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Lidar Collection (QL2) of all or part of Schuyler, Seneca, Steuben, Tompkins, Wayne and Yates Counties, NY Lidar

Lidar Processing & Accuracy Report

March 2021

EXECUTIVE SUMMARY

The New York State Information Technology Services (NYSITS) contracted with The Sanborn Map Company, Inc. (Sanborn) to provide remote sensing services for NYSDOP 2020 in the form of lidar. Utilizing a multi-return system, Light Detection and Ranging (Lidar) detects 3-dimensional positions and attributes to form a point cloud. The high accuracy airborne system is integrated with both Global Navigation Satellite System (GNSS) and an Inertial Measure Unit (IMU) for accurate position and orientation. Acquisition of the project area's ~1945mi² was completed on May 13th, 2020.

The Leica TerrainMapper was used to collect data for the aerial survey campaign. The sensor is attached to the aircraft's underside and emits rapid laser pulses that are used to calculate ranges between the aircraft and subsequent terrain below. The Airborne Lidar System (ALS) is boresighted by completing multiple passes over a known ground surface before the project acquisition. During data processing, the system calibration parameters are updated and used during post-processing of the lidar point cloud.

Differential GNSS unit in aircraft sampled positions at 2Hz or higher frequency. Lidar data was only acquired when GNSS PDOP is ≤4 and at least 6 satellites are in view. Collection conditions were for leaf-off vegetation. The atmosphere was free of clouds and fog between the aircraft and ground. The ground was free of snow and extensive flooding or any other type of inundation.

The contents of this report summarize the methods used to establish the base station coordinates, perform the lidar data acquisition and processing as well as the results of these methods.

CONTENTS

1.0 INTRODUCTION

This document contains the technical write-up of the lidar campaign, including system calibration techniques, and the collection and processing of the lidar data.

1.1 Contact Information

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

Shawn Benham, PMP
Vice President of Programs
The Sanborn Map Company, Inc.
1935 Jamboree Drive, Suite 100
Colorado Springs, CO 80920
(719) 502-1296
sbenham@sanborn.com

1.2 Purpose of Lidar Acquisition

The objective of this project is to acquire detailed surface elevation data for use in conservation planning, design, research, floodplain mapping, dam safety assessments and elevation modeling, etc. Classified LAS files are used to show the manually reviewed bare earth surface. This allows the user to create Intensity Rasters, Breaklines and Raster DEM. The purpose of these lidar data was to produce high accuracy 3D hydro-flattened Digital Elevation Model (DEM) with a 1-meter cell size.

1.3 Project Location

Schuyler, Seneca, Steuben, Tompkins, Wayne, and Yates counties, New York, covering approximately 1945 square miles.

