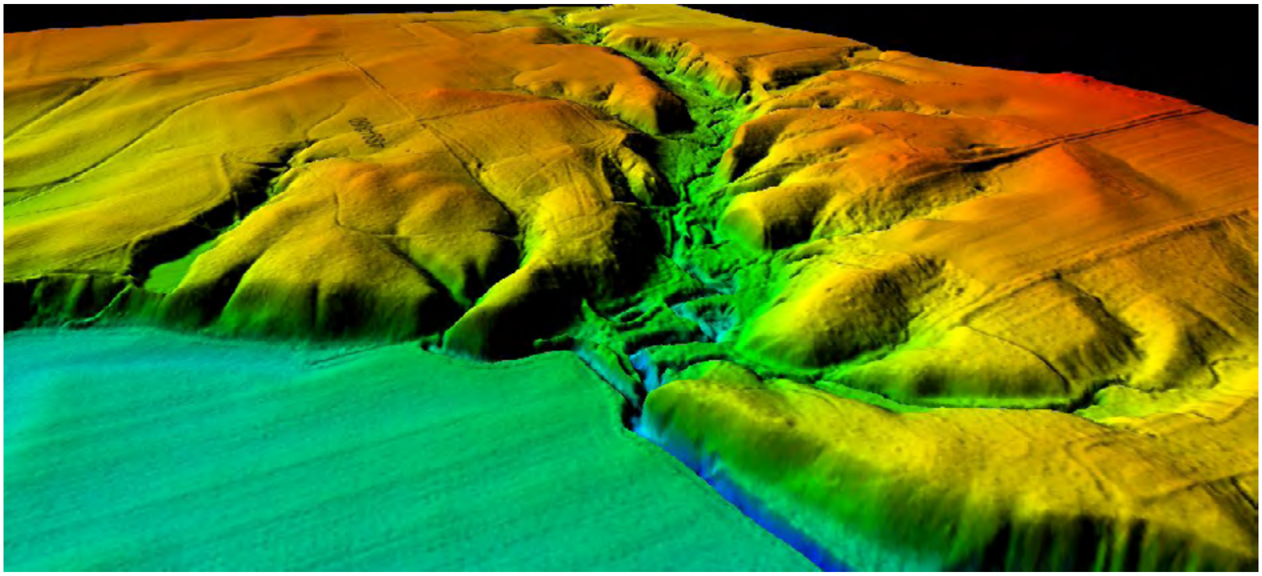
2014 Madison County, Illinois
2 PPSM
LiDAR Report



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2 PPSM LiDAR Survey

Madison County, Illinois

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1. Introduction

This report contains a summary of the Light Detection and Ranging (LiDAR) data acquisition and processing for the project area to include Madison County, Illinois.

1.1 Contact Info

Questions regarding the technical aspects of this report should be addressed to:

Quantum Spatial
4020 Technology Parkway
Sheboygan, WI 53083
Attention: Sonja Ellefson (Certified Photogrammetrist)
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1.2 Purpose

Quantum Spatial acquired high accuracy LiDAR data of Madison County in accordance with needs outlined by the Facilities and Services, Planning Division of the University of Illinois Urbana-Champaign. Data provided to Facilities and Services will aid in analysis, planning and management of Madison County.

1.3 Project Locations

The Project area is located in southwest Illinois and borders the Mississippi River. The acquisition area includes all of Madison County. Image 1.3 shows a graphic of the area of acquisition.

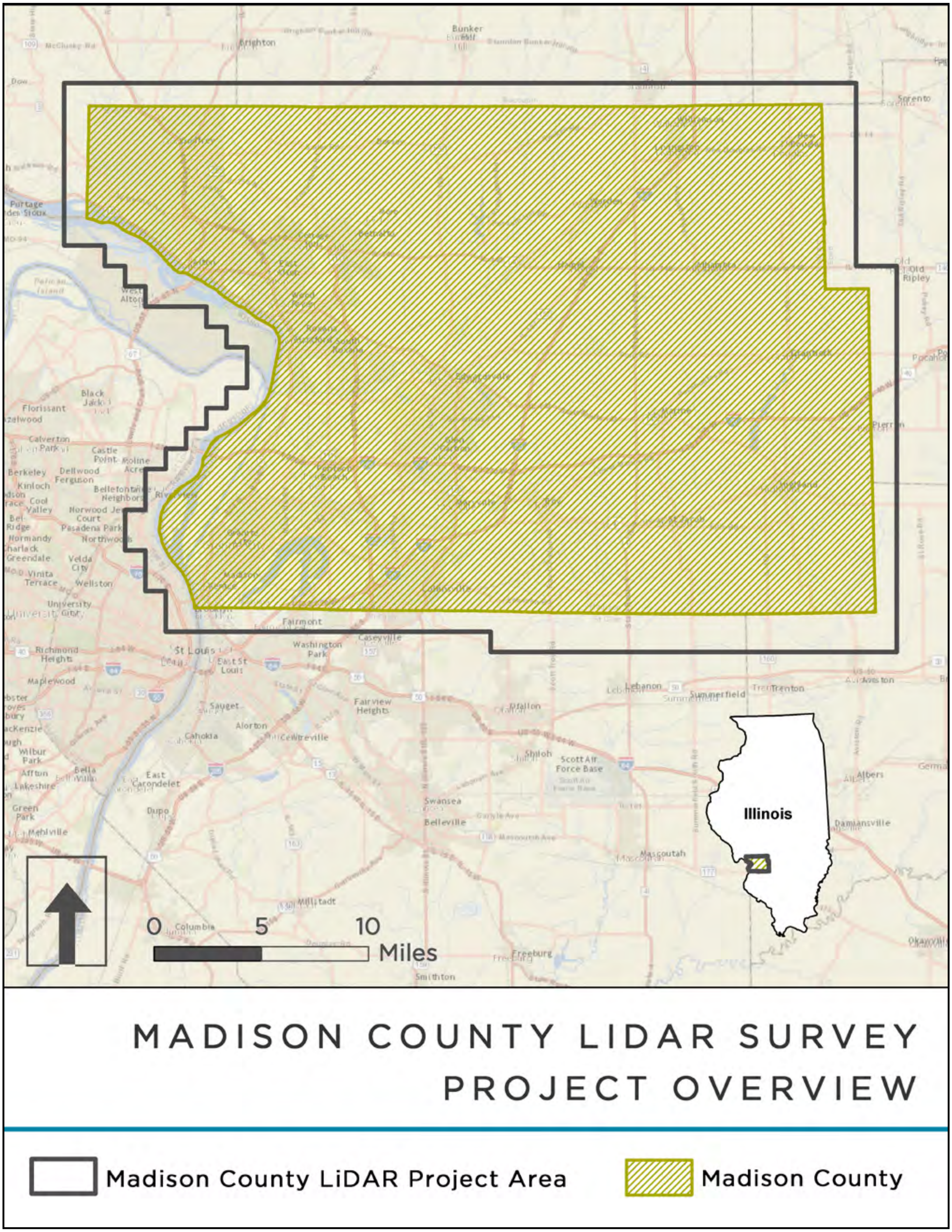
1.4 Time Period

LiDar data acquisition for complete coverage of the project was acquired between March 23rd and March 31st of 2014. Data collection was completed in six (6) flight missions totally sixty-eight (68) flight lines including cross flights.

1.5 Project Scope

Data acquired with aircraft and sensor operated by Quantum Spatial, Inc. is high accuracy LiDAR topographic data and is complete for the surface of Madison County. The project area is approximately 710 square miles.

Image 1.3: The image below shows the Madison County study area.



2. Geodetic Control

Ground surveys were conducted to provide control points for LiDAR dataset indexing. Additional ground control points were collected in represented ground cover categories to provide for vertical accuracy assessment of the dataset pursuant to Federal Emergency Management Agency (FEMA) guidelines. See Section 9 for the geodetic control summary.

3. LiDAR Acquisition and Procedures

Image 3.1: Underbelly of QSI aircraft

3.1 Acquisition Time Period

LiDAR data acquisition and Airborne GPS control were completed between March 23 and March 31, 2014. The project area was completely acquired in sixty-eight flight lines.

3.2 LiDAR Planning

The LiDAR data for this project was collected with an aircraft operated by Quantum Spatial. The aircraft was equipped with LiDAR sensor systems as well as systems to collect GPS and IMU positioning data during flight. All flight planning was completed using Leica MissionPro software and data collection was completed using a Leica ALS70 sensor.

3.3 LiDAR Acquisition

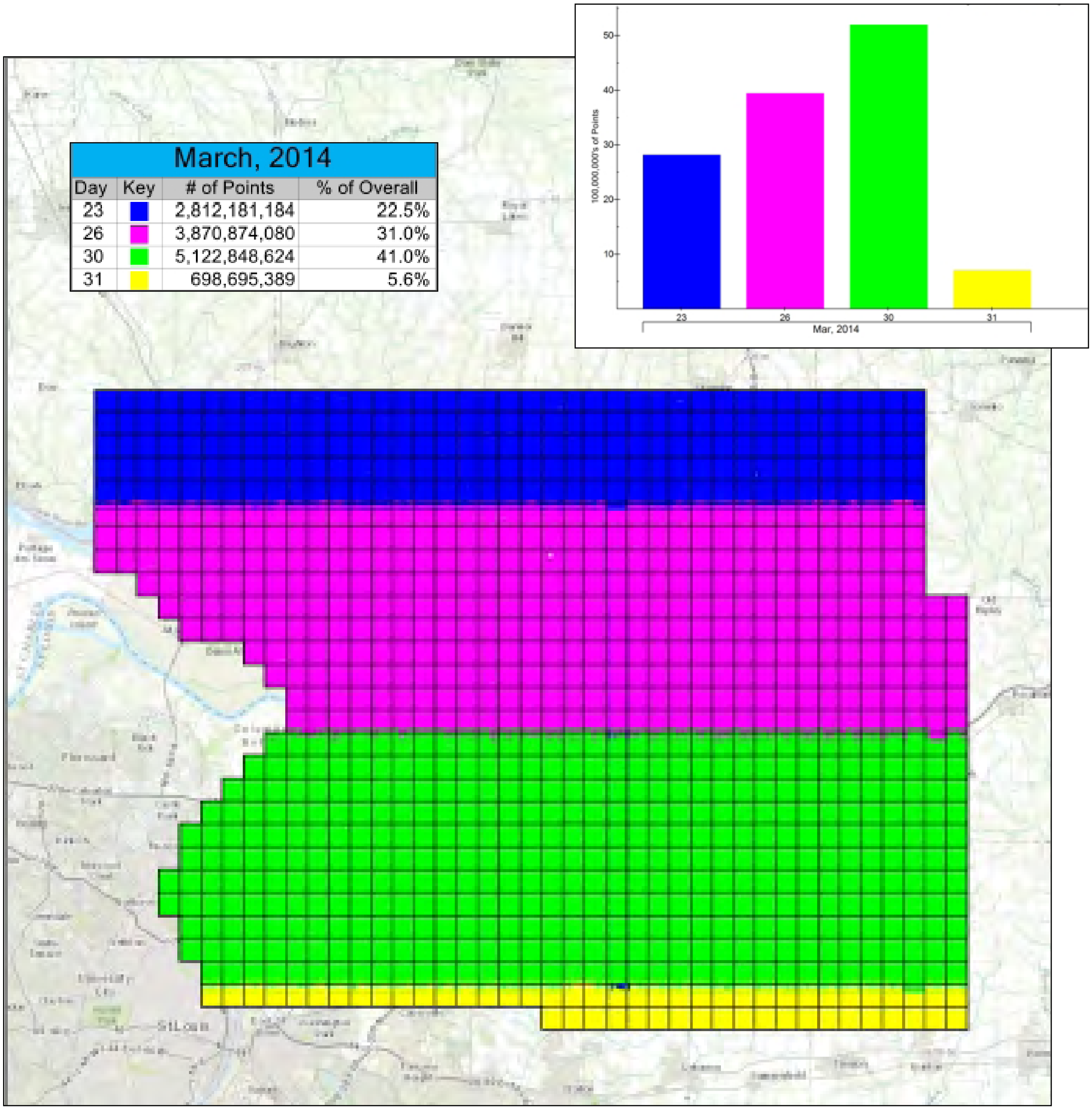
Data acquired from sixty-eight (68) flight missions were utilized to provide project area coverage. Refer to Table 3.0 for acquisition parameters. Acquired swaths can be seen in Image 3.0 on the following page. Section 7 contains the flight logs.

A Leica sensor was used on board a Piper Navajo aircraft. Airborne GPS and IMU position and trajectory data of the LiDAR sensor were also acquired during the time of flight.

Before take-off, the LiDAR system and the Airborne GPS and IMU system were initialized for a period of five minutes and continued in operation after landing for another five minutes. The missions acquired data according to the planned flight lines and included a minimum of one cross flight. The cross flights were flown perpendicular to the planned flight lines and their was data used in the in-situ calibration of the sensor.

