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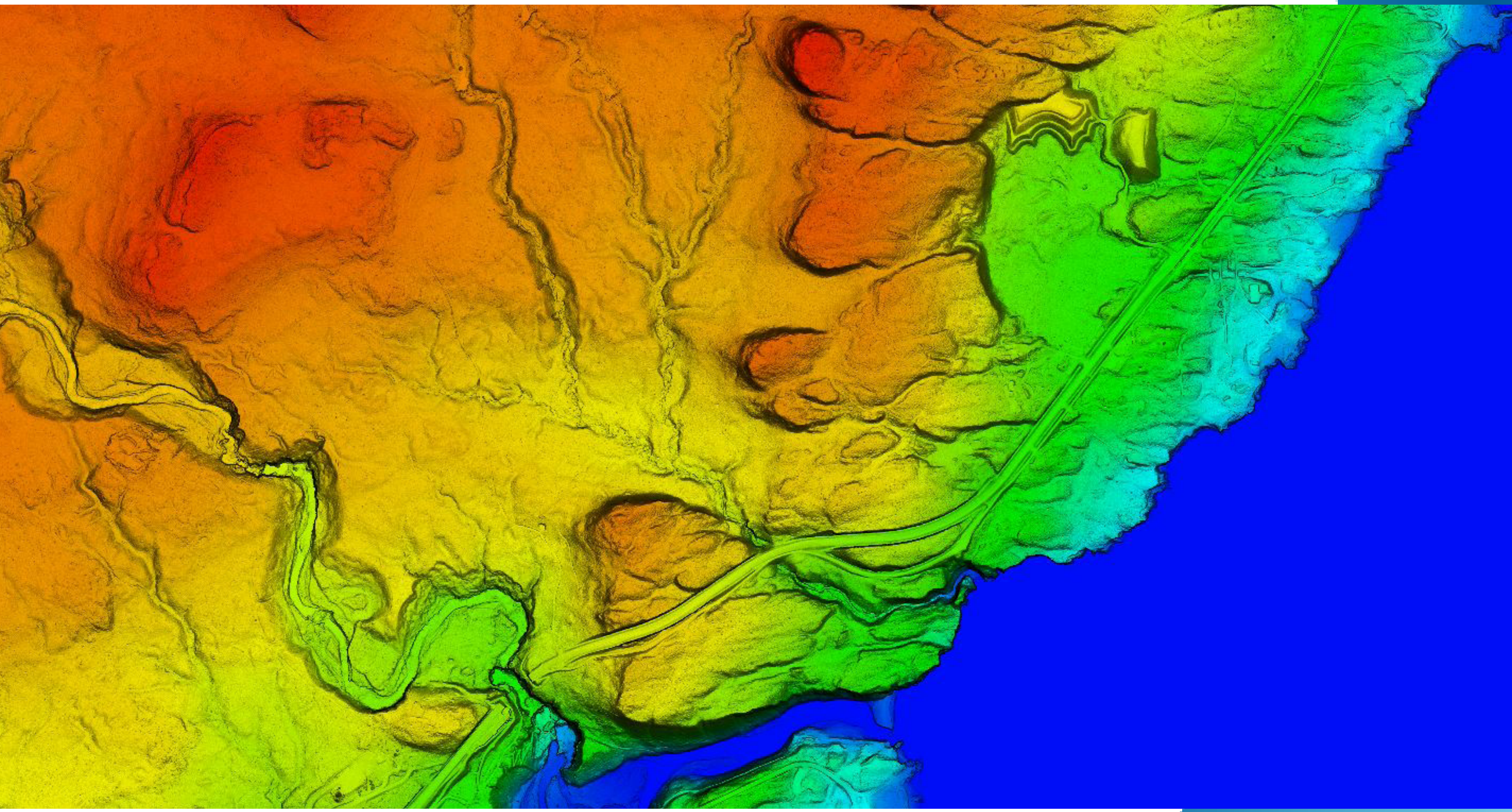

Submitted: June 6, 2022

MN_LAKESUPERIOR_2021_B21 LIDAR PROCESSING REPORT

2022

Project ID: 218910

Work Unit: 218907

Prepared for:

USGS
science for a changing world

Prepared by:

NV5 GEOSPATIAL

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1. Summary / Scope

1.1. Summary

This report contains a summary of the MN_LakeSuperior_2021_B21, Work Unit 218907 lidar acquisition task order, issued by USGS under their Contract G16PC00016 on April 19, 2021. The task order yielded a project area covering 4,976 square miles over Minnesota. 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
8 pts / m2	1,998 m	58.5°	20%	≤ 10 cm

1.3. Coverage

The project boundary covers 4,976 square miles over Minnesota. Project extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from April 25, 2021 to May 2, 2021 in 12 total lifts. See “Section: 2.4. Time Period” for more details.

1.5. Issues

There were no issues to report. There are 16 empty LAS files. Fifteen of them are fully covered by Lake Superior and one is completely inside an inland lake.

MN_LakeSuperior_2021_B21 Work Unit 218907 Projected Coordinate System: 2011 Universal Transverse Mercator Zone 15N Horizontal Datum: NAD83(2011) Vertical Datum: NAVD88 (GEOID 18) Units: Meters	
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	• 0.5-meter Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format • 0.5-meter Intensity images in GeoTIFF format
Vectors	Shapefiles (*.shp) • Project Boundary • Lidar Tile Index • Calibration and QC Checkpoints (NVA/VVA) • Building Footprint Polygons Geodatabase (*.gdb) • Continuous Hydro-flattened Breaklines
Reports	Reports in PDF format • Focus on Delivery • Processing Report
Metadata	XML Files (*.xml) • Breaklines • Classified Point Cloud • DEM • Intensity Imagery

