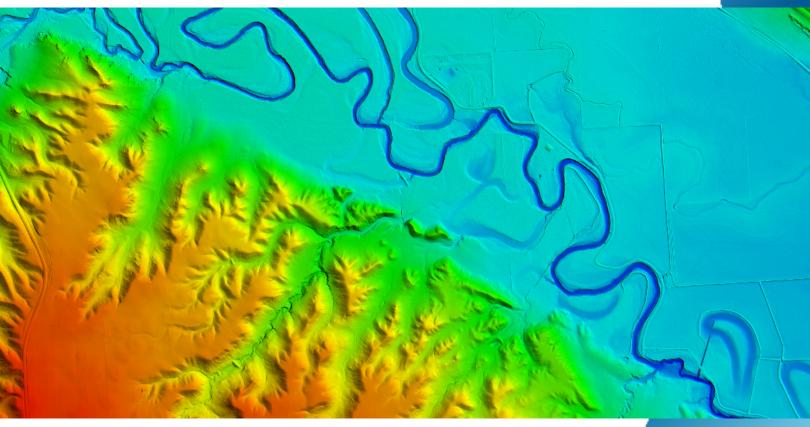
NV5 GEOSPATIAL



MT STATEWIDE PHASE2 2020 B20 LIDAR PROCESSING REPORT

2023

Submitted: May 18, 2023

Project ID: 197114 Work Unit: 197111

Prepared for:



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Prepared by:
NV5
SEOSPATIAL



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1. Summary / Scope

1.1. Summary

This report contains a summary of the MT_Statewide_Phase2_2020_B20, Work Unit 197111 lidar acquisition task order, issued by USGS under their Contract G16PC00016 on 08/12/2020. The task order yielded a project area covering 2,388 square miles over Montana. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

1.2. Scope

Aerial topographic lidar was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned Lidar Specifications

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
2 pts / m2	2500 m	58.5°	20%	≤ 10 cm

1.3. Coverage

The project boundary covers 2,388 square miles over Montana. Project extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from October 8, 2020 to May, 11 2021 in 14 total lifts. See "Section: 2.4. Time Period" for more details.

1.5. Issues

There were no issues to report.



MT_Statewide_Phase2_2020_B20 Work Unit 197111 Projected Coordinate System: Montana State Plane FIPS 2500 Horizontal Datum: NAD83(2011) Vertical Datum: NAVD88 (GEOID 18)

Units: Meters

Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	 1-meter Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format 1-meter Intensity images in GeoTIFF format 1-meter Maximum Surface Height Raster 1-meter Swath Seperation Images
Vectors	Shapefiles (*.shp) Project Boundary Lidar Tile Index Calibration and QC Checkpoints (NVA/VVA) Geodatabase (*.gdb) Continuous Hydro-flattened Breaklines Flightlines Swath
Reports	Reports in PDF format • Focus on Delivery • Focus on Accuracy • Survey Report • Processing Report
Metadata	XML Files (*.xml) Breaklines Classified Point Cloud DEM Intensity Imagery



MT Statewide Phase2 2020 B20 Work Unit 197111 Boundary

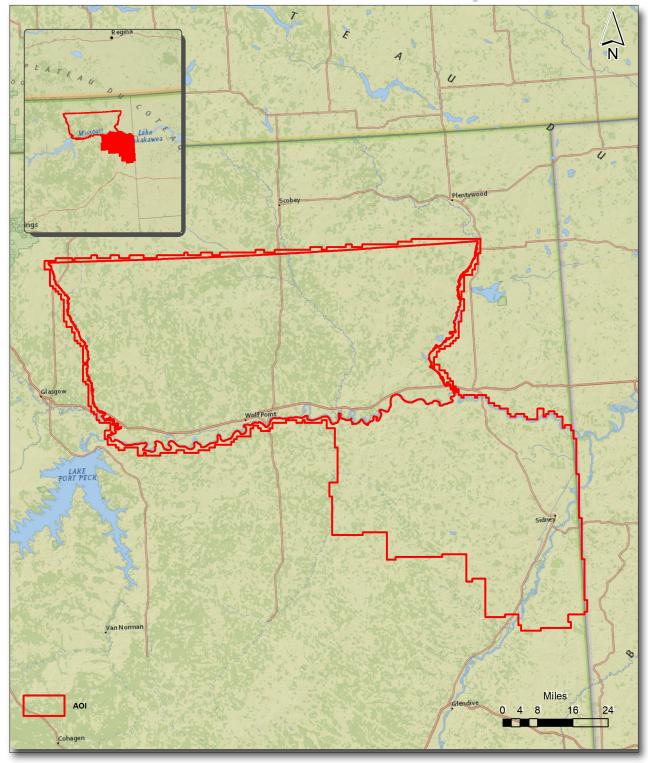


Figure 1. Work Unit Boundary



2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using RiPARAMETER planning software.

2.2. Lidar Sensor

NV5 Geospatial utilized Riegl LMS-Q1560 and VQ1560ii lidar sensors (Figure 2), serial number(s) 1264, 4051, and 3543, for data acquisition.

The Riegl LMS-Q1560 system has a laser pulse repetition rate of up to 800 kHz. This sensor has forward/backward looking capability and a wide field of view for ultra wide area mapping. There is a two channel scanner that utilizes MTA processing, echo digitization, and waveform analysis.

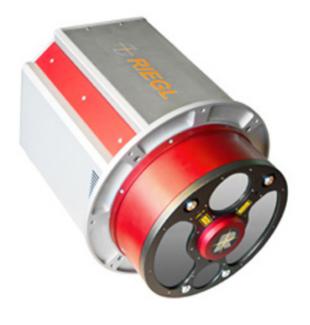
The Riegl 1560II system is a dual channel waveform processing airborne scanning system. It has a laser pulse repetition rate of up to 4 MHz resulting in up to 2.66 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA) and an integrated IMU/GNSS unit.

A brief summary of the aerial acquisition parameters for the project are shown in the lidar System Specifications in Table 2.

Table 2. Lidar System Specifications

		Riegl LMS-Q1560 (1264)	Riegl VQ1560ii (4051)	Riegl VQ1560ii (3543)
Terrain and	Flying Height	2,300 m	2,300 m	2,300 m
Aircraft Scanner	Recommended Ground Speed	160 kts	160 kts	160 kts
	Field of View	60°	60°	60°
Scanner	Scan Rate Setting Used	89 lps	91 lps	102 lps
Lacor	Laser Pulse Rate Used	400 kHz	400 kHz	500 kHz
Laser	Multi Pulse in Air Mode	yes	yes	yes
C	Full Swath Width	2,577 m	2,577 m	2,577 m
Coverage	Line Spacing	2,062 m	2,062 m	2,062 m
Point Spacing	Average Point Spacing	0.63 m	0.63 m	0.58 m
and Density	Average Point Density	2.5 pts / m ²	2.5 pts / m ²	3 pts / m²

Figure 2. Riegl LMS-Q1560 and VQ1560ii Lidar Sensors







2.3. Aircraft

All flights for the project were accomplished through the use of customized planes. Plane type and tail numbers are listed below.

Lidar Collection Planes

- Piper PA-31-7400992, Tail Number(s): C-GJMT
- Piper PA-31-310, Tail Number(s): C-GKSX
- Piper PA-31-521, Tail Number(s): C-FFRY

These aircraft provided an ideal, stable aerial base for lidar acquisition. These aerial platforms have relatively fast cruise speeds, which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art Riegl lidar systems. NV5 Geospatial's operating aircraft can be seen in Figure 3 below.



