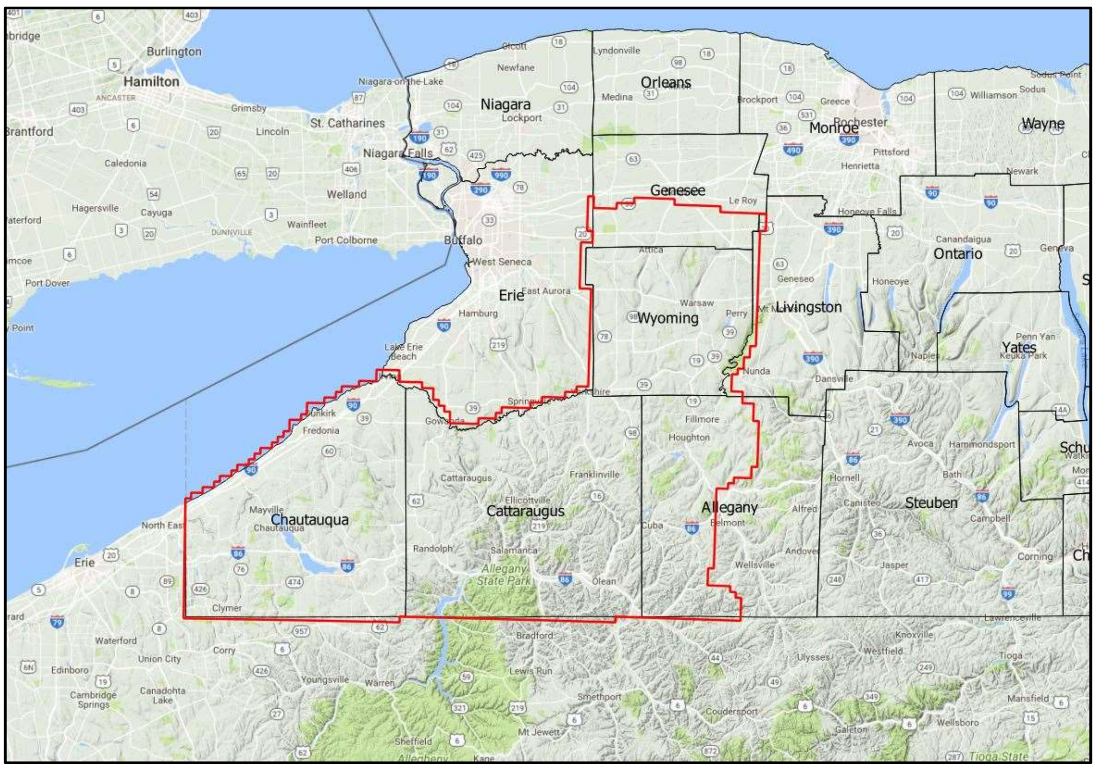
New York State
Airborne LiDAR Acquisition Report Addendum

for

New York State Office of Information Technology Services

10B Airline Drive

Albany, New York 12235



Southwest 17-B (Fall)

by

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Axis Project 13367-1710

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Section 1: Table of Contents

Section 2: Introduction

This Addendum accompanies the original project acquisition report titled *"New York State Airborne LiDAR Acquisition Report for the New York State Office of Information Technology Services; Southwest 17-B (Fall)";* dated January 2018. Airborne Imaging, during the Fall of 2017, acquired LiDAR from November 15, 2017 to December 4, 2017.
See Figure 1 below.