Table 3.0: Acquisition Parameters 2 points per square meter (ppsm)	
Sensor Type	Leica ALS - 70
Sensor ID	SN7220
Field of View	+/- 20 degrees
Flying Height (Above Mean Sea Level)	7064 m
Pulse Rate Frequency	261,000 Hz
Scan Angle (degrees)	40 degrees
Ground Speed	150 kts
Targeted Pulse Density	2.0 ppsm
Minimum Overlap	55%

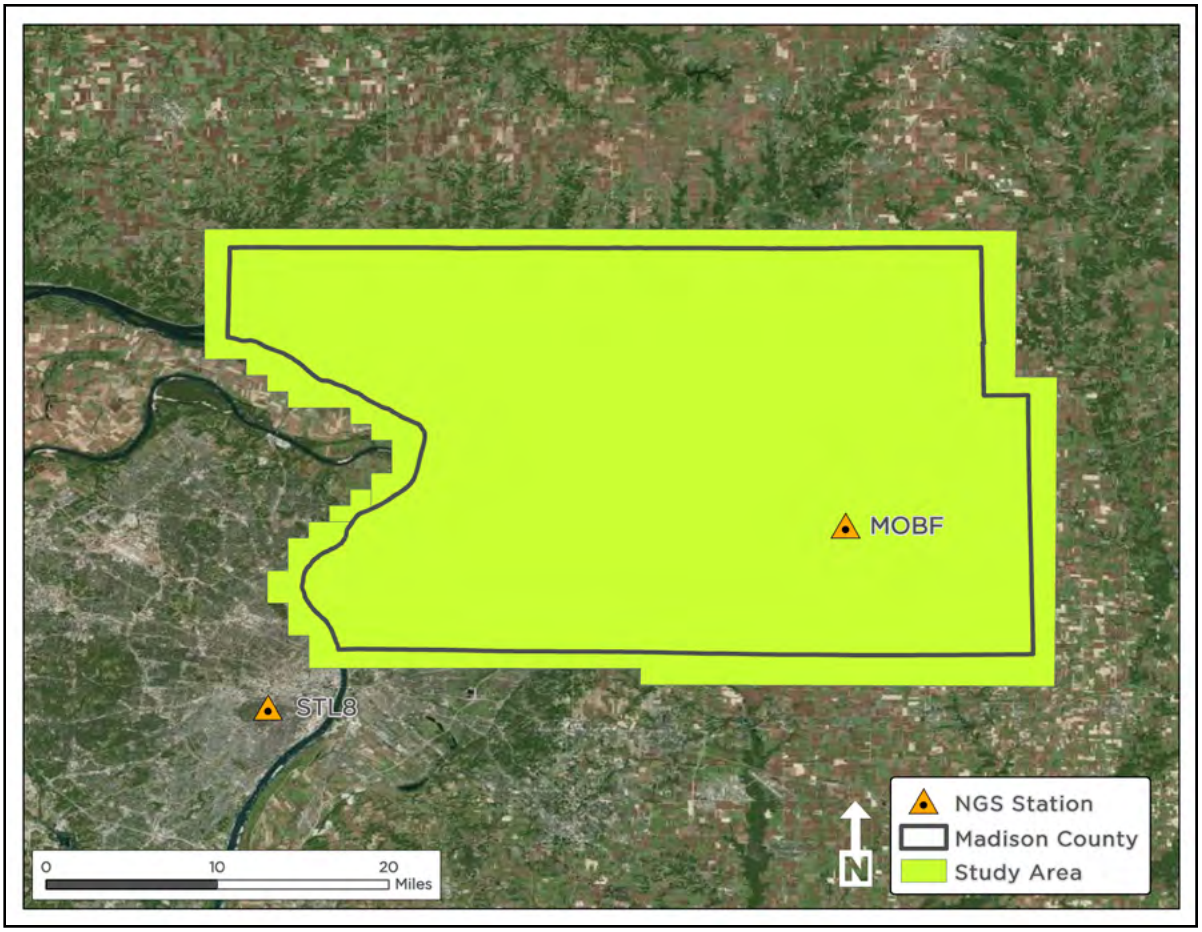
Image 3.3a: Swaths for two points per square meter (ppsm) data, colored by mission date.



3.4 LiDAR Trajectory Processing

Missions were processed using a Continuously Operating Reference Station (CORS). Horizontal and vertical control for the check point survey consisted of two National Geodetic Survey (NGS) stations- MOBF and STL8. The image below demonstrates the sites relative to the project area.

Image 3.4: Relative location of CORS stations to the study area.



4. Quality Control Surveys

Ground survey points were collected by Quantum Spatial, Inc. The point measurements were used in calibration and evaluation of LiDAR data position.

See Section 9 for further details of the ground survey control data.

5. LiDAR Calibration and Processing

5.1 LiDAR Calibration

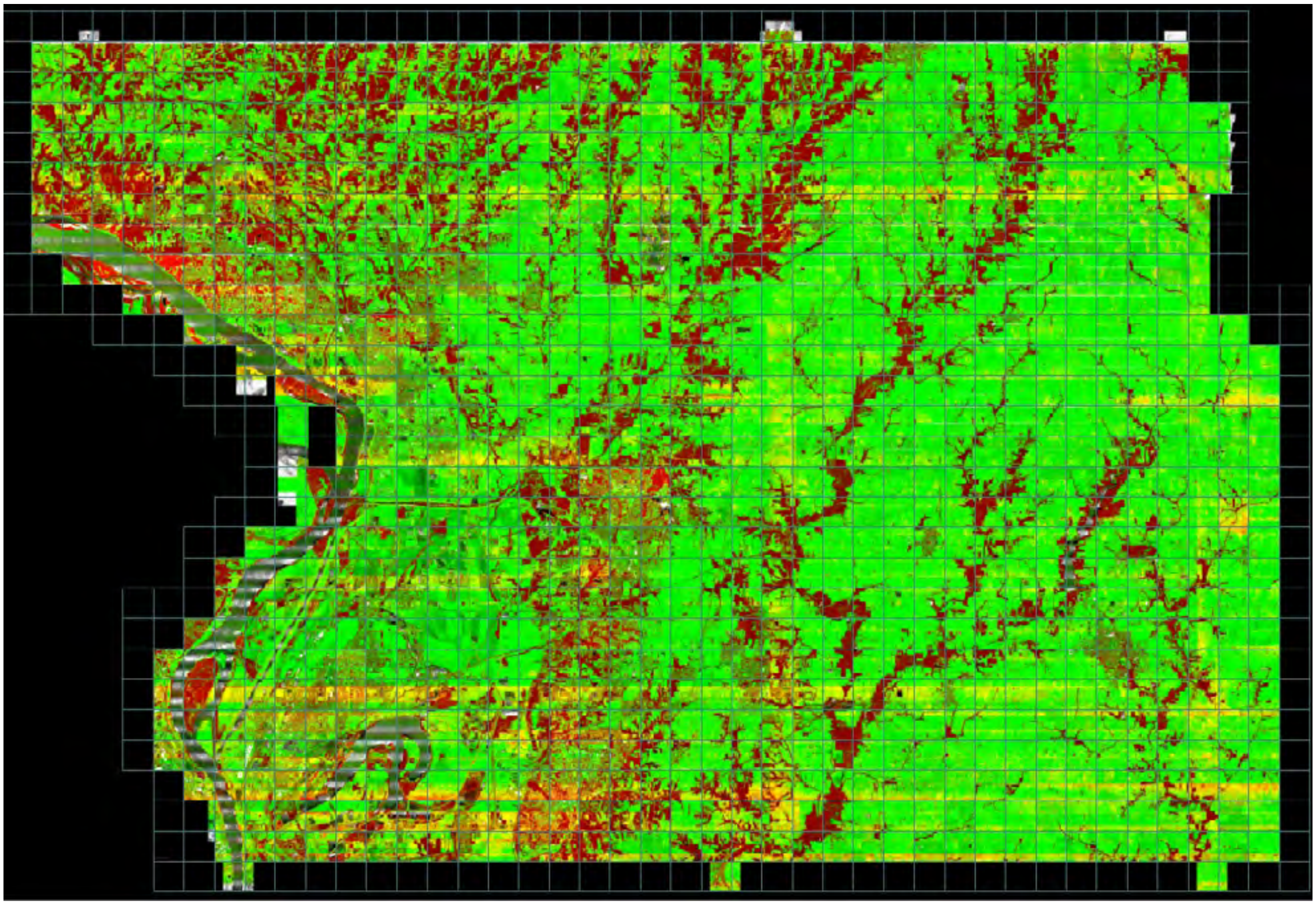
Table 5.1 LiDAR Calibration Steps	Software Used
Resolve GPS kinematic corrections for aircraft position and aligns all source data by time and filters. Smoothes the data, and provides a trajectory file indicating the latitude, longitude, ellipsoidal height, roll, pitch and heading of the scanner at intervals of 1/200 second in .sol format.	**Leica IPAS TC v. 3.2**
Calculate laser point position by associating .sol file information to each laser point return time, with offsets relative to scan angle, intensity, etc. included. As part of this process, correction for atmospheric refraction (bending) of the light path and correction for variations in the speed of light over the path are made. The post processor also provides inputs for various alignment coefficients (e.g., roll, pitch, heading, range offsets, etc.).This process creates the raw laser point cloud data for the entire survey in *.las (ASPRS v1.2) format, in which each point maintains the corresponding scan angle, return number (echo), intensity, and x, y, z information.	**Leica ALS Post Processor v. 2.75 Build #25**
Import .las strips from ALS Post Processer into GeoCue for calibration. Populate relative bin layout of mission extent. Filter bins for noise and run ground by flight line macro for calibration.	**GeoCue v. 2013.1.45.1**
Test relative accuracy using ground classified points per each flight line. Perform automated line-to-line calibrations for system attitude parameters (pitch, roll, heading), mirror flex (scale). Calibrations are performed on ground-classified points from paired flight lines. Every flight line is used for relative accuracy calibration.	**TerraMatch v. 14, TerraScann v.14, GeoCue v. 2013.1.45.1**
QC each mission line-to-line calibration by running DZ-orthos for each mission and after each mission is merged together for final project coverage	**GeoCue v. 2013.1.45.1**
Assess Fundamental vertical accuracy via direct comparisons of LiDAR data points to ground survey data.	**TerraScan v.13**
Assess vertical accuracy via direct comparisons of Digital Elevation Models to ground survey data.	**TopoAnalyst**

5.2 LiDAR Processing

The LAS files are imported, verified, and parsed into manageable, tiled grids using GeoCue version 2012.1.27.7. GeoCue allows for ease of data management and process tracking. Relative accuracy of flightline to flightline alignment is assessed. Image 5.2a illustrates relative vertical alignment of flightlines.

- Green indicates a flightline difference of less than 0.20 feet;
- Yellow.... 0.20 - 0.40 feet;
- Orange... 0.40 - 0.60 feet;
- Red........ 0.60 feet or greater.

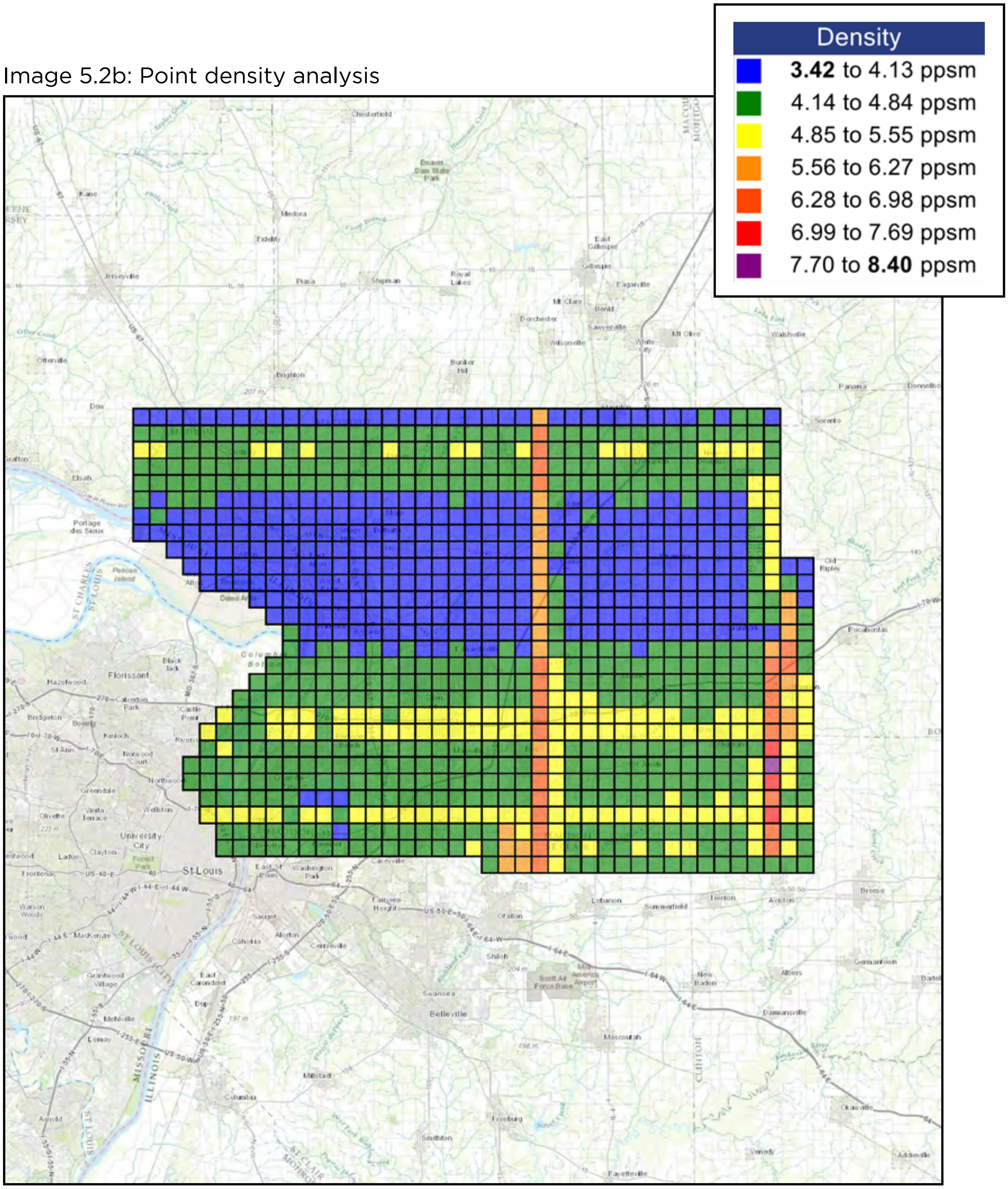
Image 5.2a: Relative Accuracy Assessment



Areas containing dense vegetation coverage or inundation from water will show a greater elevation offset than is actually present in the ground data. This is due to these regions having a high number of returns from vegetation or non-ground objects and few returns from the ground causing the elevation offset to be exaggerated.

Each tile within the study area is evaluated to ensure that the desired point density has been met. Image 5.2b illustrates the results of the point density analysis. Quantum Spatial utilizes proprietary software to complete this task. A grid, sized according to the USGS version 13 specifications, based on the nominal post spacing, is used for point analysis. The USGS version 13 specification allows that a grid size up to 2 times the nominal post spacing be used. Point density is analyzed on the basis of this grid space size or cell and the result indicates the point density of the sampled tiles.