Figure 3. NV5 Geospatial's Planes



2.4. Time Period

Project specific flights were conducted between October 8, 2020 to May, 11 2021. Fourteen aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
10082020A (SN4051,C-GKSX)	10/08/2020 3:53:45 PM	10/08/2020 4:29:12 PM
10092020A2 (SN4051,C-GKSX)	10/09/2020 6:43:40 PM	10/09/2020 10:12:01 PM
10102020A (SN3543,C-FFRY)	10/10/2020 6:00:50 PM	10/10/2020 10:19:59 PM
10102020A (SN4051,C-GKSX)	10/10/2020 5:10:06 PM	10/10/2020 9:21:13 PM
10132020A (SN3543,C-FFRY)	10/13/2020 5:04:40 PM	10/13/2020 9:20:24 PM
10132020A (SN4051,C-GKSX)	10/13/2020 5:05:46 PM	10/13/2020 9:17:17 PM
11042020A (SN3543,C-FFRY)	11/04/2020 7:07:51 PM	11/04/2020 10:15:15 PM
11052020B (SN3543,C-FFRY)	11/05/2020 6:25:48 PM	11/05/2020 10:13:44 PM
11062020A (SN3543,C-FFRY)	11/06/2020 4:11:16 PM	11/06/2020 8:48:35 PM
04302021A (SN1264,C-GJMT)	4/30/2021 4:08:30 PM	4/30/2021 7:32:40 PM
05012021A (SN1264,C-GJMT)	5/01/2021 3:35:09 PM	5/01/2021 7:23:27 PM
05072021A (SN1264,C-GJMT)	5/07/2021 3:51:05 PM	5/07/2021 8:26:56 PM
05102021A (SN1264,C-GJMT)	5/10/2021 2:07:38 PM	5/10/2021 4:47:58 PM
05112021A (SN1264,C-GJMT)	5/11/2021 2:13:21 PM	5/11/2021 3:12:27 PM



3. Processing Summary

3.1. Flight Logs

Flight logs were completed by Lidar sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.



3.2. Lidar Processing

Applanix + POSPac software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the lidar sensor during all flights. Applanix POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a "Smoothed Best Estimate Trajectory" (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the lidar missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

Point clouds in flightline swath format were created using the RiPROCESS software. The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Each flightline swath point cloud was calibrated using Strip Align software that corrects systematic geometric errors and improves the relative and absolute accuracy of the flightline swath point cloud. The calibrated point cloud swaths were imported into GeoCue distributive processing software and the imported data was then tiled so further processing could take place in TerraScan software. Using TerraScan, the vertical accuracy of the surveyed ground control was tested and any vertical bias was removed from the data. TerraScan and TerraModeler software packages were then used for automated data classification and manual cleanup. The data were manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

DEMs and Intensity Images are then generated using proprietary software. In the bare earth surface model, above-ground features are excluded from the data set. Global Mapper is used as a final check of the bare earth dataset.

Software	Version
Applanix + POSPac	8.6
RiPROCESS	1.8.6
Microstation Connect	10.16.02.34
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
TerraModeler	21.008
TerraScan	21.016
TerraMatch	21.007
StripAlign	2.21



3.3. LAS Classification Scheme

The classification classes are determined by Lidar Base Specifications 2.1 and are an industry standard for the classification of lidar point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

Table 3. LAS Classifications

	Classification Name	Description		
1	Processed, but Unclassified	Laser returns that are not included in the ground class, or any other project classification		
2	Bare earth	Laser returns that are determined to be ground using automated and manual cleaning algorithms		
7	Low Noise	Laser returns that are often associated with scattering from reflective surfaces, or artificial points below the ground surfaces.		
9	Water	Laser returns that are found inside of hydro features		
17	Bridge Deck	Laser returns falling on bridge decks		
18	High Noise	Laser returns that are often associated with birds or artificial points above the ground surface		
20	Ignored Ground	Ground points that fall within the given threshold of a collected hydro feature.		

3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare- earth surface is finalized; it is then used to generate all hydro-breaklines through headsup digitization.

All ground (ASPRS Class 2) lidar data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using proprietary tools. A buffer of 1 meter was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 20). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 20).



Class 2) points were reclassified to the correct classification after the automated classification was completed.

Any noise that was identified either through manual review or automated routines was classified to the appropriate class (ASPRS Class 7 and/or ASPRS Class 18) followed by flagging with the withheld bit.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for all point cloud data. NV5 Geospatial's proprietary software was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

3.5. Hydro-Flattened Breakline Processing

Class 2 lidar was used to create a bare earth surface model. The surface model was then used to heads-up digitize 2D breaklines of Inland Streams and Rivers with a 100 foot nominal width and Inland Ponds and Lakes of 2 acres or greater surface area.

Elevation values were assigned to all Inland streams and rivers using NV5 Geospatial's proprietary software.

All ground (ASPRS Class 2) lidar data inside of the collected inland breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 3 feet was also used around each hydro-flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 20).

The breakline files were then translated to Esri file geodatabase format using Esri conversion tools.

Breaklines are reviewed against lidar intensity imagery to verify completeness of capture. All breaklines are then compared to TINs (triangular irregular networks) created from ground only points prior to water classification. The horizontal placement of breaklines is compared to terrain features and the breakline elevations are compared to lidar elevations to ensure all breaklines match the lidar within acceptable tolerances. Some deviation is expected between breakline and lidar elevations due to monotonicity, connectivity, and flattening rules that are enforced on the breaklines. Once completeness, horizontal placement, and vertical variance is reviewed, all breaklines are reviewed for topological consistency and data integrity using a combination of Esri Data Reviewer tools and proprietary tools.

3.6. Hydro-Flattened Raster DEM Processing

Class 2 lidar in conjunction with the hydro breaklines were used to create a 1-meter Raster DEM. Using automated scripting routines within proprietary software, a GeoTIFF file was created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.



3.7. Intensity Image Processing

Intensity images represent reflectivity values collected by the lidar sensor during acquisition. Proprietary software generates intensity images using first returns and excluding those flagged with a withheld bit. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written during product generation.

3.8. Swath Separation Raster Processing

Swath Separation Images are rasters that represent the interswath alignment between flight lines and provide a qualitative evaluation of the positional quality of the point cloud. NV5 Geospatial proprietary software generated 1-meter raster images in GeoTIFF format using last returns, excluding points flagged with the withheld bit, and using a point-in-cell algorithm. Images are generated with a 75% intensity opacity and (4) absolute 8-cm intervals, see below for interval coloring. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written to the file during product generation. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the images against what is required before final delivery.





MT Statewide Phase2 2020 B20 Work Unit 197111 Tile Layout

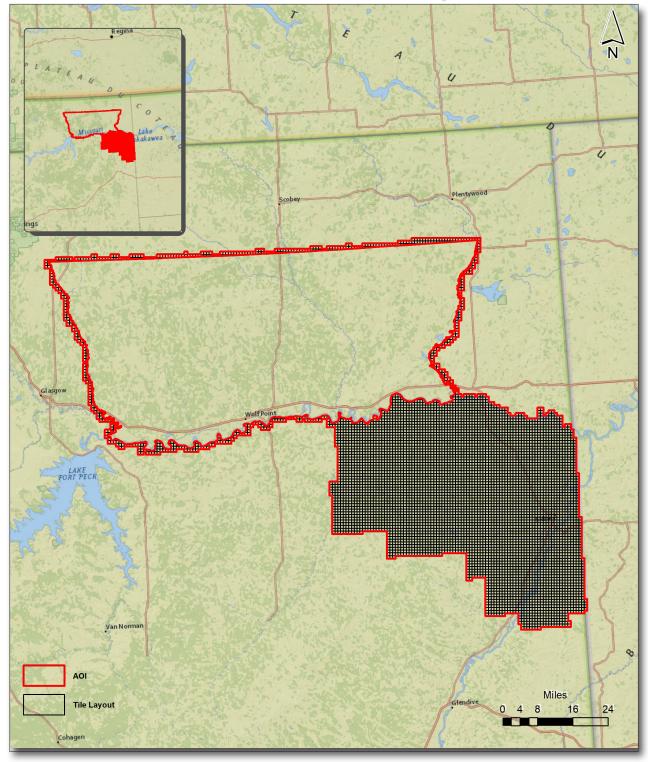


Figure 4. Lidar Tile Layout



4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 5.