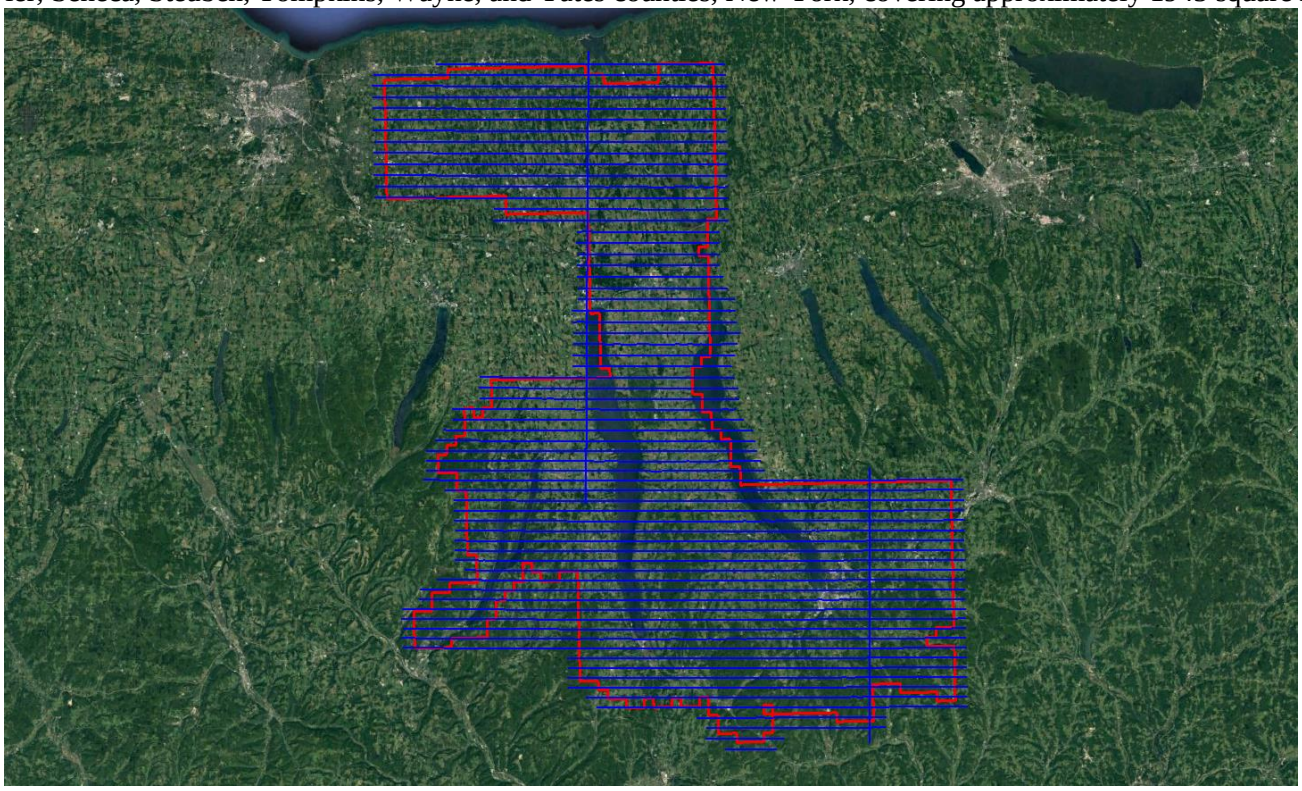


Figure 1: DPA and Trajectories As-Flown

2.0 PROCESSING

2.1 Introduction

The ABGNSS/IMU data was post-processed using Waypoint Inertial Explorer software to create Smoothed Best Estimate Trajectory (SBET) file(s). Please see **Appendix B** for an in-depth assessment of the processed airborne trajectories. The SBET was then combined with the laser range measurements in Leica HxMap software to produce the 3-dimensional coordinates resulting in an accurate set of Raw Point Cloud (RPC) mass points. These raw swath (*.las) files are output in WGS84, UTM, Ellipsoid, Meters and transformed to the project Coordinate Reference System (CRS) upon ingest into GeoCue before project wide calibration.

The Leica HxMap pre-processing software created raw swath files with all return values. This multi-return information was processed and classified to obtain the required feature for delivery. All lidar data is processed using the ASPRS binary LAS format version 1.4. **Table 4** illustrates the achieved point cloud statistics.

Category	Value
Total Points	31,009,511,127
Nominal Pulse Spacing (m)	0.60
Nominal Pulse Density (pls/m²)	2.8
Nominal Pulse Spacing (ft)	1.98
Nominal Pulse Density (pls/ft²)	0.3
Aggregate Total Points	25,243,762,779
Aggregate Nominal Pulse Spacing (m)	0.53
Aggregate Nominal Pulse Density (pls/m²)	3.6
Aggregate Nominal Pulse Spacing (ft)	1.74
Aggregate Nominal Pulse Density (pls/ft²)	0.3