MN_LakeSuperior_2021_B21
Work Unit 218907 Boundary

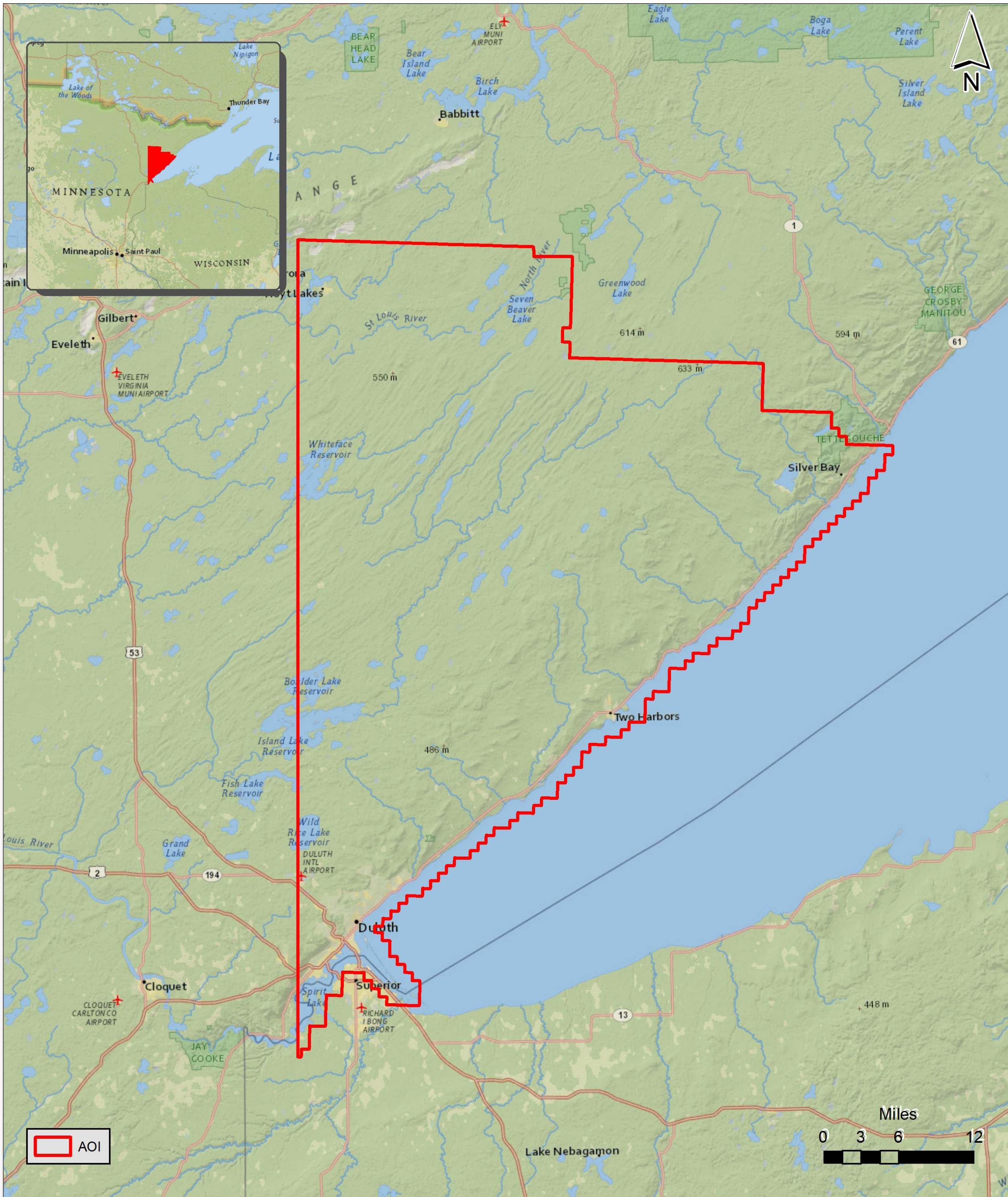


Figure 1. Work Unit Boundary

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 and FMS Planner planning software.

2.2. Lidar Sensor

NV5 Geospatial utilized Riegl VQ1560i and VQ1560ii as well as Optech Galaxy T2000 lidar sensors (Figure 3), serial number(s) 3544, 4051, and 413 , for data acquisition.

The Riegl 1560i system has a laser pulse repetition rate of up to 2 MHz resulting in more than 1.3 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to an unlimited number of targets per pulse from the laser.

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.

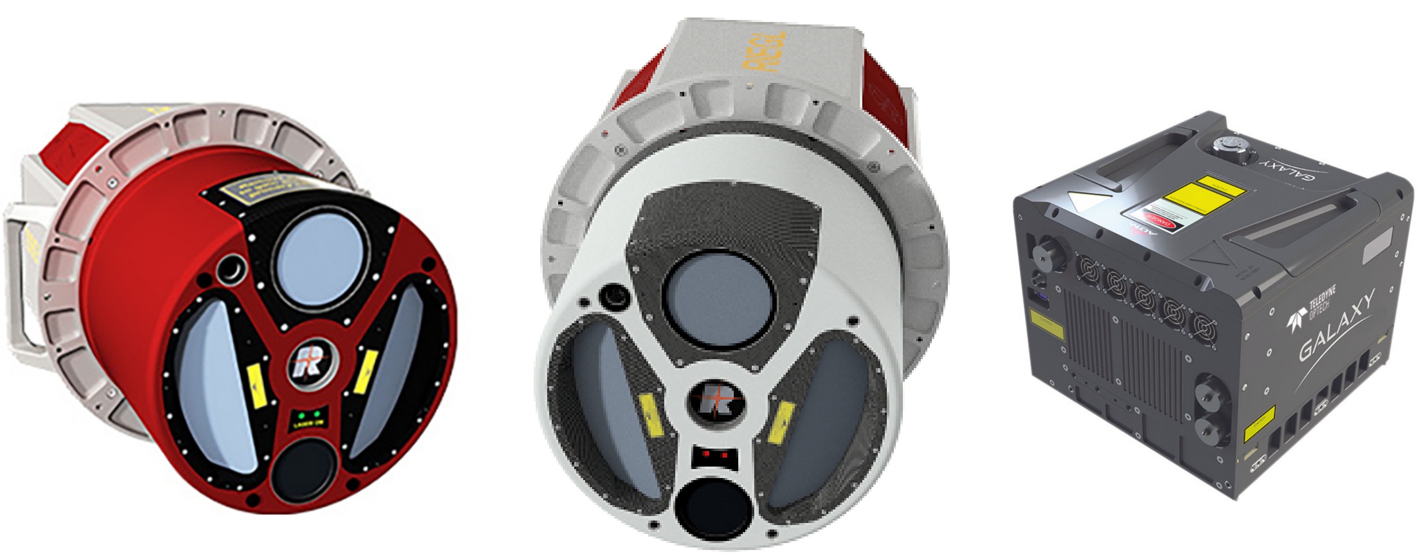
The Optech Galaxy T2000 is a wide-area lidar sensor. This sensor is enhanced with a continuous operating envelope, a dynamic field of view, real-time sensor protocol, and a high-performance scanner. This sensor has 2 MHz “on-ground” collection rates and is capable of 8 returns per emitted pulse.