MT Statewide Phase2 2020 B20 Work Unit 197111 Lidar Coverage

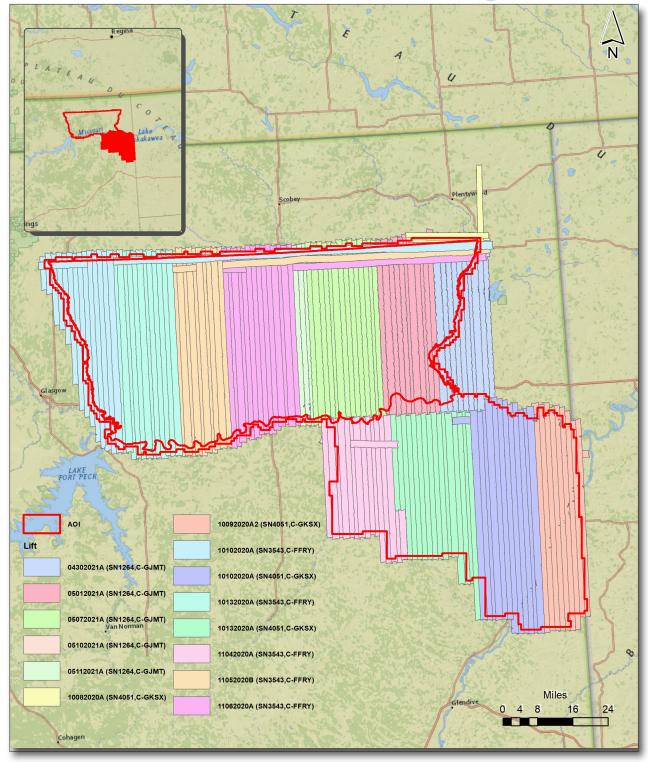


Figure 5. Lidar Coverage



5. Geometric Accuracy

5.1. Horizontal Accuracy

Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained RMSE_r value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial Data Accuracy (NSSDA) reporting standard where a theoretical point will fall within the obtained radius 95% of the time. Based on a flying altitude of 2,300 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.25 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

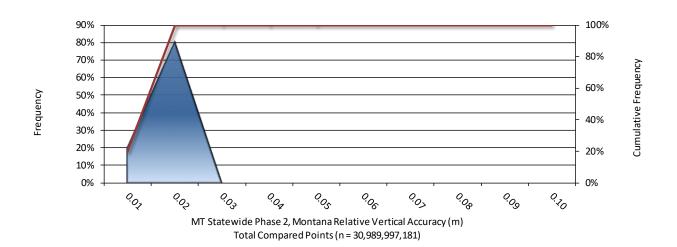
Horizontal Accuracy			
RMSE _r	0.47 ft		
	0.14 m		
ACC _r	0.82 ft		
	0.25 m		



5.2. Relative Vertical Accuracy

Relative vertical accuracy refers to the internal consistency of the data set as a whole: the ability to place an object in the same location given multiple flight lines, GPS conditions, and aircraft attitudes. When the lidar system is well calibrated, the swath-to-swath vertical divergence is low (<0.10 meters). The relative vertical accuracy was computed by comparing the ground surface model of each individual flight line with its neighbors in overlapping regions. The average (mean) line to line relative vertical accuracy for the MT_Statewide_Phase2_2020_B20 project was 0.034 feet (0.010 meters). A summary is shown below.

Relative Vertical Accuracy			
Sample	173 flight line surfaces		
A	0.034 ft		
Average	0.010 m		
Madian	0.037 ft		
Median	0.011 m		
	0.036 ft		
RMSE	0.011 m		
Standard Davistics (1g)	0.004 ft		
Standard Deviation (1σ)	0.002 m		
1.057	0.008 ft		
1.96σ	0.002 m		





Project Report Appendices

The following section contains the appendices as listed in the MT Statewide Phase 2 2020 B20 Lidar Project Report.



Appendix A

Flight Logs

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Julian	

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LIDAR Flight Log

C-FFRY N. Emson

Aircraft

Project 3202_QSI_Montana_Phase1 Pilot

October 10, 2020

Date

Location Estevan Airport CYEN

Mission Objective

System Riegl VQ-1560ii GSM Trimble GNSS17 Applanix AP60 43 S2223543 Scanner 1 Drive Scanner 2 Drive **GPS Rx** Unit $\frac{1}{8}$ Operator Dan Arteaga

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Additional Notes T-8C H-61% **⊙** 50 hr **O** 100 hr Time to next maintenance:

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	Aircraft Block Time	
Engine On 17:00	Takeoff 17:17	AGL
Engine Off 23:20 Landing 23:11	Landing 23:11	Targe
Total 6.3 hrs	Total 5.9 hrs	Laser

	Σ	Mission	n Plan	
AGL Height	2300	Ε	Pulse Rate	Pulse Rate 400 (x2) kHz
Target Speed	160	kts	Scan Rate	sd 68
Laser Current	100	%	FOV	60 degs

	Comments															
Mission ID	Time Stamp	•	180049	1	184919	185442	190049	191320	192321	193638	195210	200917	202553	204443	210320	212244
Line Aborted	nmi to End															
Line	Time										,					
Time	End	1759	1840	1845	1852	1859	1908	1920	1932	1948	2006	2023	2041	2101	2121	2140
GPS Tim	Start	1754	1800	1840	1849	1844	1900	1913	1923	1936	1952	2009	2025	2044	2103	2122
Flight	Direction	ı	•		170	350	170	350	170	350	170	350	170	350	170	350
Lidar	File Name		432028401		432028402	432028403	432028404	432028405	432028406	432028407	432028408	432028409	432028410	432028411	432028412	432028413
	Flight Line	F8	X-tie	Figure 8	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012

Flight)
284	
Ilian Day	

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LIDAR Flight Log



Operator Dan Arteaga

C-FFRY N. Emson

Aircraft

Project 3202_QSI_Montana_Phase1 Pilot

October 10, 2020

Date

Location Estevan Airport CYEN

Mission Objective

ystem R	ystem Riegl VQ-1560ii GSM	560ii GSM	Add
nit	S2223543	43	Ψ
2	Applanix AP60	√P60	Ŧ
PS Rx	Trimble GNSS17	SNSS17	hp
canner 1 Drive	Drive	43	¥
canner 2 Drive	2 Drive		Ë
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AIRBORNEIMAGING

oa-1008 MLS-580m 8C 61%

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Pre Mission 1709 1714	r S Time End 1714	A Clea D 50 hr	
	2320	2315	Post Mission
	End	Start	Alignment
Start	S Time	d9	Static
GPS Time Start		O 50 hr	
Static Start Start	A Clean Harbors Compar	A Clea	

degs

9

. 2

%

100 160

Laser Current **Target Speed** AGL Height

89 lps

kts | Scan Rate

m Pulse Rate 400 (x2) kHz

2300

Mission Plan

Aircraft Block Time

Takeoff 17:17 **Landing** 23:11 Total 5.9 hrs

Engine Off 23:20 **Engine On 17:00**

hrs

6.3

Total

	Comments								
Mission ID	Time Stamp	214308	220322						
Line Aborted	nmi to End								
Line	Time								
GPS Time	End	2200	2221	2227					
GPS	Start	2143	2203	2221					
Flight	Direction	170	350	-					-
LiDAR	File Name	432028414	432028415						
	Flight Line	1013	1014	F8					

Julian Day 287

Flight A

Aircraft

Project 3202_QSI_Montana_Phase1 Pilot

October 13, 2020

Date

Location Estevan Sask Airport

Mission Objective

LIDAR Flight Log

GPS Ry Systen Scanne Scanne NM Unit Operator Dan Arteaga C-FFRY N. Emson

Time	ler 2 Drive
AML	ler 1 Drive 43
hpa-	Trimble GNSS17
09-H	Applanix AP60
T-5C	S2223543
Additi	m Riegl VQ-1560ii GSM

