



## **Yukon, Mayo – 2024 LiDAR & Orthophoto Request**

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Submitted to: Government of Yukon  
Prepared by McElhanney

## **Yukon, Mayo – 2021 & 2022 LiDAR & Orthophoto Datasets**

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Our file: 2611-19372-09

A faint, stylized topographic map of a mountainous region, likely the Sierra Nevada, is visible in the upper portion of the page. The map features contour lines and a dashed line representing a boundary or path.

**Your Challenge.  
Our Passion.**



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## Project Summary

McElhanney Ltd (MCSL) performed a LiDAR and aerial photography acquisition for the Community of Mayo in Yukon, as shown in Figure 1. The site was flown on two separate dates: September 12<sup>th</sup>, 2021, and June 17<sup>th</sup>, 2022. This report describes the acquisition, post-processing and quality control methodology used to produce the final elevation models.

## 1. Mission Plan

**Project:** Community of Mayo, LiDAR and Ortho

**Date:** 2021-09-12; 2022-06-17

**Location:** Mayo, YT

**Topography:** low relief

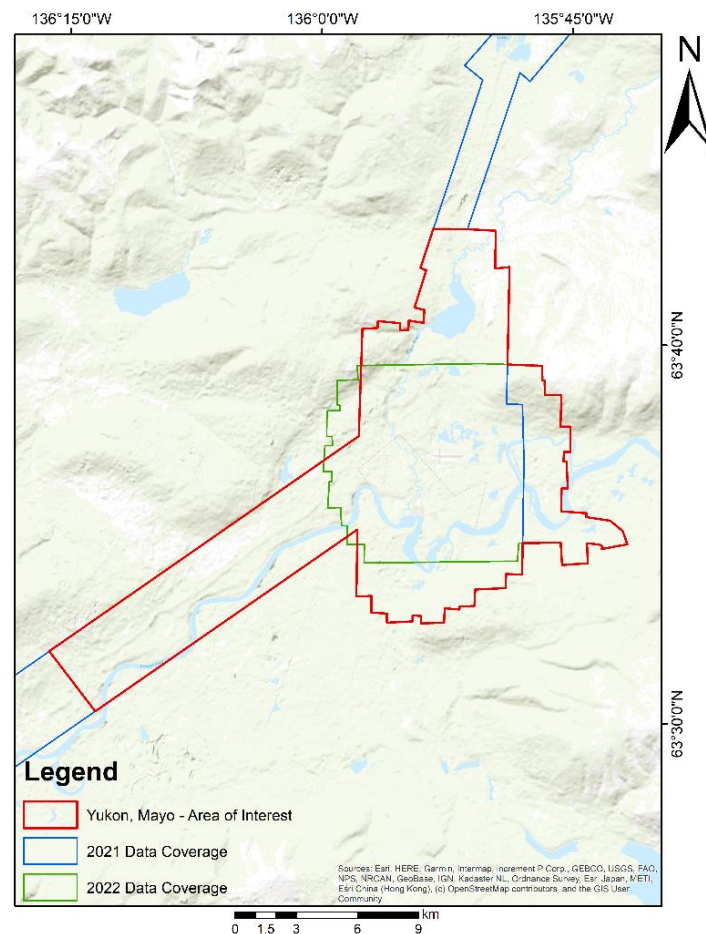


Figure 1 - LiDAR Survey Site



## 2. 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

### 3. Data Processing

All GPS and IMU data was processed using Inertial Explorer v8.9 software. The laser data was extracted using Leica HxMap 4.3 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 Differential Global Positioning Systems (DGPSs) to process the trajectories, and the coordinates were calculated in NAD83.

### 4. Point Density

Bare earth point density varies with canopy closure, understory density and topographic features. The mean density of the point cloud was measured and shown in the following table for each dataset.

Table 1 - Measured Point Density

|              | Point-Cloud Density<br>(points/m <sup>2</sup> ) | Bare-Earth Density<br>(points/m <sup>2</sup> ) | Bare-Earth Mean<br>Point Spacing (m) |
|--------------|-------------------------------------------------|------------------------------------------------|--------------------------------------|
| 2021 Dataset | 22.21                                           | 6.44                                           | 0.39                                 |
| 2022 Dataset | 34.25                                           | 11.22                                          | 0.30                                 |

### 5. Calibration

#### System: Leica TM-2 – 2021 Calibration

#### LiDAR Calibration flight:

Calibration Date: March 13, 2021 Location: Abbotsford, BC

Base station used for calibration (in NAD83(CSRS) UTM Zone 10N v4e2002):

- BCAB E548989.214m N5433471.780m h72.996m

The LiDAR system calibration was flown over the 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 = -0.180 m Y = -0.239 m Z = -1.188 m

IMU Lever arms in (m):

x: 0 y: 0 z: 0

**System: Leica TM-2 – 2022 Calibration****LiDAR Calibration flight:**

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

Base station used for calibration (in NAD83(CSRS) UTM Zone 10N v4e2002):

- BCAB E548989.214m N5433471.780m h72.996m

The LiDAR system calibration was flown over the 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

## 6. Quality Control

The LiDAR data consistencies have been checked between the flight lines using Leica-Hxmap software during GNSS post-processing and using Terrascan software during classification and QC.

