

PROJECT REPORT

FOR

Kenai Fjords NP Glaciers Lidar

AERO-METRIC, INC.

November 14, 2008

USGS CONTRACT NO. 07CRCN002

USGS TASK ORDER NO: 07002C0023

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Overview

During 2007, the United States Geological Survey (USGS) awarded the contract number 07CRCN0002 to Aero-Metric, Inc., to provide LIDAR acquisition and derived mapping products for approximately 145 square miles, which covers the Harding Ice Field, Exit Glacier, and Bear Glacier west of Seward, Alaska. This report will outline acquisition planning, data processing, and deliverable products. Appendix A contains the system calibration report.

Flight Planning

The data for this project was collected with Aero-Metric's Optech Gemini-167 lidar system (Serial Number 03SEN145). This sensor is capable of recording 4 returns for each pulse generated. All flight planning and acquisition was completed using Optech's ALTM-Nav, version 1.0.67b (flight planning and lidar control software). All flight lines were flown with 60% side lap in order to achieve point spacing of approximately 2.0 meters (m). The entire area was covered using 46 flight lines over the ice field, plus one cross flight at each end of the project, and two cross flights over the Seward airport. The following are the system settings for acquiring the data for this project.

- Flying Height (Above Ground): 3800 meters
- Laser Pulse Rate: 33.33 kHz
- Mirror Scan Frequency: 20.7 Hz
- Scan Angle (+/-): 12°
- Side Lap: 60 %
- Ground Speed: 160 kts

Acquisition

The lidar data for the project was acquired between 16:48 and 23:56 (GMT) on August 30, 2008.

The following were the meteorological conditions during acquisition.

Temperature: 54° F
Pressure: 29.95 in. Hg
Clouds: None
Wind Speed: 9 kts

Two, dual frequency GPS receivers, collecting data at a rate of 2 Hz, were set up by Aero-Metric during the acquisition phase of this project, one at each of the following points.

1. SWD 1
2. SWD 2

These monuments were established by Aero-Metric for previous projects and are located at the Seward Airport.

Processing

The airborne GPS/IMU data was processed using POSPac 4.4 (Applanix, Inc.). This software utilized the multiple GPS stations established during acquisition in order to compute a 2 Hz GPS trajectory with an estimated accuracy of +/- 10.0 centimeters. The GPS trajectory was used to process the IMU data, and create a 200 Hz airborne trajectory.

The raw lidar data was merged with the processed ABGPS/IMU data using Optech's DASHMap version 1.1. Each flight line was computed individually in LAS 1.1 format.

Final system misalignment and mirror scale corrections were computed using TerraMatch 8.001 (TerraSolid, Ltd.). These corrections were applied to all of the data collected in the mission. Once all of the biases were removed from the data from each mission, the data were combined into one dataset.

Automated classification algorithms in TerraScan 8.001 (TerraSolid, Ltd.) module were used to produce the majority of the bare-earth dataset. The remainder of the data was classified using manual classification techniques.

Upon completion of the bare-earth dataset the final deliverable products were produced.

Accuracy Assessment

The final lidar dataset was using kinematic road profile collected by Aero-Metric, near the project area. During acquisition the flight lines were extended over these roads to provide adequate verification. The ground truth points were compared against the lidar using TerraScan, which computes the difference between each ground truth point and the lidar generated surface. These differences are recorded in an output file in ASCII format. This file is imported into Microsoft Excel, where a statistical analysis is performed.

All of the results from the check point datasets were assessed at the 95% confidence interval ($1.96 \times \text{RMSE}$), in accordance to the National Standard for Spatial Data Accuracy (NSSDA). The following are the NSSDA 95th percentile confidence interval from each vegetation class tested.