Additional	T-5C	%09-H	hpa-1013	AMLS-58	Time to ne
egl VQ-1560ii GSM	S2223543	Applanix AP60	Trimble GNSS17	Drive 43	Drive

Notes	Se		A Clea	A I R B O R N E I M A G I N G A Clean Harbors Company
3 80m				
ext ma	aint	ext maintenance:	⊙ 50 hr O 100 hr	
		77770	45 	GPS Time
		Static))
HZ		Alignment	Start	End
		Pre Mission	1552	1557
degs		Post Mission	2219	2224

	Aircraft Block Time		N	issio	Mission Plan	
Engine On 15:44 Takeoff 16:02	Takeoff 16:02	AGL Height	2300	Ε	m Pulse Rate 400 (x2)	400 (x2)
Engine Off 22:26 Landing 22:16	Landing 22:16	Target Spee	d 160	kts	arget Speed 160 kts Scan Rate 267H;	267H;
Total 6.7 hrs Total 6.2 hrs	Total 6.2 hrs	Laser Curre	aser Current 100 % FOV	%	FOV	09

3PS Time	End	1557	2224	
<u>5</u>	Start	1552	2219	
Static	Alignment	Pre Mission	Post Mission	
	400 (x2) kHz	267Hz	60 degs	
n Plan	Pulse Rate 400 (x2) kHz		09	
Mission Plan	m Pulse Rate 400 (x2) kHz	kts Scan Rate 267Hz		

 LiDAR	Flight	GPS Tim	Time	Line	Line Aborted	Mission ID	
File Name	Direction	Start	End	Time	nmi to End	Time Stamp	Comments
	1	1659	1704				
432028701	1	1704	1720			170439	
432028702	170	1728	1745			172837	
432028703	350	1747	1805			174709	
432028704	170	1807	1824			180720	
432028705	350	1826	1843			182621	
432028706	170	1846	1903			184625	
432028707	350	1906	1923			190618	
432028708	170	1926	1944			192627	
432028709	350	1946	2003			194622	
432028710	170	2006	2023			200603	
432028711	350	2026	2041			202615	
432028712	170	2044	2102			204450	
432028713	350	2104	2120			210443	
	1	2121	2126				

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LIDAR Flight Log

Operator Dan Arteaga Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie C-FFRY Aircraft November 04 , 2020 **Estevan Airport** Mission Objective Location Date

System Riegl \	System Riegl VQ-1560ii GSM
Unit S2	S2223543
IMU Appla	Applanix AP60
GPS Rx Trin	Trimble GNSS17
Scanner 1 Drive	43
Scanner 2 Drive	

Additic	T-120	H-44	hpa-1	AMLS	Time	
n Riegl VQ-1560ii GSM	S2223543	Applanix AP60	x Trimble GNSS17	er 1 Drive 43	er 2 Drive	

Additional Notes	T-12C	H-44%	hpa-1008	AMLS-581m	Time to next main
egl VQ-1560ii GSM	S2223543	Applanix AP60	Trimble GNSS17	Drive 43	Drive

A Clean Harbors Company

		Time to next maintenance:		⊙ 50 hr O 100 hr	
ssio	ssion Plan		Static	GP	GPS Time
Ε	Pulse Rate	m Pulse Rate 500(x2) kHz	Alignment	Start	End
kts	kts Scan Rate	267Hz	Pre Mission	1756	1801
%	% FOV	eo degs	Post Mission	2307	2312

Target Speed Laser Current

Mission Plan

Aircraft Block Time

Takeoff 18:05 Landing 23:05 Total 5.0 hrs

Engine Off 23:20 Engine On 17:30

hrs

2.8

Total

2300

AGL Height

100 160

	LiDAR	Flight	GPS Tim	lime .	Line	Line Aborted	Mission ID	
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp	Comments
F8		1	1859	1904				
1103	432030901	352	1907	1913			190751	9nm South End
1102	432030902	172	1915	1921			191545	9nm South End
1101	432030903	352	1922	1936			192257	
1100	432030904	172	1937	1950			193726	
1099	432030905	352	1952	2004			195219	
1098	432030906	172	2007	2019			200732	
1097	432030907	352	2020	2030			202023	
1096	432030907	172	2032	2044			203256	
1095	432030908	352	2045	2056			204520	
1094	432030909	172	2057	2109			205750	
1093	432030910	352	2110	2121			211018	
1092	432030911	172	2122	2133			212229	
1091	432030912	352	2134	2145			213457	
1090	432030913	172	2146	2157			214645	

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309
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LIDAR Flight Log

C-FFRY

Aircraft

November 04 , 2020

Date

Estevan Airport

Location

Mission Objective

System Riegl VQ-156 Applanix Al Trimble G S22235⁴ Scanner 1 Drive **Scanner 2 Drive GPS Rx** $\frac{1}{2}$ Unit Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie Operator Dan Arteaga

Additional Notes	T-12C	H-44%	hpa-1008	AMLS-581m
60ii GSM	43	'P60	NSS17	73

	I M A G I N G
T-12C	A Clean Harbors Company
H-44%	
hpa-1008	
AMLS-581m	
Time to next maintenance:	O 50 hr

Aircraft Block Time	Takeoff 18:05	Landing 23:05	Total 5.0 hrs
	Engine On 17:30	Engine Off 23:20	Total 5.8 hrs

	Σ	Mission	n Plan	
AGL Height	2300	Ε	m Pulse Rate	500(x2) kHz
Target Speed	160	kts	kts Scan Rate	267Hz
Laser Current	100	%	% FOV	ego 09

	Static	GP	GPS Time
	Alignment	Start	End
	Pre Mission	1756	1801
	Post Mission	2307	2312
r			

	Comments										
Mission ID	Time Stamp	215840	221040								
Line Aborted	nmi to End										
Line	Time										
GPS Time	End	2209	2217	2222							
GPS	Start	2158	2210	2217							
Fliaht	Direction	352	ı	-					1	1	
LiDAR	File Name	432030914	432030915								
	Flight Line	1089	X-tie	F8							

Flight A	
310	
Julian Day	





Operator Dan Arteaga

C-FFRY

Aircraft

November 05, 2020

Date

Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie

Estevan Airport

Location

Mission Objective

System Riegl VQ-1560ii GSM	Additional Notes
Unit S2223543	T-8C
IMU Applanix AP60	H-71%
GPS Rx Trimble GNSS17	hpa-1012
Scanner 1 Drive 43	AMLS-581m
Scanner 2 Drive	Time to next main

Additional Notes	T-8C	9	, hpa-1012	AMLS-581m	Time to next maintenance: © 50 hr O 100 hr	n Static GPS Time	Pulse Rate 500(x2) kHz Alignment Start End	Rate 267Hz Pre Mission 1521 1526	60 dens Post Mission
1560ii GSM		0	SS17			ssion Plan	Pulse Rate [∈]	Scan Rate	FOV 6
1560	3543	x AP60	e GNSS17	43		ssion	Ε	kts 8	%

Mission Plan

Aircraft Block Time **Takeoff** 15:34

Engine On 15:13

2300

AGL Height

							•						
	•												
Po	sbep	09	FOV	%	100	Laser Current		hrs	0.2	Total	hrs	0.7	Total
Pr	267Hz		kts Scan Rate	kts	160	Target Speed 160		5:48	anding 15:48	Landin	15:55	Off	Engine

	Comments	Aborted Aircraft power drop to 8.2VIts							
Mission ID	Time Stamp								
Line Aborted	nmi to End								
Line	Time								
GPS Time	End								
GPS	Start								
Flight	Direction	-							
LiDAR	File Name								
	Flight Line	F8							

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Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie

Estevan Airport

Location

Mission Objective

Operator Dan Arteaga

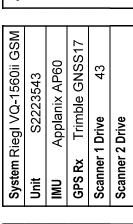
C-FFRY

Aircraft

November 05, 2020

Date

LIDAR Flight Log



GSM Additional	1-8C) H-71%	S17 hpa-1012	AMLS-58	Time to ne
egl VQ-1560ii GSM	S2223543	Applanix AP60	Trimble GNSS17	Drive 43	Drive

ional Notes	AIRBORNE
	A Clean Harbors Company
%	
1012	
.S-581m	
to next maintenance:	O 50 hr
Static	GPS Time

