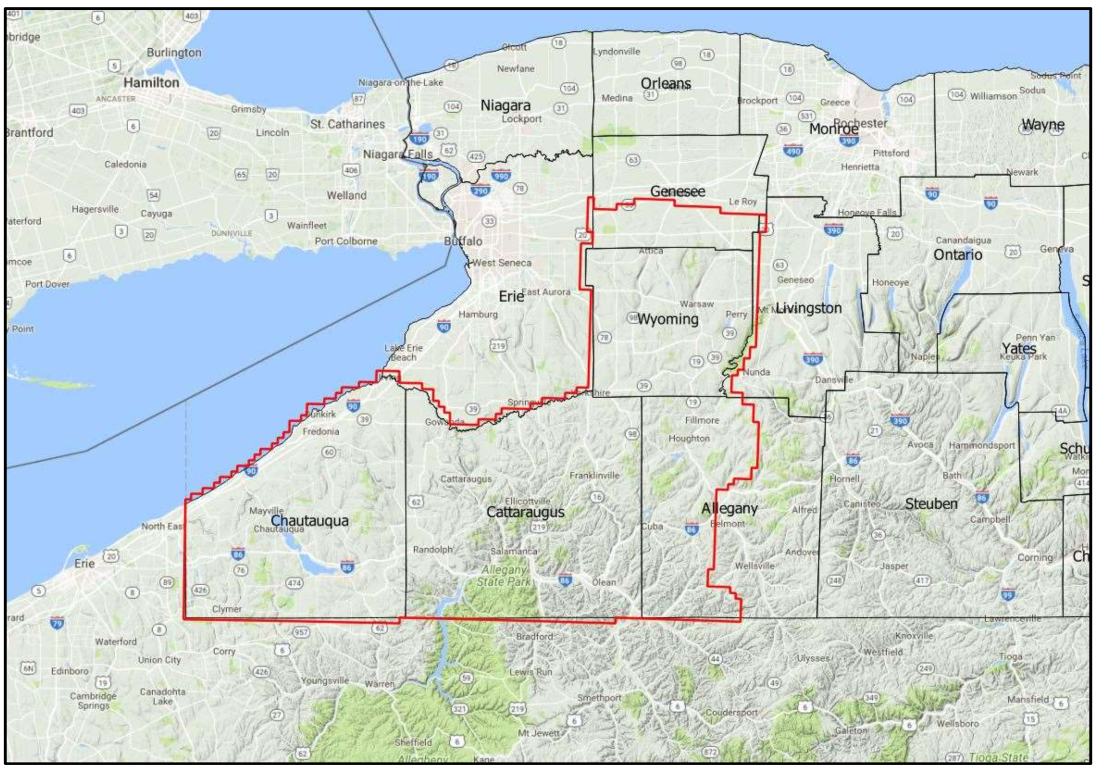
New York State
Airborne LiDAR Acquisition Report

for

New York State Office of Information Technology Services
10B Airline Drive
Albany, New York 12235



Southwest 17

by

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Axis Project 13367-1706

Section 1: Table of Contents

Section 2: Introduction

The New York State Office of Information Technology Services requested delivery of three-dimensional classified point cloud and terrain data derived from LiDAR (Light Detection and Ranging) technology for the New York State LiDAR project area covering Chautauqua, Cattaraugus, Allegany, Wyoming and Genesee Counties. The data must meet Quality B standards as defined by the State. See Table 1: “NYSOOITS LiDAR Quality Specification”.

NYSDHSES LiDAR Quality Specification		
Parameter	**Quality A**	**Quality B**
Nominal Point Spacing (m)	1.5	0.7
Vertical Accuracy (cm)	18.5	9.25
Final DEM Spacing (m)	2.0	1.0

Table 1 NYSOOITS LiDAR Quality Specification

The point cloud is to include all returns from the sensor. Points are to be classified to differentiate between bare earth and other return sources using the following classes:

- 1 Processed, but unclassified
- 2 Bare-earth ground
- 7 Noise (low noise)
- 9 Water
- 10 Ignored Ground
- 11 Withheld (if the Withheld bit is not implemented in processing software)
- 12 Overlap
- 17 Bridges
- 18 High Noise

The project area is located in Western New York State, south of Buffalo, and covers approximately 3,871 square miles. The project area includes the cities of Jamestown and Olean. See Figure 1: “Location of Project Area”. The project area measures approximately 90 miles from the eastern boundary to the western boundary and approximately 70 miles from the northern boundary to the southern boundary. See Figure 2: “Project Area”.

The acquisition planning task took into account the various terrain changes and land surface configurations within the project area and created an overall plan that was efficient and complete.

Data is stored in a non-proprietary format such as LAS and meets the requirements of “U.S. Geological Survey National Geospatial Program LiDAR Guidelines and Base Specifications, Techniques and Methods 11-B4 Version 1.2-Novermber 2014” except as specified by the governing contract.

LiDAR data was processed and projected to UTM Zone 17 North, referenced to the North American Datum 1983 (NAD83) (2011), in units of meters. The vertical datum used for the project is the North American Vertical Datum 1988 (NAVD88) in meters. Orthometric heights are to be determined using Geoid 12B.

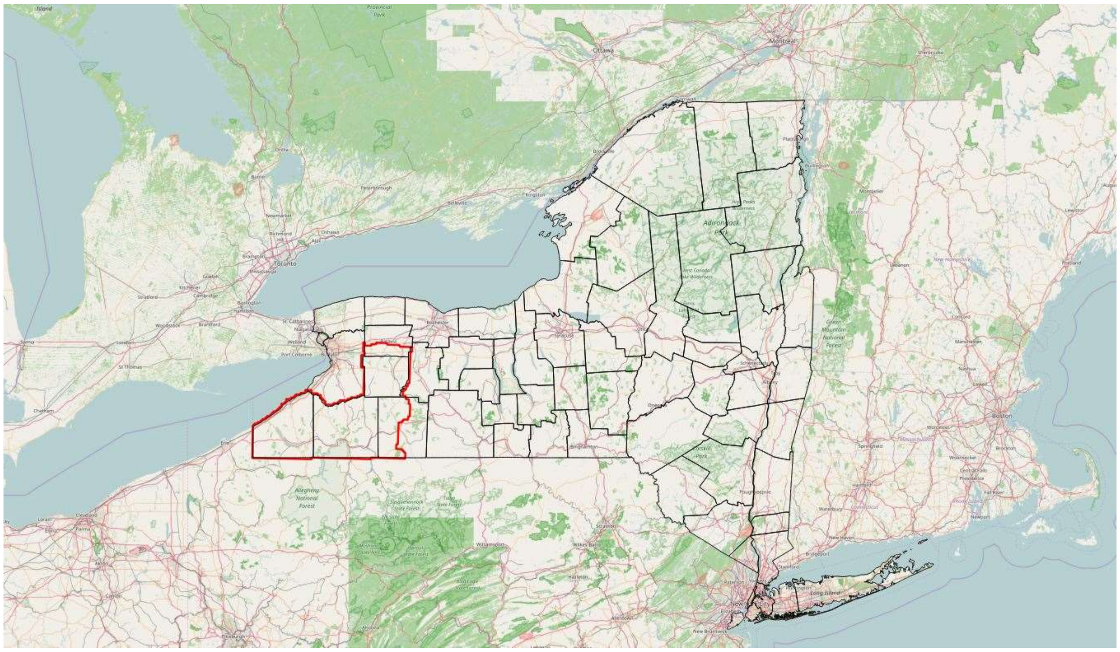


Figure 1: Location of Project Area

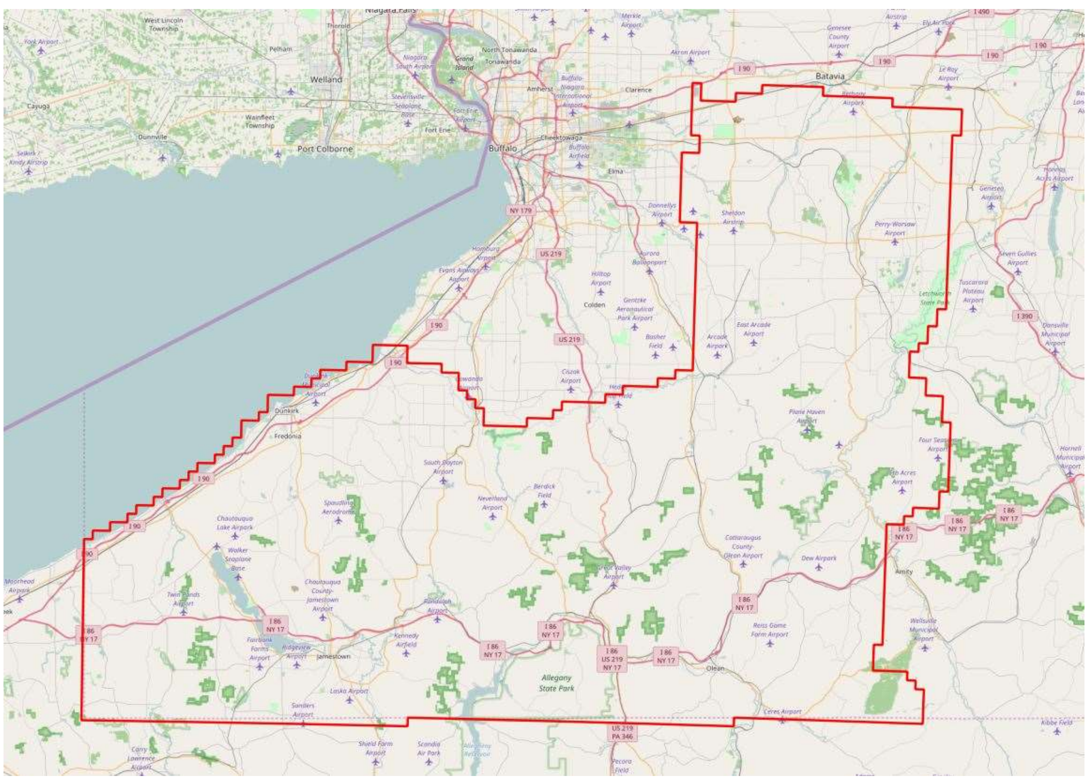


Figure 2: Project Area

Unfortunately, Axis GeoAviation and its sub-contractor, Airborne Imaging, were unable to complete acquisition of airborne LiDAR over the entire project area. Due to poor weather conditions and issues with equipment, Axis GeoAviation and Airborne Imaging acquired LiDAR data for approximately 1,809 square miles, or 46% of the original project area. See Figure 3 Working Project Area. Additional details regarding the acquisition are provided in the following section.

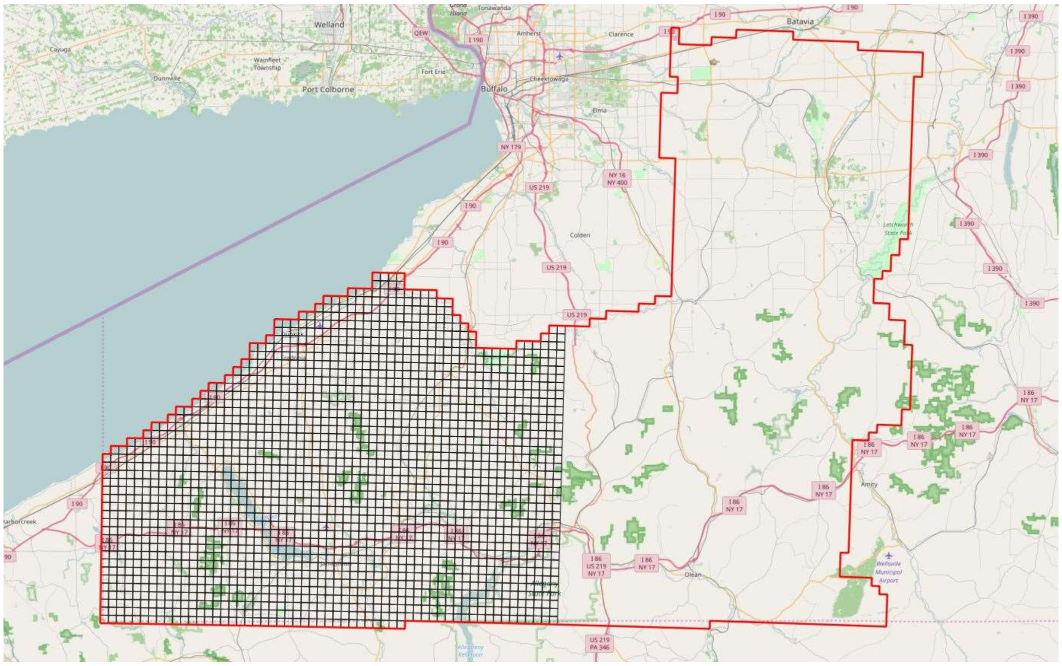


Figure 3: Working Project Area

Section 3: LiDAR Acquisition

3.1 Acquisition

Airborne LiDAR was acquired by Axis GeoAviation, based in Easton Maryland and its sub-contractor, Airborne Imaging based in Calgary, Canada. Both acquisition firms acquire airborne LiDAR with a Riegl Q1560 LiDAR system.

Table 2: "Riegl Q1560 Sensor Characteristics", provides a list of the features and characteristics for the Riegl Q1560 LiDAR system:

Minimum Range [11)]	50 m
Accuracy [12) 13)]	20 mm
Precision [12) 14)]	20 mm
Laser Pulse Repetition Rate	up to 800 kHz
Effective Measurement Rate	up to 532 kHz @ 60° scan angle
Laser Wavelength	near infrared
Laser Beam Divergence [15)]	≤ 0.25 mrad
Number of Targets per Pulse	digitized waveform processing: unlimited [16)] monitoring data output: first pulse
Scanner Performance	
Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines per channel, crossed scan lines between channels
Tilt Angle of Scan Lines	± 14° = 28°
Forward/ Backward Look in Non-Nadir Direction	± 8° at the edges
Scan Angle Range	60° total per channel, resulting in an effective FOV of 58°
Scan Speed	28 - 400 lines/sec[17)] @ laser power level ≥ 50% 20 - 400 lines/sec[18)] @ laser power level < 50%
Angular Step Width $\Delta\vartheta$ [19)]	$\Delta\vartheta \geq 0.012°$ @ laser power level ≥ 50% $\Delta\vartheta \geq 0.006°$ @ laser power level < 50%
Angle Measurement Resolution	0.001°

Table 2: Riegl Q1560 Sensor Characteristics

3.2 Acquisition Details

One-hundred, nineteen (119) lines including cross strips were planned to complete coverage of the project area. See Figure 4: “Original Flight Line Plan”. The flight plan included cross strip and calibration flight line collection to compensate and correct for the inherent IMU drift associated with all IMU systems. Weather and atmospheric conditions were to be monitored and LiDAR missions conducted only when conditions existed that would not degrade sensor ability in the collection of data.

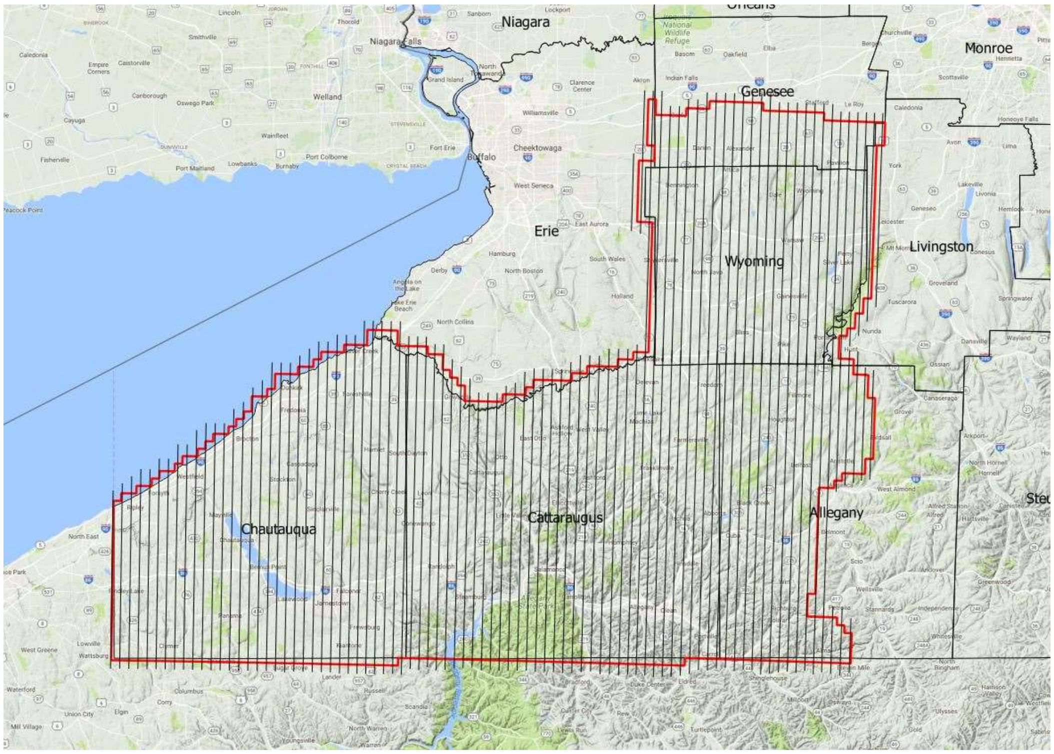


Figure 4: Original Flight Line Plan (119 flightlines)

Airborne Imaging was assigned to acquire thirty-seven (37) lines starting on the western boundary of the project in Chautauqua County and progressing eastward. Axis GeoAviation was assigned the remaining eighty-two (82) lines starting at the Chautauqua Cattaraugus County border and progressing eastward. Lingering snow cover and unfavorable weather conditions delayed the first acquisition mission by Airborne Imaging, until Monday, April 17. Airborne acquired a total of seven lines before weather conditions became unfavorable. Upon review of the data, Airborne determined that one of their Q1560 sensor channels was not operating correctly during acquisition. The dataset was discarded.

Airborne Imaging determined that adjusting the flying altitude from 8,100 ft. above ground level AMSL to 4,050 ft. AMSL would eliminate the need for two-channel operation. At the new altitude, a single channel would be able to acquire LiDAR at the density and spacing required for the project. However, acquiring LiDAR at the lower altitude increased the number of flight lines from thirty-seven (37) to eighty-seven (87). On Tuesday April 18, Airborne acquired thirteen (13) lines at the lower altitude and after reviewing the data, found it to be within specification.

Airborne acquired thirty-three (33) lines on Sunday, April 23 and forty-one (41) lines on Monday, April 24.

Axis GeoAviation began LiDAR acquisition on Sunday, April 23 and acquired six (6) flightlines. On Monday, April 24 ten (10) lines more lines were acquired. After a review of the data acquired on April 23, it was determined that a channel in the Axis Q1560 sensor malfunctioned and that the first data set would need to be reacquired.

Due to unfavorable weather conditions, the next acquisition was not attempted until Monday, May 8. However, low clouds prevented acquisition. On Tuesday, May 9, Axis reacquired the first six lines and one additional line.

After a review of the data acquired during the May 9 acquisition, it was determined that "leaf-out" conditions had progressed to a point where "ground hits" in wooded areas were significantly impacted. The decision was made to cease LiDAR acquisition until the leaves drop in the autumn of 2017.

3.3 LiDAR Flightline Orientation

Figure 5: "Actual Flight Line Acquisition", illustrates the location and number of flightlines that were acquired during the Spring of 2017.

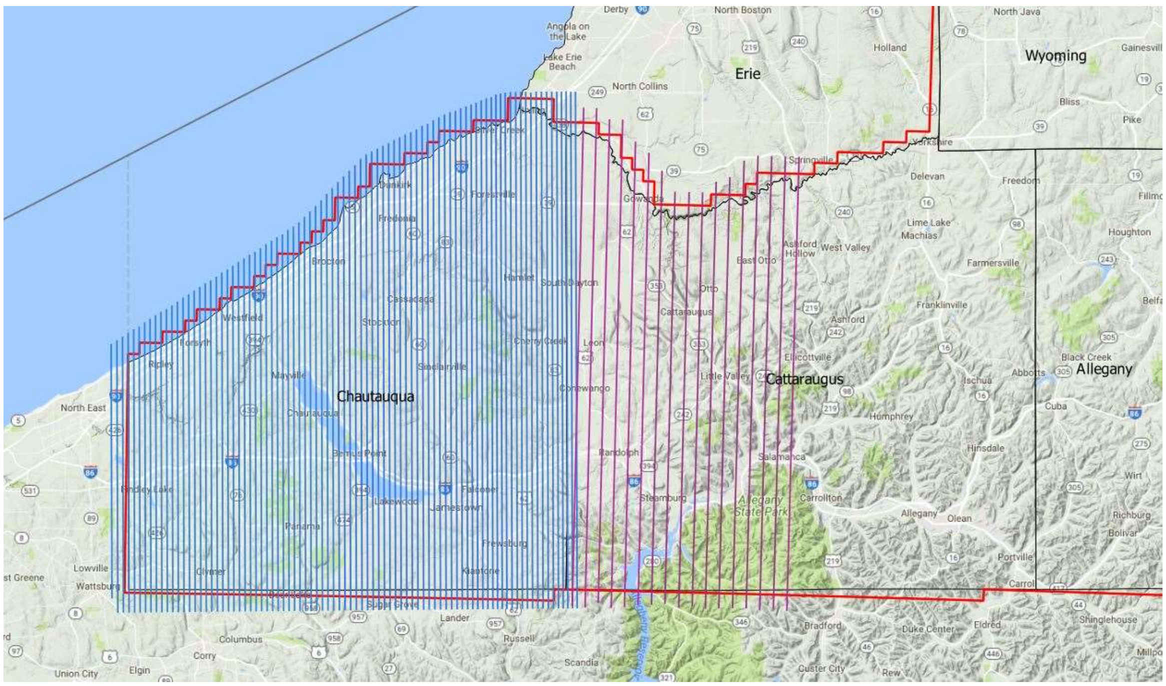


Figure 5: Actual Flight Line Acquisition

3.4 Acquisition Flight Summary

LiDAR acquisition missions were flown between April 17, 2017 and May 9, 2017. Flights were planned at various flying heights above 8,100 ft. AMSL. The revised Airborne Imaging plan decreased the flying height to 4,050 ft. AMSL.

Flight Logs for each acquisition mission are 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 each successful lift.
Table 3: "Acquisition Dates and Parameters", provides a summary of the acquisition missions.

The System Parameters for LiDAR Acquisition are provided below in Table 4: "System Parameters for LiDAR Acquisition" and Table 5: "Revised System Parameters for LiDAR Acquisition".

Date of Mission(s)	Mission Number	Number of Lifts	# of Lines Acquired	Mission Time (LTC)	Aircraft Tail Number
April 17, 2017*	AI-1	1	7	14:05-17:21	C-GKSX
April 18, 2017	AI-2	2	13	12:50-13:22 15:54-21:15	C-GKSX
April 23, 2017	AI-3	2	33	14:43-20:39 21:45-02:37	C-GKSX
April 23, 2017*	AG-1	1	6	12:44 – 14:35	N223TC
April 24, 2017	AI-4	2	41	13:54-19:30 20-57:0118	C-GKSX
April 24, 2017	AG-2	2	10	09:34 – 12:22	N223TC
May 8, 2017	AG-3	1	0	14:10 – 14:40	N223TC
May 9, 2017	AG-4	1	7	08:01 – 10:14	N223TC

*Indicates missions with equipment issues

Table 3: Acquisition Dates and Parameters

(AI= Airborne Imaging; AG=Axis GeoAviation)

3.5 LiDAR System Acquisition Limitations

There are several limiting factors to LiDAR data acquisition which include weather, ground conditions, satellite configuration and equipment malfunctions.