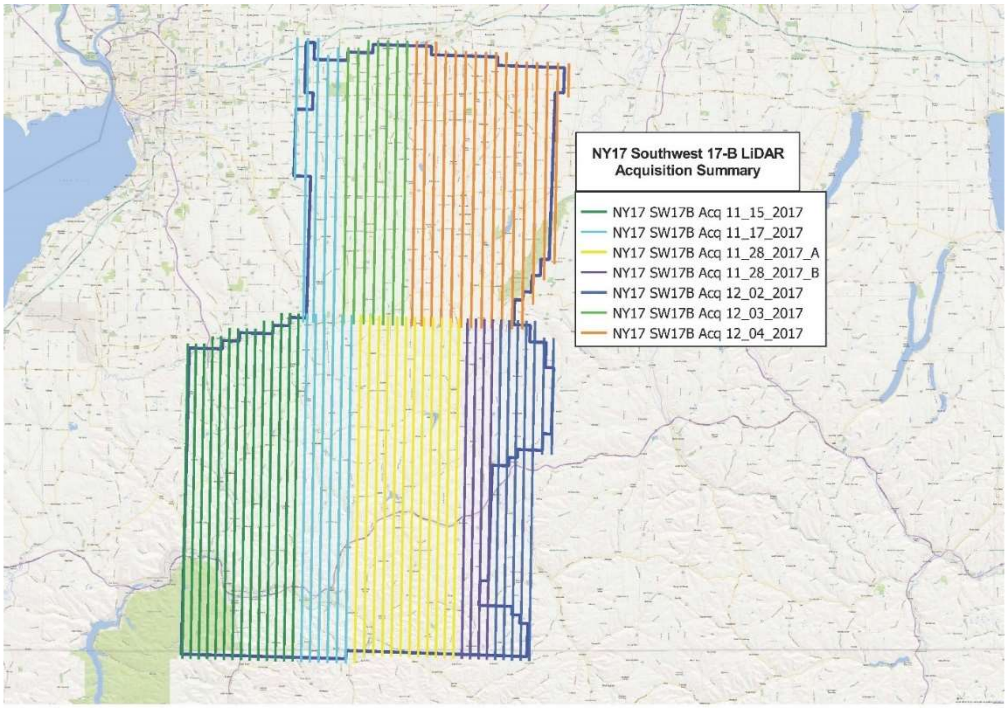


Figure 1: Southwest 17-B Actual Flight Lines Acquired (Fall Acquisition)

The initial data reviews did not uncover any significant issues in the quality and coverage of the acquired data. However, subsequent reviews identified two areas of concern.

On the final day of acquisition, in one of the last flightlines acquired, a hole in the data was identified and the data reviewed in this area. It was determined that the sensor experienced an MTA (multiple time around capability) issue. Because the hole was located near the eastern edge of the project, data from a previous project, Allegany-Steuben, was reviewed for coverage. Upon further investigation, it was determined that the hole was sufficiently covered by the Allegany Steuben data. This resolution was provided to the State for review and approval. During this period, Axis discovered another area that contained an excessive amount of noise. Again, the data in this area was reviewed and found to have been affected by an MTA issue. The area with the high amount of noise was in the same flightlines as the hole identified earlier. The area containing the "hole" and "noisy data" is shown in Figure 2.

After consulting with the State and Airborne Imaging, Axis determined that the best solution was to reacquire the data over this area. LiDAR was re-acquired by Airborne Imaging on April 22, 2018.

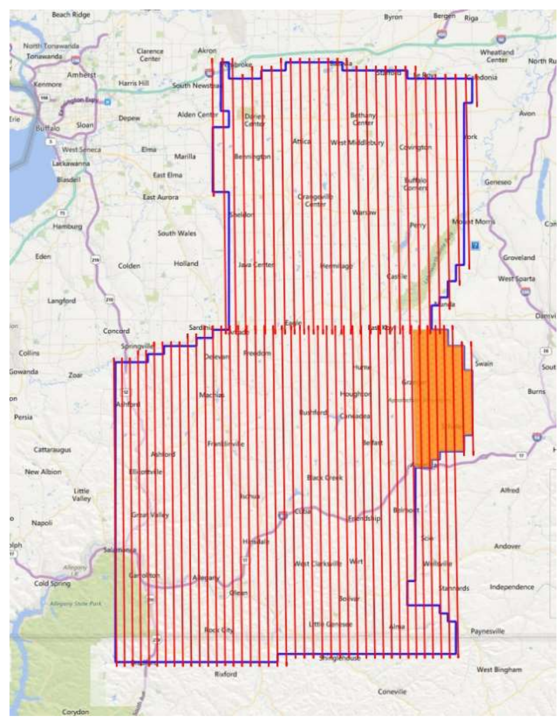


Figure 2 Southwest 17-B Area of Re-Acquisition

Section 3: LiDAR Acquisition

3.1 Acquisition

Airborne LiDAR was acquired by Airborne Imaging based in Calgary, Canada with a Riegl VQ1560i LiDAR sensor. The VQ1560i sensor was installed in a Piper PA31 twin engine aircraft with the tail number of C-GKSX. The acquisition occurred on Saturday, April 22, 2018. See Figure 3 Southwest 17-B Re-Acquisition flightlines.

