November 18, 2016

FEMA Topographic Data
Aerial LiDAR Data Collection & Processing
Branch County, MI
Project Plan (Pre-flight)

Purpose

The Strategic Alliance For Risk Reduction (STARR II) has been tasked to provide the Federal Emergency Management Agency (FEMA) with topographic data for Branch county, Michigan. For this effort, Continental Mapping Consultants (Continental) collected, processed, and classified high accuracy LiDAR data.

The area of interest (AOI) covers approximately five hundred twenty (520) square miles and is located in south central Michigan.

Planned Schedule

Data Acquisition- November 18, 2016 – April 30, 2017
Data Processing-May 1, 2017-July 27, 2017
Data Delivery-July 28, 2017

Project Personnel

Project Manager- (Project POC)	Benjamin Leonard Continental Mapping Consultants Inc Continental Building 121 South Bristol Street Sun Prairie, WI 53590 Phone #-> (608) 501.1561 Email->bleonard@continentalmapping.com
Survey Crew	Compass Data Inc.

Prior to the survey or aerial lidar acquisition, Continental will contact the STARR II POC of the specific dates in which staff and/or aircraft will be onsite.

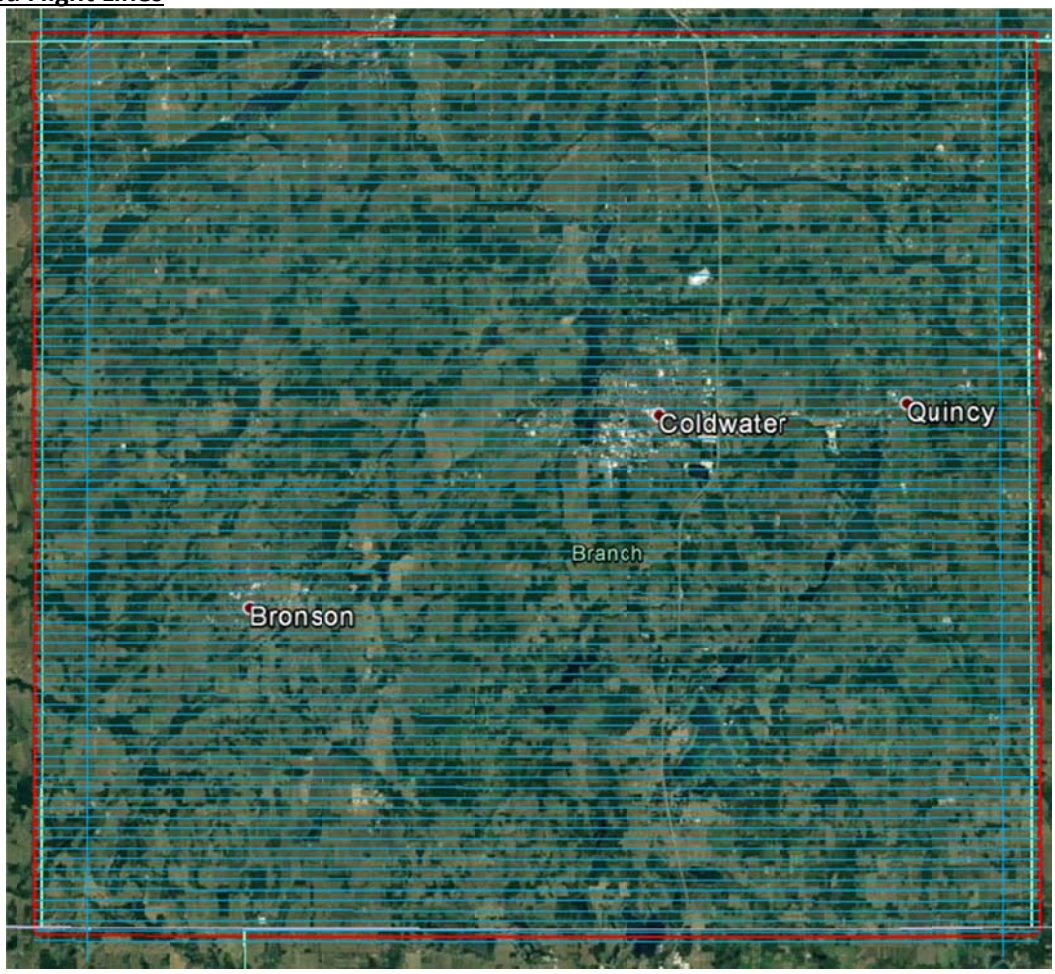
Aircraft & Sensor Information

Aircraft-> Cessna 206 Tail #N85PE
Registration/Ownership->GRW Aerial Surveys, Inc.
Sensor->Optech Gemini System Settings (SN246)
Planning Software-> ALTM-Nav Planner

Acquisition Parameters

Parameters	10 cm RMSEz (non-vegetated)
Flying Height	5500’ AMSL
Aircraft Ground Speed (knots)	120
Pulse Rate (Hz)	70000
Scan Rate (Hz)	43.6
Full Field of View (degrees)	16
Multi-Pulse	Yes
Full Swath Width (meters)	802
Swath Overlap (percentage)	50%
Average point density (pts/m^2)	2

Proposed Flight Lines



Base Stations
Battle Creek- MIBC (Michigan Department of Transportation)
Coldwater – MICW (Michigan Department of Transportation)

Risk

In the occurrence that an issue arises with the primary aircraft or sensor, Continental's partner has a Leica ALS 80 and aircraft stationed in Willoughby OH, that will be utilized. If re-flights are determined to necessary, re-flights will occur as soon as weather permits.

Calibration Processing/Testing Methodology

The team will utilize a number of software packages to complete the calibration process. Below are the individual tasks and software packages.

PosPac v7.1 software to process the sbet and precision files. Optech Lidar Mapping Suite v2.4.1.14540 used for LAS creation. TerraMatch will then be used to refine the calibration of the LiDAR dataset. The trajectory files and point cloud swaths are imported into GeoCue to perform project setup and calibration QC. This project set up phase sets the project parameters, tiling scheme, and is the platform for initial macro runs. After the LiDAR boresite calibration is checked, the flight lines are then adjusted using a z-bump method to each other to within projection specifications for relative accuracy. Control values are run against the point cloud to verify the accuracy of the data prior to classification. Flightline

separation images are created to confirm the LiDAR dataset is within project specifications for relative accuracy. A final overall z adjustment is performed to the ground survey control.

Internal Verification Quality Control

Continental will utilize various software packages and techniques to verify the accuracy of the data. Utilizing QCoherent's LP360, Continental will run a survey to las check, followed by seamline analysis. The survey to las check will calculate the deviation between the survey point elevation and the point cloud elevation and export a Non-Vegetated Vertical Accuracy (NVA) report. The second check will check the seamlines of the point cloud swaths. The third check, the Vegetated Vertical Accuarcy (VVA) testing will occur after the ground classification has been completed. Other software like Terra Solid and Global Mapper will be utilized to verify the results of LP360. Once all of the deliverables have been produced and verified, the data will move to the Quality office for final review. The Quality office will verify that the correct procedures were followed, test the data, and will verify that all of the deliverables in the SOW are finished.

LIDAR REPORT

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

AERIAL LIDAR DATA COLLECTION & PROCESSING
BRANCH COUNTY, MICHIGAN

.DATA CREATED BY THE STRATEGIC ALLIANCE FOR RISK REDUCTION (STARR II)

CONTINENTAL MAPPING CONSULTANTS, INC.

APRIL 2017

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Overview

1.1 Vendor Contact Information:

Continental Mapping Consultants, Inc.
121 South Bristol Street
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(888) 815-3327

Contact: Benjamin Leonard
Telephone: (608) 501.1561
Email: bleonard@continentalmapping.com

1.2 Purpose

The Strategic Alliance For Risk Reduction (STARR II) has been tasked to provide the Federal Emergency Management Agency (FEMA) with topographic data for Branch county, Michigan. For this effort, Continental Mapping Consultants (Continental) collected, processed, and classified high accuracy LiDAR data.

The area of interest (AOI) covers approximately five hundred twenty (520) square miles and is located in south central Michigan. The AOI and specific project boundary are shown in Figure 1.1.

Project Specifications/Accuracy Requirements

The specifications of this project were to conform to all applicable FEMA Standards, USGS LiDAR Base Specification v1.2 (2014), ASPRS LAS Specification Version 1.4-R13 (2013), and ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014).

LiDAR will be collected using the following requirements:

- Atmospheric conditions will be cloud and fog free between the aircraft and the ground
- Ground conditions will be snow free without extensive flooding or other inundation

The county boundary was downloaded from the State of Michigan website, and buffered by 100 meters. All classified LiDAR point cloud data, breaklines, and DEMs were created to the extent of the buffered project area.

The classification codes followed the USGS LiDAR Base Specification v1.2 (2014) classes utilizing the following:

- Class 1 – Processed, but unclassified
- Class 2 – Bare earth
- Class 7 – Low noise
- Class 9 – Water
- Class 10 – Ignored ground (near a breakline)
- Class 17 – Bridge decks
- Class 18 – High noise

Class 1 will be used for feature points that are not in Classes 2, 7, 9, 10, 17 and 18.
Class 2 will be used for feature points that represent the bare-earth.
Class 7 will be used for feature points that represent low noise.
Class 9 will be used for feature points that represent water.
Class 10 will be used for feature points that represent ignored ground near breaklines.
Class 17 will be used for feature points that represent bridge decks.
Class 18 will be used for feature points that represent high noise.

Resolution of LiDAR – To comply with the USGS Lidar Base Specification QL2, the project was flown at an altitude to produce at least 2 ppsm.

Quality Level (QL)	Aggregate nominal pulse spacing (ANPS) (m)	Aggregate nominal pulse density (ANPD) (pls/m^2)
QL0	≤0.35	≥8.0
QL1	≤0.35	≥8.0
QL2	≤0.71	≥2.0
QL3	≤1.41	≥0.5

Figure 1.1 Nominal Pulse Spacing Requirements

Absolute Vertical Accuracy Requirement

The USGS Lidar Base Specification QL2 non-vegetated RMSE accuracy requirement is 10 cm RMSE.

