S.C Department of Natural Resources

LiDAR Campaign (Hampton County, SC) Report of Survey

2011

EXECUTIVE SUMMARY

S.C. Department of Natural Resources contracted with Sanborn to provide LiDAR mapping services for Hampton County. Utilizing multi-return systems, Light Detection and Ranging (LiDAR) data in the form of 3-dimensional positions of a dense set of mass points was collected for approximately 563 square miles between March 20th 2010 and March 24th 2010. All systems consist of geodetic GPS positioning, orientation derived from high-end inertial sensors and high-accurate 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 terrain below.

Specifically, the Optech Orion M-200 LiDAR system was used to collect data for the survey campaign. 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.

Three airborne GPS (Global Positioning System) base stations were used in the Hampton County project. The first station was created at the north corner of the intersection of Magnolia Street and Cemetery Road. The second created station, BASE3, was created northeast of Shirley, off of Augusta Stage Coach Road. The last base station, BASE4, was established southeast of Early Branch, adjacent to Yemassee Highway. These three base stations were tied to each other to create a GPS survey network. The coordinates of these stations were checked against each other with the three dimensional GPS baseline created at the airborne support set up and determined to be within project specifications.

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.

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1.0 INTRODUCTION

This document contains the technical write-up of the LiDAR campaign, including standard specifications, system calibration techniques, field procedures, and the accuracy 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 High Resolution Elevation data for the SCDNR 2010 project, this LiDAR operation was designed to create high resolution data sets that will establish an authoritative source for elevation information for Hampton County.

1.3 Project Location

Figure 1: Area of Collection

1.4 Standard Specifications for LiDAR

Table 1: LiDAR Specifications

Data Acquisition		
Requirement	Description	
Returns per pulse	LiDAR sensor shall be capable of recording up to 3 (or more) returns per pulse, including 1st and last returns	
Scan angle	≤ ±20 degrees	*
Swath overlap	Nominal sidelap on adjoining swaths, i.e., survey shall be designed for 50% overlap coverage at planned aircraft height above ground	50%
Design pulse density (nominal)	Pulses/m2 (includes swath overlap; e.g., with 30% sidelap, ≥ 2 pulse/m2 in each swath)	≥1
GPS procedures	At least 2 GPS reference stations in operation during all missions, sampling positions at 1 Hz or higher frequently. Differential GPS baseline lengths shall not exceed 30 km. Differential GPS unit in aircraft shall sample position at 2 Hz or higher. LiDAR data shall only be acquired when GPS PDOP is ≤ 3.5 and at least 6 satellites are in view.	*
Data Collection Season	Target window for collection of LiDAR data ends Spring of 2010. This may be extended with approval by State program managers	*
Survey conditions	Leaf-off and no significant snow cover, as observed by state contract representatives.	*
Geographic Coverage and Continuity		
Coverage	No voids between swaths. No voids because of cloud cover or instrument failure.	
Swath overlap	≤ 50% no-overlap area per project.	

2.0 LIDAR CALIBRATION

2.1 Introduction

LiDAR calibrations are performed to determine and therefore eliminate systematic biases that occur within the hardware of the Optech Orion M-200 system. Once the biases are determined they can be modeled out. The systematic biases are corrected for include scale, roll, and pitch.

The following procedures are intended to prevent operational errors in the field and office work, and are designed to detect inconsistencies. The emphasis is not only on the quality control (QC) aspects, but also on the documentation, i.e., on the quality assurance (QA).

2.2 Calibration Procedures

When Sanborn receives raw point cloud data from its subcontractors, calibration proceedures using TerraSolid products are applied; inlcuding TerraScan and TerraMatch. Utilizing these two tools, Sanborn is able to correct each intiviual raw data strip to precisely match the two overlapping swaths. In return, the RMSE of the enitre project is substantually lower, resulting in a more accurate dataset. TerraMatch samples the data perpenicular to the flight pattern to assess and correct for roll errors, pitch errors, and heading errors.

Throughout the Hampton County project, flight direction consisted of a southwest to northeast flight pattern. Rows of small sample tiles were placed perpendicular to the raw strips, and populated with the raw point cloud data. Once the population of the data is complete, a filter is applied to each sample tile. The filter classifies bare earth and building rooftops per flight line in order for TerraMatch to recognize the individual strips and their features, allowing the software to find corrections for roll, pitch, and heading throughout the project. Once the adjustments are calculated, the settings are applied to the final delivery tiles.