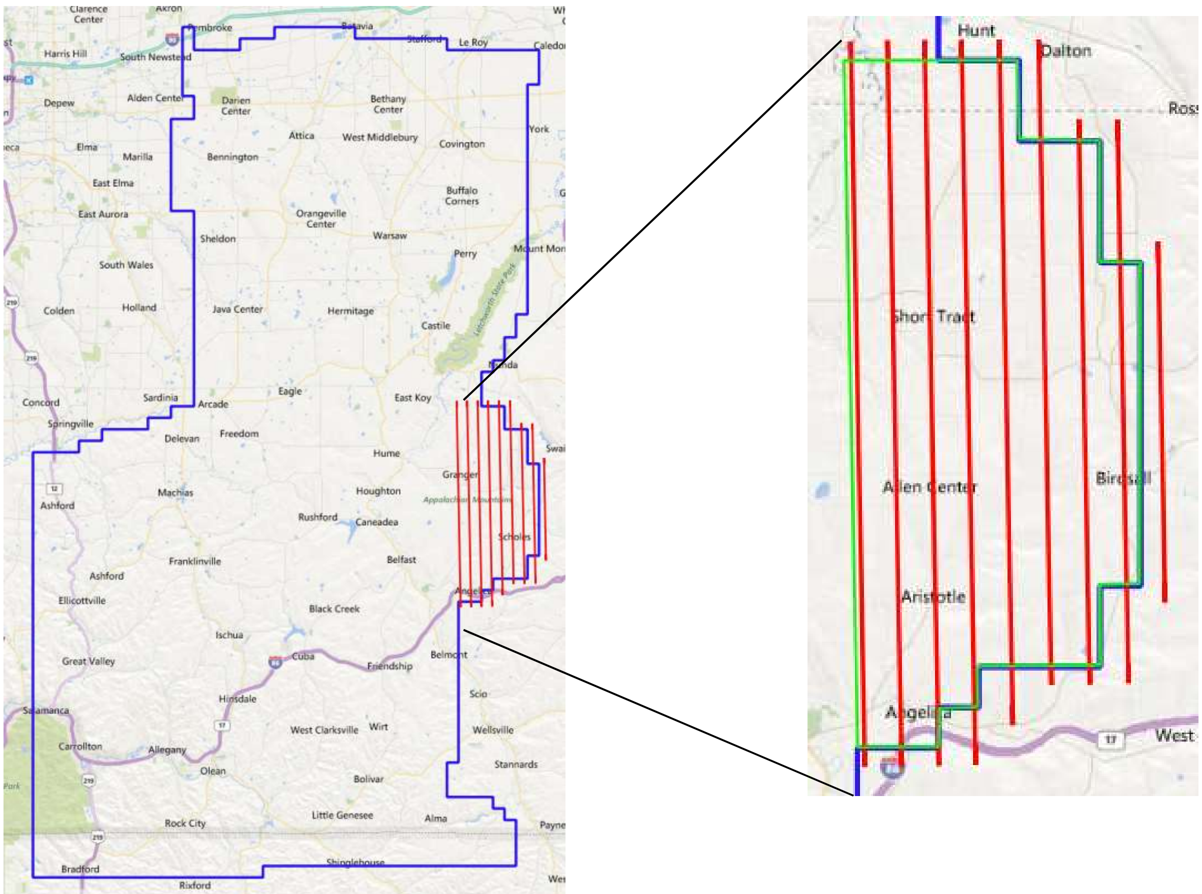


Figure 3 Southwest 17-B Re-Acquisition Flightlines

3.2 Acquisition Details

Airborne Imaging acquired nine (9) flightlines. The “hole” and “noise area” could have been covered with fewer lines. However, Airborne Imaging and Axis planned for acquiring more lines to allow for a better adjustment to the original lines that were acquired in the Fall of 2017.

Airborne Imaging began monitoring conditions on April 4, 2018. Snow on the ground prevented acquisition until Thursday, April 12. There was agreement between the State, Axis and Airborne Imaging that the snow cover on the ground had melted. Weather conditions were unfavorable until April 21. Airborne Imaging reported that they could not mobilize on that day due to an aircraft issue. Fortunately, the issue was corrected and Airborne Imaging was able to acquire the re-flights on the next day.

3.3 Acquisition Flight Summary

One LiDAR acquisition mission was flown on April 22, 2018. Flights were planned at various flying heights above 7,500 ft. AMSL.