Quality Level (QL)	RMSE$_z$ (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)
QL0	≤5.0	≤9.8
QL1	≤10.0	≤19.6
QL2	≤10.0	≤19.6
QL3	≤20.0	≤39.2

Figure 1.2 Project Accuracy Requirements

Deliverables-

- FEMA Certification of Completion
- Flight Reports and Flight Logs
- Raw lidar point cloud swaths in LAS v1.4
    - Including associated swath index in shapefile format
- Tiled/classified lidar point clouds in LAS v1.4
    - Including associated tile index in shapefile format
- 3D breaklines
    - ESRI File Geodatabase Polygon Z Feature Class
    - Polygon Z Feature Class Topology report
    - Polygon Z in shapefile format
- Hydro-Flattened DEMS in ERDAS Imagine .IMG 32-bit floating point format
    - Including associated DEM tile index in shapefile format
- Acquisition Spatial Data
- Metadata
- Ancillary Information

Figure 1.3: Branch County, Michigan

Project Constraints

- Lake effect snow.
- Lake effect clouds.
- Required lower altitude flights, due to cloud ceiling height
- Leaf Off requirement

2.1 Acquisition

2.2 Project Planning

A detailed project planning was performed for this project. Planning was based on project specific requirements, the project constraints, and industry best practices. The basis of planning for the project area included the required accuracies, shape of the project area, the amount and type of vegetation within the project area, and the required data post spacing. A brief summary of the aerial acquisition parameters for this project are shown in Table 2.1. To acquire the accuracies required, a control layout with checkpoints was developed. These points were presented to the STARR II for review, and surveyed by Compass Data, Inc. along with the required validation points.

Table 2.1: Planned LiDAR System Specifications

Parameters	10 cm RMSEz (non-vegetated)
Flying Height	1402 m AGL
Aircraft Ground Speed (knots)	120
Pulse Rate (Hz)	70000
Scan Rate (Hz)	43.6
Full Field of View (degrees)	16
Multi-Pulse	Yes
Full Swath Width (meters)	802
Swath Overlap (percentage)	50%
Average point density (pts/mˆ2)	2

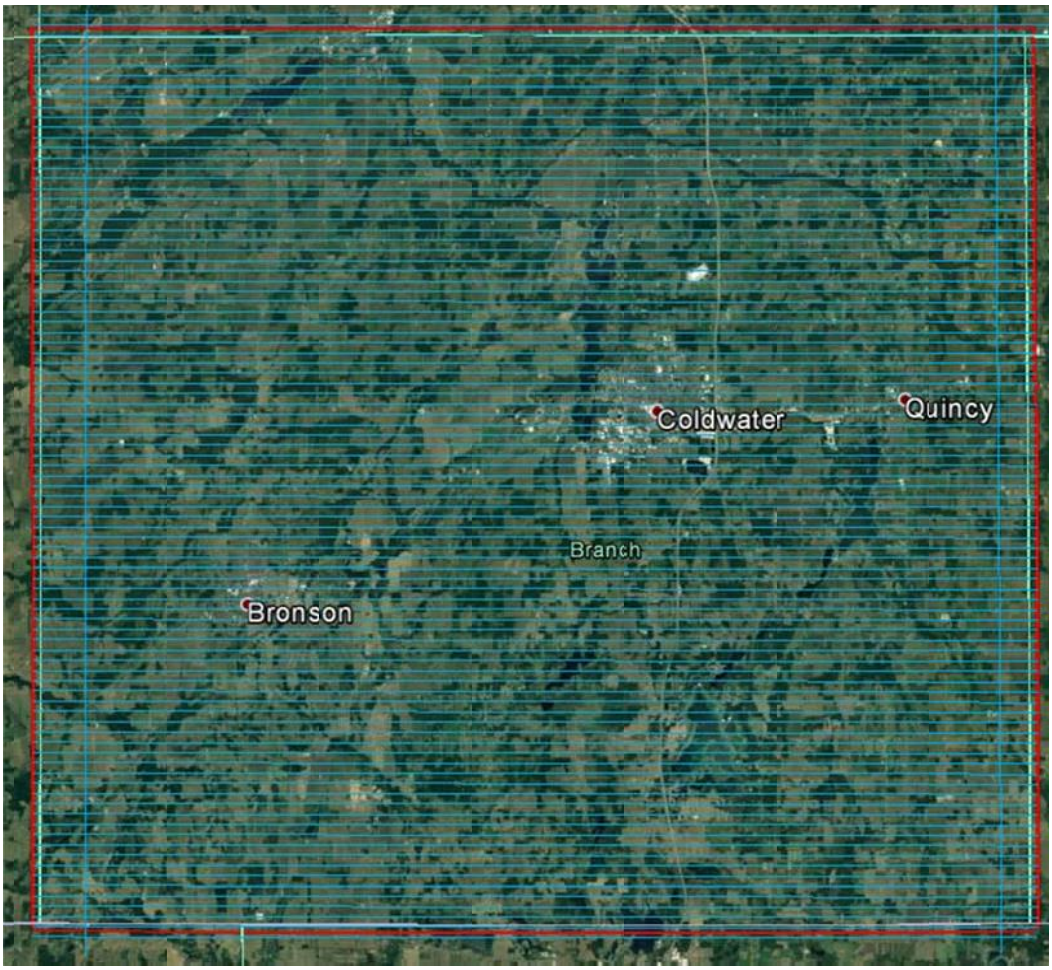

Figure 2.1 Planned Flight Lines

2.3 Ground Survey

All survey responsibilities were performed by Compass Data, Inc.

Datum

Coordinate Reference System:
Michigan State Plane South, FIPS 2113
Horizontal Datum: NAD83 (2011), Epoch 2010.00
X, Y Linear Units: International Survey Feet Vertical
Datum: NAVD88, Geoid 12B
Z Linear Units: International Feet

2.4 Aerial LiDAR

Aerial LiDAR Base Station

The base stations determine where LiDAR can be collected with the highest confidence of accuracy as determined by reading the same satellites in the aircraft and on the ground. Base Stations typically are set at airports and provide coverage within 20 to 25 miles of the base if possible in order to cover in its entirety. Due to the timing constraints of weather and leaf off conditions requirement, and the high quality of the CORS network, the MIBC station located in Battle Creek and the MICW station located in Coldwater were used for this project. Both stations collect a 1 second sampling rate and are maintained by the Michigan Department of Transportation.

Aerial LiDAR Boresight Procedures

The purpose of boresighting is to determine the offset values for the IMU used in the LiDAR sensor. To determine the boresight offset values, the LiDAR sensor has to be flown in a certain configuration over a well-controlled site. The boresighting is done both prior to the flight of the project area and after. This insures that the quality of the LiDAR was maintained throughout the process.

Aerial LiDAR Acquisition

The aerial survey teams were deployed at the first opportunity based on availability of acceptable weather conditions. Due to snow cover and lake effect precipitation, the flight was delayed until March. ALTM-Nav Planner software was utilized to conduct the final flight planning. The sensor used was an Optech Gemini, which is owned and operated by GRW Aerial Surveys, Inc. Due to weather conditions at the collection site or acquisition logistics, 14 total lifts were completed for collection. There were 90 project flight lines, and 6 cross flights collected of which 2 (lines 68 & 77) were used for calibrating. There was also 1 line (line 76) not used in production due to excessive cloud coverage that was successfully collected for coverage in an adjacent lift. The LiDAR acquisition started on March 22, 2017 and ended on April 24, 2017.

Table 2.3: Flight Line Detail

Flight Plan Line	LAS LINE	TRJ NAME	Flight Date
1	1	s0001	3/22/2017
2	2	s0002	3/22/2017
3	3	s0003	3/22/2017
4	4	s0004	3/22/2017
5	5	s0005	3/22/2017
6	6	s0006	3/22/2017
7	7	s0007	3/22/2017
8	8	s0008	3/22/2017

9	9	s0009	3/22/2017
10	10	s0010	3/22/2017
11	11	s0011	3/22/2017
12	12	s0012	3/22/2017
13	13	s0013	3/22/2017
14	14	s0014	3/22/2017
15	15	s0015	3/22/2017
16	16	s0016	3/22/2017
17	17	s0017	3/22/2017
18	18	s0018	3/22/2017
19	19	s0019	3/23/2017
20	20	s0020	3/23/2017
21	21	s0021	3/23/2017
22	22	s0022	3/23/2017
23	23	s0023	3/23/2017
24	24	s0024	3/23/2017
25	25	s0025	3/23/2017
26	26	s0026	3/23/2017
27	27	s0027	3/23/2017
28	28	s0028	3/23/2017
29	29	s0029	3/23/2017
30	30	s0030	3/23/2017
31	31	s0031	3/23/2017
32	32	s0032	3/23/2017
33	33	s0033	3/23/2017
34	34	s0034	3/23/2017
35	35	s0035	3/23/2017
36	36	s0036	4/12/2017
37	37	s0037	4/12/2017
38	38	s0038	4/12/2017
39	39	s0039	4/12/2017
40	40	s0040	4/12/2017
41	41	s0041	4/12/2017
42	42	s0042	4/12/2017
43	43	s0043	4/12/2017
44	44	s0044	4/12/2017
45	45	s0045	4/12/2017
46	46	s0046	4/12/2017

47	47	s0047	4/12/2017
48	48	s0048	4/12/2017
49	49	s0049	4/12/2017
50	50	s0050	4/12/2017
51	51	s0051	4/12/2017
52	52	s0052	4/12/2017
53	53	s0053	4/12/2017
54	54	s0054	4/12/2017
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56	56	s0056	4/14/2017
57	57	s0057	4/14/2017
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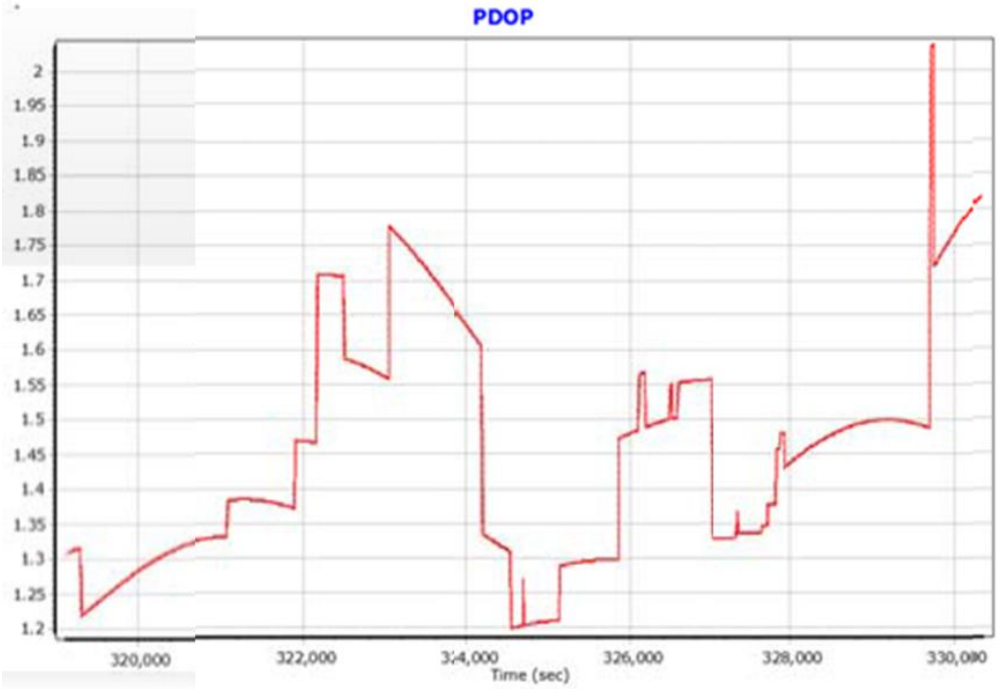
60	60	s0060	4/14/2017
61	61	s0061	4/14/2017
62	62	s0062	4/14/2017
63	63	s0063	4/14/2017
64	64	s0064	4/14/2017
65	65	s0065	4/14/2017
66	66	s0066	4/14/2017
67	67	s0067	4/14/2017
68	68	s0068	4/18/2017
69	69	s0069	4/18/2017
70	70	s0070	4/18/2017
71	71	s0071	4/18/2017
72	72	s0072	4/19/2017
73	73	s0073	4/19/2017
74	74	s0074	4/19/2017
75	75	s0075	4/19/2017
76	76	s0076	4/19/2017
77	77	s0077	4/23/2017
78	78	s0078	4/23/2017
79	79	s0079	4/23/2017
80	80	s0080	4/23/2017
81	81	s0081	4/23/2017
82	82	s0082	4/23/2017
83	83	s0083	4/23/2017
84	84	s0084	4/23/2017