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 VQ1560i (3544)	Riegl VQ1560ii (4051)	Optech Galaxy T2000 (413)
Terrain and Aircraft Scanner	Flying Height	1,326 m	1,500 m	1,828 m
	Recommended Ground Speed	180 kts	160 kts	145 kts
Scanner	Field of View	58.5°	60°	38°
	Scan Rate Setting Used	2 x 200 (lps)	350 Hz	95 Hz
Laser	Laser Pulse Rate Used	2 x 1000 kHz	2000 kHz	1100 kHz
	Multi Pulse in Air Mode	6-11	Yes	Yes
Coverage	Full Swath Width	1,484 m	1,700 m	1342 m
	Line Spacing	1,190 m	1,385 m	994 m
Point Spacing and Density	Average Point Spacing	.459 m	0.353 m	.330 m
	Average Point Density	9.70 pts / m^2	>8 pt/m2	9.12 pts / m^2

Figure 2. Riegl VQ1560i, Riegl VQ1560ii, and Optech Galaxy T2000 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-31-310 Navajo C, Tail Number(s): C-GKSX
- Cessna 402 (twin-piston), Tail Number(s): N41GD
- Cessna 206 Stationair (piston-single), Tail Number(s): N223TC

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 state-of-the-art Riegl and Optech lidar systems. Some of NV5 Geospatial's operating aircraft can be seen in Figure 4 below.

Figure 3. Some of NV5 Geospatial's Planes

2.4. Time Period

Project specific flights were conducted between April 25, 2021 and May 2, 2021. Twelve aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
04252021A1 (SN3544,N223TC)	4/25/2021 1:05:22 PM	4/25/2021 5:50:00 PM
04252021A2 (SN3544,N223TC)	4/25/2021 7:16:35 PM	4/25/2021 9:45:29 PM
04282021A (SN3544,N223TC)	4/28/2021 6:19:34 PM	4/28/2021 8:31:23 PM
04282021A (SN413,N41GD)	4/28/2021 8:40:14 PM	4/29/2021 1:04:43 AM
04302021A (SN4051,C-GKSX)	4/30/2021 12:56:46 PM	4/30/2021 6:27:24 PM
04302021A (SN413,N41GD)	4/30/2021 2:38:29 PM	4/30/2021 7:20:00 PM
04302021A1 (SN3544,N223TC)	4/30/2021 1:03:58 PM	4/30/2021 3:02:27 PM
05012021A (SN4051,C-GKSX)	5/01/2021 1:27:43 PM	5/01/2021 6:51:27 PM
05012021A2 (SN3544,N223TC)	5/01/2021 7:26:41 PM	5/01/2021 8:09:02 PM
05022021A (SN4051,C-GKSX)	5/02/2021 1:01:10 PM	5/02/2021 6:00:08 PM
05022021A1 (SN3544,N223TC)	5/02/2021 1:13:49 PM	5/02/2021 4:30:50 PM
05022021A2 (SN3544,N223TC)	5/02/2021 5:57:01 PM	5/02/2021 8:17:21 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 were created using Optech LMS and 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. The point cloud is imported into GeoCue distributive processing software. Imported data is tiled and then calibrated using TerraMatch and proprietary software. Using TerraScan, the vertical accuracy of the surveyed ground control is tested and any bias is removed from the data. TerraScan and TerraModeler software packages are then used for automated data classification and manual cleanup. The data are 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.

Finally, proprietary software is used to perform statistical analysis of the LAS files.

Software	Version
Optech LMS	4.4
Applanix + POSPac	8.6
RiPROCESS	1.8.6
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
TerraModeler	21.008
TerraScan	21.016
TerraMatch	21.007

3.3. LAS Classification Scheme

The classification classes are determined by Lidar Base Specifications 2020, Revision A 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 surface
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 heads-up 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 0.5 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 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 0.5 meters 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.

3.8. Hydro-Flattened Raster DEM Processing

Class 2 lidar in conjunction with the hydro breaklines were used to create a 0.5-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.

3.9. Intensity Image Processing

GeoCue software was used to create the deliverable intensity images. All withheld points were ignored during this process. This helps to ensure a more aesthetically pleasing image. The GeoCue software was then used to verify full project coverage as well. GeoTIFF files with a cell size of 0.5-meter were then provided as the deliverable for this dataset requirement.

3.10. Height 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. Proprietary software was used to create 0.5-meter raster images in GeoTIFF format.