A Flight Log for the acquisition mission is provided in Section 4 Flight Logs. Calibration lines were run at the beginning or end of the day and a cross strip running east or west was obtained at the end of the lift.
Table 1: "Acquisition Date and Parameters", provides a summary of the acquisition mission.

Date of Mission	Mission Number	Number of Lifts	# of Lines Acquired	Sensor	Mission Time (LTC)	Aircraft Tail Number
April 22, 2018	AI-1	1	9	VQ1560i	18:15 – 19:51	C-GKSX

Table 1: Acquisition Date and Parameters

The System Parameters for LiDAR Acquisition are provided in Section 3.5 in Table 2: "System Parameters for LiDAR Acquisition with a VQ1560i" on Page 6 of this report.

3.4 Acquisition Issues and Resolutions

When analyzing the swath data from the original Southwest 17-B acquisition conducted in December, 2017, it was noted that the data from the Riegl VQ1560i sensor had more dropout areas than from the Q1560 sensor. A "dropout" area is defined as an area where the emitted light pulse was absorbed by the surface material and a reflectance value was not recorded by the sensor. In addition, Airborne Imaging admitted to filtering the data, especially in the lower reflectance ranges to eliminate noise. However, after adding the data that had been filtered, the swath data from the VQ1560i still had more areas of dropout points than the Q1560.

The dropout areas were located over surfaces (rooftops) with very dark composite roofing material and over areas with very low near infrared reflectivity. Note that the dropout areas are small in size and that the data still meets USGS 3DEP density specifications.

This situation was discussed with Airborne Imaging. In an effort to reduce the number of dropouts caused by low reflectance materials, Airborne Imaging lowered the altitude of the aircraft for the reflights from 2,300 m to 2,000 m. The Scan Rate was increased from 179 Hz to 252 Hz and the Pulse Rate was increased from 700 kHz to 1400 kHz. The line spacing was reduced from .89 m to .63 m. These adjustments increased the Nominal Pulse Density to 5.07 pls/m^2. Even with the noted changes in acquisition parameters, small areas were identified with dropout points. Again, due to the small size of the dropout areas, the acquired re-flight swath data meets USGS 3DEP specifications.

3.5 LiDAR System Acquisition Parameters

LiDAR acquisition was planned to meet the following specifications in Table 2: "System Parameters for LiDAR Acquisition with a VQ1560i".

Item	Parameter
System	Riegl VQ1560i
Nominal Pulse Spacing (m)	0.63
Nominal Pulse Density (pls/m²)	5.07
Nominal Flight Height (MSL meters)	2000
Nominal Flight Speed (kts)	160
Pass Heading (degree)	179,359
Sensor Scan Angle (degree)	60
Scan Rate	252 Hz
Pulse Rate of Scanner (kHz)	1400 kHz (700 kHz per channel)
Line Spacing (m)	.63
Pulse Duration of Scanner (ns)	3
Pulse Width of Scanner (m)	0.60
Central Wavelength of Sensor Laser	1064nm
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	2241
Nominal Swath Overlap (%)	30%
Scan Pattern	Parallel scan lines per channel, crossed scan lines between channels

Table 2: System Parameters for LiDAR Acquisition with a VQ1560i

Section 4: Flight Logs

Julian Day 112	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date April 22, 2018	Aircraft C-GKSX
Project 3135 Warsaw	Pilot A. Murray
Location KESN	Operator O. Duran
Mission Objective	

System	Riegl VQ1560i
Unit	S2222 738
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Aircraft Block Time		
Engine On 15:52	Ramp Out 16:20	Takeoff 16:33
Engine Off 20:43	Ramp In 20:35	Landing 20:31
Total 4.9 hrs	Total 4.3 hrs	Total 4.0 hrs

Mission Plan			
AGL Height	2000 m	Pulse Rate	1400 KHz
Target Speed	160 kts	Scan Rate	252 Hz
Laser Current	100 %	FOV	60 Deg's

Static Alignment	GPS Time	
	Start	End
Pre Mission	16:13	16:18
Post Mission	20:35	20:40

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
KAR NYFS		↻	18:15	18:20			—	
1		N	18:23	18:29			180422_182336	
2		S	18:32	18:37			183223	
3		N	18:41	18:47			184128	
4		S	18:50	18:56			185037	
5		N	18:59	19:04			185938	
6		S	19:08	19:13			190810	
7		N	19:16	19:21			191649	
8		S	19:24	19:28			192408	
9		N	19:32	19:35			193230	
x-tie		—	19:37	19:40			193748	
KAR NYFS		↻	19:46	19:51			—	