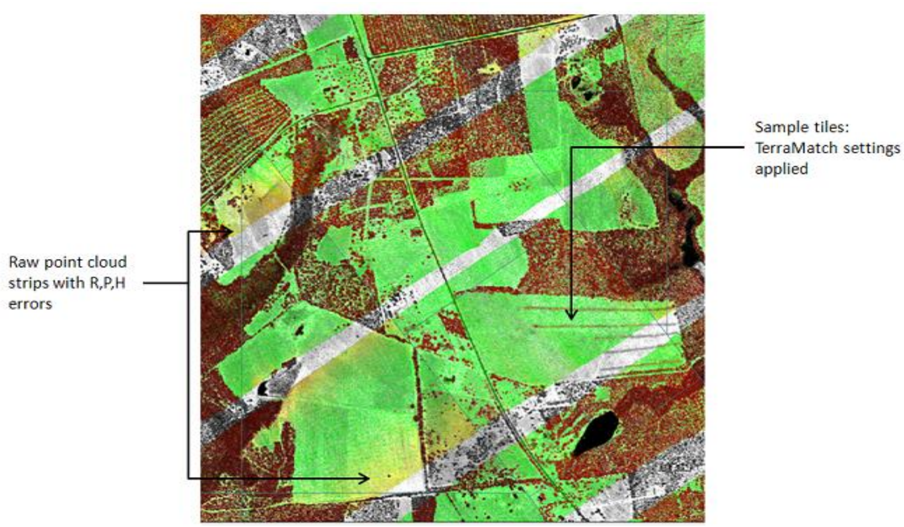

Figure 2: TerraMatch Tiling Sample

3.0 LIDAR FLIGHT AND SYSTEM REPORT

3.1 Introduction

This section addresses LiDAR system, flight reporting and data acquisition methodology used during the collection of the Hampton county campaign. Although Towill conducts all LiDAR with the same rigorous and strict procedures and processes, all LiDAR collections are unique.

3.2 Field Work Procedures

A minimum of two GPS base stations were set for the Hampton County project, which is within the project area or within the required baseline specifications of the project.

Pre-flight checks such as cleaning the sensor head glass are performed. A four minute INS initialization is conducted on the ground, with the engines running, prior to flight, to establish fine-alignment of the INS. GPS ambiguities are resolved by flying within ten kilometers of the base stations.

The flight missions were typically four or five hours in duration including runway calibration flights flown at the beginning and the end of each mission. During the data collection, the operator recorded information on log sheets which includes weather conditions, LiDAR operation parameters, and flight line statistics. Near the end of the mission GPS ambiguities are again resolved by flying within ten kilometers of the base stations, to aid in post-processing.

Table 2 shows the planned LiDAR acquisition parameters with a flying height of 1600 meters above ground level (AGL) for the Optech system on a mission to mission basis.

Table 2: LiDAR Acquisition Parameters

Average Altitude	1600 Meters AGL
Airspeed	~140 knots
Scan Frequency	34 Hertz
Scan Width Half Angle	20 Degrees
Pulse Rate	70,000 Hertz

Preliminary data processing was performed in the field immediately following the missions for quality control of GPS data and to ensure sufficient overlap between flight lines. Any problematic data could then be re-flown immediately as required. Final data processing was completed in the Colorado Springs office.

Table 3: Collection Dates, Times, Average Per Flight Collection Parameters and PDOP

Mission	Date	Sensor	Start Time	End Time	Altitude (m)	Airspeed (Knots)	Scan Angle	Scan Rate	Pulse Rate	PDOP
079a	Mar 20	Optech	12:52	17:23	1600	140	40˚	34	70000	2.1
079b	Mar 20	Optech	20:08	00:16	1600	140	40˚	34	70000	2.7
082a	Mar 23	Optech	12:53	17:21	1600	140	40˚	34	70000	3.0
082b	Mar 23	Optech	20:03	00:45	1600	140	40˚	34	70000	2.7
083a	Mar 24	Optech	13:09	17:41	1600	140	40˚	34	70000	2.4
083b	Mar 24	Optech	19:05	20:33	1600	140	40˚	34	70000	2.8

3.3 Final LiDAR Processing

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 4 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 client required 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 4: Processing Accuracies and Requirements

Accuracy of LiDAR Data (H)	1m RMSE
Accuracy of LiDAR data in bare areas	15 cm RMSE

4.0 GEODETIC AUTHENTICATION

4.1 Final LiDAR Verification

The LiDAR data was evaluated using a collection of 6 NGS benchmarks; see figure 3 for diagram. For Hampton County, the standard deviation is 0.353 feet and the root mean squared is 0.324 feet. The LiDAR data was compared to each of these benchmarks yielding much better result than was required for the project. Table 5 indicates the results for Hampton County and each point including the overall results as it compares to the LiDAR data set.