During a LiDAR acquisition mission, there can be no clouds below the aircraft, rain, fog or excessive humidity between the sensor and the ground. Excessive, heavy winds, engaging the aircraft perpendicular to the line of flight, can result in "crab" of the aircraft which results in "gaps" or "slivers' in the data between flight lines. Ground conditions which include pools of standing water and ditches filled with moving water affect the accuracy of LiDAR returns. The number of satellites "visible" to the aircraft during acquisition is an important factor and a poor Global Positioning System (GPS) configuration will contribute to less than desired accuracy. Therefore, satellite configuration, measured by PDOP (Positional Dilution of Precision) is checked each morning to ensure acquisition occurs during the most favorable geometric configuration of the satellites. Finally, despite the best maintenance routines and practices, systems malfunction and fail. Operator awareness is paramount to identifying the exact moment when a system malfunctions. This enables the crew to stop acquisition and correct the issue before continuing. At times, lines acquired with anomalies will need to be re-acquired.

3.6 Acquisition Issues and Resolutions

Unfortunately, there were two (2) missions that experienced unexpected equipment malfunctions and one (1) mission aborted due to unexpected poor weather conditions. The following discussion identifies the missions, the type of issue and the actions taken to overcome the problem.

- April 17, 2017; Airborne Imaging identified an issue with their Riegl Q1560 sensor during their initial acquisition. Airborne noticed that one of the channels was indicating a 60% return. The crew believed that there was fog or moisture interfering with the channel and returned to the airport to clear the fog and/or remove the moisture.

Upon further review, Airborne decided that neither fog nor moisture was the issue. They determined that one of the channels was intermittingly failing. To work around this issue, Airborne Imaging decided to re-plan the acquisition utilizing only one of the channels. The next day, Airborne acquired LiDAR at the lower altitude and reported no channel issues. The data was thoroughly reviewed and found to be within project specifications.

- April 23, 2017: Axis GeoAviation acquired six (6) flightlines of LiDAR. Upon review of the data, the crew noticed that one of the channels malfunctioned and that the data set was incomplete. The decision was made to re-acquire the lines; the lines were re-acquired on May 9th.

- May 8, 2017; After determining that the weather conditions were favorable, the Axis crew launched. By the time the plane arrived at the acquisition area, low clouds had moved into the area and the crew was forced to return to base without acquiring data.

3.7 LiDAR System Acquisition Parameters

LiDAR acquisition was planned to meet the following specifications in Table 4: "System Parameters for LiDAR Acquisition".
Table 5: "Revised System Parameters for LiDAR Acquisition, (Airborne Imaging)" provides the acquisition parameters for the revised Airborne Imaging acquisition at the flying height of 1,200 m.

Item	Parameter
System	Riegl Q1560
Nominal Pulse Spacing (m)	0.76
Nominal Pulse Density (pls/m²)	2.87
Nominal Flight Height (MSL meters)	2469
Nominal Flight Speed (kts)	135-150
Pass Heading (degree)	180,360
Sensor Scan Angle (degree)	58.52
Scan Rate	162 lps
Pulse Rate of Scanner (kHz)	766 kHz
Line Spacing (m)	.83
Pulse Duration of Scanner (ns)	5
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)	2561
Nominal Swath Overlap (%)	20%
Scan Pattern	Parallel scan lines per channel, crossed scan lines between channels

Table 4: System Parameters for LiDAR Acquisition

Item	Parameter
System	Riegl Q1560
Nominal Pulse Spacing (m)	0.65
Nominal Pulse Density (pls/m²)	2.4
Nominal Flight Height (MSL meters)	1200
Nominal Flight Speed (kts)	160
Pass Heading (degree)	180,360
Sensor Scan Angle (degree)	58.52
Scan Rate	400 lps
Pulse Rate of Scanner (kHz)	266.7 kHz
Line Spacing (m)	.4
Pulse Duration of Scanner (ns)	3
Pulse Width of Scanner (m)	0.9
Central Wavelength of Sensor Laser	1064nm
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	1344.5
Nominal Swath Overlap (%)	20%
Scan Pattern	Parallel scan lines per channel, crossed scan lines between channels

Table 5: Revised System Parameters for LiDAR Acquisition

CORS Reference Stations

The presence of a strong CORS (Continuously Operating Reference Station) and base station configuration allowed for the LiDAR to be acquired with Global Navigation Satellite System (GNSS) techniques and procedures. Table 6; "GPS Reference Station Coordinates" and Figure 6; "GPS Reference Stations" below contain a listing and graphic of the CORS and base stations that were used during the processing, their calculated latitude, longitude and ellipsoid height. Minor variations in position, due to changes in satellite availability, geometry and varying availability of the CORS stations, were observed, and are of millimeter level magnitude. These variations had no impact on system positioning and are unavoidable.

NAME	LATITUDE (N)	LONGITUDE (W)	ELEVATION (M)
NYBT	42°59’17.96241" N	078°07’20.40109" W	262.067 m
NYDV	42°32’56.12556" N	077°41’52.62049" W	187.388 m
NYFD	42°25'41.81700 "N	079°20'22.74609" W	211.313 m
NYFS	42°12’16.82473" N	078°08’37.96443" W	441.350 m
NYHB	42°43’02.69515" N	078°50’47.29975" W	211.326 m
NYPF	43°05’35.51718" N	077°31’31.13761" W	112.319 m
NYLP	43°09'54.88682" N	078°45'13.38358" W	165.129 m
NYSM	42°11’31.41330" N	078°44’50.49096" W	409.409 m
PAJP	40°56'44.68533" N	078°57'03.39516" W	379.265 m
PAPC	41°45'51.89816" N	078°01'24.35457" W	484.597 m
PACS	41°14'21.82931" N	079°25'45.31937" W	413.288 m
UPTC	41°37'43.73270" N	079°39'50.64793" W	341.980 m

Table 6: GPS Reference Station Coordinates

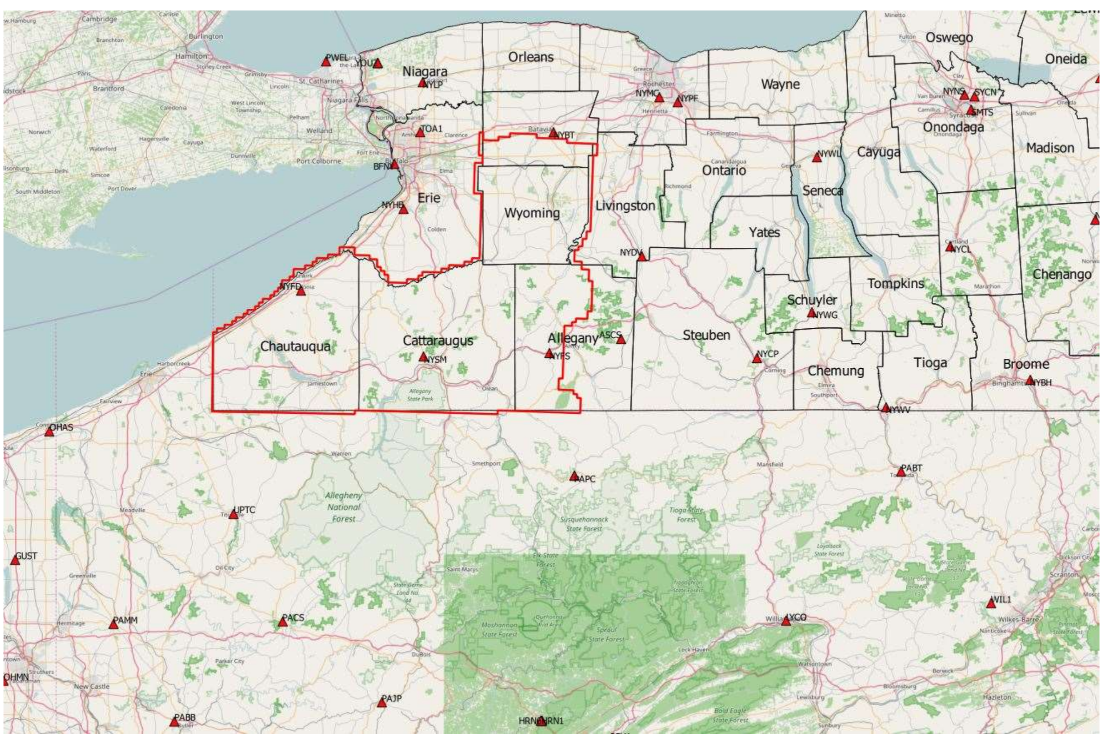


Figure 6: GPS Reference Stations

3.8 Airborne GPS Kinematic and Processing

The Differential GPS unit in the aircraft collected positions at 2Hz. Airborne GPS data was processed using the POS Pac MMS v.8.0 software. Flights were flown with a minimum of 6 satellites in view (10° above the horizon) and with a PDOP of ≤3 when laser online. Distances from base station to aircraft were kept to a maximum of 50km.

For all flights, the GPS data can be classified as good, with GPS residuals of 3cm average or better but none larger than 15cm being recorded when the laser is online.

Data collected by the LiDAR unit is reviewed for completeness, acceptable density and to make sure all data is captured without errors or corrupted values. In addition, all GPS, aircraft trajectory, mission information, and ground control files are reviewed and logged into a database.

AXIS and Airborne Imaging utilize the latest in Airborne-GPS (AGPS) and Inertial Measurement Unit (IMU) systems to determine the precise three-dimensional trajectory of their aircraft in flight. These state of the art sensor systems use the global navigation satellite system (GNSS), pitch-roll-yaw sensors, accelerometers and gyrocompasses to measure and record every change in the attitude, speed and direction of the aircraft during its data collection mission.

These measurements are linked together according to a precise time baseline that is collected as part of the GNSS message stream, allowing corrections for attitude variations to be known at the exact time the digital sensor records an image.

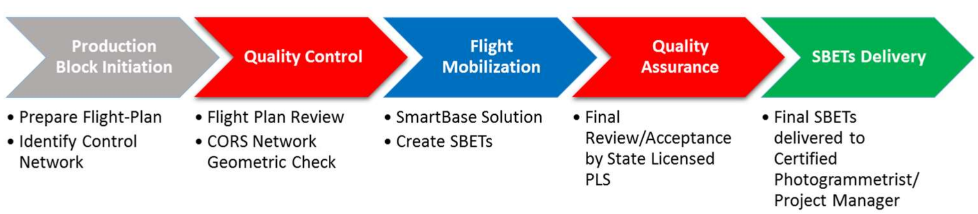
AGPS/IMU Processing

Axis and Airborne Imaging use Applanix POS Pac MMS v.8.0 to process Airborne GNSS/IMU datasets and compute Smoothed Best Estimated Trajectory (SBET) files for our LiDAR missions. This state-of-the-art GNSS/IMU processing technology uses a combination of GNSS data collected onboard the aerial platform during the mission, twenty-four (24) hours of satellite geometry and ephemeris data from the National CORS network that surrounds the flight mission footprint, and data from the onboard IMU that tracks the heading, acceleration/deceleration, pitch, roll and yaw of the aircraft during the flight.

The processing software uses all of the data inputs to determine the precise three-dimensional trajectory of the aircraft during the mission. The process includes operator managed and software driven QA/QC checks, and a professional land surveyor monitors the entire process, focusing on the geometry and spacing of the CORS network control points around the project area, data integrity and software are properly configured to account for the system hardware locations in relation to the IMU reference location.

The workflow for each production block will follow a structured path, modified as needed to make adjustments for buy ups or other optional tasks:

SBET Processing Workflow Chart



First, a flight plan and project are reviewed prior to mobilization to confirm CORS network geometry, station availability and data observation rates. Once approved for flight, the mission is executed by the flight operations team within the parameters of the flight plan, STATE requirements, applicable mapping guidelines, industry standards and our own inhouse protocols. These requirements include collection of data on the ground before and after the flight, proper manipulation of the IMU during flight to avoid heading drift and careful navigation of the aircraft to avoid loss of satellite lock during the entire mission such as unduly steep banking turns, flight line deviations, or operation during turbulent conditions. Upon return to the airfield, the IMU and other data are downloaded and posted to our computer network for post processing. Post processing involves assembling flight data from the onboard GNSS and IMU, downloaded CORS vector data for a time balanced observation period centered on the takeoff to touchdown flight window of the data collection mission, published and vetted positional data for the CORS control stations, broadcast and precise ephemeris data documenting the projected and actual positions of the satellites during the mission.

GNSS Base Stations for the SmartBase processing are selected based on conformance with requirements of the software, including distance from the center of the flight mission, network station spacing, observation rates of the network base stations, and availability of both broadcast and precise ephemeris data for the satellites included in the GNSS dataset.

All of these datasets are linked to the project database, checked for accuracy and readied for processing. The software uses a proprietary process to compute GNSS based forward and backward trajectories, IMU based forward and backward trajectories based on accelerometer and gyrocompass data, pitch, roll and yaw sensors, and then combine all of the independent solutions into a precisely computed string of plane and sensor positions during the mission. Due to the speed of travel of the aircraft, positioning is determined at the rate of fifty (50) times per second, based on actual observed data from equipment operating at that recording interval, not from interpolated data from equipment operating at slower data rates. This method yields truer positioning from direct observation rather than estimated positions between true fixes. The IMU system operates at very high speed, typically at two hundred measurements (200) per second, which allows the system to maintain a precise track on changes in aircraft attitude during acquisition. The GNSS data is combined with the IMU data to bridge the separations in position fixes and refine the precision of the planes trajectory down to nearly centimeter level three-dimensional precision.

The software downloads GNSS data from the CORS stations around the project area, and performs a dataset integrity check of the GNSS RINEX files to find errors in the data such as gaps, incompatible collection rates or missing antenna information. The Applanix SmartBase software includes a SmartBase Quality Check module that performs an extremely accurate network analysis and adjustment on all the base-lines and reference stations in the network. The Quality Check module uses 18 to 24 hours of reference station data to accurately compute the base-lines between one station set as the control and the rest of the stations. The long duration of data is used to ensure that all multipath variations due to changes in satellite positions are averaged out as much as possible.

The output of the Quality Check module is a table indicating the estimated error for each set of reference station coordinates. If the estimated error is larger than 5 cm, the coordinates are flagged as unacceptable, indicating the input coordinate cannot be trusted. The user has the option of using the adjusted coordinates instead of the input coordinates, or not using the reference station at all in the Applanix SmartBase computations.

Additional quality checks are made on the individual reference station observation files before the Applanix SmartBase is computed. The final result of this process ensures the integrity of the computed reference station data and coordinates are known and trusted before the airborne data set is even processed.

Once the network framework is approved, the software establishes a Virtual Reference Station in close proximity to the project area. This technology is known as the Applanix SmartBase Solution, and allows the software to minimize vector length from the primary base station to the aircraft, minimizing the effect of atmospheric and other systematic errors. Once the Virtual Reference Station is established, forward and backward processing of the GNSS and IMU datasets is executed to determine the exact path, known as the Smoothed Best Estimated Trajectory (SBET), of the airborne platform and its associated equipment.

ABGPS/IMU QA Review & Analysis

Once the SBET file is created, reports and output files of the data are automatically generated for review by the system operator. The primary analysis tool are the charts showing differences in values for aircraft roll-pitch and yaw values, positional quality information, satellite health and geometry, signal to noise ratios, and variances in direction or velocity vectors between forward and backward processed data that indicate some environmental variable has affected the data. The primary means of mitigating these errors is proper positioning support by the surrounding base station network, management of flight path length to eliminate IMU drift, and flight procedures that avoid interruption of satellite data reception.

ABGPS/IMU Data Finalization and Preparation for LiDAR Production

The SBET QA/QC review is finalized by independent assessment of the output charts and reports showing deviations between processing directions, spikes in aircraft attitude variations and quality of GNSS data and positional fixes. IMU data is put to further use in the next step of the data processing workflow, when Exterior Orientations of the digital sensor systems are determined and corrections are applied to the images based on changes in aircraft orientation at the time of exposure.

GPS processing results for each lift are included in Section5: GPS Processing.

Section 4: Flight Logs

Airborne Imaging; April 17, 2017

Julian Day 107	Flight A

LIDAR Flight Log

Date April 17, 2017	Aircraft C-GKSX	System Riegl Q1560	Additional Notes
Project 3126_Chautauqua	Pilot O. Kamerman	Unit 2220754	Wind: 350 @ 9knts @ KJHW 13:35 UTC +4
Location Jamestown, NY	Operator A. Fox	IMU Applanix AP50	Temp: 11°c 50% RH
Mission Objective Determined moisture on the lens causing low returns on Scanner 2		GPS Rx Trimble	Pressure: 1019 hPa 3011 inHg
		Scanner 1 Drive B1	Clouds: clear
		Scanner 2 Drive B2	Visibility: 16.1km Altitude @ KJHW 525m/1722 ft

Aircraft Block Time		
Engine On 13:48	Ramp Out	Takeoff 14:05
Engine Off 17:30	Ramp In	Landing 17:21
Total 3.7 hrs	Total hrs	Total 3.3 hrs

Mission Plan			
AGL Height	2300 m	Laser Pulse Rate	800 Hz
Target Speed	160 kts	Scan Rate	185 Hz
Laser Current	100 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:56	14:01
Post Mission	17:24	17:29

Flight Line	LiDAR File Name	Flight Direction	Flight Altitude	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Comments Time Stamp: 170417_
Test strip			8000’	14:11:30	14:12:13			
Cal Line 39		150	8000’	14:17:29	14:18:13			
Cal Line 39		330	8000’	14:22:28	14:23:21			
037		360	8000’	14:32:20	14:47:20			
036		180	8000’	14:50:43	15:04:23			
035		360	8000’	15:07:39	15:22:40			Noticing low returns on Scanner 2??
034		180	8000	15:25:49	15:39:34			Cloud 1 mile from south end
031		360	8000’	15:43:20		15:44:51		Clouds on line; artifacts left side of swath
XTie		90	8000’	15:47:18	15:49:13			Lines 33-37
033		360	8000’	15:56:26	16:10:44			25 nmi from N end? very very very slight
032		180	8000’	16:13:57		16:24:00	10 nmi	Fly south 10 nmi when clouds clear
038 - XTie		270	8000’	16:29:03	16:44:13			
Test				16:45:42	16:46:32			
001		180	8000’	16:50:24	16:58:00			Clouded out - RTB
Cal Line 39		330	8000’	17:08:23	17:09:12			
Cal Line 39		150	8000’	17:11:59	17:12:47			

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Airborne Imaging; April 18, 2017; Lift 1

Julian Day 108	Flight A

LIDAR Flight Log

Date April 18, 2017	Aircraft **C-GKSX**	System **Riegl Q1560**	Additional Notes	
Project 3126_Chautauqua	Pilot O. Kamerman	Unit **2220754**	Wind: 050 @ 4nts	@ KJHW 12:35 UTC +4
Location Jamestown, NY	Operator A. Fox	IMU **Applanix AP50**	Temp: 5°c 75% RH	
Mission Objective		GPS Rx **Trimble**	Pressure: 1027 hPa	3034 inHg
		Scanner 1 Drive A1	Clouds: clear	
		Scanner 2 Drive A2	Visibility: 16.1km	Altitude @ KJHW 525m/1722 ft

Aircraft Block Time		
Engine On 12:37	Ramp Out	Takeoff 12:50
Engine Off 13:28	Ramp In	Landing 13:22
Total 0.9 **hrs**	Total **hrs**	Total 0.5 **hrs**

Mission Plan			
AGL Height	**2300 m**	Laser Pulse Rate	800 **Hz**
Target Speed	160 **kts**	Scan Rate	**185 Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	12:42	12:47
Post Mission	13:24	13:27

Flight Line	LiDAR File Name	Flight Direction	Flight Altitude	GPS Time		Line Aborted		Comments
				Start	End	Time	nmi to End	Time Stamp: 170417_
Test strip			8000'	12:56:52	12:57:35			Looks ok
Cal Line 39		330	8000'	13:02:04	13:02:54			Low ranges 75-85% channel 2
Cal Line 39		150	8000'	13:05:54	13:06:39			Still low ranges
Test		360	8000'	13:07:34	13:08:57			Channel 2 low ranges 65-75% - swath showing
								problems on the left side - RTB
								Waited out fog this morning

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Airborne Imaging; April 18, 2017; Lift 2 Page 1

Julian Day 108	Flight B

LIDAR Flight Log

Date April 18, 2017	Aircraft C-GKSX	System **Riegl Q1560**	Additional Notes
Project 3126_Chautauqua	Pilot O. Kamerman	Unit **2220754**	Wind: 030 @ 6nts @ KJHW 15:35 UTC +4
Location Jamestown, NY	Operator A. Fox	IMU **Applanix AP50**	Temp: 12°c 40% RH
Mission Objective		GPS Rx **Trimble**	Pressure: 1028 hPa 3034 inHg
Lower altitude flight plan to troubleshoot scanner 2		Scanner 1 Drive B1	Clouds: clear
		Scanner 2 Drive B2	Visibility: 16.1km Altitude @ KJHW 525m/1722 ft

Aircraft Block Time		
Engine On 15:41	Ramp Out	Takeoff 15:54
Engine Off 21:24	Ramp In	Landing 21:15
Total 5.8 **hrs**	Total **hrs**	Total 5.4 **hrs**

Mission Plan			
AGL Height	**2300 m**	Laser Pulse Rate	800 **Hz**
Target Speed	160 **kts**	Scan Rate	**185 Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	15:46	15:52
Post Mission	21:18	21:23

Flight Line	LiDAR File Name	Flight Direction	Flight Altitude	GPS Time		Line Aborted		Comments
				Start	End	Time	nmi to End	Time Stamp: 170417_
Test strip			5400'	15:58:24	15:59:43			Looks ok
Cal Line 89		330	5400"	16:01:49	16:02:33			Ranges are equal
Cal Line 89		150	5400'	16:05:29	16:06:16			
87		360	4400"	16:13:18	16:27:32			
86		180	4400'	16:30:31	16:44:19			
85		360	4400'	16:47:23	17:01:48			
84		180	4400'	17:04:50	17:18:29			
83		360	4400"	17:21:37	17:35:41			
XTie		270	4400'	17:39:19	17:40:31			
80		180	8000'	17:49:05		17:58:17	11.4 nmi	@ 2300m 100% power. Clouds at 14 nmi to end
78		360	8000'	18:02:17	18:11:35			Shortened north of xtie only; cloud 20.5 nmi to end
82		180	4400'	18:18:43		18:23:28		Still high params cripes
82		180	4400'	18:32:29	18:46:19			@ 1200m 25% power. Turb – 9 miles remaining
81		360	4400'	18:49:39	19:03:34			Turb 13 nmi from end
80		180	4400'	19:06:52	19:30:24			
79		360	4400'	19:23:27	19:37:19			Turb 15 nmi from end

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Airborne Imaging; April 18, 2017; Lift 2 Page 2

Julian Day 108	Flight B

LIDAR Flight Log

Date April 18, 2017	Aircraft **C-GKSX**	System **Riegl Q1560**		Additional Notes	
Project 3126_Chautauqua	Pilot O. Kamerman	Unit **2220754**		Wind: 020 @ 6nts	@ KJHW 20:35 UTC +4
Location Jamestown, NY	Operator A. Fox	IMU **Applanix AP50**		Temp: 16°c 40% RH	
Mission Objective		GPS Rx **Trimble**		Pressure: 1025 hPa	3028 inHg
		Scanner 1 Drive	B1	Clouds: clear	
		Scanner 2 Drive	B2	Visibility: 16.1km	Altitude @ KECP 525m/1722 ft

Aircraft Block Time		
Engine On 15:41	Ramp Out	Takeoff 15:54
Engine Off 21:24	Ramp In	Landing 21:15
Total 5.8 **hrs**	Total **hrs**	Total 5.4 **hrs**

Mission Plan			
AGL Height	**2300 m**	Laser Pulse Rate	800 **Hz**
Target Speed	160 **kts**	Scan Rate	**185 Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	15:46	15:52
Post Mission	21:18	21:23