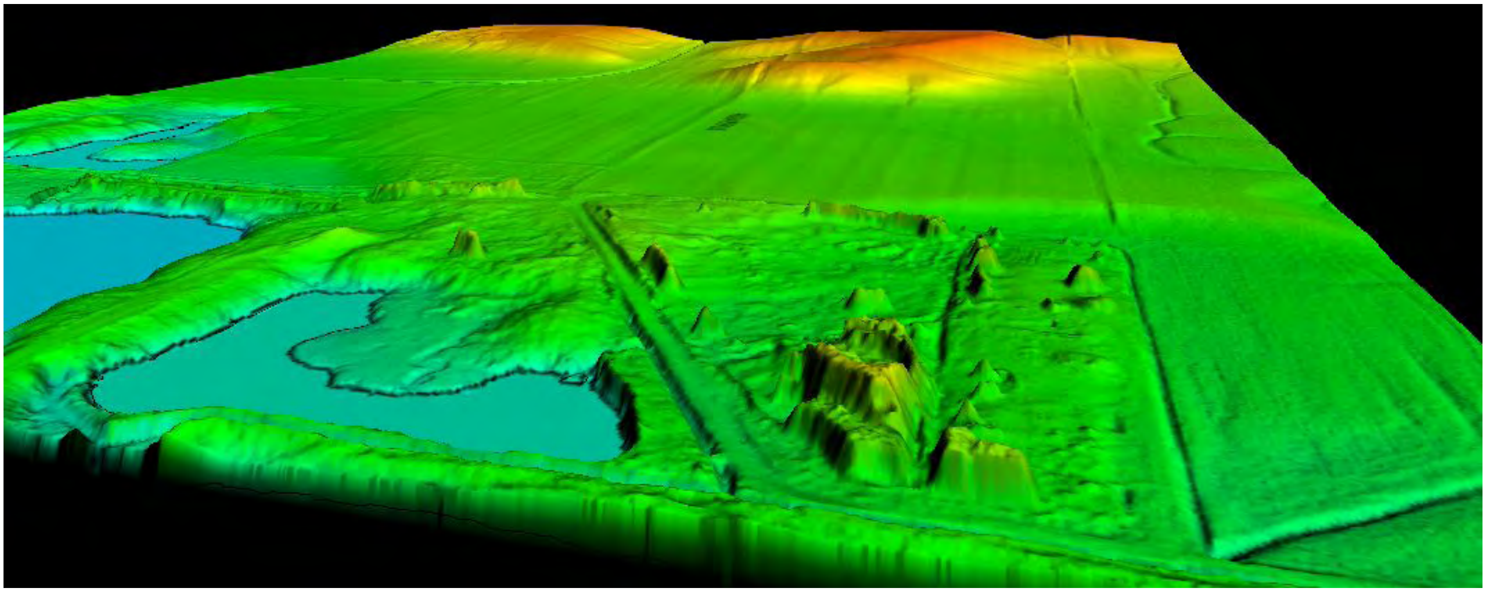
Image 5.2b: Point density analysis



Once both the accuracy between swaths and data density is accepted an automated classification algorithm is performed using TerraSolid's TerraScan, version 013.011. This produces the majority of the bare-earth datasets. Further, the data is processed to classify specific vegetation classes and man-made structures.

The remainder of the data is classified using manual classification techniques. The majority of the manual editing involves changing points initially classified as ground (class 2), to unclassified or non-ground (class 1). Erroneous low points and high points, including clouds, are classified to Noise (class 7).

Image 5.2c: Bare earth ground model representation of LiDAR points.



5.3 Check Point Validation

To ensure position of the assembled data it is verified against surveyed ground control data. TerraScan computes the vertical differences between surveyed ground control points and LiDAR collected points.

Check points are surveyed within the project area to provide calibration checks of the LiDAR point cloud. A report indicating comparative positional statistics is produced when LiDAR has been adjusted to control and can be found in Section 9 of this report.

Twenty (20) ground check points were made across the project area to be used in adjusting the data to position. These twenty points were collected by Quantum Spatial, as part of the one hundred twenty (120) ground check points collected for the project; please see Section 11 for a table of all check points, as well as the accuracy assessment results.

5.4 Vertical Accuracy Assessment

Vertical accuracy assessment is conducted by comparing ground survey check point z values to processed LiDAR data z values by horizontal proximity. Differences in z values are calculated to express an RMSEz value.

As documented in the Task Order, to meet USGS QL2 requirements, collected data was to achieve an RMSE of 9.25cm (0.30 ft) in the open terrain land cover category based on a Triangulated Integrated Network (TIN) of the LiDAR points and from values of the Digital Elevation Models (DEM) derived from LiDAR data. Quantum Spatial achieved a fundamental vertical accuracy (FVA) of 15.85 cm at a 95% confidence level with an RMSE of 7.93 cm utilizing twenty (20) open terrain ground survey check points .

Table 5.4a: FVA Data Compared to TIN

	Ground Cover Category	Number of Checkpoints	Result cm (ft.)
FVA	Open Terrain	20	15.85 cm (0.52 ft.)
RMSEz	Open Terrain	20	7.93 cm (0.26 ft.)

Per compliance with the U.S. Geological Survey National Geospatial Program LiDAR Base Specification, Version 1.0, consolidated vertical accuracy (CVA) was to achieve 36.3 cm (1.2 ft) at 95th Percentile based on the DEM; and supplemental vertical accuracy (SVA) had a target for each of the ground cover category of 36.3 cm (1.2 ft) at 95th Percentile. Ground cover categories are Bare Earth/Open Terrain, Urban, Tall Weeds, Brush, and Forest. The achieved consolidated vertical accuracy was 8.56 cm. Please see Table 5.4b for supplemental vertical accuracy results.

Table 5.4b: Accuracy Results

	Ground Cover Category	Number of Checkpoints	Result cm (ft.)
FVA	Open Terrain	20	8.05 cm (0.264 ft.)
CVA	All Categories	100	8.56 cm (0.281 ft.)
SVA	Urban	20	5.15 cm (0.169 ft.)
SVA	Tall Grass	20	8.05 cm (0.264 ft.)
SVA	Brush	20	12.22 cm (0.401 ft.)
SVA	Forest	20	7.80 cm (0.256 ft.)

5.5 LiDAR Data Delivery

Point cloud data supplied is in the following format:

- LAS, version 1.2
- GPS times adjusted to Adjusted Standard GPS time

Classified point cloud data is also being supplied using the following criteria.

- LAS, version 1.2 in 5000 foot grid
- Classification scheme:
  - 1 - Unclassified
  - 2 - Ground
  - 3 - Low Vegetation
  - 4 - Medium Vegetation
  - 5 - High Vegetation
  - 6 - Building
  - 7 - Low Point (noise)
  - 8 - Model Key-point
  - 9 - Water
  - 10 - Ignored Ground

LiDAR-derived products:

- 2.5 ft resolution hydro-flattened DEM in *.img format
- TIN surface provided in *.TIN format, by tile
- DAT, output with TIN from Geopack, in *.dat format

Shapefiles:

- Hydro breaklines (Microstation *.dgn and ESRI geodatabase format)
- *Las delivery tile index (Microstation *dgn and ESRI geodatabase format)

USGS-compliant metadata for delivered products

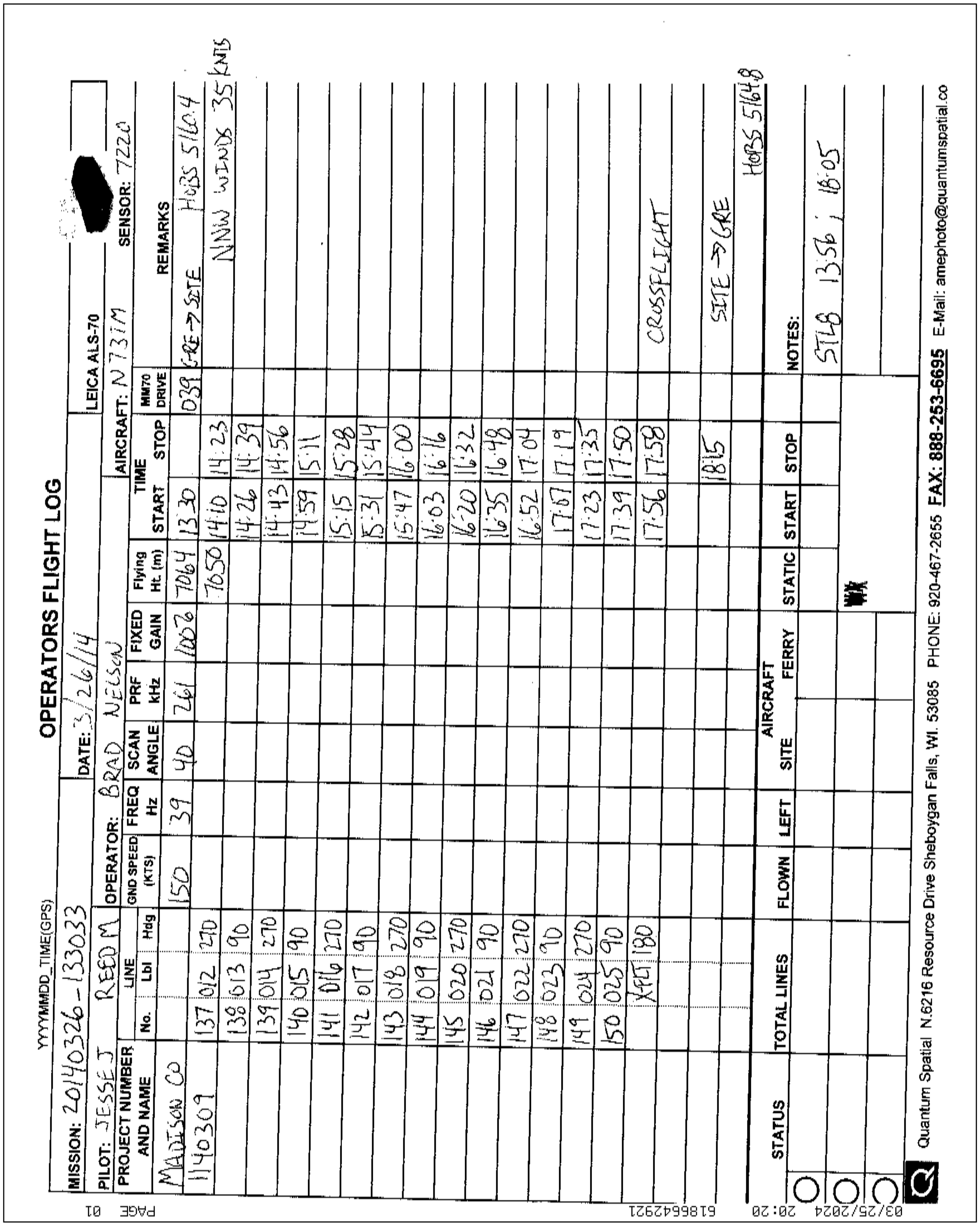
6. Conclusion

Sound procedures and use of new technologies ensure this project data and derivative products will serve as reliable information and models for the University of Illinois Urbana - Champaign. The models produced are accurate and representative of surface conditions at the time of data acquisition.

7. Flight Logs and NGS Datasheets

7.1 Flight Logs

Image 7.1 a: Mission 20140326_133033



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140326_133033 DATE: 3/26/14 LEICA ALS-70 [redacted]

PILOT: JESSE J REED M OPERATOR: BRAD NELSON AIRCRAFT: N731M SENSOR: 7220

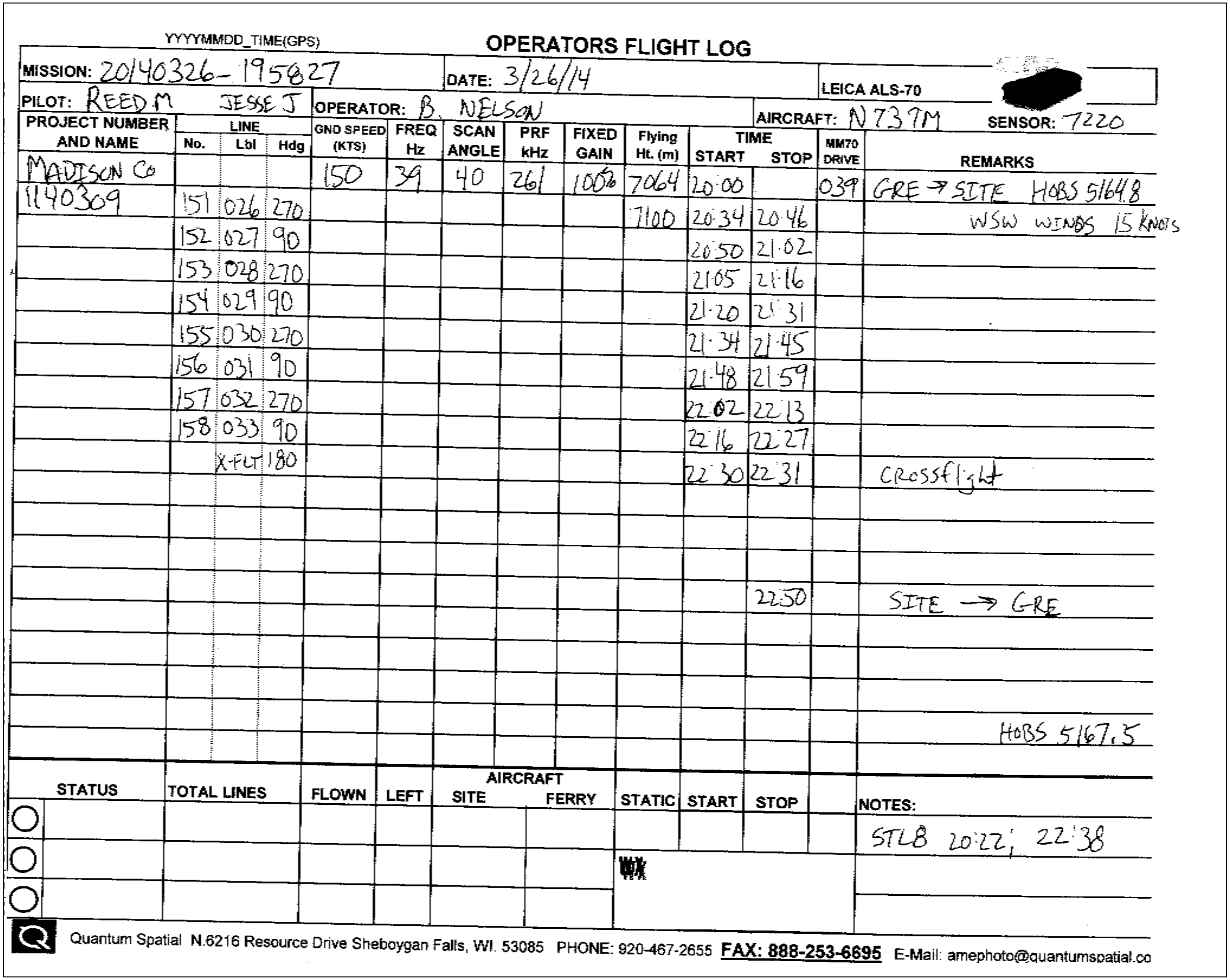
PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
MADISON CO				150	39	40	261	1006	7064	13:30		039	GRE → SITE HOBS 5160.4
1140309	137	012	270						7050	14:10	14:23		NNW WINDS 35 KNTS
	138	013	90							14:26	14:39		
	139	014	270							14:43	14:56		
	140	015	90							14:59	15:11		
	141	016	270							15:15	15:28		
	142	017	90							15:31	15:44		
	143	018	270							15:47	16:00		
	144	019	90							16:03	16:16		
	145	020	270							16:20	16:32		
	146	021	90							16:35	16:48		
	147	022	270							16:52	17:04		
	148	023	90							17:07	17:19		
	149	024	270							17:23	17:35		
	150	025	90							17:39	17:50		
		XFLT	180							17:56	17:58		CROSSFLIGHT
											18:15		SITE → GRE
													HOBS 5164.8

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
									STL8 13:56 ; 18:05

Quantum Spatial N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 **FAX: 888-253-6695** E-Mail: amephoto@quantumspatial.co

PAGE 01 6186642921 20:20 03/25/2024

Image 7.1b: Mission 20140326_195827



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140326-195827 DATE: 3/26/14 LEICA ALS-70 [redacted]