### 6.1 Comparison of Bare Earth LiDAR Data with Control Data – Vertical Accuracy

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

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

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 1585 check points were used for the 2021 dataset analysis, and 132 check points were used for the 2022 dataset. The location and type of check points used for this analysis is shown in Figure 3.

| 2021 Dataset Analysis |          |
|-----------------------|----------|
| Number of points:     | 1585     |
| Average dz            | -0.000 m |
| Minimum dz            | -0.117 m |
| Maximum dz            | +0.125 m |
| Average magnitude     | 0.029 m  |
| Root mean square      | 0.038 m  |
| Std deviation         | 0.038 m  |
| 2022 Dataset Analysis |          |
| Number of points:     | 132      |
| Average dz            | +0.001 m |
| Minimum dz            | -0.048 m |
| Maximum dz            | +0.086 m |
| Average magnitude     | 0.019 m  |
| Root mean square      | 0.025 m  |
| Std deviation         | 0.025 m  |

### 6.2 LiDAR Horizontal Accuracy

Establishing LiDAR horizontal accuracy involves a visual assessment relying on the ability to locate features in the LiDAR point cloud. When a feature is identified, its location is then compared to the location of control points measured at the feature in the field. The ability to locate features in LiDAR data is strongly linked to the point-cloud density, and thus, mean point-spacing achieved over the assessment area.



## 7. Deliverables

Final output data is provided in NAD83(CSRs) UTM Zone 08 and the elevations are based on CGVD28 and CGVD2013 geoid model. The deliverables include the following items for both datasets:

- Classified LiDAR data in las and xyz file formats. 1km<sup>2</sup> tiles. Files are separated by bare-earth (ground points, BE filename suffix) and non-bare-earth points (above ground points, NBE filename suffix).
- LiDAR model key points in xyz format.
- Index map
- 10 cm-pixel, 8-bit natural colour RGB orthophoto in 1km<sup>2</sup> Geotiff tiles and ecw ortho-mosaic formats – 2021 Dataset
- 15 cm-pixel, 8-bit natural colour RGB orthophoto in 1km<sup>2</sup> Geotiff tiles and ecw ortho-mosaic formats – 2022 Dataset
- Project report
- Metadata