Table 4: Point Cloud Statistics

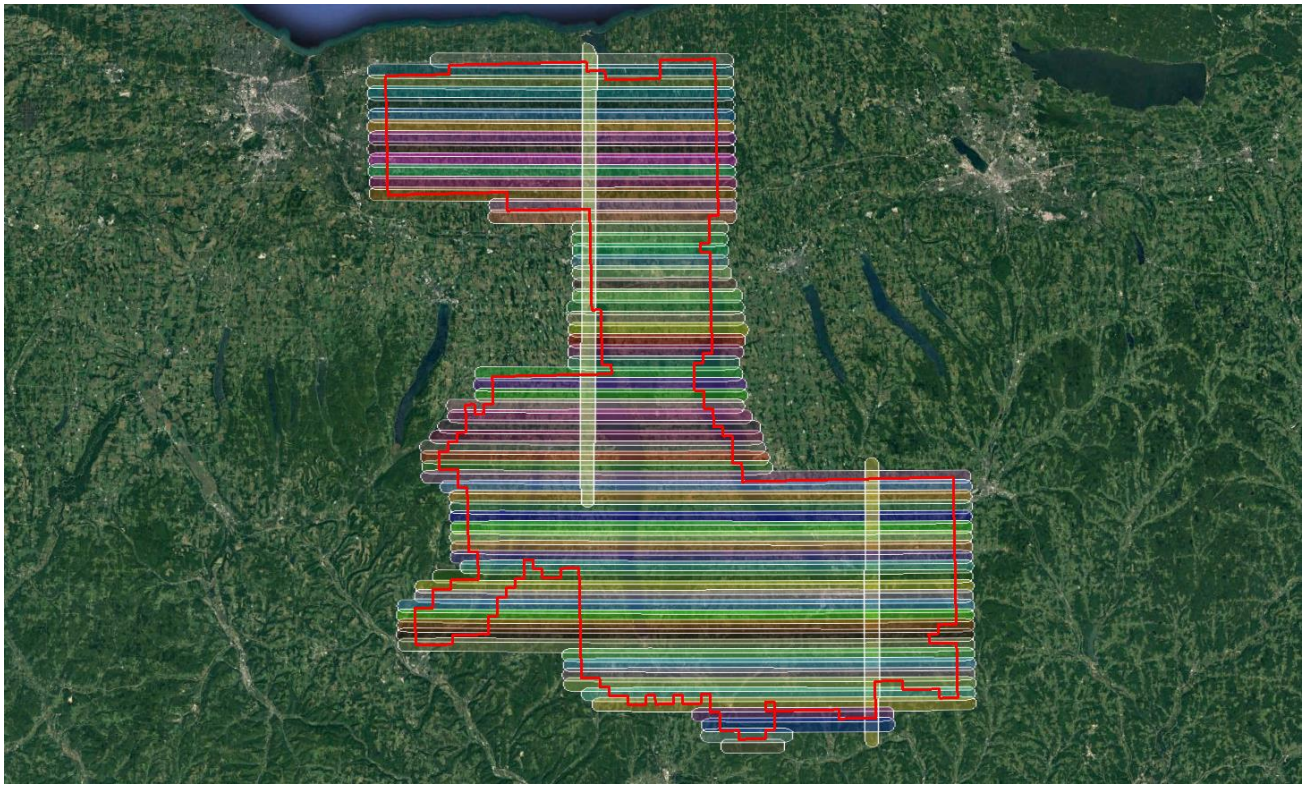


Figure 3: Raw Point Cloud Coverage

2.2 Coordinate Reference System

Horizontal Datum: North American Datum of 1983 (2011)
Projection: Universal Transverse Mercator Zone 18 North
Vertical Datum: North American Vertical Datum of 1988
Geoid Model: Geoid12B
Units: Meters

2.3 Lidar Matching

Sanborn uses Leica HxMap software and the latest boresight values to combine the processed SBET with the laser scan files to produce the lidar point cloud. The data is processed by mission and/or block and is output in ASPRS LASv1.4 Point Data Record Format (PDRF) 6 with 16bit linearly scaled intensities to the nearest 0.001 3D position. Each mission is produced in WGS84, UTM, Ellipsoid, Meters and transformed to the project CRS upon import into GeoCue.

Each mission in imported into GeoCue where each individual flight line is assigned a unique flight line number. The SBET is cut per mission into TerraScan Trajectory files based on flight line number and timestamp to be utilized during the lidar natching process. The project area(s) are broken into logical blocks based on AOIs or predetermined delivery blocks and the individual flight lines are populated into lidar matching tile grids. These lidar matching tile grids are prepared for scanner, line, mission, block and eventual project wide lidar matching routines by first running point cloud filters to identify ground and building features to be used during any TerraMatch processes.

After successful point cloud filters have been run on the lidar matching dataset TerraMatch is used to extract Tie Line Observations. TerraMatch Tie Lines are 3D vectors extracted from the lidar point cloud intended to reduce the overwhelming data size to a more manageable amount. Each Tie Line is extracted using a series of parameters designed to identify features such a flat or sloping ground or roofline apexes that geospatially correlates to the same observation of an overlapping flight line. These observed 3D vectors are then utilized across multiple solution iterations to reduce the average offset from line to line, mission to mission, and block to block. TerraMatch Solutions are calculated to adjust Roll, Heading, Pitch, Mirror Scale, X, Y and Z in combination to reduce the Root Mean Square Deviation (RMSDr and RMSDz). These solutions are calculated, applied, and reviewed throughout the lidar matching process.