PILOT: REED M JESSE J OPERATOR: B. NELSON AIRCRAFT: N737M SENSOR: 7220

PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
MADISON Co				150	39	40	261	100%	7064	20:00		039	GRE → SITE HOBS 5164.8
1140309	151	026	270						7100	20:34	20:46		WSW WINDS 15 KNOTS
	152	027	90							20:50	21:02		
	153	028	270							21:05	21:16		
	154	029	90							21:20	21:31		
	155	030	270							21:34	21:45		
	156	031	90							21:48	21:59		
	157	032	270							22:02	22:13		
	158	033	90							22:16	22:27		
		X-FLT	180							22:30	22:31		Crossflight
											22:50		SITE → GRE
													HOBS 5167.5

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP
○								
○						WX		
○								

NOTES: STL8 20:22; 22:38

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Image 7.1c: Mission 20140326_195827 pg. 2

GPS OBSERVATION LOG for GREEPORT **Station ID** PID: JB2034

Please fill in **ALL information**

MISSION NAME 20140326-195827 JULIAN DATE 085
DATE 03/26/14 OBSERVER BDN
PROJECT NUMBER(S) 140309
PROJECT NAME(S) MADISON CO, IL

OBSERVATION: START TIME 19:40 (Z)
STOP TIME 23:00 (Z)

HEIGHT: LABELS)

SLANT (TRIPOD)
START ____ METERS
END ____ METERS
MEAN ____ METERS

VERTICAL (BIPOD- SEE STICKER
FIXED HEIGHT 1.042M
FIXED HEIGHT 1.040M
2,0M

RECIEVER TYPE:	RECIEVER S/N: (CIRCLE ONE)			
5700	0034	0256	1911	2175
	4565	8368		
4000	6670	9934	9835	9849
– NOVATEL	12130007–			

ANTENNA TYPE:	ANTENNA S/N: (CIRCLE ONE)			
ZEPHYR (TRM39105)	0258	0037	7743	9686
ZEPHYR GEODETIC (TRM41249)	8395	9163		
COMPACT L1-L2- NO GP (TRM22020- GP)	0865	4056	4404	4725
NOVATEL	17577			

MONUMENT INFORMATION:

(CIRCLE ONE) EXISTING NEW

(CIRCLE ONE) BRASS CAP ALUMINUM SPIKE PK NAIL

OTHER STEEL ROD IN SLEEVE

HEIGHT ABOVE GROUND: –0– CM PHOTO TAKEN: YES NO

TOP OF ROD

IF NEW, DRAW SKETCH OF MONUMENT AND LOCATION ON THE BACK OF THIS SHEET.

OPUS COORDINATES (FOR PROCESSOR)

LATITUDE ____ ELLIPSOID HEIGHT

NAD 83 1997 N 38°50'05.04262" W 089° 22' 33.95042" ELLIP 131.225

03/25/2024 20:20 6186642921 PAGE 03

Image 7.1d: Mission 20140330_151028

OPERATORS FLIGHT LOG

YYYYMMDD_TIME(GPS)

MISSION: 20140330_151028 DATE: 3/30/2014 LEICA ALS-70 [redacted]

PILOT: CAM S OPERATOR: BRAD N AIRCRAFT: N73TM SENSOR: 7220

PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
MADISON Co				150	39	40	261	100%	7064	12:50	13:10	039	GRE → CPS HOBS 5167.5
140309										15:20			CPS → SITE
	159	34	270	150	39	40	261	100%	7050	15:48	15:59		N WINDS 20 KNOTS
	160	35	90							16:03	16:15		
	161	36	270							16:19	16:31		
	162	37	90							16:34	16:46		
	163	38	270							16:50	17:02		
	164	39	90							17:06	17:19		
	165	40	270							17:22	17:34		
	166	41	90							17:38	17:51		
	167	42	270							17:54	18:07		
	168	43	90							18:10	18:23		
	169	44	270							18:27	18:39		
	170	45	90							18:43	18:56		
	171	46	270							18:59	19:12		
	172	47	90							19:15	19:28		
		X-FLT	0							19:31	19:34		CROSSFLIGHT
											19:55		SITE → CPS

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
○				4.2	0.6				STL8 15:31, 19:45
○						WX			
○									HOBS 5172.3

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Image 7.1e: Mission 20140330_202954

OPERATORS FLIGHT LOG

YYYYMMDD_TIME(GPS)

MISSION: 20140330-202954 DATE: 3/30/14 LEICA ALS-70 [redacted]

PILOT: CAM S. OPERATOR: BRAD N. AIRCRAFT: N73TM SENSOR: 7220

PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
MADISON CO				150	39	40	261	100%	7064	20:45		035	CPS → SITE HOBS 5172.3
1140309	173	48	270							21:02	21:15		
	174	49	90							21:19	21:31		
	175	50	270							21:35	21:48		
	176	51	90							21:51	22:04		
	177	52	270							22:07	22:20		
	178	53	90							22:24	22:36		
	179	54	270							22:39	22:52		
	180	55	90							22:55	23:08		
	181	56	270							23:11	23:24		
	182	57	90							23:27	23:39		
		X-FLT	0							23:42	23:45		CROSSFLIGHT
											24:05		SITE → CPS
													HOBS 5175.6

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	5' START	5' STOP	NOTES:
○				3.0	0.3		20:33	24:12	STL8 20:51 ; 23:54
○						WX			
○									

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Image 7.1f: Mission 20140331_003140

OPERATORS FLIGHT LOG

YYYYMMDD_TIME(GPS)

MISSION: 20140331_003140 | DATE: 3/31/14 | LEICA ALS-70 [redacted]

PILOT: CAM S. | OPERATOR: BRAD N. | AIRCRAFT: N73TM | SENSOR: 7220

PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
MADISON CO				150	39	40	261	100%	7064	0:45		035	CPS→SITE HOBS 5175.6
1140309	. X-FLT		0							1:00	—		CROSSFLIGHT ABORTED
	183	58	270							1:06	1:18		
	184	59	90							1:22	1:34		
	185	60	270							1:37	1:50		
	186	61	90							1:53	2:05		
	187	62	270							2:09	2:16		
	X-	FLT	0							2:19	2:20		CROSSFLIGHT
											2:40		SITE → GRE
													HOBS 5177.5

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	5' START	5' STOP	NOTES: FINAL
O			0	1.6	0.3		0:36	2:50	STL8 0:52 ; 2:29
O									
O									

Quantum Spatial N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 **FAX: 888-253-6695** E-Mail: amephoto@quantumspatial.co

Image 7.1g: Mission 20140331_003140 pg. 2

GPS OBSERVATION LOG for GREENPORT Station ID PID : JB2034

Please fill in ALL information

MISSION NAME 20140330_151028, 202954, 003140 JULIAN DATE 089
DATE 3 /30/14 OBSERVER BDN
PROJECT NUMBER(S) MADISON COUNTY, IL
PROJECT NAME(S) 140309

OBSERVATION: START TIME 12:15
STOP TIME 27:00

HEIGHT: LABELS) **SLANT (TRIPOD)** **VERTICAL (BIPOD- SEE STICKER** Fixed 2.0M

START ______ METERS FIXED HEIGHT 1.042M
END ______ METERS FIXED HEIGHT 1.040M
MEAN ______ METERS

RECIEVER TYPE:	RECIEVER S/N: (CIRCLE ONE)			
5700	0034	0256	1911	2175
	4565	8368		
4000	6670	9934	9835	9849
NOVATEL	12130007			

ANTENNA TYPE:	ANTENNA S/N: (CIRCLE ONE)			
ZEPHYR (TRM39105)	0258	0037	7743	9686
ZEPHYR GEODETIC (TRM41249)	8395	9163		
COMPACT L1-L2- NO GP (TRM22020- GP)	0865	4056	4404	4725
NOVATEL	17577			

MONUMENT INFORMATION:

(CIRCLE ONE) EXISTING NEW
(CIRCLE ONE) BRASS CAP ALUMINUM SPIKE PK NAIL
OTHER STEEL ROD

HEIGHT ABOVE GROUND: 0 CM PHOTO TAKEN: YES NO

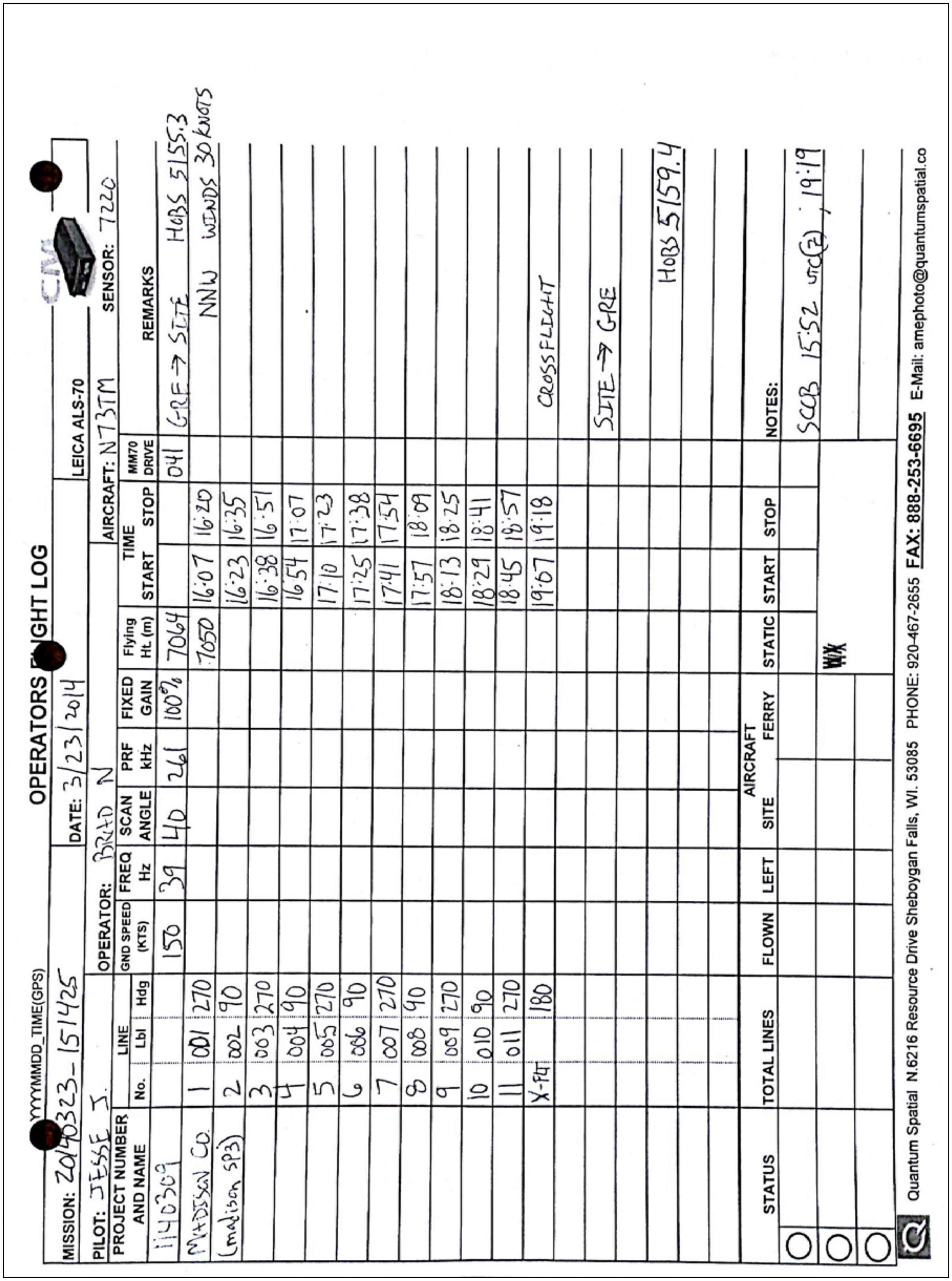
IF NEW, DRAW SKETCH OF MONUMENT AND LOCATION ON THE BACK OF THIS SHEET.

OPUS COORDINATES (FOR PROCESSOR)

LATITUDE ______ **ELLIPSOID HEIGHT**

NAD 83 1997 N 38°50'05.04262" ELLIP
W 89°22'33.95042" 131.225

Image 7.1h: Mission 20140323_151425



OPERATORS FLIGHT LOG

MISSION: 20140323_151425 (YYYYMMDD_TIME(GPS)) | DATE: 3/23/2014 | LEICA ALS-70

PILOT: JESSE J. | OPERATOR: BRAD N | AIRCRAFT: N73TM | SENSOR: 7220

PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
1140309				150	39	40	261	100%	7064			041	GRE → SITE HOBS 5155.3
MADISON CO.	1	001	270						7050	16:07	16:20		NNW WINDS 30 KNOTS
(madison SP3)	2	002	90							16:23	16:35		
	3	003	270							16:38	16:51		
	4	004	90							16:54	17:07		
	5	005	270							17:10	17:23		
	6	006	90							17:25	17:38		
	7	007	270							17:41	17:54		
	8	008	90							17:57	18:09		
	9	009	270							18:13	18:25		
	10	010	90							18:29	18:41		
	11	011	270							18:45	18:57		
	X-FLT		180							19:07	19:18		CROSSFLIGHT
													SITE → GRE
													HOBS 5159.4

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
									SCCB 15:52 UTC(?), 19:19
						W/X			

Quantum Spatial N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 FAX: 888-253-6695 E-Mail: amephoto@quantumspatial.co

