Yukon-2023 Lakes

LiDAR and Airphoto
Data Capture and Processing

LiDAR and Air Photo Report

Our File: 2611 19372-08

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1. Introduction

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

The site was flown on August 28th, 2023. This report describes the acquisition, post-processing and quality control methodology used to produce the final elevation models.

2. Mission Plan

Project: Yukon Lakes

Date: 2023-08-28

Location: Teslin and Marsh Lake, YT

Topography: low relief

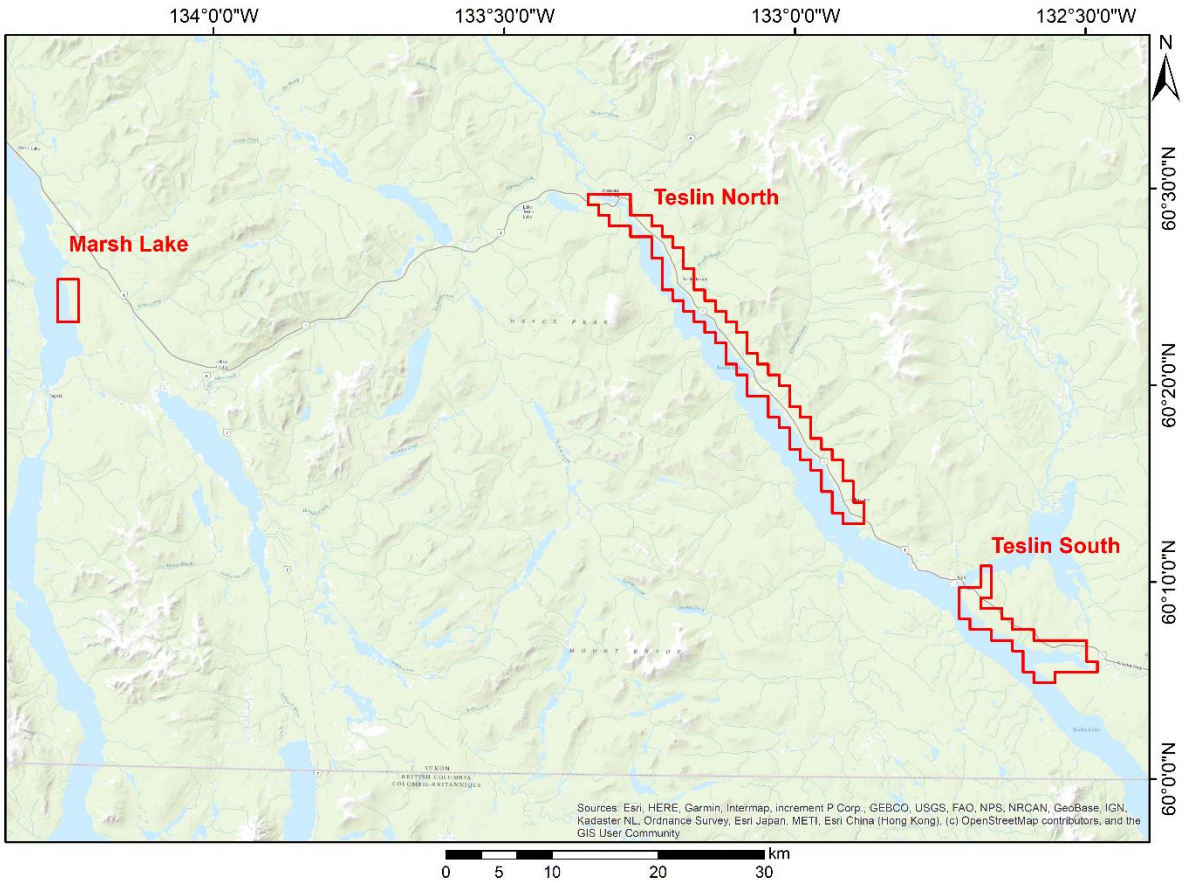


Figure 1 - LiDAR Survey Site

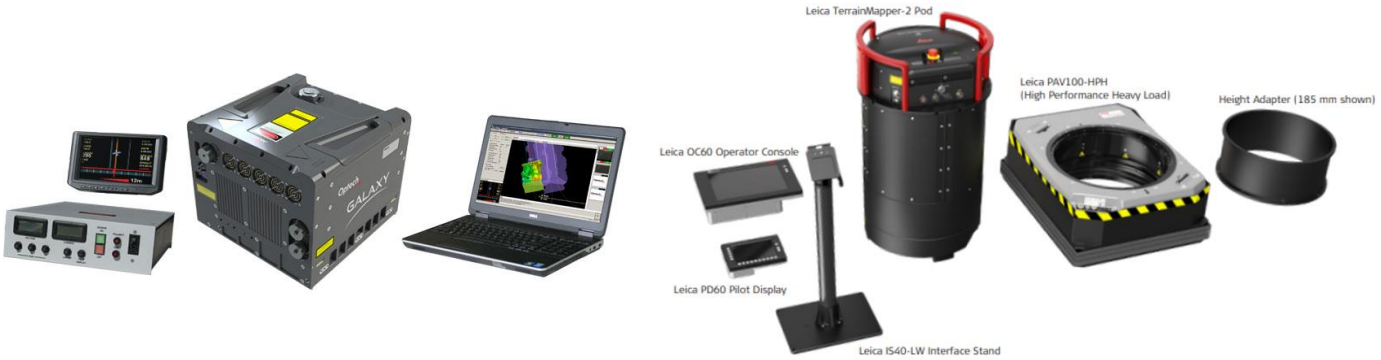
3. Equipment

McElhanney utilized the Optech Galaxy-T2000 System, and Leica TerrainMapper-2 (Figure 3).