	AGL Height	Target Speed	Laser Currer
k Time	5:34	5:48	hrs
Aircraft Block Time	Takeoff 1	Landing 15:48	Total 0.2 hrs
	Engine On 15:13 Takeoff 15:34	Engine Off 15:55	Total 0.7 hrs
	Engine	Engine	Total

	Σ	Mission	n Plan	
AGL Height	2300	Ε	m Pulse Rate	500(x2) kHz
Target Speed	160	kts	Scan Rate	267Hz
Laser Current	100	%	100 % FOV	ego degs

Static	GP	GPS Time
Alignment	Start	End
Pre Mission	1521	1526
Post Mission		

	Comments									
Mission ID	Time Stamp									
Line Aborted	nmi to End									
Line	Time									
Time	End									
GPS Time	Start									
Flight	Direction							-	ı	
LiDAR	File Name									
	Flight Line						X-tie	x-tie	F8	

Flight A	
310	
Julian Day	

Aircraft

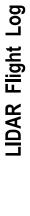
November 05, 2020

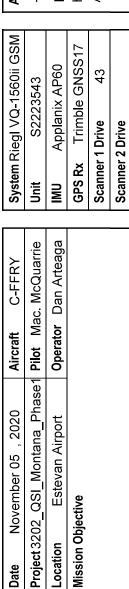
Date

Estevan Airport

Location

Mission Objective





Additional Notes	T-8C	H-71%	hpa-1012	AMLS-581m	Time to next maint
Riegl VQ-1560ii GSM	S2223543	Applanix AP60	Trimble GNSS17	r 1 Drive 43	· 2 Drive

	A Clean Harbors Company	And the second s			: • • 50 hr O 100 hr	Static GPS Time	Alignment Start End	Pre Mission 1521 1526	Post Mission
Additional Notes	T-8C	H-71%	hpa-1012	AMLS-581m	Time to next maintenance:		m Pulse Rate 500(x2) kHz	267Hz Pr	60 degs Po
1560ii GSM	3	090	e GNSS17	43		ssion Plan	Pulse Rate	Scan Rate	FOV
-156	3543	x AP60	e G			ssio	Ε	kts	%

100 160

Laser Current

Target Speed AGL Height

Engine Off 15:55 Engine On 15:13

hrs

0.7

Total

Mission Plan

Aircraft Block Time **Takeoff** 15:34 Landing 15:48 Total 0.2 hrs

2300

	Comments							
Mission ID	Time Stamp	-						
Line Aborted	nmi to End							
Line	Time							
GPS Time	End							
GPS	Start							
Flight	Direction	-						
LiDAR	File Name							
	Flight Line							

Flight /	•
310	,
Julian Day	

LIDAR Flight Log

)	,		
Date November 05 , 2020 Airc	50	Aircraft	C-FFRY
Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie	Phase1	Pilot Ma	c. McQuarrie
Location Estevan Airport Ope		Operator	Operator Dan Arteaga
Mission Objective			

System F	System Riegl VQ-1560ii GSM	МS	۷
Unit	S2223543		
IMU	Applanix AP60		
GPS Rx	Trimble GNSS17		
Scanner 1 Drive	1 Drive 43		
Scanner 2 Drive	2 Drive		

Additional	1-8C	H-71%	hpa-1012	AMLS-58	Time to ney
m Riegl VQ-1560ii GSM	S2223543	Applanix AP60	Rx Trimble GNSS17	ner 1 Drive 43	ner 2 Drive

	Aircraft Block Time		Missi	Mission Plan	
Engine On 15:13	5:13 Takeoff 15:34	AGL Height	2300 n	Pulse Rate	m Pulse Rate 500(x2) kHz
Engine Off 15:55	15:55 Landing 15:48	Target Speed 160 kts Scan Rate 267Hz	160 kts	Scan Rate	267Hz
Total 0.7 hrs	hrs Total 0.2 hrs	Laser Current 100 % FOV	100 %	FOV	e0 degs

Post Mission

	Comments						
Mission ID	Time Stamp						
Line Aborted	nmi to End						
Line	Time						
Time	End						
GPS Tii	Start						
Fliaht	Direction						
LiDAR	File Name						
	Flight Line						

Flight A
310
Julian Day

Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie

Estevan Airport

Location

Mission Objective

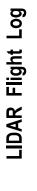
Operator Dan Arteaga

C-FFRY

Aircraft

November 05, 2020

Date



System Riegl VQ-1560ii GSM
Unit S2223543
IMU Applanix AP60
GPS Rx Trimble GNSS17
Scanner 1 Drive 43
Scanner 2 Drive

Additional Notes	T-8C	H-71%	hpa-1012	AMLS-581m	Time to next mainter
1560ii GSM	3543	x AP60	GNSS17	43	

S	aintenance:		₹	Pre N	Post
		Static	Alignment	Pre Mission	Post Mission
A Glea	⊙ 50 hr O 100 hr	9	Start	1521	
A I R B O R N E I M A G I N G A Clean Harbors Company		GPS Time	End	1526	

	[
Ľ		Total 0.2 hrs	Total 0.7 hrs
_		Landing 15:48	Engine Off 15:55
A		Takeoff 15:34	Engine On 15:13 Takeoff 15:34
		Aircraft Block Time	

	Σ	Mission	n Plan	
AGL Height	2300	Ε	Pulse Rate	500(x2) kHz
Target Speed	160	kts	Scan Rate	267Hz
Laser Current	100	%	FOV	ego degs

Engine Off 15:55	Landing 15:48	5:48		Target Speed	160 kts	Scan Rate	267Hz	Pre Mission	1521	1526
Total 0.7 hrs	Total 0.2	hrs		Laser Current	100 %	FOV 60	sbap	Post Mission		
	LiDAR	Flight	S49	GPS Time	Line	Line Aborted	Mission ID			
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp		Comments	S

Flight	
311	
Julian Day	

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LIDAR Flight Log

C-FFRY

Aircraft

November 06 , 2020

Date

Estevan Airport

Location

Mission Objective

%|₽|<u>₹</u>|₽|%|% Operator Dan Arteaga Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie

AIRBORNEIMAGING

A Clean Harbors Company **⊙** 50 hr **O** 100 hr

ince:

Additional Notes
T-4C
H-81%

Additional Notes	T-4C	H-81%	hpa-1009	AMLS-581m	Time to next maintenar	
ystem Riegl VQ-1560ii GSM	Init S2223543	MU Applanix AP60	PS Rx Trimble GNSS17	canner 1 Drive 43	canner 2 Drive	

GPS Time	Start End	1523 1528	2137 2142	
Static	Alignment	Pre Mission	Post Mission	
	kHz	2	degs	