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.5
1        National Geodetic Survey,   Retrieval Date = OCTOBER  6, 2014
 DL2754 ***********************************************************************
 DL2754  CORS          -  This is a GPS Continuously Operating Reference Station.
 DL2754  DESIGNATION -  ST LOUIS 8 CORS ARP
 DL2754  CORS_ID       -  STL8
 DL2754  PID           -  DL2754
 DL2754  STATE/COUNTY-  IL/ST CLAIR
 DL2754  COUNTRY       -  US
 DL2754  USGS QUAD     -  LEBANON (1991)
 DL2754
 DL2754                        *CURRENT SURVEY CONTROL
 DL2754  ______________________________________________________________________
 DL2754* NAD 83(2011) POSITION- 38 36 39.89287(N) 270 14 28.74698(E)   ADJUSTED
 DL2754* NAD 83(2011) ELLIP HT-    158.474 (meters)        (08/??/11)   ADJUSTED
 DL2754* NAD 83(2011) EPOCH    -  2010.00
 DL2754* NAVD 88 ORTHO HEIGHT -           **(meters)           **(feet)
 DL2754  ______________________________________________________________________
 DL2754  NAD 83(2011) X  -      21,018.979 (meters)                    COMP
 DL2754  NAD 83(2011) Y  - -4,990,463.446 (meters)                    COMP
 DL2754  NAD 83(2011) Z  -  3,958,771.032 (meters)                    COMP
 DL2754  GEOID HEIGHT    -          -30.70  (meters)                    GEOID12A
 DL2754
 DL2754  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
 DL2754  Type                                        Horiz  Ellip  Dist(km)
 DL2754  -------------------------------------------------------------------
 DL2754  NETWORK                                      1.44   4.85
 DL2754  -------------------------------------------------------------------
 DL2754  NOTE: Click here for information on individual local accuracy
 DL2754  values and other accuracy information.
 DL2754
 DL2754
 DL2754.The coordinates were established by GPS observations
 DL2754.and adjusted by the National Geodetic Survey in August 2011.
 DL2754
 DL2754.NAD 83(2011) refers to NAD 83 coordinates where the reference
 DL2754.frame has been affixed to the stable North American Tectonic Plate.
 DL2754
 DL2754.The coordinates are valid at the epoch date displayed above
 DL2754.which is a decimal equivalence of Year/Month/Day.
 DL2754
 DL2754.The PID for the CORS L1 Phase Center is DL2755.
 DL2754
 DL2754.The XYZ, and position/ellipsoidal ht. are equivalent.
 DL2754
 DL2754.The ellipsoidal height was determined by GPS observations
 DL2754.and is referenced to NAD 83.
 DL2754
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```
DL2754. The following values were computed from the NAD 83(2011) position.
DL2754
DL2754;                   North         East     Units Scale Factor Converg.
DL2754;SPC IL W     -   215,876.220   735,532.935   MT  0.99995672   +0 15 16.6
DL2754;SPC IL W     -   708,253.90  2,413,160.97   sFT  0.99995672   +0 15 16.6
DL2754;UTM  16      - 4,277,229.405   259,798.009   MT  1.00031057   -1 43 20.4
DL2754
DL2754!             -  Elev Factor  x  Scale Factor =   Combined Factor
DL2754!SPC IL W     -   0.99997514  x   0.99995672  =   0.99993186
DL2754!UTM  16      -   0.99997514  x   1.00031057  =   1.00028570
DL2754
DL2754                          SUPERSEDED SURVEY CONTROL
DL2754
DL2754  NAD 83(CORS)-  38 36 39.89301(N)    270 14 28.74621(E) AD(2002.00) c
DL2754  ELLIP H (05/??/09)  158.484  (m)                       GP(2002.00) c c
DL2754
DL2754.Superseded values are not recommended for survey control.
DL2754
DL2754.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
DL2754.See file dsdata.txt to determine how the superseded data were derived.
DL2754
DL2754_U.S. NATIONAL GRID SPATIAL ADDRESS: 16SBH5979877229(NAD 83)
DL2754
DL2754_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
DL2754
DL2754                          STATION DESCRIPTION
DL2754
DL2754'DESCRIBED BY NATIONAL GEODETIC SURVEY 2011
DL2754'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
DL2754'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
DL2754'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DL2754'   ftp://cors.ngs.noaa.gov/cors/README.txt
DL2754'   ftp://cors.ngs.noaa.gov/cors/coord/coord_08
DL2754'   ftp://cors.ngs.noaa.gov/cors/station_log
DL2754'   http://geodesy.noaa.gov/CORS

*** retrieval complete.
Elapsed Time = 00:00:02
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The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

