Minto 2019
LiDAR and Airphoto
Data Capture and Processing

<u>LiDAR and Air Photo Report</u>

Our File:

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1. Introduction

McElhanney Ltd (MCSL) performed a LiDAR and aerial photography acquisition for Minto, shown in Figure 1.

The site was flown on September 26th, and 27th. This report describes the acquisition, post-processing and quality control methodology used to produce the final elevation models.

2. Mission Plan

Project: Minto LiDAR and Aerial photo Project
Date: 2019-09-26, 2019-09-27
Location: Minto
Topography: low relief

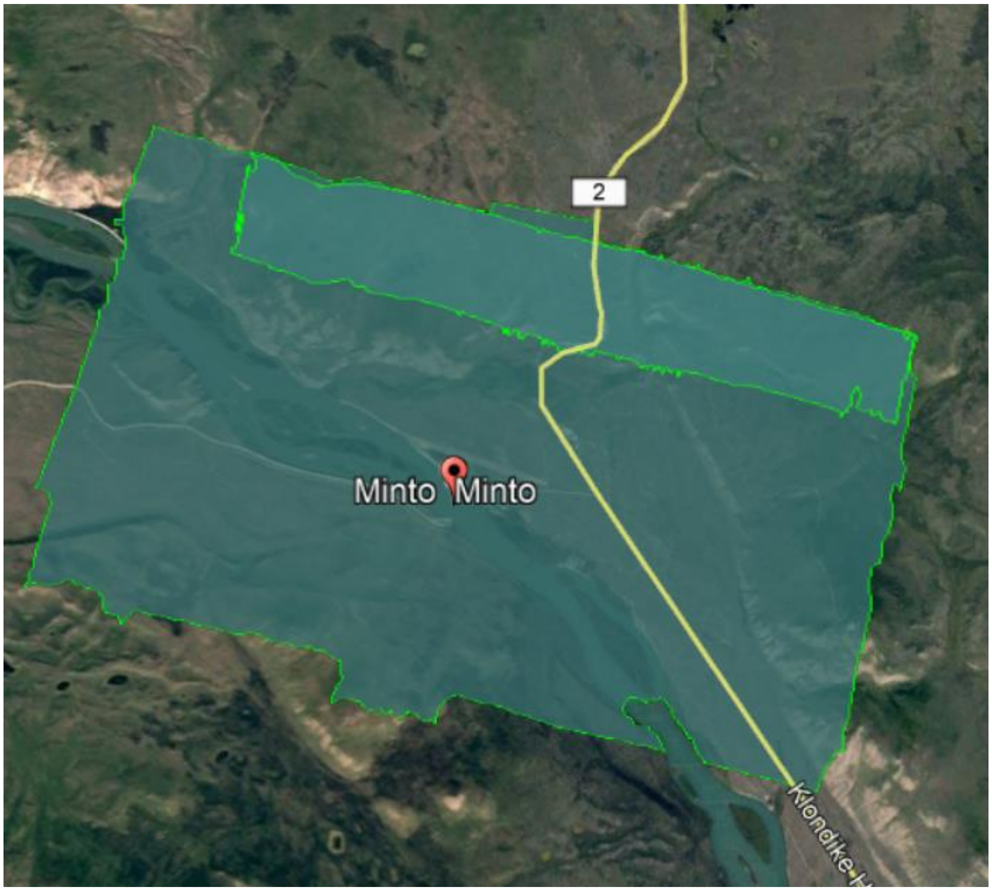

Figure 1– LiDAR Survey Site

3. Equipment

McElhanney utilized the Optech Galaxy system for LiDAR Capture (Figure 2). For Product Specifications of Optech Galaxy please see

http://www.teledyneoptech.com/index.php/product/optech-altm-galaxy/

The Galaxy was mounted on Piper Navajo fixed wing Aircraft.

Figure 2 – Optech Galaxy components

On Board Camera Phase One iXU-RS1000 RGB simultaneous capture (Figure 3.)