MN_LakeSuperior_2021_B21
Work Unit 218907 Tile Layout

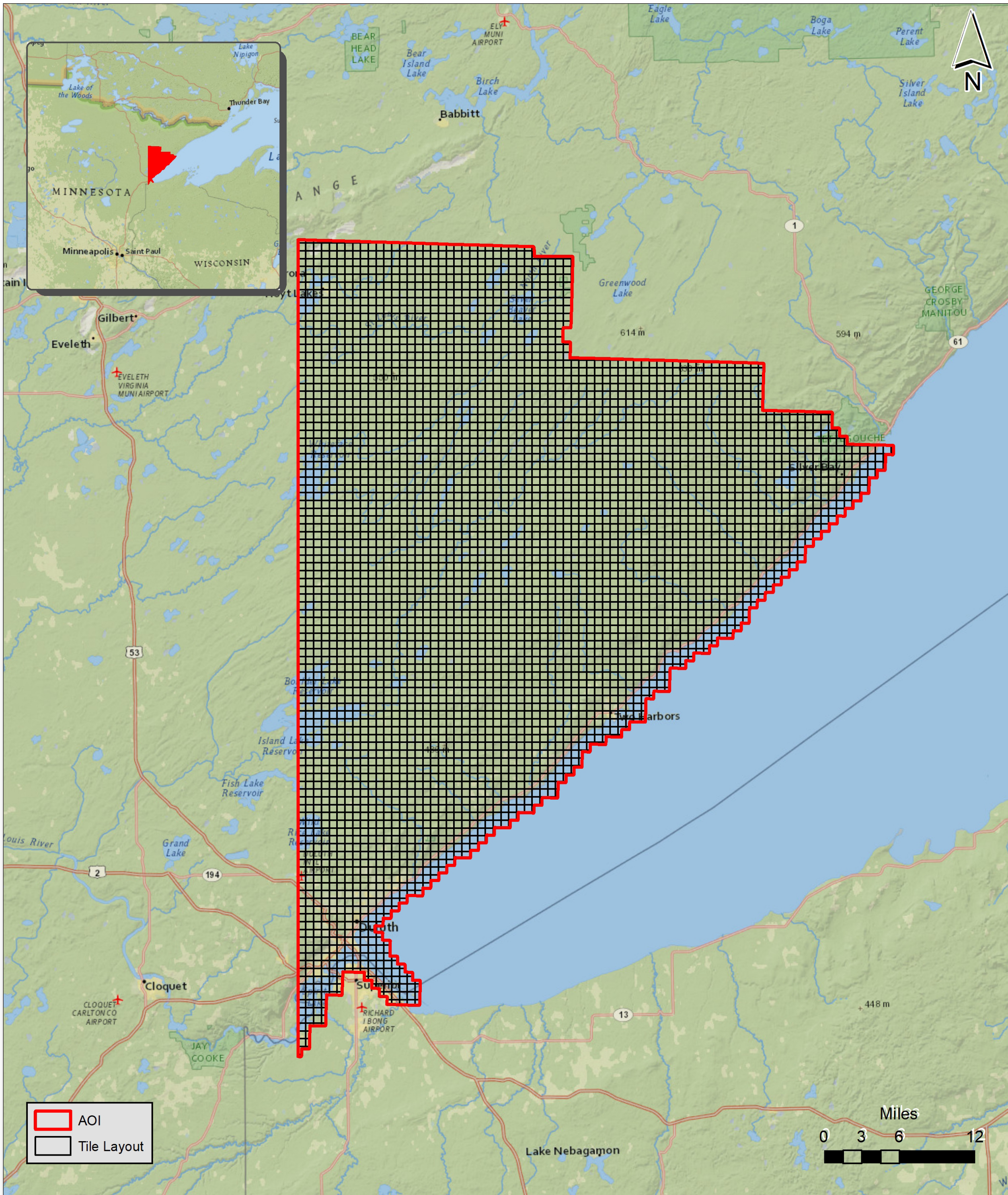


Figure 4. Lidar Tile Layout

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.

MN_LakeSuperior_2021_B21
Work Unit 218907 Lidar Coverage

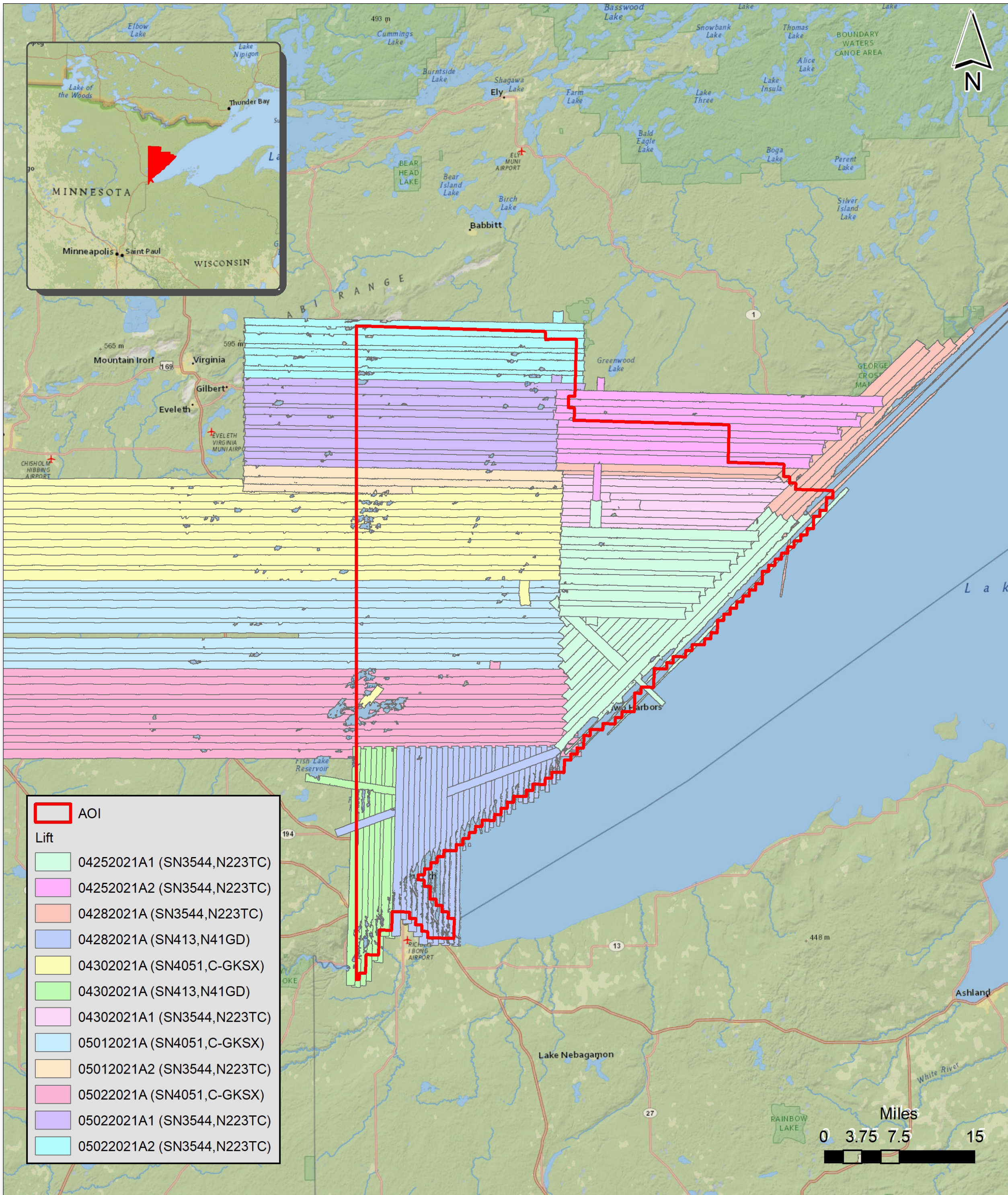


Figure 5. Lidar Coverage

5. Geometric Accuracy

5.1. Horizontal Accuracy

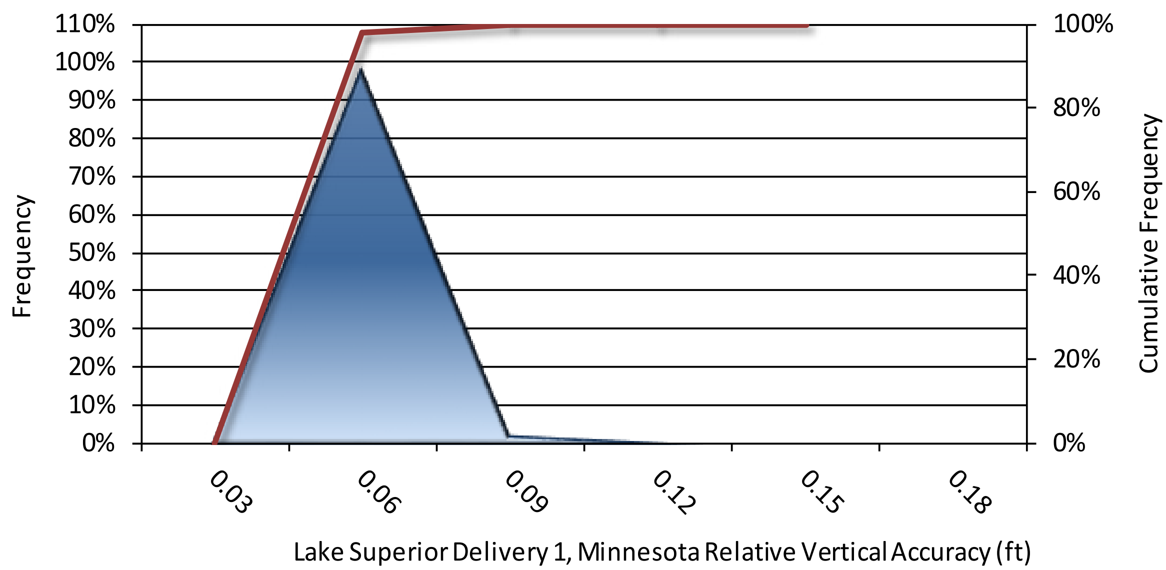
Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained $RMSE_r$ value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial 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 1,828 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.20 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

Horizontal Accuracy	
$RMSE_r$	0.38 ft
	0.12 m
ACC_r	0.65 ft
	0.20 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 MN_LakeSuperior_2021_B21 project was 0.041 feet (0.013 meters). A summary is shown below.