85	85	s0085	4/23/2017
86	86	s0086	4/23/2017
87	87	s0087	4/23/2017
88	88	s0088	4/23/2017
89	89	s0089	4/23/2017
90	90	s0090	4/24/2017
91	91	s0091	4/24/2017
92	92	s0092	4/24/2017
93	93	s0093	4/24/2017
94	94	s0094	4/24/2017
95	95	s0095	4/24/2017
96	96	s0096	4/24/2017
97	97	s0097	4/24/2017

Position Dilution of Precision Report (PDOP)

03/22/2017 A



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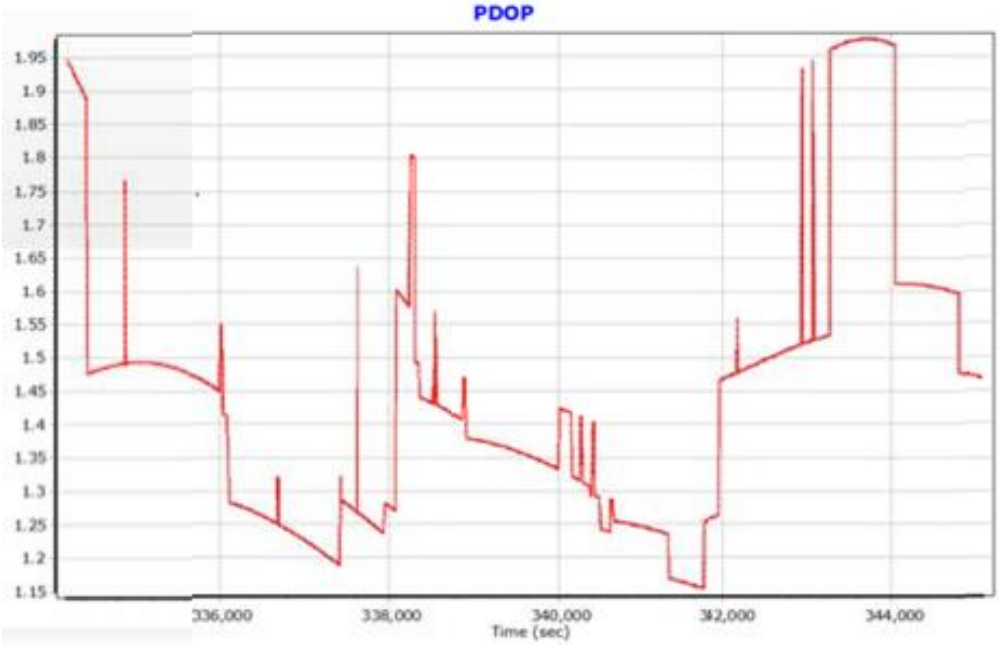

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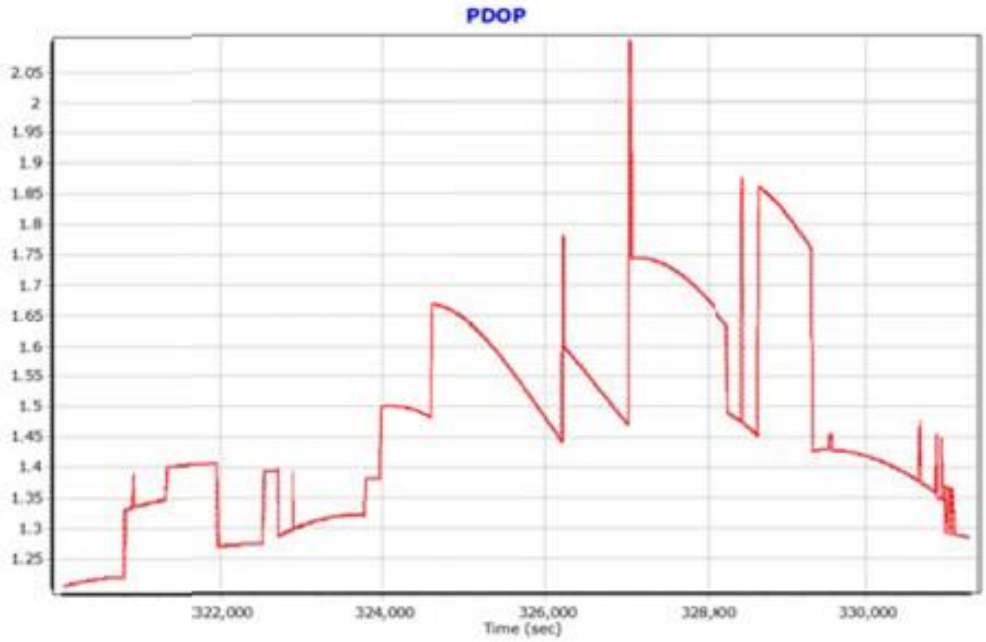

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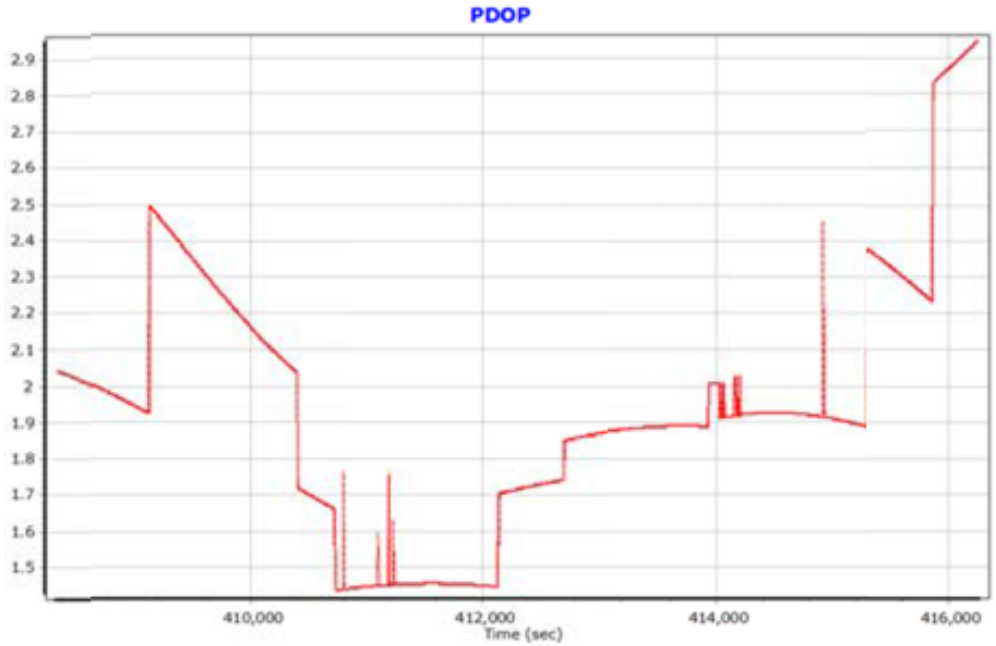

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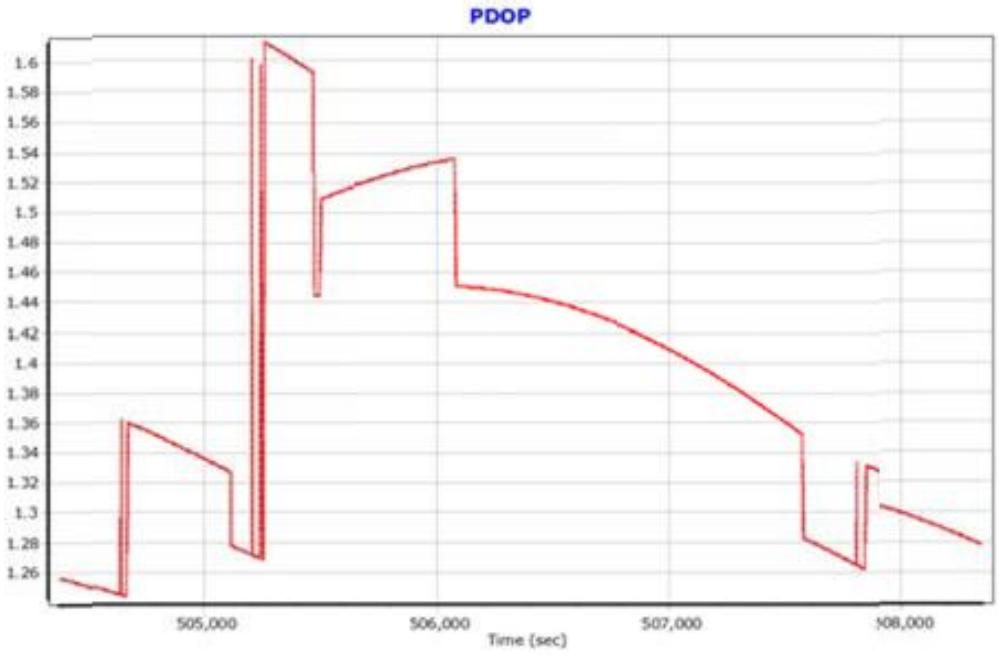