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PROGRAM = datasheet95, VERSION = 8.5
1        National Geodetic Survey,   Retrieval Date = OCTOBER  6, 2014
 DN6075 ***********************************************************************
 DN6075  CORS         -  This is a GPS Continuously Operating Reference Station.
 DN6075  DESIGNATION -  MODOT BELLEFONT CORS ARP
 DN6075  CORS_ID      -  MOBF
 DN6075  PID          -  DN6075
 DN6075  STATE/COUNTY-  MO/ST LOUIS
 DN6075  COUNTRY      -  US
 DN6075  USGS QUAD    -  COLUMBIA BOTTOM (1998)
 DN6075
 DN6075                       *CURRENT SURVEY CONTROL
 DN6075  ______________________________________________________________________
 DN6075* NAD 83(2011) POSITION- 38 45 51.51926(N) 269 45 12.30754(E)   ADJUSTED
 DN6075* NAD 83(2011) ELLIP HT-   132.628 (meters)        (03/??/12)   ADJUSTED
 DN6075* NAD 83(2011) EPOCH   -  2010.00
 DN6075* NAVD 88 ORTHO HEIGHT -          **(meters)           **(feet)
 DN6075  ______________________________________________________________________
 DN6075  NAD 83(2011) X  -    -21,431.508 (meters)                     COMP
 DN6075  NAD 83(2011) Y  - -4,979,808.689 (meters)                     COMP
 DN6075  NAD 83(2011) Z  -  3,972,032.534 (meters)                     COMP
 DN6075  GEOID HEIGHT    -         -31.39  (meters)                     GEOID12A
 DN6075
 DN6075.Formal positional accuracy estimates are not available for this CORS
 DN6075.because its coordinates were determined in part using modeled
 DN6075.velocities. Approximate one-sigma accuracies for latitude, longitude,
 DN6075.and ellipsoid height can be obtained from the short-term time series.
 DN6075.Additional information regarding modeled velocities is available on
 DN6075.the CORS Coordinates and Multi-Year CORS Solution FAQ web pages.
 DN6075
 DN6075.The coordinates were established by GPS observations
 DN6075.and adjusted by the National Geodetic Survey in March 2012.
 DN6075
 DN6075.NAD 83(2011) refers to NAD 83 coordinates where the reference
 DN6075.frame has been affixed to the stable North American Tectonic Plate.
 DN6075
 DN6075.The coordinates are valid at the epoch date displayed above
 DN6075.which is a decimal equivalence of Year/Month/Day.
 DN6075
 DN6075.The PID for the CORS L1 Phase Center is DN6076.
 DN6075
 DN6075.The XYZ, and position/ellipsoidal ht. are equivalent.
 DN6075
 DN6075.The ellipsoidal height was determined by GPS observations
 DN6075.and is referenced to NAD 83.
 DN6075
 DN6075. The following values were computed from the NAD 83(2011) position.
 DN6075
```

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DN6075;                     North          East     Units Scale Factor Converg.
DN6075;SPC MO E      -   325,298.425   272,023.947   MT  0.99993930   +0 09 31.2
DN6075;UTM  15       - 4,294,223.106   739,232.408   MT  1.00030482   +1 43 29.2
DN6075
DN6075!              -  Elev Factor  x  Scale Factor =   Combined Factor
DN6075!SPC MO E      -   0.99997919  x   0.99993930  =   0.99991849
DN6075!UTM  15       -   0.99997919  x   1.00030482  =   1.00028400
DN6075
DN6075                          SUPERSEDED SURVEY CONTROL
DN6075
DN6075  NAD 83(CORS)-  38 45 51.51933(N)    269 45 12.30654(E) AD(2002.00) c
DN6075  ELLIP H (03/??/12)  132.624  (m)                       GP(2002.00) c c
DN6075
DN6075.Superseded values are not recommended for survey control.
DN6075
DN6075.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
DN6075.See file dsdata.txt to determine how the superseded data were derived.
DN6075
DN6075_U.S. NATIONAL GRID SPATIAL ADDRESS: 15SYC3923294223(NAD 83)
DN6075
DN6075_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
DN6075
DN6075                          STATION DESCRIPTION
DN6075
DN6075'DESCRIBED BY NATIONAL GEODETIC SURVEY 2012
DN6075'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
DN6075'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
DN6075'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DN6075'   ftp://cors.ngs.noaa.gov/cors/README.txt
DN6075'   ftp://cors.ngs.noaa.gov/cors/coord/coord_08
DN6075'   ftp://cors.ngs.noaa.gov/cors/station_log
DN6075'   http://geodesy.noaa.gov/CORS

*** retrieval complete.
Elapsed Time = 00:00:02
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8. LiDAR GPS Processing Plots

Image 8.0a: PDOP Plot for mission 20140323_151425

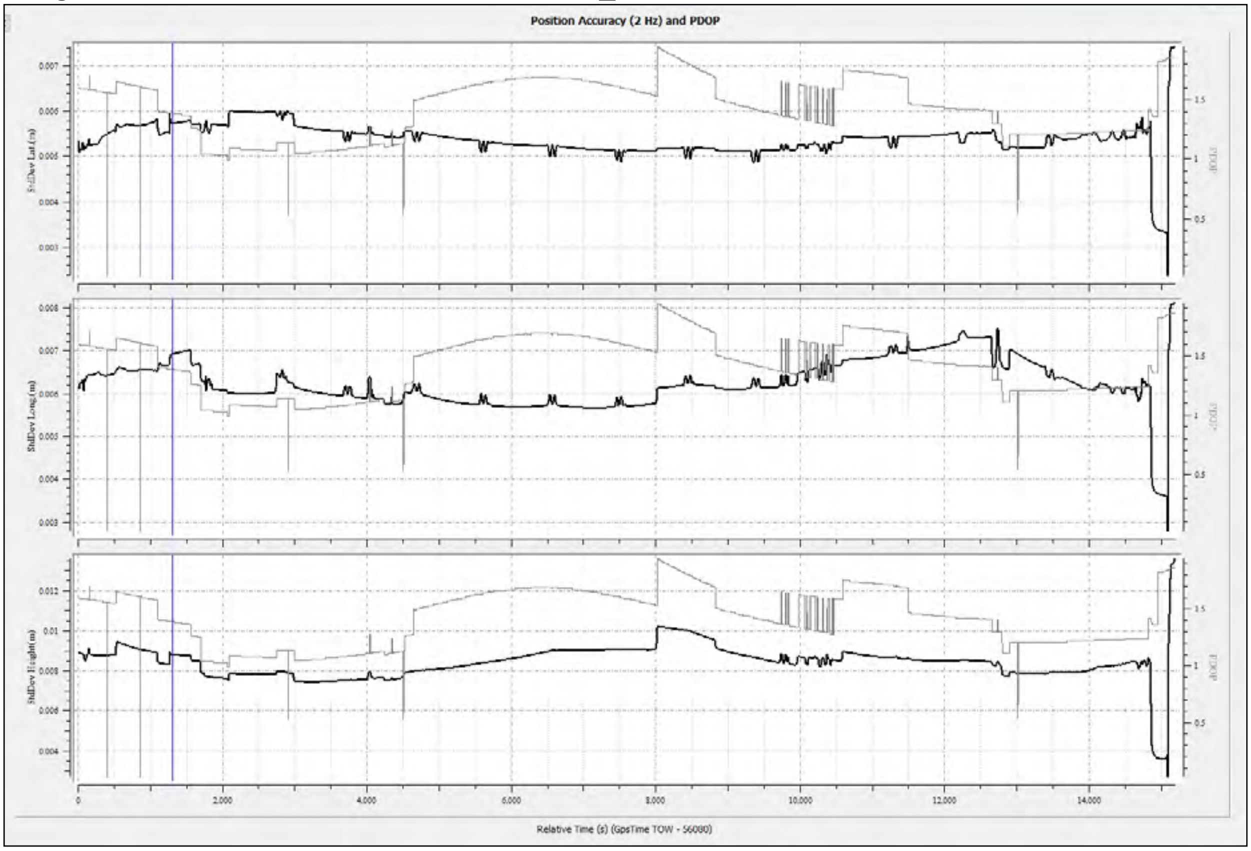