# **Appendix A**

## **LiDAR Flight Parameters**

Table 2 - Flight Parameters 2021-09-12

| Flight Line Label | Swath Width [m] | Alt MSL [m] | Length [m] | 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] |
|-------------------|-----------------|-------------|------------|--------------|----------------------------|---------------------|-----------|----------------------------|-----------------------|---------------------|
| A06               | 1310            | 2402        | 14700      | Circle       | 1500000                    | 150                 | 40        | 197.7                      | 23:49:40 tt           | 23:52:53 tt         |
| A07               | 1310            | 2396        | 17400      | Circle       | 1500000                    | 150                 | 40        | 17.9                       | 23:43:52 tt           | 23:47:37 tt         |
| A08               | 1310            | 2421        | 16600      | Circle       | 1500000                    | 150                 | 40        | 41                         | 23:55:59 tt           | 23:59:39 tt         |
| A09               | 1310            | 2421        | 16400      | Circle       | 1500000                    | 150                 | 40        | 221.3                      | 0:01:33 tt            | 0:05:10 tt          |
| A10               | 1310            | 2418        | 17800      | Circle       | 1500000                    | 150                 | 40        | 41.3                       | 0:06:51 tt            | 0:10:41 tt          |
| A11               | 1310            | 2418        | 4400       | Circle       | 1500000                    | 150                 | 40        | 220.5                      | 0:14:40 tt            | 0:15:42 tt          |
| A12               | 1310            | 2548        | 16300      | Circle       | 1500000                    | 150                 | 40        | 58                         | 0:19:48 tt            | 0:23:13 tt          |
| A13               | 1310            | 2594        | 17400      | Circle       | 1500000                    | 150                 | 40        | 238.5                      | 0:25:01 tt            | 0:28:56 tt          |
| A14               | 1310            | 2628        | 11300      | Circle       | 1500000                    | 150                 | 40        | 58.4                       | 0:30:58 tt            | 0:33:37 tt          |
| A15               | 1310            | 2422        | 8500       | Circle       | 1500000                    | 150                 | 40        | 141.3                      | 0:37:41 tt            | 0:39:50 tt          |
| A15               | 1310            | 2422        | 8500       | Circle       | 1500000                    | 150                 | 40        | 141.3                      | 0:45:46 tt            | 0:47:45 tt          |
| A16               | 1310            | 2422        | 8300       | Circle       | 1500000                    | 150                 | 40        | 321.9                      | 0:41:45 tt            | 0:43:40 tt          |
| 001               | 1310            | 2360        | 48500      | Circle       | 1500000                    | 150                 | 40        | 54.1                       | 21:51:18 tt           | 22:01:48 tt         |
| 002               | 1310            | 2354        | 48100      | Circle       | 1500000                    | 150                 | 40        | 234.1                      | 22:03:40 tt           | 22:14:15 tt         |
| 003               | 1310            | 2354        | 47800      | Circle       | 1500000                    | 150                 | 40        | 54.1                       | 22:16:01 tt           | 22:27:03 tt         |
| 004               | 1310            | 2341        | 40600      | Circle       | 1500000                    | 150                 | 40        | 234.1                      | 22:29:38 tt           | 22:39:09 tt         |
| 001               | 1310            | 2373        | 12900      | Circle       | 1500000                    | 150                 | 40        | 359.9                      | 22:47:40 tt           | 22:50:47 tt         |
| 002               | 1310            | 2374        | 14000      | Circle       | 1500000                    | 150                 | 40        | 179.9                      | 22:52:33 tt           | 22:55:40 tt         |
| 003               | 1310            | 2373        | 14000      | Circle       | 1500000                    | 150                 | 40        | 359.9                      | 22:57:22 tt           | 23:00:34 tt         |
| 004               | 1310            | 2376        | 14000      | Circle       | 1500000                    | 150                 | 40        | 179.9                      | 23:02:25 tt           | 23:05:38 tt         |
| 005               | 1310            | 2376        | 16500      | Circle       | 1500000                    | 150                 | 40        | 359.9                      | 23:07:22 tt           | 23:11:07 tt         |
| 006               | 1310            | 2372        | 18800      | Circle       | 1500000                    | 150                 | 40        | 179.9                      | 23:13:34 tt           | 23:17:55 tt         |
| 007               | 1310            | 2363        | 18200      | Circle       | 1500000                    | 150                 | 40        | 359.9                      | 23:19:53 tt           | 23:23:52 tt         |
| 008               | 1310            | 2360        | 17300      | Circle       | 1500000                    | 150                 | 40        | 179.9                      | 23:25:59 tt           | 23:29:46 tt         |
| 009               | 1310            | 2360        | 15400      | Circle       | 1500000                    | 150                 | 40        | 359.9                      | 23:31:40 tt           | 23:35:05 tt         |
| 010               | 1310            | 2360        | 8000       | Circle       | 1500000                    | 150                 | 40        | 179.9                      | 23:37:52 tt           | 23:39:45 tt         |

Table 3 - Flight Parameters 2022-06-17

| Flight Line Label | Swath Width [m] | Alt MSL [m] | Length [m] | 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] |
|-------------------|-----------------|-------------|------------|--------------|----------------------------|---------------------|-----------|----------------------------|-----------------------|---------------------|
| 094               | 1310            | 2391        | 8767.1     | Circle       | 2000000                    | 150                 | 40        | 268.8                      | 20:05:06              | 20:07:33            |
| 095               | 1310            | 2389        | 9946       | Circle       | 2000000                    | 150                 | 40        | 88.8                       | 20:00:52              | 20:03:25            |
| 096               | 1310            | 2377        | 10649.8    | Circle       | 2000000                    | 150                 | 40        | 268.9                      | 19:56:11              | 19:59:00            |
| 097               | 1310            | 2375        | 11238.7    | Circle       | 2000000                    | 150                 | 40        | 88.8                       | 19:51:37              | 19:54:30            |
| 098               | 1310            | 2372        | 11416.3    | Circle       | 2000000                    | 150                 | 40        | 268.8                      | 19:46:53              | 19:49:58            |
| 099               | 1310            | 2358        | 11465.6    | Circle       | 2000000                    | 150                 | 40        | 88.8                       | 19:42:29              | 19:45:22            |
| 100               | 1310            | 2358        | 11377.1    | Circle       | 2000000                    | 150                 | 40        | 268.8                      | 19:37:59              | 19:40:57            |
| 101               | 1310            | 2360        | 11136.7    | Circle       | 2000000                    | 150                 | 40        | 88.8                       | 19:33:42              | 19:36:31            |
| 102               | 1310            | 2368        | 10508.8    | Circle       | 2000000                    | 150                 | 40        | 268.9                      | 19:29:16              | 19:32:00            |
| 103               | 1310            | 2374        | 9442.1     | Circle       | 2000000                    | 150                 | 40        | 333.9                      | 19:17:08              | 19:23:15            |
| 103               | 1310            | 2374        | 9442.1     | Circle       | 2000000                    | 150                 | 40        | 88.8                       | 19:25:28              | 19:27:43            |
| 104               | 1310            | 2372        | 7286.1     | Circle       | 2000000                    | 150                 | 40        | 88.6                       | 19:14:14              | 19:16:01            |