Relative Vertical Accuracy	
Sample	150 flight line surfaces
Average	.048 ft
	.015 m
Median	.048 ft
	.015 m
RMSE	.048 ft
	.015 m
Standard Deviation (1σ)	.006 ft
	.002 m
1.96σ	.011 ft
	.003 m



Project Report Appendices

The following section contains the appendices as listed in the MN_LakeSuperior_2021_B21 Lidar Project Report.

Appendix A

Flight Logs

Julian Day	120	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 30th, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ⦿ 50 hr ○ 100 hr

Aircraft Block Time

Engine On	12:25	**Takeoff**	12:49	
Engine Off	18:59	**Landing**	18:50	
Total	6.6 hrs	**Total**	6.0 hrs	

Mission Plan

AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp 210430	Comments
							210430_123859	
Test Strip		N/A	12:56	12:57			210430_125645	DC error, quick test. No issues.
Figure 8		8	13:01	13:06				6000 ft +/-
X-Tie_1001-1	512112001	0.00 +/-	13:08	13:13			130832	6000 ft +/-
1001	512112002	273.0	13:17	13:39			131727	6099 ft a few low clouds around
1002	512112003	091.0	13:42	14:02			134218	6099 ft
1003	512112004	273.0	14:06	14:27			140602	6099 ft
1004	512112005	091.0	14:30	14:50			143023	6099 ft, had to turn quick for traffic.
1005	512112006	273.0	14:53	15:14			145302	6099 ft
1006	512112007	091.0	15:17	15:37			151744	6099 ft
1007	512112008	273.0	15:41	16:02			154131	6099 ft
1008	512112009	091.0	16:05	16:26			160533	6099 ft
1009	512112010	273.0	16:29	16:50			162943	6099 ft Getting rough
1010	512112011	091.0	16:54	17:14			165400	6099 ft
1011	512112012	273.0	17:17	17:39			171758	6099 ft

Julian Day	120	**Flight**	A

LIDAR Flight Log

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A Clean Harbors Company

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Mission Plan					
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Target Speed	160	kts	**Scan Rate**	172/179plane	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210430	
1012	512112013	090.9	17:42	18:02			210430_174217	6099 ft
1013	512112014	272.9	18:06	18:27			180629	6099 ft
Figure 8		8	18:27	18:32				6100 ft+/-

Julian Day 120	Flight A

LIDAR Flight Log

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A Clean Harbors Company

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Julian Day	120	Flight	A

LIDAR Flight Log

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Mission Plan

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Static Alignment	GPS Time	
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Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210430	

LIDAR Flight Log

Julian Day 120 | **Flight** A

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A Clean Harbors Company

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Project Info	
Project #	Project Name
20210171:1A-1	LakeSuperior_QL1

Crew	Equipment
Pilot	Aircraft Make/Model
Ryan	Cessna 401
Operator	Sensor Make/Model
Chris	Optech Galaxy T2000

Wind Dir (°)	Wind Speed (kts)	Visibility (mi)
150	8	10

Air Speed (kts)	Altitude AGL (ft)
145	6,000

Point Spacing (m)	Point Density (ppsm)
0.33	9.12

Line #	Direction	Start Time (UTC)	End Time (UTC)
119	70	20:40:12	20:49:42
1	182	20:53:40	20:54:28
2	2	20:58:56	21:00:15
3	182	21:03:44	21:04:59
4	2	21:08:31	21:10:02
5	182	21:13:17	21:14:59
6	2	21:19:24	21:21:05
7	182	21:25:03	21:26:56
8	2	21:31:42	21:33:49
9	182	21:37:40	21:39:48
10	2	21:44:34	21:46:42
11	182	21:50:06	21:52:25
12	2	21:56:39	21:59:16
13	182	22:03:01	22:05:44
14	2	22:09:34	22:12:36
15	182	22:16:03	22:18:57
16	2	22:22:50	22:26:04
17	182	22:30:17	22:33:28
18	2	22:38:03	22:41:33
19	182	22:45:25	22:49:02
20	2	22:52:45	22:56:33
21	182	22:59:54	23:07:09
22	2	23:11:18	23:18:31
23	182	23:21:56	23:29:04
24	2	23:32:52	23:40:07

Additional Comments

Drive 1

Survtech Lidar Acquisition Log

	Unique ID	Flight Date (UTC)
	Day118_5060413_1	04/28/2021

		Time	
	Aircraft Tail #	Hobbs Start	Local Start
	N41GD	1295.2	03:13:00
	Sensor Serial #	Hobbs End	Local End
	5060413	1300.4	08:25:00

Conditions

	Ceiling (ft)	Cloud Cover	Temp. (°C)	De
	12,000	Clear	12.2	

Altitude MSL (ft)	Airfield Elevation (ft)
7,400	1,428

Settings

Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)
38	95	1100

Verify S-Turns Bef

Time On-Line	Satellite	PDOP	Line Notes
00:09:30	26	0.94	G
00:00:48	26	0.96	G
00:01:19	26	0.95	G
00:01:15	26	0.94	G
00:01:31	25	1.01	G
00:01:42	24	1.04	G
00:01:41	24	1.02	G
00:01:53	25	0.9	G
00:02:07	24	0.98	G
00:02:08	25	0.93	G
00:02:08	28	0.82	G
00:02:19	28	0.82	G
00:02:37	26	0.89	G
00:02:43	26	0.9	G
00:03:02	26	0.9	G
00:02:54	27	0.89	G
00:03:14	27	0.89	G
00:03:11	27	0.93	G
00:03:30	25	1.01	G
00:03:37	27	0.91	G
00:03:48	26	0.95	G
00:07:15	25	1	G
00:07:13	26	1.05	G
00:07:08	26	0.95	G
00:07:15	24	1.14	G