Sanborn takes advantage of both visual and statistical validation methodologies to review and ensure overlap consistency of the lidar data meets and/or exceeds project specifications. Differential Elevation (dZ) rasters are color ramp (Dark Green, Green, Yellow, Orange, Red) based visual representations produced to identify vertical offsets between flight lines. The dZ rasters are reviewed in their entirety for flight lines and areas that exceed the required RMSDz. Furthermore, an additional set of TerraMatch Tie Lines are produced after solutions are applied and a Tie Line Report is produced to assess the X. Y. and Z offset averages and magnitudes for the whole project including each line individually. This visual and statistical review guarantees the relative accuracy of the lidar dataset. **Table 5** outlines the relative accuracy requirements of the project. **Tables 6 – 9** are the relative accuracies achieved.

Category	Value (m)	Value (ft)
Smooth Surface Repeatability	≤0.060	≤0.197
Swath overlap difference, RMSDz	≤0.080	≤0.262

Table 5: Relative Accuracy Requirements

No Data	< 0.08m	0.08m to 0.16m	0.16m to 0.24m	> 0.24m
No Data	< 0.262ft	0.262ft to 0.524ft	0.524ft to 0.786ft	> 0.786ft

Figure 4: Swath Separation Images

Line	X	Y	Z	Line	X	Y	Z	Line	X	Y	Z
1	0.015	0.017	0.008	**23**	0.019	0.026	0.008	**45**	0.024	0.023	0.009
2	0.022	0.026	0.009	**24**	0.022	0.024	0.007	**46**	0.022	0.020	0.008
3	0.013	0.015	0.009	**25**	0.023	0.019	0.007	**47**	0.021	0.022	0.008
4	0.023	0.026	0.009	**26**	0.023	0.019	0.008	**48**	0.019	0.022	0.008
5	0.021	0.021	0.009	**27**	0.019	0.019	0.007	**49**	0.020	0.021	0.008
6	0.022	0.021	0.009	**28**	0.028	0.024	0.007	**50**	0.019	0.023	0.008
7	0.026	0.024	0.009	**29**	0.027	0.026	0.007	**51**	0.019	0.024	0.008
8	0.017	0.015	0.009	**30**	0.020	0.017	0.007	**52**	0.015	0.018	0.008
9	0.021	0.021	0.009	**31**	0.026	0.021	0.007	**53**	0.021	0.026	0.008
10	0.019	0.021	0.009	**32**	0.026	0.023	0.007	**54**	0.019	0.022	0.008
11	0.018	0.024	0.009	**33**	0.021	0.020	0.007	**55**	0.022	0.024	0.008
12	0.014	0.020	0.008	**34**	0.024	0.025	0.007	**56**	0.013	0.016	0.008
13	0.022	0.024	0.008	**35**	0.022	0.023	0.008	**57**	0.022	0.029	0.008
14	0.014	0.013	0.007	**36**	0.023	0.026	0.008	**58**	0.020	0.025	0.008
15	0.028	0.021	0.008	**37**	0.017	0.018	0.007	**59**	0.021	0.024	0.008
16	0.021	0.018	0.007	**38**	0.025	0.024	0.007	**60**	0.027	0.027	0.008
17	0.020	0.019	0.008	**39**	0.021	0.024	0.007	**61**	0.023	0.027	0.008
18	0.019	0.020	0.007	**40**	0.023	0.026	0.007	**62**	0.021	0.028	0.008
19	0.020	0.029	0.009	**41**	0.024	0.024	0.008	**63**	0.020	0.016	0.009
20	0.016	0.020	0.008	**42**	0.022	0.023	0.007	**64**	0.032	0.028	0.008
21	0.018	0.021	0.008	**43**	0.023	0.025	0.008	**65**	0.021	0.018	0.008
22	0.018	0.025	0.008	**44**	0.017	0.017	0.008	**66**	0.025	0.020	0.007

Table 6: Average Magnitudes by Line (Meters)

Category	X	Y	Z
Average Magnitude	0.020	0.022	0.008
RMS Values	0.031	0.035	0.011
Maximum Values	0.159	0.159	0.123
Observation Weight	78413.0	78413.0	573332.0

Table 7: Internal Observation Statistics (Meters)