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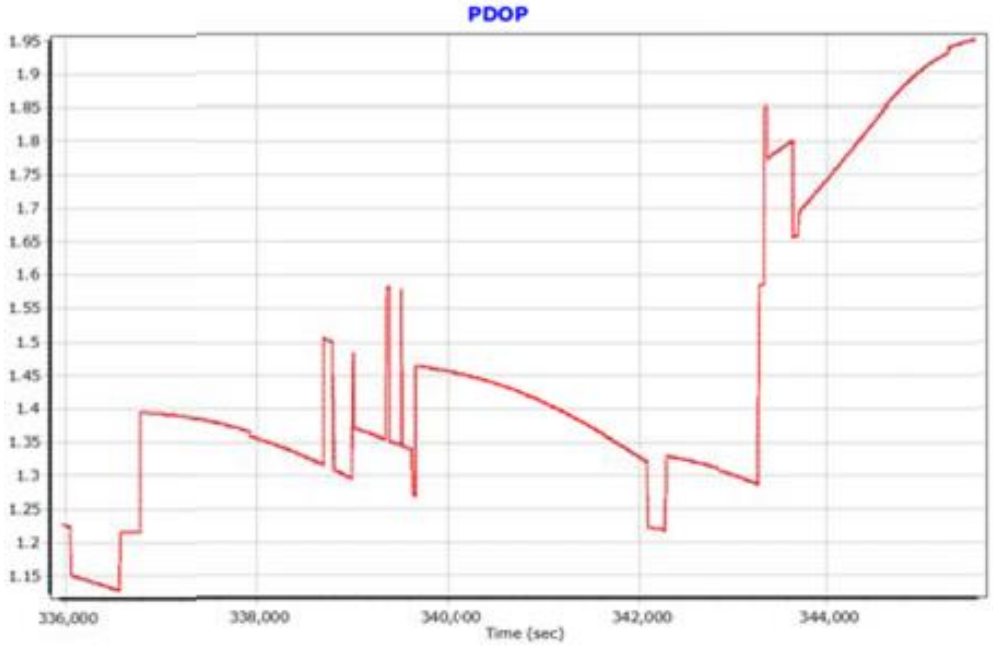

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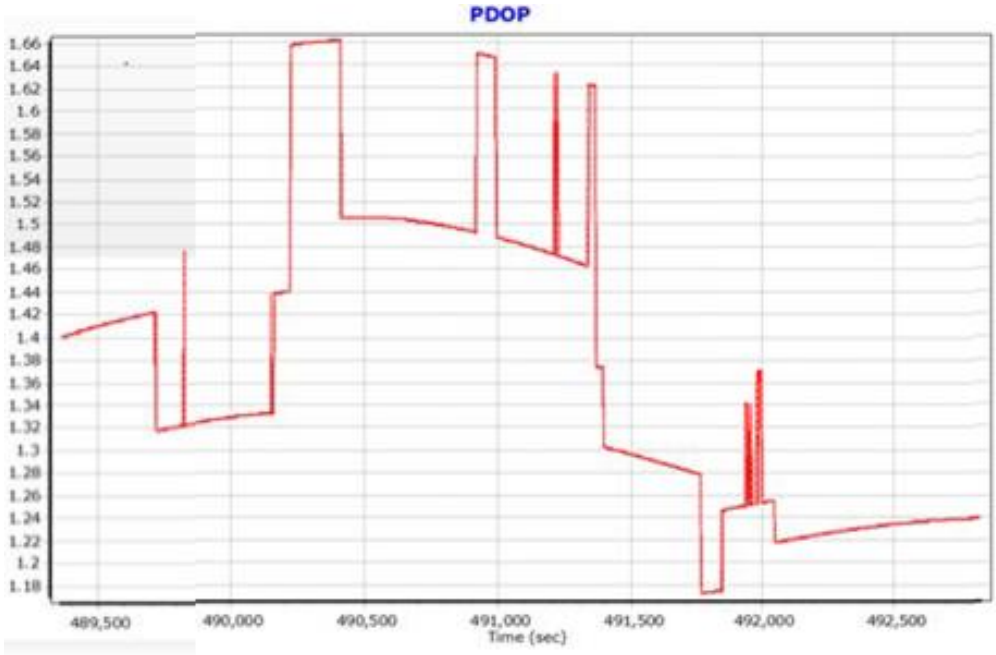

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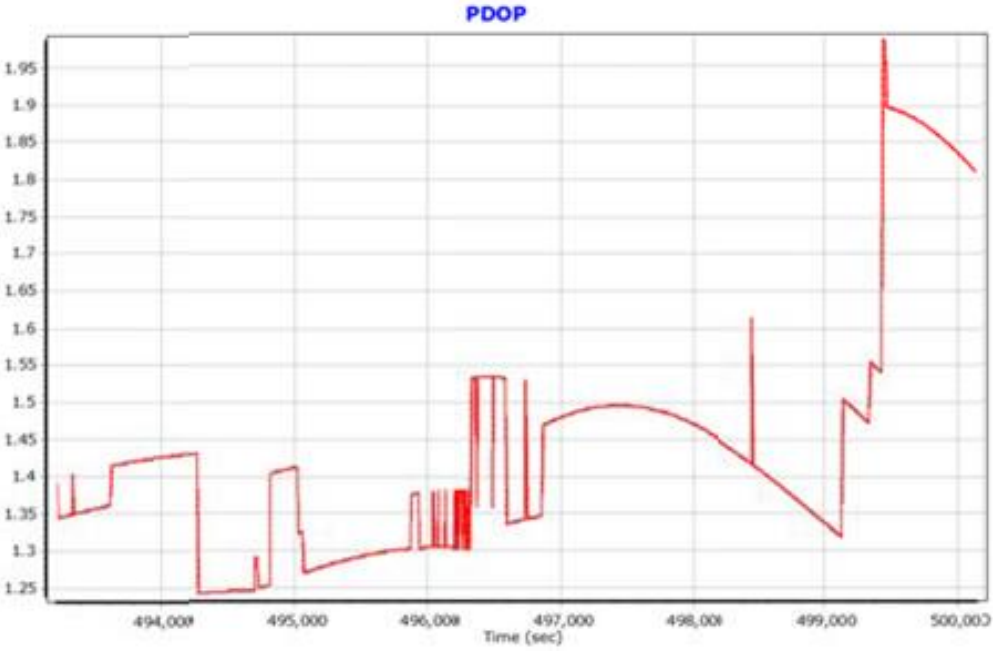

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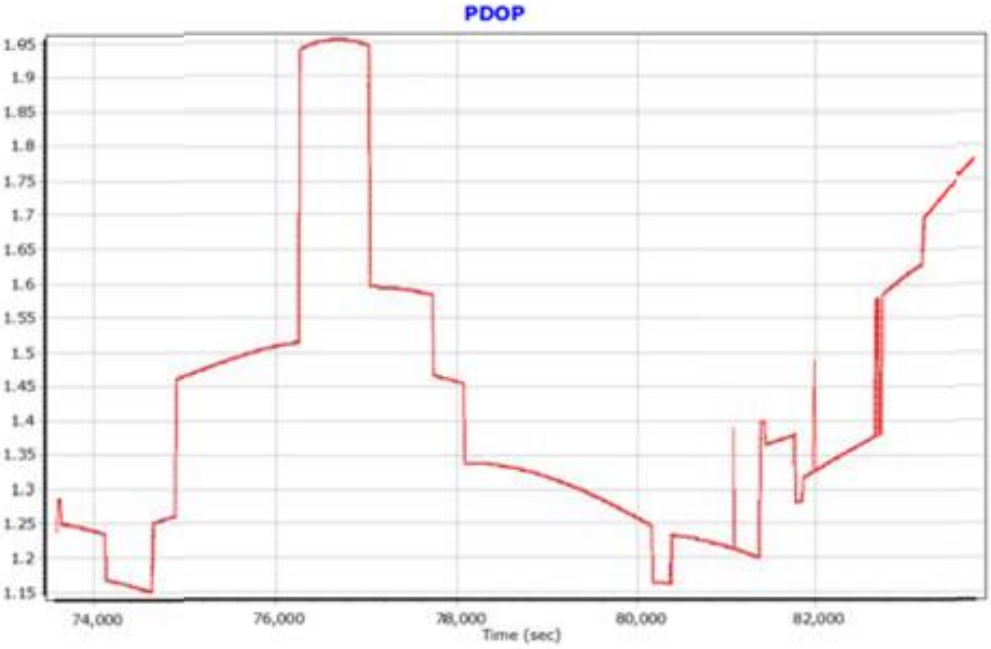

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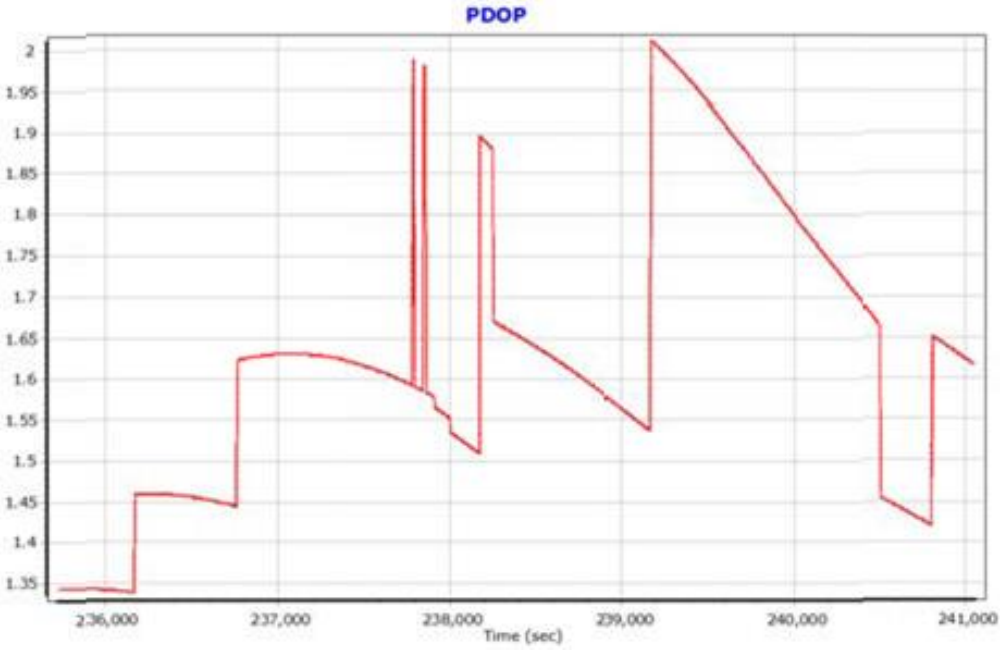

