2022 Whitehorse Airport, Yukon

LiDAR and Airphoto
Data Capture and Processing

LiDAR and Air Photo Report

Our File: 2611 19372-07

Submitted To: Panya Lipovsky, PGeo.

Surficial Geologist | Energy, Mines and Resources | Yukon Geological Survey
Mailing address: P.O. Box 2703 (K-14), Whitehorse, YT, Y1A 2C6
T 867-667-8520 | geology.gov.yk.ca | Yukon.ca

Submitted By:
McElhanney Ltd.
200-858 Beatty Street
Vancouver, BC
V6B 1C1
Tel: (604) 424 4784

Prepared by: Morteza Esfandiari, MSc., EIT.
Contact: Azadeh Koohzare, PhD., PEng.

March 25, 2024

Table of Contents

List of Figures

List of Tables

1. Introduction

McElhanney Ltd (MCSL) performed a LiDAR and aerial photography acquisition for Whitehorse Airport area shown in Figure 1.

The site was flown on June 19th. This report describes the acquisition, post-processing and quality control methodology used to produce the final elevation models.

2. Mission Plan

Project: Whitehorse Airport

Date: 2022-06-19

Location: Whitehorse Airport, YT

Topography: low relief

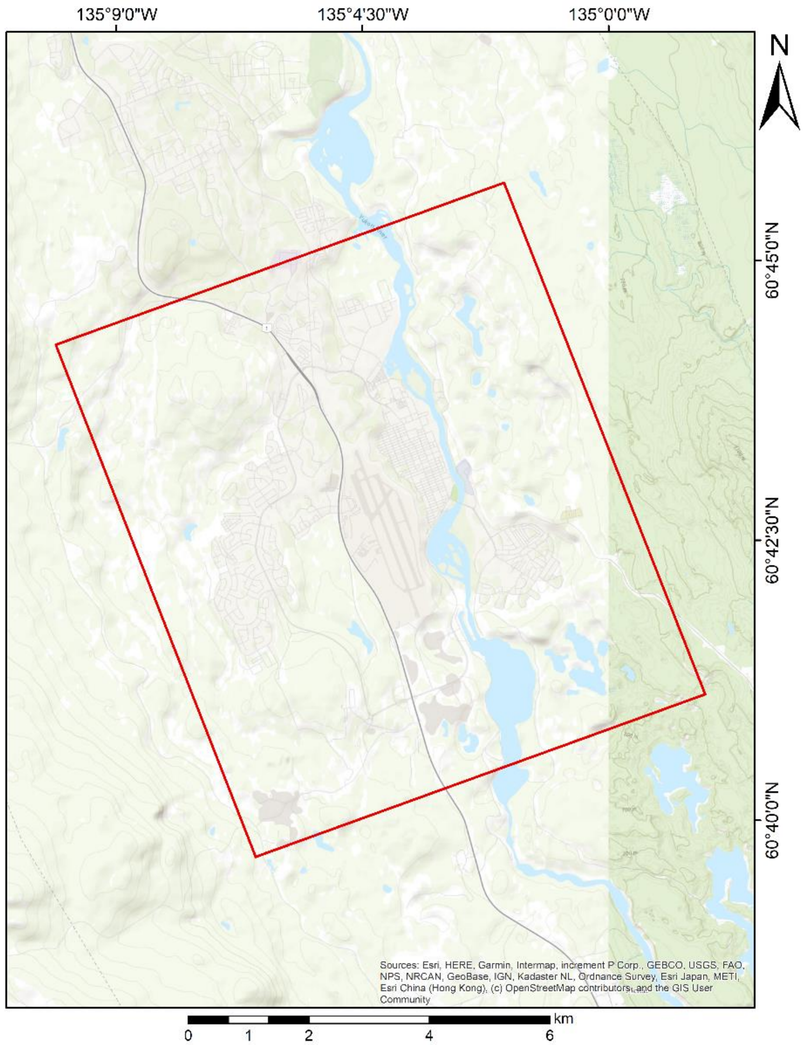

Figure 1 - LiDAR Survey Site

3. Equipment

McElhanney utilized the Leica Terrain Mapper -2 (TM2), Hyperion2+ system for LiDAR Capture (Figure 2).

For Product Specifications please see

https://leica-geosystems.com/products/airborne-systems/topographic-lidar-sensors/leica-terrainmapper-2

The LiDAR system is mounted on Piper Navajo fixed wing aircraft.

