Rabitfoot – 2024 LiDAR & Orthophoto

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Prepared by McElhanney

Contact
Azadeh Koohzare, P.hD., P.Eng
Division Manager
+1 604-424-4784
akoohzare@mcelhanney.com

Address
200 – 858 Beatty Street, Vancouver BC Canada, V6B 1C1

Prepared by
Morteza Esfandiari, M.Sc., EIT

Reviewed by
Azadeh Koohzare, P.hD., P.Eng

Our file: 2611-19372-11

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Project Summary

McElhanney Ltd. performed a LiDAR and aerial photography acquisition for City of Whitehorse, YT as shown in Figure 1. The site was flown on August 4th, 2024. This report describes the acquisition, post-processing and quality control methodology used to produce the final elevation models.

1. Mission Plan

Project: Rabitfoot

Date: 2024-08-04

Location: City of Whitehorse, YT

Topography: low relief valley

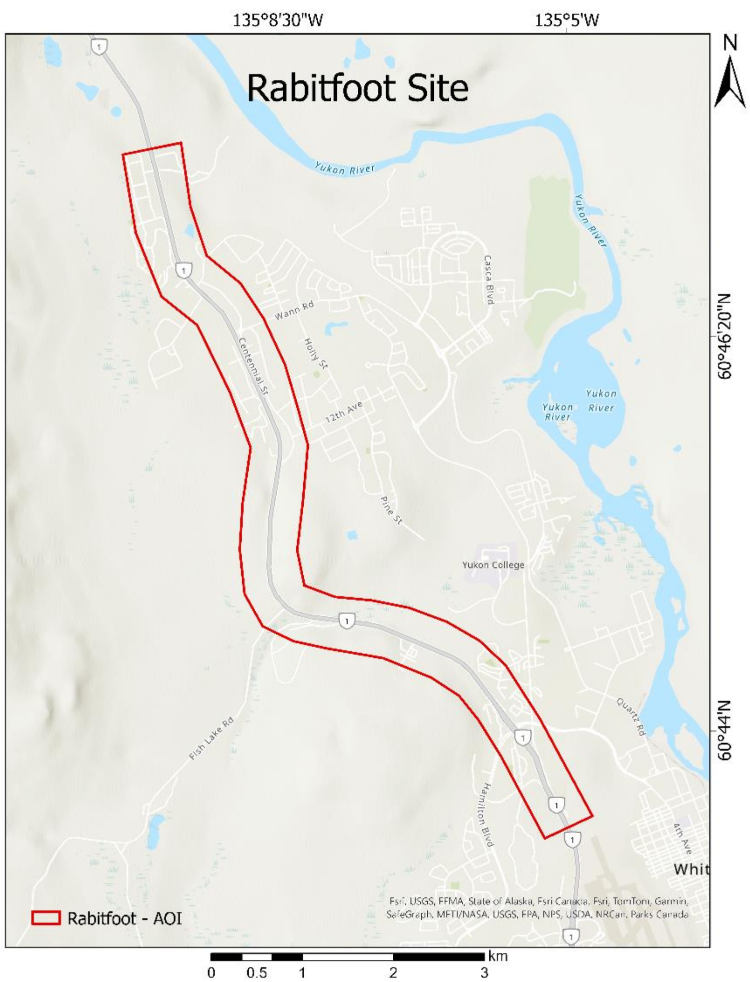

Figure 1 - LiDAR Survey Site

2. Equipment

McElhanney utilized the Leica TerrainMapper-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 4.5 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 Positioning (PPP) to process the trajectories, and the coordinates were calculated in NAD83(CSRS).

4. Point Density

Bare earth point density varies with canopy closure, understory density and topographic features. The mean density of the point cloud for both sites was measured and is reported in Table 1.