m Pulse Rate 500(x2) kHz

2300

Mission Plan

Aircraft Block Time

Takeoff 15:31 **Landing** 21:36 **Total** 6.1 hrs

Engine Off 21:45 Engine On 15:15

hrs

6.5

Total

267Hz

kts | Scan Rate

9

₽ 2 %

100 160

Laser Current **Target Speed AGL Height**

Mission ID Comments	- dui	161115	163847		165927	165927 171736	165927 171736 173536	165927 171736 173536 175355	165927 171736 173536 175355 181215	165927 171736 173536 175355 181215	165927 171736 173536 175355 181215 183039	165927 171736 173536 175355 181215 183039 184851	165927 171736 173536 175355 181215 183039 190659	165927 173536 175355 181215 183039 190659 192451	165927 171736 173536 175355 181215 183039 194851 192451 200003
nmi to End	I'me Stamp	161115	163847		165927	165927 171736	165927 171736 173536	165927 171736 173536 175355	165927 171736 173536 17535 175355 181215	165927 171736 173536 175355 181215 183039	165927 171736 173536 175355 181215 183039 184851	165927 171736 173536 175355 181215 183039 184851 190659	165927 171736 173536 175355 181215 183039 184851 190659 192451	165927 171736 173536 175355 181215 183039 184851 190659 192451 194236	165927 171736 173536 175355 181215 183039 184851 190659 192451 194236 200003
IIIIIE Oraliip		161115	163847	465007	/76001	170027	171736 173536	171736 171736 173536 175355	171736 173536 175355 181215	171736 173536 175355 181215 183039	171736 173536 175355 181215 183039 184851	171736 173536 175355 181215 183039 184851 190659	171736 173536 175355 181215 183039 184851 190659	171736 173536 175355 181215 183039 184851 190659 192451	171736 173536 175355 181215 183039 194851 190659 192451 194236
		1611	1638	70807	6001	1717:	1717.	1717. 1735. 1753.	1747; 1747; 1735; 1812	1717. 1735. 1753. 1830.	1717. 1717. 1735. 1753. 1812. 1830.	1717. 1735. 1753. 1812. 1830. 1848.	1717. 1717. 1735. 1753. 1812. 1830. 1906.	1717 1717 1735 1753 1810 1830 1906 1906 1924	1717 1735 1753 1812 1830 1848 1906 1906 1924
_															
End Time		1634	1657		1716	1716	1716 1734 1752	1716 1734 1752 1810	1716 1734 1752 1810	1716 1734 1752 1810 1828	1716 1734 1752 1810 1828 1847	1716 1734 1752 1810 1828 1847 1904	1716 1734 1752 1810 1828 1847 1904 1923	1716 1734 1752 1810 1828 1847 1904 1923 1940	1716 1734 1752 1810 1828 1847 1904 1923 1940 1958
Start		1611 1	1638 1		1659 1										
		1	171	, = (351	351	351 171 351	351 171 351 171	351 171 351 171 351	351 171 351 171 351	351 171 351 171 351 351	351 171 351 171 351 171	351 171 351 171 351 351 351	351 171 351 171 351 171 351	351 171 171 171 351 171 351 351
		131101	432031102												
File Name		432031101	432031	432031103		43203	432037	432031 432031 432031 432032	432031 432031 432033 432033	432031 432031 432031 432037 432037	432031 432031 432031 432031 432032 432033	432031 432031 432031 432037 43203 43203 43203	432031 432031 432031 432031 43203 43203 43203 43203 43203 43203	432031 432031 432031 432031 43203 43203 43203 43203 43203 43203	432031 432031 432031 432031 432031 432032 432032 432032 432032 432033 432033 432033
Flight Line	F8	X-Tie	1037	1038	000	1039	1039	1039 1040 1041	1039 1040 1041 1042	1039 1040 1041 1042 1043	1039 1040 1042 1043 1043	1039 1040 1041 1042 1043 1044	1039 1040 1042 1043 1044 1045	1039 1040 1042 1043 1045 1046	1039 1040 1041 1042 1043 1045 1046 1047

Flight \not	
311	
Julian Day	

Aircraft

November 06, 2020

Date

Estevan Airport

Location

Mission Objective

LIDAR Flight Log

Operator Dan Arteaga Project 3202_QSI_Montana_Phase1 Pilot Mac. McQuarrie C-FFRY

ı	
	Scanner 2 Drive
_	Scanner 1 Drive 43
	GPS Rx Trimble GNSS17
	IMU Applanix AP60
	Unit S2223543
⋖	System Riegl VQ-1560ii GSM

Additional Notes		A	AIRBORNE
T-4C		A Cle	A Clean Harbors Company
H-81%			
hpa-1009			
AMLS-581m			
Time to next maintenance:		O 50 hr O 100 hr	
	Static	49	GPS Time
500(x2) kHz	Alignment	Start	End
267H7	Dre Miceion	1523	1528

Air	Aircraft Block Time		Miss	Mission P
Engine On 15:15 Takeoff 15:31	akeoff 15:31	AGL Height	2300 m Puls	n Pul
Engine Off 21:45 Landing 21:36	anding 21:36	Target Speed 160 kts Sca	160 kt	s Sca
Total 6.5 hrs Total 6.1 hrs	otal 6.1 hrs	Laser Current 100 % FOV	100 %	, FO

me		Miss	Mission Plan		Static	
	AGL Height	2300	m Pulse Rat	m Pulse Rate 500(x2) kHz	Alignment	0,
	Target Speed 160 kts Scan Rate 267Hz	160 kt	s Scan Rate	267Hz	Pre Mission	1
	Laser Current 100 % FOV	100 %	% FOV	e0 degs	Post Mission	7
	a.					

Engine On 15:15	. Takeoff 15:31	:31		AGL Height	2300 m	Pulse Rate 500(x2) kHz	0(x2) kHz	Alignment	nt	Start	End
Engine Off 21:45	Landing 21:36	:36		Target Speed	160 kts	Scan Rate	267Hz	Pre Mission		1523	1528
Total 6.5 hrs	Total 6.1	hrs		Laser Current	100 %	FOV 60	degs	Post Mission	u	2137	2142
	LiDAR	Flight	GP.	GPS Time	Line	Line Aborted	Mission ID	_			
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp			Comments	•
1050	432031115	351	2035	2050			203501				
F8		•	2052	2057							

Julian Day 282

Flight A

LIDAR Flight Log

R. Gemmel C-GKSX Y. Kadota QL1 first priority. Will not finish, but will get close. Operator Aircraft Pilot 1001-1003 next flight, along with QL 2. 3202_QSI_Montana October 8, 2020 CYEN Mission Objective Location Project Date

System	VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	1 Drive A1
Scanner 2 Drive	2 Drive A1

Additic	Press	abont	Possi	routin	Time
VQ-1560ii	51	Applanix AP60	Trimble GNSS17	er 1 Drive A1	r 2 Drive A1
_			J	<u></u>	<u></u>

tes	
S N	
tion	
Addi	
_	

sed to finish, but pilot concerned t fuel, with high winds at CYEN. ible extra time for circuits/re ig. Better safe than sorry.

A Clean Harbors Company AIRBORNIMAGING

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⊙ 50 hr
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ا ب
5 2+/
7
45.2+/-
7 1
naintenance:
naintenance:
naintenance:
naintenance:
to next maintenance:
naintenance:

.

	AGL Height	Target Speed	Laser Current
Aircraft Block Time	Takeoff 15:18	Landing 20:59	Total 5.7 hrs
	Engine On 14:54 Takeoff 15:18	Engine Off 21:08 Landing 20:59	Total 6.2 hrs

	Σ	issio	Mission Plan	
AGL Height	1800	ш	m Pulse Rate	700 KHz
Target Speed	160	kts	Scan Rate 13	Scan Rate 134(136 plane)
Laser Current	100	%	% FOV	eo degs

Static	19	GPS Time
Alignment	Start	End
Pre Mission	15:06	15:11
Post Mission	21:02	21:07

	Lidar	Flight	GPS Tim	Time	Line	Line Aborted	Mission ID	
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Z01008 Time Stamp	Comments
							201008_150610	
Test-Strip		245.0+/-	15:31	15:31			201008_153111	8700 ft
Figure 8		8	15:46	15:51				8100 ft
X-Tie	512028201	174.0+/-	15:53	15:59			155345	8200 ft
1031	512028202	266.5	16:03	16:09			160325	7800 ft
1030	512028203	0.980	16:13	16:19			161308	7800 ft
1029	512028204	266.4	16:22	16:29			162238	7800 ft
1028	512028205	6'580	16:32	16:38			163229	7800 ft
1027	512028206	266.5	16:42	16:48			164207	7800 ft
1026	512028207	0.980	16:51	16:58			165153	7800 ft
1025	512028208	266.4	17:01	17:08			170131	7800 ft
1024	512028209	0.980	17:11	17:17			171124	7800 ft
1023	512028210	266.5	17:21	17:27			172100	7800 ft
1022	512028211	0.980	17:30	17:36			173047	7800 ft
1021	512028212	266.5	17:40	17:46			174014	7800 ft