Flight Line	LiDAR File Name	Flight Direction	Flight Altitude	GPS Time		Line Aborted		Comments
				Start	End	Time	nmi to End	Time Stamp: 170417_
77		180	4400'	19:40:30	19:54:30			Circuit breaker for laptop popping often
78		360	4400"	19:57:58	20:11:46			
76		180	4400'	20:14:49	20:28:37			Popping almost continuously
75		360	4400"	20:31:57	20:45:57			Remained turbulent on south ends of lines
X-Tie		090	4400'	20:49:28	20:51:12			
Cal Line 89		150	4400'	21:02:12	21:02:51			
Cal Line 89		330	4400'	21:06:21	21:07:02			

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Airborne Imaging; April 23, 2017; Lift 1 Page 1

Julian Day 113	Flight A

LIDAR Flight Log

AIRBORNE IMAGING — A Clean Harbors Company

Date	April 23, 2017	Aircraft	C-GKSX
Project	3126 Chautauqua	Pilot	O. Kamerman
Location	KJHW	Operator	O. Duran
Mission Objective			

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	A1
Scanner 2 Drive	A2

Additional Notes

Aircraft Block Time		
Engine On 14:25	Ramp Out 14:39	Takeoff 14:43
Engine Off 20:49	Ramp In 20:42	Landing 20:39
Total 6.4 hrs	Total 6.1 hrs	Total 5.9 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	800 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	14:34	14:39
Post Mission	20:42	20:47

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
CAL KJHW		NW	14:51	14:51			170423_145114	
CAL KJHW		SE	14:55	14:56			145523	
74		N	15:02	15:16			150240	
73		S	15:19	15:33			151938	
72		N	15:36	15:49			153605	
71		S	15:53	16:07			155336	
70		N	16:10	16:23			161026	
69		S	16:27	16:40			162724	
68		N	16:43	16:57			164355	
67		S	17:00	17:13			170038	
66		N	17:16	17:30			171657	
65		S	17:33	17:47			173345	
64		N	17:50	18:03			175007	
63		S	18:06	18:20			180638	
62		N	18:23	18:36			182320	

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Airborne Imaging; April 23, 2017; Lift 1 Page 2

Julian Day 113	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 23 2017	Aircraft	C-GKSX
Project	3126 Chautauqua	Pilot	O. Kamerman
Location	KJHW	Operator	O. Duran
Mission Objective			

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	A1
Scanner 2 Drive	A2

Additional Notes

Aircraft Block Time		
Engine On 14:25	Ramp Out 14:39	Takeoff 14:43
Engine Off 20:49	Ramp In 20:42	Landing 20:39
Total 6.4 hrs	Total 6.1 hrs	Total 5.9 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	800 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	14:34	14:39
Post Mission	20:42	20:47

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
61		S	18:39	18:52			183929	
60		N	18:56	19:09			185606	
59		S	19:12	19:25			191210	
58		N	19:28	19:41			192827	
57		S	19:44	19:57			194427	
56		N	20:00	20:13			200035	
Tie		E	20:17	20:20			201730	
CAL KJHW		SE	20:29	20:30			202934	
CAL KJHW		NW	20:33	20:34			203317	

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Airborne Imaging; April 23, 2017; Lift 2 Page 1

Julian Day 113	Flight B

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 23, 2017	Aircraft	C-GKSX
Project	3126 Chautauqua	Pilot	O. Kamerman
Location	KJHW	Operator	O. Duran
Mission Objective			

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	B1
Scanner 2 Drive	B2

Additional Notes

Aircraft Block Time		
Engine On 21:30	Ramp Out 21:42	Takeoff 21:45
Engine Off 02:46	Ramp In 02:40	Landing 02:37
Total 5.3 hrs	Total 5.0 hrs	Total 4.9 hrs

Mission Plan	
AGL Height 1200 m	Pulse Rate 800 KHz
Target Speed 160 kts	Scan Rate ~250 Hz
Laser Current 25 %	FOV 60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	21:36	21:41
Post Mission	02:40	02:45

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
CAL KJHW		NW	21:50	21:51			170423_215045	
CAL KJHW		SE	21:54	21:55			215437	
88		W	22:03	22:17			220311 ←	• "Data Recorder Warning"
Test strip		—	22:19	22:20			221921	• SDF file corrupted (Message at
Test strip		—	22:20	22:20			222013	the end of the line)
88		E	22:22	22:36			222249	• Warning 1022 SDF_Sync_Error
55		N	22:44	22:57			224445	• Warning 1025 SDF_Checksum_Error
54		S	23:01	23:13			230108	
53		N	23:17	23:29			231720	
52		S	23:33	23:45			233318	
51		N	23:49	00:01			234914	
50		S	00:04	00:17			000446	
49		N	00:20	00:32			002025	
48		S	00:35	00:47			003532	
47		N	00:50	01:02			005032	

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Airborne Imaging; April 23, 2017; Lift 2 Page 2

Julian Day	113	Flight	B

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 23, 2017	Aircraft	C-GKSX
Project	3126 Chautauqua	Pilot	O. Kamerman
Location	KJHW	Operator	O. Duran
Mission Objective			

System	**Riegl Q1560**
Unit	**2220754**
IMU	**Applanix AP50**
GPS Rx	**Trimble**
Scanner 1 Drive	B1
Scanner 2 Drive	B2

Additional Notes

Aircraft Block Time					
Engine On	21:30	Ramp Out	21:42	Takeoff	21:45
Engine Off	02:46	Ramp In	02:40	Landing	02:37
Total	5.3 **hrs**	Total	5.0 **hrs**	Total	4.9 **hrs**

Mission Plan			
AGL Height	1200 **m**	Pulse Rate	800 **KHz**
Target Speed	160 **kts**	Scan Rate	~250 **Hz**
Laser Current	25 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	21:36	21:41
Post Mission	02:40	02:45

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
46		S	01:05	01:17			010530	
45		N	01:20	01:31			012016	
44		S	01:34	01:46			013458	
43		N	01:49	02:00			014928	
42		S	02:03	02:15			020355	
Tie		E	02:18	02:20			021801	
CAL KJHW		NW	02:24	02:24			022417	
CAL KJHW		SE	02:28	02:29			022845	

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Axis GeoAviation; April 23, 2017

LiDAR and Imagery Flight Report — **Project(s): NYSW LiDAR**

Pilot: SW		Project Number(s): 217021
Operator: ZM		Project Name(s): NYSW LiDAR
Aircraft: Cessna 206 N223TC		Block Number:

LiDAR Unit: Q1560	Scan Rate: 155 lps	Camera Unit: Phase One IXU-180	Date: 04-23-2017
MTA Zones:	Ground Speed Start (kts): 145 kts	View Angle (deg):	Sun Angle: > 30 Degrees
PRR (kHz):	Altitude(feet AMT): 8003	Endlap (%):	Lens: #2-11976481k
Laser Power (%): 100%	Point Spacing (m): .72 m	Side-Lap(%):	Point Density (ppms): 2.25

Direction	Line #	From	To	Start Time	Flying Height (AMSL) (ft)	Remarks	Clouds	Turbulance
196	6	N	S	1244	8265	Leaves covering most trees	N/A	N/A
7	5	S	N	1301	8216			
195	4	N	S	1319	8190			
7	3	S	N	1336	8118			
196	2	N	S	1354	8121			
5	1	S	N	1412	8128			
	x-tie	W	E	1435	8200			

Cloud Cover Codes: ⊕ = High Thin ● = Solid Overcast O = Clear

Remarks:

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Airborne Imaging; April 24, 2017; Lift 1 Page 1

Julian Day 114	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date April 24, 2017	Aircraft C-GKSX
Project 3126 Chautauqua	Pilot O. Komerman
Location KJHW	Operator O. Duran
Mission Objective	

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	A1
Scanner 2 Drive	A2

Additional Notes

Aircraft Block Time		
Engine On 13:37	Ramp Out 13:52	Takeoff 13:54
Engine Off 19:40	Ramp In 19:32	Landing 19:30
Total 6.1 hrs	Total 5.7 hrs	Total 5.6 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	800 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:43	13:48
Post Mission	19:32	19:37

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
CAL KJHW		NW	14:02	14:03			170424_140229	
CAL KJHW		SE	14:06	14:07			140637	
41		N	14:14	14:25			141418	• When flying over the Lake,
40		S	14:28	14:40			142853	the following error appeared:
39		N	14:43	14:54			144320	'Chanel 1/2 does not receive echoes'
38		S	14:57	15:08			145750	
37		N	15:12	15:22			151210	
36		S	15:26	15:37			152614	
35		N	15:40	15:50			154027	
34		S	15:54	16:04			155420	
33		N	16:08	16:18			160805	
32		S	16:22	16:32			162202	
31		N	16:35	16:45			163534	
30		S	16:49	16:59			164917	
29		N	17:02	17:12			170227	

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Airborne Imaging; April 24, 2017; Lift 1 Page 2

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Julian Day 114	Flight A

Date April 24, 2017	Aircraft C-GKSX
Project 3126 Chautauqua	Pilot O. Kamerman
Location KJHW	Operator O. Duran
Mission Objective	

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	A1
Scanner 2 Drive	A2

Additional Notes

Aircraft Block Time		
Engine On 13:37	Ramp Out 13:52	Takeoff 13:54
Engine Off 19:40	Ramp In 19:32	Landing 19:30
Total 6.1 hrs	Total 5.7 hrs	Total 5.6 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	800 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	13:43	13:48
Post Mission	19:32	19:37

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
28		S	17:15	17:25			171547	
27		N	17:29	17:38			172910	
26		S	17:42	17:52			174259	
25		N	17:55	18:05			175546	
24		S	18:08	18:18			180841	
23		N	18:21	18:30			182121	
22		S	18:33	18:43			183358	
21		N	18:46	18:55			184634	
20		S	18:58	19:08			185856	
Tie		E	19:12	19:16			191206	
CAL KJHW		NW	19:20	19:21			192051	
CAL KJHW		SE	19:25	19:25			192500	

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Airborne Imaging; April 24, 2017; Lift 2 Page 1

Julian Day 114	Flight B

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date April 24, 2017	Aircraft C-GKSX
Project 3126 Chautauqua	Pilot O. Kamerman
Location KJHW	Operator O. Duran
Mission Objective	

System	Riegl Q1560
Unit	2220754
IMU	Applanix AP50
GPS Rx	Trimble
Scanner 1 Drive	B1
Scanner 2 Drive	B2

Additional Notes

Aircraft Block Time		
Engine On 20:43	Ramp Out 20:54	Takeoff 20:57
Engine Off 01:28	Ramp In 01:21	Landing 01:18
Total 4.8 hrs	Total 4.5 hrs	Total 4.4 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	800 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	20:49	20:54
Post Mission	01:21	01:26

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
CAL KJHW		NW	21:04	21:04			170424_210414	
CAL KJHW		SE	21:08	21:09			210835	
19		N	21:18	21:27			211818	
18		S	21:30	21:39			213039	
17		N	21:42	21:51			214258	
16		S	21:54	22:04			215458	
15		N	22:07	22:15			220705	
14		S	22:18	22:27			221853	
13		N	22:30	22:39			223050	
12		S	22:42	22:51			224219	
11		N	22:54	23:02			225402	
10		S	23:05	23:13			230520	
9		N	23:16	23:24			231650	
8		S	23:28	23:36			232805	
7		N	23:39	23:47			233933	

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Airborne Imaging; April 24, 2017; Lift 2 Page 2

Julian Day 114	Flight B

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date April 24, 2017	Aircraft C-GKSX	System	Riegl Q1560
Project 3126 Chautauqua	Pilot O. Kamerman	Unit	2220754
Location KJHW	Operator O. Duran	IMU	Applanix AP50
Mission Objective		GPS Rx	Trimble
		Scanner 1 Drive	B1
		Scanner 2 Drive	B2

Additional Notes

Aircraft Block Time		
Engine On 20:43	Ramp Out 20:54	Takeoff 20:57
Engine Off 01:28	Ramp In 01:21	Landing 01:18
Total 4.8 hrs	Total 4.5 hrs	Total 4.4 hrs

Mission Plan			
AGL Height	1200 m	Pulse Rate	200 KHz
Target Speed	160 kts	Scan Rate	~250 Hz
Laser Current	25 %	FOV	60 Deg's

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	20:49	20:54
Post Mission	01:21	01:26

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
6		S	23:50	23:58			235036	
5		N	00:01	00:09			000154	
4		S	00:12	00:21			001249	
3		N	00:24	00:31			002410	
2		S	00:35	00:43			003500	
1		N	00:46	00:53			004619	
Tie		E	00:56	01:00			005658	
CAL KJHW		SE	01:07	01:08			010753	
CAL KJHW		NW	01:11	01:12			011145	

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Axis GeoAviation; April 24, 2017; Lift 1 Page 1

LiDAR and Imagery Flight Report — **Project(s): NYSW LiDAR**

Pilot: SW		Project Number(s): 217021
Operator: ZM		Project Name(s): NYSW LiDAR
Aircraft: Cessna 206 N223TC		Block Number:

LiDAR Unit: Q1560	Scan Rate: 155 lps	Camera Unit: Phase One IXU-180	Date: 04-23-2017
MTA Zones:	Ground Speed Start (kts): 145 kts	View Angle (deg):	Sun Angle: > 30 Degrees
PRR (kHz):	Altitude(feet AMT): 8003	Endlap (%):	Lens: #2-11976481k
Laser Power (%): 100%	Point Spacing (m): .72 m	Side-Lap(%):	Point Density (ppms): 2.25

Direction	Line #	From	To	Start Time	Flying Height (AMSL) (ft)	Remarks	Clouds	Turbulence
192	7	N	S	934	8295	Light haze	Clear	None
10	8	S	N	950	8364	Light haze	Clear	
190	9	N	S	1006	8505	Light haze	Clear	
9	10	S	N	1022	8462	Light haze	Clear	
190	11	N	S	1038	8439	Light haze	Clear	
10	12	S	N	1054	8439	Light haze	Clear	
189	13	N	S	1110	8479	Light haze	Clear	
10	14	S	N	1127	8544	Light haze	Clear	
189	15	N	S	1143	8530	Light haze	Clear	
10	16	S	N	1200	8561	Light haze	Clear	
300	x-tie	E	W	1222	8500	Light haze	Clear	

Cloud Cover Codes ⊕ = High Thin ● = Solid Overcast O = Clear

Remarks:

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Axis GeoAviation; April 24, 2017; Lift 2 Page 1

LiDAR and Imagery Flight Report **Project(s): NYSW LiDAR**

Pilot: SW		Project Number(s): 217021	
Operator: ZM		Project Name(s): NYSW LiDAR	
Aircraft: Cessna 206 N223TC		Block Number:	
LiDAR Unit: Q1560	Scan Rate: 155 lps	Camera Unit: Phase One IXU-180	Date: 04-23-2017
MTA Zones:	Ground Speed Start (kts): 145 kts	View Angle (deg):	Sun Angle: > 30 Degrees
PRR (kHz):	Altitude(feet AMT): 8003	Endlap (%):	Lens: #2-11976481k
Laser Power (%): 100%	Point Spacing (m): .72 m	Side-Lap(%):	Point Density (ppms): 2.25

Direction	Line #	From	To	Start Time	Flying Height (AMSL) (ft)	Remarks	Clouds	Turbulence
189	17	N	S	1410	8570	Aborted for turbulence. Pushed off line several times. Altitudes all over the place.	Clear	Moderate
	18	S	N		8626			
	19	N	S		8636			
	20	S	N		8672			
	21	N	S		8718			
	22	S	N		8735			
	23	N	S		8757			

Cloud Cover Codes ⊕ = High Thin ●= Solid Overcast O = Clear

Remarks:

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Axis GeoAviation; May 09, 2017;

LiDAR and Imagery Flight Report Project(s): NYSW LiDAR

Pilot: SW	Project Number(s): 217021
Operator: ZM	Project Name(s): NYSW LiDAR
Aircraft: Cessna 206 N223TC	Block Number:

LiDAR Unit: Q1560	Scan Rate: 155 lps	Camera Unit: Phase One IXU-180	Date: 04-23-2017
MTA Zones:	Ground Speed Start (kts): 145 kts	View Angle (deg):	Sun Angle: > 30 Degrees
PRR (kHz):	Altitude(feet AMT): 8003	Endlap (%):	Lens: #2-11976481k
Laser Power (%): 100%	Point Spacing (m): .72 m	Side-Lap(%):	Point Density (ppms): 2.25

Direction	Line #	From	To	Start Time	Flying Height (AMSL) (ft)	Remarks	Clouds	Turbulence
2	1	S	N	801	8128			
199	2	N	S	821	8121			
359	3	S	N	839	8118			
195	4	N	S	858	8190			
359	5	S	N	915	8216			
197	6	N	S	934	8265			
359	17	S	N	953	8570			
287	xtie	E	W	1014	8570			

Cloud Cover Codes ⊕ = High Thin ● = Solid Overcast O = Clear

Remarks:

Page 1 of 1

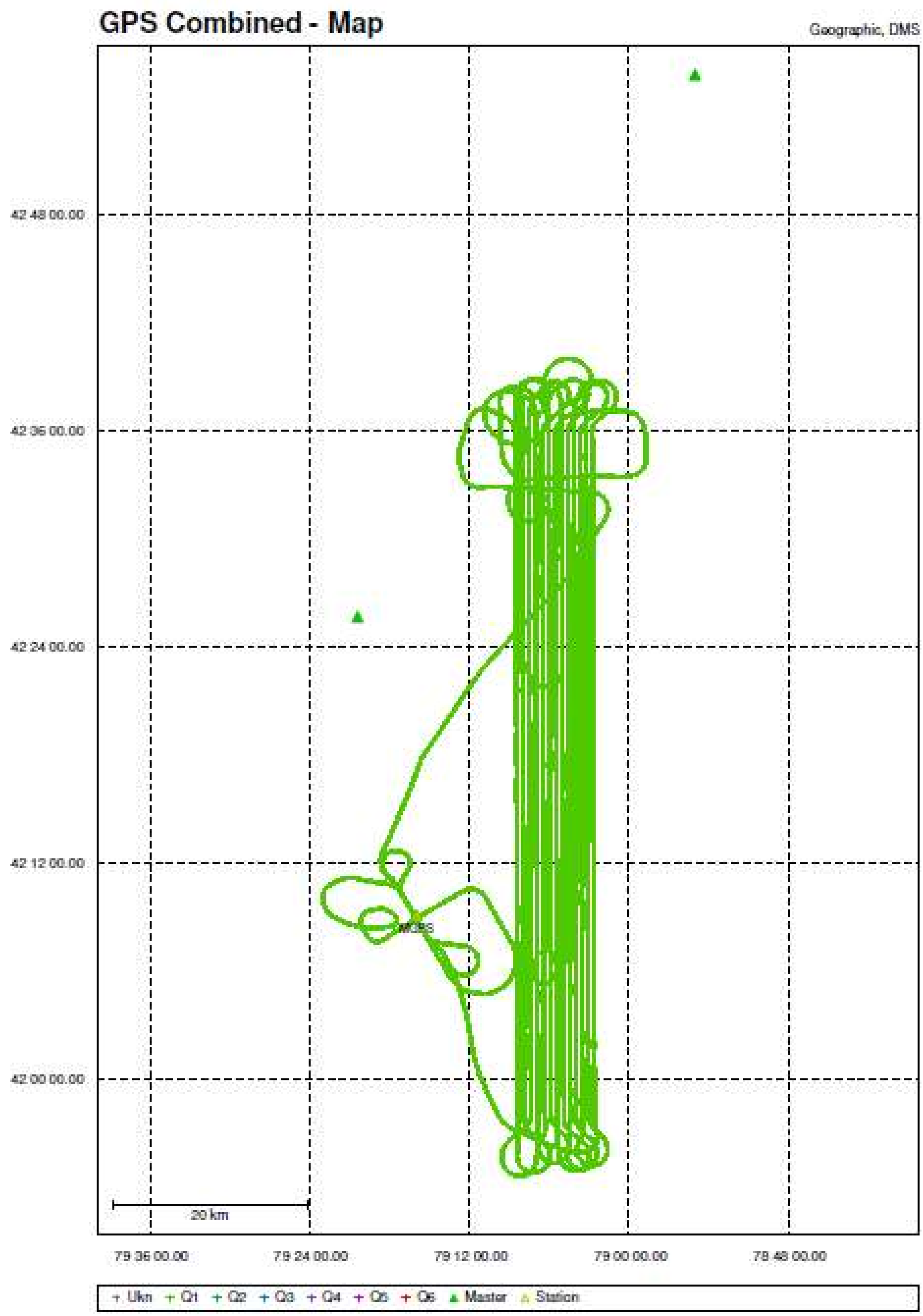
Section 5: GPS Processing Plots

POSPac MMS Version 7.1

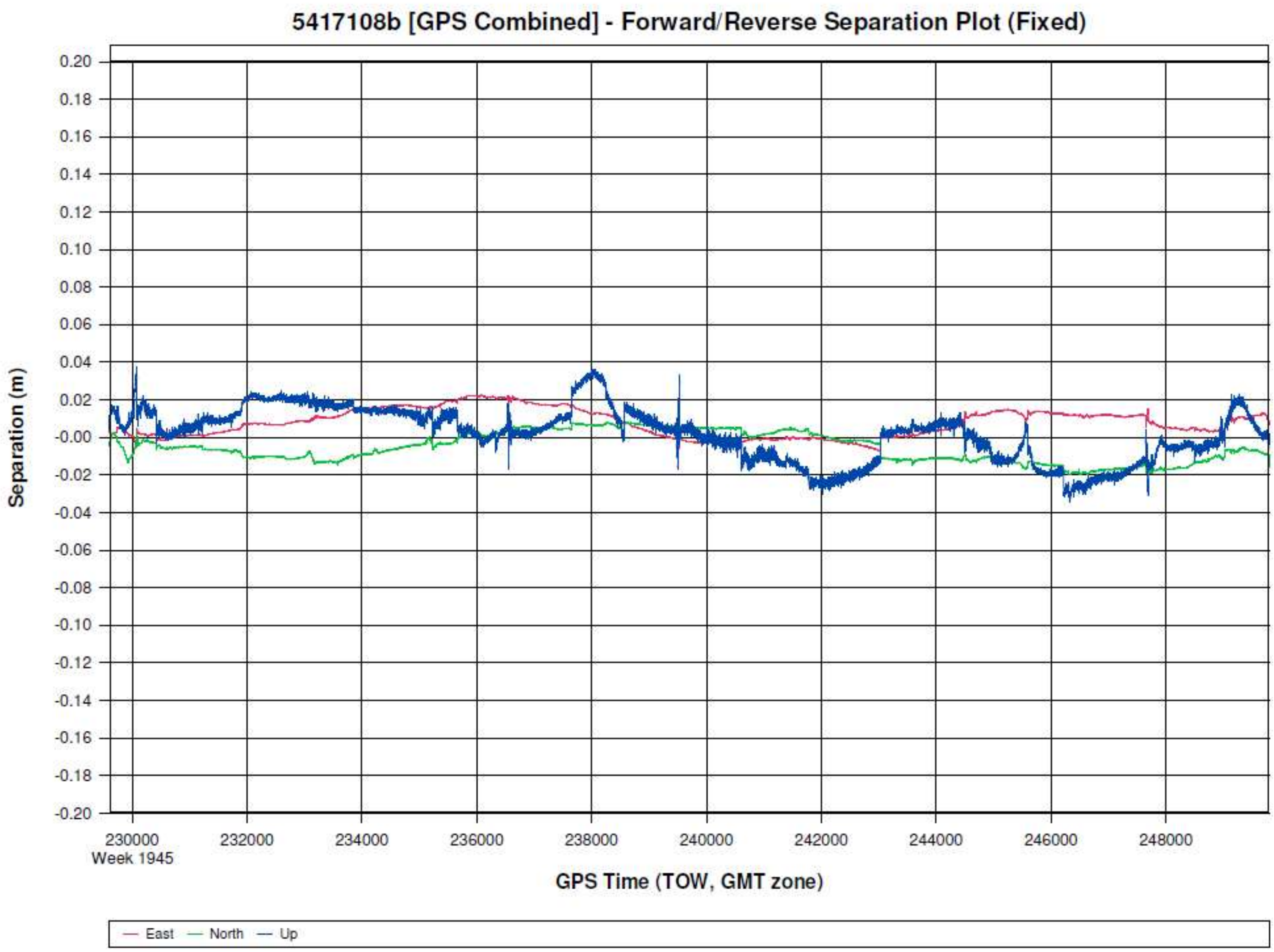
Plots by lift of the Coverage Map, Estimated Position Accuracy, Number of Satellites, Combined Separation, and PDOP.

