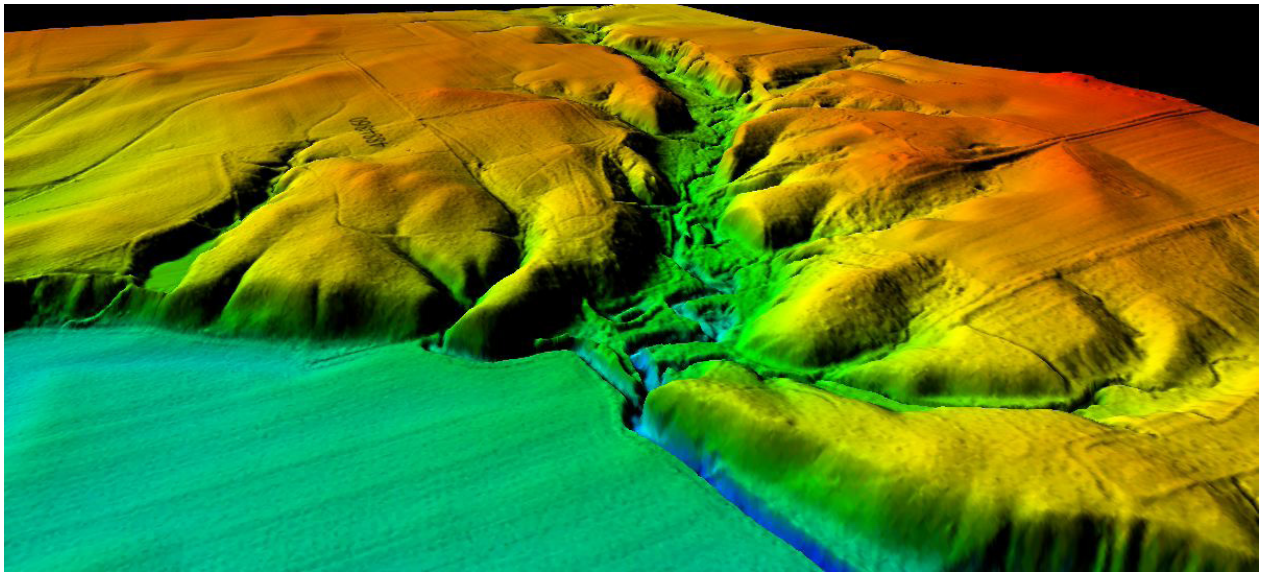
2014 Will County, Illinois
1 PPSM
LiDAR Report



Prepared for:

University of Illinois at Urbana-Champaign
UIUC Facilities & Services, Planning Division
1501 S Oak Street
Champaign, IL 61820

Prepared by:

Quantum Spatial
4020 Technology Parkway
Sheboygan, WI 53083
P: 920.457.3631
F: 920.457.0410

Contract ID: PSSU14R19

Quantum Spatial Project No: 1140310.02

Table of Contents

1 PPSM LiDAR Survey

Will County, Illinois

1. Introduction

This report contains a summary of the Light Detection and Ranging (LiDAR) data acquisition and processing for the project area to include Will 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)
Phone: (920) 803-5825
Email: sellefson@quantumspatial.com

1.2 Purpose

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

1.3 Project Locations

This project consists of Will County, Illinois. The area of acquisition is approximately 922 square miles, located in northeastern Illinois. Image 1.3 on the following page shows the relative location of this area.

1.4 Time Period

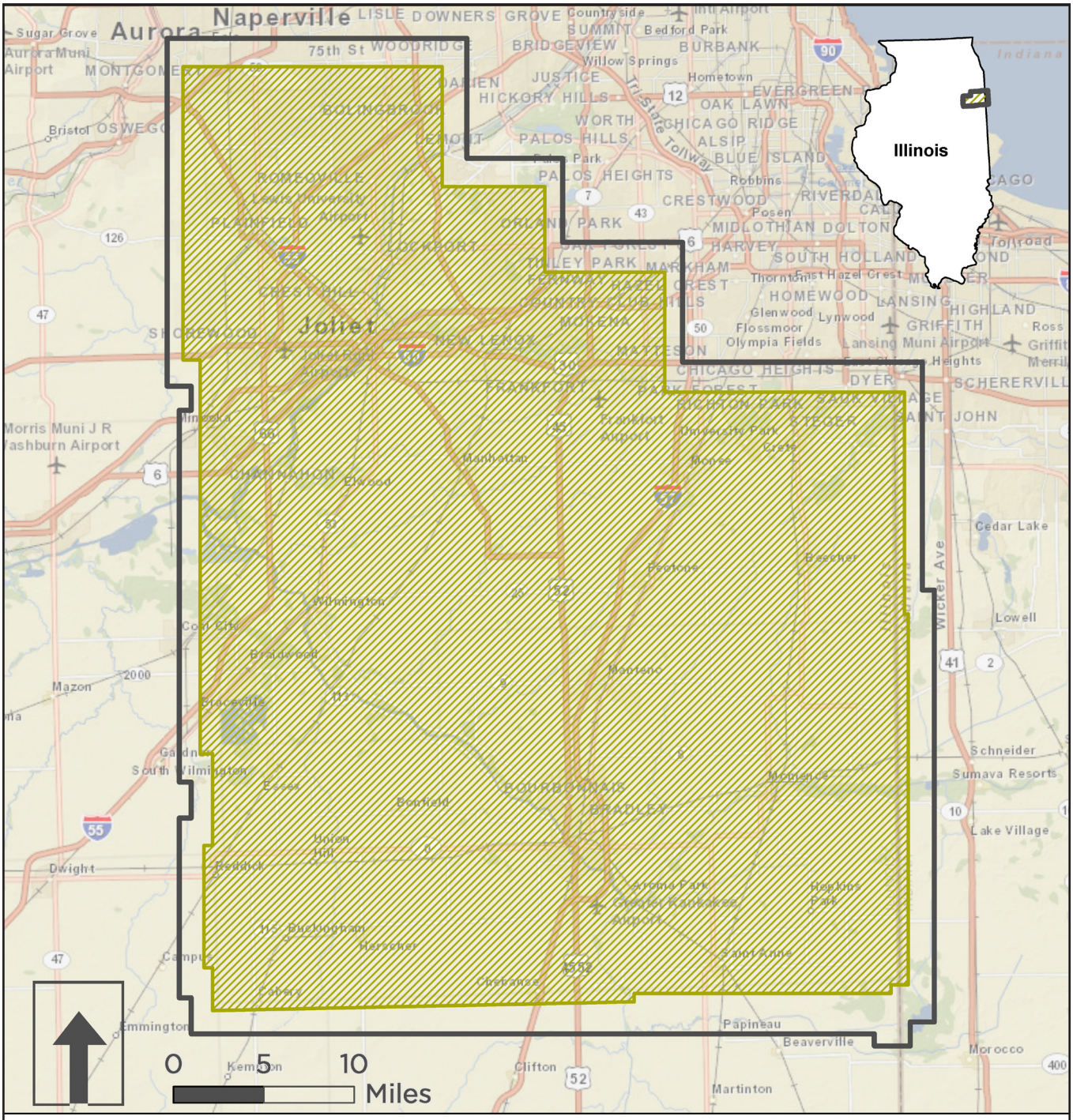
LiDAR data acquisition for complete coverage of the project occurred between April 5th and April 19th, 2014. Data collection was completed in eleven (11) flight missions totaling one hundred forty-nine (149) flight lines, including cross flights.

1.5 Project Scope

Data acquired with aircraft and LiDAR sensor operated by Quantum Spatial, Inc. is high accuracy LiDAR topographic data and is complete for the surface of Will County. The project area is approximately 922 square miles.

As documented in the Task Order, collected data was to achieve a Fundamental Vertical Accuracy (FVA) of 18.13cm (0.59 ft) at a 95% confidence level, and have an RSME 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.

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



WILL COUNTY LIDAR SURVEY PROJECT OVERVIEW

Will County LiDAR Project Area

Will County

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.

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 April 5th and April 19th, 2014. Data from the eleven (11) flight missions are included in the project.

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 eleven (11) 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.

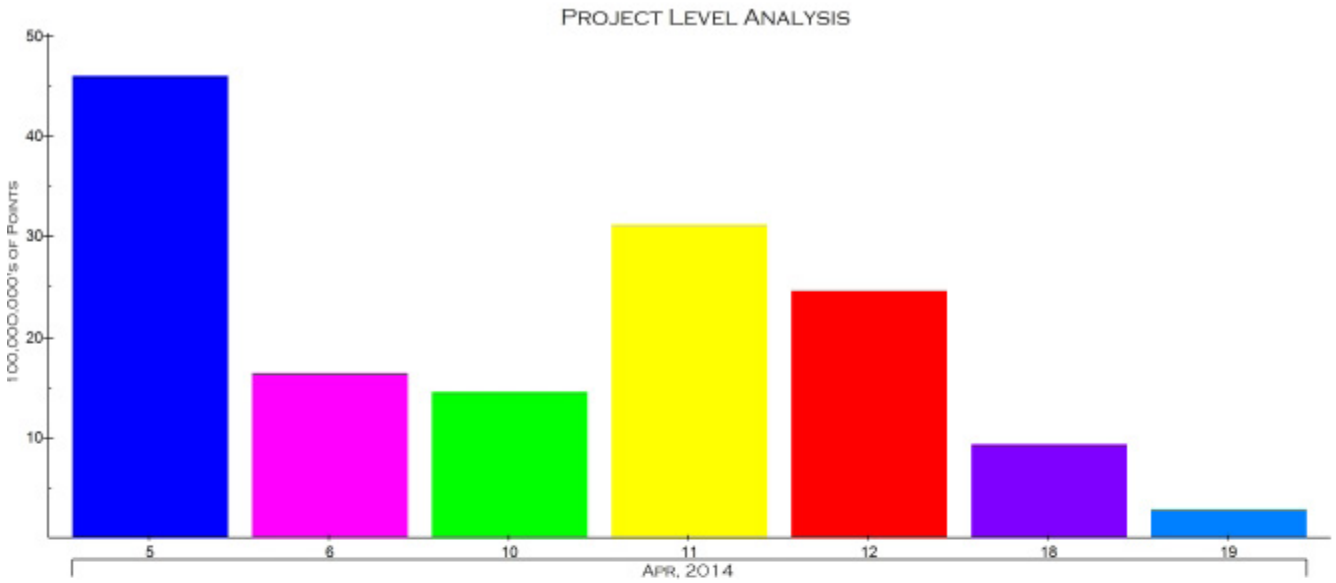
A Leica ALS70 sensor was used on board a fixed-wing aircraft. Airborne GPS and IMU position and trajectory data of the LiDAR sensor were also acquired during the time of flight.

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 (usually two) cross flights. The cross flights were flown perpendicular to the planned flight lines and their was data used in the in-situ calibration of the sensor.

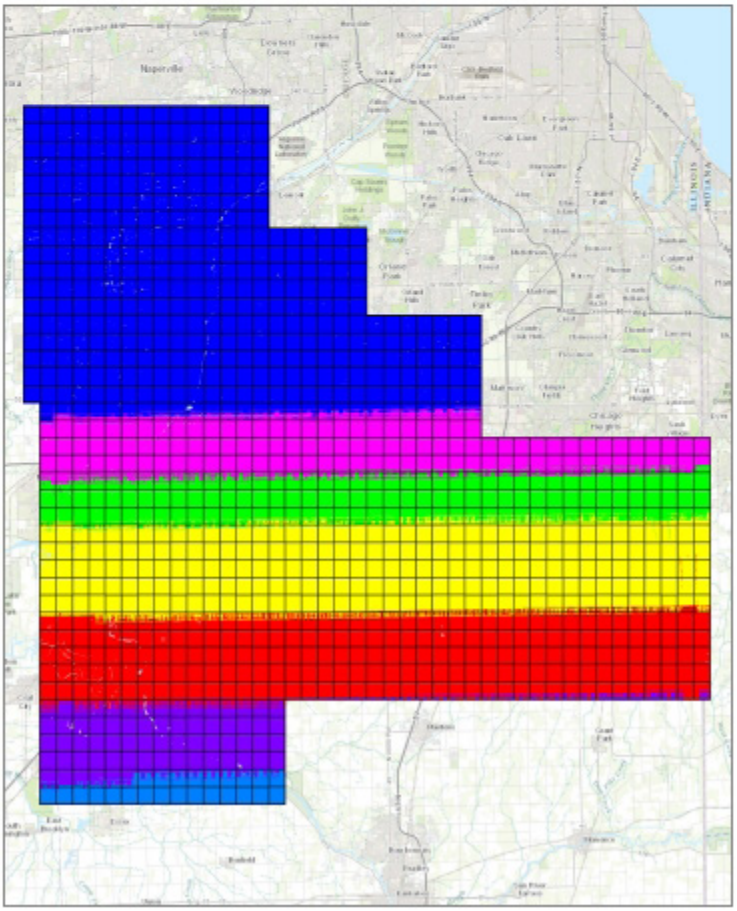
Table 3.0: Acquisition Parameters
1 point per square meter (ppsm)

Sensor Type	Leica ALS - 70
Sensor ID	SN7161
Field of View	+/- 20 degrees
Flying Height (Above Ground Level)	1,900 meters
Pulse Rate Frequency	273 kHz
Scan Angle (degrees)	40 degrees
Ground Speed	150 kts
Targeted Pulse Density	1.0 ppsm
Minimum Overlap	55%

Image 3.3a: Swaths for 1 point per square meter (ppsm) data, colored by mission date.



APRIL, 2014			
Day	Key	# of Points	% of Overall
5		4,588,103,230	31.9%
6		1,631,847,113	11.4%
10		1,447,011,675	10.1%
11		3,077,665,857	21.4%
12		2,442,648,291	17.0%
18		915,959,751	6.4%
19		270,531,069	1.9%



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

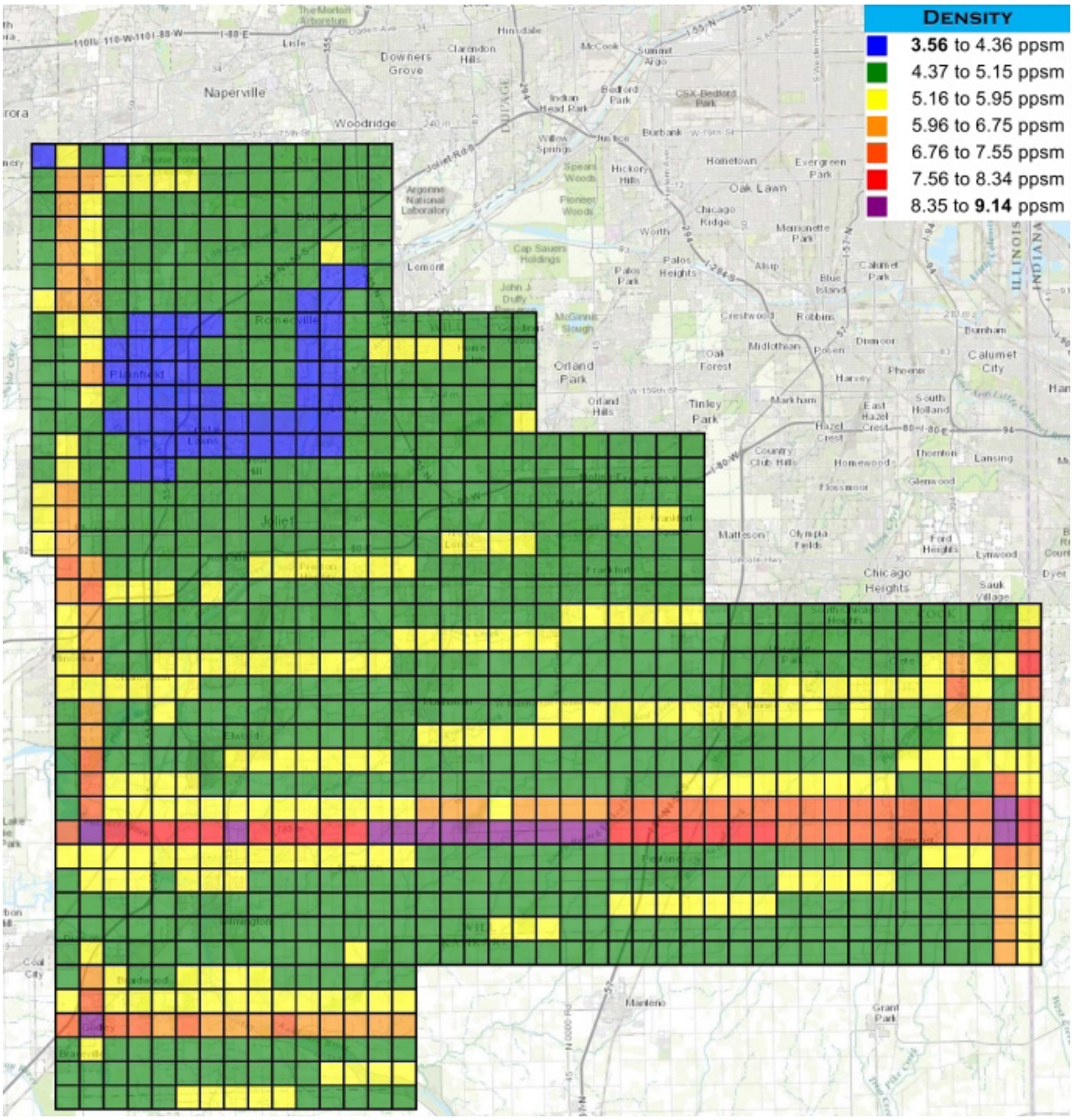
Table 5.1 LiDAR Calibration Steps	Software Used
Resolve GPS kinematic corrections for aircraft position and aligns all source data by time and filters. Smoothes the data, and provides a trajectory file indicating the latitude, longitude, ellipsoidal height, roll, pitch and heading of the scanner at intervals 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 flight-line to flightline alignment is assessed. 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.