Table 1 - LiDAR Point Densities

	Point-Cloud Density (points/m^2)	**Bare-Earth Density (points/m^2)**	**Bare-Earth Point Spacing (m)**
Rabitfoot	48.40	17.26	0.24

5. Calibration

System: Leica TM-2

LiDAR Calibration flight:

Calibration Date: April 11, 2024, Location: Red Deer, AB

Base station used for calibration (in NAD83(CSRS) UTM Zone 12N Epoch 2010):

- ABRE E307796.528m N5794942.885m Ellipsoid Elevation 848.617m

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 = -0.220 m Y = -0.217 m Z = 1.299 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:

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

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 2333 check points were used for this analysis.

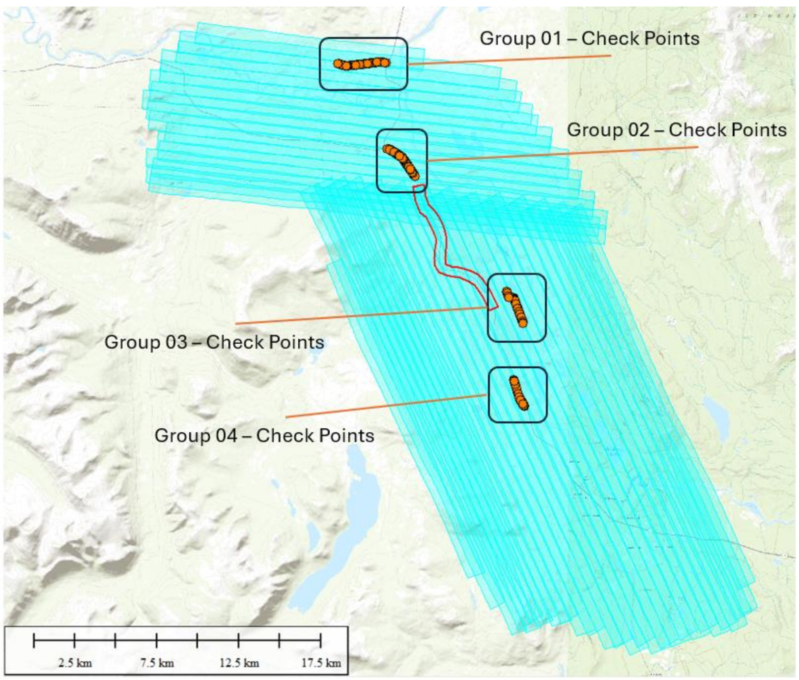

Figure 3 - Vertical check points overview

2022 - LiDAR bare-earth check points – Group 01	
Number of points: 668	
Average dz	+0.030 m
Minimum dz	-0.010 m
Maximum dz	+0.066 m
Average magnitude	0.030 m
Root mean square	0.034 m
Std deviation	0.016 m
2022 - LiDAR bare-earth check points – Group 02	
Number of points: 492	

Average dz	+0.009 m
Minimum dz	-0.038 m
Maximum dz	+0.065 m
Average magnitude	0.019 m
Root mean square	0.023 m
Std deviation	0.021 m
2022 - LiDAR bare-earth check points – Group 03	
Number of points:	896
Average dz	-0.044 m
Minimum dz	-0.094 m
Maximum dz	-0.008 m
Average magnitude	0.044 m
Root mean square	0.045 m
Std deviation	0.012 m
2022 - LiDAR bare-earth check points – Group 04	
Number of points:	277
Average dz	+0.025 m
Minimum dz	-0.001 m
Maximum dz	+0.087 m
Average magnitude	0.025 m
Root mean square	0.028 m
Std deviation	0.012 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. Figures Figure 4 and Figure 5 demonstrate the horizontal accuracy of the collected LiDAR dataset.