Category	Mismatch
Average 3D Mismatch	0.01211
Average XY Mismatch	0.03654
Average Z Mismatch	0.00800

Table 8: Overall Relative Accuracy (Meters)

Category	Observations
Section Lines	218,332
Roof Lines	39,205

Table 9: Vector Observations

2.4 Point Cloud Vertical Accuracy Assessment

The lidar dataset was evaluated using a total of seventy-three (73) check points (73 NVA). The result provided a vertical accuracy that fell within project specifications. Please see the **Attachment A** for the full Vertical Accuracy Report and the project *Metadata* for an in-depth accuracy assessment. **Table 10** outlines the absolute accuracy requirements of the project based on USGS Lidar Specification v2.1 **Table 11** shows high level statistics and mean errors for the area processed by Sanborn. The individual check point assessment can be found in **Table 12**.

Category	Value (m)	Value (ft)
RMSEz	≤0.100	≤0.328
@ 95-Percent Confidence Level	≤0.196	≤0.643

Table 10: Absolute Accuracy Requirements

Broad Land Cover Type	# of Points	RMSEz	95% Confidence Level
NVA of Point Cloud	73	0.064	0.125

Table 11: Vertical Accuracy Assessment of Check Points (Meters)

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA001	330888.082	4775517.852	130.093	130.063	GRAVEL	-0.030
NVA002	328736.762	4767791.879	135.633	135.653	SHORT GRASS	0.020
NVA003	376539.486	4702332.885	117.579	117.583	SHORT GRASS	0.004
NVA004	352792.456	4688494.062	323.437	323.476	GRAVEL	0.039
NVA005	338807.787	4769828.856	120.938	120.880	ASPHALT	-0.058
NVA006	312639.083	4771459.276	141.094	141.113	SHORT GRASS	0.019
NVA007	328796.665	4767725.226	135.515	135.505	CONCRETE	-0.010
NVA008	320760.844	4769781.360	138.788	138.649	ASPHALT	-0.139
NVA009	339545.115	4727340.059	155.992	155.971	SHORT GRASS	-0.021
NVA010	349491.348	4758538.452	160.372	160.277	ASPHALT	-0.095
NVA011	347654.285	4771633.083	120.032	119.980	GRAVEL	-0.052
NVA012	356694.494	4769825.111	127.830	127.732	ASPHALT	-0.098
NVA013	318222.533	4779065.489	144.360	144.285	ASPHALT	-0.075
NVA014	338988.352	4786440.185	114.134	114.197	ASPHALT	0.063
NVA015	310999.512	4773960.421	167.980	167.948	ASPHALT	-0.032
NVA016	340991.637	4749001.817	140.106	140.041	ASPHALT	-0.065