Pg 1 of 1

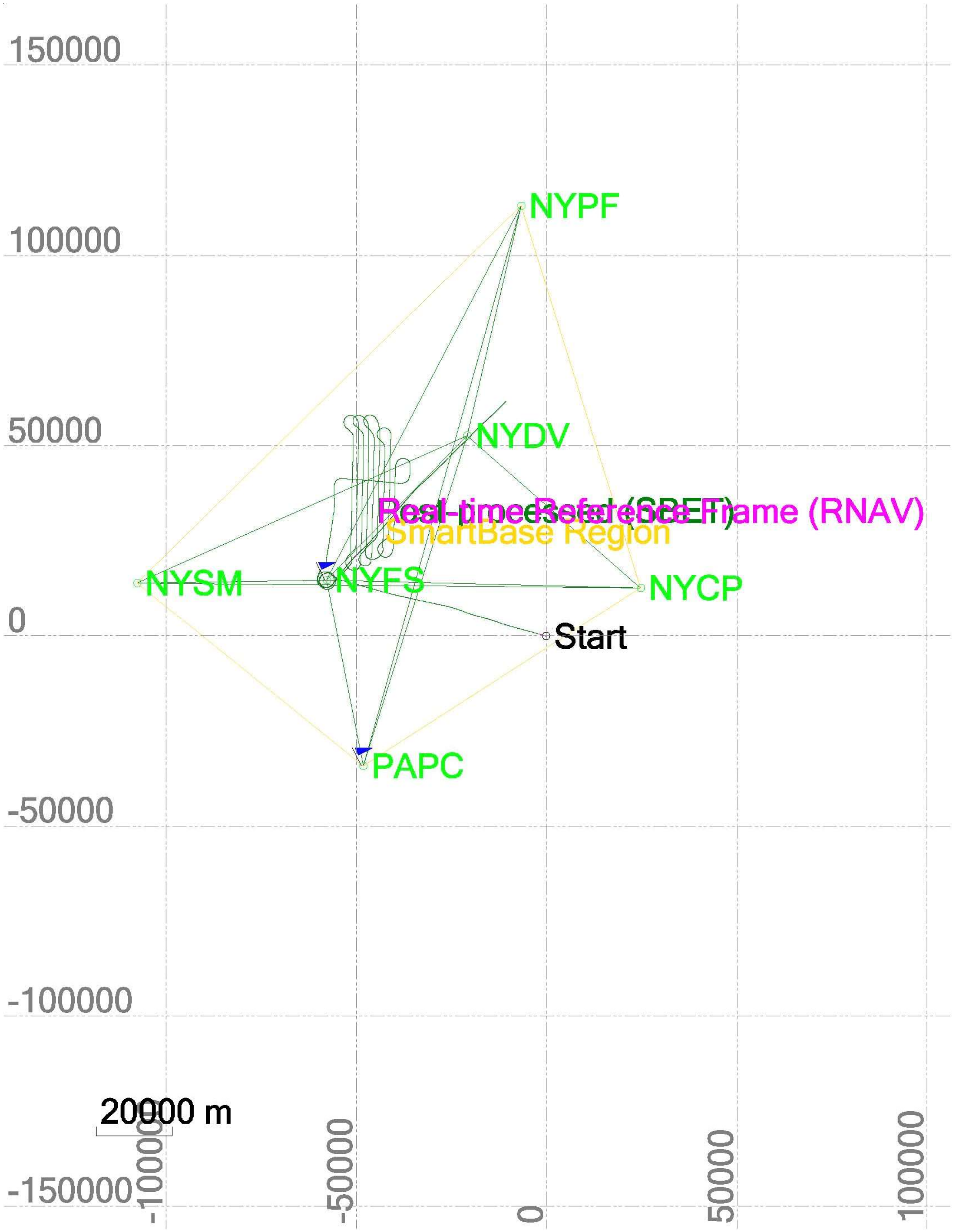
Section 5: GPS Processing Plots

POSPac MMS Version 8.1

Plots by lift of the Coverage Map, Estimated Position Accuracy, Number of Satellites, Combined Separation, and PDOP.