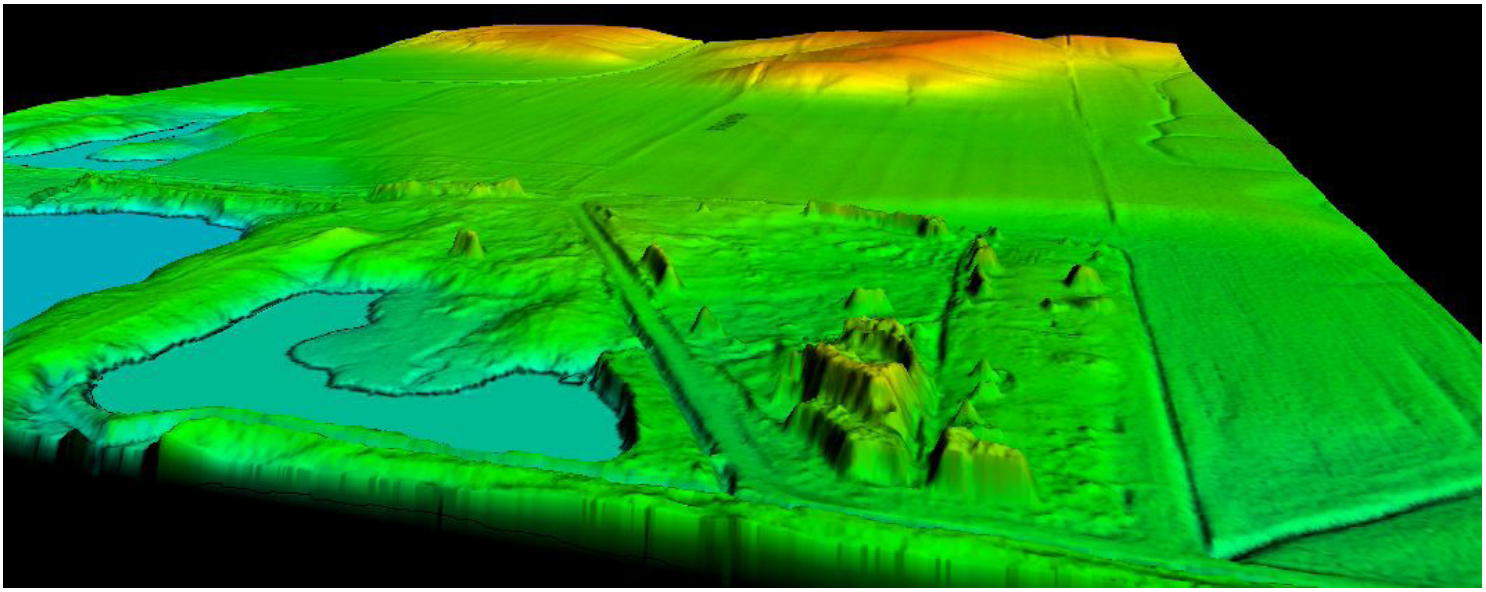
Image 5.2b: Point density analysis



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 ninety seven (97) control points collected for the project as described in Section 4, acquired from May 13th to May 15th, 2014.

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.

The Fundamental Vertical Accuracy (FVA) of the LAS data achieved 12.25 cm at a 95% confidence level with an RMSE of 6.25 cm utilizing twenty (20) Open Terrain ground survey check points compared to a Triangulated Integrated Network (TIN) of the LiDAR points.

See attached "Final_Delivery_Report" and Section 10-Accuracy Assessment for details of the ground survey control data.

Table 5.1: FVA Data Compared to TIN

	Ground Cover Category	Number of Checkpoints	Result cm (ft.)
FVA	Open Terrain	20	12.25 cm (0.40 ft.)
RMSEz	Open Terrain	20	6.25 cm (0.21 ft.)

The Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA) results are in the following table. Ground survey check points made in various ground cover categories are compared to Digital Elevation Models (DEM) derived from the LiDAR data.

Table 5.2: Accuracy Results

	Ground Cover Category	Number of Checkpoints	Result cm (ft.)
FVA	Open Terrain	20	12.25 cm (0.40 ft.)
CVA	All Categories	97	17.55 cm (0.53 ft.)
SVA	Urban	18	14.29 cm (0.47 ft.)
SVA	Tall Grass	20	15.76 cm (0.52 ft.)
SVA	Brush	20	19.10 cm (0.63 ft.)
SVA	Forest	19	14.29 cm (0.47 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 5,000 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)

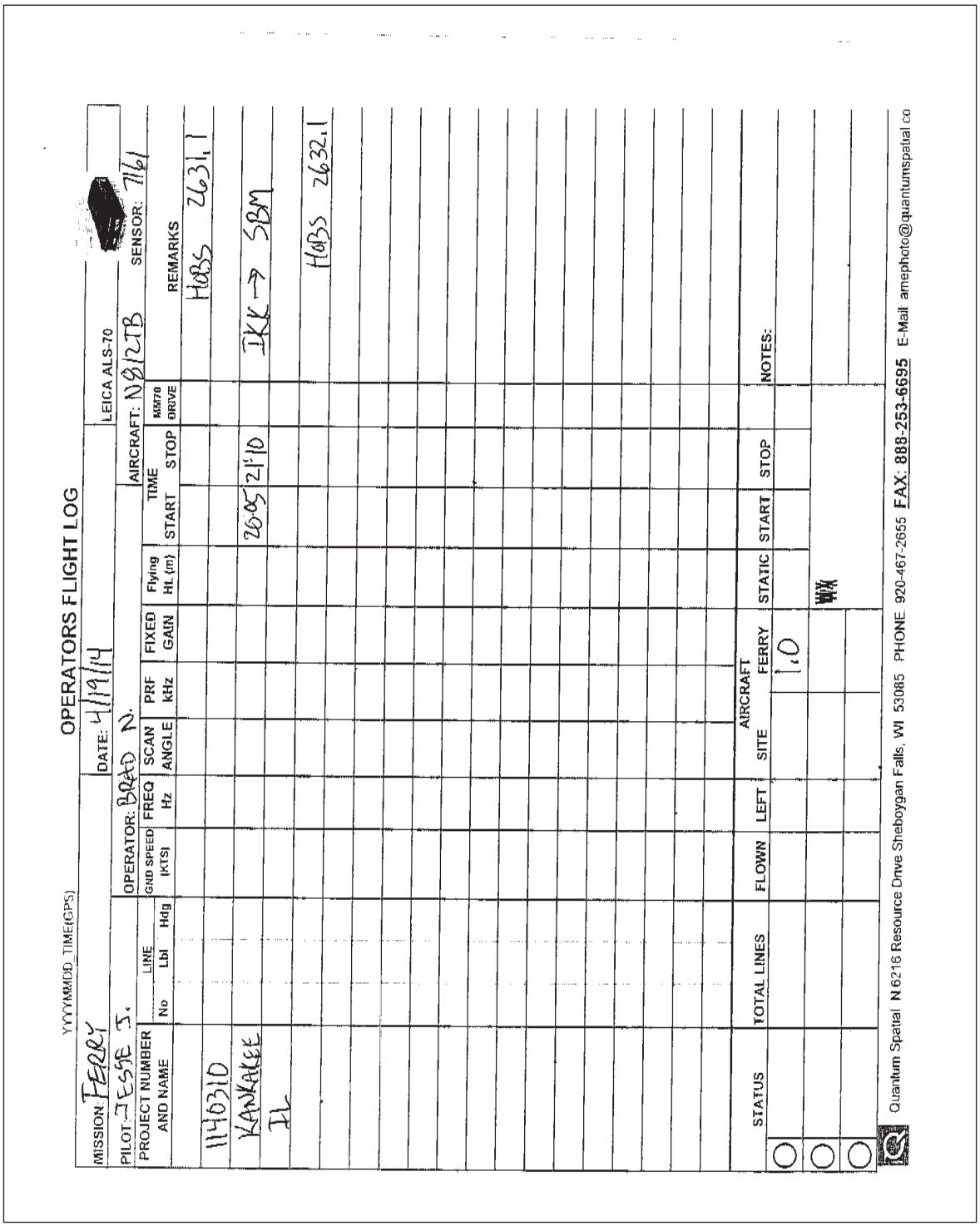
USGS-compliant metadata for delivered products

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

Image 7.1 a: Mission Ferry



OPERATORS FLIGHT LOG

YYYYMMDD_TIME(GPS)

MISSION: FERRY | DATE: 4/19/14 | LEICA ALS-70

PILOT: JESSE S. | OPERATOR: BRAD N. | AIRCRAFT: N9812TB | SENSOR: ALS

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
1140310 KANKAKEE IL													HOBS 26311
										20:05	21:10		IK → SBM
													HOBS 26321

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
○					1.0				
○						WX			
○									

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

YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140405_145031 | DATE: 4/5/14 | 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
140310												036	HOBS 5186.7
WILL COUNTY IL										13:00	14:00		SBM → BOLT C56 5187.6
				150	41	40	274		7090	15:00			C56 → SITE
140405_151630	461	001	270	155					7190	15:16	15:21		NNW WINDS 20 KNOTS
140405_152426	462	002	90	155					7170	15:24	15:29		
140405_153240	463	003	270	150					7170	15:32	15:37		
140405_154013	464	004	90	153					7170	15:40	15:45		
140405_154825	465	005	270	156					7150	15:48	15:53		
140405_155636	466	006	90	156					7175	15:56	16:01		
140405_160446	467	007	270	158					7170	16:05	16:09		
140405_161249	468	008	90	156					7180	16:13	16:18		
140405_162045	469	009	270	156					7185	16:21	16:26		
140405_162851	470	010	90	157					7190	16:29	16:34		ATC DENIES LOWER ALT
140405_163703	471	011	270	152					7180	16:37	16:42		VERIFY PIT AREA
140405_164521	472	012	90	152					7190	16:45	16:50		
140405_165329	473	013	270	152					7200	16:53	16:58		
140405_170145	474	014	90	151					7170	17:02	17:07		
140405_170946	475	015	270	155					7200	17:10	17:14		
140405_171757	476	016	90	154					7200	17:18	17:25		

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP
○		29		4.7	1.4			
○						WX		
○								

NOTES:
C56 BASE ON 14:45 OFF 24:20

PAGE 1/2

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

YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140405_145031 | DATE: 4/5/14 | 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
1140310												036	-CONTINUE-
WILL COUNTY IL				150	41	40	274		7014				
140405_172756	477	017	270	153					7180	17:28	17:35		
140405_173810	478	018	90	150					7200	17:38	17:45		
140405_174759	479	019	270	157					7200	17:48	17:55		
140405_175818	480	020	90	153					7190	17:58	18:05		
140405_180832	481	021	270	155					7200	18:08	18:15		
140405_181839	482	022	90	156					7190	18:18	18:25		
140405_182847	483	023	270	155					7200	18:29	18:35		
140405_183906	484	024	90	152					7200	18:39	18:46		1.9 mi. CLOUD
140405_184916	485	025	270	155					7215	18:49	18:56		
140405_185929	486	026	90	157					7200	18:59	19:06		
140405_191139	487	027	270	150					7220	19:11	19:21		
140405_192407	488	028	90	155					7215	19:24	19:33		
140405_193622	489	029	270	155					7225	19:36	19:45		
140405_194818	X-FLT		0	155					7250	19:48	19:53		CROSSFLIGHT
											20:10		SITE → C56
													HOBS 51928

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP		NOTES:
○		29		4.7	1.4					
○						WX				
○										PAGE 2/2

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

Image 7.1b: Mission 20140405_145031 (continued)

YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140405_210931 DATE: 4/5/14 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
1140310												036	HOBS 5192.8
WILL CONFIL										21:20			C56 → SITE
				150	41	40	274		6982				
140405_213015	490	030	270	156					7260	21:30	21:39		W WINDS 10 KNOTS
140405_214237	491	031	90	154					7250	21:42	21:51		
140405_215455	492	032	270	145					7070	21:55	22:04		
140405_220732	493	033	90	157					7060	22:07	22:16		
140405_221940	494	034	270	150					7080	22:19	22:28		
140405_223209	495	035	90	153					7080	22:32	22:41		
140405_224419	496	036	270	154					7085	22:44	22:53		
140405_225651	497	037	90	155					7080	22:57	23:06		
140405_230858	498	038	270	154					7085	23:09	23:18		
140405_232123	499	039	90	160					7070	23:21	23:30		
140405_233321	500	040	270	154					7080	23:33	23:42		
140405_234449	X	FLT	0	158					7090	23:45	2347		CROSSFLIGHT
											2405		SITE → C56
													HOBS 5195.5

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
○		11		2.3	0.4				
○						WX			
○									

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

YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

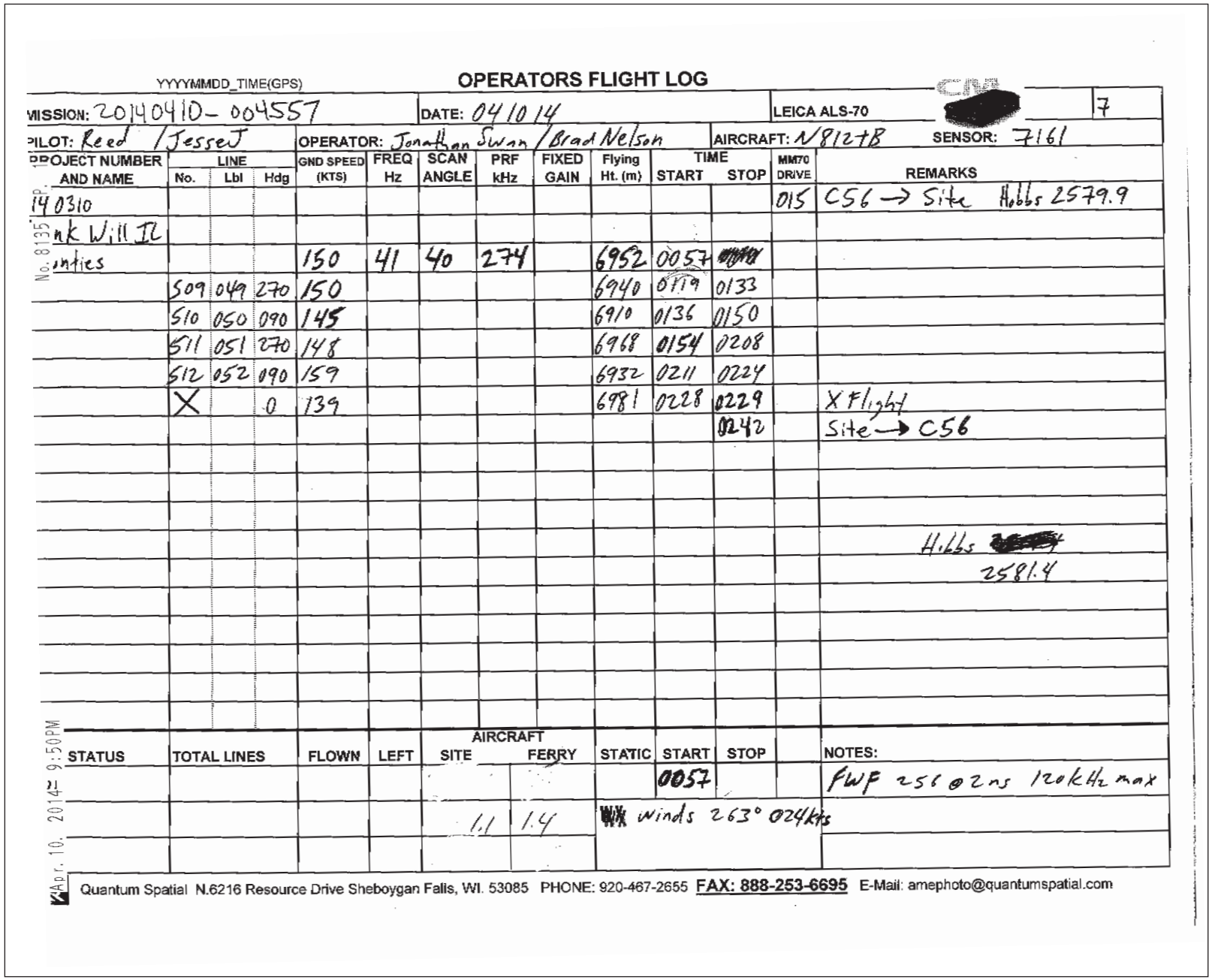
MISSION: 20140406-123119 | DATE: 4/6/14 | LEICA ALS-70