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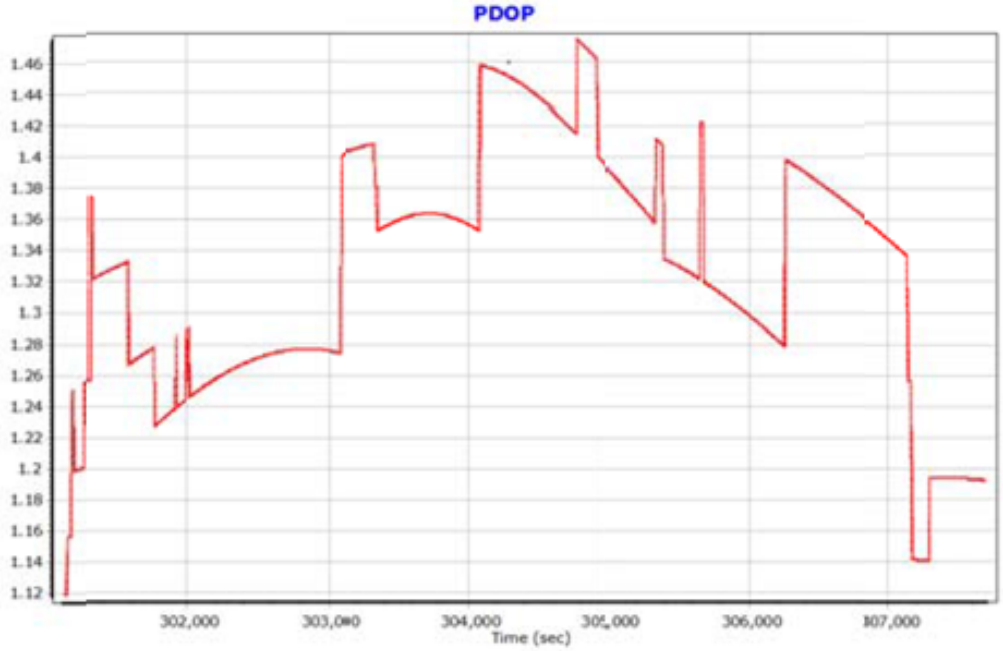

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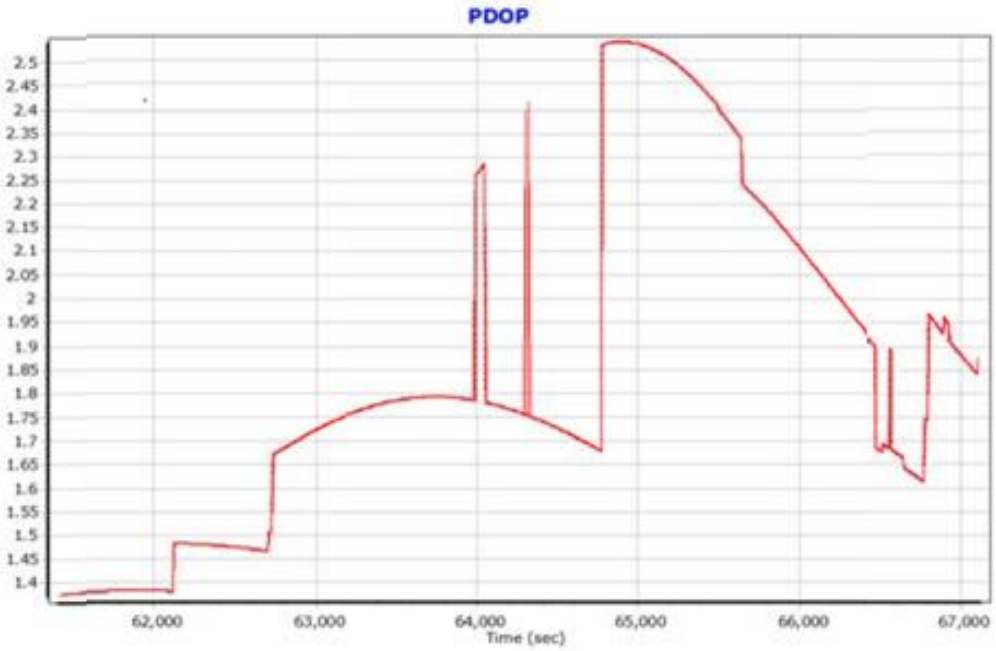

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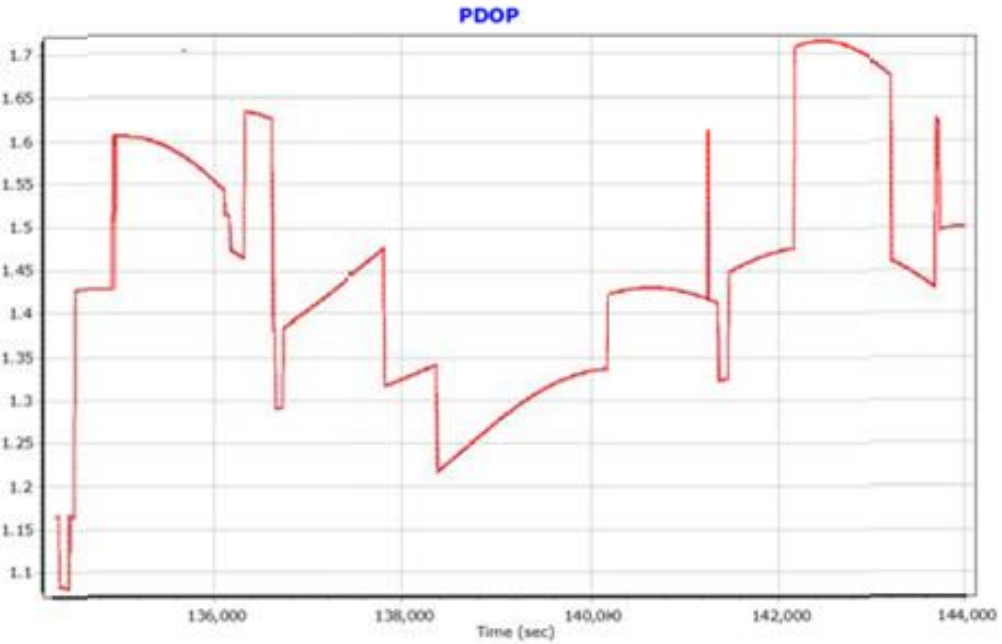

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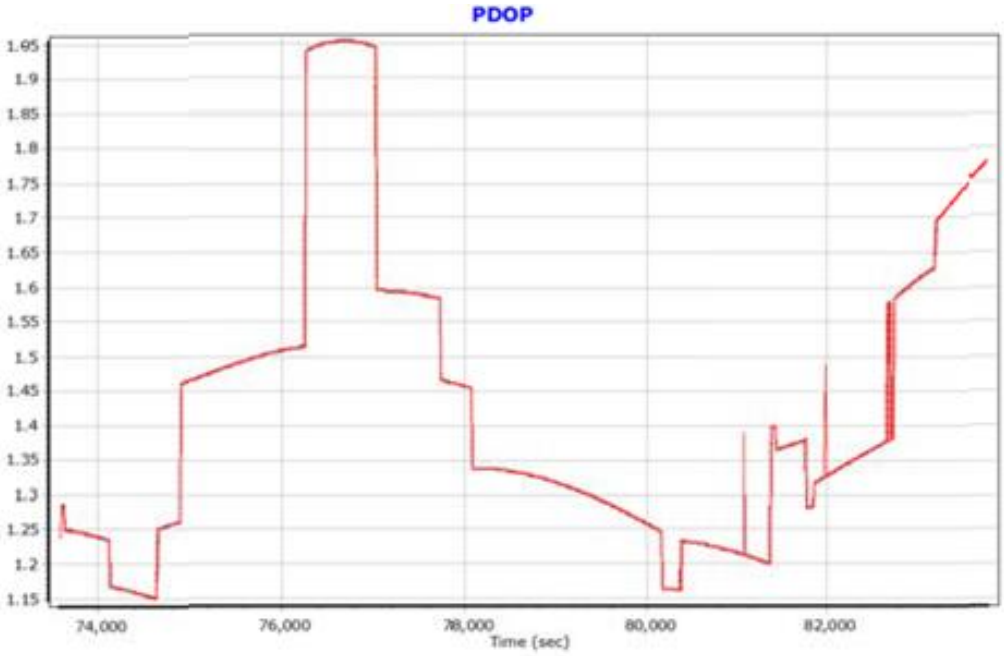


Figure 2.5: Base Station Locations

Project Site Definition	
Min/Max Ground Elevation	836-1173'
Geographic Location	Branch Co, MI
Distance Units	Int'l Feet
Coordinate System	SPC - MI-S
Horizontal Datum	NAD83 - 2011
Vertical Datum	NAVD88 – Geoid12A
Optech Gemini System Settings (SN246)	
Scan FOV	16
Flying Altitude AMSL (ft)/ AGL (ft)	5500/4600
Laser Pulse Rate (Hz)	70000
Scan Rate (Hz)	43.6
Laser Power %	100
Raw Laser Statistics	
Swath Width (ft)	2630
Swath Overlap %	50
Average Point Density	2 points/sq meter
Flight Mission Data	
Aircraft	Cessna 206 Tail #N85PE
Dates Flown	03/22/17, 03/23/17, 04/12/17, 04/14/17, 04/18/17, 04/19/17, 04/23/17, 04/24/17
Number of Flight Lines	97
Flight Speed	~125 knots
Base Station Type	CORS
GPS/INS Notes	Multi-CORS/TPOS
Data Processing	
Tile Layout Used	Arbitrary
Class 1	Unclassified
Data Formats Created	LAS 1.4
Processing Notes	Line 76 omitted from production (clouds)
Accuracy Results	
Number of Control Points Used in Analysis	21
Number of Control Points Eliminated from Original Set	0
Reasons for Point Removal	N/A
Average Elevation Variation	0.038
Minimum Elevation Dz	0.19
Maximum Elevation Dz	0.14
RMS	0.98
Standard Deviation	0.93
Horizontal Accuracy	<1m

3.0 Processing Summary

The Continental team utilized PosPac v7.1 software to process the sbet and precision files. Optech Lidar Mapping Suite v2.4.1.14540 used for LAS creation. TerraMatch was then used to refine the calibration of the LiDAR dataset. The trajectory files and point cloud swaths are imported into GeoCue to perform project setup and calibration QC. This project set up phase sets the project parameters, tiling scheme, and is the platform for initial macro runs.

After import, checkpoints are run against the point cloud to verify the accuracy of the data prior to classification. The detailed description of this process is below in 4.0 Accuracy Assessment. After verifying the a curacy, the processing continues. Multiple macros are run through

TerraScan to flag overlap, and to classify the ground. Due to differing terrain, this step may take multiple iterations. Once the analyst has verified the results with the ground macro, the ground classification QC begins.

During the QC phase, analysts are reclassifying the point cloud in areas where the macro was not able to, or were misclassified. Multiple macros are run on the dataset after the ground classification is complete including water macros. The water macros utilize the hydro breaklines that were manually digitized. These digitized breaklines were classified as ponds and rivers. After the hydro features were digitized, the ponds were flattened. This process calculated the lowest elevation of the feature, and used that elevation to populate the remaining vertices. This process verifies that all ponds are flat.

