Barrow LiDAR – 2013
Acquisition and Processing Report
October 3rd, 2013

aerometric

Geospatial Solutions

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1 INTRODUCTION

This report contains a summary of the data acquisition and processing for the Barrow LiDAR project completed under a work order from the Earth and Natural Sciences Division of the Los Alamos National Laboratory (LANL).

1.1 Contact Info

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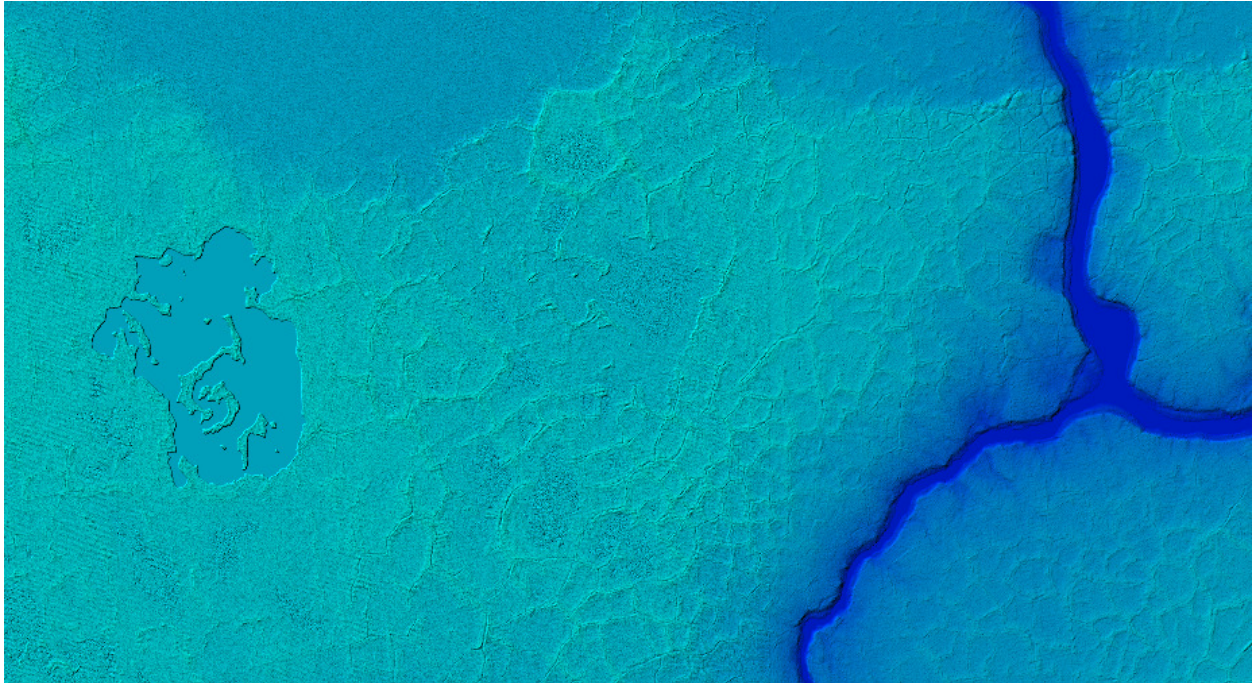
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1.2 Purpose

LANL requested the acquisition of LiDAR data in the North Slope Borough of Alaska east of downtown Barrow, AK.

Aero-Metric, Inc. (AeroMetric) acquired LiDAR data for an area that comprises approximately 32.7 square kilometers inside the project boundary. This acquisition was carried out to comply with LANL's need for high resolution elevation data in the region. AeroMetric's Leica ALS-70 LiDAR system was used in the collection of data for this project.

1.3 Project Location

The western boundary of this project area is located approximately 3.3 km east of eastern edge of the runway at the Wiley Post—Will Rogers Memorial Airport in Barrow, Alaska. The area is approximately 2.8 km wide in the east-west direction and extends approximately 12.4 km south from the breakwaters in the north.

1.4 Project Scope

This project involved new LiDAR data acquisition at a planned nominal point density of 16 points per meter (ppm). This data was to be calibrated such that all systematic errors were accounted for. The project required bare-earth classification for the production of digital elevation models.

1.5 Project Spatial Reference System

The project spatial reference system for this delivery is as follows:

Projected Coordinate System: UTM Zone 4 North
Horizontal Datum: NAD83 (2011)
Vertical Datum: NAVD88 (GEOID09)
Horizontal / Vertical Units: Meters

1.6 Time Period

LiDAR project planning was carried out June of 2012 and June of 2013.

LiDAR data acquisition was completed on July 12, 2013. One mission was flown.