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
1140310												036	HOBS 5195.5
WILL COUNTY II				150	41	40	274		6827	12:40			C56 → SITE
140406-125559	501	041	270	150					6860	12:56	13:05		
140406-130756	502	042	90	156					6850	13:08	13:17		
140406-132402	503	043	270	155					6860	13:24	13:37		
140406-134041	504	044	90	156					6870	13:40	13:54		
140406-135701	505	045	270	150					6880	13:57	14:10		
140406-141332	506	046	90	153					6860	14:13	14:27		
140406-143008	507	047	270	150					6880	14:30	14:43		
140406-144621	X-	FLT	180	165					6860	14:46	14:48		CROSS FLIGHT
140406-145125	508	048	90	155					6860	14:51	15:05		
											15:15		SITE → C56 HOBS 5198.0
										15:30	16:25		C56 → SBM HOBS 5198.9

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP		NOTES:
○		8		2.2	1.2					
○						WX				
○										

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



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140410_004557 DATE: 04/10/14 LEICA ALS-70 [redacted] 7

PILOT: Reed / JesseJ OPERATOR: Jonathan Swan / Brad Nelson AIRCRAFT: N8127B SENSOR: 7161

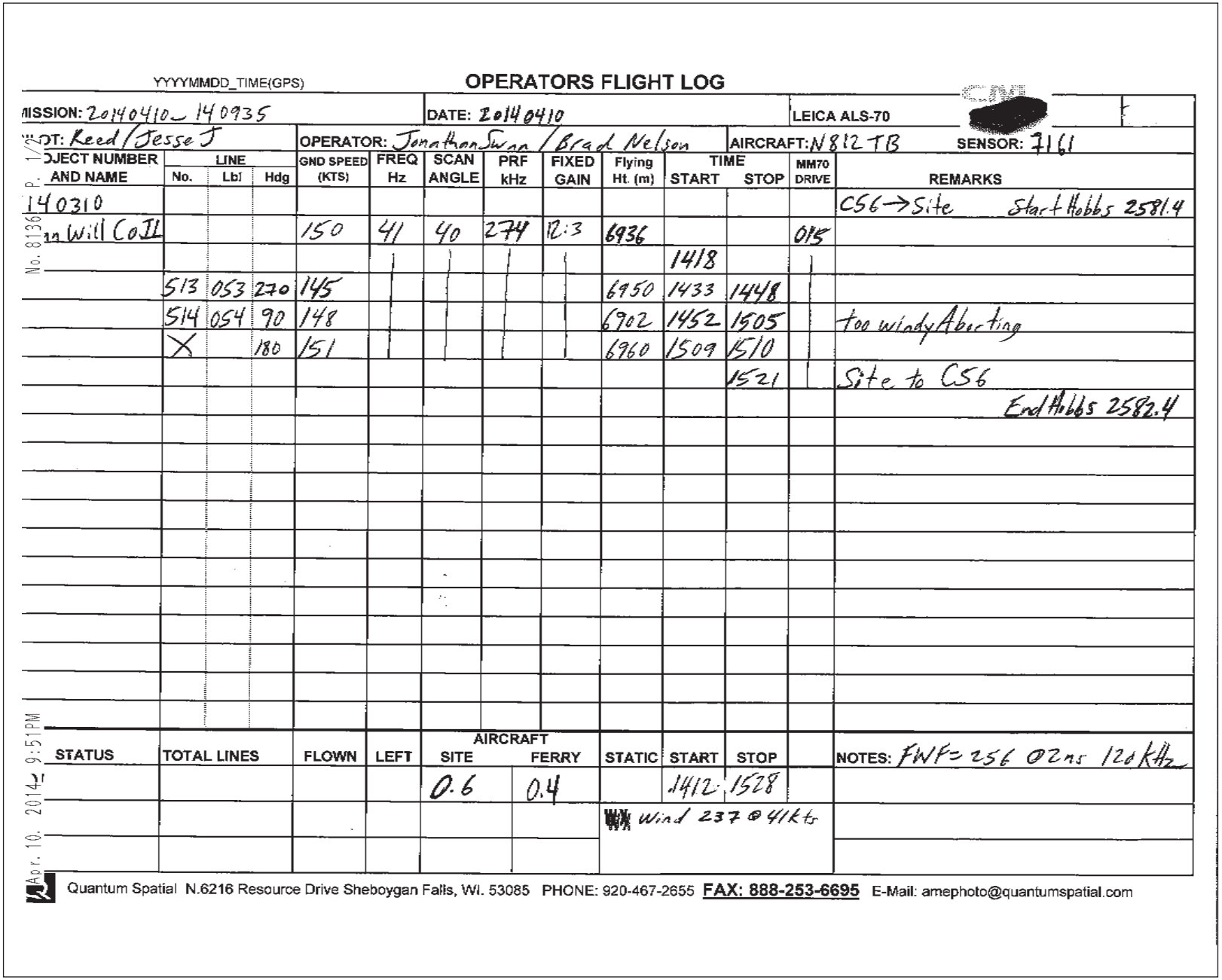
PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
140310												015	C56 → Site Hobbs 2579.9
nk Will IL													
inties				150	41	40	274		6952	0057	[redacted]		
	509	049	270	150					6940	0119	0133		
	510	050	090	145					6910	0136	0150		
	511	051	270	148					6968	0154	0208		
	512	052	090	159					6932	0211	0224		
	X		0	139					6981	0228	0229		X Flight
											0242		Site → C56
													Hobbs [redacted] 2581.4

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP		NOTES:
							0057			FWF 256@2ns 120kHz max
				1.1	1.4	Wx winds 263° 024kts				

Apr. 10, 2014 9:50PM

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

Image 7.1e: Mission 20140410_004557



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140410_140935 DATE: 20140410 LEICA ALS-70

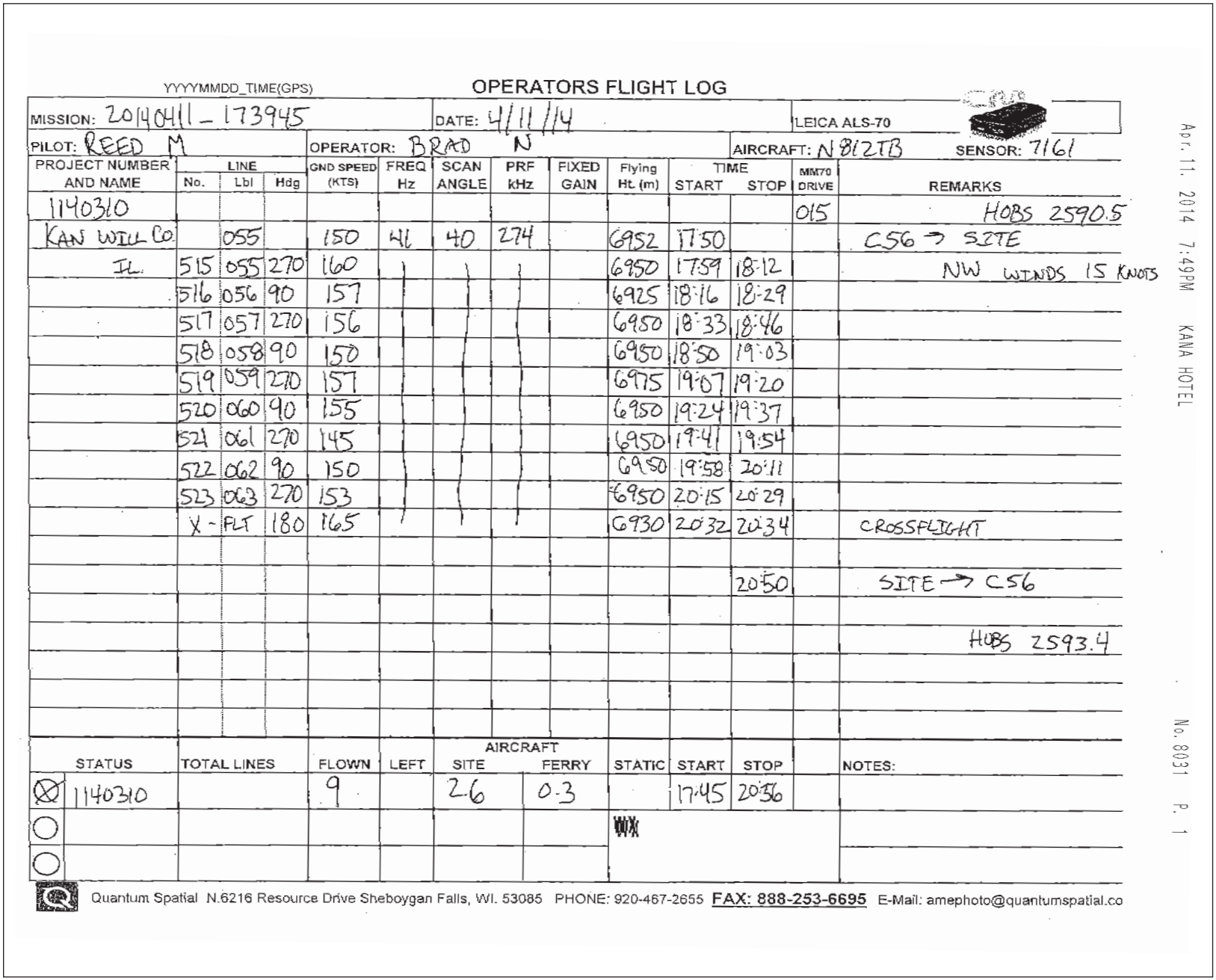
PROJECT: Reed/Jesse J OPERATOR: Jonathan Swan / Brad Nelson AIRCRAFT: N812TB SENSOR: 7161

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
140310													CS6→Site Start Hobbs 2581.4
Jan Will Coll				150	41	40	274	12:3	6936			015	
										1418			
	513	053	270	145					6950	1433	1448		
	514	054	90	148					6902	1452	1505		too windy Aborting
	X		180	151					6960	1509	1510		
											1521		Site to CS6
													End Hobbs 2582.4

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
				0.6	0.4		1412	1528	FWF=256 @2ns 120kHz
						WX Wind 237 @ 41kts			

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

Image 7.1f: Mission 20140410_140935



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140411_173945 DATE: 4/11/14 LEICA ALS-70

PILOT: REED M OPERATOR: BRAD N AIRCRAFT: N812TB SENSOR: 7161

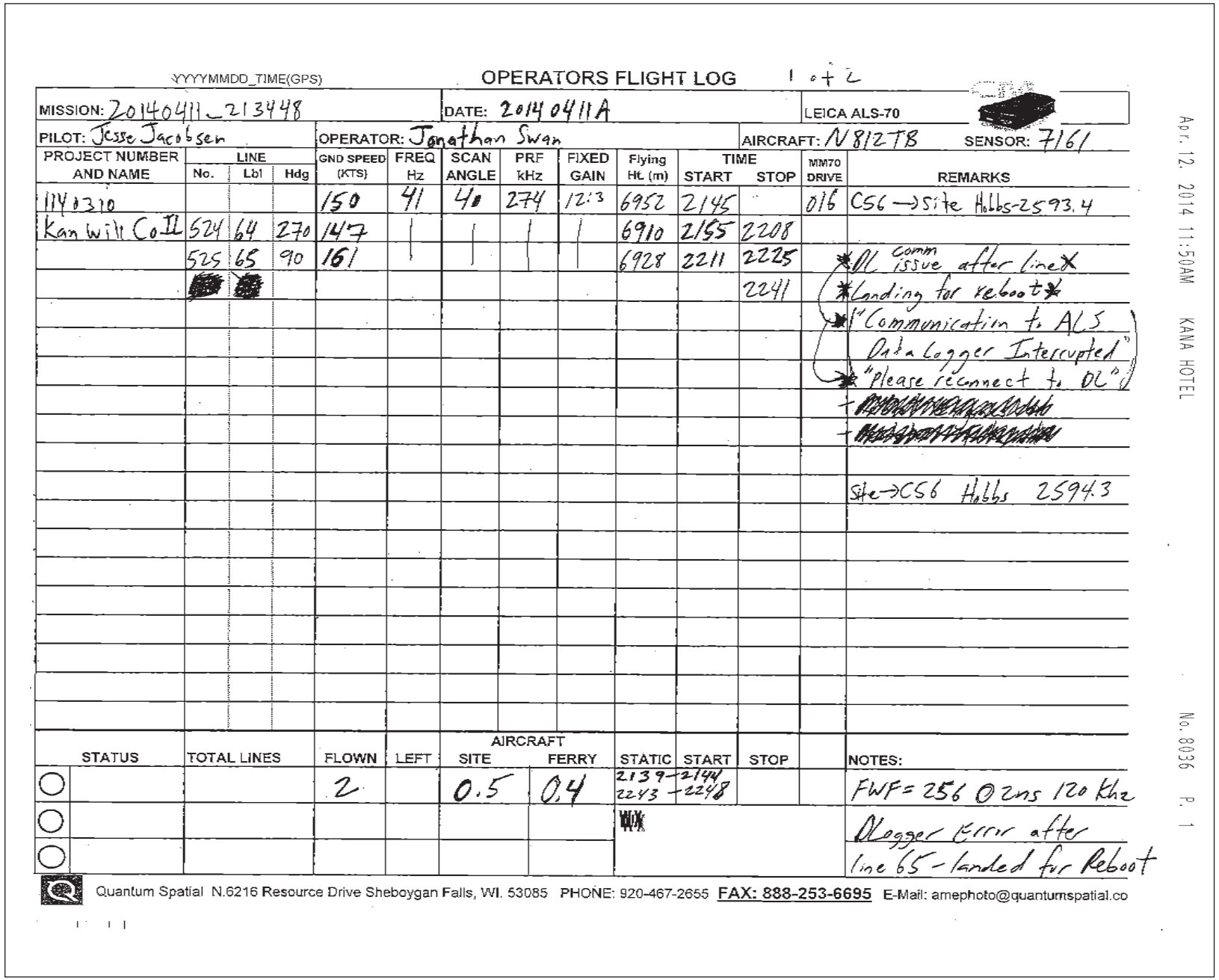
PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
1140310												015	HOBS 2590.5
KAN WILL CO		055		150	41	40	274		6952	17:50			C56 → SITE
IL	515	055	270	160					6950	17:59	18:12		NW WINDS 15 KNOTS
	516	056	90	157					6925	18:16	18:29		
	517	057	270	156					6950	18:33	18:46		
	518	058	90	150					6950	18:50	19:03		
	519	059	270	157					6975	19:07	19:20		
	520	060	90	155					6950	19:24	19:37		
	521	061	270	145					6950	19:41	19:54		
	522	062	90	150					6950	19:58	20:11		
	523	063	270	153					6950	20:15	20:29		
	X-FLT		180	165					6930	20:32	20:34		CROSSFLIGHT
											20:50		SITE → C56
													HOBS 2593.4

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
⊗ 1140310		9		2.6	0.3		17:45	20:56	
○						WX			
○									

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

Apr. 11. 2014 7:49PM KANA HOTEL No. 8031 P. 1

Image 7.1g: Mission 20140411_173945



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG 1 of 2

MISSION: 20140411_213448 DATE: 20140411A LEICA ALS-70

PILOT: Jesse Jacobsen OPERATOR: Jonathan Swan AIRCRAFT: N812TB SENSOR: 7161

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
1140310				150	41	40	274	12:3	6952	2145		016	CS6 → Site Hobbs-2593.4
Kan Will Co II	524	64	270	147	|	|	|	|	6910	2155	2208	
	525	65	90	161	|	|	|	|	6928	2211	2225	* OL comm issue after line X
	[redacted]	[redacted]										2241	* Landing for reboot *
													* "Communication to ALS Data Logger Interrupted"
													* "Please reconnect to OL" *
													[redacted]
													[redacted]
													Site → CS6 Hobbs 2594.3