Smooth Surface, No Brush: 0.082 meters

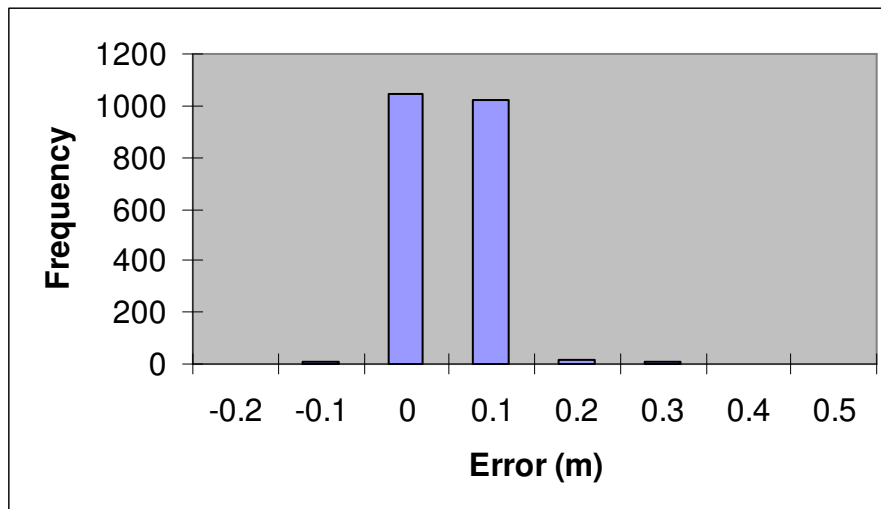


Figure 1: Histogram for Smooth Surface, No Brush

Deliverables

Point Cloud Data: all returns in both LAS and ASCII x, y, z, i formats.

Bare-Earth processed elevation data: derived from variably spaced Lidar data. These data have been delivered in ESRI .SHP and ASPRS LAS 1.1 formats.

1. Bare-earth tile size is 2 kilometers by 2 kilometers.
2. Bare-earth surface includes the top of water bodies not underwater terrain.
3. Dense vegetation data voids were minimized by automated and manual removal processes.

2-meter Raster Grid File: in ESRI ARCGRID format with floating point option selected.

Projection/ Datum: point cloud and bare-earth processed data shall be UTM NAD83-CORS96 Epoch 2003, meters, orthometric heights

Tile Naming Scheme: The tiles will be 2000 x 2000 meter tiles tied to the National Grid. The index is in shape file format in the project coordinate system.

Metadata: Project and tile level metadata describing lidar production process with FGDC-compliant metadata is provided in extensible markup language (.xml) format for each data tile.

Quality Control: Results from the quality control data check points in Microsoft Excel (.xls) format.

Conclusions

The lidar data for this project was acquired with a nominal point spacing of approximately 2.0 meters. The vertical accuracy, assessed at the 95% confidence interval was 0.082 meters on open surfaces. Areas having vegetation cover on the ground, levee side slopes, and other steep areas should be considered less accurate. These areas should not be used for engineering purposes without proper field checking in accordance with National Map Accuracy Standards.

Calibration and Testing Report

ALTM Gemini-167
(Serial Number: 03SEN145)

June 11, 2008
Aero-Metric, Anchorage

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Overview

The purpose of this report is to document the results from the calibration flight collected on June 11, 2008. All flights were completed over the Palmer Airport calibration course. The pulse rate frequencies covered in this report are 50 and 70 kHz.

Aircraft: *Piper Navajo - N6GR*

System: *Optech Gemini-167 (Serial Number: 03SEN145)*

GPS/IMU Processing Software: *Applanix POSPac version 4.4*

Laser Processing Software: *DASHMap version 1.1*

Calibration Software: *TerraScan and TerraMatch (TerraSolid, Ltd.) version 8.001*

Intensity Range Testing

The purpose of this test is to verify the system is receiving returning signals from both highly reflective and highly absorbent surfaces. If the system is not receiving signals from dark surfaces, such as pavement, this may be indicative of a system malfunction, and would require maintenance. No problems were detected during this test. The following are the intensity range values over highly reflective (runway paint stripe) and low reflective (black pavement) surfaces.

Altitude (m)	Pulse Rate Frequency (kHz)	Intensity Ranges			
		Runway Stripe		Pavement	
		Minimum	Maximum	Minimum	Maximum
600	33	1340	2120	180	240
1000	100	170	200	13	18
1500	70	120	141	8	12

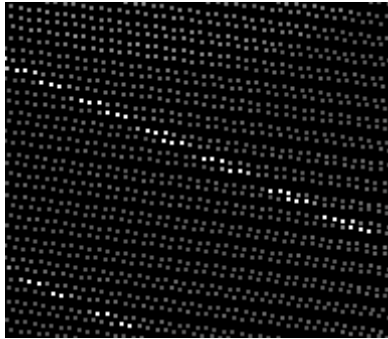


Figure 2: Sample intensity image used for test

System Calibration Procedures

The system was calibrated for 70 and 100kHz. The flight plan used was 6080103_Lidar_Calibration_Palmer_Airport_V1.pln, and the methodology for calibration is as follows.