NVA017	349636.245	4752001.954	137.639	137.572	ASPHALT	-0.067
NVA018	354371.063	4751723.361	140.291	140.224	ASPHALT	-0.067
NVA019	357068.164	4745804.651	136.326	136.311	GRAVEL	-0.015
NVA020	352193.507	4742700.242	169.611	169.556	GRAVEL	-0.055
NVA021	347017.692	4713768.199	263.326	263.376	BARE SOIL	0.050
NVA022	362485.081	4712096.295	318.204	318.251	SHORT GRASS	0.047
NVA023	346148.583	4720161.273	136.947	136.955	ASPHALT	0.008
NVA024	344818.440	4738994.463	177.241	177.213	GRAVEL	-0.028
NVA025	346204.299	4783296.063	116.005	115.875	GRAVEL	-0.130
NVA026	352632.074	4786952.389	113.109	113.007	ASPHALT	-0.102
NVA027	339047.691	4757241.618	153.581	153.542	ASPHALT	-0.039
NVA028	352747.292	4786914.317	112.010	111.921	ASPHALT	-0.089
NVA029	349277.191	4734853.546	220.724	220.707	SHORT GRASS	-0.017
NVA030	350801.603	4726710.008	296.905	296.945	ASPHALT	0.040
NVA031	349745.343	4752040.615	137.848	137.870	ASPHALT	0.022
NVA032	358836.879	4720082.547	262.087	262.126	ASPHALT	0.039
NVA033	337700.198	4709808.974	301.752	301.673	ASPHALT	-0.079
NVA034	347946.638	4698027.621	298.965	299.000	ASPHALT	0.035
NVA035	359293.649	4701291.438	366.262	366.309	GRAVEL	0.047
NVA036	365878.270	4699683.423	338.631	338.596	GRAVEL	-0.035
NVA037	368758.797	4711832.567	117.878	117.919	ASPHALT	0.041
NVA038	368987.527	4691156.147	322.081	322.166	CONCRETE	0.085
NVA039	377171.404	4698127.662	267.549	267.494	SHORT GRASS	-0.055
NVA040	374066.530	4687225.952	285.680	285.725	GRAVEL	0.045
NVA041	358641.457	4683783.855	339.088	339.053	ASPHALT	-0.035
NVA042	377119.136	4698183.193	265.216	265.181	ASPHALT	-0.035
NVA043	389129.556	4694483.228	340.638	340.652	GRAVEL	0.014
NVA044	381537.077	4701256.640	275.948	276.000	GRAVEL	0.052
NVA045	379776.572	4704900.233	321.615	321.592	ASPHALT	-0.023
NVA046	375708.130	4710834.004	238.738	238.810	SHORT GRASS	0.072
NVA047	367031.134	4718337.540	221.882	222.045	BARE SOIL	0.163
NVA048	347431.588	4685040.230	172.628	172.701	GRAVEL	0.073
NVA049	342190.882	4691856.185	303.902	303.948	GRAVEL	0.046
NVA050	340995.342	4699505.187	379.542	379.502	SHORT GRASS	-0.040
NVA051	346111.035	4707052.198	257.855	257.824	ASPHALT	-0.031
NVA052	312335.841	4693948.375	334.687	334.653	ASPHALT	-0.034
NVA053	318348.577	4699930.862	426.535	426.519	BARE SOIL	-0.016
NVA054	326011.824	4704509.933	336.695	336.697	BARE SOIL	0.002
NVA055	322910.357	4718522.267	255.427	255.573	SHORT GRASS	0.146
NVA056	309503.776	4783920.296	151.035	150.975	SHORT GRASS	-0.060
NVA057	312426.536	4693779.115	339.585	339.525	ASPHALT	-0.060
NVA058	337698.603	4709881.284	301.204	301.130	BARE SOIL	-0.074
NVA059	339545.411	4727415.771	155.912	155.903	ASPHALT	-0.009
NVA060	321686.605	4710833.056	346.880	346.807	GRAVEL	-0.073
NVA061	332857.223	4719596.406	316.392	316.456	GRAVEL	0.064
NVA062	330993.088	4723968.281	224.191	224.280	ASPHALT	0.089
NVA063	321065.123	4725675.481	303.511	303.596	SHORT GRASS	0.085
NVA064	322873.758	4718540.704	256.473	256.599	BARE SOIL	0.126

NVA065	321686.909	4710777.154	346.571	346.491	ASPHALT	-0.080
NVA066	393302.437	4704980.734	331.659	331.661	ASPHALT	0.002
NVA067	387813.982	4716133.174	305.287	305.382	ASPHALT	0.095
NVA068	377219.658	4718833.823	305.056	305.115	ASPHALT	0.059
NVA069	379892.526	4704916.692	322.323	322.350	ASPHALT	0.027
NVA070	393425.596	4705078.090	333.071	333.046	ASPHALT	-0.025
NVA071	386227.937	4704580.326	309.723	309.760	SHORT GRASS	0.037
NVA072	330778.650	4731310.802	337.194	337.142	SHORT GRASS	-0.052
NVA073	322487.106	4787937.329	134.996	134.945	ASPHALT	-0.051

Table 12: Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Meters)