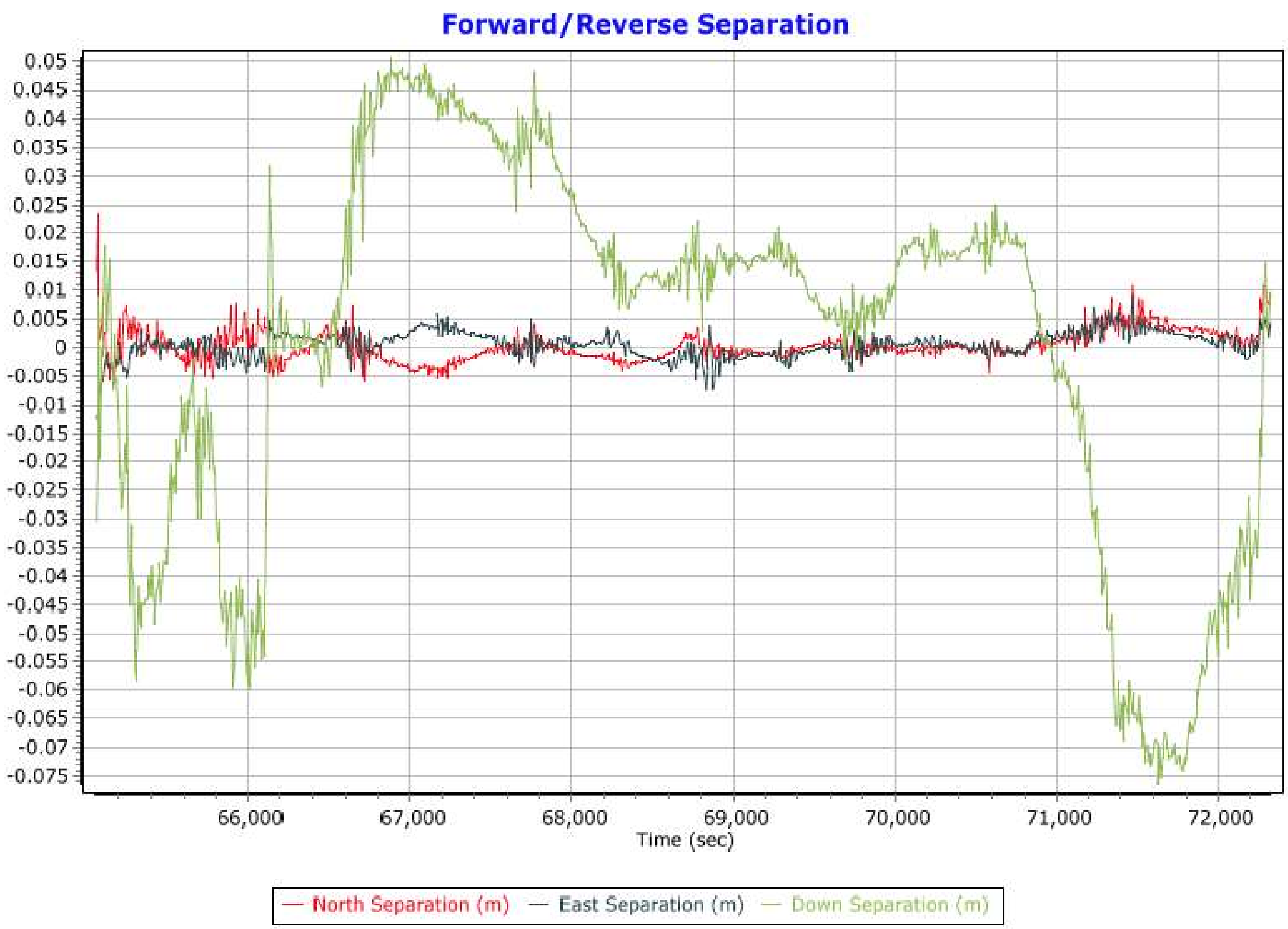
April 22, 2018

Coverage Map: The Coverage Map plot shows the Aircraft GPS-IMU Trajectory in reference to localized GPS Reference Stations.