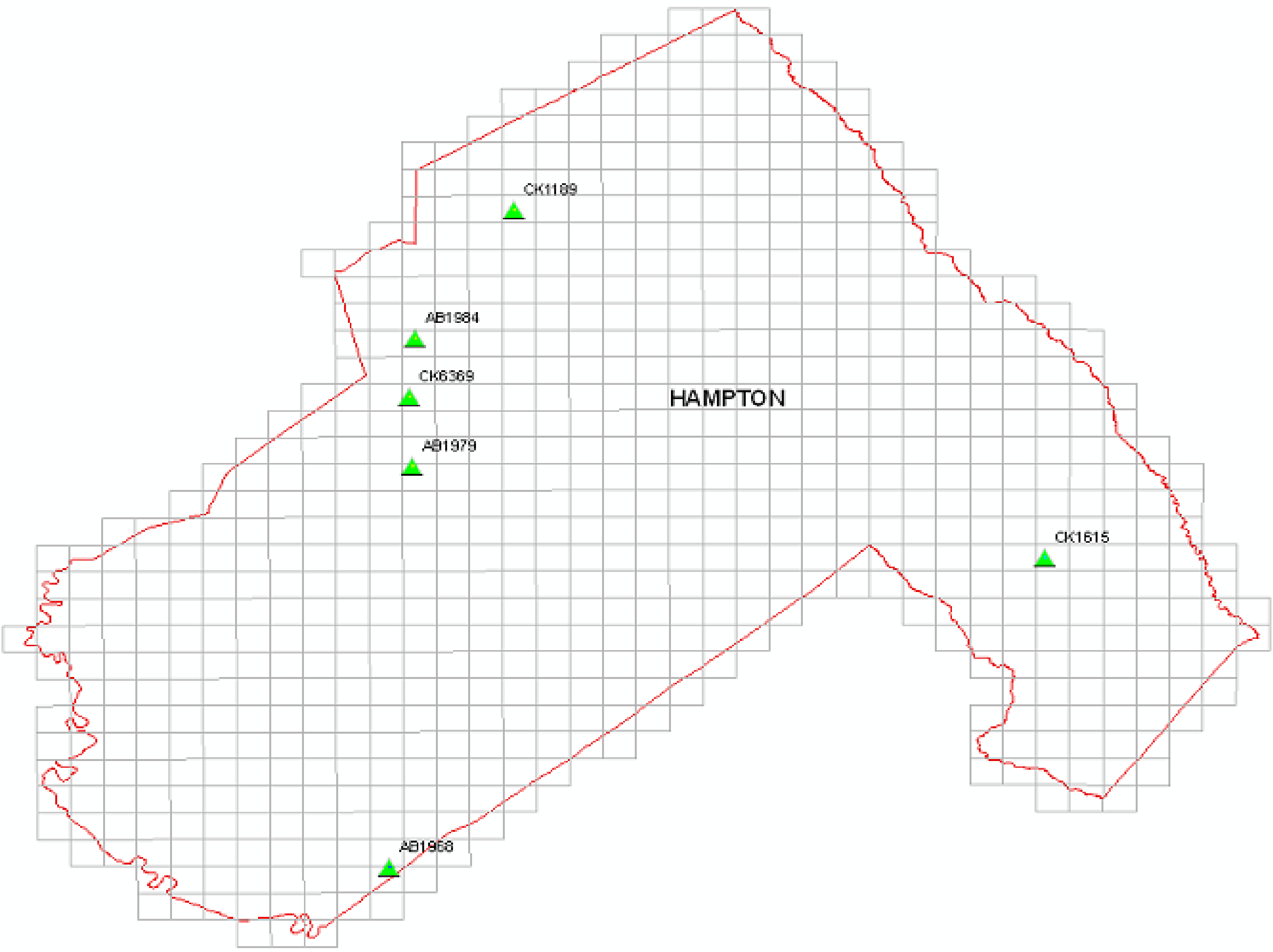

Figure 3: Hampton Survey Checkpoint Diagram

Table 5: LiDAR Accuracy Assessment based on the Checkpoint Survey (Feet)

Name	Vegetation Class	Easting	Northing	Known Z	Laser Z	Dz
AB1979	Bare Earth	1926740.130	348952.480	140.090	139.670	-0.420
AB1984	Bare Earth	1927159.690	372987.980	136.190	135.930	-0.260
AB1968	Bare Earth	1923096.230	274228.290	57.480	57.570	+0.090
CK1189	Bare Earth	1942108.620	396793.010	134.930	135.450	+0.520
CK6369	Bare Earth	1926354.750	361927.530	138.150	138.470	+0.320
CK1615	Bare Earth	2021564.470	331816.270	75.000	74.940	-0.060

Average dz	+0.032
Minimum dz	-0.420
Maximum dz	+0.520
Average Magnitude	0.278
Root Mean Square	**0.324**
Std deviation	0.353

5.0 COORDINATES AND DATUM

5.1 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.

5.2 Horizontal Datum

The final horizontal coordinates are provided in State Plane HARN South Carolina FIPS 3900 on the North American Datum of 1983 (NAD83 adjustment of 1992) units of intl feet.

5.3 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 in units of survey feet.