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP		NOTES:
○		2		0.5	0.4	2139–2144 2243–2248				FWF = 256 @ 2ns 120 Khz
○						WX				Logger Error after
○										line 65 – landed for Reboot

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

Apr. 12. 2014 11:50AM KANA HOTEL No. 8036 P. 1

Image 7.1h: Mission 20140411_213448

YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG 2 of 2

MISSION: 20140411_225147 | DATE: 20140411 B | LEICA ALS-70

PILOT: Jesse J | OPERATOR: Jonathan S | AIRCRAFT: N812TB | SENSOR: 7161

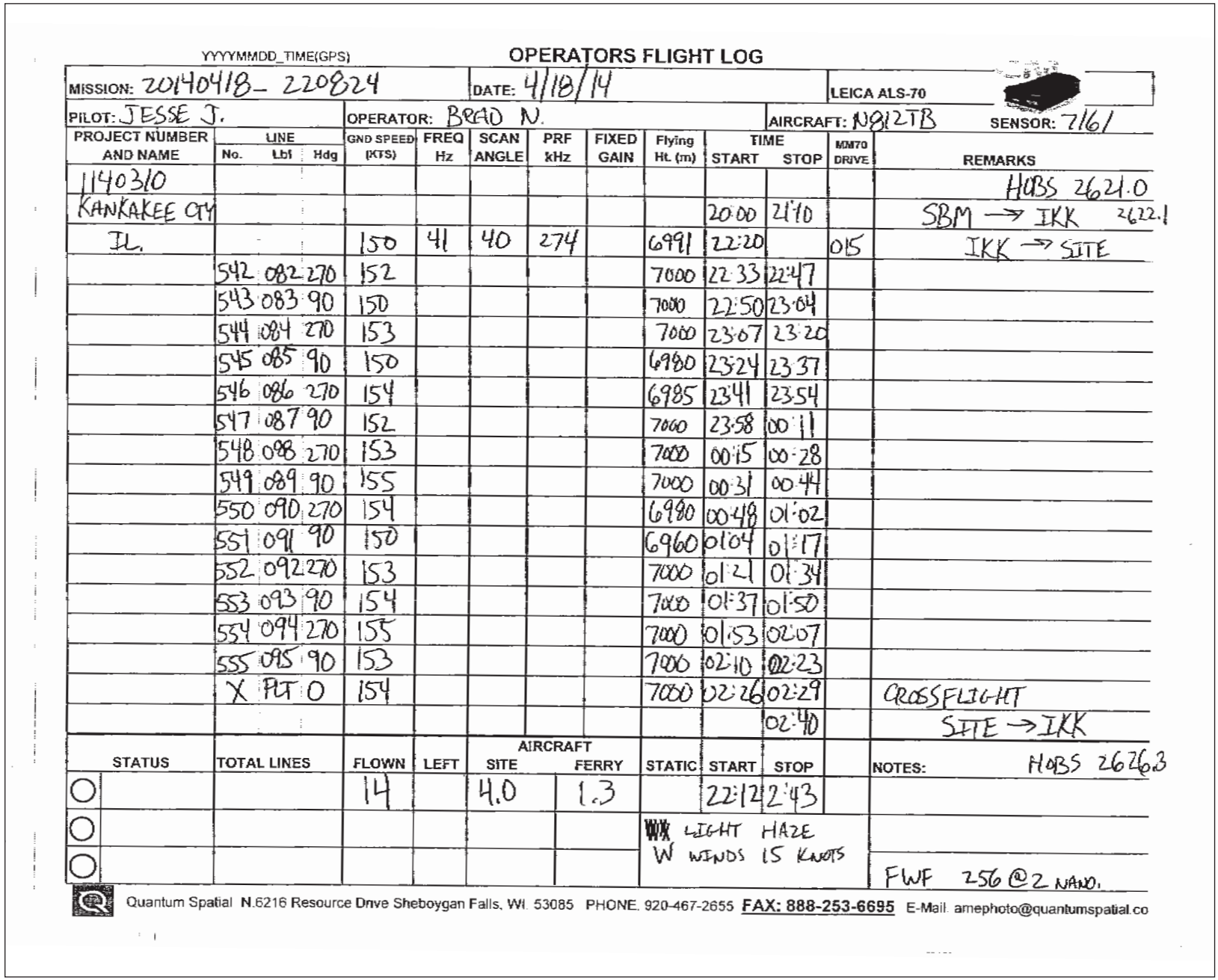
PROJECT NUMBER AND NAME	LINE No.	LINE Lbl	LINE Hdg	GND SPEED (KTS)	FREQ Hz	SCAN ANGLE	PRF kHz	FIXED GAIN	Flying Ht. (m)	TIME START	TIME STOP	MM70 DRIVE	REMARKS
1140310	[redacted]	[redacted]	[redacted]	150	41	40	274	12:3	6952	2306		016	CS6→Site Hobbs 2594.3
Kan Will Co IL	524	64	270	148					6926	2313	2327		Reflight
	525	65	90	155					6930	2330	2344		Reflight
	526	66	270	144					6962	2347	0001		
	527	67	90	153					6860	0003	0017		
	528	68	270	154					6902	0020	0034		
	529	69	90	153					6864	0037	0051		
	530	70	270	148					6899	0053	0107		
	531	71	90	157					6886	0111	0124		
	532	72	270	149					6923	0127	0141		
	533	73	90	152					6917	0144	0158		
	534	74	270	148					6914	0200	0214		
	535	75	90	157					6903	0218	0231		
	536	76	270	158					6931	0235	0248		
	537	77	90	155					6912	0251	0305		
	X	Flight		149					6937	0308	0311		UL001
											0322		Site→CS6 Hobbs 2598.5

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES
○		14		4.0	0.2		2259 0323	2304 0328	FWF=256@2ns 120kHz
○						[redacted]			
○									

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

Apr. 12. 2014 11:50AM KANA HOTEL No. 8036 P. 2

Image 7.1i: Mission 20140411_225147



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140418_220824 DATE: 4/18/14 LEICA ALS-70

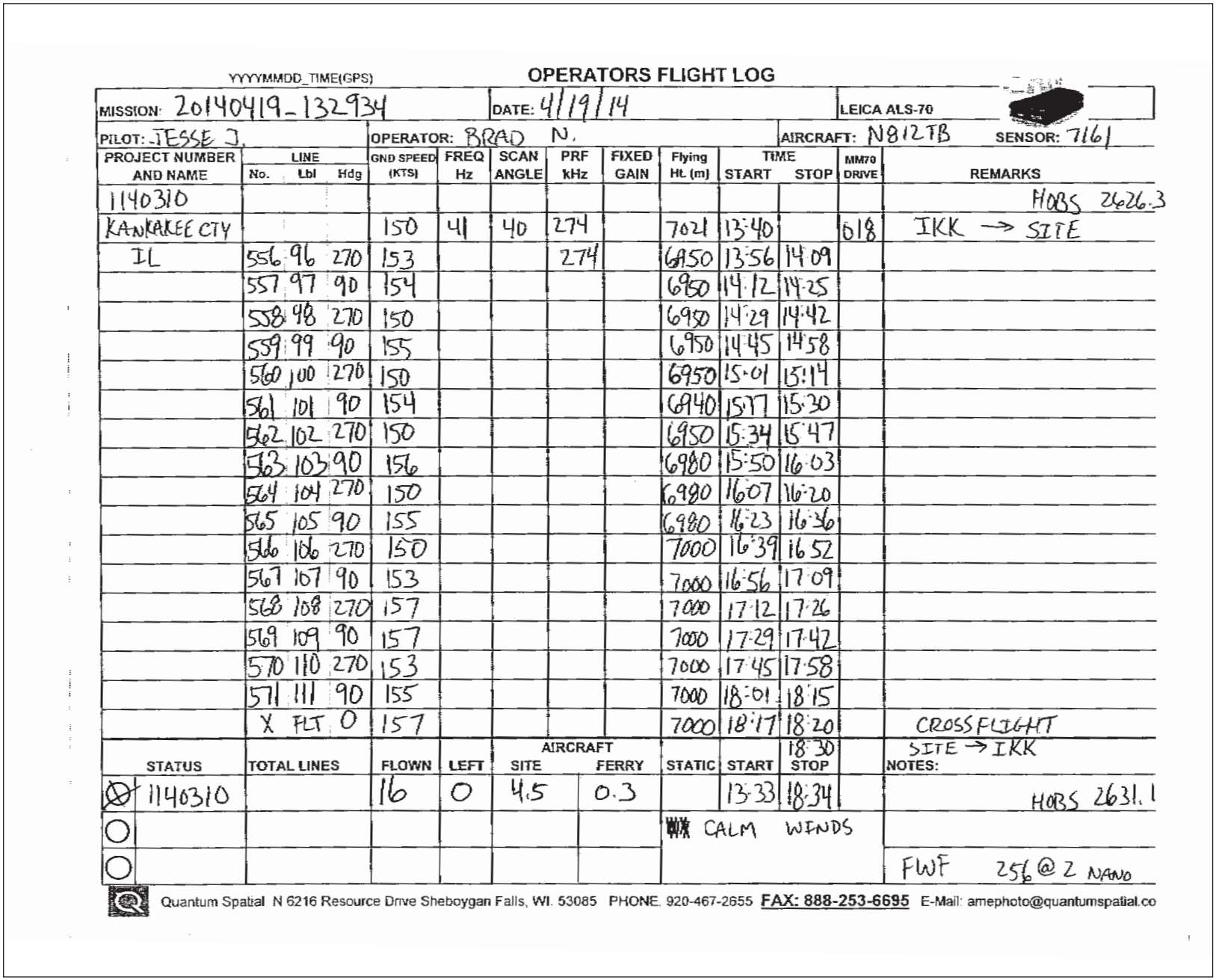
PILOT: JESSE J. OPERATOR: BRAD N. AIRCRAFT: N812TB SENSOR: 7161

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
1140310													HOBS 2621.0
KANKAKEE CTY										20:00	21:10		SBM → IKK 2622.1
IL.				150	41	40	274		6991	22:20		015	IKK → SITE
	542	082	270	152					7000	22:33	22:47		
	543	083	90	150					7000	22:50	23:04		
	544	084	270	153					7000	23:07	23:20		
	545	085	90	150					6980	23:24	23:37		
	546	086	270	154					6985	23:41	23:54		
	547	087	90	152					7000	23:58	00:11		
	548	088	270	153					7000	00:15	00:28		
	549	089	90	155					7000	00:31	00:44		
	550	090	270	154					6980	00:48	01:02		
	551	091	90	150					6960	01:04	01:17		
	552	092	270	153					7000	01:21	01:34		
	553	093	90	154					7000	01:37	01:50		
	554	094	270	155					7000	01:53	02:07		
	555	095	90	153					7006	02:10	02:23		
	X	PLT	0	154					7000	02:26	02:29		CROSSFLIGHT
											02:40		SITE → IKK

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES
○		14		4.0	1.3		22:12	2:43	HOBS 2676.3
○						WX LIGHT HAZE W WINDS 15 KNOTS			
○									FWF 256 @ 2 NAND.

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

Image 7.1j: Mission 20140418_220824



YYYYMMDD_TIME(GPS)

OPERATORS FLIGHT LOG

MISSION: 20140419_132934 DATE: 4/19/14 LEICA ALS-70

PILOT: JESSE J. OPERATOR: BRAD N. AIRCRAFT: N812TB SENSOR: 7161

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
1140310													HOBS 2626.3
KANKAKEE CTY				150	41	40	274		7021	13:40		618	IKK → SITE
IL	556	96	270	153			274		6950	13:56	14:09		
	557	97	90	154					6950	14:12	14:25		
	558	98	270	150					6950	14:29	14:42		
	559	99	90	155					6950	14:45	14:58		
	560	100	270	150					6950	15:01	15:14		
	561	101	90	154					6940	15:17	15:30		
	562	102	270	150					6950	15:34	15:47		
	563	103	90	156					6980	15:50	16:03		
	564	104	270	150					6980	16:07	16:20		
	565	105	90	155					6980	16:23	16:36		
	566	106	270	150					7000	16:39	16:52		
	567	107	90	153					7000	16:56	17:09		
	568	108	270	157					7000	17:12	17:26		
	569	109	90	157					7000	17:29	17:42		
	570	110	270	153					7000	17:45	17:58		
	571	111	90	155					7000	18:01	18:15		
	X	FLT	0	157					7000	18:17	18:20		CROSS FLIGHT
											18:30		SITE → IKK

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START	STOP	NOTES:
⊘ 1140310		16	0	4.5	0.3		13:33	18:34	HOBS 2631.1
○						CALM WINDS			
○									FWF 256 @ 2 NAND

