507	Constrained

Vertical

Code	NGS Station Name	PID	Constrain
AI4215	SGF D	AI4215	Checkpoint
AC7184	GR 38	AC7184	Checkpoint
AC7221	GR 82	AC7221	Checkpoint
HD1507	WILLIS RESET	HD1507	Constrained

Table 6: Survey Loop Closure Summary

Loop	Δ Horiz (ft.)	Δ Vert (ft.)	Dist. (ft.)	ppm
AI4215: AC7184: AC7221: AI4215	0.001	0.019	195197.382	0.099
AI4215: AC7184: HD1507: AI4215	0.005	-0.016	165031.907	0.101
AI4215: AC7221: HD1507: AI4215	0.002	-0.013	229551.255	0.058
AC7184: AC7221: HD1507: AC7184	0.002	0.022	252840.830	0.088

3.3 Final LiDAR Verification

The LiDAR data was evaluated using a collection of 17 GPS surveyed checkpoints. See Figure 7 for diagram. For Greene Co., Missouri the standard deviation is 0.110 feet and the root mean squared is 0.106 feet. The LiDAR data was compared to each of these classes yielding a much better result than was required for the project. Table 8 indicates the results for Greene Co., Missouri and each point including the overall results as it compares to the LiDAR data set.

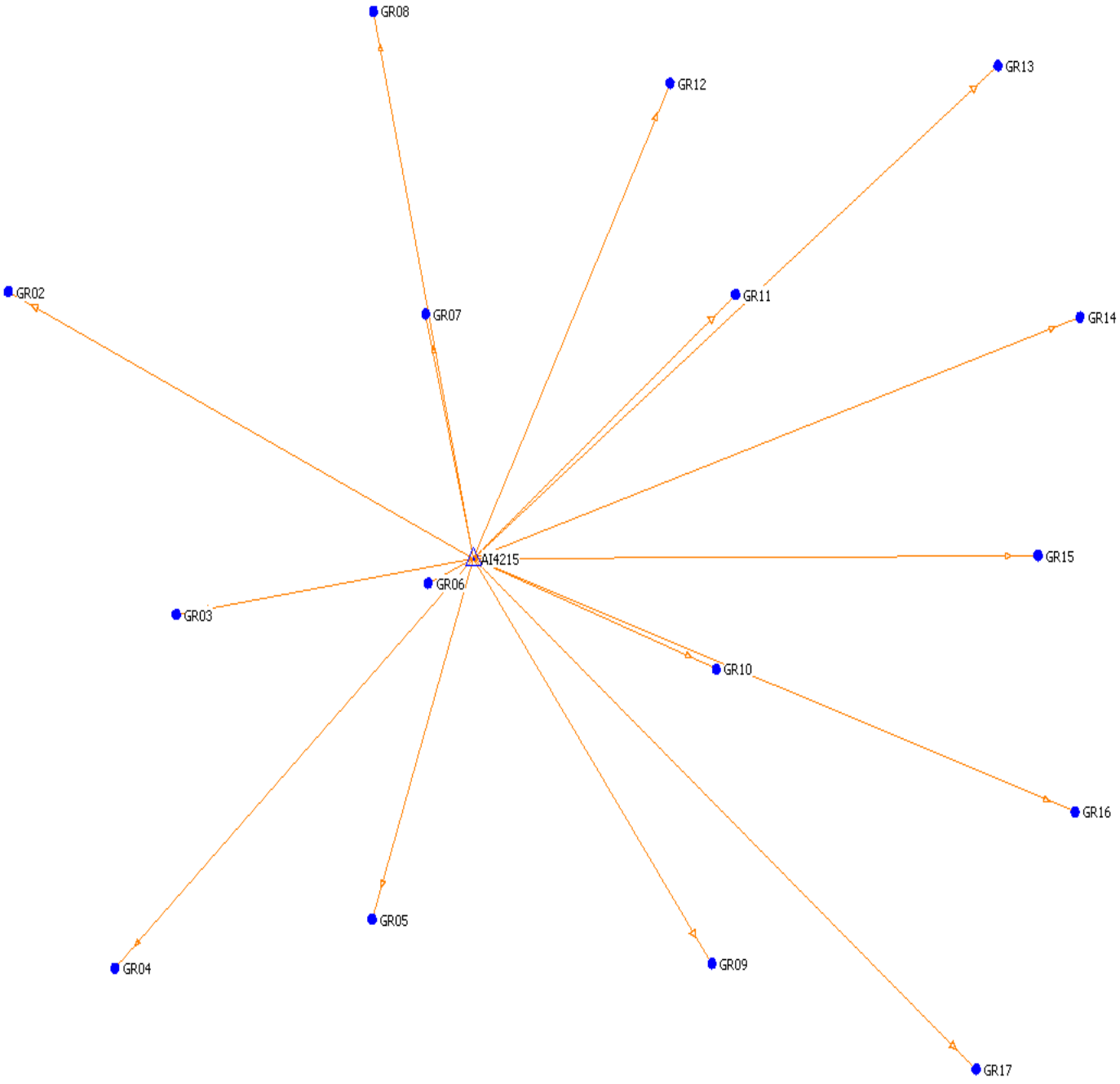

Figure 7: Greene Co. Survey Checkpoint Diagram

Table 8: LiDAR Accuracy Assessment based on the Checkpoint Survey (US feet)

Number	Easting	Northing	Known Z	Laser Z	Dz
1	1460872.233	539788.261	1454.403	1454.430	+0.027
2	1455501.597	515665.163	1412.092	1412.050	-0.042
3	1460264.395	489726.930	1393.725	1393.520	-0.205
4	1447627.812	463680.892	1386.539	1386.590	+0.051
5	1413877.341	474364.311	1295.880	1295.890	+0.010
6	1414434.588	504172.881	1292.456	1292.580	+0.124
7	1416861.384	542094.196	1197.894	1197.790	-0.104
8	1408511.025	563469.358	1068.462	1068.460	-0.002
9	1450402.299	565264.642	1207.435	1207.180	-0.255
10	1337586.440	473889.727	1283.194	1283.290	+0.096
11	1345419.498	509696.884	1199.340	1199.310	-0.030
12	1323954.336	542388.318	1019.917	1020.020	+0.103
13	1370644.201	570779.621	1142.120	1142.080	-0.040
14	1377297.902	540113.799	1218.212	1218.320	+0.108
15	1377605.842	512883.497	1274.515	1274.640	+0.125
16	1370443.675	478863.496	1244.958	1245.020	+0.062
17	1383426.672	515332.163	1259.748	1259.720	-0.028

Average dz	-0.000
Minimum dz	-0.255
Maximum dz	+0.125
Average Magnitude	0.083
Root Mean Square	0.106
Standard Deviation	0.110

4.0 COORDINATES AND DATUM

4.1 Introduction

The final adjustment was constrained to the published NAD83 geodetic coordinates (ϕ, λ) and NAVD88 elevations. The adjustment was cross-referenced to the GEOID03 model to enable the estimation of orthometric heights.

4.2 Horizontal Datum

The final horizontal coordinates are provided in the North American Datum of 1983/1997 (NAD83/97) adjustment as referenced to the Missouri State Plane Coordinates System, Central Zone, in United States Survey Feet.

4.3 Vertical Datum

The final orthometric elevations were determined for all points in the network using GEOID03 model and are provided on the North American Vertical Datum of 1988 (NAVD88) latest adjustment, in United States Survey Feet.