QC surveys were performed on September 30 and October 1, 2012 by the Ukpeagvik Inupiat Corporation (UMIAQ) specifically for this project.

All required data products were completed by October 3, 2013.

2   LIDAR ACQUISITION & PROCEDURES

2.1 Acquisition Time Period

LiDAR data included in this delivery was acquired on July 12, 2013.

2.2 LiDAR Planning

The LiDAR data for this project was collected with AeroMetric's Leica ALS-70 LiDAR system. All flight planning and acquisition was completed using Leica FPES.

AeroMetric used the following sensor acquisition settings:

- Flight Altitude (Above Ground Level): 700 meters
- Laser Pulse Rate: 350 kHz
- Mirror Scan Frequency: 58 Hz
- Scan Angle (+/-): 40°
- Side Lap: 50 %
- Ground Speed: 150 kts
- Desired Point Density: 8 ppm

2.3 LiDAR Acquisition

The LiDAR data for this project was acquired in one mission. Airborne GPS and IMU data was collected during acquisition for use in determining the sensor's position.

The mission included the acquisition of all planned project lines and cross flights. The cross flights were flown perpendicular to the planned flight lines and their data used in the in-situ calibration of the sensor.

2.4 ABGPS and IMU Processing

The mission was processed using Leica IPAS-TC software to determine both the airborne GNSS trajectory, and the blending of inertial data. AeroMetric operated a GPS base station on location during the acquisition of this data. The position of the base station and raw GPS data were computed by AeroMetric for use in processing.

GNSS Processing Results

Resultant metrics from the airborne processing are shown in **Figure 1** below. While processing, IPAS-TC estimates the trajectory both from beginning to end and from end to beginning, providing two independent trajectories. The differences are evaluated and used as on overall accuracy assessment tool. The IPAS-TC plot shown below includes combined separation values for the Latitude (top), Longitude (middle), and height (bottom). Laser on times are highlighted in blue.
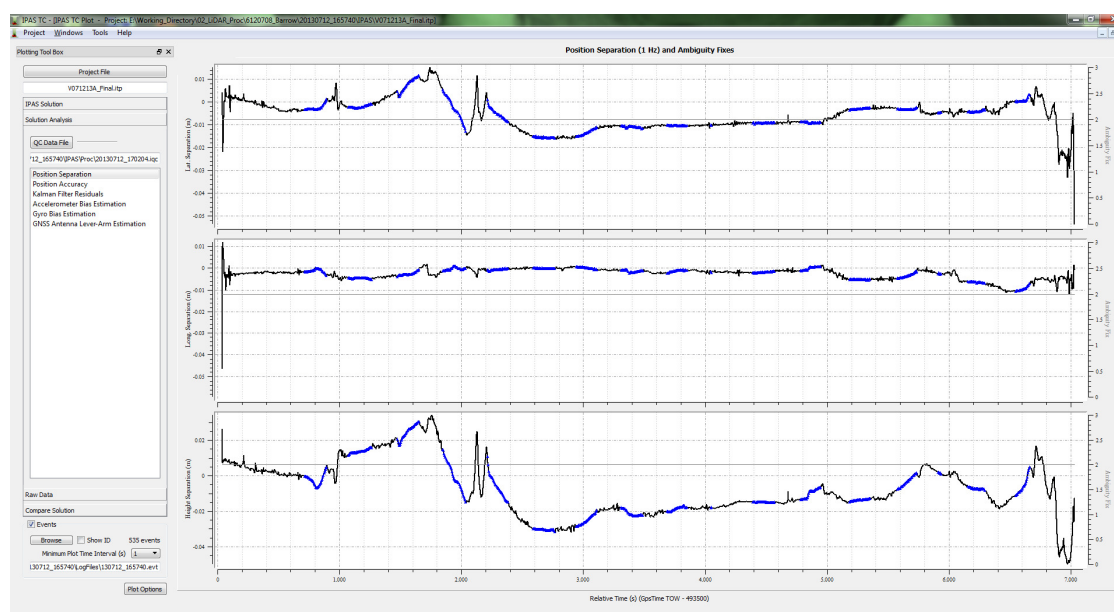
Combined Separation Results:

Figure 1 – Combined Separation Results Within +/-0.02m horizontally, +/-0.04m vertically.

2.5 LiDAR Point Cloud Generation

The airborne GNSS/IMU post processed data along with the LiDAR raw measurements were processed using Leica ALSPP v 2.79. One LAS 1.2 file was generated per flightline.

2.6 LiDAR Calibration

Introduction

The purpose of the LiDAR system calibration is to refine the system parameters in order for the post-processing software to produce a "point cloud" that best fits relatively from swath to swath. If the results of the calibration are good, then adjusting the calibrated point cloud to ground control should provide a data set that is an optimal representation of the terrain for the given data's resolution.