Airborne Imaging; April 18, 2017; Lift 2

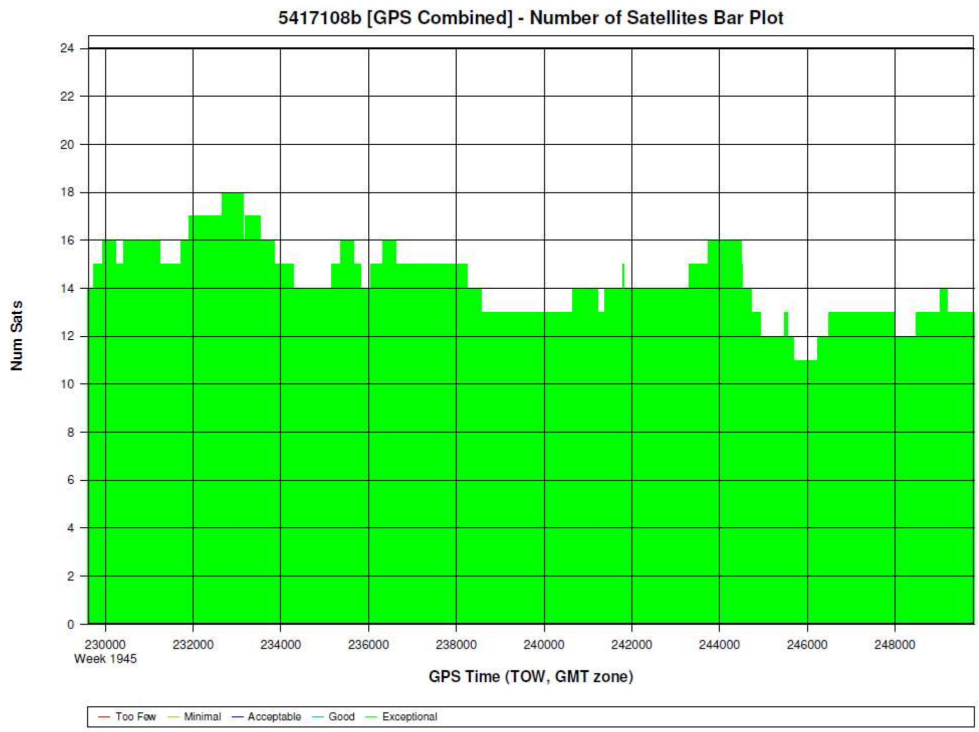
Coverage Map: The Coverage Map plot shows the Aircraft GPS-IMU Trajectory in reference to localized GPS Reference Stations.



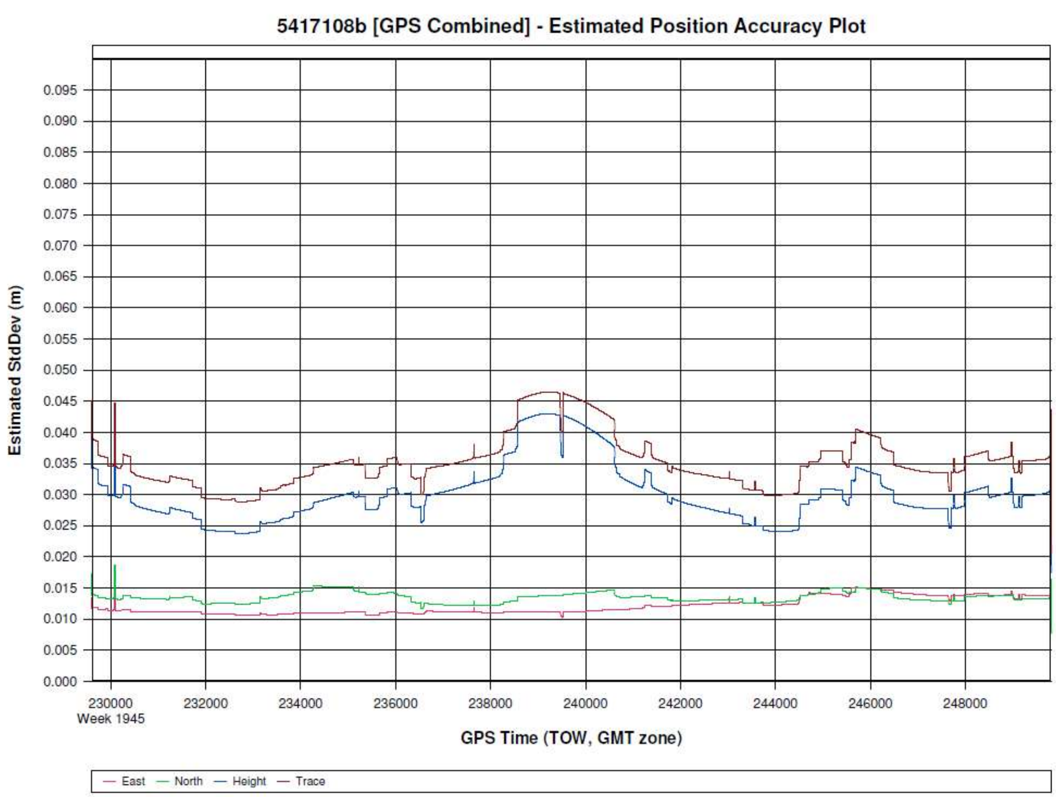
Combined Separation: Plots the north, east, and height position difference between any two solutions loaded into the project. This is most often the forward and reverse processing results, unless other solutions have been loaded from the Combine Solutions dialog. Plotting the difference between forward 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.



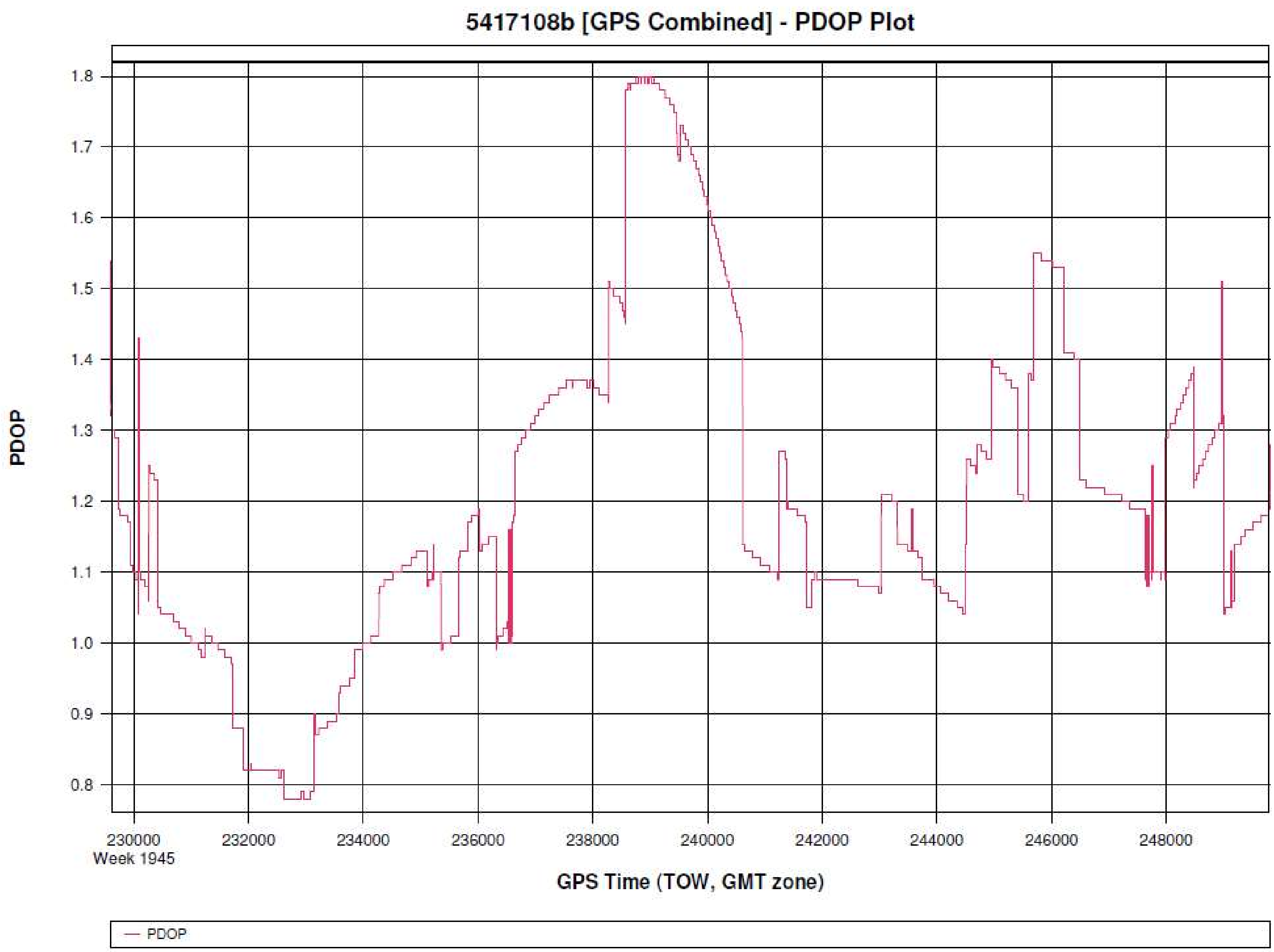
Number of Satellites: Plots the number of satellites used in the solution as a function of time. The number of GPS satellites, GLONASS satellites and the total number of satellites are distinguished with separate lines.



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

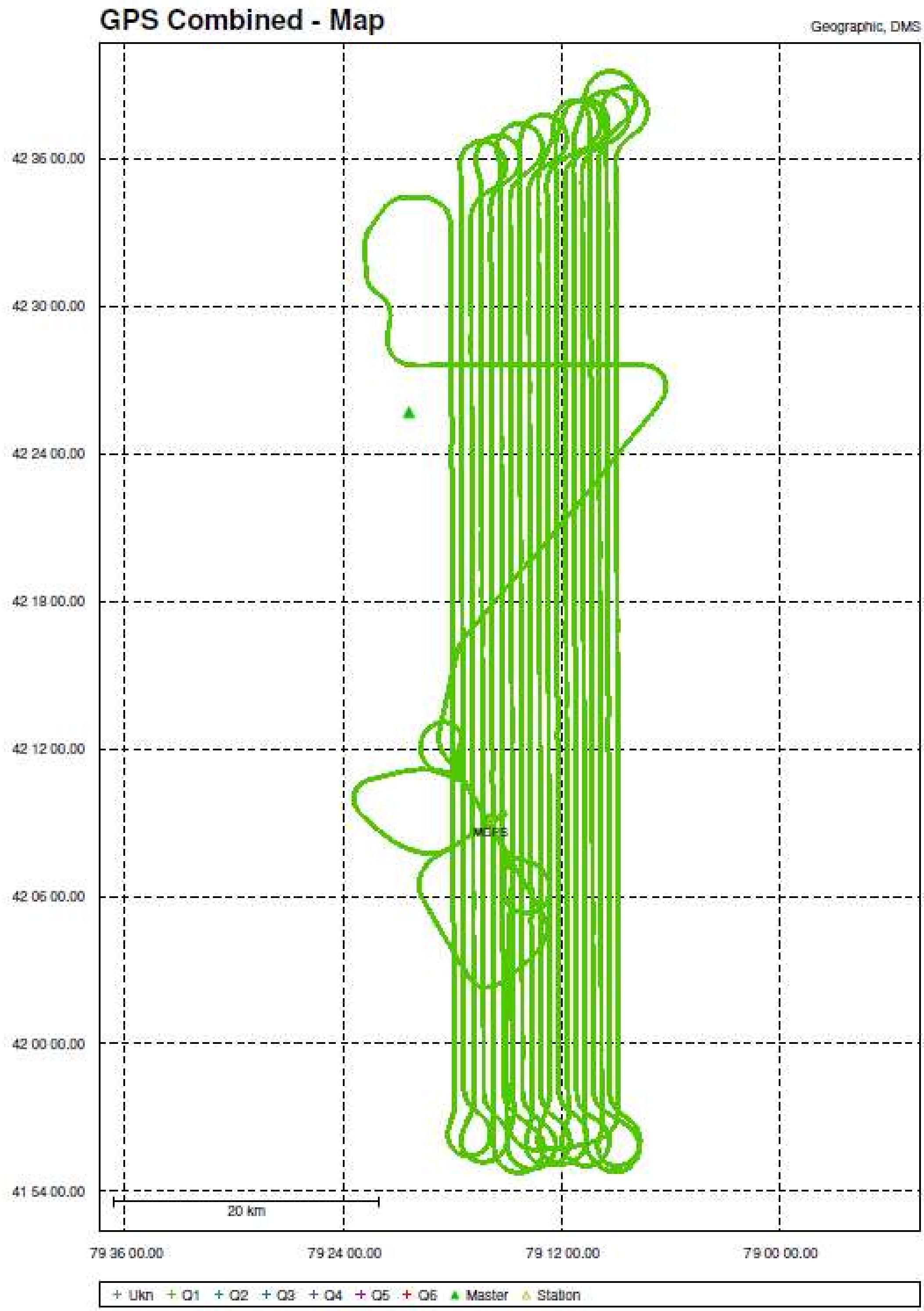


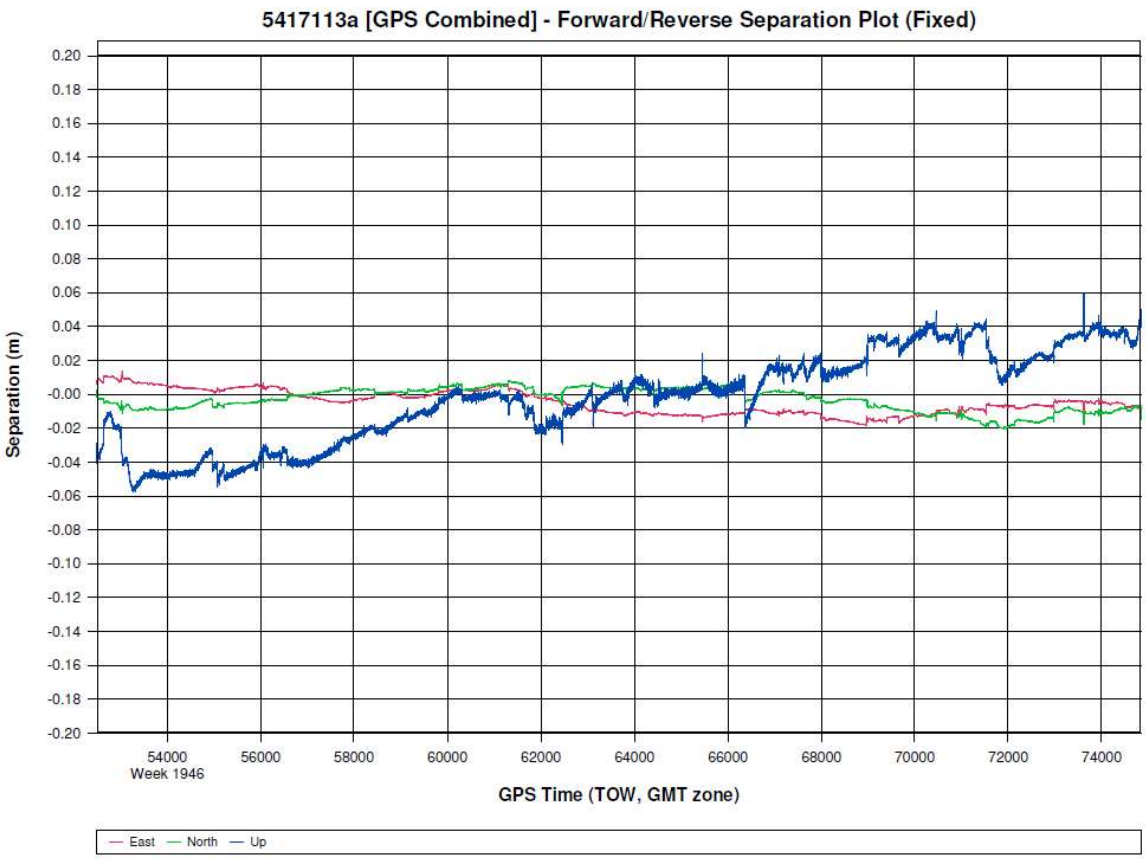
PDOP: PDOP is a unit less number which indicates how favorable the satellite geometry is to 3D positioning accuracy. A strong satellite geometry, where the PDOP is low, occurs when satellites are well distributed in each direction (north, south, east and west) as well as directly overhead. Values in 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

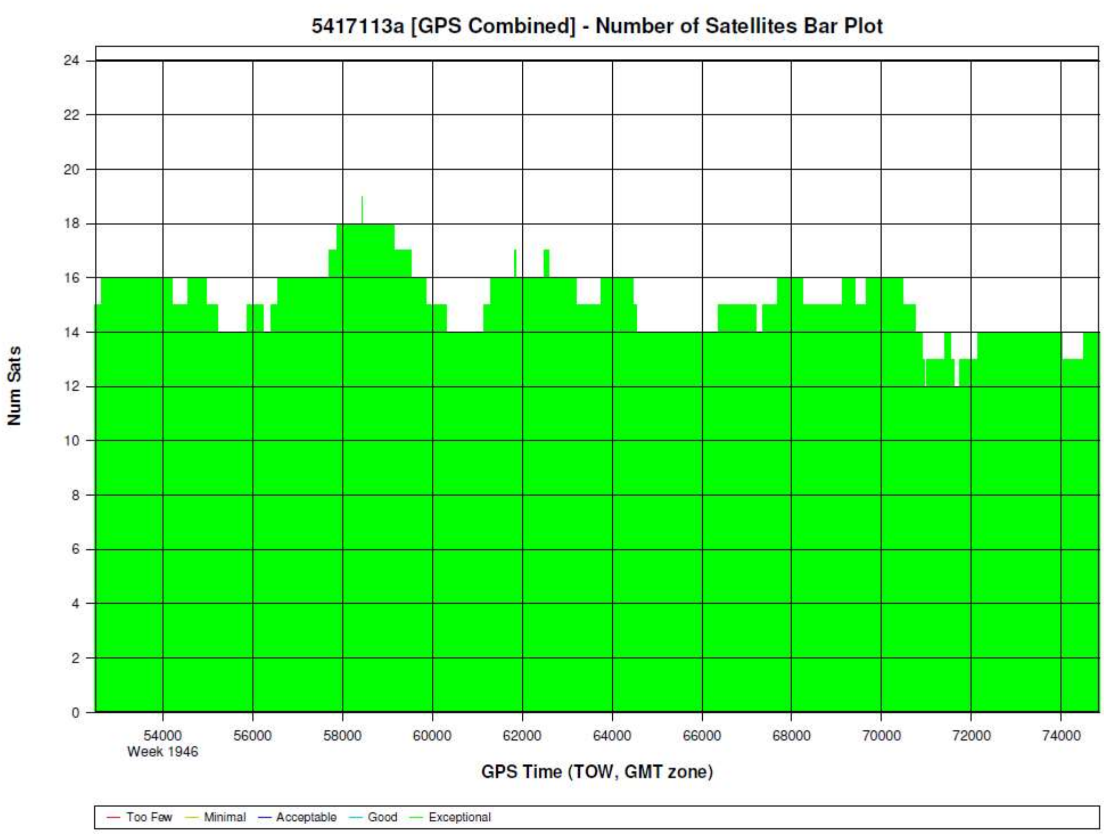


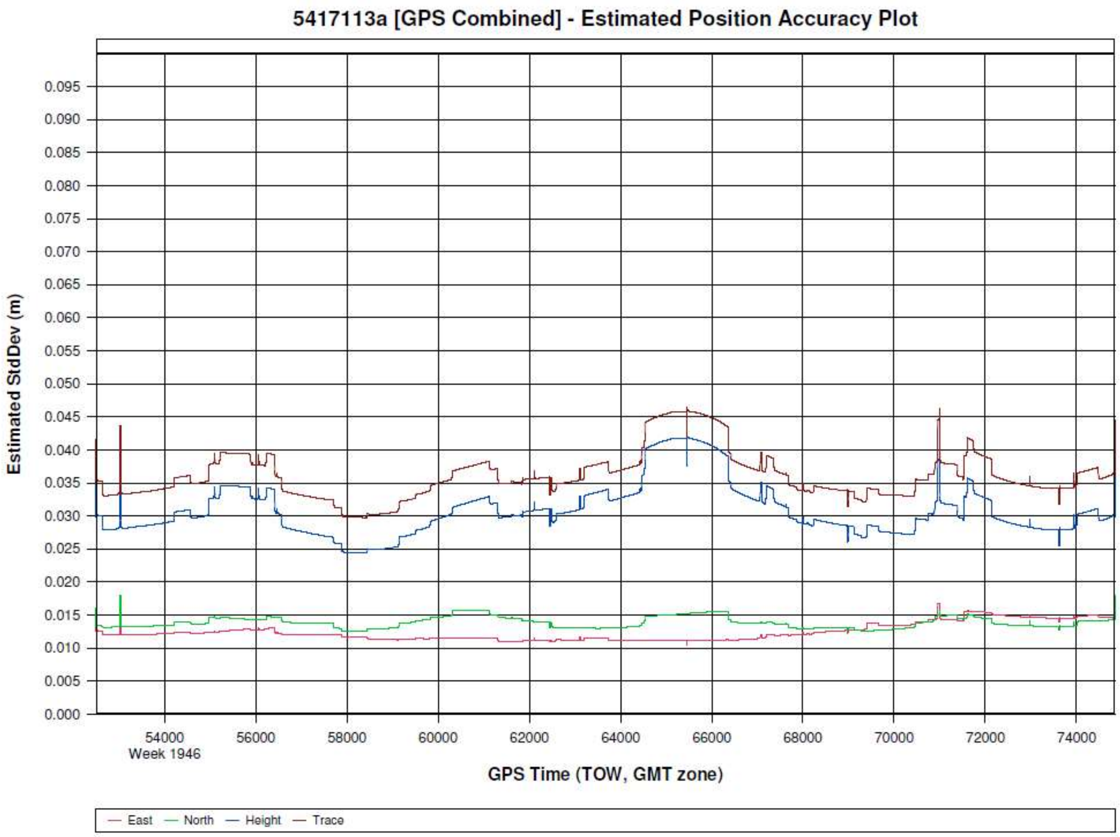
poor.