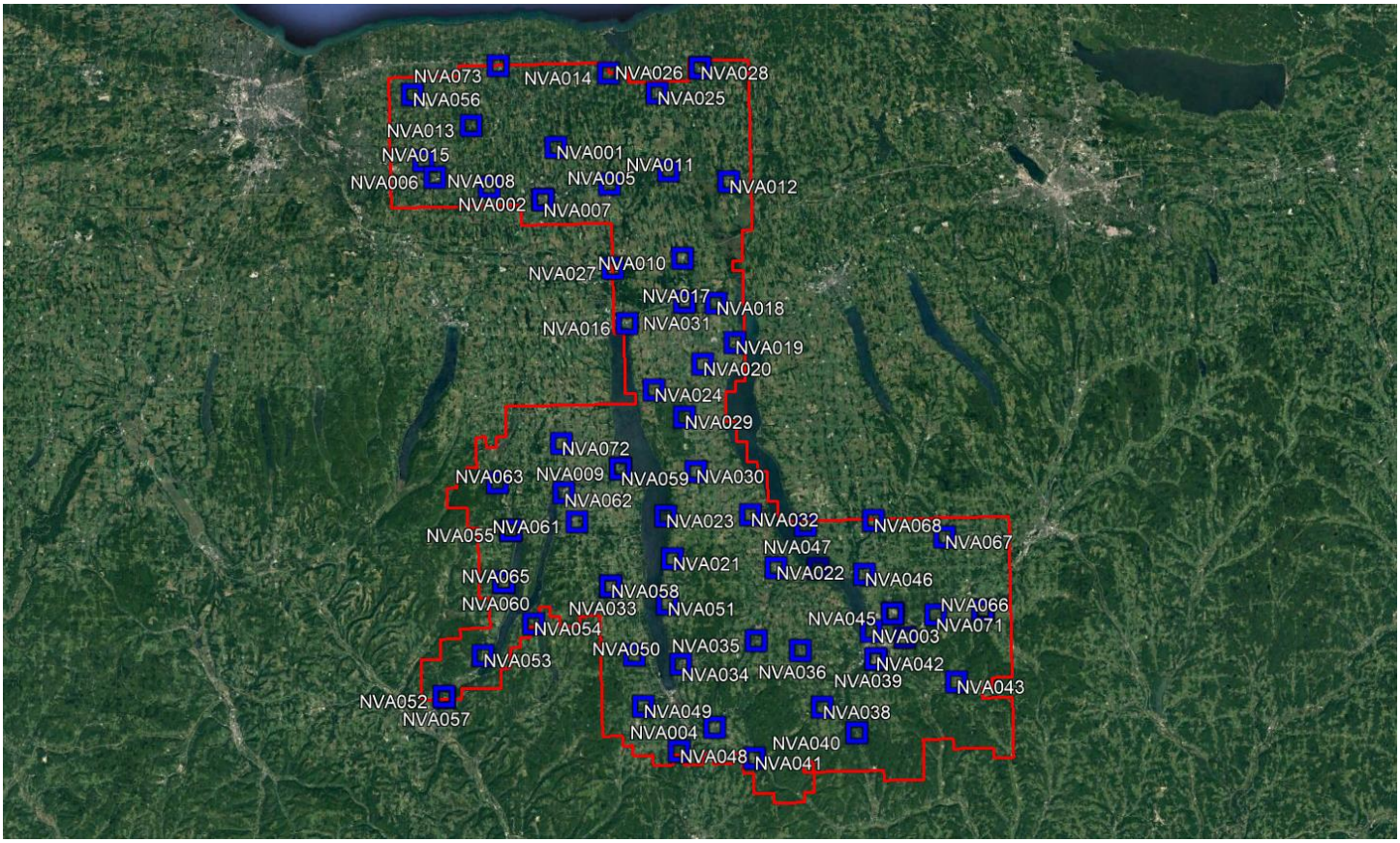


Figure 5: Non-vegetated Check Point Distribution

2.5 Lidar Classification

Lidar filtering was accomplished using GeoCue with TerraSolid processing and modeling software. The filtering process reclassifies all the data into classes within the point cloud classification scheme. Once the data is classified, the entire dataset is reviewed and manually edited for anomalies that are outside the required guidelines of the product specification or contract requirements. This can include, but is not limited to, classifying bridges, structures, filling culverts, and manually analyzing the bare-earth surface by classifying features that belong in non-extraneous classification codes. **Table 13** outlines the point classes leveraged in the lidar dataset.

Code	Description	Definition
1	Unclassified	Processed, but unclassified
2	Ground	Bare-earth surface
7	Low Noise	Erroneous returns below bare-earth surface
9	Water	Hydrologically identified water surface points
17	Bridge Decks	Structure carrying a means of transit of higher elevation
18	High Noise	Erroneous atmospheric returns above bare-earth surface
20	Ignored Ground	Bare-earth points near breaklines
21	Snow	Unavoidable snow or snow pack
22	Temporal Exclusion	Nonfavored data in intertidal zones
Flag	Overlap	Overage points lying within overlapping areas of two or more swaths
Flag	Withheld	Outliers, blunders, noise points, geometrically unreliable points near the extreme edge of the swath

Table 13: Lidar Classification Scheme

2.6 Vertical Accuracy Assessment

The lidar dataset was evaluated using a total of one hundred and thirty-one (131) check points (73 NVA + 58 VVA). The result provided a vertical accuracy that fell within project specifications. Please see the **Attachment A** for the full Vertical Accuracy Report and the project *Metadata* for an in-depth accuracy assessment. **Table 14** outlines the absolute accuracy requirements of the project. **Table 15** shows high level statistics and mean errors for the area processed by Sanborn. The individual check point assessments can be found in **Table 16 -19**.