1. Lines 1 and 2 flown in opposing directions (north and south), with the following settings. These lines are the basis upon which all other flight lines were calibrated. These lines were flown during each mission.
 - a. PRF: 33kHz
 - b. Altitude (AGL): 600 meters
 - c. Scan Angle (+/-): 6°
 - d. Scan Frequency: 70 Hz
2. Lines 4 -30 were flown perpendicular to lines 1-3, and in alternating directions (east and west). Below are the system settings, and date flown for each line.

	Pulse Rate (kHz)	Scan Freq. (Hz)	Scan Angle (+/-)	Altitude-MSL	Date Flown
Line 1	33	70	6	600	6/4/2008
Line 2	33	70	6	600	6/4/2008
Line 13	70	31	25	1500	6/4/2008
Line 14	70	31	25	1500	6/4/2008
Line 15	100	40	25	1000	6/4/2008
Line 16	100	40	25	1000	6/4/2008
*Lines 3 – 12 and 16-22 are used for different frequencies, and were not acquired during this mission					

3. The GPS/IMU trajectory was computed using POSPac version 4.4 (Applanix, Inc.). Two dual-frequency GPS units were set up at the calibration site, minimizing the baseline length and GPS error during acquisition.
4. Each pulse was positioned and assigned an intensity values using DASHMap version 1.1 (Optech, Inc.). The following files were used for the initial processing (see Appendix B for more details). Each flight line was computed as a separate file in LAS 1.1 format.
 - a. ALTM_145_March_2008.res
 - b. 2008_03SSEN145_33k.txt
 - c. 2008_03SSEN145_50k.txt
 - d. 2008_03SSEN145_70k.txt
 - e. 2008_03SSEN145_100k.txt
 - f. 2008_03SSEN145_125k.txt
 - g. 2008_03SSEN145_142k.txt
 - h. 2008_03SSEN145_166k.txt

5. Lines 1 and 2 were imported into TerraScan (TerraSolid, Ltd.) for MicroStation version 8.001. Bare-earth data was classified by flight line, and were adjusted using TerraMatch (TerraSolid, Ltd.).

TerraMatch was used to compute any misalignments in roll, pitch and heading, and also compute any systematic mirror scale. These misalignments are computed in an iterative process by comparing the bare-earth surface models from each overlapping flight line.

6. Once Lines 1 and 2 are adjusted, they are used as the calibration surface for the remainder of the flight lines.

7. The corrections computed by TerraMatch were applied to ALTM_145_March_2008.res, and new *.res files were created for each PRF. The data was reprocessed in DASHMap using the appropriately modified *.res file and step 5 was repeated. If the new TerraMatch results were minimal, the corrections were applied correctly and the system was properly calibrated for those settings.

70 kHz Calibration Results

Flight lines used: 1-2 and 13-14

TerraMatch Results

	Execution Time (sec)	Number of Iterations	Points	Heading Shift	Roll Shift	Pitch Shift	Mirror Scale
Initial	3698.6	49	2940948	-0.0084	+0.0160	+0.0037	-0.00106
Calibrated	68.5	1	2940948	-0.0002	+0.0003	+0.0003	0.0000

100 kHz Calibration Results

Flight lines used: 1-2 and 15-16

TerraMatch Results

	Execution Time (sec)	Number of Iterations	Points	Heading Shift	Roll Shift	Pitch Shift	Mirror Scale
Initial	414.5	7	2074553	-0.0004	-0.0013	-0.0009	+0.00012
Calibrated	60.7	1	2624612	-0.0005	0.0000	+0.0005	0.0000

Conclusions

The system is operating properly for the pulse rates of 70 and 100 kHz. No problems were detected during data acquisition and processing. The *.res files created during this calibration can be used for the duration of this installation.