Julian Day 282

Flight A

LIDAR Flight Log

R. Gemmel C-GKSX Y. Kadota QL1 first priority. Will not finish, but will get close. Operator Aircraft Pilot 1001-1003 next flight, along with QL 2. 3202_QSI_Montana October 8, 2020 CYEN Mission Objective Location Project Date

Unit IMU Appla GPS Rx Trim	51 Apple AP60
\ X	niv ADRO
	3
	Trimble GNSS17
Scanner 1 Drive	A1
Scanner 2 Drive	A1

Additic	Press	abon	Possi	routin	Time
VQ-1560ii	51	Applanix AP60	Trimble GNSS17	ner 1 Drive A1	ner 2 Drive A1
E			X.	Jer	ıer

s Company

Additional Notes	Pressed to finish, but pilot concerned	about fuel, with high winds at CYEN.	Possible extra time for circuits/re		Ime to next maintenance: 45.277	Statio	700 KHz Alignment Start	4(136 plane) Pre Mission 15:06	
AIRBORN	A Clean Harbors Compa			- 0	100 NF	GPS Time	End	6 15:11	

Scan Rate 134(136 pl 9

kts %

<u>Б</u>

100 160

Laser Current **Target Speed AGL Height**

m Pulse Rate

1800

Mission Plan

Aircraft Block Time

15:18

Takeoff

Engine On 14:54 Engine Off 21:08

Landing 20:59

5.7 hrs

Total

hrs

6.2

Total

	LiDAR	Flight	GPS Time	Time	Line	Line Aborted	Mission ID	
Flight Line	File Name	Direction	Start	End	Time	nmi to End	Time Stamp 201008	Comments
1020	512028213	0.980	17:49	17:55			201008_174951	7800 ft
1019	512028214	266.5	17:59	18:05			175908	7800 ft
1018	512028215	0.980	18:08	18:14			180847	7800 ft
1017	512028216	266.4	18:18	18:24			181817	7800 ft
1016	512028217	0.980	18:27	18:33			182750	7800 ft
1015	512028218	266.4	18:37	18:44			183726	7800 ft
1014	512028219	0.980	18:47	18:53			184716	7800 ft
1013	512028220	266.4	18:56	19:03			185659	7800 ft
1012	512028221	085.8	19:06	19:12			190643	7800 ft

20:05

512028227

1006

1007

8000 ft

200505

7900 ft 7900 ft 7900 ft 7900 ft 7900 ft

191616

19:22 19:32 19:42 19:51 20:02 20:11

19:16

266.5

512028222

1011 1010

19:25 19:35 19:45 19:55

085.8 266.5 0.980 266.5 085.8

512028223 512028224 512028225 512028226

1009 1008

192557

194540

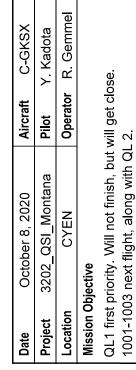
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LIDAR Flight Log





System VQ-1560ii Unit 51 IMU Applanix AP60 GPS Rx Trimble GNSS17 Scanner 1 Drive A1 Scanner 2 Drive A1		
A Rx nner 1 [System	VQ-1560ii
RX Inner 1 [Unit	51
GPS Rx Trimble GNSS17 Scanner 1 Drive A1 Scanner 2 Drive A1	IMU	Applanix AP60
	GPS Rx	Trimble GNSS17
	Scanner	
	Scanner	

Additi	Pres	abor	Poss	routi	Time
VQ-1560ii	51	Applanix AP60	Trimble GNSS17	e A1	.e A1
tem		App	Rx Tri	nner 1 Drive	nner 2 Drive

)-1560ii	iOii	Additional Notes	es	A	AIRBORNE
51		Pressed to f	Pressed to finish, but pilot concerned		Clean Harbors Company
iix AP60	09c	about fuel, w	about fuel, with high winds at CYEN.		
le GI	le GNSS17	Possible ext	Possible extra time for circuits/re		
	A1	routing. Bett	routing. Better safe than sorry.	#	
-	A1	Time to next m	Time to next maintenance: $45.2 \pm / \odot$ 50 hr O 100 hr	9 50 hr 🔿 100 h	r
Nissic	lission Plan		Static	9	GPS Time
Ε	m Pulse Rate	e 700 KHz	Alignment	Start	End
kts	Scan Rate	kts Scan Rate 134(136 plane)	Pre Mission	15:06	15:11
%	FOV	sbep 09	Post Mission	21:02	21:07

100 160

Laser Current Target Speed **AGL Height**

1800

Mission Plan

Aircraft Block Time **Takeoff** 15:18 Landing 20:59 **Total** 5.7 hrs

> Engine Off 21:08 Engine On 14:54

hrs

6.2

Tota

	Comments	8000 ft	8000 ft	8100 ft
Mission ID	201008 Time Stamp	201008_201442	202434	
Line Aborted	nmi to End			
Line	Time			
GPS Time	End	20:21	20:30	20:34
Sd9	Start	20:14	20:24	20:31
Flight	Direction	266.4	086.0	8
LiDAR	File Name	512028228	512028229	
	Flight Line	1005	1004	Figure 8

	Page 3 of 3
	v 20200520

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LIDAR Flight Log



Date	October 9, 2020	Aircraft	C-GKSX
Project	3202_QSI_Montana	Pilot	Y. Kadota
Location	CYEN	Operator	Operator R. Gemmel
Mission Objective	bjective		

System	VQ-1560ii
Unit	21
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	1 Drive B1
Scanner 2 Drive	2 Drive B1

Additional Note	Cloud to the	lines on CL1.			Time to next ma	
VQ-1560ii		× AP60	Trimble GNSS17	B1	B1	
V 'A	51	Applanix AP60	Trimble	r 1 Drive	r 2 Drive	

Additional Notes
Cloud to the west, head east after 3
lines on CL1.

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39.5+/- © 50 hr O 100 hr naintenance:

		'	Aircraft Block Time	3lock Tir	ne
Engine	o	Engine On 16:53	Takeoff 17:09	17:09	
Engine Off 22:57	Off	22:57	Landing 22:49	22:49	
Total 6.1 hrs	6.1	hrs	Total 5.7 hrs	.7 hrs	

	2	Mission	n Plan	
AGL Height	1800	Е	Pulse Rate	700 KHz
Target Speed	160	kts	Scan Rate 13	Scan Rate 134(136 plane)
Laser Current	100	 %	-0۸	60 degs
ì				

Static	СР	GPS Time
Alignment s	Start	End
Pre Mission	17:00	17:05
Post Mission 2	22:51	22:56

									2				
	Comments		8100 ft	8200 ft	8000 ft	8000 ft	8100 ft	8100 ft	SWITCH TO HIGH PLAN QL2				
Mission ID	201009	201009_170027		201009_174209	174739	175720	180646						
Line Aborted	nmi to End												
Lir	Time												
GPS Time	End		17:40	17:43	17:54	18:03	18:13	18:17					
GPS	Start		17:35	17:42	17:47	17:57	18:06	18:13					
Flight	Direction		8	-/+0'221	266.4	6'980	266.5	8					
LiDAR	File Name			512028301	512028302	512028303	512028304						
	Flight Line		Figure 8	X-Tie_1	1003	1002	1001	Figure 8					

Page 1 of 1

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LIDAR Flight Log

R. Gemmel C-GKSX Y. Kadota Operator Aircraft Pilot 3202_QSI_Montana October 10, 2020 CYEN Mission Objective Location Project Date

System VQ-1560ii Unit 51 IMU Applanix AP60 GPS Rx Trimble GNSS17 Scanner 1 Drive A1 Scanner 2 Drive A1		
RX Inner 1 [System	VQ-1560ii
IMU Applanix AP60 GPS Rx Trimble GNSS17 Scanner 1 Drive A1 Scanner 2 Drive A1	Unit	51
GPS Rx Trimble GNSS17 Scanner 1 Drive A1 Scanner 2 Drive A1	IMU	Applanix AP60
	GPS Rx	Trimble GNSS17
	Scanner	
	Scanner	