Phase One Industrial – Cameras iXU-RS1000 series

iXU-RS1000 series

Camera Type	iXU-RS1000
Camera Specifications	
Lens type	Rodenstock / Schneider-Kreuznach
Focal length F (mm)	RS lenses: 32, 40, 50, 70, 90, 110, 150 SK lenses: 28, 55, 80, 110, 150, 240
FOV (across line, deg)	86.5 (28mm) – 12.9 (240mm)
FOV (along flight line, deg)	70.3 (28mm) – 9.7 (240mm)
Aperture	f/5.6
Exposure principle	Leaf shutter
Exposure (sec)	1/2000 to 1/125
Image capture rate	1 frame every 0.6 sec
Light Sensitivity (ISO)	50-6400
Dynamic Range (db)	>84
Spectral characteristics	R,G,B
Sensor Specifications	
CMOS pixel size (μm)	4.6
CMOS array (pix)	11,608 x 8,708
Analog-to-digital-conversion (bit)	14
Frame / Image Specifications	
Frame geometry	Central projection
Image size (pixel)	11,608 x 8,708
Image volume (MP)	100
Color	RGB or NIR
Typical image size (MB)	300
Image format	Phase One RAW, TIFF, JPEG
Operational Specifications	
Power Consumption	< 10W
Dimensions (depends on lens)	97.4 x 93 x <218 mm
Weight (depends on lens)	< 2 kg

PHASEONE
Specialty Imaging Solutions

Figure 3 – Phase One Camera Series

4. Flight Plan

Table 1: Flight Parameters- 2019-09-26

Strip ID	Start [s]	Stop [s]	PRF [kHz]	Scan Frequency [Hz]	Scan Swath [deg]	Speed Avg [m/s]	Height Avg [m]
1	427226.7	427230.9	4.2	400	66	50	74.9
2	427242.5	427339.2	96.7	400	66	50	80.3
3	427862.3	427974.8	112.5	400	66	50	75.4
4	428091.9	428096.1	4.2	400	66	50	77.7
5	428112.4	428116.7	4.2	400	66	50	76.9
6	428384	428488.1	104.1	400	66	50	78.4
7	428686.4	428804.5	118.1	400	66	50	75.1
8	429020.6	429134.9	114.4	400	66	50	77.3
9	429360.3	429479.4	119	400	66	50	74.1
10	429699.1	429807	107.8	400	66	50	78.8
11	430031.4	430144.8	113.5	400	66	50	76.4
12	430377.6	430483.6	106	400	66	50	81.2
13	430782.7	430880.3	97.6	400	66	50	73.5
14	432200.5	432317.6	117.2	400	66	50	81.2
15	432594.3	432705.9	111.6	400	66	50	77.2
16	432961.1	433087.7	126.5	400	66	50	76.5
17	433305.5	433427.4	121.8	400	66	50	79.2
18	433679.8	433807.3	127.5	400	66	50	76.3
19	434027.9	434035	7.1	400	66	50	78.6
20	434046.6	434154.5	107.8	400	66	50	76.5
21	434409.7	434533.4	123.7	400	66	50	78.8
22	434756	434876.9	120.9	400	66	50	78.2
23	435131.1	435257.7	126.5	400	66	50	76.8
24	435485.8	435602.1	116.3	400	66	50	78.4
25	435796.6	435812.1	15.4	400	66	50	87.6

Table 1: Flight Parameters- 2019-09-27

Strip ID	Start [s]	Stop [s]	PRF [kHz]	Scan Frequency [Hz]	Scan Swath [deg]	Speed Avg [m/s]	Height Avg [m]
1	498719.4	498836.6	117.2	400	66	50	80.6
2	499064.8	499070.9	6.1	400	66	50	84.5
3	499452.1	499597.3	145.2	400	66	50	79.5
4	499826.4	499972.5	146.1	400	66	50	77
5	500241.7	500385	143.3	400	66	50	79.4
6	500608.5	500750.9	142.4	400	66	50	75.9
7	501033.2	501141	107.8	400	66	50	76.1
8	501347.7	501404.2	56.5	400	66	50	77.3
9	504844	504958.4	114.4	400	66	50	77.9
10	505192.1	505303.7	111.6	400	66	50	80.4
11	505529.1	505643.5	114.4	400	66	50	79.1
12	505881.9	505999.1	117.2	400	66	50	77
13	506227.2	506342.5	115.3	400	66	50	79
14	506573.5	506689.7	116.3	400	66	50	78.7
15	506923.5	507040.7	117.2	400	66	50	78.7
16	507279.1	507297.3	18.2	400	66	50	80.4
17	507308	507395.3	87.3	400	66	50	79
18	507615.1	507733.2	118.1	400	66	50	77.5
19	507920.3	507991.7	71.4	400	66	50	82.9
20	508379.5	508497.6	118.1	400	66	50	74.7