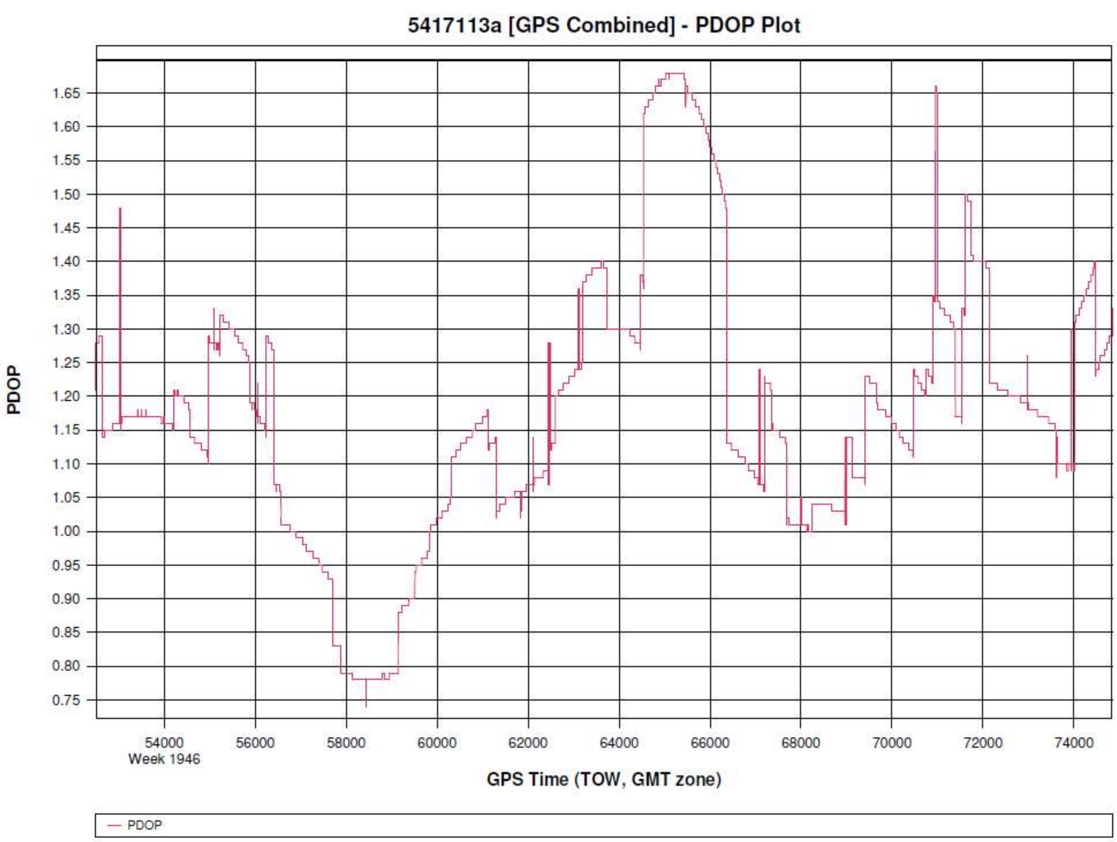
Airborne Imaging; April 23, 2017; Lift 1



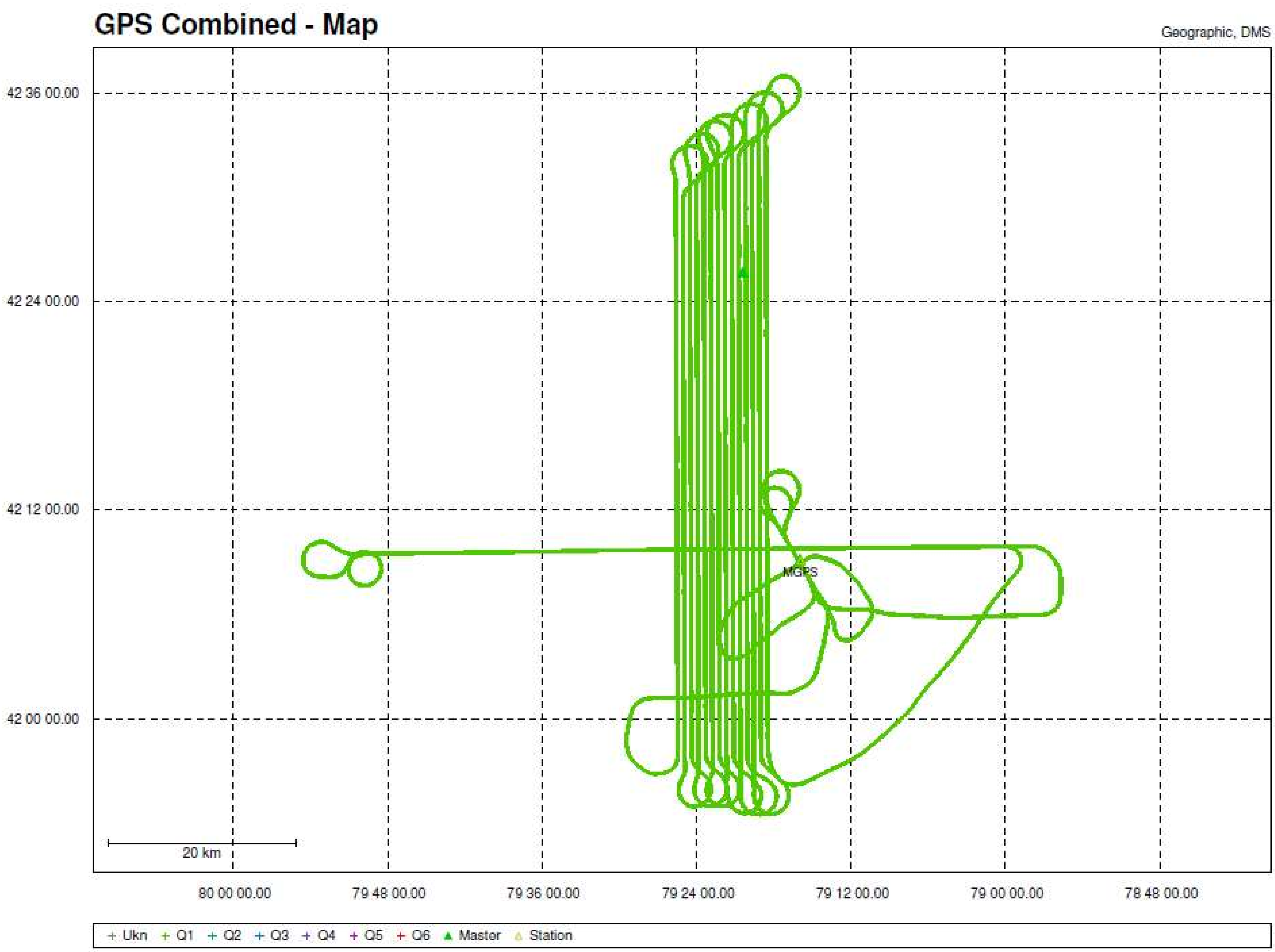

5417113a [GPS Combined] - Forward/Reverse Separation Plot (Fixed)
Separation (m)
GPS Time (TOW, GMT zone)
Week 1946
East
North
Up

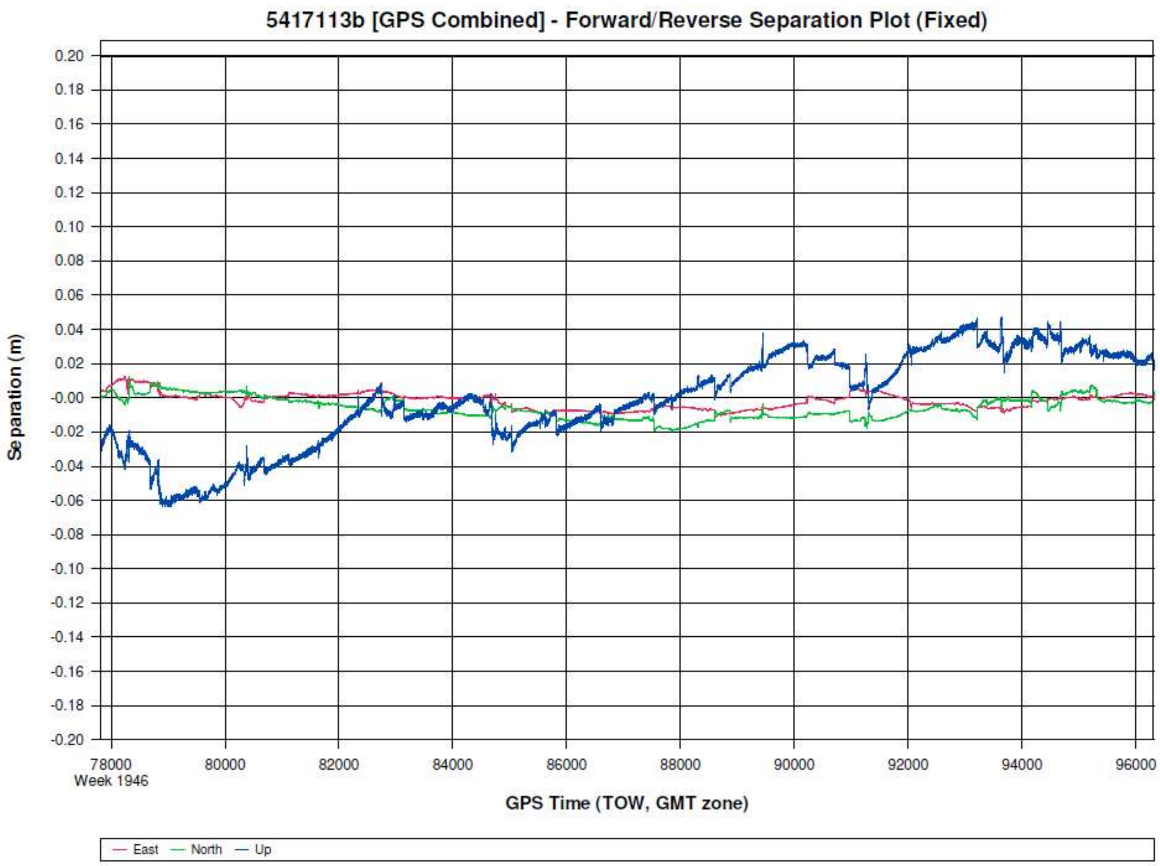

5417113a [GPS Combined] - Number of Satellites Bar Plot
Num Sats
GPS Time (TOW, GMT zone)
Week 1946
Too Few
Minimal
Acceptable
Good
Exceptional

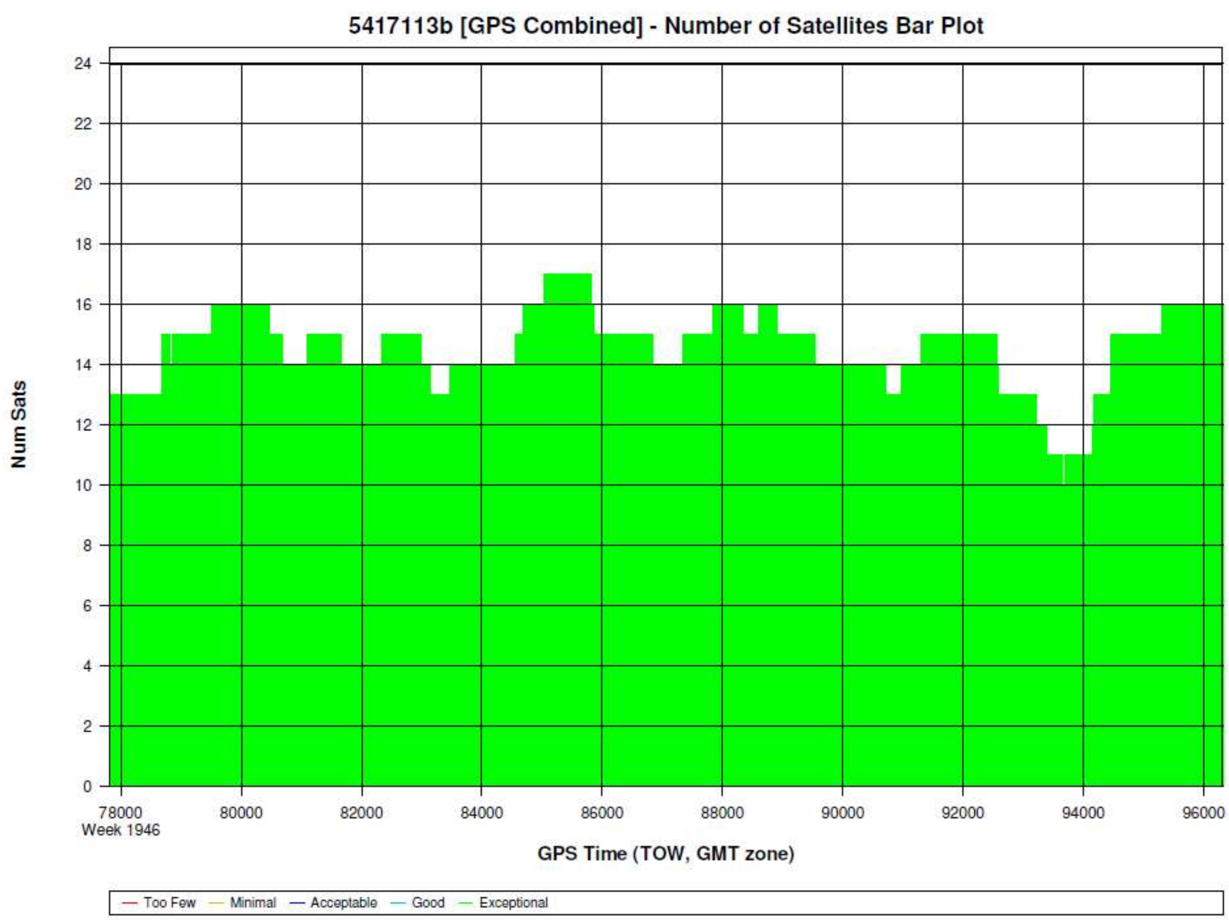

5417113a [GPS Combined] - Estimated Position Accuracy Plot
Estimated StdDev (m)
GPS Time (TOW, GMT zone)
Week 1946
East
North
Height
Trace


5417113a [GPS Combined] - PDOP Plot
PDOP
GPS Time (TOW, GMT zone)
Week 1946
PDOP

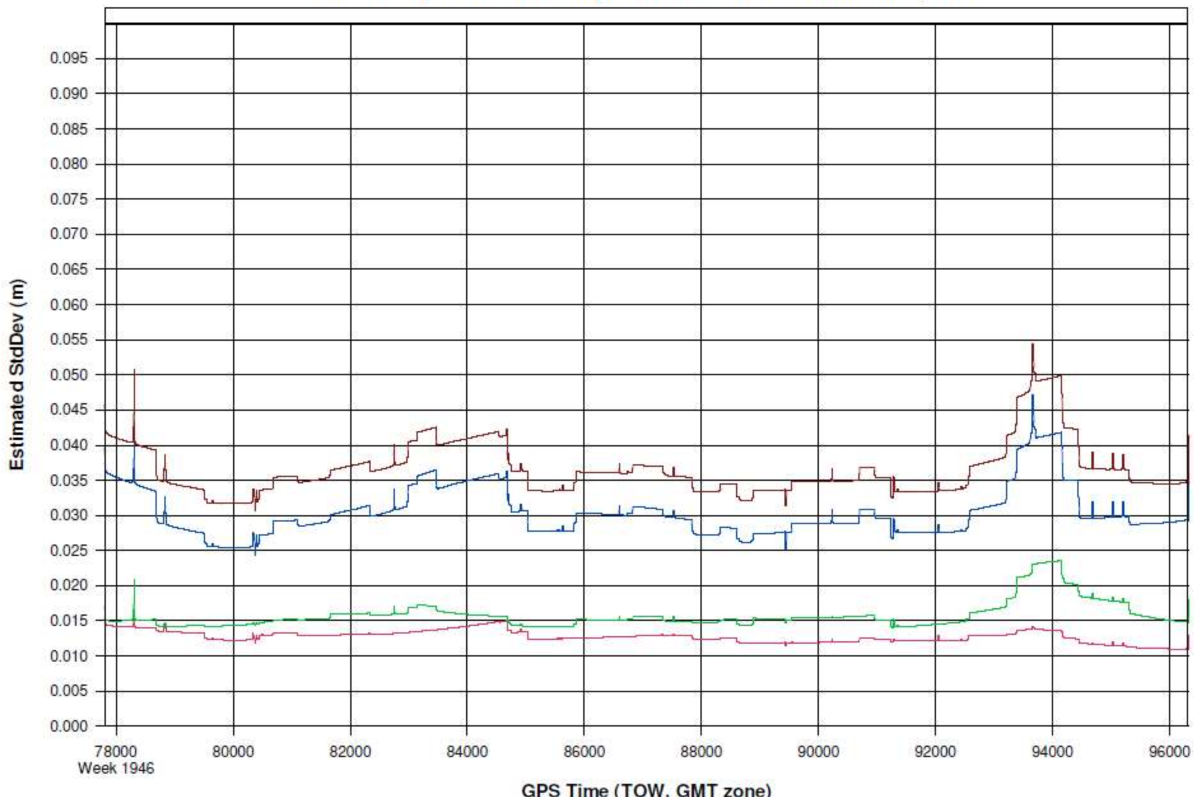
Airborne Imaging; April 23, 2017; Lift 2



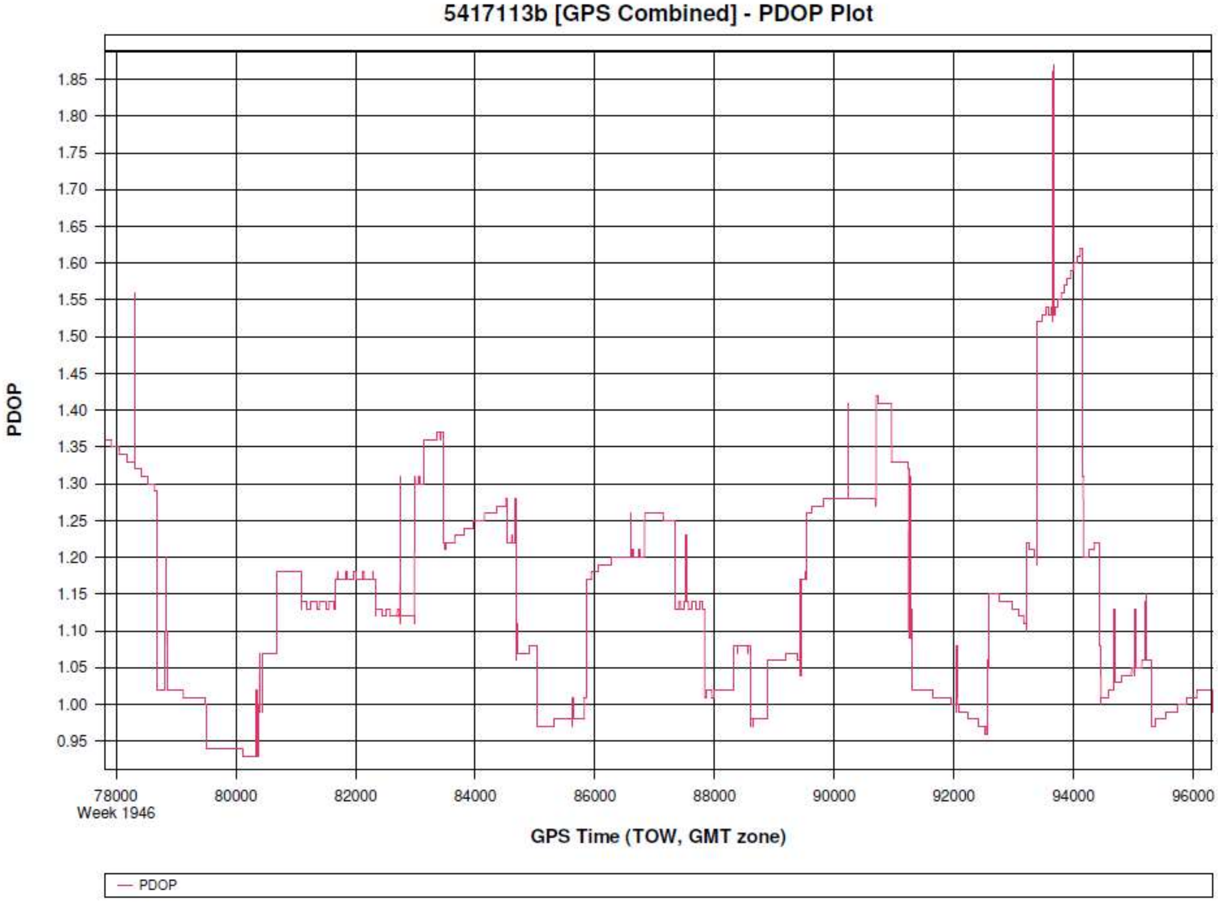

5417113b [GPS Combined] - Forward/Reverse Separation Plot (Fixed)
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
78000
Week 1946
80000
82000
84000
86000
88000
90000
92000
94000
96000
GPS Time (TOW, GMT zone)
East
North
Up


5417113b [GPS Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
78000
Week 1946
80000
82000
84000
86000
88000
90000
92000
94000
96000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

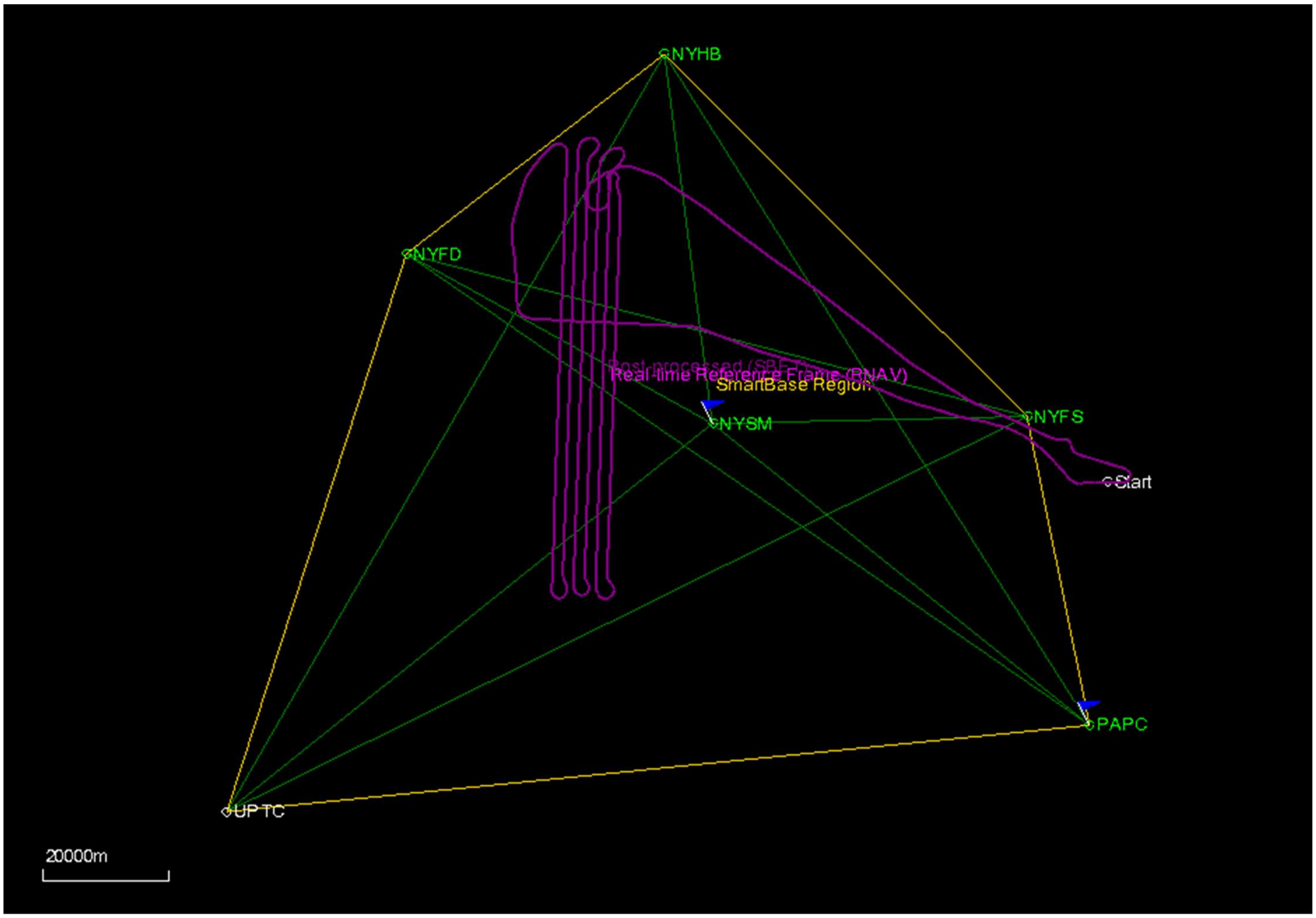
5417113b [GPS Combined] - Estimated Position Accuracy Plot