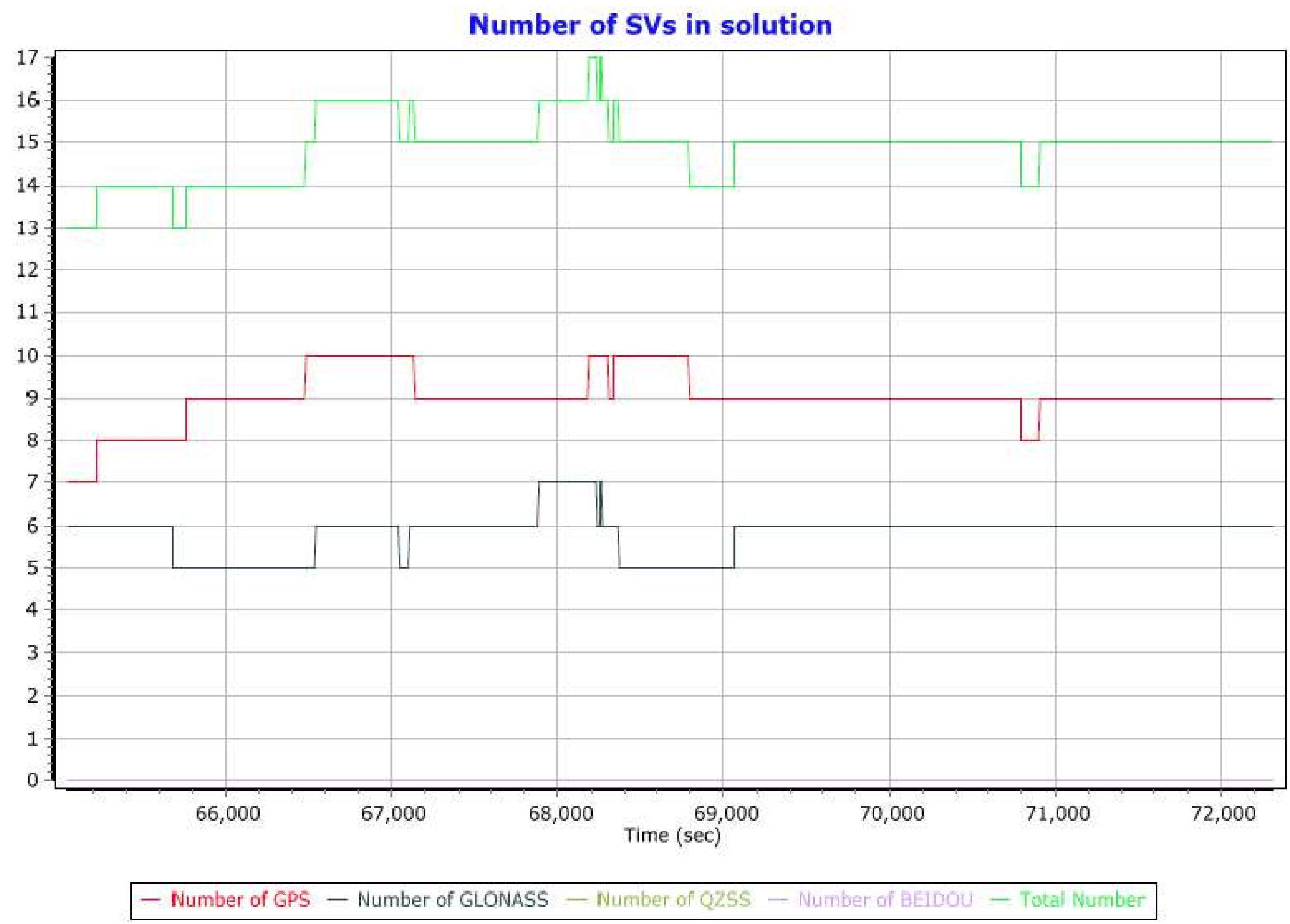


Combined Separation:

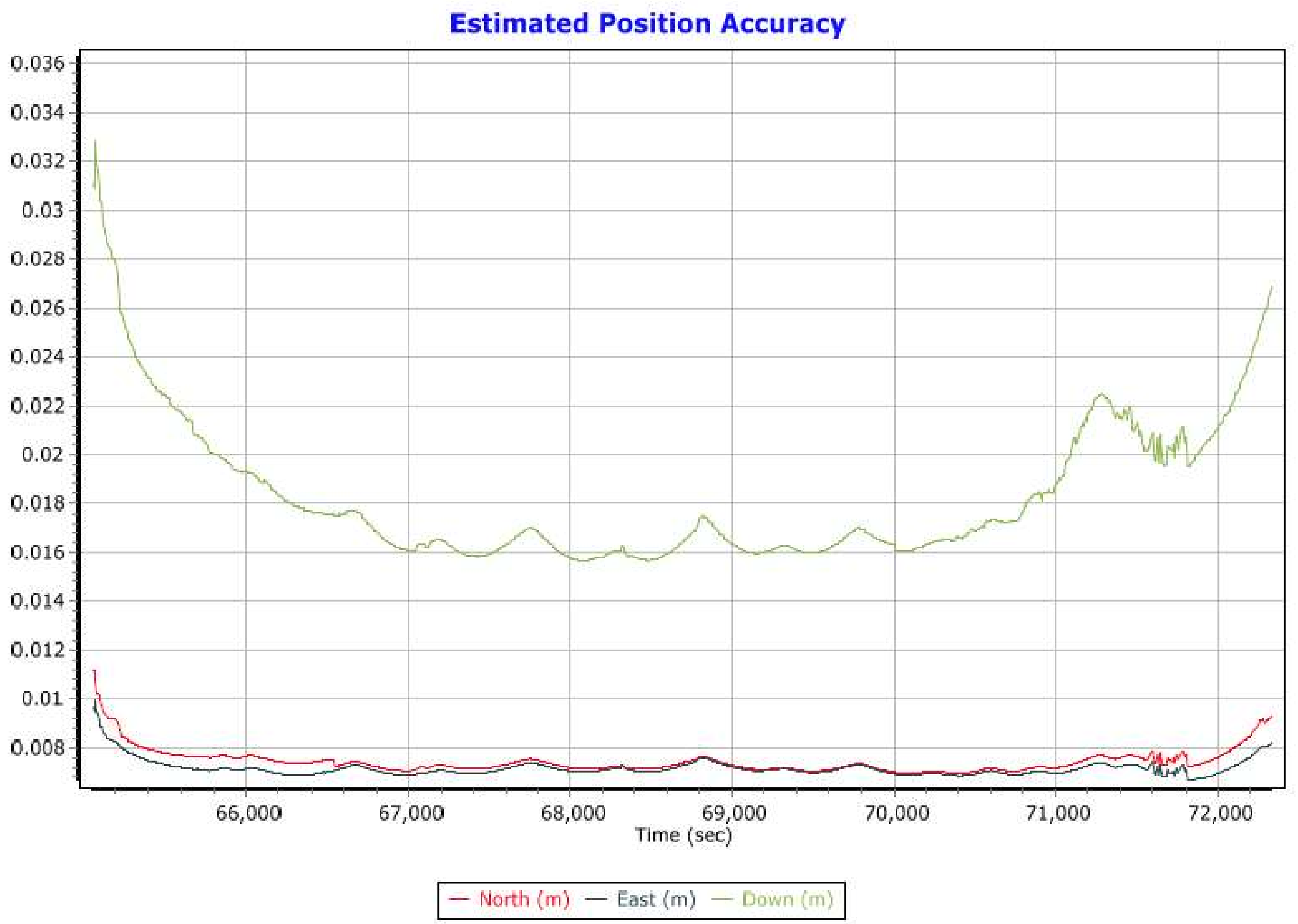
Plots the north, east, and height position difference between any two solutions loaded into the project. This is most often the forward and reverse processing results, unless other solutions have been loaded from the Combine Solutions dialog. Plotting the difference between forward and reverse solutions can be very helpful in quality checking. When processing both directions, no information is shared between forward and reverse processing. Thus both directions are processed independently of each other. When forward and reverse solutions agree closely, it helps provide confidence in the solution. To a lesser extent, this plot can also help gauge solution accuracy.



Number of Satellites: Plots the number of satellites used in the solution as a function of time. The number of GPS satellites, GLONASS satellites and the total number of satellites are distinguished with separate lines.



Estimated Position Accuracy: The Estimated Position Accuracy plot shows the standard deviations of the east, north, and up directions versus time for the solution.



PDOP: PDOP is a unit less number which indicates how favorable the satellite geometry is to 3D positioning accuracy. A strong satellite geometry, where the PDOP is low, occurs when satellites are well distributed in each direction (north, south, east and west) as well as directly overhead. Values in the range of 1-2 indicate very good satellite geometry; 2-3 are adequate in the sense that they do not generally, by themselves, limit positioning accuracy. Values between 3 and 4 are considered marginal, and values approaching or exceeding 5 can be considered poor.