Verify S-Turns Aft

Date		
	Day of Year	Flight #
	118	1

	Airports
UTC Start	Departing
20:13:00	KDLH
UTC End	Arriving
01:25:00	KDLH

ew Point (°C)	Pressure ("Hg)
2.8	29.96

	Laser Power (%)
	100

ore Mission	Yes

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er Mission	Yes

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Project Info	
Project #	**Project Name**
20210171:1A-1	LakeSuperior_QL1

Crew	Equipment
Pilot	**Aircraft Make/Model**
Ryan	Cessna 401
Operator	**Sensor Make/Model**
Chris	Optech Galaxy T2000

Wind Dir (°)	Wind Speed (kts)	Visibility (mi)
150	8	10

Air Speed (kts)	Altitude AGL (ft)
145	6,000

Point Spacing (m)	Point Density (ppsm)	
0.33	9.12	

Line #	Direction	Start Time (UTC)	End Time (UTC)
25	182	23:43:22	23:50:30
26	2	23:54:28	00:01:42
27	182	00:05:09	00:12:12
28	2	00:16:06	00:23:06
29	182	00:26:46	00:33:26
30	2	00:37:49	00:44:23
31	182	00:48:05	00:54:19
32	2	00:57:53	01:04:47

Additional Comments

Survtech Lidar Acquisition Log

	Unique ID	Flight Date (UTC)
	Day118_5060413_1	04/28/2021

		Time	
	Aircraft Tail #	Hobbs Start	Local Start
	N41GD	1295.2	03:13:00
	Sensor Serial #	Hobbs End	Local End
	5060413	1300.4	08:25:00

Conditions

	Ceiling (ft)	Cloud Cover	Temp. (°C)	De
	12,000	Clear	12.2	

Altitude MSL (ft)	Airfield Elevation (ft)	
7,400	1,428	

Settings

Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)
38	95	1100

Verify S-Turns Bef

Time On-Line	Satellite	PDOP	Line Notes
00:07:08	26	1	G
00:07:14	28	0.95	G
00:07:03	28	0.96	G
00:07:00	27	0.96	G
00:06:40	30	0.85	G
00:06:34	30	0.86	G
00:06:14	31	0.86	G
00:06:54	30	0.87	G
			Dri

Verify S-Turns Aft

Date		
	Day of Year	Flight #
	118	1

	Airports
UTC Start	Departing
20:13:00	KDLH
UTC End	Arriving
01:25:00	KDLH

ew Point (°C)	Pressure ("Hg)
2.8	29.96

	Laser Power (%)
	100

ore Mission	Yes

s/Comments

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er Mission	Yes

Project Info

Project #	Project Name
20210171:1A-1	LakeSuperior_QL1

Crew	Equipment
Pilot	**Aircraft Make/Model**
Ryan	Cessna 401
Operator	**Sensor Make/Model**
Chris	Optech Galaxy T2000

Wind Dir (°)	Wind Speed (kts)	Visibility (mi)
320	10	10

Air Speed (kts)	Altitude AGL (ft)
145	6,000

Point Spacing (m)	Point Density (ppsm)
0.33	9.12

Line #	Direction	Start Time (UTC)	End Time (UTC)
33	182	14:38:27	14:45:08
34	2	14:50:00	14:56:56
35	182	15:00:28	15:07:58
36	2	15:12:47	15:20:30
37	182	15:24:26	15:32:34
38	2	15:36:46	15:45:26
39	182	15:49:35	15:57:55
40	2	16:02:00	16:10:38
41	182	16:14:36	16:23:01
42	2	16:27:09	16:35:49
43	182	16:38:45	16:46:59
44	2	16:55:41	17:10:09
45	182	17:13:24	17:27:19
46	2	17:31:43	17:46:13
47	182	17:49:12	18:03:08
48	2	18:07:13	18:21:30
49	182	18:24:27	18:38:49
50	2	18:43:01	18:57:34
Manuel Tie		19:16:17	19:20:03

Additional Comments

Named This Missions IMU (210430B)

Survtech Lidar Acquisition Log

	Unique ID	Flight Date (UTC)
	Day120_5060413_1	04/30/2021

	Aircraft Tail #	Hobbs Start	Local Start
	N41GD	1301.7	09:13:00
	Sensor Serial #	Hobbs End	Local End
	5060413	1307.1	02:37:00

Time

Conditions

	Ceiling (ft)	Cloud Cover	Temp. (°C)	De
	12,000	Clear	-0.6	

Altitude MSL (ft)	Airfield Elevation (ft)
7,430	1,428

Settings

Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)
38	95	1100

Verify S-Turns Bef

Time On-Line	Satellite	PDOP	Line Notes
00:06:41	28	0.97	Gc
00:06:56	28	0.98	Gc
00:07:30	31	0.86	Gc
00:07:43	32	0.84	Gc
00:08:08	31	0.84	Gc
00:08:40	30	0.88	Gc
00:08:20	31	0.85	Gc
00:08:38	32	0.8	Gc
00:08:25	30	0.87	Gc
00:08:40	29	0.92	Gc
00:08:14	30	0.91	Gc
00:14:28	30	0.95	Gc
00:13:55	30	0.93	Gc
00:14:30	28	0.91	Gc
00:13:56	29	0.82	Gc
00:14:17	30	0.78	Gc
00:14:22	28	0.8	Gc
00:14:33	28	0.81	Gc
00:03:46	27	0.85	Gc
			Dri

Verify S-Turns Aft

Date		
	Day of Year	Flight #
	120	1

	Airports
UTC Start	Departing
14:13:00	KDLH
UTC End	Arriving
19:37:00	KDLH

ew Point (°C)	Pressure ("Hg)
-5.6	30.19

	Laser Power (%)
	100

ore Mission	Yes

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ter Mission	Yes

Julian Day 120	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date April 30th, 2021	**Aircraft** C-GKSX		
Project 3221_QSI_LakeSuperior	**Pilot** L. Bastien		
Location KDLH	**Operator** R. Gemmel		

Mission Objective
-Holding +02.00 pitch O/S as per management.