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

Image 7.1k: Mission 20140419_132934

8 LiDAR GPS Processing Plots

Image 8.0a: PDOP Plot for mission 20140405_145031

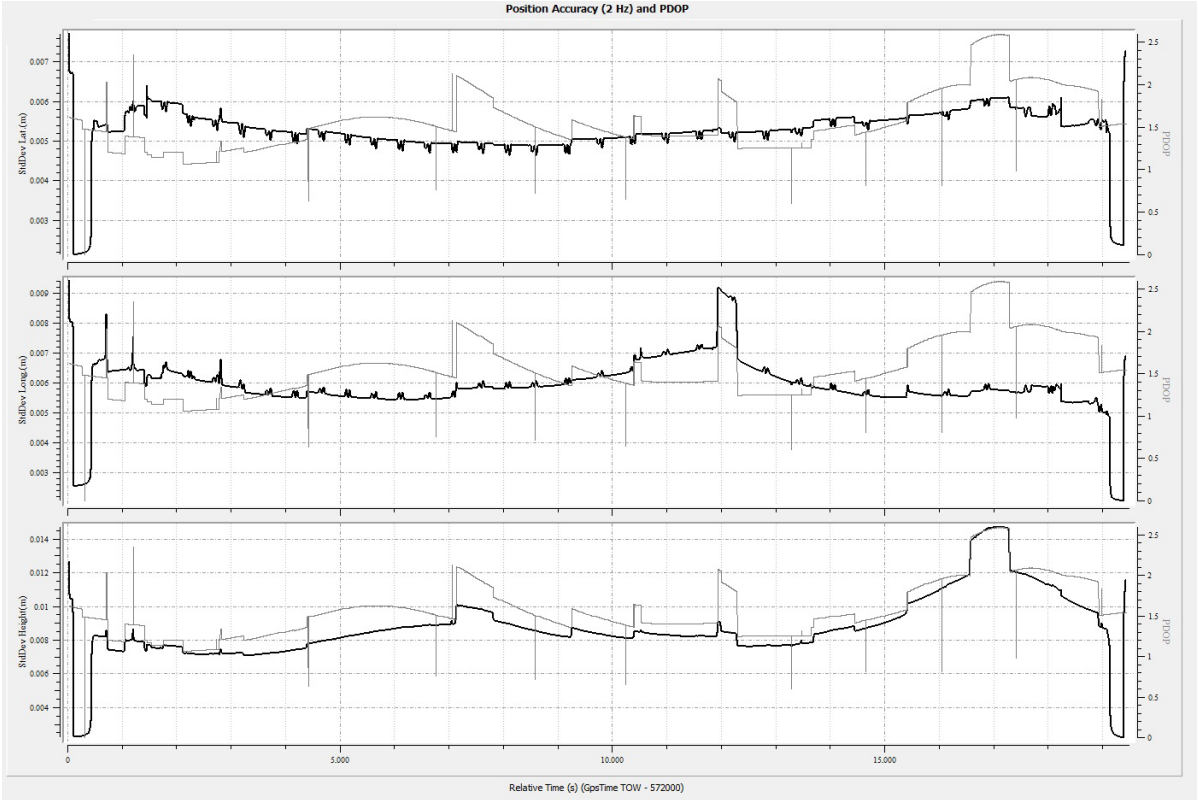


Image 8.0b: Separation Plot for mission 20140405_145031

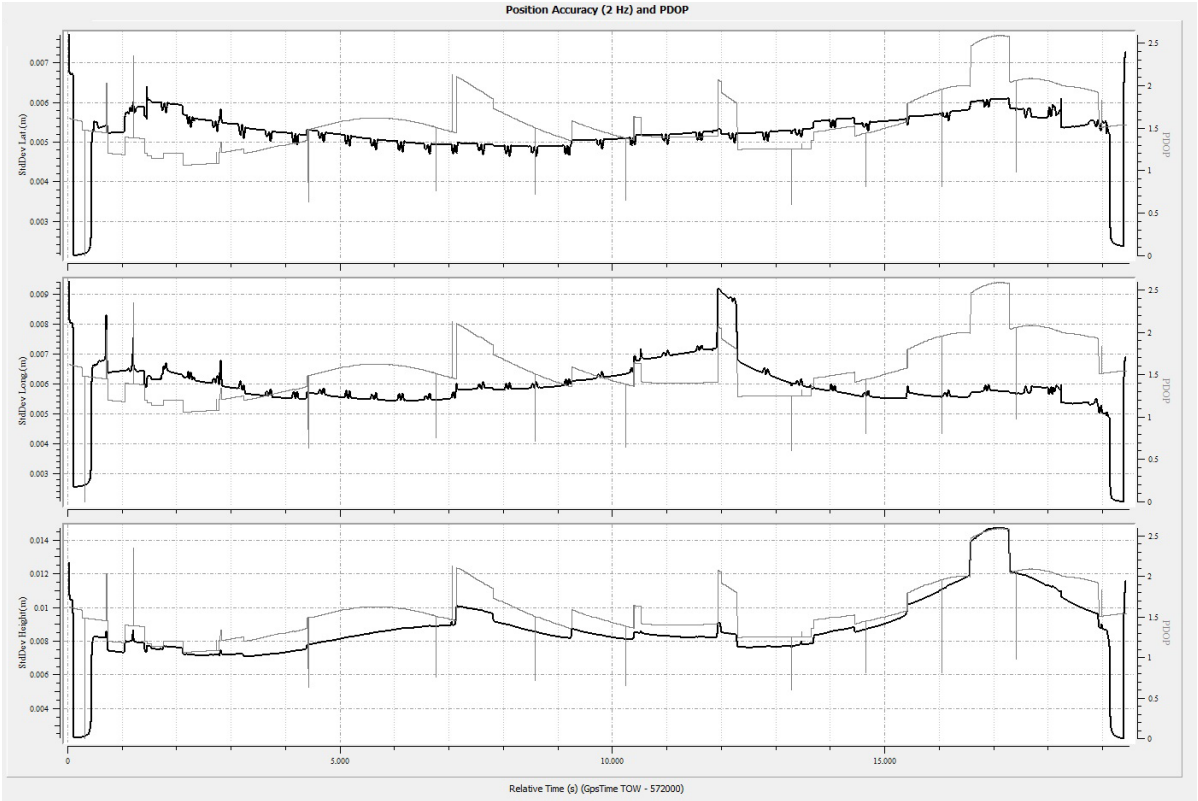


Image 8.0c: PDOP Plot for mission 20140405_210931

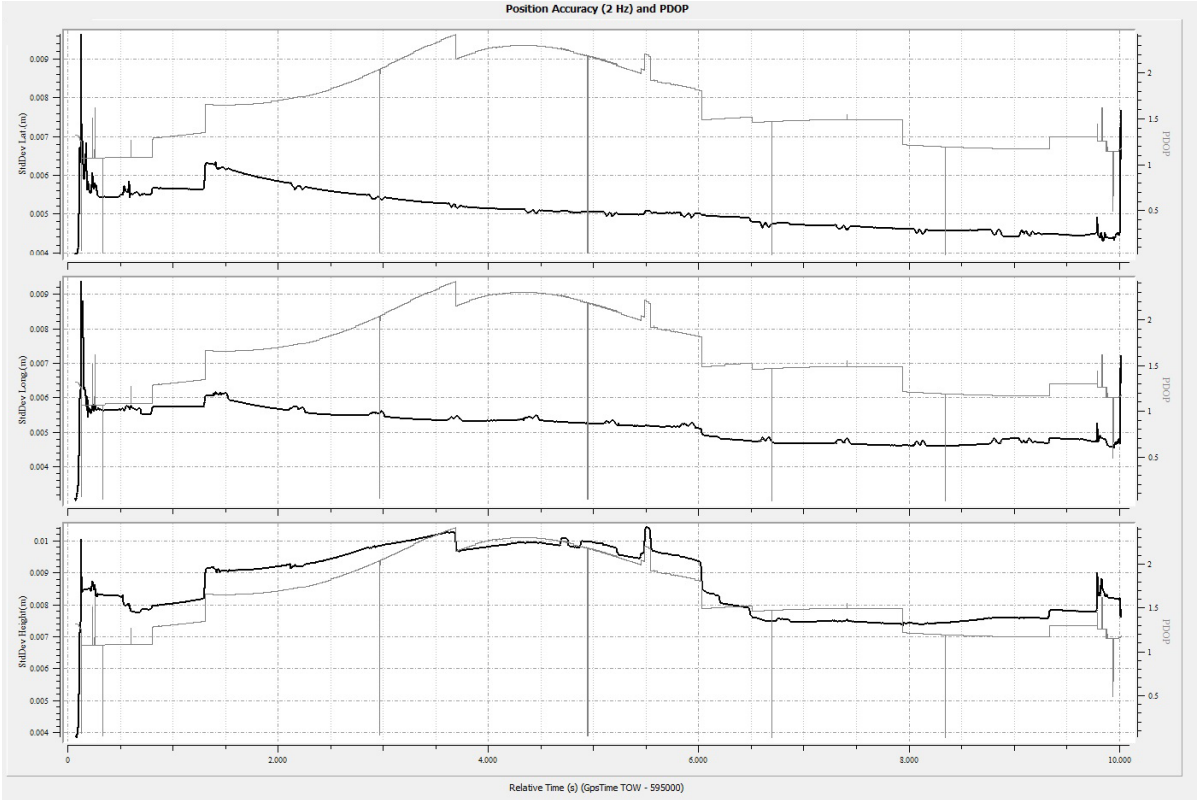


Image 8.0d: Separation Plot for mission 20140405_210931

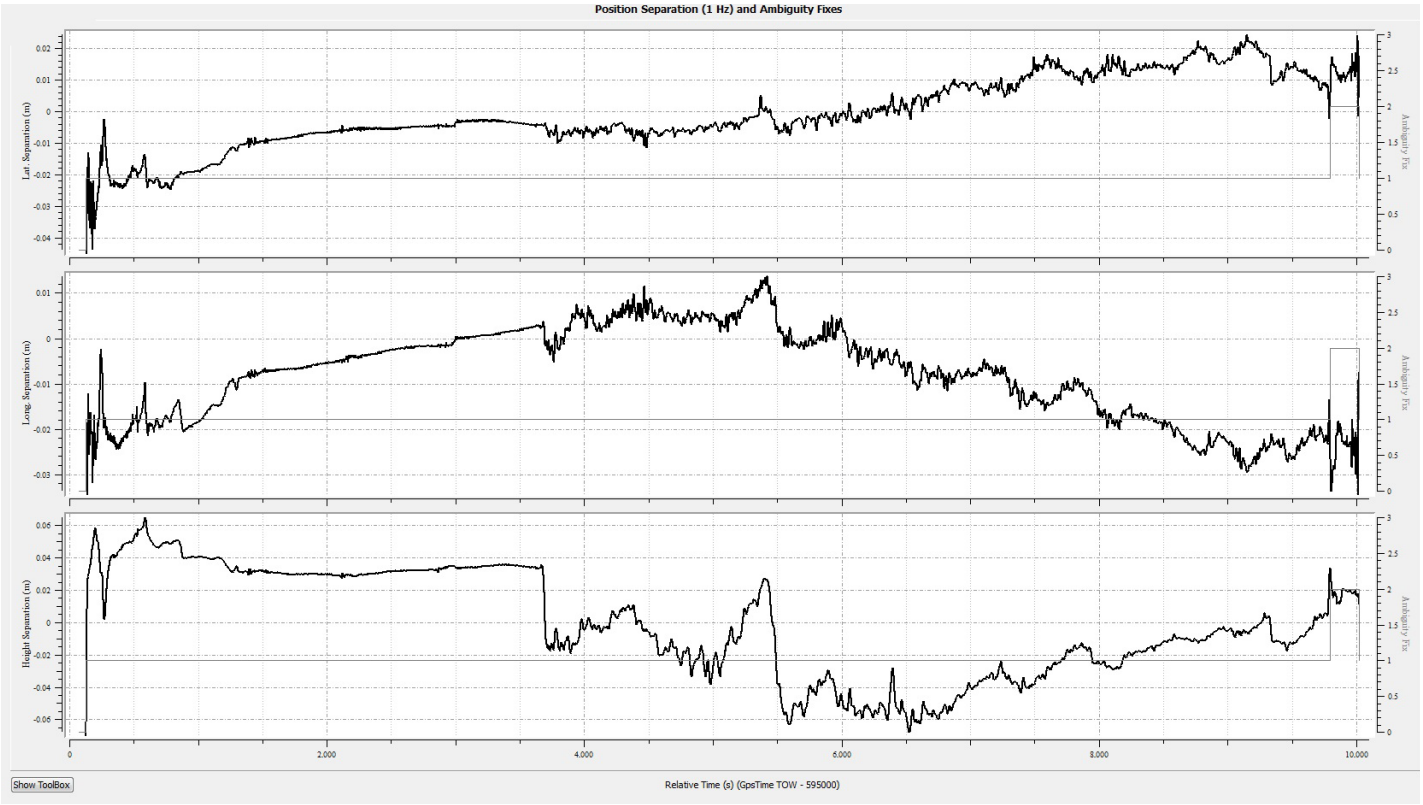


Image 8.0e: PDOP Plot for mission 20140406_123119

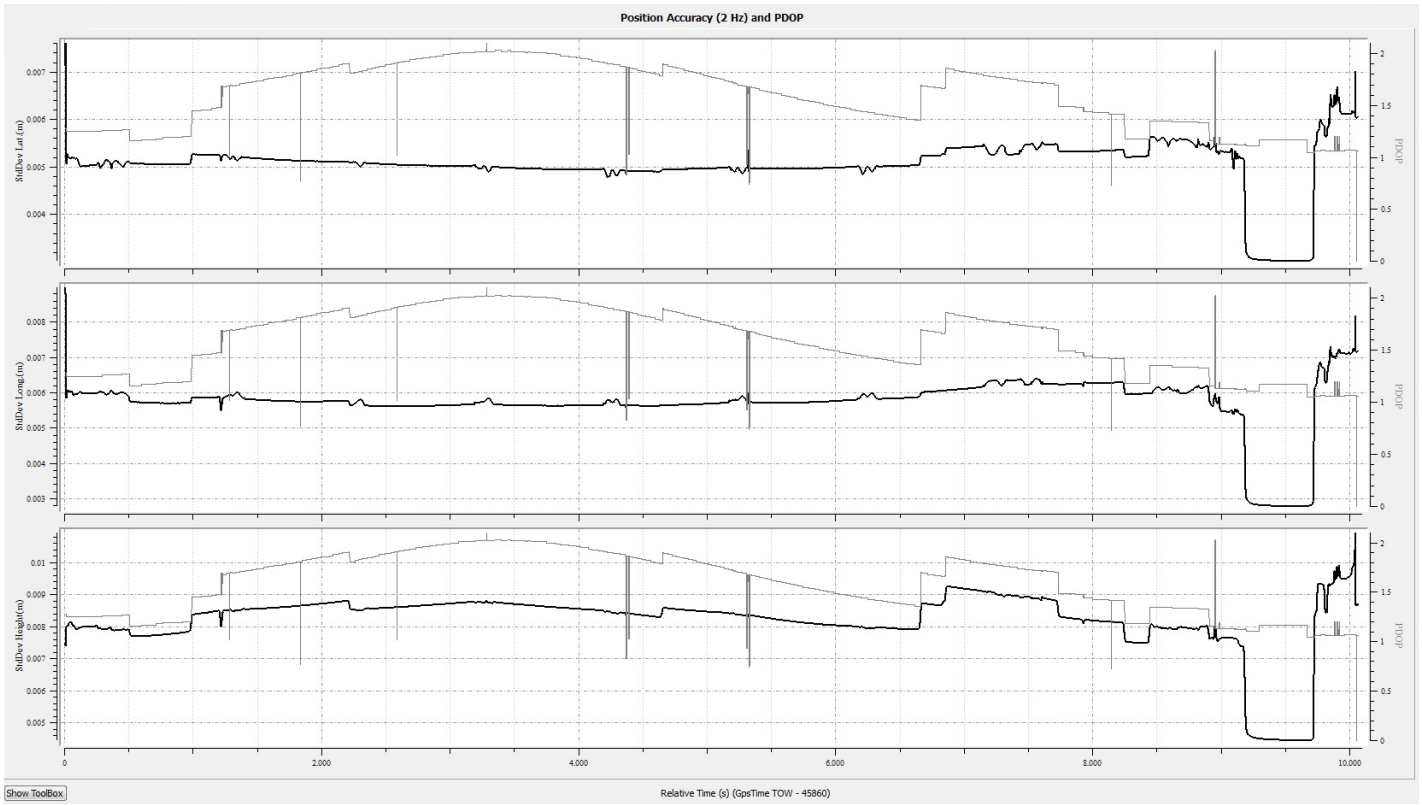


Image 8.0f: Separation Plot for mission 20140406_123119

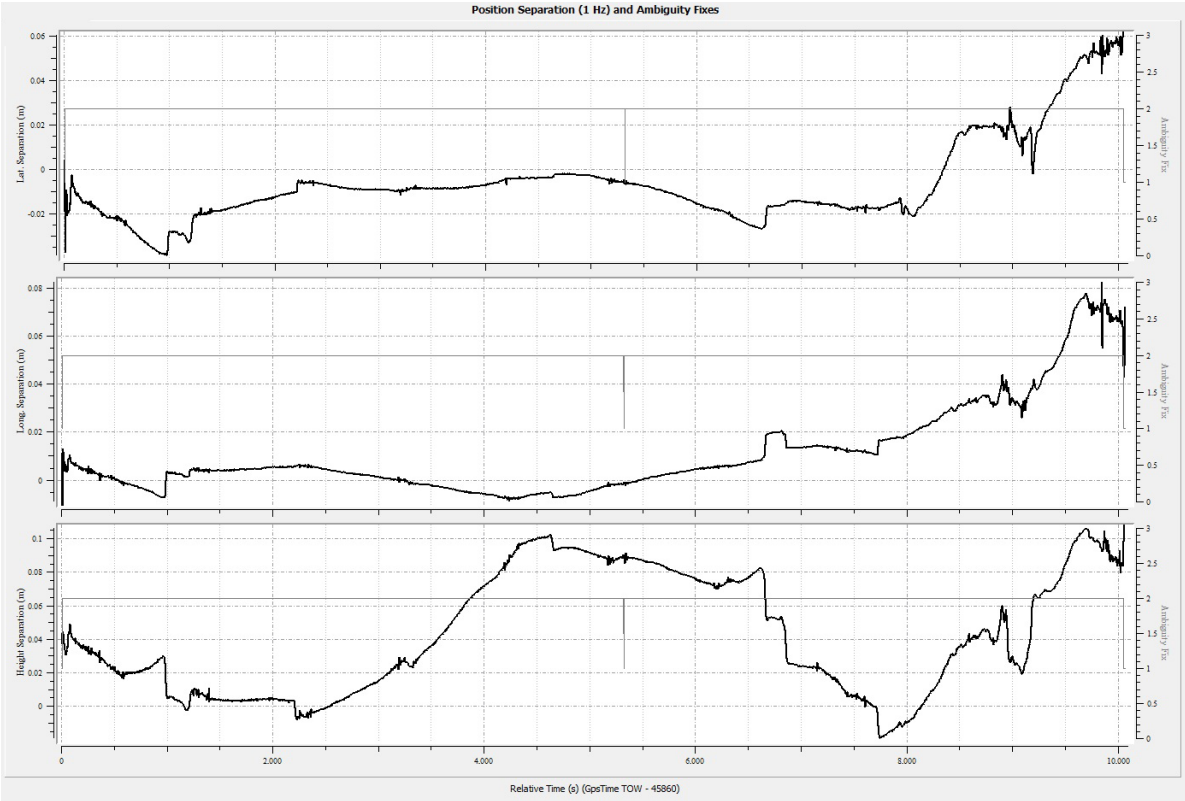


Image 8.0g: PDOP Plot for mission 20140410_004557

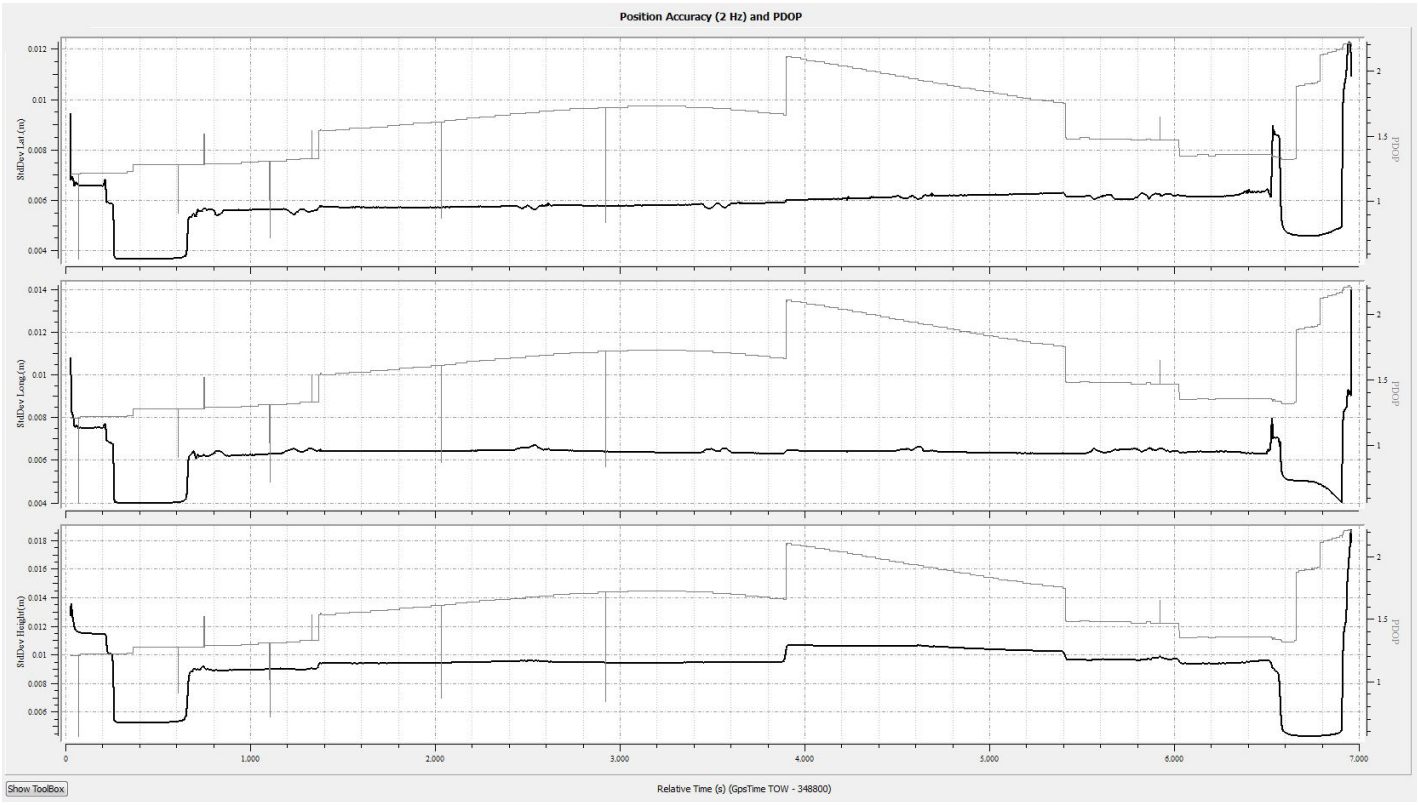


Image 8.0h: Separation Plot for mission 20140410_004557

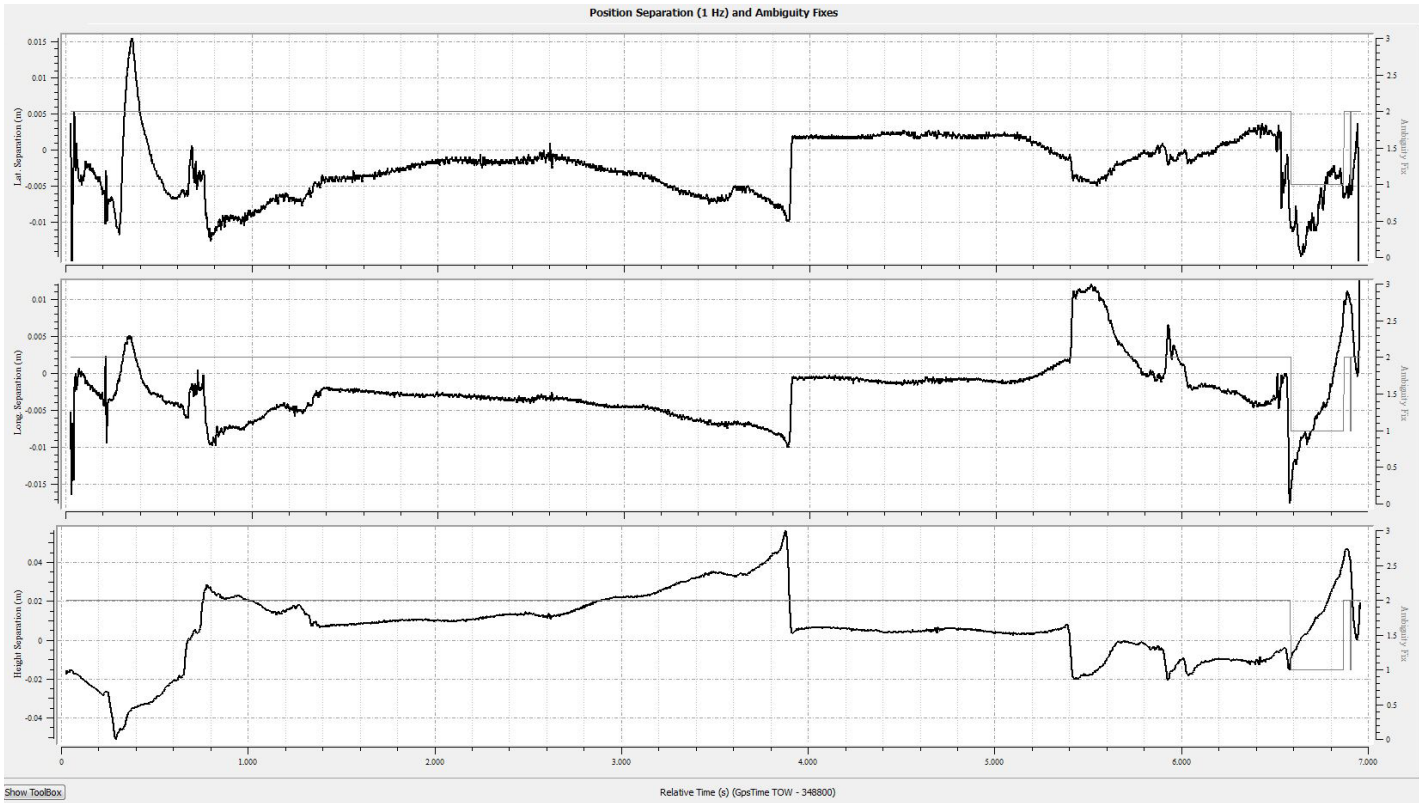


Image 8.0i: PDOP Plot for mission 20140410_140935

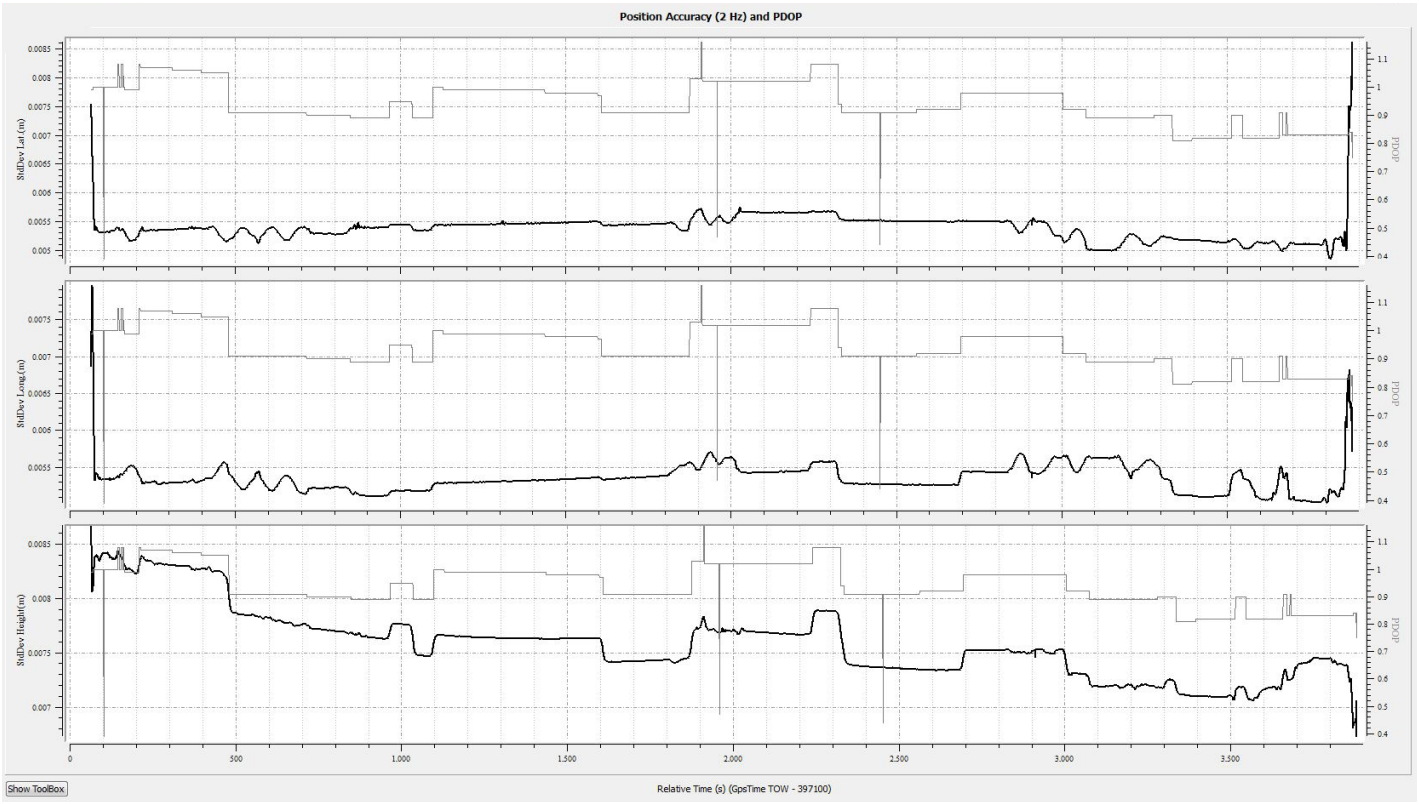


Image 8.0j: Separation Plot for mission 20140410_140935

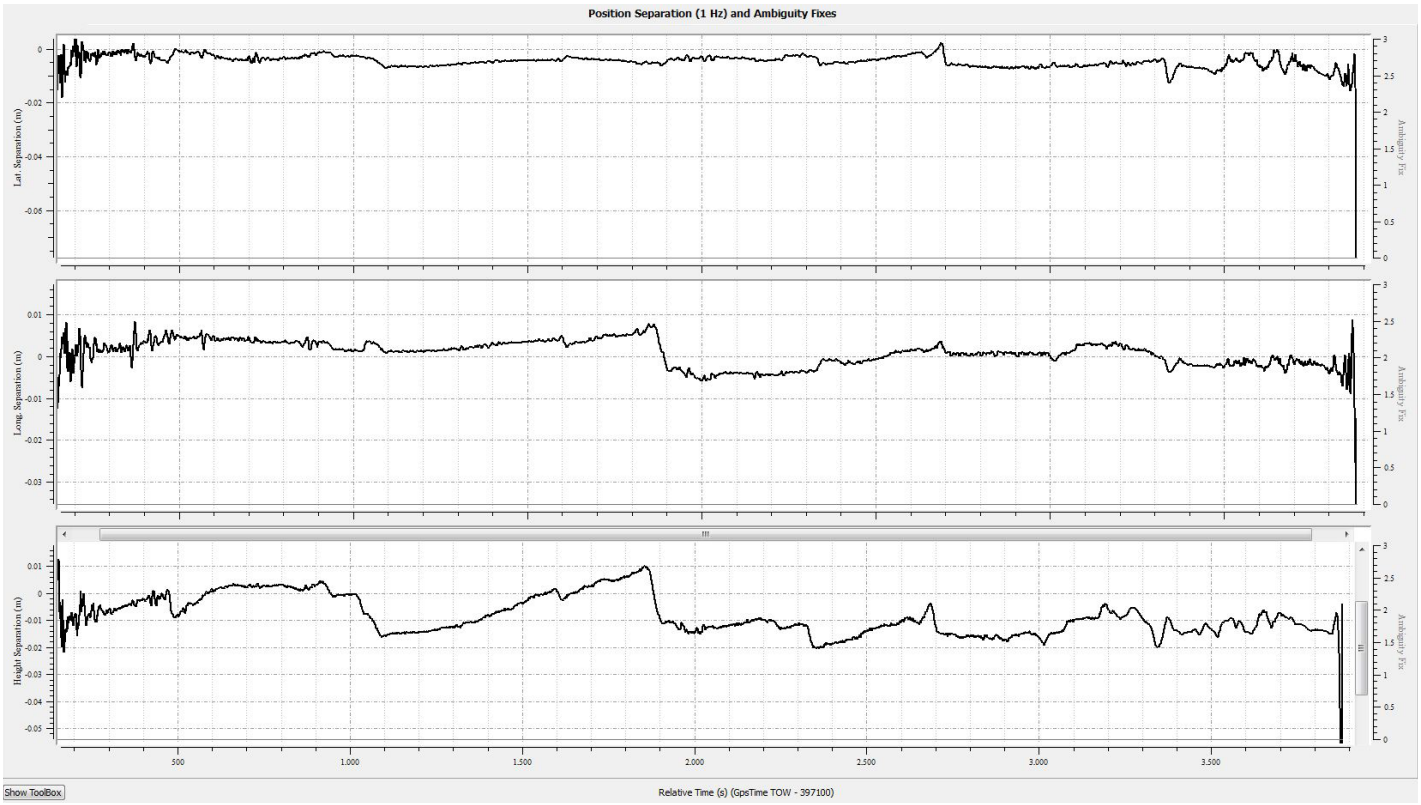


Image 8.0k: PDOP Plot for mission 20140411_173945

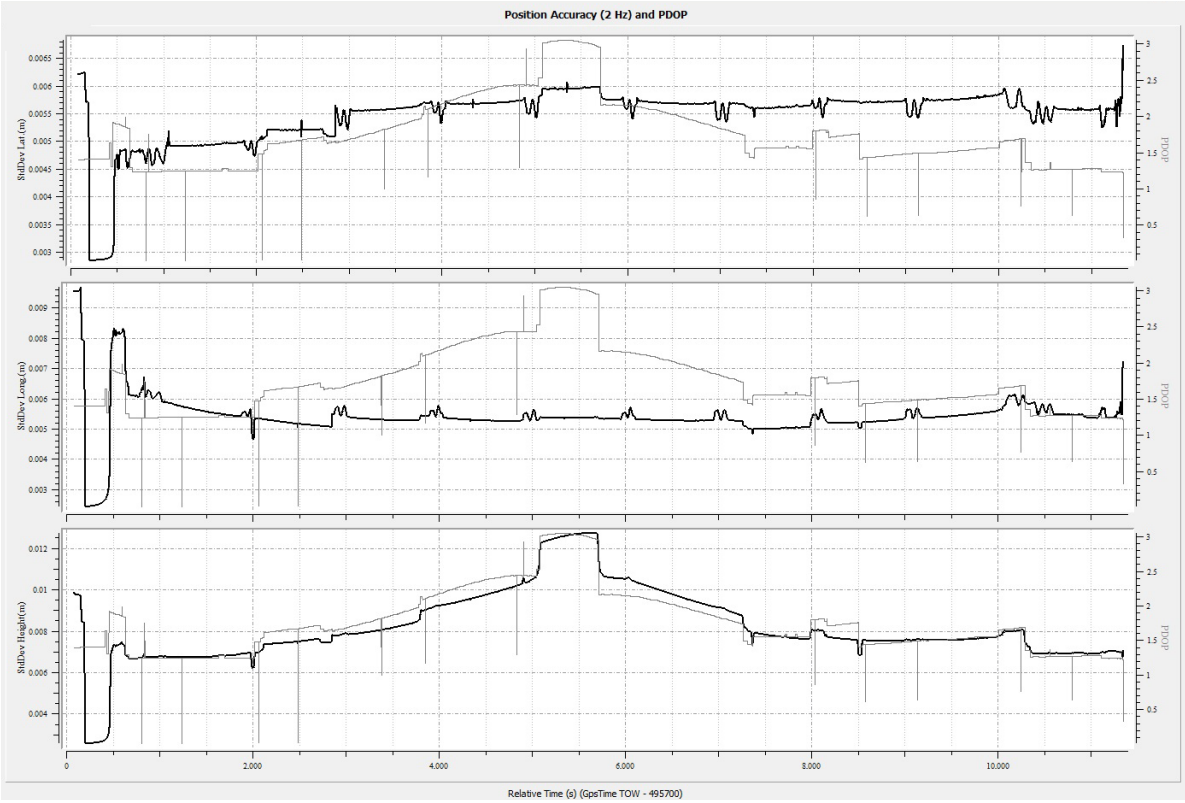


Image 8.0l: Separation Plot for mission 20140411_173945

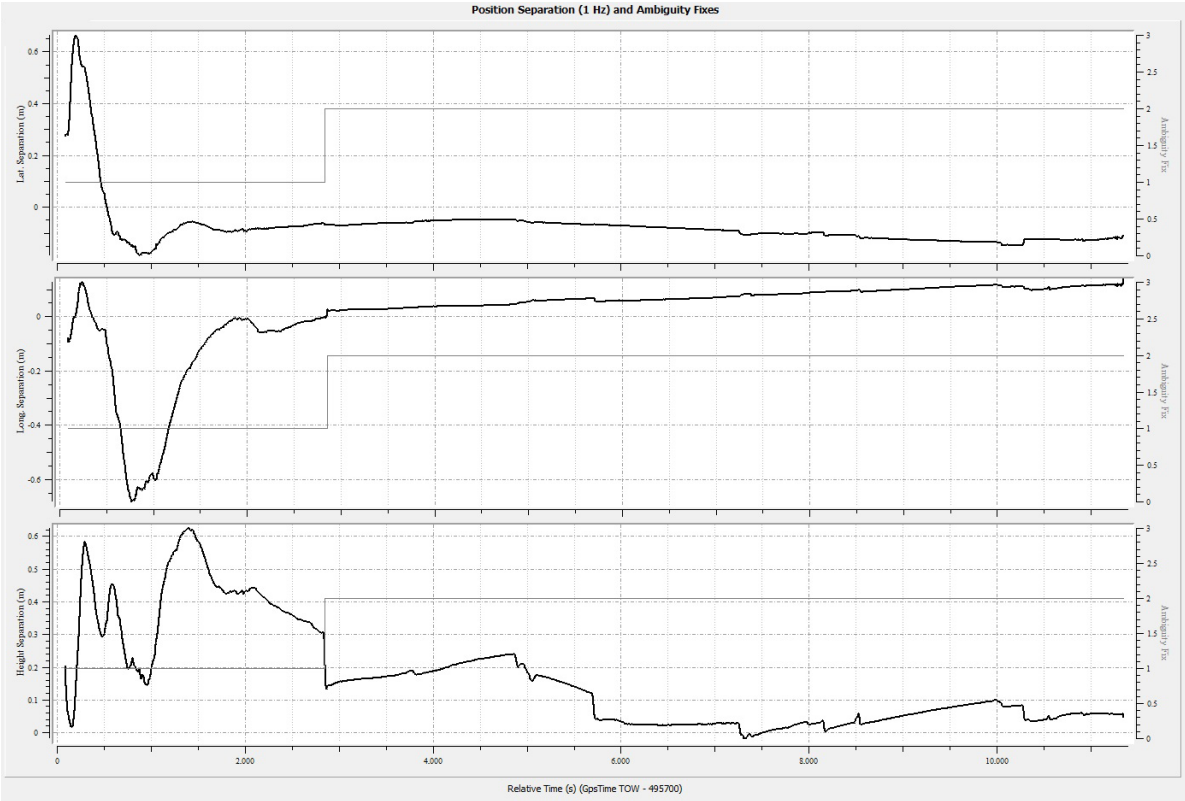


Image 8.0m: PDOP Plot for mission 20140411_213448

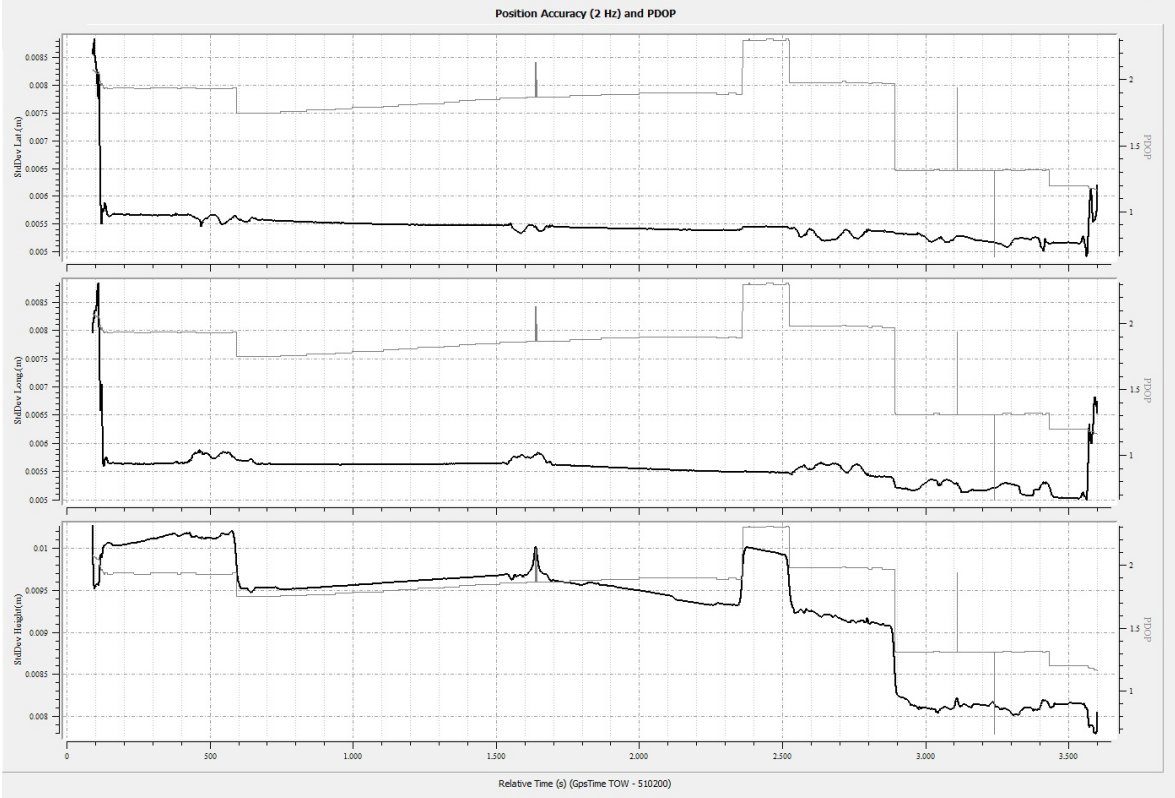


Image 8.0n: Separation Plot for mission 20140411_213448

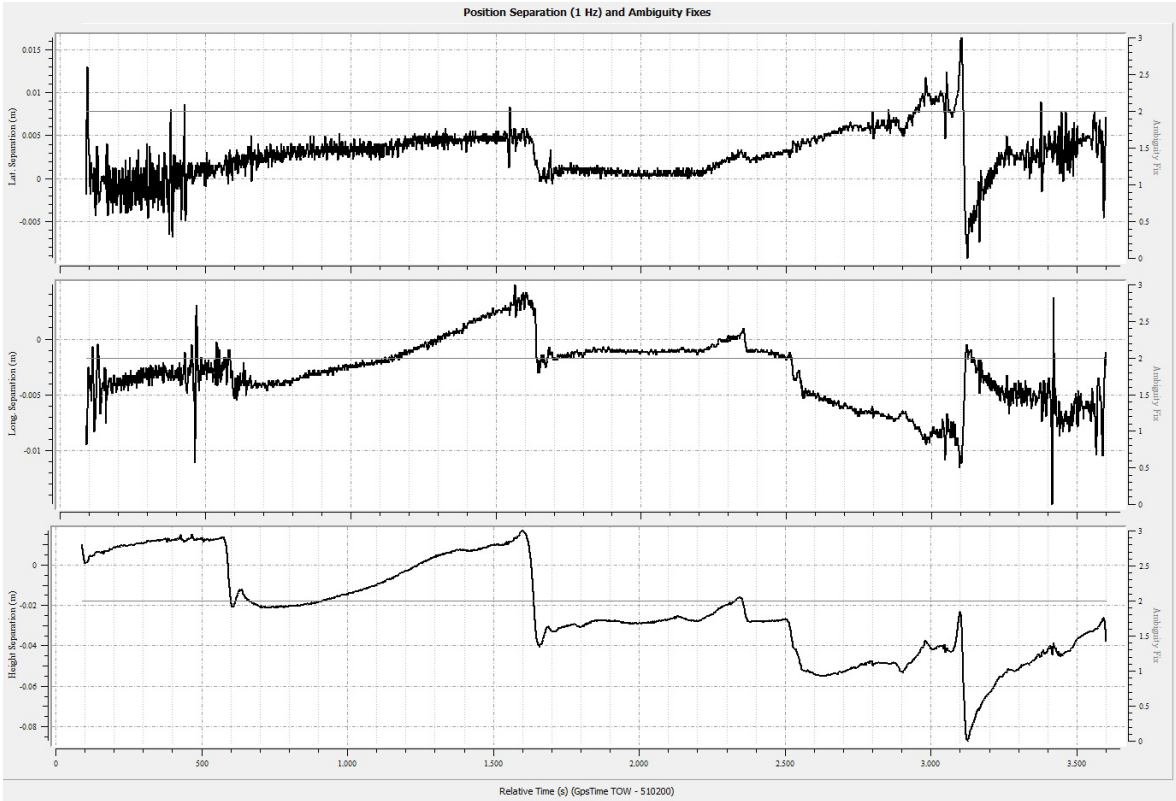


Image 8.0o: PDOP Plot for mission 20140418_220824

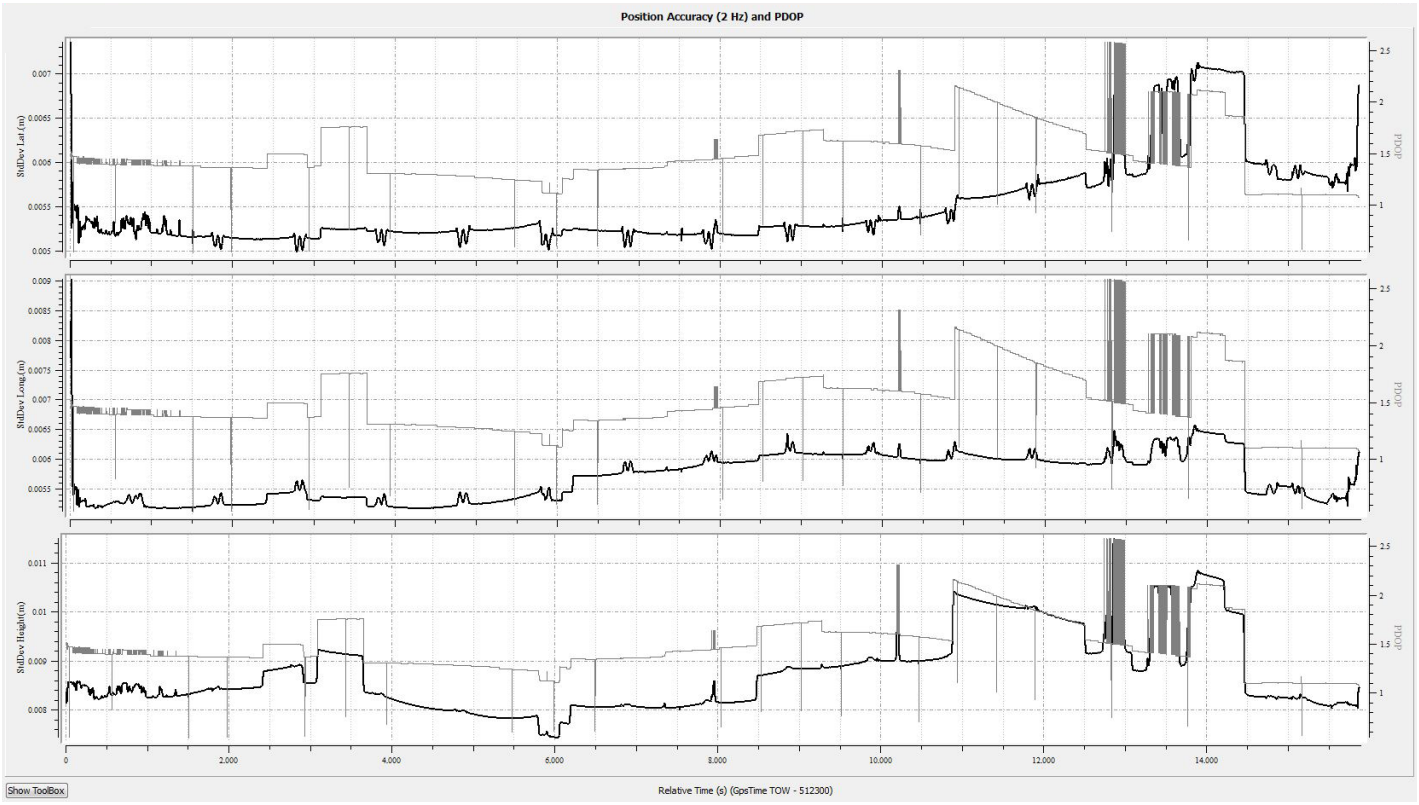


Image 8.0p: Separation Plot for mission 20140418_220824

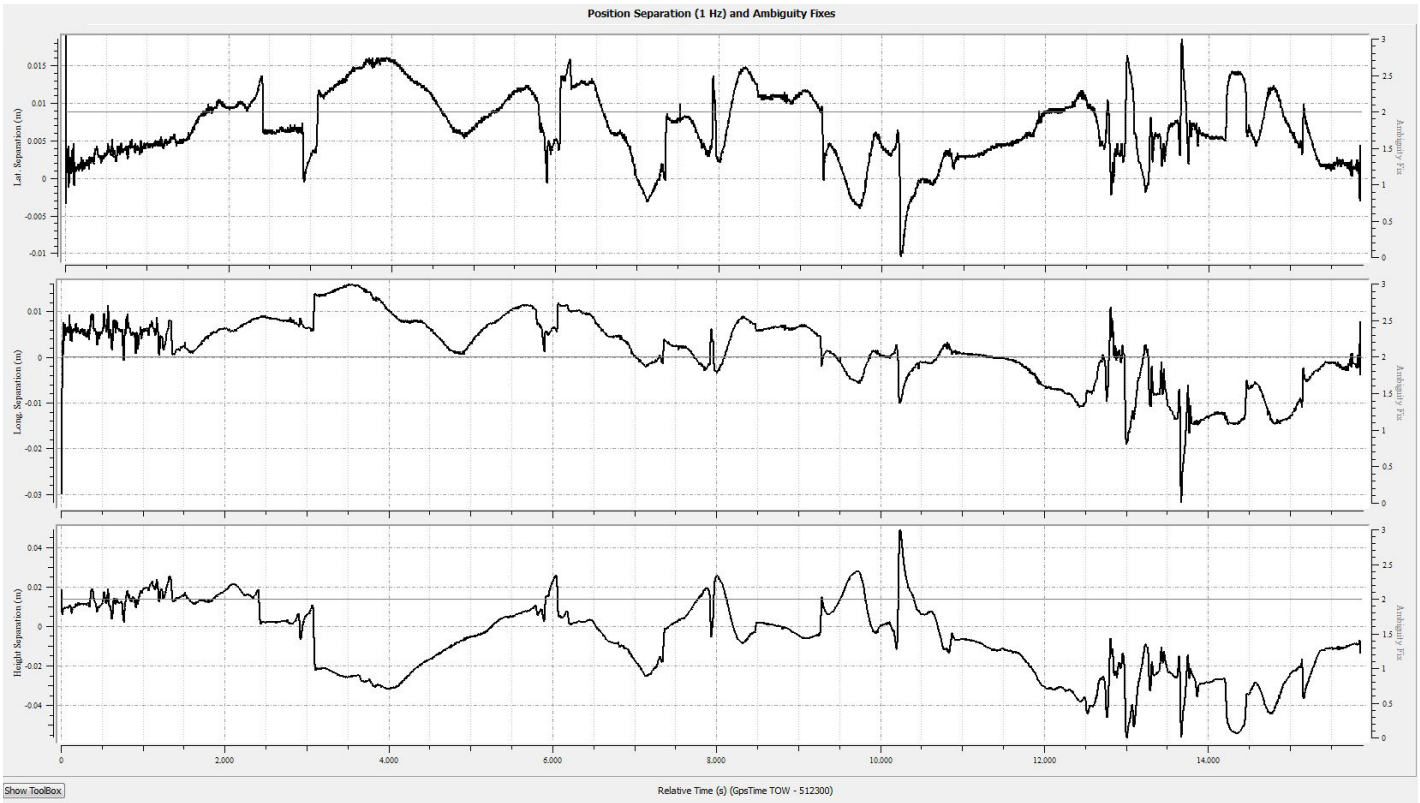


Image 8.0q: PDOP Plot for mission 20140419_132934

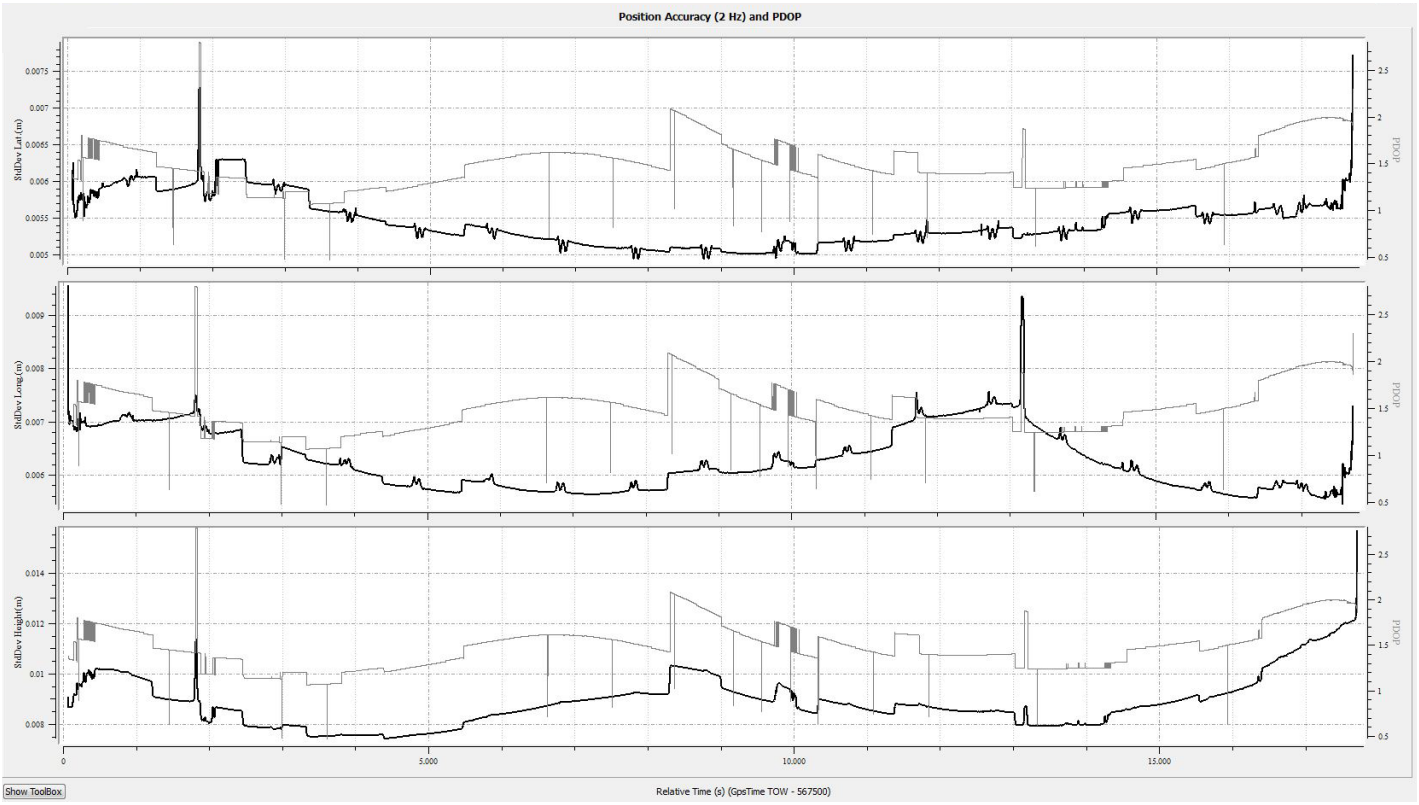
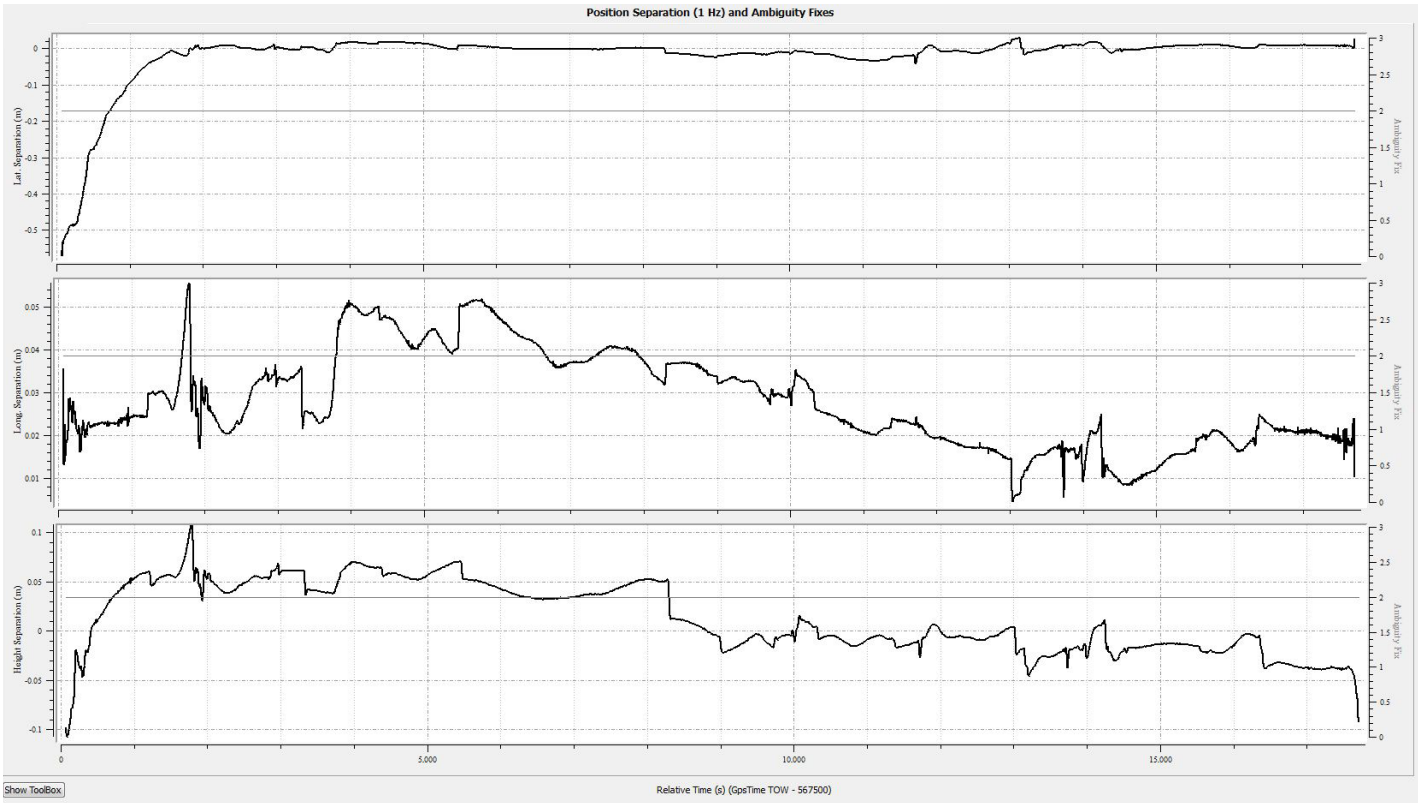


Image 8.0r: Separation Plot for mission 20140419_132934



9 QA/QC Output Control Report

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

Image 9.1: Will County Control Report

Will County Control Report					
Number	Easting	Northing	Known Z	Laser Z	Dz