Calibration Procedures

AeroMetric routinely performs two types of calibrations on its LiDAR systems. The first calibration, system calibration, is performed whenever the LiDAR system is installed in the aircraft. This calibration is performed to define the system parameters affected by the physical misalignment of the system versus aircraft. The second calibration, in-situ calibration, is performed for each mission using that missions data. This calibration is performed to refine the system parameters that are affected by the on site conditions as needed.

System Calibration and Correction Software

AeroMetric utilizes an array of specialty software packages for computing and evaluating its LiDAR calibration parameters. For this project, TerraSolid's TerraMatch v 12.001 (TMatch) package was the primary tool utilized in the computation and correction of systematic errors. This software has tools for correcting fine-alignment errors in the orientation of the sensor, as well as other system parameters such as mirror scale.

In-situ Calibration

The in-situ calibration is performed as needed using the mission's data. This calibration is performed to refine the system parameters that may change slightly with time, as well as to correct for any additional swath-to-swath errors.

For each mission, planned lines are flown parallel to each other, with some perpendicular cross flights. The processed data of the crossing lines is compared using TMatch software to determine if any systematic errors are present.

In TerraSolid's TerraScan v 12.003 (TerraScan), points can be viewed by offset from overlapping flightlines. This is done by generating independent TINs of each flightline and computing distances from those TINs. This provides a useful tool for visualizing and identifying systematic calibration errors. See **Figure 2** for example.
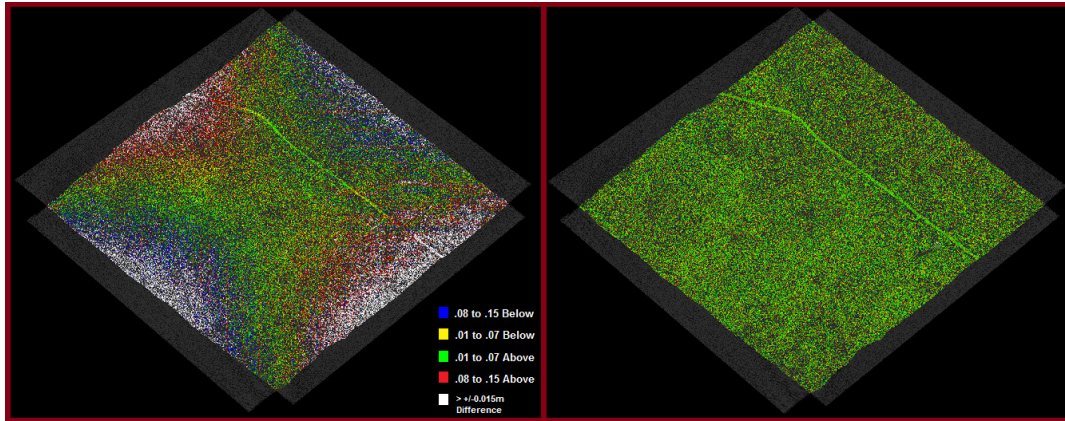

Figure 2 - Perpendicular Lines Colored by Offset Before and After Systematic Corrections are Applied

2.7 LiDAR Processing

LAS files were imported and parsed into manageable, tiled grids using GeoCue version 2012.1.27.7. GeoCue allows for ease of data management and process tracking.

The first step after the data has been processed and calibrated is to perform a relative accuracy assessment of the flight lines. To perform this assessment, AeroMetric uses GeoCue to create orthophotos colored by elevation differences. These images provide a visual interpretation of how well flight lines match, and are a useful tool in determining either the success or need to re-evaluate the in-situ calibration procedure.

Once the calibration results have been verified, the point cloud data is then "auto-classified". This process involves running multi-step ground, building and error classification routines on the entire project. The goal of these routines is to automatically identify and classify atmospheric noise, roofs of buildings, and more importantly, the apparent ground surface. These routines are often tested and modified in an attempt to optimize their effectiveness for a given project's unique terrain.

Once the data has been auto-classified, it is manually reviewed in TerraScan. Manual classification techniques are utilized to re-classify features as necessary. This can involve adding data to the ground or buildings classes where the automated routines did not, or points from the ground or building classes that are incorrectly classified.

2.8 LiDAR Point Density

One of the stipulations for this project was achieving a minimum of 8 points per square meter (ppm) in the final ground classified data. Following LiDAR classification, a point density analysis was carried out to verify that this requirement had indeed been met. As can be seen in **Figure 3**, the only portions of the project not meeting or exceeding the 8ppm limit are water bodies.