The river polygons that were digitized were ran against a monotonicity tool. This tool utilized the elevation of a centerline that had the correct elevation and pushed that elevation to the river polygon. This process not only maintains the monotonicity of the river, but also ensures that the river is flat from bank to bank. Then rigorous quality steps are performed each classification level. The bare earth lidar points that were within 3 feet of the water were classified to class 10. After the analysts have completed the QC process in TerraScan, raster files were produced into 32-bit floating GeoTiffs and Erdas Imagine IMG files using LP360. These files were creted using only the ground class. The DEMS are ran against proprietary tools to identify any remaining potential blunders. These checks look for issues with the breaklines, and the overall DEM deviations.

4.0 Accuracy Assessment

Continental utilized various software packages and techniques to verify the accuracy of the data. Utilizing QCoherent's LP360, Continental ran a survey to las check, followed by seamline analysis (swath to swath analysis) to verify the absolute and relative accuracy of the dataset. The survey to las check calculates the deviation between the survey point elevation and the point cloud elevation and exports an RMSE report. This check was run by Continental, utilizing the provided control. This check was also run by Compass Data Inc. utilizing the NVA points. The second check, calculates the deviation between the seamlines of the point cloud swaths. This check is performed in QCoherent's GeoCue after classifying the initial ground. The output of the seamline analysis is represented visually on an intensity image. These images were delivered with the project deliverables. Below is the specification for this check.

Quality Level (QL)	Smooth surface repeatability (cm)	Swath overlap difference, $RMSD_Z$ (cm)	Swath overlap difference, maximum (cm)
QL0	≤3	≤4	±8
QL1	≤6	≤8	±16
QL2	≤6	≤8	±16
QL3	≤12	≤16	±32

Table 4.1 Seamline analysis requirements

The third and final check, the Bare Earth surface Non-Vegetated and Vegetated Vertical Accuracy (VVA) testing occurred after the ground classification has been completed. The VVA testing was performed by Compass Data Inc.

Quality Level (QL)	$RMSE_z$ (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)	VVA at 95th percentile (cm)
QL0	≤5.0	≤9.8	≤14.7
QL1	≤10.0	≤19.6	≤29.4
QL2	≤10.0	≤19.6	≤29.4
QL3	≤20.0	≤39.2	≤58.8

Table 4.2 NVA and VVA accuracy requirements

LiDAR Swath Non-Vegetated Vertical Accuracy Assessment

There were 37 NVA points collected and tested using swath data in Branch County. The NVA test has passed with a 95% confidence level of 6.5 cm.

Bare Earth Non-Vegetated Vertical Accuracy Assessment

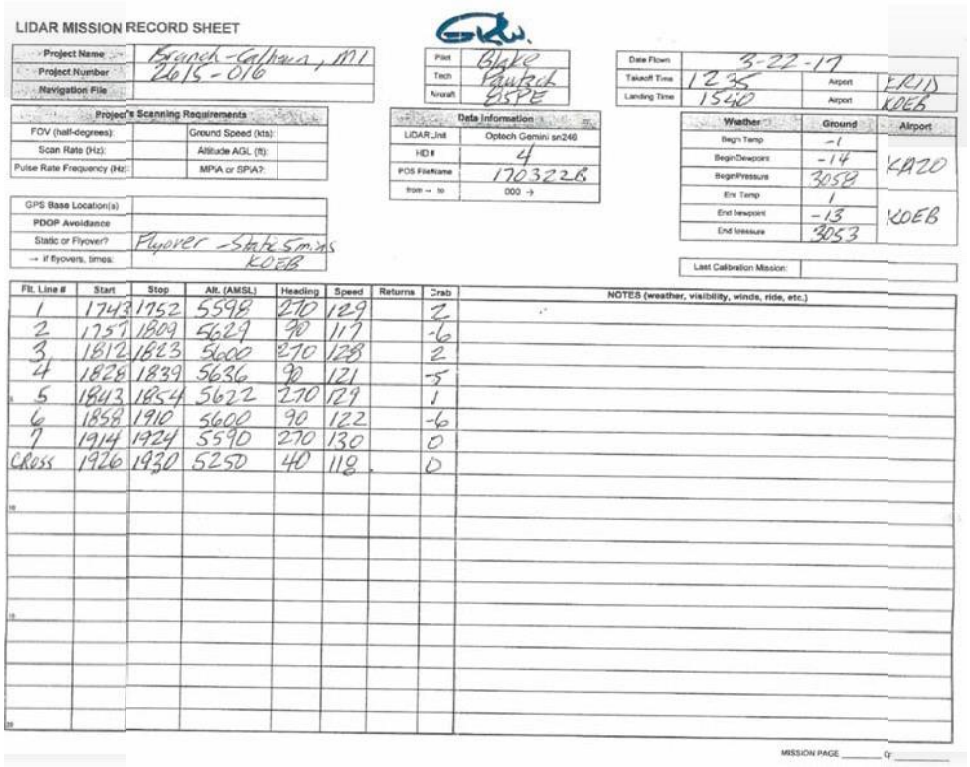
There were 37 NVA points collected and tested using bare earth DEMs in Branch County. The NVA test has passed with a 95% confidence level of 5.5 cm.

Bare Earth Vegetated Vertical Accuracy Assessment

There were 28 VVA points collected and tested using bare earth DEMs in Branch County. The VVA test has passed at a 95th percentile of 7.7 cm.

Once all the deliverables have been produced and verified, the data was moved to the Quality office for final review. The Quality office verifies that the correct procedures were followed, tests the data, and verifies that all the deliverables in the SOW are finished.

APPENDIX A FLIGHT LOG



LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPiA or SPiA?	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Flyover - Static 5 mins KOEB
→ if flyovers, times:	

Pilot	Blake
Tech	Paulick
Aircraft	8SPE

Data Information	
LIDAR Unit	Optech Gemini sn246
HD #	4
POS File Name	170322B
from → to	000 →

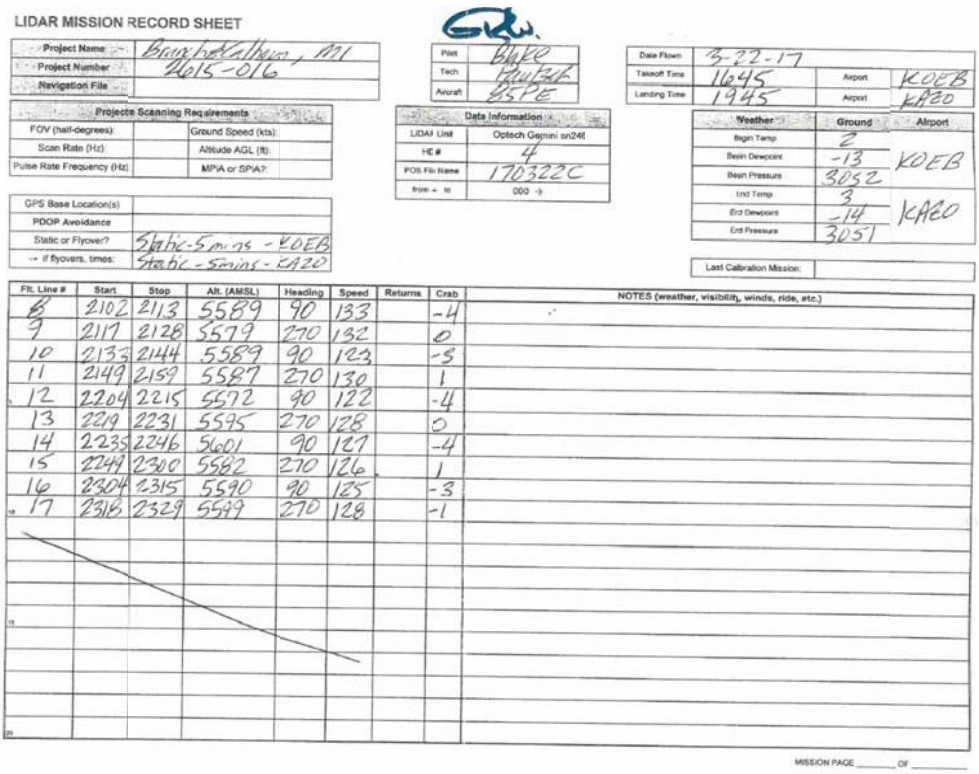
Date Flown	3-22-17		
Takeoff Time	1235	Airport	FMN
Landing Time	1540	Airport	KOEB

Weather	Ground	Airport
Begin Temp	-1	
Begin Dewpoint	-14	KAZO
Begin Pressure	3058	
End Temp	1	
End Dewpoint	-13	KOEB
End Pressure	3053	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
1	1743	1752	5598	270	129		2	
2	1751	1809	5629	90	117		-6	
3	1812	1823	5600	270	128		2	
4	1828	1839	5636	90	121		-5	
5	1843	1854	5622	270	129		1	
6	1858	1910	5600	90	122		-6	
7	1914	1924	5590	270	130		0	
Cross	1926	1930	5250	40	118		0	

MISSION PAGE _____ OF _____



LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Projects Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPiA or SPiA?	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static-5 mins - KOEB
→ if flyovers, times:	Static - 5mins - KAZO

Pilot	Blake
Tech	Paulick
Aircraft	8SPE

Data Information	
LIDAR Unit	Optech Gemini sn246
HD #	4
POS File Name	170322C
from → to	000 →

Date Flown	3-22-17		
Takeoff Time	1645	Airport	KOEB
Landing Time	1945	Airport	KAZO

Weather	Ground	Airport
Begin Temp	2	
Begin Dewpoint	-13	KOEB
Begin Pressure	3052	
End Temp	3	
End Dewpoint	-14	KAZO
End Pressure	3051	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
8	2102	2113	5589	90	133		-4	
9	2119	2128	5579	270	132		0	
10	2133	2144	5589	90	123		-5	
11	2149	2159	5587	270	130		1	
12	2204	2215	5572	90	122		-4	
13	2219	2231	5595	270	128		0	
14	2235	2246	5601	90	127		-4	
15	2249	2300	5582	270	126		1	
16	2304	2315	5590	90	125		-3	
17	2318	2329	5599	270	128		-1	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Pilot	Blake
Tech	Paetsch
Aircraft	PSE

Date Flown	3-23-17		
Takeoff Time	0855	Airport	KAZO
Landing Time	1155	Airport	KOEB

Project's Scanning Requirements

FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

Data Information

LiDAR Unit	Optech Gemini sn246
HI: #	1
POS File Name	170323A
from → to	000 →

Weather	Ground	Airport
Begin Temp	-4	KAZO
Begin Dewpoint	-10	
Begin Pressure	3049	
End Temp	2	KOEB
End Dewpoint	-14	
End Pressure	3047	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static - 5 mins - KAZO
→ if flyovers, times:	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
18	1319	1329	5620	90	128		-1	
19	1334	1344	5592	270	127		-4	
20	1349	1359	5579	90	127		3	
21	1403	1414	5589	270	124		-6	
22	1419	1430	5584	90	127		3	
23	1434	1445	5560	270	123		-6	
24	1450	1500	5583	90	128		4	
25	1504	1515	5592	270	124		-5	
26	1520	1530	5605	90	126		4	
27	1534	1545	5602	270	123		-8	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Pilot	Blake
Tech	Paetsch
Aircraft	PSE