On-board camera is Leica MFC150 / Leica MFC150-NIR Camera Head - simultaneous capture.

Figure 2 - Leica TerrainMapper-2 system components

4. Flight Plan

Table 1 - Flight Parameters 2022-06-19

Flight Line Label	Swath Width [m]	Alt MSL [m]	Length [km]	Scan Pattern	Used Laser Pulse Rate [Hz]	Used Scan Rate [Hz]	FOV [deg]	Flown Line Direction [deg]	Line begin time [UTC]	Line end time [UTC]
036	1310	2422	19222.5	Circle	2000000	150	40	359.3	22:46:31	22:50:47
037	1310	2414	20482.7	Circle	2000000	150	40	179.4	22:52:19	22:57:23
038	1310	2411	20642.2	Circle	2000000	150	40	359.4	22:58:46	23:03:24
039	1310	2409	20766.4	Circle	2000000	150	40	179.3	23:05:01	23:10:21
040	1310	2409	19658.4	Circle	2000000	150	40	359.4	23:12:00	23:16:46
041	1310	2411	17805.5	Circle	2000000	150	40	179.3	23:18:42	23:23:19
042	1310	2423	13472	Circle	2000000	150	40	359.3	23:24:33	23:27:38

043	1310	2428	11898.3	Circle	2000000	150	40	179.3	23:29:25	23:32:29
044	1310	2425	11035.5	Circle	2000000	150	40	359.4	23:33:49	23:36:28
045	1310	2427	11101.5	Circle	2000000	150	40	179.3	23:38:05	23:41:02
046	1310	2428	10951	Circle	2000000	150	40	359.4	23:42:29	23:45:13
047	1310	2506	10007.4	Circle	2000000	150	40	179.4	23:46:44	23:49:35
048	1310	2537	5688.9	Circle	2000000	150	40	359.3	23:50:54	23:52:10
061	1310	2436	27793.5	Circle	2000000	150	40	329.7	20:46:18	20:52:14
062	1310	2435	28256.5	Circle	2000000	150	40	149.8	20:53:57	21:00:45
063	1310	2432	28495.1	Circle	2000000	150	40	329.7	21:02:14	21:08:36
064	1310	2432	28499.8	Circle	2000000	150	40	149.8	21:10:29	21:17:15
065	1310	2428	28221.4	Circle	2000000	150	40	329.7	21:18:41	21:25:29
066	1310	2428	27645.9	Circle	2000000	150	40	149.8	21:27:20	21:33:59
067	1310	2428	27392.4	Circle	2000000	150	40	329.7	21:35:31	21:41:52
068	1310	2428	26718.7	Circle	2000000	150	40	149.8	21:43:41	21:50:13
069	1310	2422	26368.8	Circle	2000000	150	40	329.7	21:52:07	21:58:17
070	1310	2425	27206.3	Circle	2000000	150	40	149.7	21:59:45	22:06:27
071	1310	2418	27352.5	Circle	2000000	150	40	329.7	22:07:53	22:14:15
072	1310	2412	27154.2	Circle	2000000	150	40	149.7	22:15:55	22:22:27
073	1310	2409	26654.4	Circle	2000000	150	40	329.8	22:24:21	22:30:41
074	1310	2409	25422.6	Circle	2000000	150	40	149.7	22:32:26	22:39:06

5. Data Processing

All GPS and IMU data was processed using Inertial Explorer v8.9 software. The laser data was extracted using Leica HxMap 3.6 software. The GPS antenna position in the airplane was calculated by post-processing the raw data at one (1) second intervals for the entire flight. We have used Precise Point Position (PPP) to process the trajectories, and the coordinates were calculated in NAD83(CSRS).

6. Point Density

Bare earth point density varies with canopy closure, understory density and topographic features. Mean density of the point cloud and bare-earth was measured and can be seen in the following table.

Table 2 - Measured point density for project sites

Area	Point-cloud pts/m^2	Bare-earth pts/m^2
Whitehorse Airport	16.27	47.39

7. Calibration

System: Leica TM-2

LiDAR Calibration flight:

Calibration Date: April 24, 2022 Location: Abbotsford, BC

Base station used for calibration (in NAD83(CSRS) v4e2002):

- BCAB N 49° 03’ 7.81125” W 122° 19’ 46.2715” 72.996m

The LiDAR system calibration was flown over calibration site. The lever arms (offset between GPS antenna IMU and Laser Mirror), were calibrated based on 31 ground survey points.