Table 1 - Sensor specifications

Sensro	Link
Optech Galaxy-T2000	http://www.teledyneoptech.com/index.php/product/optech-altm-galaxy/
Leica TerrainMapper-2	https://leica-geosystems.com/products/airborne-systems/topographic-lidar-sensors/leica-terrainmapper-2

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



(a) (b)

Figure 2 – Optech Galaxy-T2000 (a), and Leica TerrainMapper-2 (b) components

4. Flight Plan

Table 2 - Flight Parameters 2023-07-09

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]
008	1310	2436	41684.1	Circle	2000000	150	40	321.4	19:25:55	19:35:49
009	1310	2431	42482.1	Circle	2000000	150	40	141.3	19:37:32	19:47:21
010	1310	2445	42054.7	Circle	2000000	150	40	321.4	19:49:11	19:59:17
011	1310	2462	41302.3	Circle	2000000	150	40	141.4	20:01:06	20:10:41
012	1310	2487	39621	Circle	2000000	150	40	321.4	20:12:41	20:22:18
013	1310	2493	37319.3	Circle	2000000	150	40	141.3	20:24:20	20:32:55

014	1310	2504	32467.1	Circle	2000000	150	40	321.4	20:34:44	20:42:16
015	1310	2440	5744.6	Circle	2000000	150	40	178.1	18:18:33	18:19:59
016	1310	2441	5642.5	Circle	2000000	150	40	358.1	18:21:55	18:23:24
017	1310	2460	5673.9	Circle	2000000	150	40	178	18:25:21	18:26:54

Table 3 - Flight Parameters 2023-08-27

Strip ID	Start [s]	Stop [s]	Duration [s]	PRF [kHz]	Scan Frequency [Hz]	Scanner Half Angle [deg]	Speed Avg [m/s]	Height Avg [m]
1	65078.3	65202.7	124.3	1200	95	22	73 .4	2019.9
2	65344.9	65400.5	55.6	1200	95	22	71.7	2022.4
3	65540	65628.3	88.3	1200	95	22	73.3	2022.9
4	65847	66070.7	223.6	1200	95	22	72.7	2081.6
5	66896.7	67119.4	222.7	1200	95	22	72.2	2074.1
6	67253.2	67456.3	203.1	1200	95	22	72.8	2092.8
7	67593.9	67792.3	198.4	1200	95	22	71.7	2092.2
8	67965.4	68155.4	190	1200	95	22	73.8	2083.8
9	68299.5	68491.4	191.9	1200	95	22	73.3	2044.4
10	68987.1	69179	191.9	1200	95	22	73.3	2048.1
11	69308.2	69490.8	182.6	1200	95	22	72.3	1993.8
12	69648	69807.2	159.2	1200	95	22	73.5	1997.4
13	70035.3	70150.6	115.4	1200	95	22	74	2075

5. Data Processing

All GPS and IMU data for Galaxy-T2000 was processed using POSPac MMS 8.7 software. The laser data was extracted using Teledyne Optech LMS v4.1 software. The Leica TerrainMapper-2 GPS and IMU data was processed using Inertial Explorer v8.9, and the laser data was extracted using Leica HxMap 4.2 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 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. The measured point density for all returns and ground points is presented in the following table.

Table 4 - Measured point density for project sites

Area	All Returns (pts/m^2)	Bare Earth (pts/m^2)
Marsh Lake	46.00	16.99
Teslin North	56.27	15.85
Teslin South	30.67	10.22

7. Calibration

System: Leica TerrainMapper-2

LiDAR Calibration flight:

Calibration Date: Feburary 24, 2023 Location: Abbotsford, BC

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

- BCAB N 49° 03’ 07.81125” 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 = -0.219 m Y = -0.230 m Z = +1.246 m

IMU Lever arms in (m):

x: 0 y: 0 z: 0

System: Optech Galaxy T2000

LiDAR Calibration flight:

Calibration Date: August 01, 2023 Location: Red Deer, AB

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

- ABRD N 52° 16’ 16.381569” W 113° 49’ 01.47521278” 848.5524m epoch 2010

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 = 0.266 m Y = -0.449 m Z = -1.176 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:

$$Area - 01\ RMSE_z = Sqrt\ \left[\sum (Z_{Lidar(i)} - Z_{check(i)})^2/n\right] = 0.035m$$

$$Area - 02\ RMSE_z = Sqrt\ \left[\sum (Z_{Lidar(i)} - Z_{check(i)})^2/n\right] = 0.024m$$

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 1740 check points were used for this analysis.

Area-1		**Area-2**	
n=256		n=1484	
Average dz	-0.000 m	Average dz	-0.000 m
Minimum dz	-0.106 m	Minimum dz	-0.088
Maximum dz	+0.084 m	Maximum dz	+0.056
Average magnitude	0.027 m	Average magnitude	0.014
Root mean square	0.035 m	Root mean square	0.024
Std deviation	0.035 m	Std deviation	0.024

9. Deliverables

Final output data is provided in NAD83CSRS UTM Zone 08 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