Date Flown	3-23-17		
Takeoff Time	1320	Airport	KOEB
Landing Time	1630	Airport	KRID

Project's Scanning Requirements

FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

Data Information

LiDAR Unit	Optech Gemini sn246
HI#	1
POS File Name	170323B
from → to	000 →

Weather	Ground	Airport
Begin Temp	4	KOEB
Begin Dewpoint	-12	
Begin Pressure	3042	
End Temp	6	KOEB
End Dewpoint	-12	
End Pressure	3034	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static 5 mins - KOEB
→ if flyovers, times:	Flyover

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
28	1743	1753	5583	90	133		6	
29	1758	1810	5572	270	116		-10	
30	1815	1825	5590	90	131		6	
31	1830	1842	5590	270	122		-10	
32	1849	1857	5592	90	129		6	
33	1901	1912	5526	270	125		-10	
CROSS	1915	1922	5460	176	120		1	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kt):	
Scan Rate (Hz):		Altitude AGL (ft)	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static-OEB 5mins
→ if flyovers, times:	Static-OEB 5mins

Pilot	Blake
Tech	Paulsen
Aircraft	85PE

Data Information	
LiDAR Unit	Optech Gemini sn248
HD #	1
POS file Name	170412P
from → to	000 →

Date Flown	4-12-17		
Takeoff Time	1250	Airport	KOEB
Landing Time		Airport	KOEB

Weather	Ground	Airport
Begin Temp	8	
Begin Dewpoint	4	KOEB
Begin Pressure	3037	
End Temp	14	
End Dewpoint	2	KOEB
End Pressure	3036	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
34	1711	1725	5572	270	110		6	
35	1729	1739	5586	90	128		-6	
36	1743	1757	5588	270	107		8	
37	1801	1812	5590	90	125		-9	
38	1816	1830	5562	270	109		7	
39	1833	1843	5585	90	134		-8	
40	1846	1859	5605	270	108		6	
41	1902	1913	5622	90	130		-8	
42	1916	1928	5559	270	110		7	
43	1932	1942	5609	90	129		-6	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch-Calhoun, MI
Project Number	2015-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts:	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static-OEB 5mins
→ if flyovers, times:	Static-OEB 5mins

Pilot	Blake
Tech	Paulsen
Aircraft	85PE

Data Information	
LiDAR Unit	Optech Gemini sn24(
HD #	1
POS File Name	170412B
from→ to	000 →

Date Flown	4-12-17		
Takeoff Time	1722	Airport	KOEB
Landing Time	1955	Airport	KOEB

Weather	Ground	Airport
Begin Temp	14	
Begin Dewpoint	0	KOEB
Begin Pressure	3035	
End Temp	13	
End Dewpoint	-1	KOEB
End Pressure	3038	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
44	2134	2145	5563	90	131		-4	
45	2149	2201	5542	270	112		3	
46	2205	2215	5582	90	132		-3	
47	2219	2231	5569	270	110		4	
48	2234	2244	5580	90	129		-5	Greenhouse
49	2248	2300	5561	270	108		2	
50	2303	2314	5576	90	126		-1	
51	2319	2329	5593	270	110		1	
52	2332	2343	5580	90	136		-4	

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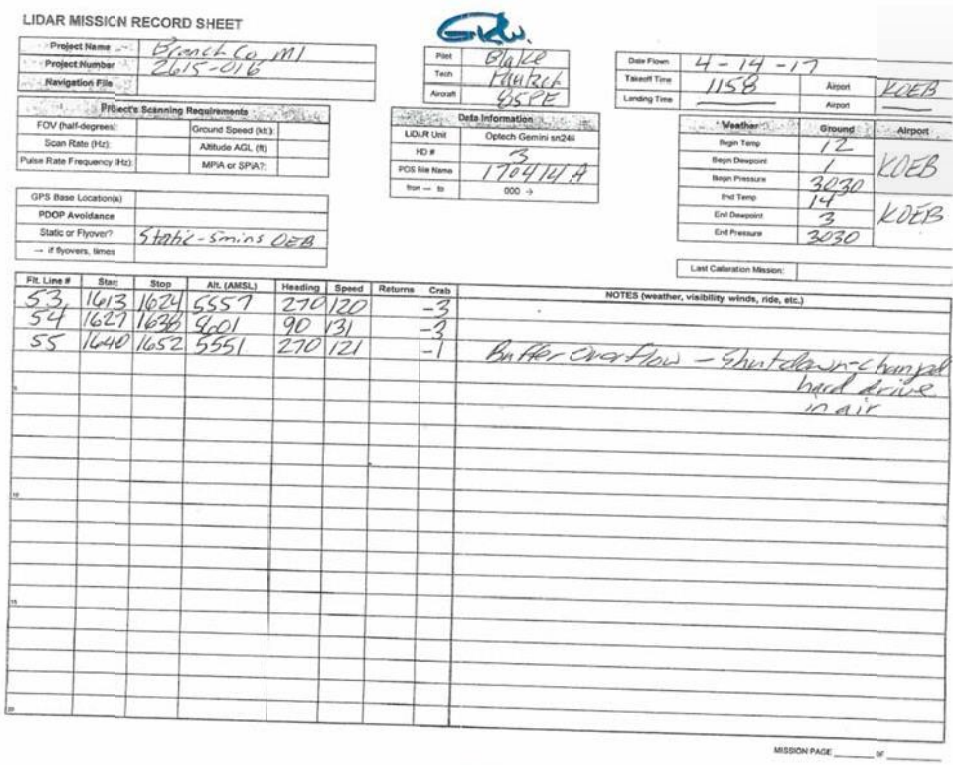


LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kt):	
Scan Rate (Hz):		Altitude AGL (ft)	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static - 5mins OEB
→ if flyovers, times	

Pilot	Blake
Tech	Hunzel
Aircraft	65PE

Data Information	
LiDAR Unit	Optech Gemini sn246
HD #	3
POS file Name	170414A
from → to	000 →

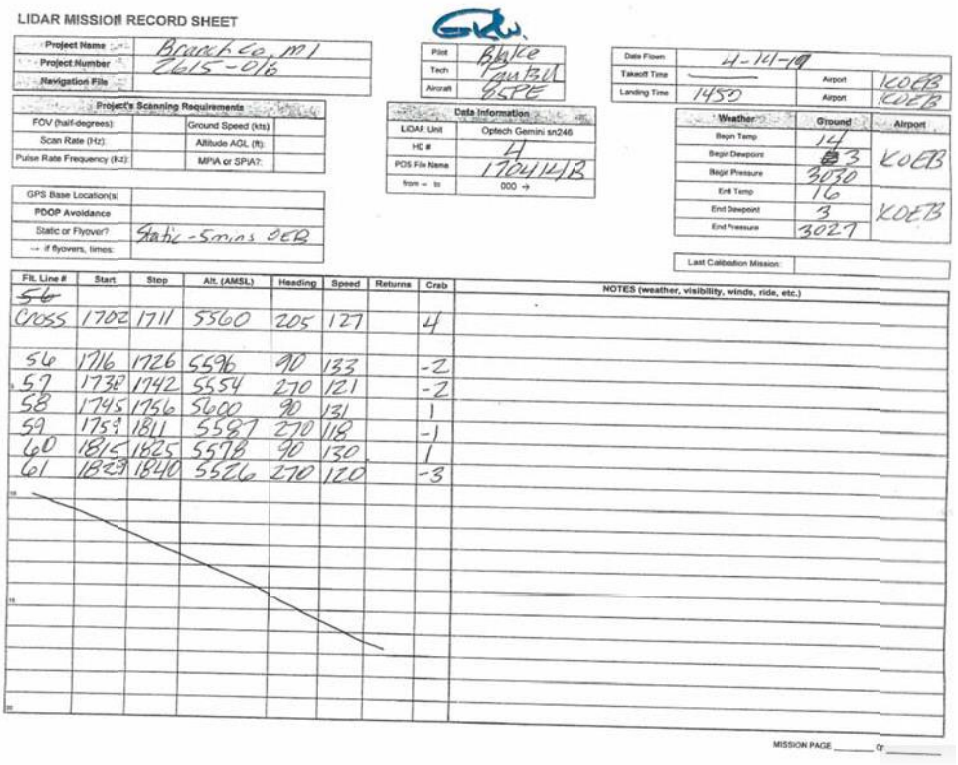
Date Flown	4-14-17		
Takeoff Time	1158	Airport	KOEB
Landing Time		Airport	

Weather	Ground	Airport
Begin Temp	12	
Begin Dewpoint	1	KOEB
Begin Pressure	3030	
End Temp	14	
End Dewpoint	3	KOEB
End Pressure	3030	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
53	1613	1624	5557	270	120		-3	
54	1627	1638	5601	90	131		-3	
55	1640	1652	5551	270	121		-1	Buffer overflow - shut down sn + changed hard drive in air

MISSION PAGE ____ of ____



LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts)	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (kz):		MPIA or SPIA?:	

GPS Base Location(s):	
PDOP Avoidance	
Static or Flyover?	Static - 5mins OEB
→ if flyovers, times:	

Pilot	Blake
Tech	Hunzel
Aircraft	65PE

Data Information	
LiDAR Unit	Optech Gemini sn246
HD #	4
POS File Name	170414B
from → to	000 →

Date Flown	4-14-17		
Takeoff Time		Airport	KOEB
Landing Time	1450	Airport	KOEB

Weather	Ground	Airport
Begin Temp	14	
Begin Dewpoint	3	KOEB
Begin Pressure	3030	
End Temp	16	
End Dewpoint	3	KOEB
End Pressure	3027	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
~~56~~								
Cross	1702	1711	5560	205	127		4	
56	1716	1726	5596	90	133		-2	
57	1738	1742	5554	270	121		-2	
58	1745	1756	5600	90	131		1	
59	1759	1811	5587	270	118		-1	
60	1815	1825	5576	90	130		1	
61	1829	1840	5526	270	120		-3	

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LIDAR MISSION RECORD SHEET

Project Name	Branch
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static-5mins OEB
→ if flyovers, times:	

Pilot	Blake
Tech	Paul Bell
Aircraft	85PE

Data Information	
LIDAR Unit	Optech Gemini sn246
Flt #	4
POS File Name	170414 c
from → to	000 →

Date Flown	4-14-17		
Takeoff Time	1608	Airport	KOEB
Landing Time	1903	Airport	KLEX