1	1018836.862	1831633.703	667.970	667.490	-0.480
2	1036396.056	1731782.360	600.683	600.290	-0.393
3	1084867.774	1738572.801	702.995	702.810	-0.185
4	1118109.175	1742297.748	776.729	776.390	-0.339
5	1160632.651	1742172.905	772.295	772.010	-0.285
6	1191498.483	1737869.309	697.374	697.110	-0.264
7	1039502.725	1703032.198	562.393	562.660	0.267
8	1089047.569	1706170.493	691.301	690.940	-0.361
9	1150598.947	1702659.486	724.235	724.400	0.165
10	1198238.945	1703546.319	733.701	733.930	0.229
11	1029424.082	1668096.188	590.347	590.210	-0.137
12	1052019.609	1835970.320	723.148	722.660	-0.488
13	1056400.982	1668864.026	597.780	597.880	0.100
14	1020649.830	1794380.920	604.219	603.960	-0.259
15	1060140.484	1796049.901	584.702	584.730	0.028
16	1092137.162	1796349.749	748.228	748.110	-0.118
17	1021213.736	1768210.955	579.906	579.630	-0.276
18	1048507.226	1769286.099	647.264	646.880	-0.384
19	1085826.677	1765053.740	646.145	646.180	0.035
20	1117578.784	1763054.991	720.252	720.090	-0.162

Average dz	-0.17 ft
Minimum dz	-0.49 ft
Maximum dz	0.27 ft
Average magnitude	0.25 ft
Root mean square	0.23 ft
Std deviation	0.28 ft

10 Imagery of Control Locations

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

11 Accuracy Assessment

Image 11.0a: Vertical Accuracy Assessment

	LC Class	Count	Minimum	Maximum	St. Dev.	RMSE	95%	95th	Mean	Median	Skew
SVA	-	77	-0.64	0.77	0.27	0.30	-	0.58	0.13	0.12	0.03
CVA	-	97	-0.64	0.77	0.26	0.28	-	0.53	0.12	0.11	0.10
Bare Earth (FVA)	1	20	-0.30	0.52	0.20	0.21	0.40	-	0.08	0.10	0.18
Tall Weeds	2	20	-0.12	0.67	0.22	0.30	-	0.52	0.20	0.18	0.46
Brush Lands	3	20	-0.14	0.77	0.25	0.32	-	0.63	0.20	0.14	0.78
Forested	4	19	-0.24	0.71	0.25	0.26	-	0.50	0.07	0.08	0.81
Urban Areas	5	18	-0.64	0.48	0.33	0.32	-	0.47	0.02	0.03	-0.26

Image 11.0b: Ground check points used for accuracy assessment

Point #	Easting	Northing	Known Z	LIDAR Z	DZ	LC Class
1	1018690	1831661	666.265	666.15	-0.115	1
2	1051319	1836646	726.793	726.94	0.147	1
3	1021005	1794342	604.127	604.25	0.123	1
4	1059044	1794873	567.989	568.1	0.111	1