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN
AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time		
Engine On 12:25	**Takeoff** 12:49	
Engine Off 18:59	**Landing** 18:50	
Total 6.6 hrs	**Total** 6.0 hrs	

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210430	
							210430_123859	
Test Strip		N/A	12:56	12:57			210430_125645	DC error, quick test. No issues.
Figure 8		8	13:01	13:06				6000 ft +/-
X-Tie_1001-1	512112001	0.00 +/-	13:08	13:13			130832	6000 ft +/-
1001	512112002	273.0	13:17	13:39			131727	6099 ft a few low clouds around
1002	512112003	091.0	13:42	14:02			134218	6099 ft
1003	512112004	273.0	14:06	14:27			140602	6099 ft
1004	512112005	091.0	14:30	14:50			143023	6099 ft, had to turn quick for traffic.
1005	512112006	273.0	14:53	15:14			145302	6099 ft
1006	512112007	091.0	15:17	15:37			151744	6099 ft
1007	512112008	273.0	15:41	16:02			154131	6099 ft
1008	512112009	091.0	16:05	16:26			160533	6099 ft
1009	512112010	273.0	16:29	16:50			162943	6099 ft Getting rough
1010	512112011	091.0	16:54	17:14			165400	6099 ft
1011	512112012	273.0	17:17	17:39			171758	6099 ft

Julian Day	120	Flight	A

LIDAR Flight Log

Date	April 30th, 2021	Aircraft	C-GKSX
Project	3221_QSI_LakeSuperior	Pilot	L. Bastien
Location	KDLH	Operator	R. Gemmel
Mission Objective			
-Holding +02.00 pitch O/S as per management.			

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ⦿ 50 hr ○ 100 hr

Aircraft Block Time					
Engine On	12:25	Takeoff	12:49		
Engine Off	18:59	Landing	18:50		
Total	6.6 hrs	Total	6.0 hrs		

Mission Plan					
AGL Height	1500	m	Pulse Rate	1000 KHz	
Target Speed	160	kts	Scan Rate	172/179plane	
Laser Current	100	%	FOV	60	degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210430	
1012	512112013	090.9	17:42	18:02			210430_174217	6099 ft
1013	512112014	272.9	18:06	18:27			180629	6099 ft
Figure 8		8	18:27	18:32				6100 ft+/-

Julian Day	120	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 30th, 2021	Aircraft	C-GKSX
Project	3221_QSI_LakeSuperior	Pilot	L. Bastien
Location	KDLH	Operator	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN
AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:25	Takeoff	12:49	
Engine Off	18:59	Landing	18:50	
Total	6.6 hrs	Total	6.0 hrs	

Mission Plan				
AGL Height	1500	m	Pulse Rate	1000 KHz
Target Speed	160	kts	Scan Rate	172/179plane
Laser Current	100	%	FOV	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 210430	Comments
			Start	End	Time	nmi to End		

Julian Day 120	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 30th, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:25	**Takeoff**	12:49	
Engine Off	18:59	**Landing**	18:50	
Total	6.6 hrs	**Total**	6.0 hrs	

Mission Plan					
AGL Height	1500	m	**Pulse Rate**	1000 KHz	
Target Speed	160	kts	**Scan Rate**	172/179plane	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp 210430	Comments

Julian Day	120	Flight	A

LIDAR Flight Log

Date	April 30th, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	B1
Scanner 2 Drive	B1

Additional Notes

CP780.423-476
VERY STRONG WINDS DRAFTS
*OTHER SURVEY AIRCRAFT IN
AREA/SAME ALTITUDE

Time to next maintenance: 43.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On 12:25	**Takeoff** 12:49			
Engine Off 18:59	**Landing** 18:50			
Total 6.6 hrs	**Total** 6.0 hrs			

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:38	12:43
Post Mission	18:53	18:58

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp 210430	Comments

Julian Day 121 | Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	May 1, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1014+

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	C1
Scanner 2 Drive	C1

Additional Notes

CP780.477-526
VERY STRONG WINDS 50NM
*SPEED VARIES W/ DIRECTION
130/170+/- hard to maintain

Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time

Engine On 12:56		**Takeoff** 13:13		
Engine Off 19:15		**Landing** 19:06		
Total 6.3	hrs	**Total** 5.9	hrs	

Mission Plan

AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:03	13:08
Post Mission	19:09	19:14

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210501	
							210501_130319	Traffic
Figure 8		8	13:20	13:24				In ascent 4800-6000 ft
X-Tie_14-25	512112101	0.0 +/-	13:27	13:31			210501_132743	6200 ft +/-
1014	512112102	273.0	13:36	14:01			133638	6099 ft
1015	512112103	091.0	14:04	14:24			140435	6099 ft hit gust start of line, looks fine
1016	512112104	273.0	14:28	14:53			142842	6099 ft
1017	512112105	091.0	14:56	15:16			145640	6099 ft
1018	512112106	273.0	15:20	15:45			152036	6099 ft PCS error end of line
								Did not auto stop. Looks okay though
1019	512112107	091.0	15:49	16:09			154912	6099 ft
1020	512112108	273.1	16:13	16:37			161300	6099 ft
1021	512112109	091.0	16:40		16:51	23 NM +/-	164011	6099 ft Glitch quit mid line
								displaying strange line on snapshot
1021	512112110	092.1	16:58	17:07			165826	6099 ft east 24 NM
1022	512112111	272.3	17:10	17:35			171026	6099 ft

Julian Day	121	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	May 1, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1014+

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	C1
Scanner 2 Drive	C1

Additional Notes

CP780.477-526
VERY STRONG WINDS 50NM
*SPEED VARIES W/ DIRECTION
130/170+/- hard to maintain

Time to next maintenance: 37.6 +/- ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:56	**Takeoff**	13:13	
Engine Off	19:15	**Landing**	19:06	
Total	6.3 hrs	**Total**	5.9 hrs	

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:03	13:08
Post Mission	19:09	19:14

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210501	
1023	512112112	091.0	17:38	17:58			210501_173802	6099 ft
1024	512112113	273.0	18:03	18:27			180303	6099 ft
1025	512112114	091.0	18:30	18:51			183012	6000 ft
Figure 8		8	18:51	18:55				6000 ft

Julian Day	121	Flight	A

LIDAR Flight Log

Date	May 1, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1014+

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	C1
Scanner 2 Drive	C1

Additional Notes

CP780.477-526
VERY STRONG WINDS 50NM
*SPEED VARIES W/ DIRECTION
130/170+/- hard to maintain

Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:56	**Takeoff**	13:13	
Engine Off	19:15	**Landing**	19:06	
Total	6.3 hrs	**Total**	5.9 hrs	

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:03	13:08
Post Mission	19:09	19:14

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID (Time Stamp 210501)	Comments

Julian Day	121	Flight	A

LIDAR Flight Log

Date	May 1, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1014+

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	C1
Scanner 2 Drive	C1

Additional Notes

CP780.477-526
VERY STRONG WINDS 50NM
*SPEED VARIES W/ DIRECTION
130/170+/- hard to maintain

Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On 12:56	**Takeoff** 13:13			
Engine Off 19:15	**Landing** 19:06			
Total 6.3 hrs	**Total** 5.9 hrs			

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	13:03	13:08
Post Mission	19:09	19:14

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210501	

Julian Day 121	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	May 1, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective
-Holding +02.00 pitch O/S as per management.
1014+

System	Riegl VQ-1560ii
Unit	51
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	C1
Scanner 2 Drive	C1

Additional Notes
CP780.477-526
VERY STRONG WINDS 50NM
*SPEED VARIES W/ DIRECTION
130/170+/- hard to maintain
Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:56	**Takeoff**	13:13	
Engine Off	19:15	**Landing**	19:06	
Total	6.3 hrs	**Total**	5.9 hrs	

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:03	13:08
Post Mission	19:09	19:14

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 210501	

LiDAR and Imagery Flight Report

Project(s): 220030 Rainey Lake

Pilot:	JT	Project Number(s):	220030 Rainey Lake	Date:	5/2/2021
Operator:	AC	Project Name(s):	1099	Mission Start (LT):	3955.2 / 3959.
Aircraft:	223TC	Hobbs Start: 3954.7 / 3959.0	Hobbs Stop: 3959.0 / 3962.3	Mission End (LT):	3958.6 / 3961.