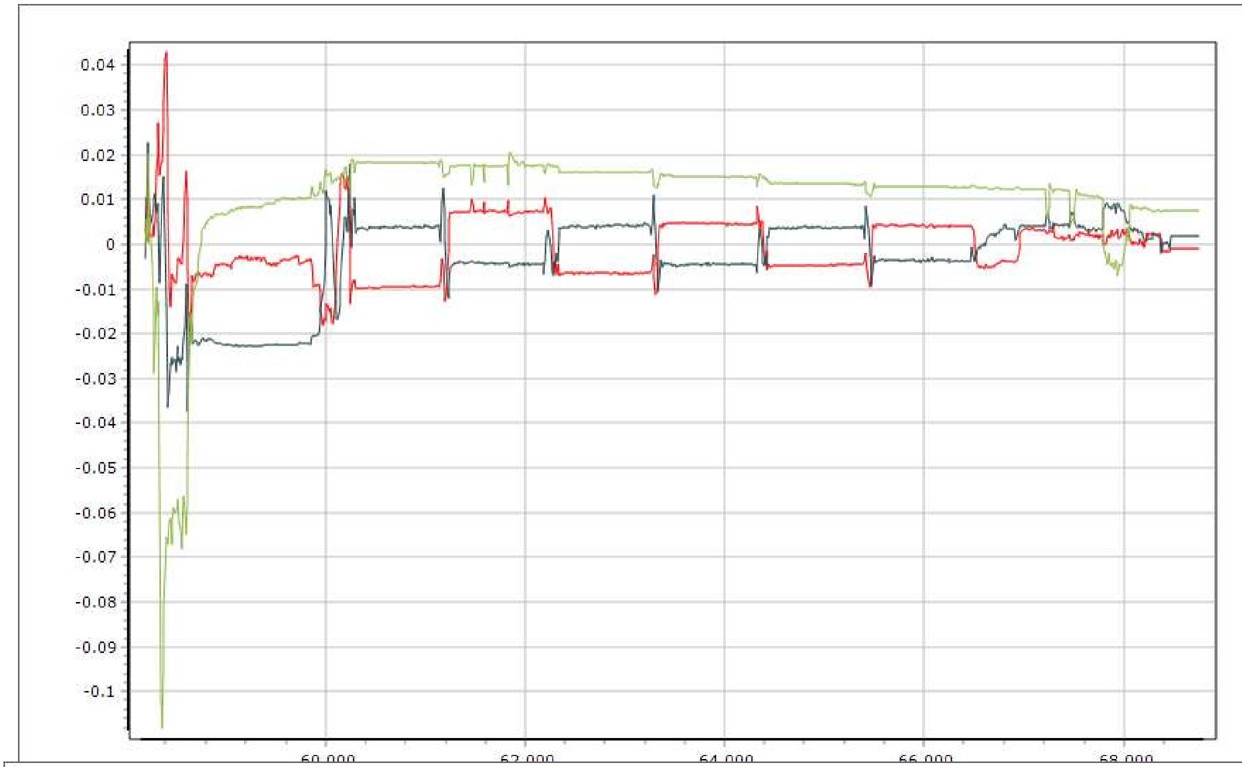


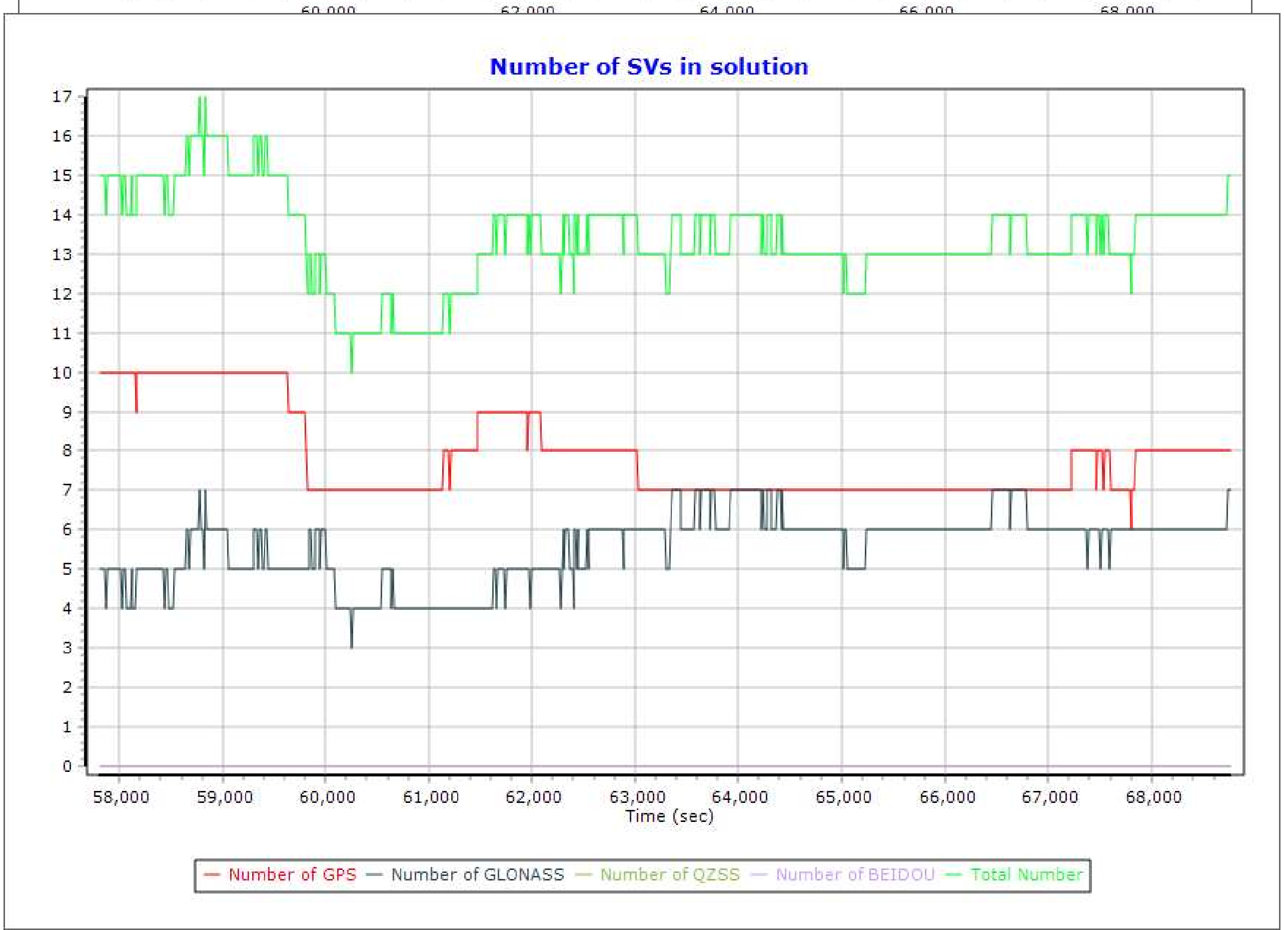
5417113b [GPS Combined] - PDOP Plot

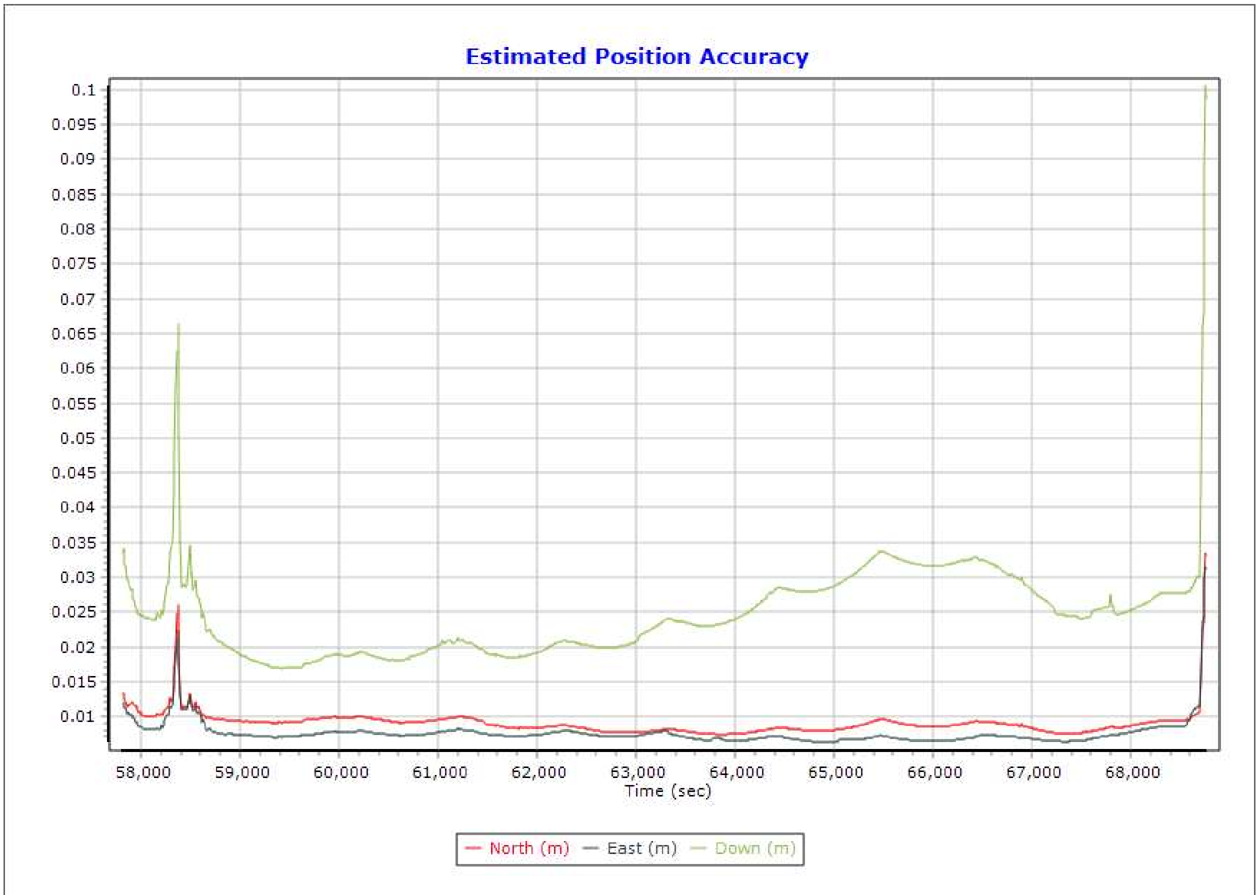


Axis GeoAviation; April 23, 2017; Lift 1



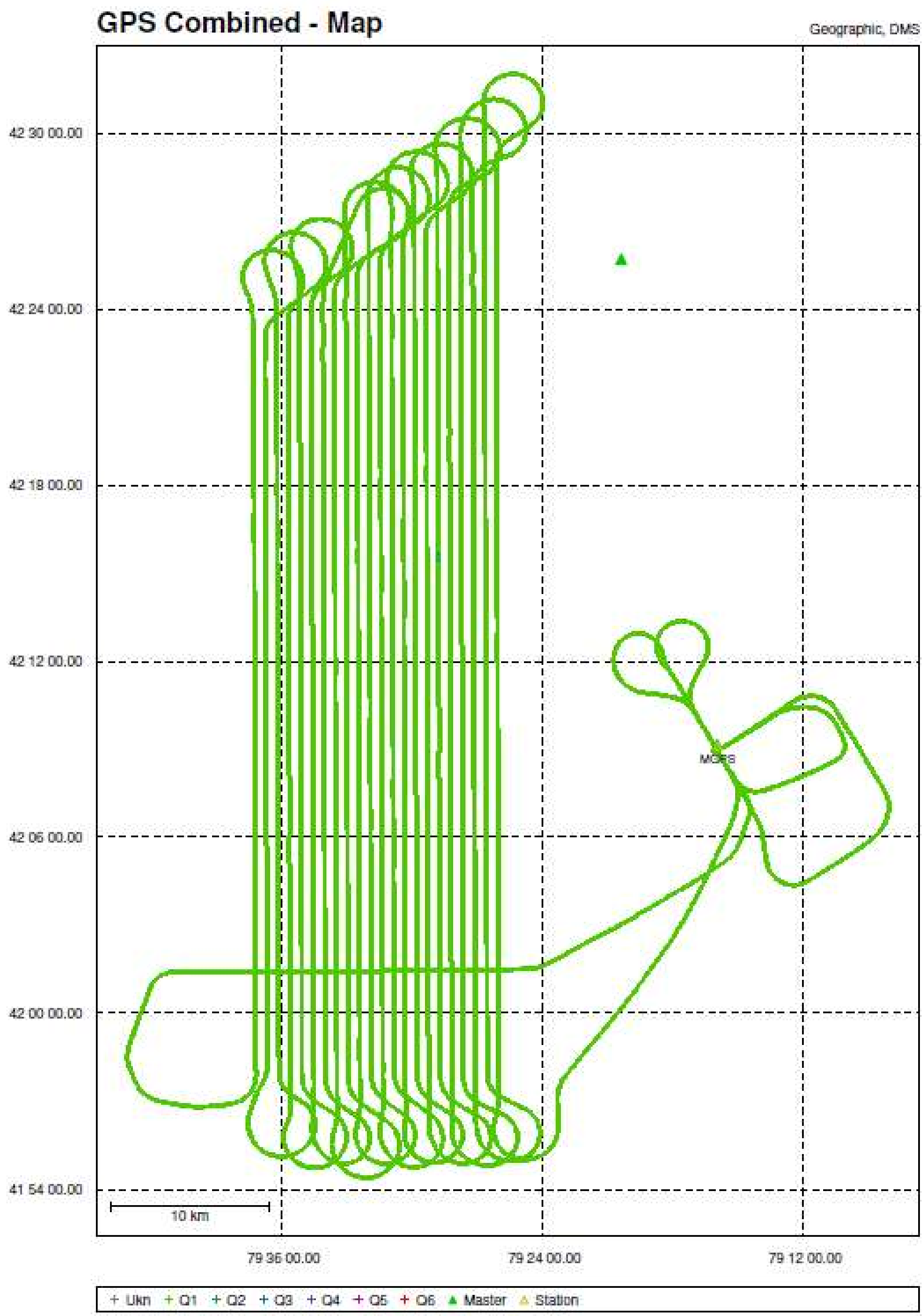

0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
60,000
62,000
64,000
66,000
68,000

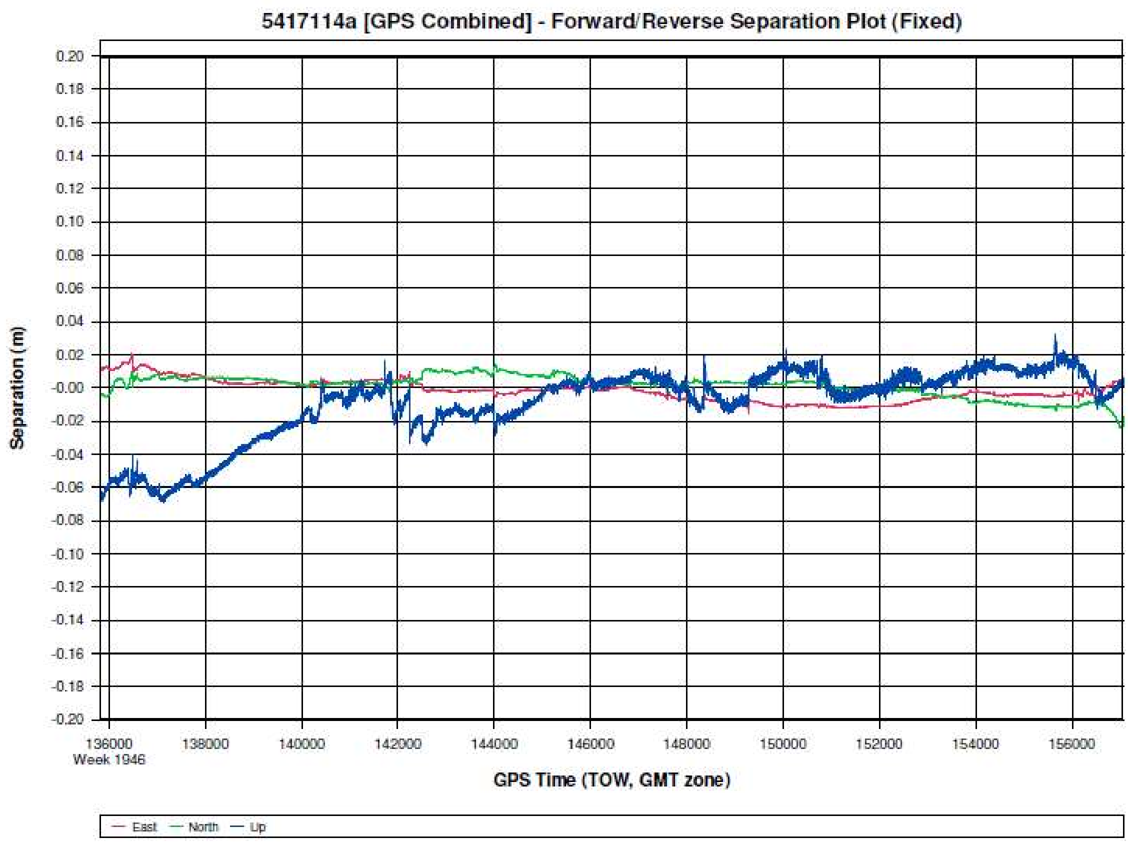

Number of SVs in solution
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
58,000
59,000
60,000
61,000
62,000
63,000
64,000
65,000
66,000
67,000
68,000
Time (sec)
Number of GPS
Number of GLONASS
Number of QZSS
Number of BEIDOU
Total Number

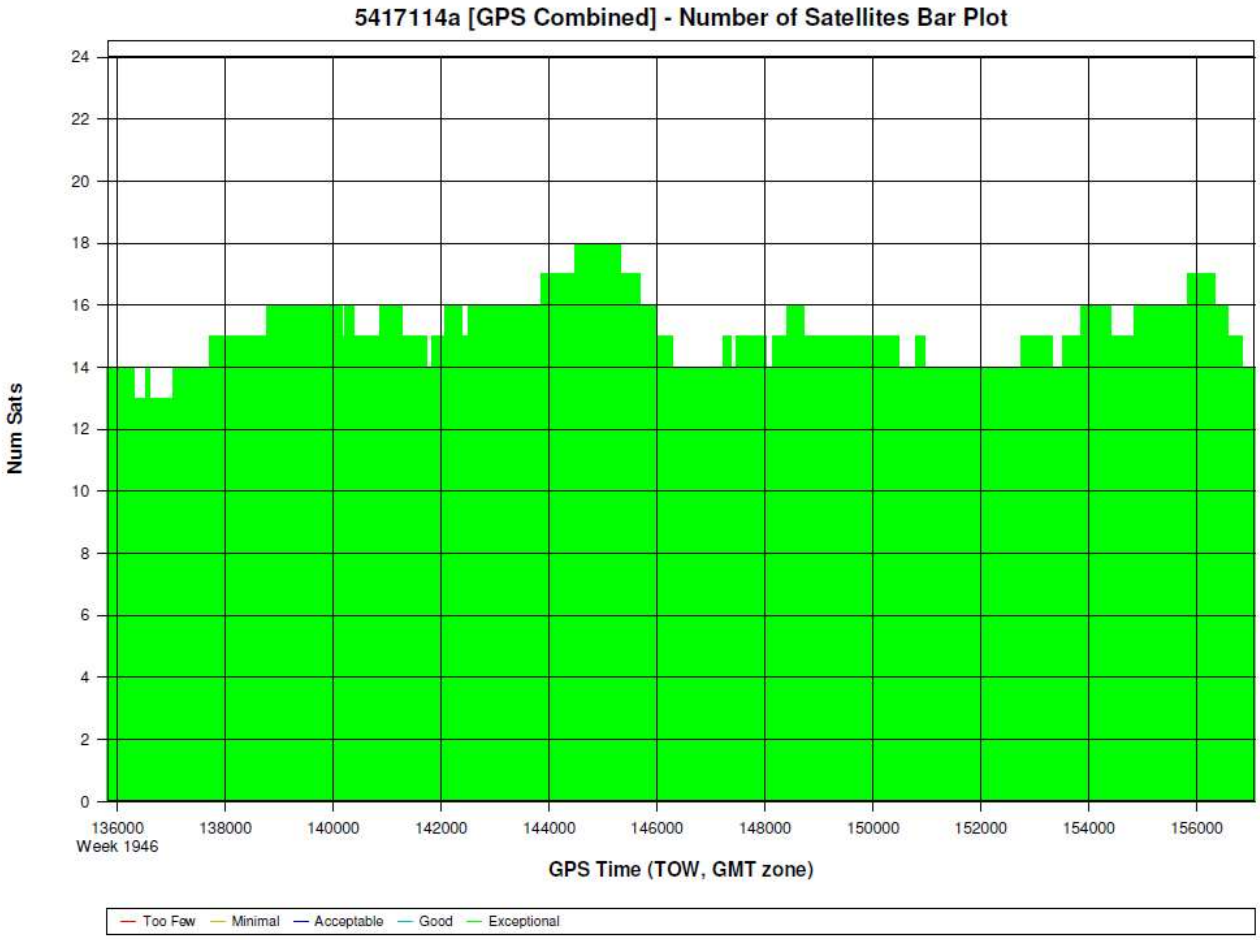

Estimated Position Accuracy
0.1
0.095
0.09
0.085
0.08
0.075
0.07
0.065
0.06
0.055
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
58,000
59,000
60,000
61,000
62,000
63,000
64,000
65,000
66,000
67,000
68,000
Time (sec)
North (m)
East (m)
Down (m)

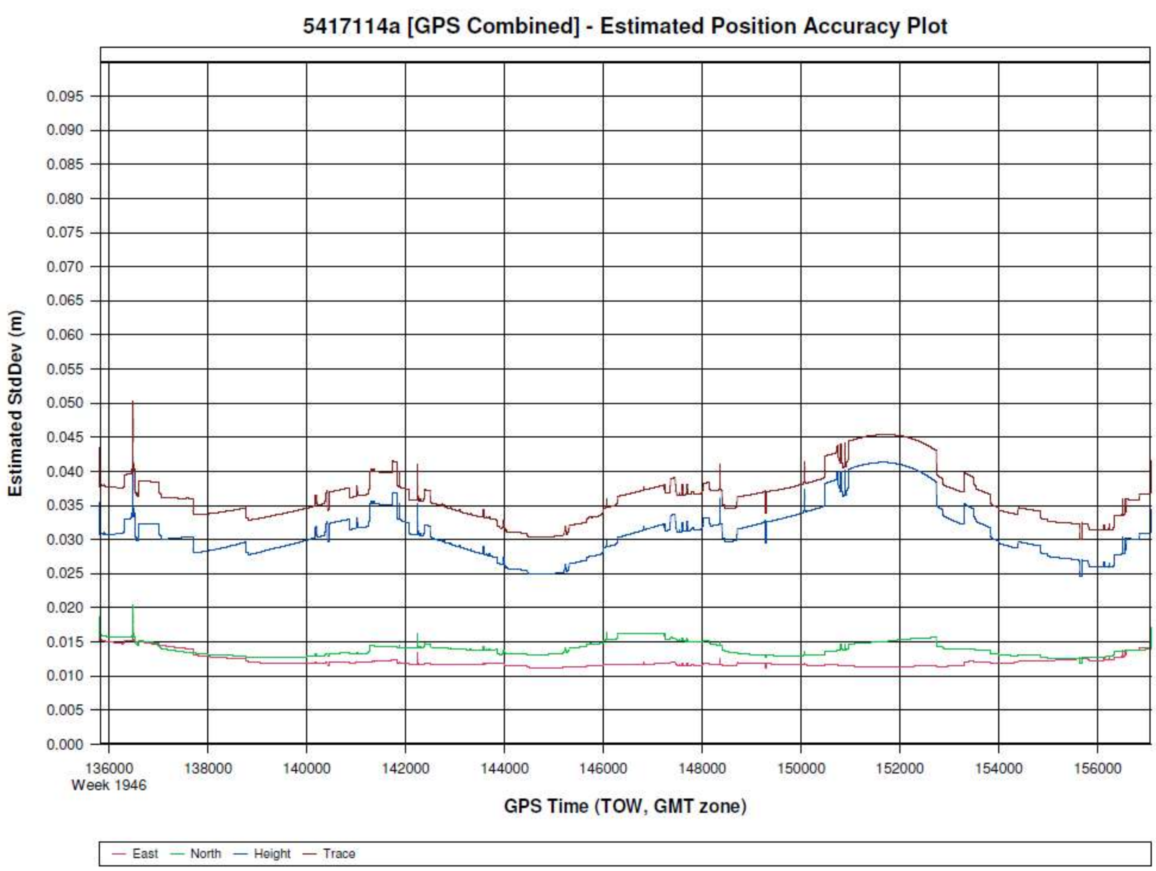

2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
58,000
59,000
60,000
61,000
62,000
63,000
64,000
65,000
66,000
67,000
68,000
Time (sec)
PDOP