5	1092737	1794541	718.372	718.89	0.518	1
6	1020090	1768377	601.569	601.74	0.171	1
7	1048673	1769075	642.515	642.76	0.245	1
8	1085875	1765000	647.356	647.58	0.224	1
9	1117183	1762763	727.888	727.98	0.092	1
10	1045551	1735064	632.747	632.56	-0.187	1
11	1081484	1738747	688.56	688.55	-0.01	1
12	1114864	1744410	778.273	777.97	-0.303	1
13	1160395	1742263	767.043	767.06	0.018	1
14	1189746	1737690	707.346	707.34	-0.005	1
15	1039321	1703346	561.414	561.44	0.027	1
16	1089050	1706101	691.572	691.47	-0.102	1
17	1150494	1703323	727.972	727.81	-0.162	1
18	1198205	1701737	747.205	747.57	0.365	1
19	1031489	1668246	592.42	592.57	0.15	1
20	1057337	1669187	604.173	604.38	0.207	1
21	1020077	1830956	669.768	669.89	0.122	2
22	1050027	1836125	734.534	734.55	0.016	2
23	1020694	1794333	603.658	603.81	0.152	2
24	1060077	1795334	579.949	579.88	-0.069	2
25	1092989	1794484	711.023	711.69	0.667	2
26	1020822	1768635	606.266	606.15	-0.116	2
27	1051035	1767838	549.471	549.8	0.329	2
28	1087139	1762572	706.327	706.81	0.484	2
29	1118593	1763012	717.912	718.41	0.498	2
30	1044154	1734454	636.28	636.19	-0.09	2
31	1082680	1738047	700.333	700.37	0.037	2
32	1115891	1742896	761.731	762.24	0.509	2
33	1160393	1742620	762.855	763.07	0.216	2

Point #	Easting	Northing	Known Z	LIDAR Z	DZ	LC Class
34	1192079	1736559	689.063	689.08	0.018	2
35	1039080	1703224	561.3	561.59	0.29	2
36	1089404	1706105	696.514	696.54	0.026	2
37	1150531	1703444	727.653	727.95	0.297	2
38	1197961	1701980	738.491	738.82	0.33	2
39	1024811	1669681	588.966	588.98	0.014	2
40	1056320	1668727	601.281	601.51	0.229	2
41	1020002	1831265	667.467	667.5	0.033	3
42	1052200	1835658	723.183	723.3	0.117	3
43	1021287	1794307	605.293	605.2	-0.093	3
44	1060287	1795704	581.71	581.99	0.28	3
45	1092847	1794355	711.381	712	0.619	3
46	1020011	1768811	600.235	600.1	-0.135	3
47	1051324	1768905	543.017	543.33	0.313	3
48	1088262	1764890	686.705	686.79	0.085	3
49	1118075	1763381	716	716.77	0.769	3
50	1036990	1732003	611.318	611.32	0.002	3
51	1082962	1737895	692.223	692.35	0.127	3
52	1116154	1742626	776.41	776.66	0.25	3