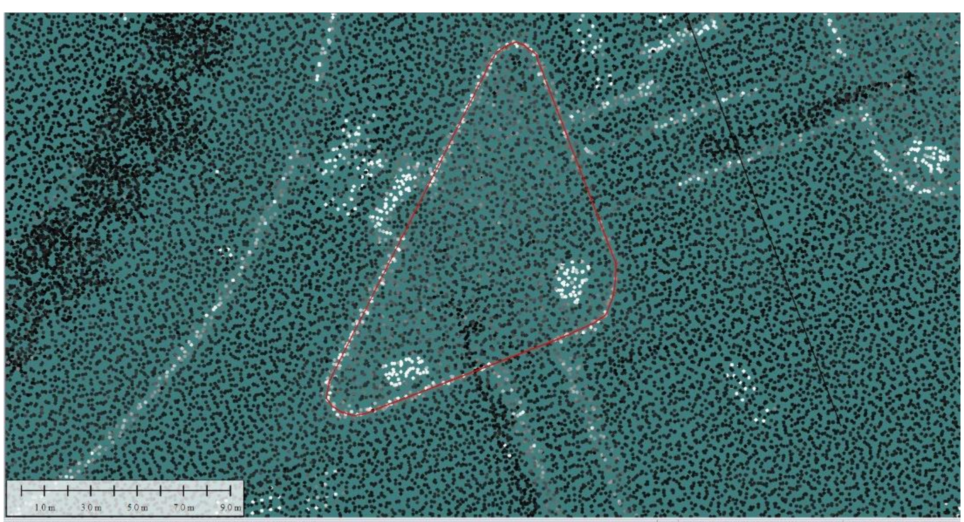

Figure 4 - Comparing LiDAR Horizontal Accuracy: Red lines are extracted from existing LiDAR data and overlaid on the current data.

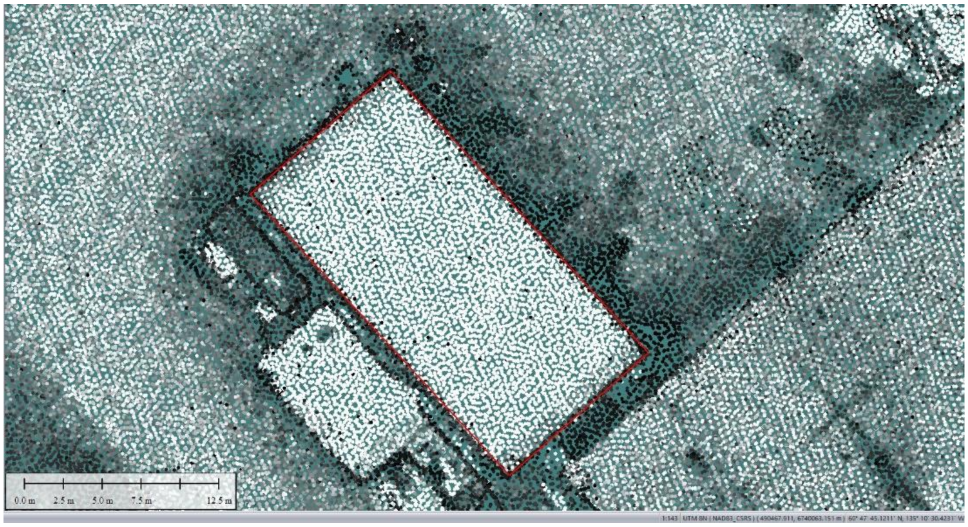

Figure 5 - Comparing LiDAR Horizontal Accuracy: Red lines are extracted from existing LiDAR data and overlaid on the current data.

7. Deliverables

Final output data is provided in NAD83(CSRS) UTM Zone 08 and the elevations are based on CGVD28-HTv2 datum. The deliverables include:

- Classified LiDAR data in las and xyz file formats. 1km² 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 1km² Geotiff tiles and ecw ortho-mosaic formats
- Project report
- Metadata