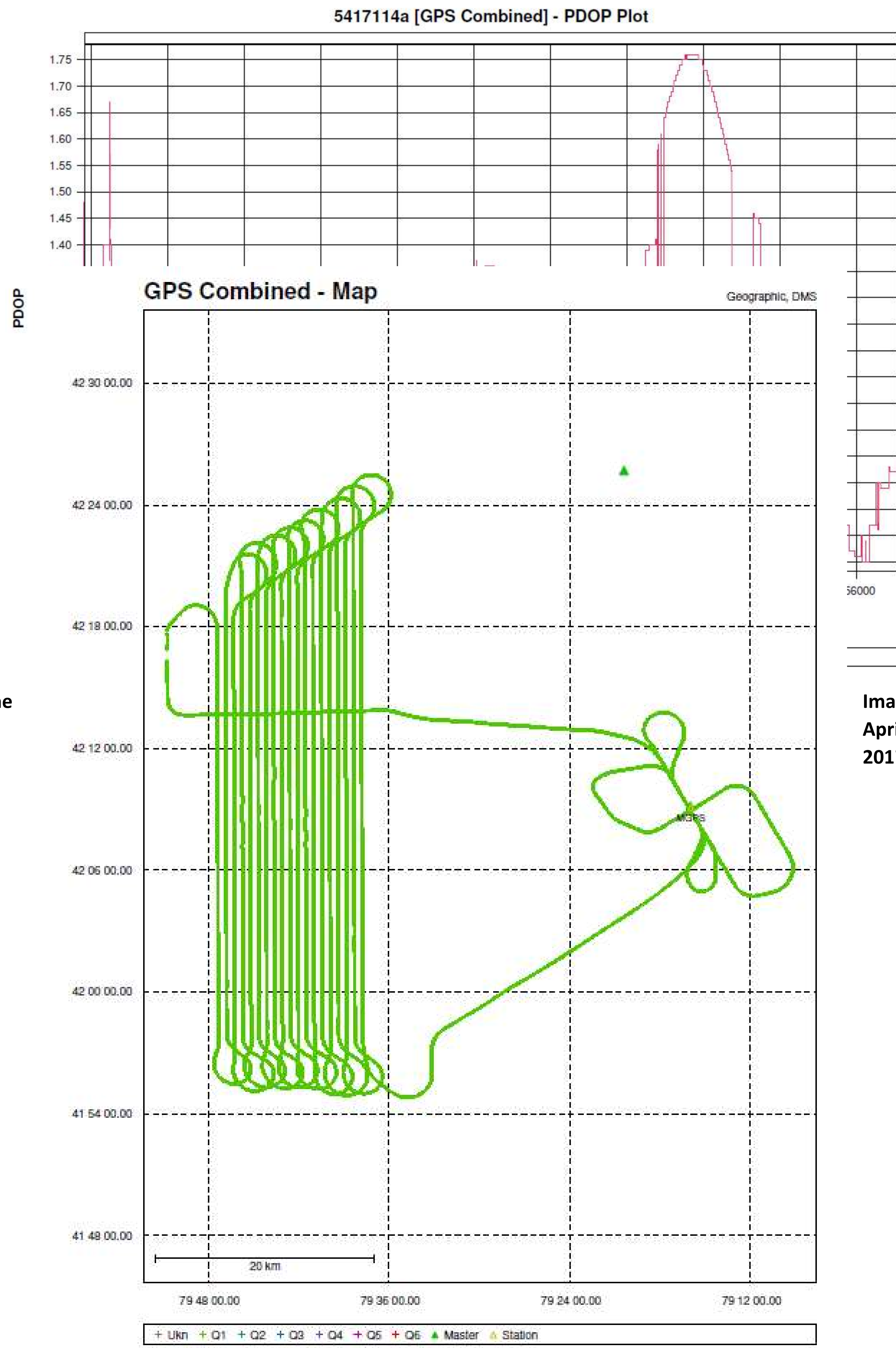
Airborne Imaging; April 24, 2017; Lift 1



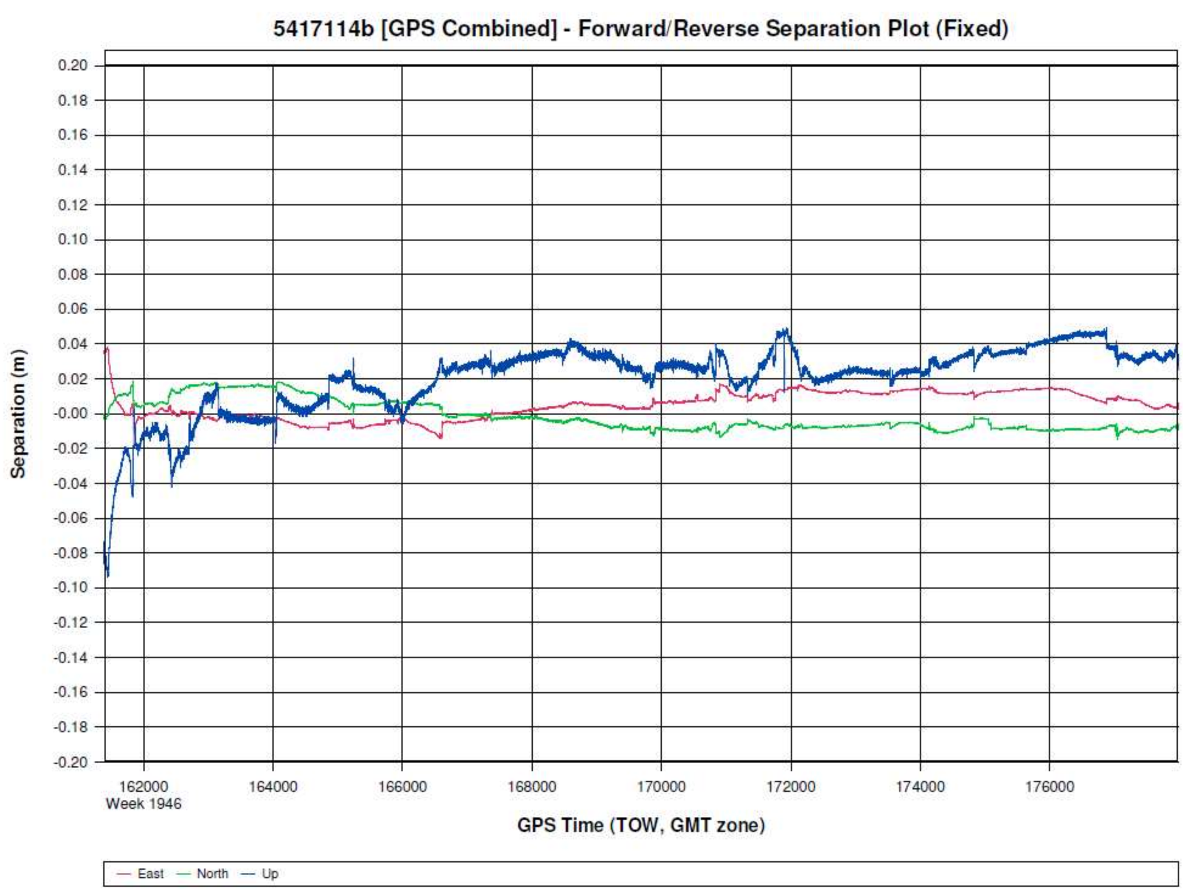

5417114a [GPS Combined] - Forward/Reverse Separation Plot (Fixed)
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
136000
Week 1946
138000
140000
142000
144000
146000
148000
150000
152000
154000
156000
GPS Time (TOW, GMT zone)
East
North
Up


5417114a [GPS Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
136000
Week 1946
138000
140000
142000
144000
146000
148000
150000
152000
154000
156000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

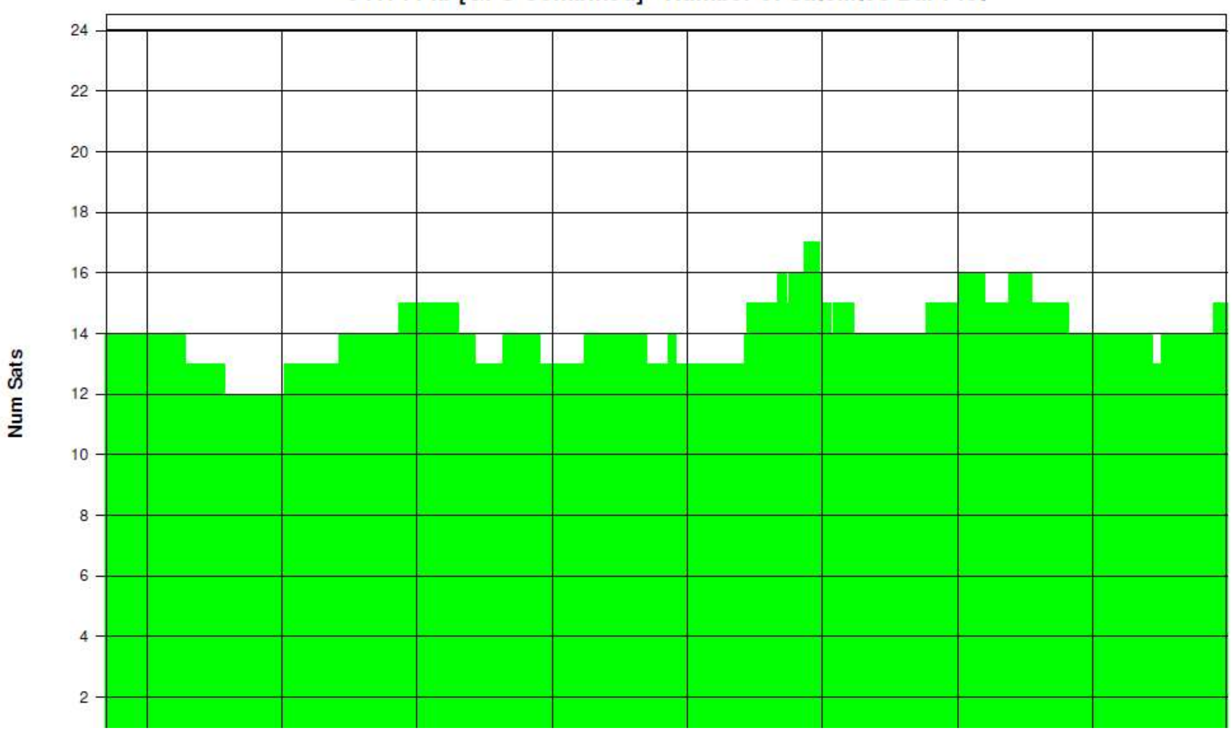

5417114a [GPS Combined] - Estimated Position Accuracy Plot
Estimated StdDev (m)
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
136000
Week 1946
138000
140000
142000
144000
146000
148000
150000
152000
154000
156000
GPS Time (TOW, GMT zone)
East
North
Height
Trace



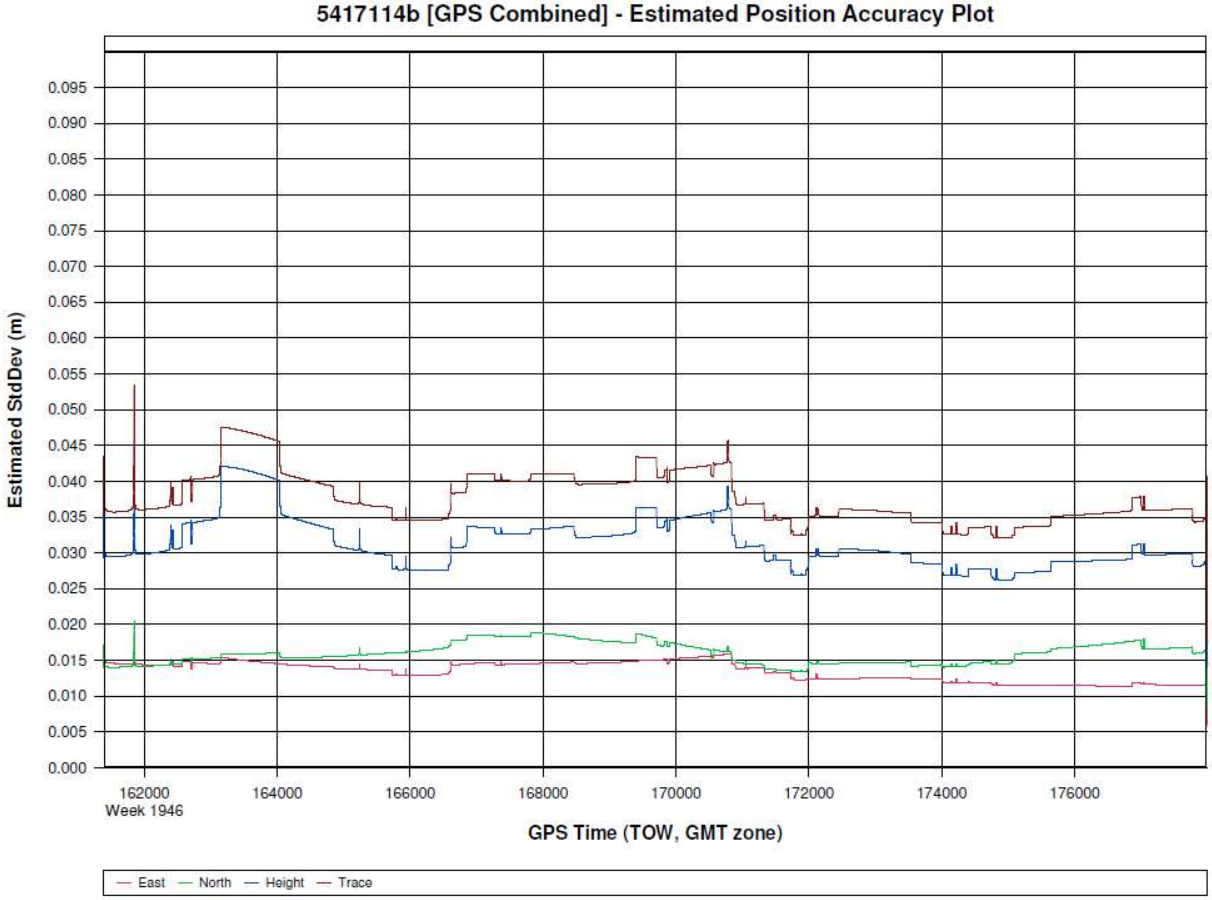
Airborne Imaging; April 24, 2017; Lift 2

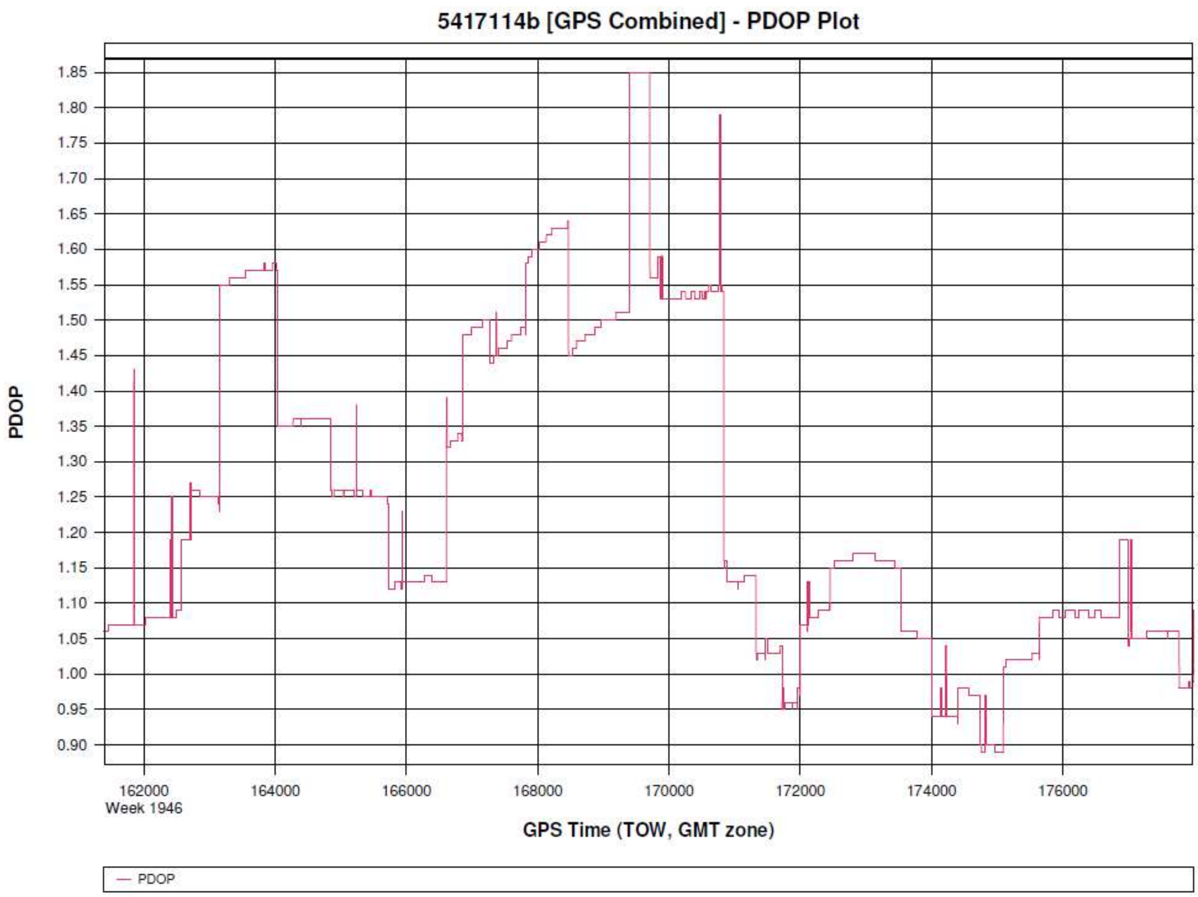

5417114b [GPS Combined] - Forward/Reverse Separation Plot (Fixed)
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
162000
Week 1946
164000
166000
168000
170000
172000
174000
176000
GPS Time (TOW, GMT zone)
East
North
Up