5. Data Processing

All GPS and IMU data was processed using PosPac MMS 8.4 software. The laser data was extracted using Teledyne Optech LMS software. The GPS antenna position in the airplane was calculated by post–processing the raw data at 1 second intervals for the entire flight.
We have used Precise Point Positioning (PPP) for the airborne GPS processing, and the coordinates were calculated in NAD83-CSRS.

The airborne positions were combined with the post–processed platform (aircraft) attitude information to generate a time tagged position and orientation solution.

The standard deviation of the airborne GPS solution for using KAR (Kinematics Ambiguity Resolution) was estimated to be 0.03, 0.04 and 0.05m in East, North and height directions, respectively.

The estimated values for the GPS antenna position were used with the laser ranges and platform angles to compute all the individual X, Y, and Z coordinates for each laser return in each flight line. The result is a processed point cloud containing all measured points.

6. Point Density

Bare earth point density varies with canopy closure, understory density and topographic features. Mean density of the point cloud was measured at nominal 9.42 pts/m^2 and the Bare earth point density was measured at nominal 5.96 pts/m^2.

7. Calibration

System: Optech ALTM Galaxy S/N 5060392
LiDAR Calibration flight:

Calibration Date: June 14, 2019 Location: Whitehorse, Yukon
The LiDAR system calibration was flown over calibration site. The lever arms (offset between GPS antenna IMU and Laser Mirror), were measured as:

Lever Arms
GPS Lever arms in (m):
x: 0.28 y: -0.445 z: -1.196

IMU Lever arms in (m):
x: 0 y: 0 z: 0

There were a total number of 10 flight lines for calibration: 9 basic orthogonal lines for LMS software analysis and 1 redundant line for better accuracy. The lines were planned as follow:

Flight line direction: 3 lines north – south and 3 lines east – west and 1-line NW-SE
All GPS with IMU data was processed using PosPac Applanix software v.8.3. and the laser data was extracted using LMS v.4.3 The GPS antenna position in the airplane was calculated by post–processing the raw data at 1 second intervals for the entire flight.

The calibration values used for this project are as follows:

imu_ex: 0.049404867 arcsec
imu_ey: -0.062994531 arcsec
imu_ez: -0.131591982 arcsec

8. Quality Control

The LiDAR data consistencies have been checked between the flight lines using Terrascan software.

Comparison of Bare Earth LiDAR data with Ground Survey Values

According to ASPRS guidelines, the vertical accuracy of LiDAR is as follows:

$$RMSE_z = Sqrt[\sum (Z_{Lidar(i)} - Z_{check(i)})^2 / n]$$ = 0.12 m

Where the ”Check” refers to the ground truth (In this project, we used survey points which are at least three times more accurate than the individual LiDAR points) and *n* is the number of check points. LiDAR 2019 was checked vs road center line points from 2014 LiDAR dataset. A total of 202 ground check points were used for this analysis.

Average dz	-0.003 m
Minimum dz	-0.110 m
Maximum dz	+0.150 m
Average magnitude	0.025 m
Root mean square	0.034 m
Std deviation	0.034 m

9. Deliverables

Final output data is provided in NAD83CSRS UTM N8 and the elevations are based on CGVD28 HT2 geoid model. The deliverables include:

- Bare Earth & Thinned model key points in las, xyz
- Non Bare Earth in las format
- Index map
- 15 cm Orthophto
- Technical report