53	1160339	1742161	765.965	766.53	0.565	3
54	1191827	1736610	693.038	692.95	-0.087	3
55	1039349	1700827	559.819	559.99	0.171	3
56	1089395	1705974	696.295	696.29	-0.005	3
57	1150423	1703433	725.933	726.09	0.157	3
58	1198038	1701954	742.365	742.82	0.455	3
59	1024675	1669445	587.192	587.28	0.088	3
60	1054928	1668941	592.308	592.67	0.361	3
61	1018902	1830882	666.096	666.22	0.124	4
62	1051363	1835478	725.173	725.25	0.077	4
63	1021271	1794533	604.976	605.08	0.104	4
64	1059028	1795011	567.58	567.73	0.15	4
65	1090591	1797305	750.955	751.2	0.245	4
66	1020488	1769257	600.01	599.77	-0.24	4
67	1051093	1767895	549.443	549.24	-0.203	4
68	1086656	1762462	701.971	702.1	0.13	4
69	1117206	1762868	721.436	721.23	-0.206	4
70	1036348	1731863	599.933	599.69	-0.243	4
71	1082704	1738100	701.192	701.19	-0.002	4
72	1116033	1741798	751.232	751.31	0.078	4
73	1160548	1742629	763.765	763.93	0.166	4
74	1191632	1735743	684.227	684.16	-0.067	4
75	1039406	1700814	559.158	559.64	0.482	4
76	1091362	1708240	698.928	698.72	-0.207	4

Point #	Easting	Northing	Known Z	LIDAR Z	DZ	LC Class
77	1150279	1702583	718.479	718.81	0.332	4
78	1198367	1699810	743.394	744.1	0.706	4
79	1031901	1668239	593.672	593.66	-0.012	4
80	1055019	1668960	593.42	593.62	0.2	5
82	1051895	1835693	724.683	724.42	-0.263	5
83	1021062	1793953	604.113	604.44	0.327	5
85	1090457	1797101	750.684	751.15	0.466	5
86	1020355	1768431	595.236	595.72	0.484	5
87	1048603	1769421	648.427	648.19	-0.237	5
89	1116500	1760403	755.702	755.29	-0.412	5
90	1036836	1732091	608.064	608.13	0.066	5
91	1081488	1738592	690.691	690.8	0.109	5
92	1115040	1744504	776.735	776.1	-0.635	5
93	1160548	1742533	773.127	772.99	-0.137	5
94	1189851	1737617	708.537	708.42	-0.117	5
95	1040015	1703312	565.26	564.88	-0.38	5
96	1088936	1706129	691.202	691.13	-0.072	5
97	1150710	1702367	729.506	729.5	-0.006	5
98	1198343	1702002	743.356	743.81	0.455	5
99	1031589	1668221	592.863	593.11	0.247	5
100	1054045	1667857	604.2	604.52	0.32	5

Thank You

Portland Office
421 SW 6th Ave.
Suite 800
Portland, OR 97204
PH: 503-505-5100
FX: 503-546-6801