Appendix A

LiDAR Flight Parameters

2024-08-04 Flight Parameters

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]
001	1374	2821	20614	Circle	1800000	150	40	335.4	15:52:44	15:57:34
002	1374	2805	27529	Circle	1800000	150	40	155.4	16:00:36	16:06:30
003	1374	2780	29266	Circle	1800000	150	40	335.5	16:09:16	16:16:01
004	1374	2747	29456	Circle	1800000	150	40	155.4	16:18:20	16:24:46
005	1374	2719	29401	Circle	1800000	150	40	335.5	16:27:03	16:33:54
006	1374	2695	29166	Circle	1800000	150	40	155.4	16:35:47	16:42:12
007	1374	2649	29074	Circle	1800000	150	40	335.5	16:44:24	16:51:08
008	1374	2646	28869	Circle	1800000	150	40	155.4	16:53:29	16:59:48
009	1374	2626	28823	Circle	1800000	150	40	335.5	17:01:59	17:08:45
010	1374	2597	28864	Circle	1800000	150	40	155.5	17:10:44	17:16:58
011	1374	2575	29233	Circle	1800000	150	40	335.5	17:18:57	17:25:37
012	1374	2558	29449	Circle	1800000	150	40	155.5	17:27:39	17:34:18
013	1374	2541	29931	Circle	1800000	150	40	335.5	17:36:21	17:43:14
014	1374	2529	30041	Circle	1800000	150	40	155.5	17:45:23	17:52:04
015	1374	2528	30117	Circle	1800000	150	40	335.4	17:54:04	18:00:59
016	1374	2528	29792	Circle	1800000	150	40	155.4	18:02:50	18:09:23
017	1374	2528	29820	Circle	1800000	150	40	335.5	18:11:50	18:18:32
018	1374	2528	29689	Circle	1800000	150	40	155.4	18:20:25	18:27:01
019	1374	2528	29223	Circle	1800000	150	40	335.5	18:28:43	18:35:07
020	1374	2528	28920	Circle	1800000	150	40	155.4	18:36:55	18:43:22
021	1374	2528	28668	Circle	1800000	150	40	335.5	18:45:02	18:51:24
022	1374	2528	28354	Circle	1800000	150	40	155.4	18:53:04	18:59:25
023	1374	2528	28118	Circle	1800000	150	40	335.6	19:00:57	19:07:13
024	1374	2528	27978	Circle	1800000	150	40	155.4	19:09:01	19:15:14
025	1374	2528	27644	Circle	1800000	150	40	335.5	19:16:48	19:22:58
026	1374	2528	27134	Circle	1800000	150	40	155.4	19:24:42	19:30:51
027	1374	2528	26322	Circle	1800000	150	40	335.4	19:32:23	19:38:13
028	1374	2528	24996	Circle	1800000	150	40	155.4	19:39:53	19:45:30
029	1374	2523	13628	Circle	1800000	150	40	276.6	21:47:08	21:50:14
030	1374	2513	19311	Circle	1800000	150	40	96.4	21:40:25	21:44:42
031	1374	2513	20546	Circle	1800000	150	40	276.6	21:34:06	21:38:42
032	1374	2513	21809	Circle	1800000	150	40	96.5	21:27:42	21:32:34
033	1374	2513	22532	Circle	1800000	150	40	276.5	21:20:59	21:26:03
034	1374	2513	23546	Circle	1800000	150	40	96.5	21:13:58	21:19:17
035	1374	2513	24290	Circle	1800000	150	40	276.5	21:06:48	21:12:13
036	1374	2513	24732	Circle	1800000	150	40	96.4	20:59:39	21:05:07

037	1374	2514	25425	Circle	1800000	150	40	276.5	20:52:14	20:58:00
038	1374	2517	25556	Circle	1800000	150	40	96.5	20:44:55	20:50:37
039	1374	2519	25354	Circle	1800000	150	40	276.5	20:37:30	20:43:10
040	1374	2522	25614	Circle	1800000	150	40	96.5	20:29:55	20:35:41
041	1374	2522	26413	Circle	1800000	150	40	276.4	20:22:29	20:28:21
042	1374	2523	27173	Circle	1800000	150	40	96.5	20:14:43	20:20:56
043	1374	2523	27566	Circle	1800000	150	40	276.5	20:06:38	20:12:44
044	1374	2523	27640	Circle	1800000	150	40	96.5	19:58:54	20:05:07
045	1374	2523	27607	Circle	1800000	150	40	276.4	19:51:13	19:57:12