Lever Arms

GPS Lever arms in (m):

X = -0.218 m Y = -0.224 m Z = 1.298 m

IMU Lever arms in (m):

x: 0 y: 0 z: 0

8. Quality Control

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

Comparison of Bare Earth LiDAR data with Existing LiDAR Ground Points

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

Area - 01

$$RMSE_z = Sqrt[\sum(Z_{Lidar(i)} - Z_{check(i)})^2 / n] = 0.027\text{m}$$

Area - 02

$$RMSE_z = Sqrt[\sum(Z_{Lidar(i)} - Z_{check(i)})^2 / n] = 0.031\text{m}$$

Area – 03

$$RMSE_z = Sqrt[\sum(Z_{Lidar(i)} - Z_{check(i)})^2 / n] = 0.103\text{m}$$

Area – 04

$$RMSE_z = Sqrt[\sum(Z_{Lidar(i)} - Z_{check(i)})^2 / n] = 0.022\text{m}$$

Area – 05

$$RMSE_z = Sqrt[\sum(Z_{Lidar(i)} - Z_{check(i)})^2 / n] = 0.059\text{m}$$

Where the "Check" refers to the ground truth (in this project, we used existing LiDAR ground points) and *n* is the number of check points. A total of 2,014 check points were used for this analysis shown in Figure 3. Check points distributed across 'QC Area -01' represent the accuracy of area of interest. Below the figure, detailed accuracy metrics corresponding to these checkpoints can be found.

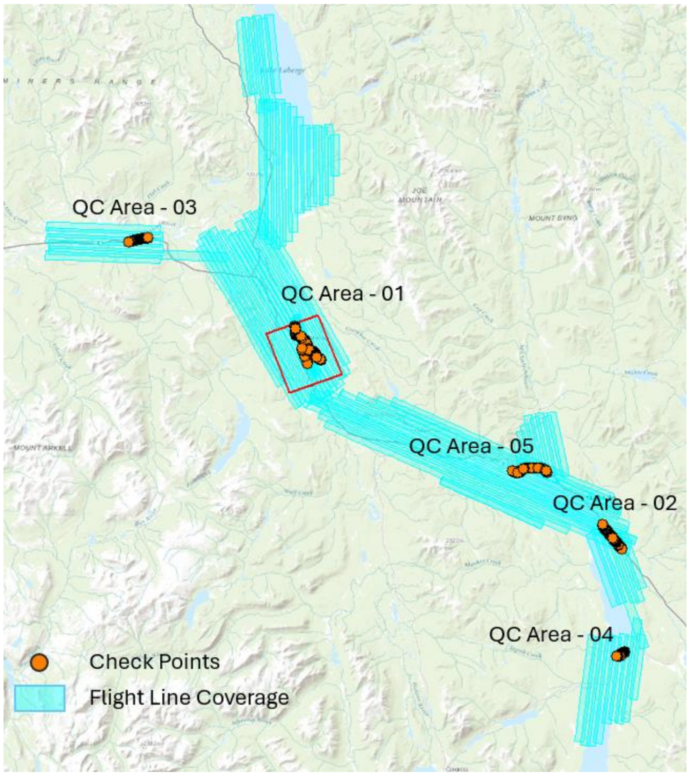

Figure 3 - Controls used for vertical check

QC Area – 01

N=308
Average dz +0.018 m
Minimum dz -0.048 m
Maximum dz +0.064 m
Average magnitude 0.023 m
Root mean square 0.027 m
Std deviation 0.020 m

QC Area - 02

N= 538
Average dz +0.017 m
Minimum dz -0.077 m
Maximum dz +0.100 m
Average magnitude 0.024 m
Root mean square 0.031 m
Std deviation 0.026 m

QC Area – 03

N= 415
Average dz -0.063 m
Minimum dz -0.240 m
Maximum dz +0.122 m
Average magnitude 0.085 m
Root mean square 0.103 m
Std deviation 0.082 m

QC Area – 04

N= 108
Average dz +0.044 m
Minimum dz -0.003 m
Maximum dz +0.097 m
Average magnitude 0.044 m
Root mean square 0.049 m
Std deviation 0.022

QC Area – 05

N= 645
Average dz +0.055 m
Minimum dz -0.023 m
Maximum dz +0.129 m
Average magnitude 0.055 m
Root mean square 0.059 m
Std deviation 0.021 m

9. Deliverables

Final output data is provided in NAD83CSRS UTM Zone 8 and the elevations are based on CGVD28 HT2 and CGVD13 geoid models. The deliverables include:

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