5417114b [GPS Combined] - Number of Satellites Bar Plot

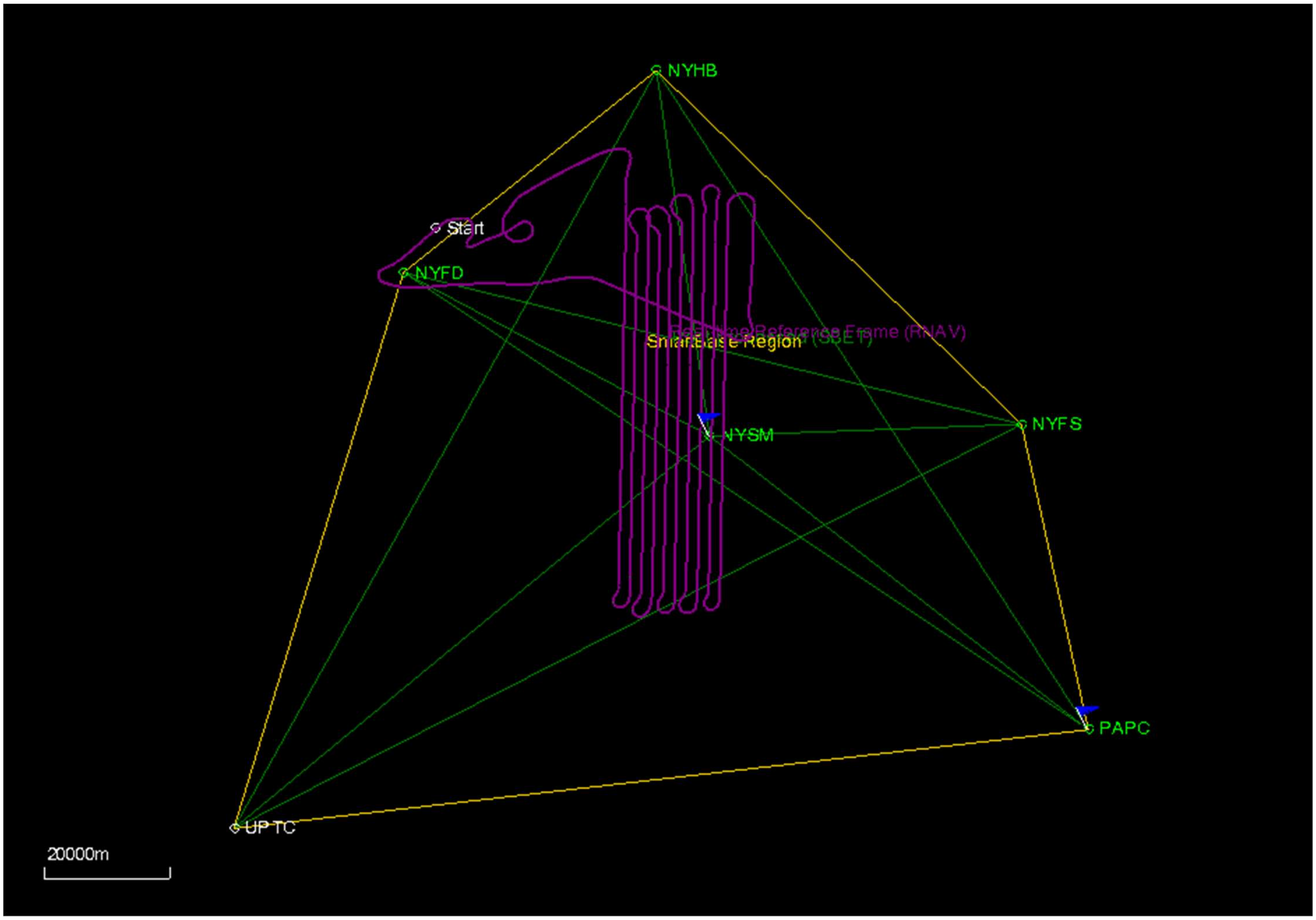


5417114b [GPS Combined] - Estimated Position Accuracy Plot

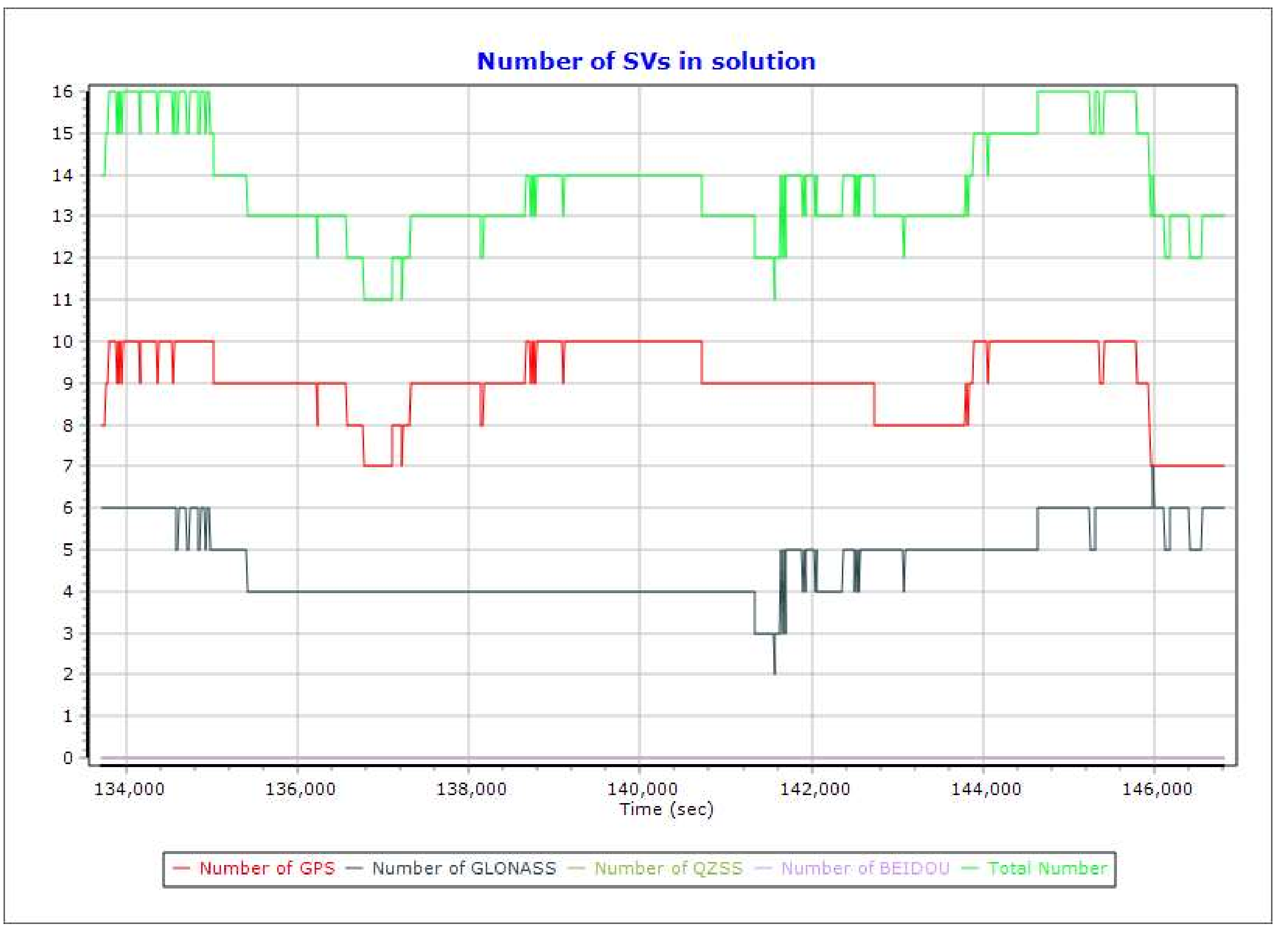


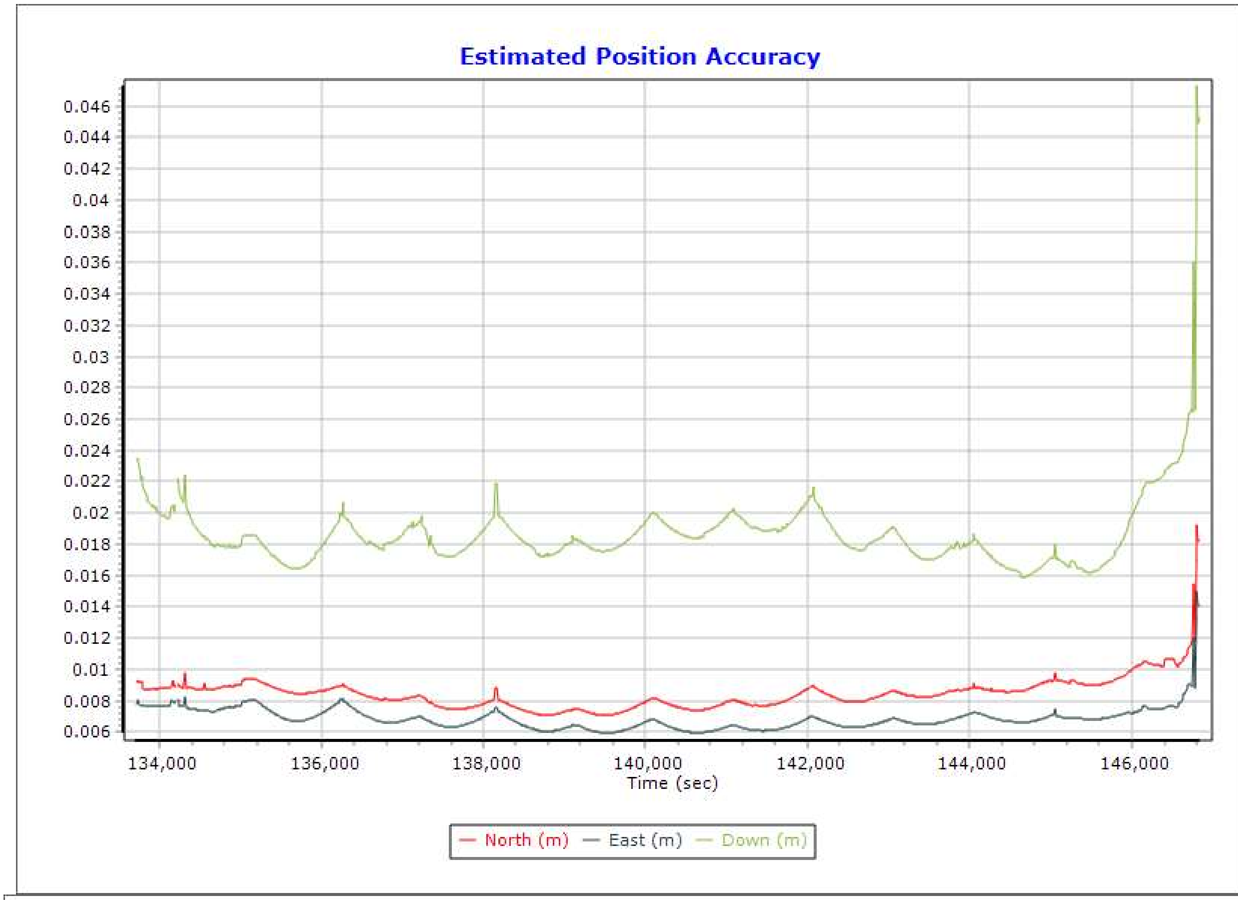

5417114b [GPS Combined] - PDOP Plot
PDOP
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
162000
Week 1946
164000
166000
168000
170000
172000
174000
176000
GPS Time (TOW, GMT zone)
PDOP

Axis GeoAviation; April 24, 2017; Lift 1

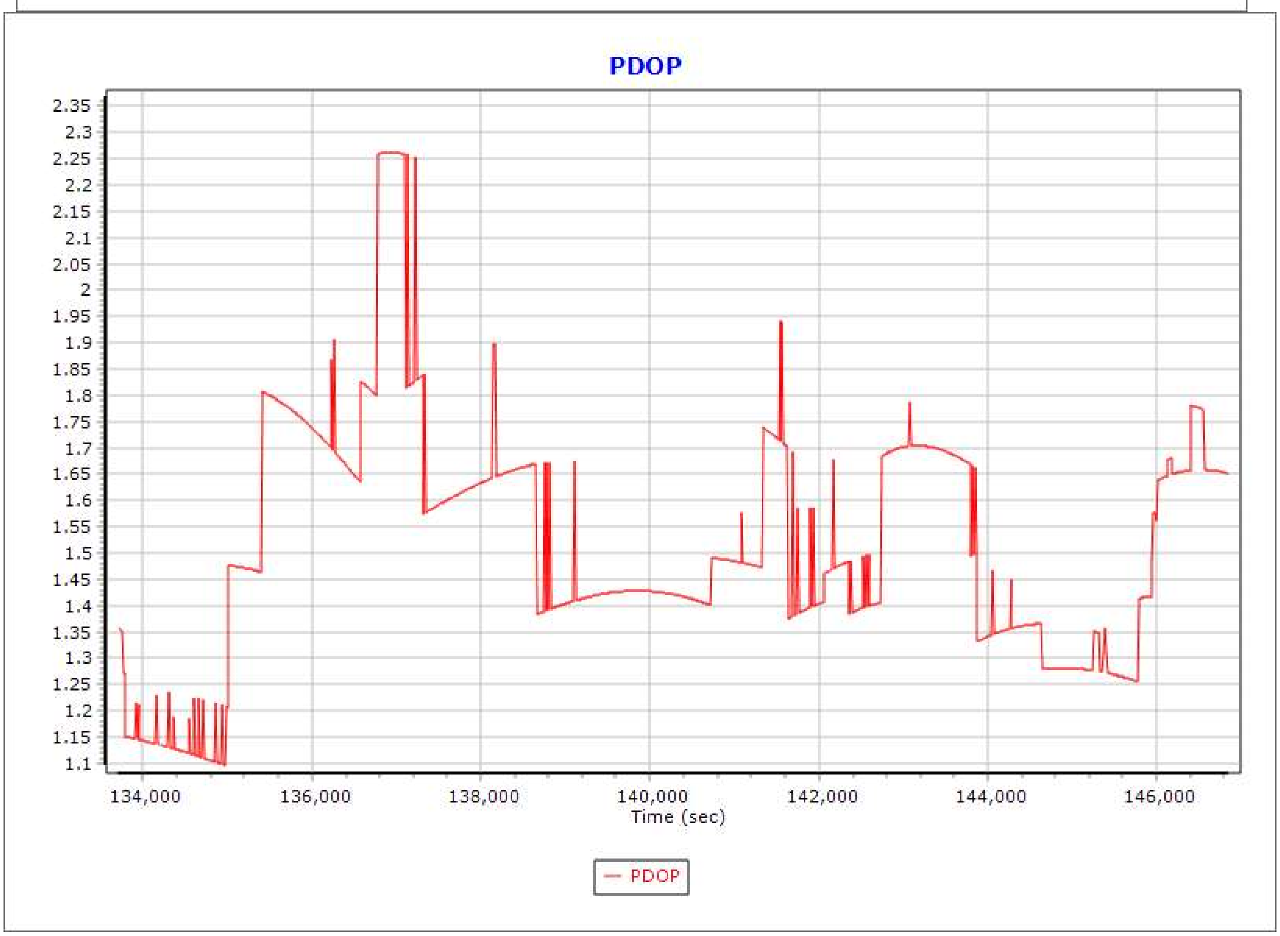



0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
-0.035
-0.04
-0.045
-0.05
134,000
136,000
138,000
140,000
142,000
144,000
146,000
Time (sec)
North (m)
East (m)
Down (m)
DR mode


Number of SVs in solution
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
134,000
136,000
138,000
140,000
142,000
144,000
146,000
Time (sec)
Number of GPS
Number of GLONASS
Number of QZSS
Number of BEIDOU
Total Number

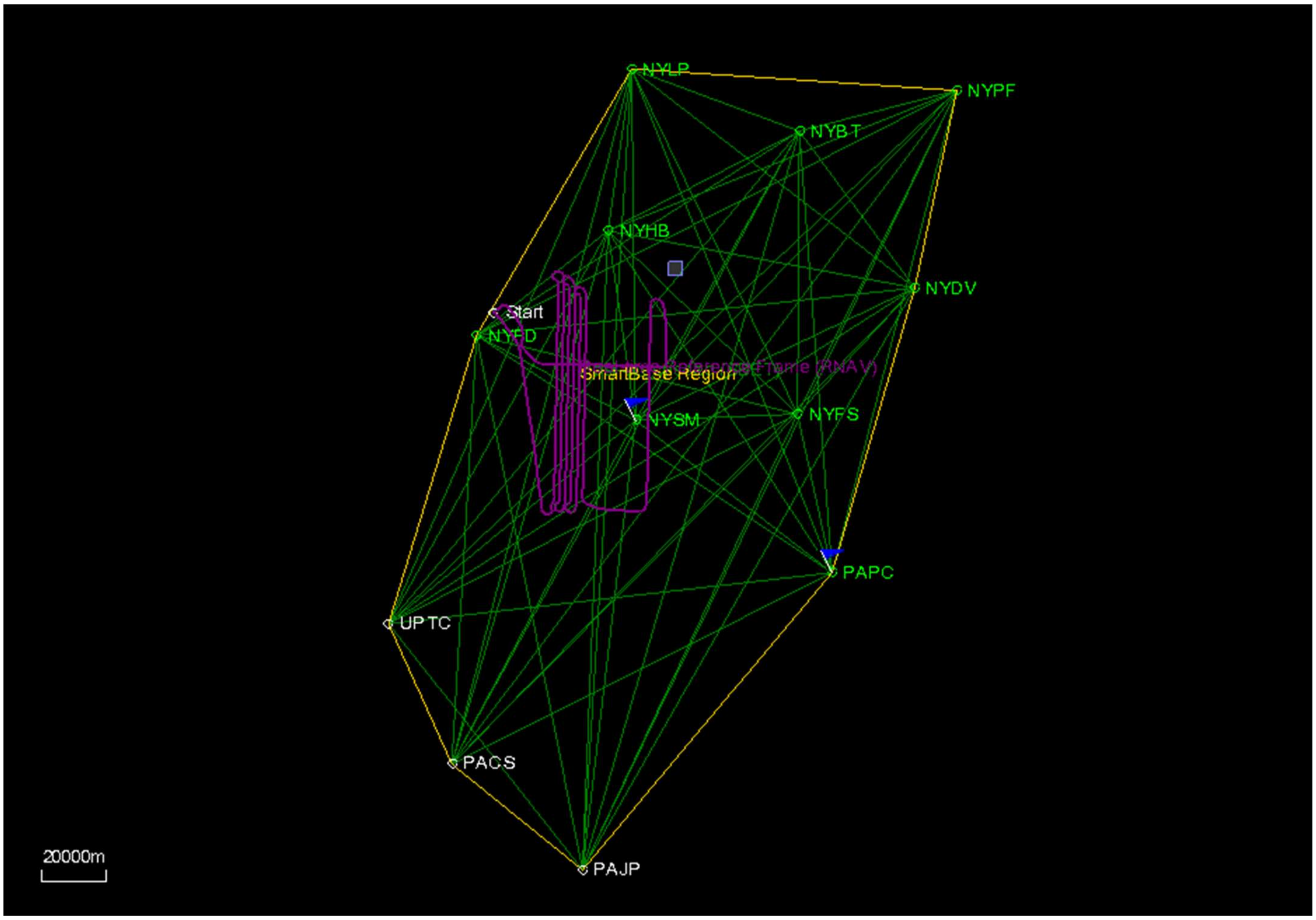


Estimated Position Accuracy
0.046
0.044
0.042
0.04
0.038
0.036
0.034
0.032
0.03
0.028
0.026
0.024
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
134,000
136,000
138,000
140,000
142,000
144,000
146,000
Time (sec)
North (m)
East (m)
Down (m)



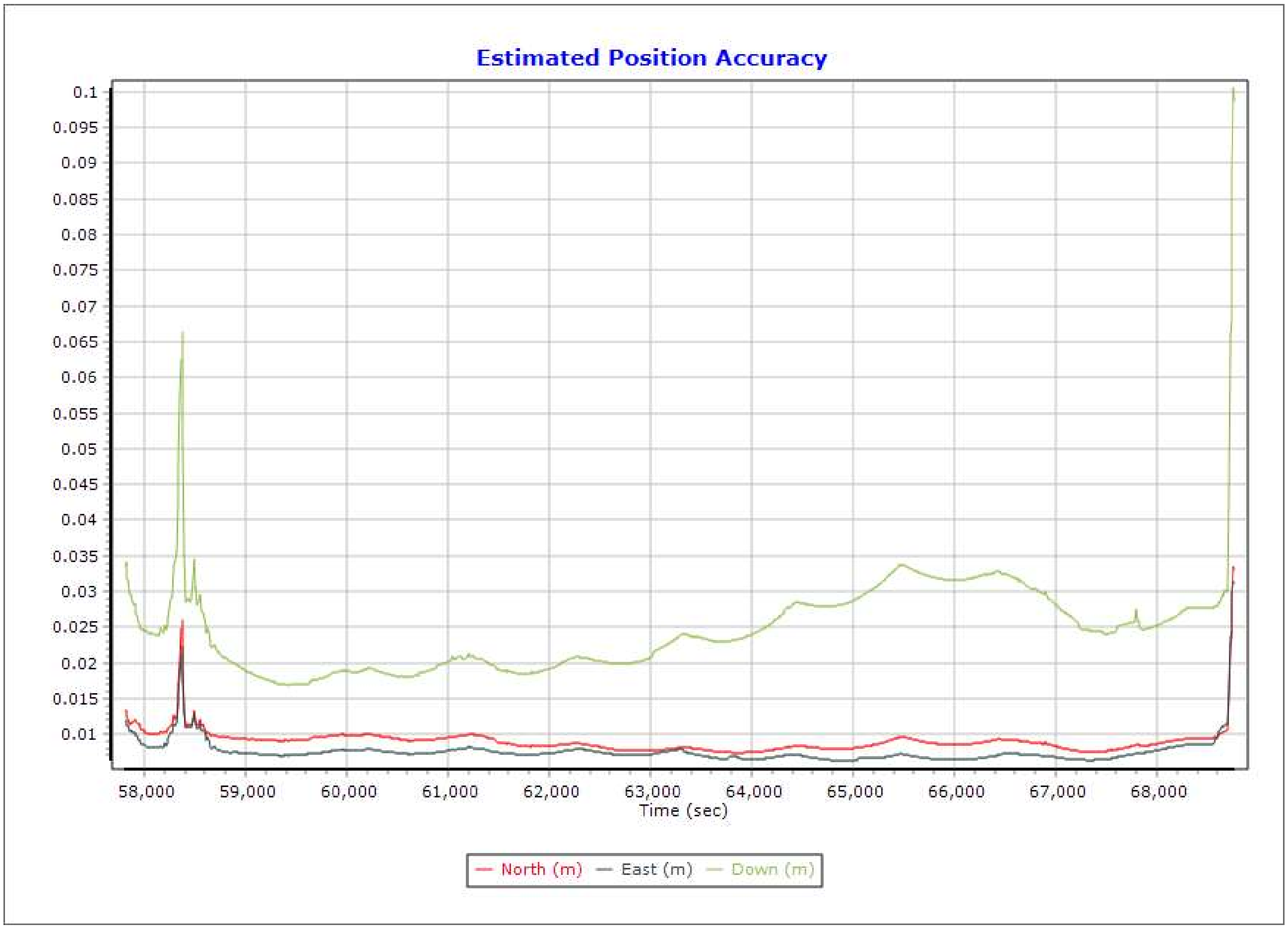
PDOP
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
134,000
136,000
138,000
140,000
142,000
144,000
146,000
Time (sec)
PDOP

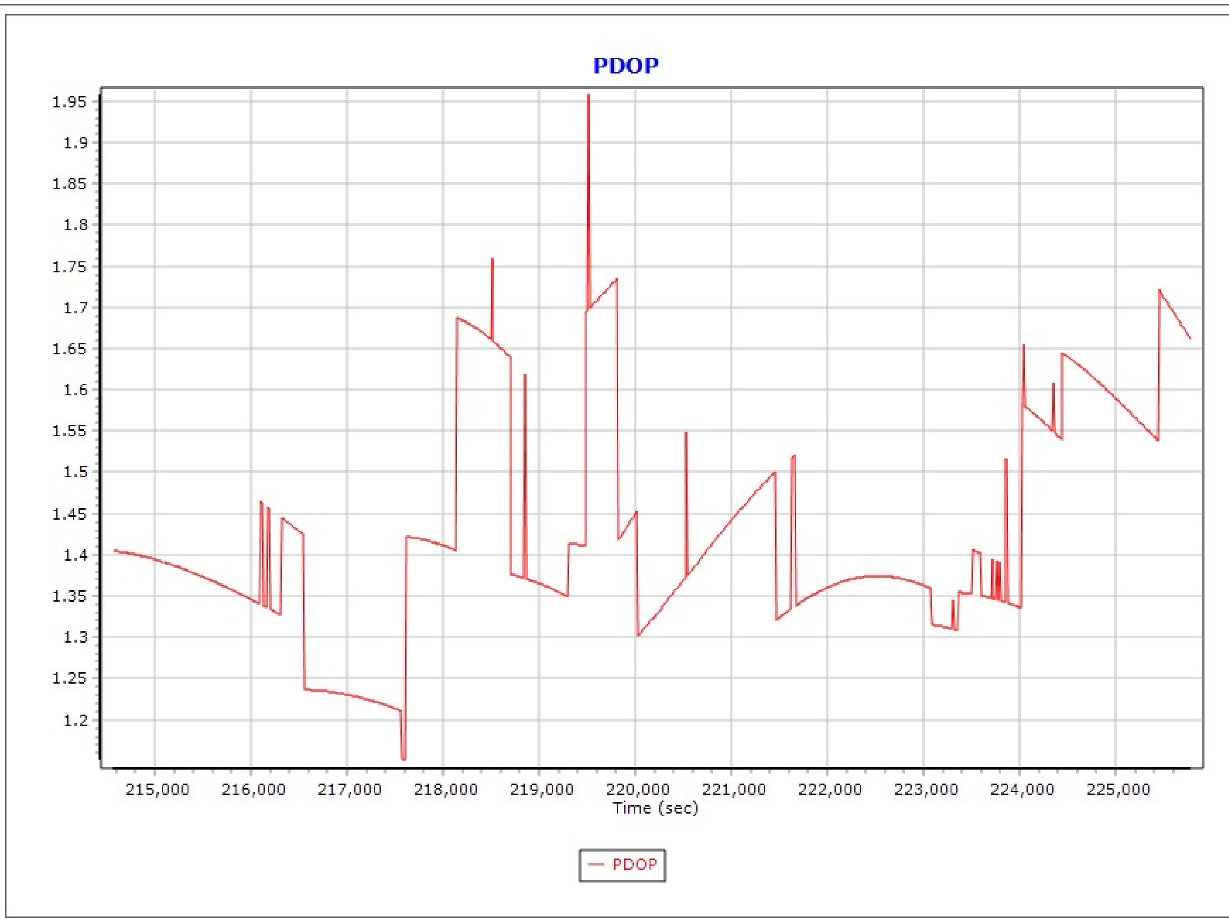
Axis GeoAviation; May 9, 2017; Lift 1




0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
216,000
218,000
220,000
222,000
224,000
Time (sec)
North (m)
East (m)
Down (m)
DR mode


Number of SVs in solution
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
215,000
216,000
217,000
218,000
219,000
220,000
221,000
222,000
223,000
224,000
225,000
Time (sec)
Number of GPS
Number of GLONASS
Number of QZSS
Number of BEIDOU
Total Number


Estimated Position Accuracy
0.1
0.095
0.09
0.085
0.08
0.075
0.07
0.065
0.06
0.055
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
58,000
59,000
60,000
61,000
62,000
63,000
64,000
65,000
66,000
67,000
68,000
Time (sec)
North (m)
East (m)
Down (m)


PDOP
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
215,000
216,000
217,000
218,000
219,000
220,000
221,000
222,000
223,000
224,000
225,000
Time (sec)
PDOP