Additional Notes					Time to next maintenance:
VQ-1560ii	51	Applanix AP60	Trimble GNSS17	er 1 Drive A1	er 2 Drive A1
_			×	\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\text{\tiny{\text{\text{\text{\text{\tiny{\tiny{\text{\text{\tiny{\tiny{\text{\text{\text{\text{\text{\text{\tiny{\text{\tiny{\tiny{\text{\text{\tiny{\tiny{\tiny{\text{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tiny{\tin	*

AIRBORNE	A Gean Harbors Company				33.8+/- © 50 hr O 100 hr	GPS Time	Start End	16:04 16:09	22:00 22:05
10						Static	Alignment	Pre Mission	Post Mission
Additional Notes					Time to next maintenance:		400 KHz	Scan Rate 89 (91 plane)	sbep 09
						an	m Pulse Rate	n Rate	
2-1560ii		ix AP60	ole GNSS17	A1	A1	Mission Plan	Puls	Sca	FOV
Ñ		⋖	lΘ			1.2	I €	kts	%

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Target Speed Laser Current

2300

AGL Height

Mission Plan

Aircraft Block Time

Takeoff 16:16 Landing 21:57 **Total** 5.7 hrs

Engine Off 22:06 Engine On 15:56

hrs

6.2

Total

	LiDAR	Flight	GPS Ti	Time	Line	Line Aborted	Mission ID	
File Name	ame	Direction	Start	End	Time	nmi to End	201010 Time Stamp	Comments
							201010_160402	
		8	17:00	17:05				9500 ft
120	512027421	083.1+/-	17:10	17:16			201010_171006	9500 ft
12	512027422	173.5	17:21	17:38			172104	9400 ft
12	512027423	353.5	17:41	17:58			174141	9400 ft
12	512027424	173.5	18:01	18:19			180152	9400 ft
12	512027425	353.5	18:22	18:40			182220	9400 ft
7	512027426	173.4	18:43	19:01			184304	9400 ft
7	512027427	353.4	19:04	19:21			190408	9400 ft
7	512027428	173.4	19:25	19:42			192510	9400 ft
7	512027429	353.3	19:45	20:02			194542	9400 ft
-	512027430	173.3	20:05	20:23			200543	9400 ft
7	512027431	353.3	20:26	20:42			202633	9500 ft
7	512027432	173.2	20:45	21:02			204529	9500 ft
7	512027433	353.2	21:05	21:21			210513	9500 ft

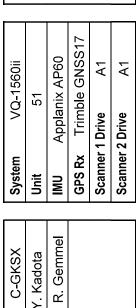
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LIDAR Flight Log

C-GKSX Y. Kadota

Aircraft Pilot





Operator

3202_QSI_Montana October 10, 2020

CYEN

Location Project Date

Mission Objective

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		Additional Notes	AIRBORNE
			A Clean Harbors Company
_			
		Time to next maintenance:	33.8+/- © 50 hr O 100 hr

	,	Aircraft Block Time
Engine On 15:56	15:56	Takeoff 16:16
Engine Off 22:06	22:06	Landing 21:57
Total 6.2 hrs	hrs	Total 5.7 hrs

			5	
AGL Height	2300	Ε	m Pulse Rate	400 KHz
Target Speed	160	kts	Scan Rate	Scan Rate 89 (91 plane)
Laser Current	100	%	% FOV	sbap 09

Static	GP	GPS Time
Alignment	Start	риЭ
Pre Mission	16:04	16:09
Post Mission	22:00	22:05

<u> </u>					l	l					
	Comments		9500 ft								
Mission ID	Time Stamp 201010	201010_160402									
Line Aborted	nmi to End										
Lin	Time										
GPS Time	End		21:26								
Sd9	Start		21:21								
Flight	Direction		8								
LiDAR	File Name										
	Flight Line		Figure 8								

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Flight A

LIDAR Flight Log



VQ-1560ii	51	Applanix AP60	Trimble GNSS17	Scanner 1 Drive B1	Scanner 2 Drive B1
System	Unit	NMI	GPS Rx	Scanne	Scanne
C-GKSX	Y. Kadota	R. Gemmel			

Operator

CYEN

Location

Project 3202_QSI_Montana_QL2 October 13, 2020

Date

1104-1117, more if possible.

Mission Objective

Aircraft Pilot



*Fair bit of yaw, due to high winds. **Additional Notes**

Hit low ceilings south 5NM of 1102 &1103, refly 7NM to include in X-Tie

⊙ 50 hr **O** 100 hr Time to next maintenance: 28.1

Aircraft Block Time	Takeoff 16:11	Landing 21:55	Total 5.7 hrs
	Engine On 15:54	Engine Off 22:03	Total 6.2 hrs
	Engi	Engi	Tota

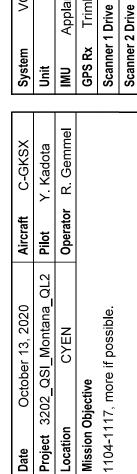
	Ž	VIISSIOII	II FIAII	
AGL Height	2300	Ε	Pulse Rate	400 KHz
Target Speed	160	kts	Scan Rate	Scan Rate 89 (91 plane)
Laser Current	100	%	FOV	s69 09

							d										
	Comments		9400 ft	9400-9500 ft	9400 ft	9400 ft	9500 ft * some cloud popping up	9500 ft	9500 ft	9600 ft	9600 ft	9500 ft					
Mission ID	201013 Time Stamp	201013_160259		201013_170545	171656	173714	175336	181015	182635	184044	185443	190935	192400	193837	195258	200732	
Line Aborted	nmi to End																
Lin	Time																
Time	End		17:05	17:11	17:32	17:50	18:06	18:23	18:37	18:51	19:05	19:20	19:35	19:50	20:04	20:18	
GPS Tim	Start		17:00	17:05	17:16	17:37	17:53	18:10	18:26	18:40	18:54	19:09	19:24	19:38	19:52	20:07	
Flight	Direction		8	081.0+/-	173.2	353.1	173.1	353.1	173.0	353.0	173.0	352.9	172.9	352.8	172.8	352.8	
LiDAR	File Name			532028721	532028722	532028723	532028724	532028725	532028726	532028727	532028728	532028729	532028730	532028731	532028732	532028733	
	Flight Line		Figure 8	X-Tie	1117	1116	1115	1114	1113	1112	1111	1110	1109	1108	1107	1106	

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7 Flight A

LIDAR Flight Log



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VQ-1560ii

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*Fair bit of yaw, due to high winds.

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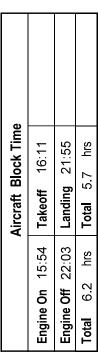
Hit low ceilings south 5NM of 1102 &1103, refly 7NM to include in X-Tie

Applanix AP60 Trimble GNSS17

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Time to next maintenance: $28.1 \odot 50 \text{ hr O} 100 \text{ hr}$



	Σ	lissio	Mission Plan	
AGL Height	2300	E	m Pulse Rate	400 KHz
Target Speed	160	kts	Scan Rate	Scan Rate 89 (91 plane)
Laser Current	100	%	FOV	60 degs

		Ī	Ī	_	_	Ī	1	Ι	Ī		ı	
	Comments	9500 ft	9500 ft	9500 ft, possible moisture, refly S. 7NM	9500 ft, possible moisture, refly S. 7NM	9500 ft						
Mission ID	Time Stamp 201013	201013_202211	203659	205143	210603							
Line Aborted	nmi to End											
Line	Time											
Time	End	20:33	20:48	21:03	21:17	21:21						
GPS Tim	Start	20:22	20:36	20:51	21:06	21:17						
Flight	Direction	172.7	352.7	172.7	352.6	8						
LiDAR	File Name	532028734	532028735	532028736	532028737							
	Flight Line	1105	1104	1103	1102	Figure 8						