Image 8.0b: Separation Plot for mission 20140323_151425

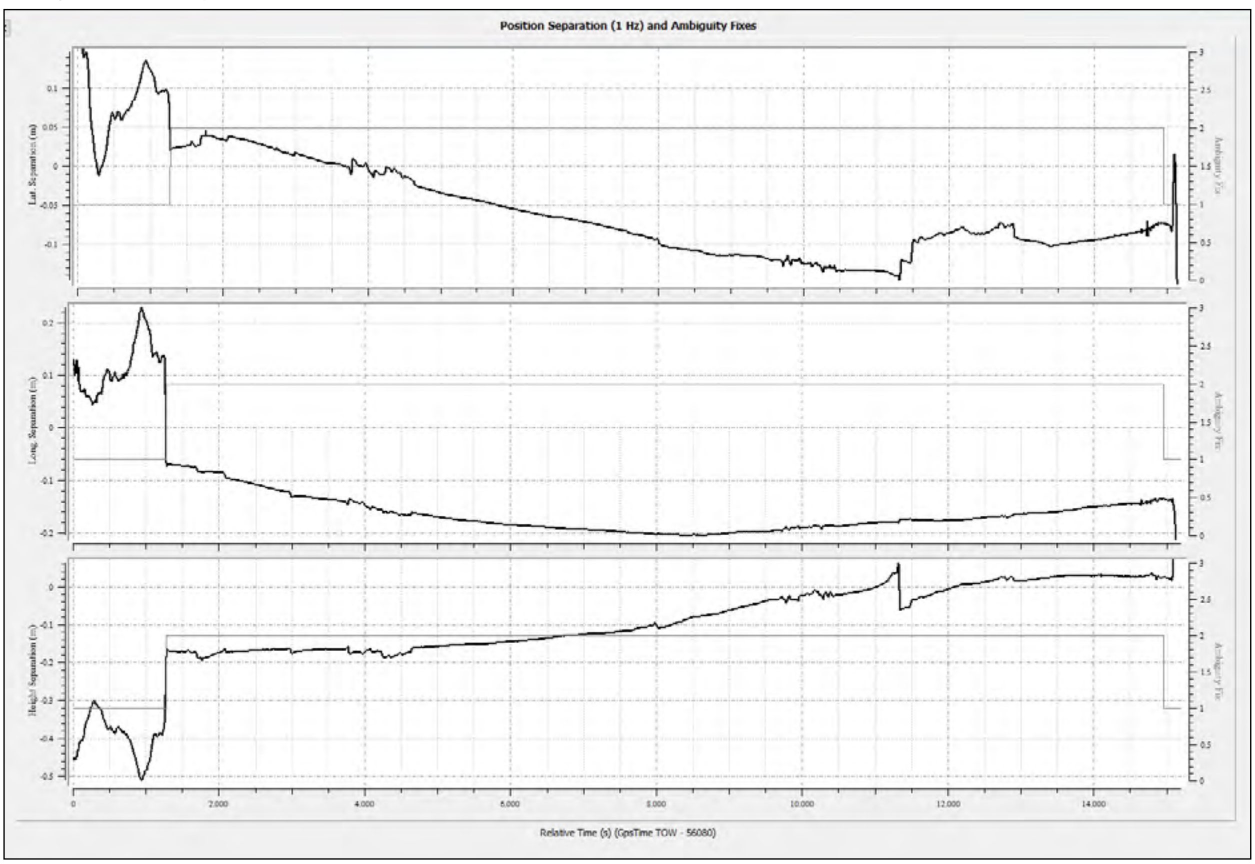


Image 8.0c: PDOP Plot for mission 20140316_133033

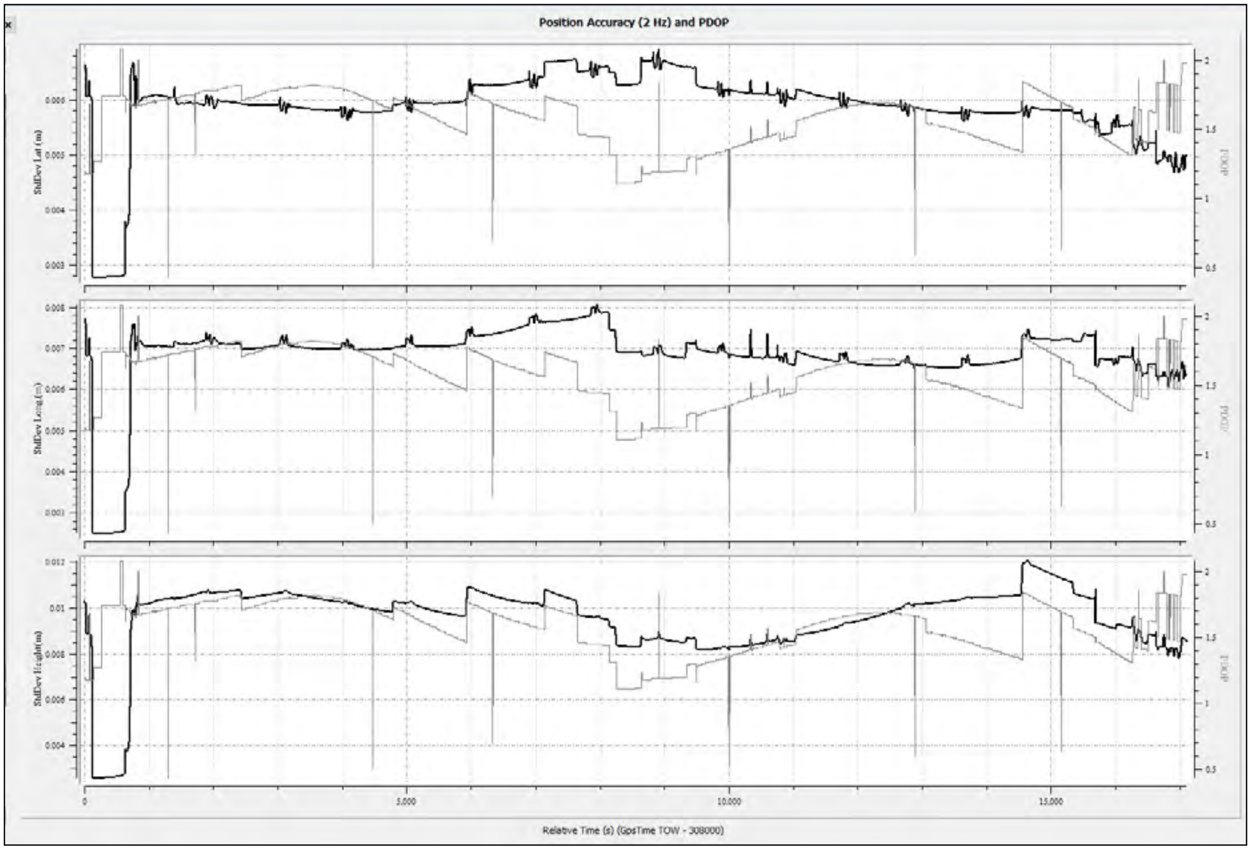


Image 8.0d: Separation Plot for mission 20140326_133033

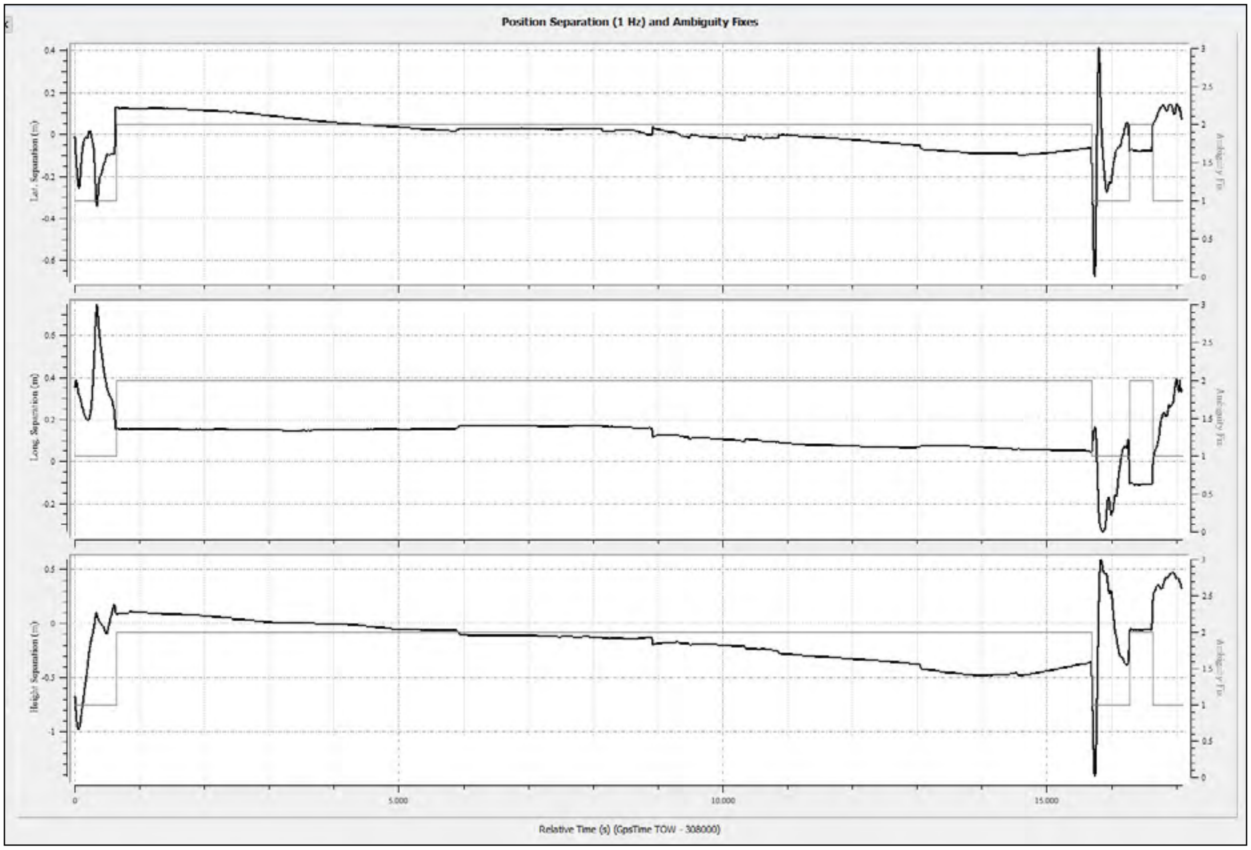


Image 8.0e: PDOP Plot for mission 20140326_195827

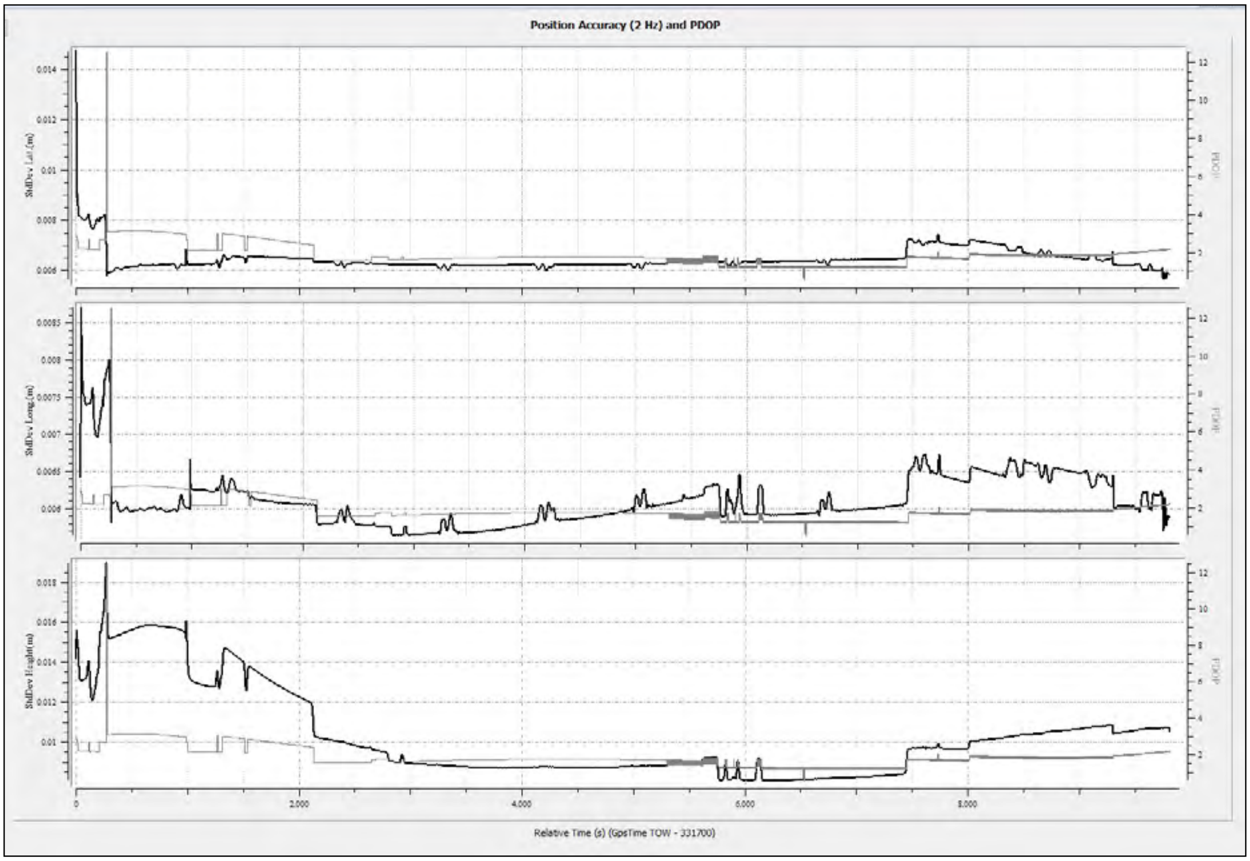


Image 8.0f: Separation Plot for mission 20140326_195827

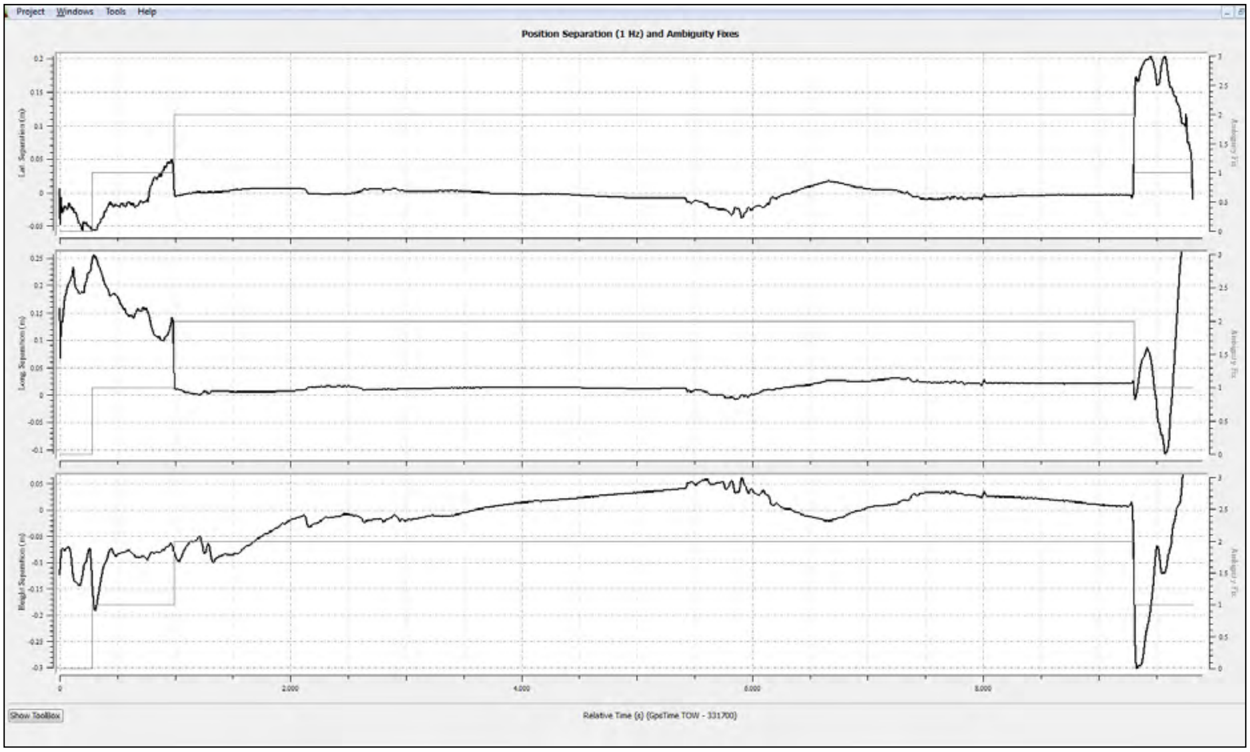


Image 8.0g: PDOP Plot for mission 20140330_151028

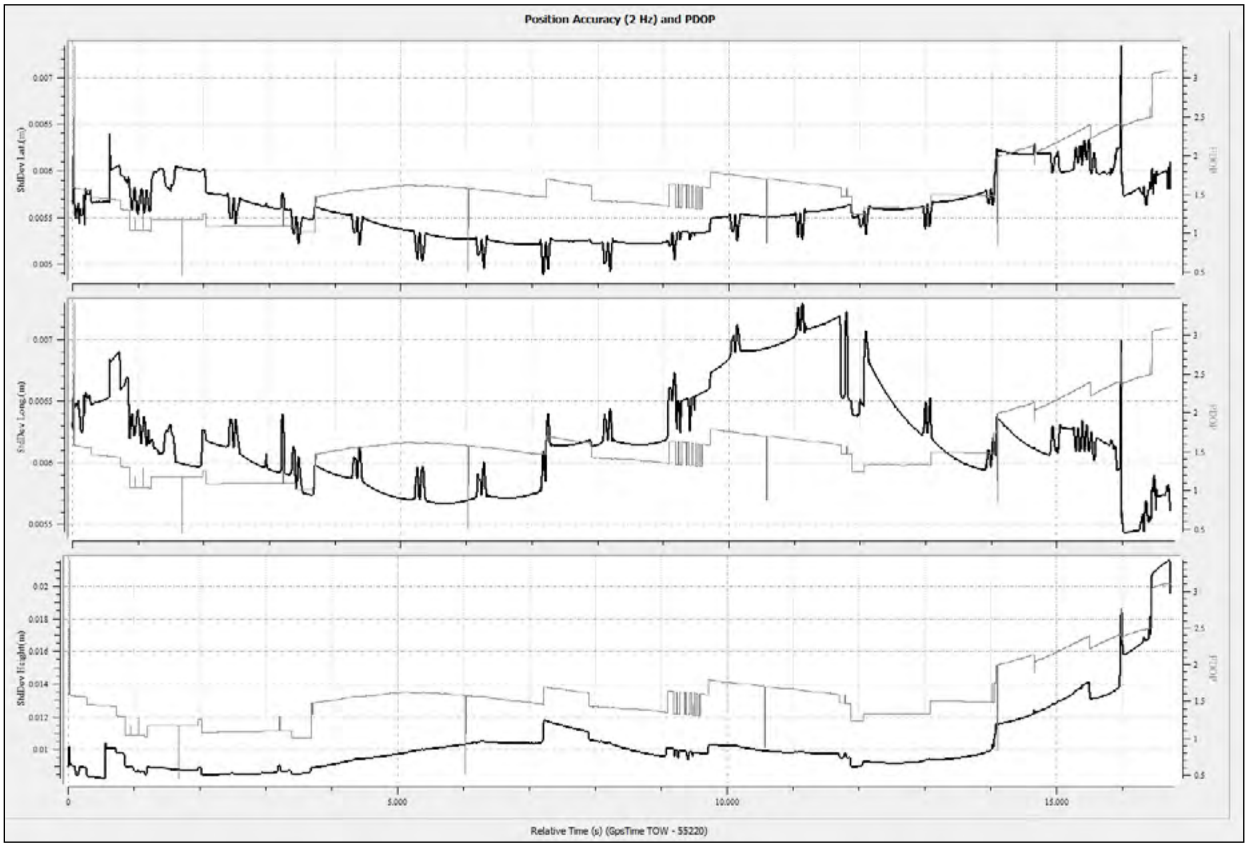


Image 8.0h: Separation Plot for mission 20140330_151028

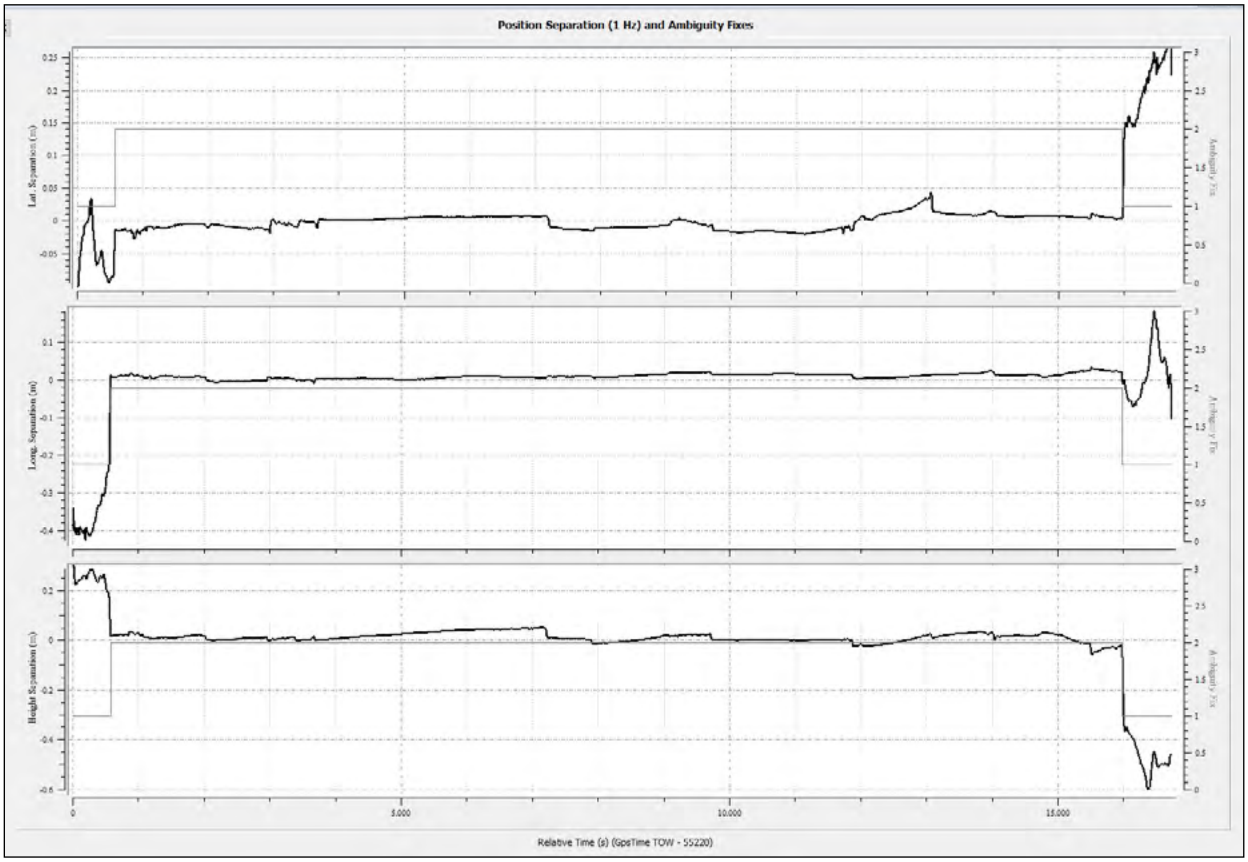


Image 8.0i: PDOP Plot for mission 20140331_003140

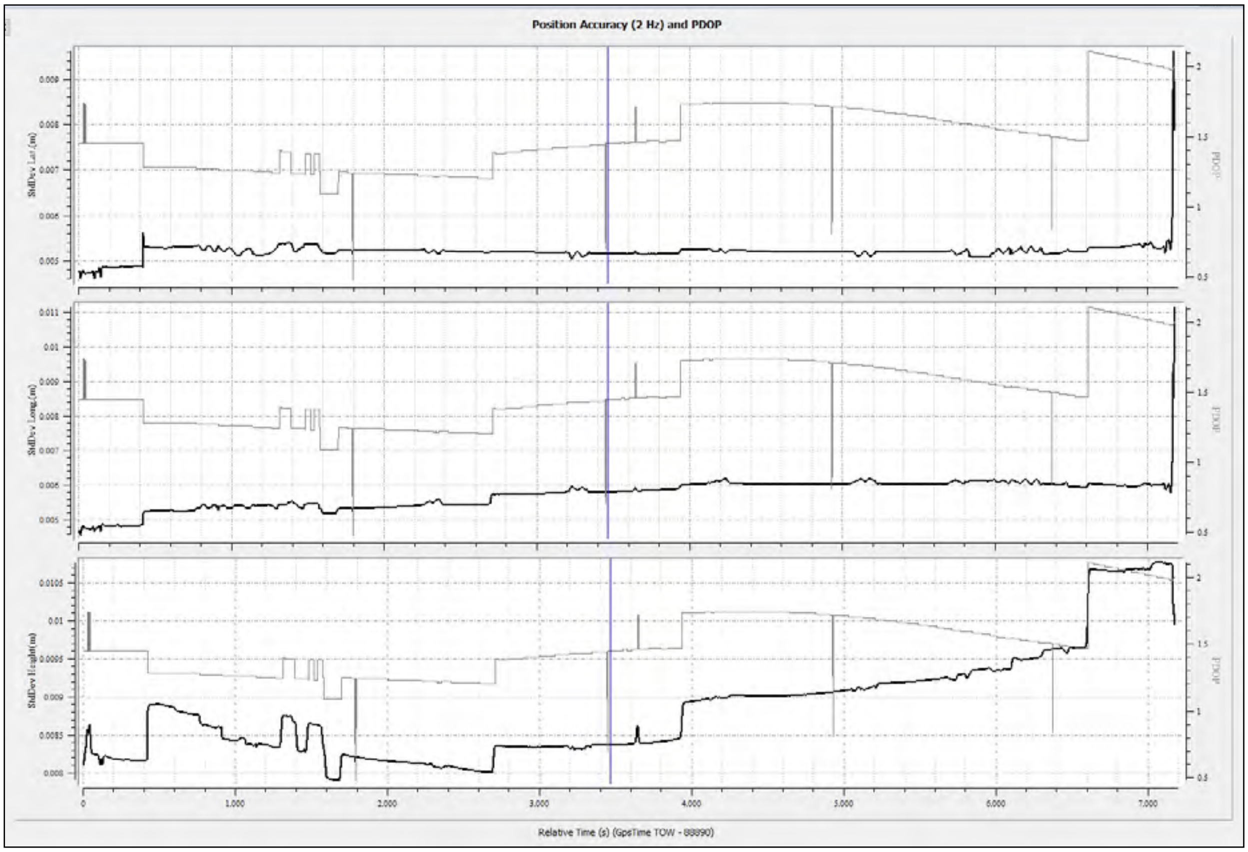


Image 8.0j: Separation Plot for mission 20140331_003140

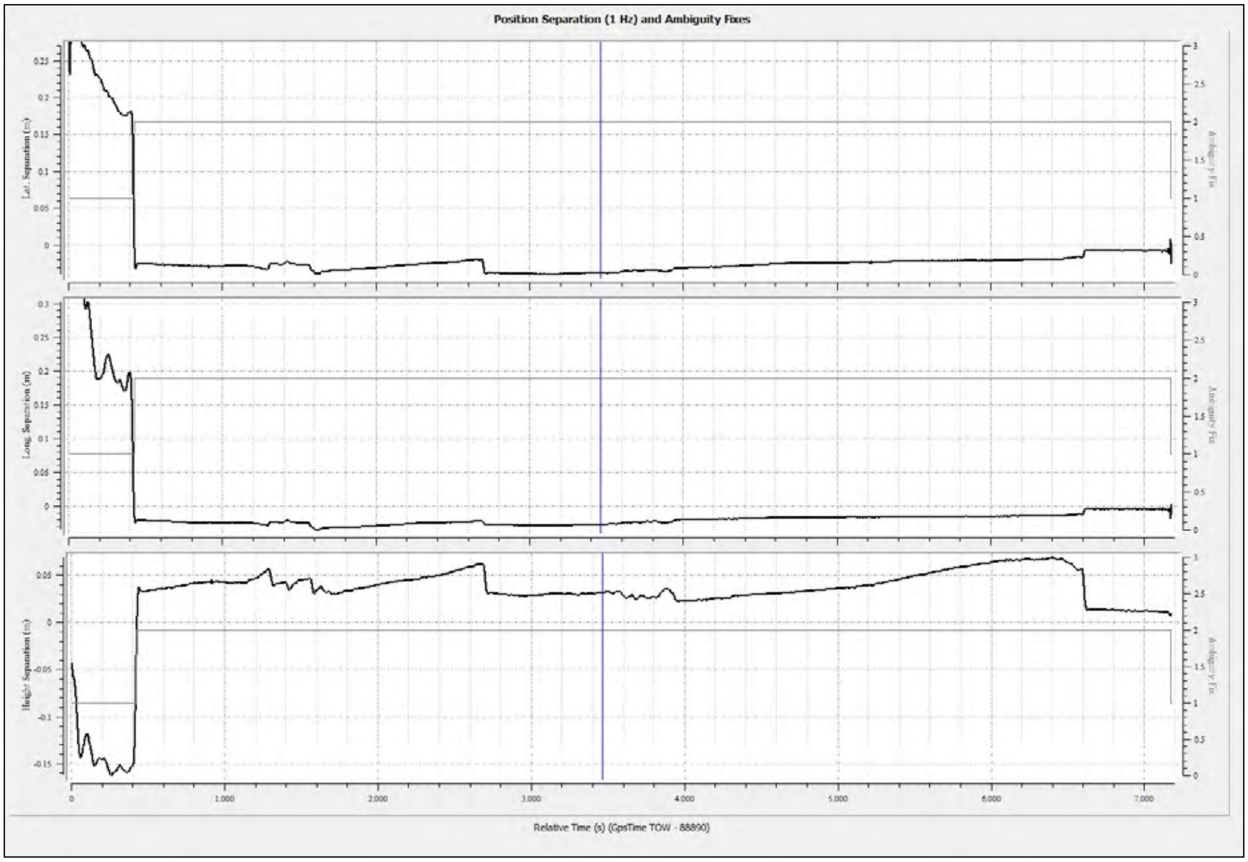


Image 8.0k: PDOP Plot for mission 20140330_202954

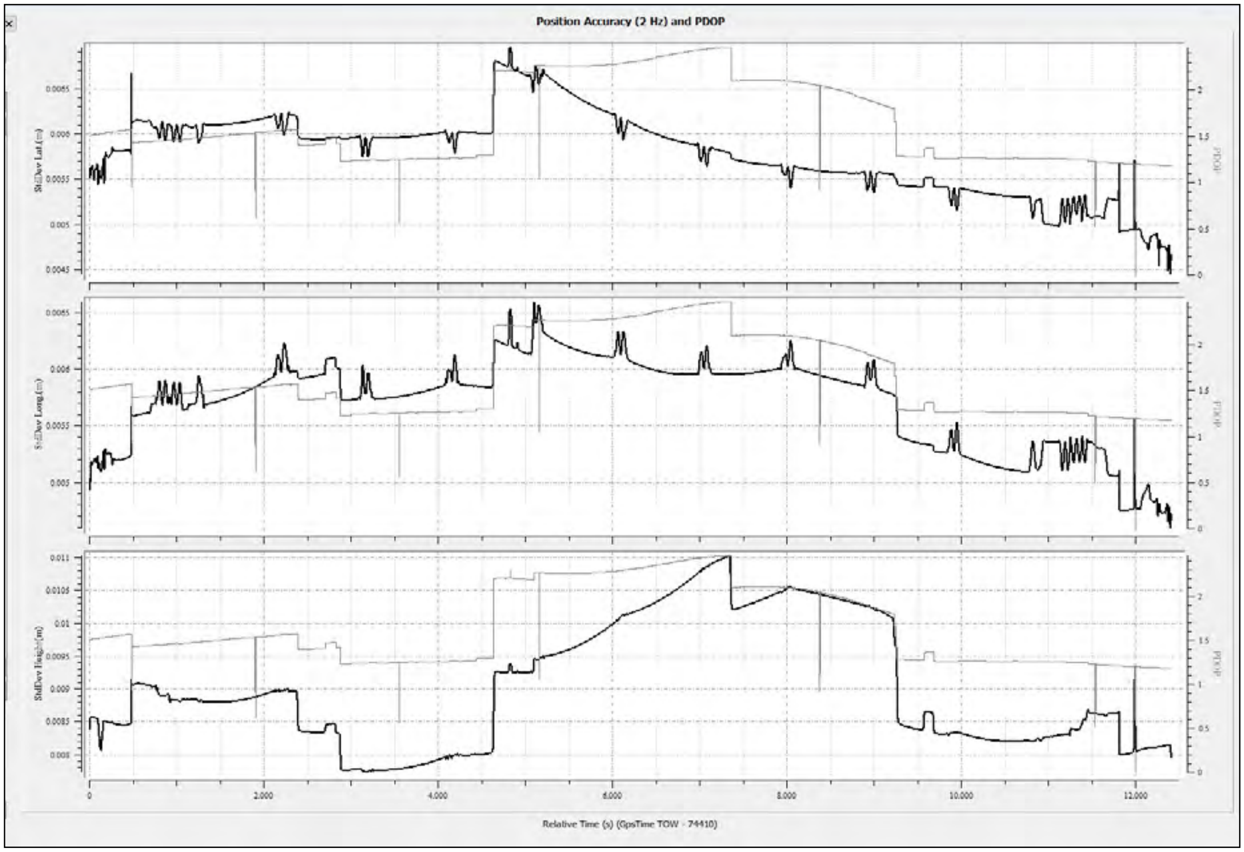
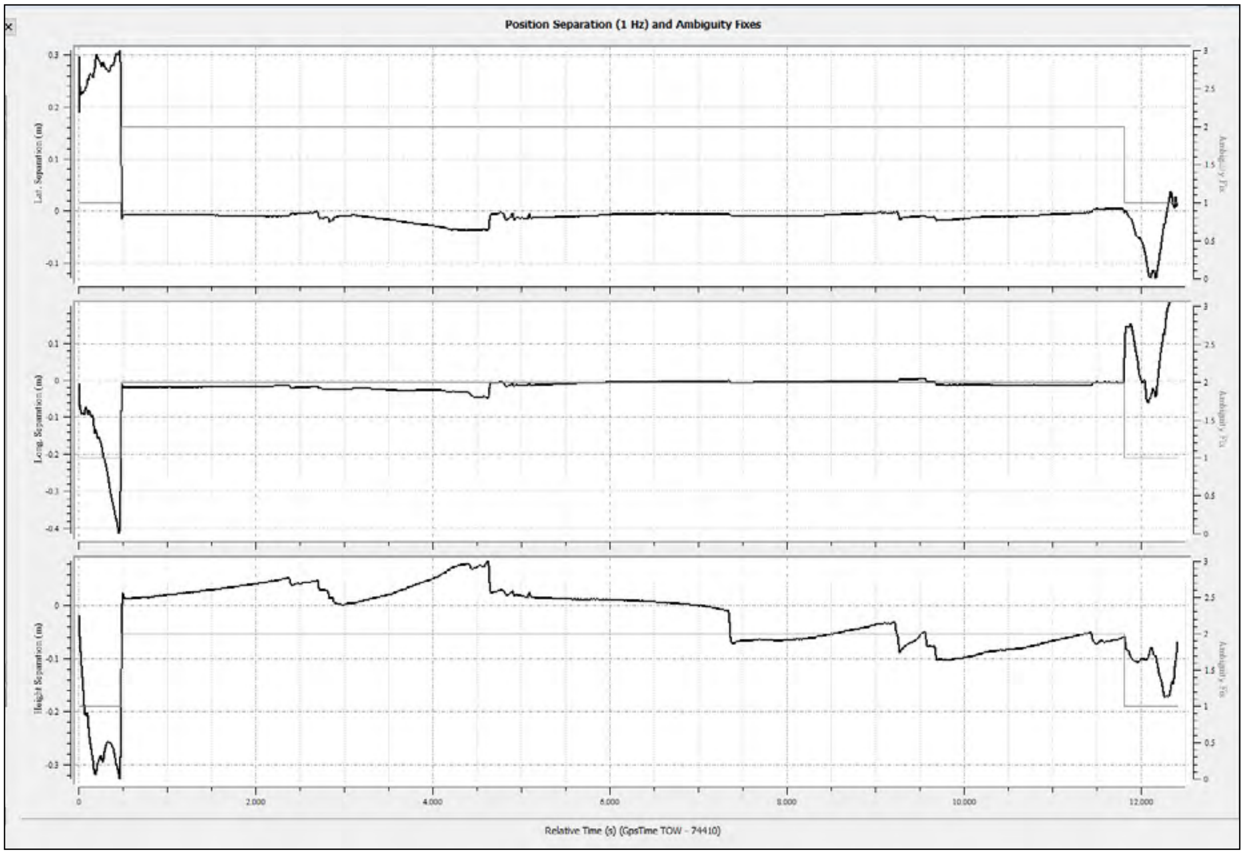


Image 8.0l: Separation Plot for mission 20140330_202954



9. Geodetic Control Summary

9.1QA/QC Output Control Report

Output Control Report on check points collected across the Madison County project area and used to calibrate LiDAR data position.

Image 9.1: Madison Control Report

Number	Easting	Northing	Known Z	Laser Z	Dz
1	2346960.683	774199.131	568.742	568.55	-0.192
2	2349475.058	759149.682	471.876	471.83	-0.046
3	2338614.591	733969.421	422.614	422.58	-0.034
4	2303497.466	750500.891	423.329	423.48	0.151
5	2325175.268	752331.045	419.291	419.27	-0.021
6	2295678.919	732518.804	411.295	411.4	0.105
7	2297172.253	761141.654	431.581	431.65	0.069
8	2292594.893	837344.654	618.923	619.17	0.247
9	2286596.637	822530.52	609.628	609.69	0.062
10	2391343.203	809280.232	544.946	544.99	0.044
11	2374820.874	774834.684	554.658	554.5	-0.158
12	2411055.034	833879.914	583.358	583.35	-0.008
13	2342648.71	812949.184	512.41	512.64	0.23
14	2366302.147	837153.929	576.045	576.3	0.255
15	2388206.861	824527.724	564.234	564.24	0.006
16	2388431.627	788164.916	518.204	517.98	-0.224
17	2407444.004	774511.647	517.693	517.62	-0.073
18	2410280.009	743042.812	511.403	511.37	-0.033
19	2376688.413	746506.588	553.801	553.83	0.029
20	2379492.059	727295.215	527.873	528.04	0.167
21	2433364.533	727045.521	503.726	503.97	0.244
22	2439344.032	747034.782	514.782	514.79	0.008
23	2436974.795	788058.775	549.054	549	-0.054

Average dz	**0.034**
Minimum dz	**-0.224**
Maximum dz	**0.255**
Average magnitude	**0.107**
Root mean square	**0.138**
Std deviation	**0.137**

10. Imagery of Control

Image 10.0a: Control Location 1

Image 10.0b: Control Location 2

Image 10.0c: Control Location 3

Image 10.0d: Control Location 4

Image 10.0e: Control Location 5

Image 10.0f: Control Location 6

Image 10.0g: Control Location 7

Image 10.0h: Control Location 8

Image 10.0i: Control Location 9

Image 10.0j: Control Location 10

Image 10.0k: Control Location 11

Image 10.0l: Control Location 12

Image 10.0m: Control Location 13

Image 10.0n: Control Location 14

Image 10.0o: Control Location 15

Image 10.0p: Control Location 16

Image 10.0q: Control Location 17

Image 10.0r: Control Location 18

Image 10.0s: Control Location 19

Image 10.0t: Control Location 20

Image 10.0u: Control Location 21

Image 10.0v: Control Location 22

Image 10.0w: Control Location 23

11. Accuracy Assessment

Image 11.0a: Vertical Accuracy Assessment

	Count	Mini-mum	Maxi-mum	St. Dev	RMSE	95%	95th	Mean	Median	Skew
SVA	100	-0.396	0.754	0.233	0.281	-	0.587	0.16	0.17	0.30
CVA	100	-0.396	0.754	0.233	0.281	-	0.587	0.16	0.17	0.30
Bare Earth (FVA)	20	-0.223	0.551	0.203	0.264	0.517	-	0.17	0.24	-0.40
Tall Weeds	20	-0.182	0.500	0.185	0.264	-	0.487	0.19	0.17	0.07
Brush Lands	20	-0.103	0.708	0.264	0.401	-	0.696	0.31	0.31	0.07

Image 11.0b: Ground check points used for accuracy assessment

Point #	Easting	Northing	Known Z	LiDAR Z	DZ	Land Class
1	2346065.86	775798.62	537.68	537.65	-0.03	1
2	2352353.69	764412.33	550.81	550.97	0.16	1
3	2336585.03	737109.95	419.43	419.69	0.26	1
4	2302491.98	746921.06	422.01	421.95	-0.06	1
5	2324951.16	765692.77	424.67	424.91	0.24	1
6	2298178.66	744254.53	413.87	413.71	-0.16	1
7	2316900.39	788818.55	431.84	431.62	-0.22	1
8	2292562.64	834819.63	616.46	616.69	0.23	1
9	2279725.792	829075.143	589.73	590.03	0.3	1
10	2390184.042	807989.582	539.015	539.32	0.305	1
11	2417841.998	809165.101	535.386	535.68	0.294	1