LiDAR Unit:	3) VQ-1560i S2223544	Scan Rate:	2X159	Camera Unit:	Phase One	Drive:	B
MTA Zones:	8 TO 12	Grnd Spd Max (kts):	130	FOV (deg):	58.52	Sun Angle:	
PRR (kHz):	2x1000	Altitude (feet AMT):	5600	Lateral Overlap (%):		Lens:	
Laser Power (%):	100	Point Spacing (m):	0.321	Forward Overlap (%):		Point Density (ppms):	11.6

		Camera Counter		Line Start/Stop						
Line #	Direction	To	From	Start Time UTC	Stop Time UTC	Altitude (Planned)	Altitude (Actual)	Remarks	Clouds	Aperture
51 XTIE	N			8:14	8:17	5655+-		AREA 1099		
38	W			8:23	8:36			27-46		
35	E			9:38	9:51					
32	W			9:53	9:07					
29	E			9:09	9:22					
28	W			9:26	9:40					
31	E			9:42	9:56					
34	W			9:58	10:11					
37	E			10:13	10:26					
36	W			10:29	10:43					
33	E			10:45	10:59					
30	W			11:01	11:14					
27	E			11:16	11:30					
51 XTIE	N			12:56	12:59					
46	W			13:04	13:18					
43	E			13:19	13:34					
40	W			13:36	13:50					
39	E			13:52	14:07					
42	W			14:10	14:25					

45	E			14:26	14:42					
44	W			14:45	14:58					
41	E			15:00	15:16			AREA 1099		

Remarks:

Julian Day	122	Flight	A

LIDAR Flight Log

Date	May 2, 2021	Aircraft	C-GKSX
Project	3221_QSI_LakeSuperior	Pilot	L. Bastien
Location	KDLH	Operator	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1026+

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

Additional Notes

CP780.530-576
VERY STRONG WINDS
*SPEED VARIES W/ DIRECTION,
doing best to maintain 160

Time to next maintenance: 37.6 +/- ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	12:30	Takeoff	12:49	
Engine Off	18:22	Landing	18:13	
Total	5.9 hrs	Total	5.4 hrs	

Mission Plan				
AGL Height	1500	m	Pulse Rate	1000 KHz
Target Speed	160	kts	Scan Rate	172/179plane
Laser Current	100	%	FOV	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	12:37	12:42
Post Mission	18:16	18:21

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 123747	
Figure 8		8	12:54	12:58	(ID for	INS-GPS 1:	210502_123747)	4000-6000 ft climb
X-Tie_26-37	512112201	008.0 +/-	13:01	13:04			130109	6200 ft
1026	512112202	273.0	13:10	13:30			131010	5899 ft
1027	512112203	091.0	13:33	13:54			133350	5899 ft
1028	512112204	273.1	13:57	14:17			135747	5899 ft
1029	512112205	090.9	14:21	14:41			142107	5800 ft
1030	512112206	273.1	14:45	15:05			144509	5800 ft
1031	512112207	091.0	15:08	15:29			150840	5800 ft
1032	512112208	273.1	15:32	15:53			153246	5800 ft
1033	512112209	091.0	15:56	16:17			155626	5600 ft
1034	512112210	273.0	16:20	16:41			162042	5400 ft
1035	512112211	091.0	16:44	17:04			164406	5400 ft
1036	512112212	273.0	17:08	17:28			170807	5400 ft
1037	512112213	091.0	17:31	17:52			173134	5400 ft
Figure 8		8	17:53	17:58				5400 ft

Julian Day	122	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	May 2, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1026+

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

Additional Notes

CP780.530-576
VERY STRONG WINDS
*SPEED VARIES W/ DIRECTION,
doing best to maintain 160

Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time

Engine On	12:30	**Takeoff**	12:49	
Engine Off	18:22	**Landing**	18:13	
Total	5.9 hrs	**Total**	5.4 hrs	

Mission Plan

AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:37	12:42
Post Mission	18:16	18:21

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 123747	
Small Island	512112214	205.0 +/-	17:58	17:58			123747_175830	5400 ft +/- Knife island, just in case.
Figure 8		8	18:01	18:05				5400 ft +/-

v 20200520

Julian Day	122	Flight	A

LIDAR Flight Log

A I R B O R N E I M A G I N G
A Clean Harbors Company

Date	May 2, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1026+

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

Additional Notes

CP780.530-576
VERY STRONG WINDS
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Total	5.9 hrs	**Total**	5.4 hrs	

Mission Plan				
AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
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Static Alignment	GPS Time Start	GPS Time End
Pre Mission	12:37	12:42
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Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 123747	

v 20200520

Julian Day 122 | Flight A

LIDAR Flight Log

Date	May 2, 2021	**Aircraft**	C-GKSX
Project	3221_QSI_LakeSuperior	**Pilot**	L. Bastien
Location	KDLH	**Operator**	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1026+

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

Additional Notes

CP780.530-576
VERY STRONG WINDS
*SPEED VARIES W/ DIRECTION,
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Time to next maintenance: 37.6 +/- ◉ 50 hr ○ 100 hr

Aircraft Block Time

Engine On	12:30	**Takeoff**	12:49	
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Total	5.9 hrs	**Total**	5.4 hrs	

Mission Plan

AGL Height	1500	m	**Pulse Rate**	1000 KHz
Target Speed	160	kts	**Scan Rate**	172/179plane
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
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Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp 123747	

Julian Day	122	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	May 2, 2021	Aircraft	C-GKSX
Project	3221_QSI_LakeSuperior	Pilot	L. Bastien
Location	KDLH	Operator	R. Gemmel

Mission Objective

-Holding +02.00 pitch O/S as per management.
1026+

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

Additional Notes

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AGL Height	1500	m	Pulse Rate	1000 KHz
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Laser Current	100	%	FOV	60 degs

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Pre Mission	12:37	12:42
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Mission ID Time Stamp 123747

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