Weather	Ground	Airport
Begin Temp	18	KOEB
Begin Dewpoint	3	
Begin Pressure	3024	
End Temp	17	KOEB
End Dewpoint	3	
End Pressure	3022	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
62	2027	2034	5514	270	115		-5	
63	2037	2048	5567	90	128		2	
64	2051	2103	5536	270	118		-3	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch Co
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kt):	
Scan Rate (Hz):		Altitude AGL (ft)	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s:	
PDOP Avoidance	
Static or Flyover?	Flyover CORS
→ if flyovers, times:	Static-5mins - OEB

Pilot	Blake
Tech	Paul Bell
Aircraft	85PE

Data Information	
LIDAR Unit	Optech Gemini sn246
Flt #	1
POS File Name	170418A
from → to	000 →

Date Flown	4-18-17		
Takeoff Time	1205	Airport	KLEX
Landing Time	1530	Airport	KOEB

Weather	Ground	Airport
Begin Temp	20	KOEB
Begin Dewpoint	4	
Begin Pressure	3022	
End Temp	20	KOEB
End Dewpoint	4	
End Pressure	3020	

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
189	1951	1802	5623	360	151		-1	Partial cross flight
190	1807	1808	5635	180	118		-1	Partial cross flight
65	1813	1824	5547	270	126		-8	
66	1829	1840	5556	180	122		3	

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Pilot	Blake
Tech	Pawlak
Aircraft	8SPE

Date Flown	4-19-17		
Takeoff Time	0745	Airport	KOEB
Landing Time	0921	Airport	KOEB

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

Data Information	
LiDAR Unit	Optech Gemini sn248
HD #	1
POS file Name	170419A
from → to	000 →

Weather	Ground	Airport
Begin Temp	17	KOEB
Begin Dewpoint	13	
Begin Pressure	3002	
End Temp	19	KOEB
End Dewpoint	15	
End Pressure	3002	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static - 5mins - OEB
→ if flyovers, times:	Static - 5mins - OEB

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
67	1154	1203	5561	90	133		-1	
68	1208	1221	5554	270	108		-1	
69	1225	1235	5564	90	132		-1	
70	1239	1252	5549	270	110		-1	
71	1255	1304	5540	90	13		0	Clouds east end

MISSION PAGE _____ OF _____

LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Pilot	Blake
Tech	Pawlak
Aircraft	8SPE

Date Flown	4-23-17		
Takeoff Time	1140	Airport	KLEX
Landing Time	1420	Airport	KOEB

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

Data Information	
LiDAR Unit	Optech Gemini sn248
HD #	4
POS file Name	170423A
from → to	000 →

Weather	Ground	Airport
Begin Temp	17	KOEB
Begin Dewpoint	1	
Begin Pressure	3009	
End Temp	19	KOEB
End Dewpoint	1	
End Pressure	3006	

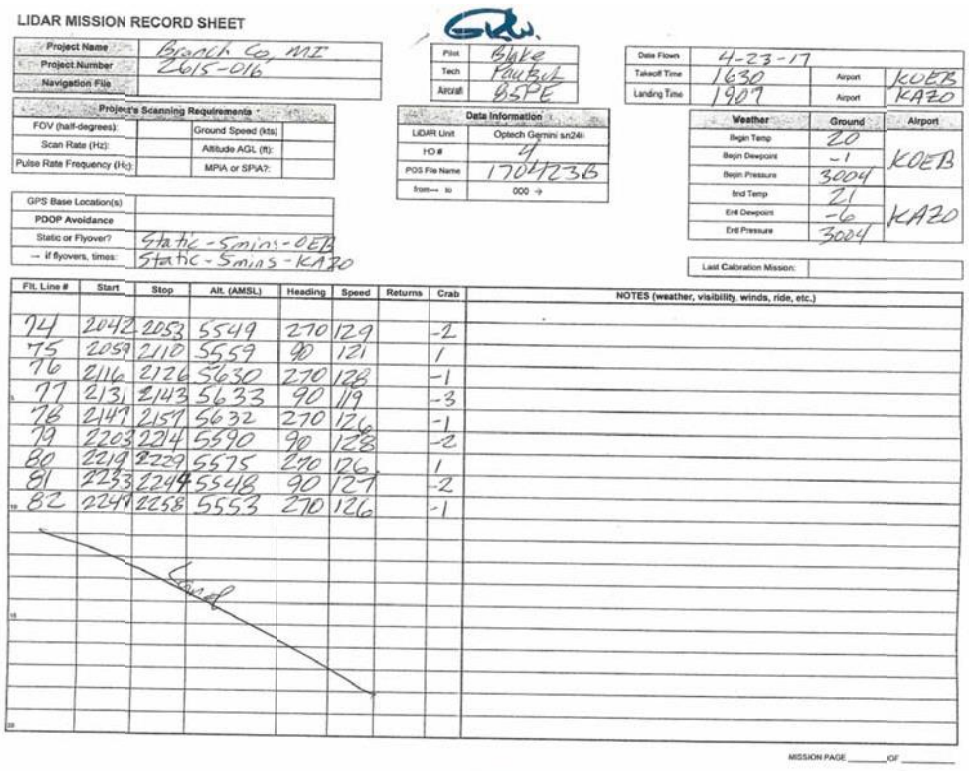
GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Flyover CORS - N. Indiana
→ if flyovers, times:	Static - 5mins - OEB

Last Calibration Mission:

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
~~190~~								
188	1723	1734	5520	360	125		-1	
71	1739	1750	5581	90	126		-4	retflight for clouds
72	1754	1805	5560	270	129		2	
73	1809	1820	5582	90	128		-5	

Land for fuel

MISSION PAGE _____ OF _____



LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static - 5mins - OEB
→ if flyovers, times:	Static - 5mins - KAZO

Pilot	Blake
Tech	Paul Bell
Aircraft	B5PE

Data Information	
LiDAR Unit	Optech Gemini sn246
IO #	4
POS File Name	170423B
from → to	000 →

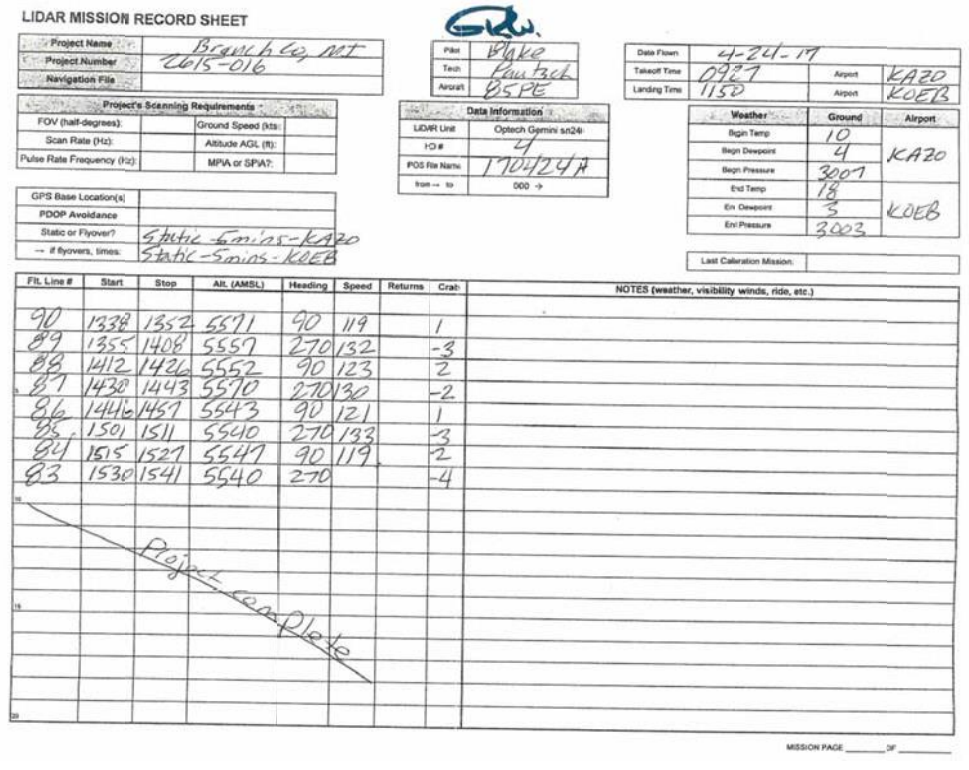
Date Flown	4-23-17		
Takeoff Time	1630	Airport	KOEB
Landing Time	1907	Airport	KAZO

Weather	Ground	Airport
Begin Temp	20	KOEB
Begin Dewpoint	-1	
Begin Pressure	3004	
End Temp	21	KAZO
End Dewpoint	-6	
End Pressure	3004	

Last Calibration Mission:	

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility, winds, ride, etc.)
74	2042	2053	5549	270	129		-2	
75	2059	2110	5559	90	121		1	
76	2116	2126	5630	270	128		-1	
77	2131	2143	5633	90	119		-3	
78	2149	2159	5632	270	126		-1	
79	2203	2214	5590	90	128		-2	
80	2219	2229	5575	270	126		1	
81	2233	2244	5548	90	127		-2	
82	2249	2258	5553	270	126		-1	
								End of

MISSION PAGE _____ OF _____



LIDAR MISSION RECORD SHEET

Project Name	Branch Co, MI
Project Number	2615-016
Navigation File	

Project's Scanning Requirements			
FOV (half-degrees):		Ground Speed (kts):	
Scan Rate (Hz):		Altitude AGL (ft):	
Pulse Rate Frequency (Hz):		MPIA or SPIA?:	

GPS Base Location(s)	
PDOP Avoidance	
Static or Flyover?	Static - 5mins - KAZO
→ if flyovers, times:	Static - 5mins - KOEB

Pilot	Blake
Tech	Paul Bell
Aircraft	B5PE

Data Information	
LiDAR Unit	Optech Gemini sn246
IO #	4
POS File Name	170424A
from → to	000 →

Date Flown	4-24-17		
Takeoff Time	0927	Airport	KAZO
Landing Time	1150	Airport	KOEB

Weather	Ground	Airport
Begin Temp	10	KAZO
Begin Dewpoint	4	
Begin Pressure	3007	
End Temp	18	KOEB
End Dewpoint	3	
End Pressure	3003	

Last Calibration Mission:	

Flt. Line #	Start	Stop	Alt. (AMSL)	Heading	Speed	Returns	Crab	NOTES (weather, visibility winds, ride, etc.)
90	1338	1352	5571	90	119		1	
89	1355	1408	5557	270	132		-3	
88	1412	1426	5552	90	123		2	
87	1430	1443	5570	270	130		-2	
86	1446	1457	5543	90	121		1	
85	1501	1511	5540	270	133		-3	
84	1515	1527	5547	90	119		-2	
83	1530	1541	5540	270			-4	
								Project Complete

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