12	2411349.856	834667.97	584.562	584.62	0.058	1
13	2343468.266	812244.78	508.739	509.29	0.551	1
14	2366346.865	837069.953	575.225	575.58	0.355	1
15	2405325.494	772165.88	515.386	515.29	-0.096	1
16	2408955.379	742193.653	531.108	531.31	0.202	1
17	2433394.972	727102.804	504.323	504.64	0.317	1
18	2439129.026	752411.678	524.179	524.6	0.421	1
19	2432474.6	759582.388	539.09	539.35	0.26	1
20	2438301.911	789511.682	547.072	547.16	0.088	1
21	2348110.65	777725.32	546.94	547.01	0.07	2
22	2336538.81	734897.88	419.34	419.32	-0.02	2
23	2304521.97	753296.65	426.20	426.37	0.17	2
24	2323372.57	758134.50	422.45	422.44	-0.01	2
25	2297716.98	732191.88	414.98	415.35	0.37	2
26	2315004.98	776638.57	428.51	428.63	0.12	2
27	2310938.32	805580.14	431.75	431.99	0.24	2

Point #	Easting	Northing	Known Z	LiDAR Z	DZ	Land Class
28	2303714.29	831942.40	563.52	563.88	0.36	2
29	2307104.25	837690.36	488.44	488.93	0.49	2
30	2374523.35	774730.58	555.19	555.17	-0.02	2
31	2405728.13	819909.06	552.28	552.76	0.48	2
32	2438650.40	839018.04	618.14	618.44	0.30	2
33	2352946.23	824260.04	559.28	559.51	0.23	2
34	2395024.66	788023.65	515.63	515.45	-0.18	2
35	2406258.94	762251.75	503.03	503.20	0.17	2
36	2408073.79	746744.77	502.18	502.26	0.08	2
37	2441285.06	727132.61	500.96	501.11	0.15	2
38	2434323.92	762302.67	537.73	537.85	0.13	2
39	2424665.33	784464.08	551.49	551.70	0.22	2
40	2438268.31	799125.10	546.19	546.69	0.50	2
41	2346471.97	772420.02	564.589	564.58	-0.009	3
42	2348606.887	758533.421	469.861	470.16	0.299	3
43	2304632.727	751400.991	423.611	423.94	0.329	3
44	2325226.823	752304.604	419.32	419.6	0.28	3
45	2307870.991	765934.856	416.84	416.77	-0.07	3
46	2299278.308	757612.809	417.876	418	0.124	3
47	2306504.751	806788.209	431.334	431.52	0.186	3
48	2298191.975	818819.576	560.465	561.05	0.585	3
49	2303607.952	826632.677	524.372	525.08	0.708	3
50	2386566.047	803556.785	530.514	530.99	0.476	3
51	2418911.465	807875.497	561.013	561.33	0.317	3
52	2429477.493	836102.675	595.494	595.49	-0.004	3
53	2361641.802	812089.842	514.632	515.09	0.458	3
54	2388473.113	789093.832	498.093	497.99	-0.103	3
55	2390393.927	808843.169	538.053	538.73	0.677	3
56	2379481.688	737780.926	536.748	537.09	0.342	3
57	2383606.617	730014.819	500.324	500.95	0.626	3
58	2409856.785	742607.626	513.575	513.6	0.025	3
59	2433252.345	737695.828	492.958	493.15	0.192	3
60	2438975.407	752130.412	516.935	517.63	0.695	3
61	2346339.969	772303.849	551.298	551.33	0.032	4
62	2340911.256	732446.79	450.839	450.91	0.071	4
63	2300141.312	745089.688	415.166	414.77	-0.396	4
64	2319735.082	764596.709	426.282	426.56	0.278	4
65	2308791.078	768386.18	415.567	415.78	0.213	4
66	2301364.111	761408.966	415.002	415.2	0.198	4
67	2312371.382	778582.997	418.585	418.42	-0.165	4
68	2299962.743	822643.24	482.791	482.93	0.139	4
69	2309106.182	837190.15	538.516	539.27	0.754	4

Point #	Easting	Northing	Known Z	LiDAR Z	DZ	Land Class
70	2306266.29	840535.576	577.092	577.39	0.298	4
71	2384166.347	773191.99	475.681	475.8	0.119	4
72	2417343.623	808400.388	554.294	554.45	0.156	4
73	2414455.06	837342.905	584.011	584.22	0.209	4
74	2388755.731	825279.035	569.444	569.45	0.006	4
75	2396458.891	793957.772	519.828	519.61	-0.218	4
76	2407590.152	773291.301	528.424	528.58	0.156	4
77	2409365.109	745153.191	511.987	511.83	-0.157	4
78	2442410.811	731174.299	464.313	464.5	0.187	4
79	2439574.973	752032.105	519.487	519.75	0.263	4
80	2439447.024	784437.867	553.27	553.22	-0.05	4
81	2345374.09	774238.89	567.71	567.52	-0.19	5
82	2350801.12	759004.52	535.31	535.16	-0.15	5
83	2337888.53	734904.31	422.87	422.78	-0.09	5
84	2301587.64	746503.00	419.64	419.45	-0.19	5
85	2321850.23	751429.62	415.56	415.50	-0.06	5
86	2297223.52	740736.85	413.55	413.58	0.03	5
87	2315865.99	788418.04	430.33	430.13	-0.20	5
88	2296289.62	829002.27	569.07	569.27	0.20	5
89	2281366.78	825505.06	595.92	596.17	0.25	5
90	2407185.12	773048.28	522.45	522.42	-0.03	5
91	2416399.81	809297.40	554.95	555.04	0.09	5
92	2411091.83	838226.23	589.05	589.40	0.35	5
93	2438821.86	839513.24	622.90	622.72	-0.18	5
94	2340776.71	810430.63	513.85	513.89	0.04	5
95	2389715.10	824880.38	569.77	569.79	0.02	5
96	2408733.78	746650.33	508.32	508.10	-0.22	5
97	2377069.41	750767.70	554.64	554.91	0.27	5
98	2377978.21	753427.44	548.91	549.08	0.17	5
99	2437942.03	749484.33	524.89	525.01	0.12	5
100	2435678.98	760344.58	535.53	535.58	0.05	5

Thank You

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