The banding of yellow and green in the center is caused by an increased point density within perpendicular flight swaths.

Figure 3 - Ground Classified Point Density

3 QC PROCEDURES

3.1 QC Summary

AeroMetric performs various QC checks throughout its processing of LiDAR data. Those associated with calibration have already been described above. Other QC procedures involve manually reviewing the work completed in data classification. This involves a more senior LiDAR analyst reviewing the work completed to ensure quality practices were utilized.

Further QC procedures involve comparison with field-survey data to remove any atmospheric bias encountered during data collection. This process involves statistically comparing the LiDAR "bare-earth" surface to collected survey data,

determining and applying a vertical offset, and generating final statistics to determine the vertical accuracy of the data.

3.2 Vertical Accuracy

UMIAQ acquired 285 check points throughout the project area. These points were provided to AeroMetric for use in determining the vertical accuracy of the LiDAR data. The computed $RMSE_z$ at the 95% confidence interval was 0.143 meters, meeting this project's specifications. See **Figure 3** for a histogram of the elevation error differences.
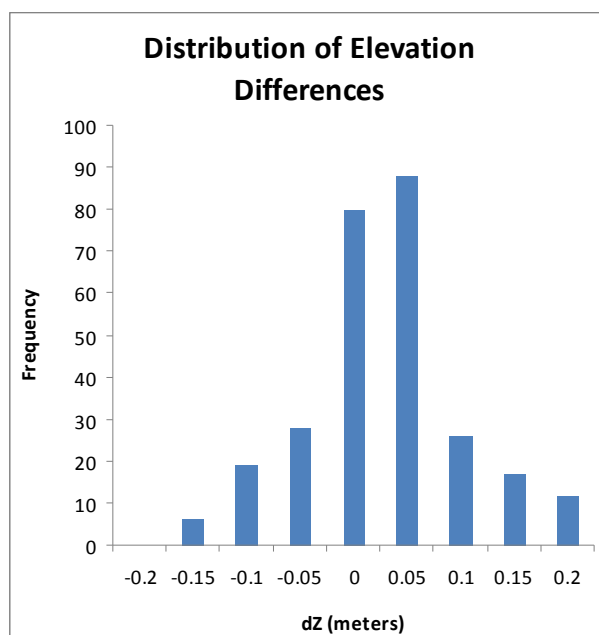

Figure 4 – Distribution of vertical error

A statistical summary of the vertical accuracy results has been compiled and can be found in another file, in the Reports folder, named: Barrow_LiDAR_Vertical_Accuracy_Results.xls.

4   DELIVERABLES

4.1 Delivered Products

All deliverables listed below use the spatial reference listed in **Section 1.5**.

Bare Earth Digital Elevation Models – Tiled, 0.25 meter resolution digital elevation models in GeoTIFF and ESRI ArcGrid (binary) formats.

LAS Data – Classified LiDAR point cloud files in ASPRS LAS 1.3 format. The points were classified in the following manner:

   Class 1: Unclassified.
   Class 2: Ground
   Class 6: Buildings
   Class 7: Error Points
   Class 9: Water
   Class 10: Breakline Proximity (Points within 0.5 meters of breaklines).

ASCII Point Files:

1. **All Points XYZ –** Tiled**,** space delimited ASCII .txt files in Easting, Northing, Elevation format. Includes all points regardless of classification.
2. **All Points XYZI –** Tiled**,** space delimited ASCII .txt files in Easting, Northing, Elevation, Intensity Value format. Intensity values range from 0-255. Includes all points regardless of classification.
3. **Bare-Earth XYZ –** Tiled**,** space delimited ASCII .txt files in Easting, Northing, Elevation format. Includes all points classified as ground.
4. **Unclassified XYZ –** Tiled**,** space delimited ASCII .txt files in Easting, Northing, Elevation format. Includes all unclassified points between 0.5 and 4.0 meters above ground.

Intensity Images – Tiled, 0.25 meter resolution 8 bit GeoTIFFs displaying LiDAR intensity values.

Breaklines – 3D Polygon shapefiles containing the boundaries and elevations of water features. This includes the ocean, all lakes larger than 2 acres, and all rivers wider than 100 feet.

Metadata – Provided as FGDC compliant project level metadata in .xml format, per deliverable type.

Reports
1. **LiDAR Acquisition and Processing Report –** This document**,** outlining acquisition, processing, and QC procedures in .doc and .pdf formats.
2. **Vertical Accuracy Results –** full results of comparison with surveyed ground points to LiDAR data, in .xls format.

Tile Index – Provided in shapefile format.

Boundary – Shapefile containing project extents.