Category	Value (m)	Value (ft)
RMSEz	≤0.100	≤0.328
@ 95-Percent Confidence Level	≤0.196	≤0.643
@ 95th Percentile	≤0.300	≤0.984

Table 14: Absolute Accuracy Requirements

Broad Land Cover Type	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Bare Earth	73	0.064	0.125	
NVA of DEM	73	0.065	0.127	
VVA of Bare Earth	73	0.063	0.123	
VVA of DEM	58	0.077		0.134

Table 15: Vertical Accuracy Assessment of Check Points (Meters)

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA001	330888.082	4775517.852	130.093	130.063	GRAVEL	-0.030
NVA002	328736.762	4767791.879	135.633	135.653	SHORT GRASS	0.020
NVA003	376539.486	4702332.885	117.579	117.583	SHORT GRASS	0.004
NVA004	352792.456	4688494.062	323.437	323.474	GRAVEL	0.037
NVA005	338807.787	4769828.856	120.938	120.879	ASPHALT	-0.059
NVA006	312639.083	4771459.276	141.094	141.113	SHORT GRASS	0.019
NVA007	328796.665	4767725.226	135.515	135.505	CONCRETE	-0.010
NVA008	320760.844	4769781.360	138.788	138.649	ASPHALT	-0.139
NVA009	339545.115	4727340.059	155.992	155.971	SHORT GRASS	-0.021
NVA010	349491.348	4758538.452	160.372	160.277	ASPHALT	-0.095
NVA011	347654.285	4771633.083	120.032	119.980	GRAVEL	-0.052
NVA012	356694.494	4769825.111	127.830	127.732	ASPHALT	-0.098
NVA013	318222.533	4779065.489	144.360	144.285	ASPHALT	-0.075
NVA014	338988.352	4786440.185	114.134	114.018	ASPHALT	-0.116
NVA015	310999.512	4773960.421	167.980	167.948	ASPHALT	-0.032
NVA016	340991.637	4749001.817	140.106	140.041	ASPHALT	-0.065
NVA017	349636.245	4752001.954	137.639	137.572	ASPHALT	-0.067
NVA018	354371.063	4751723.361	140.291	140.224	ASPHALT	-0.067
NVA019	357068.164	4745804.651	136.326	136.311	GRAVEL	-0.015
NVA020	352193.507	4742700.242	169.611	169.556	GRAVEL	-0.055
NVA021	347017.692	4713768.199	263.326	263.376	BARE SOIL	0.050
NVA022	362485.081	4712096.295	318.204	318.251	SHORT GRASS	0.047
NVA023	346148.583	4720161.273	136.947	136.955	ASPHALT	0.008
NVA024	344818.440	4738994.463	177.241	177.213	GRAVEL	-0.028
NVA025	346204.299	4783296.063	116.005	115.875	GRAVEL	-0.130
NVA026	352632.074	4786952.389	113.109	113.007	ASPHALT	-0.102
NVA027	339047.691	4757241.618	153.581	153.548	ASPHALT	-0.033
NVA028	352747.292	4786914.317	112.010	111.921	ASPHALT	-0.089
NVA029	349277.191	4734853.546	220.724	220.707	SHORT GRASS	-0.017
NVA030	350801.603	4726710.008	296.905	296.945	ASPHALT	0.040
NVA031	349745.343	4752040.615	137.848	137.834	ASPHALT	-0.014
NVA032	358836.879	4720082.547	262.087	262.126	ASPHALT	0.039
NVA033	337700.198	4709808.974	301.752	301.673	ASPHALT	-0.079
NVA034	347946.638	4698027.621	298.965	299.000	ASPHALT	0.035
NVA035	359293.649	4701291.438	366.262	366.309	GRAVEL	0.047
NVA036	365878.270	4699683.423	338.631	338.596	GRAVEL	-0.035
NVA037	368758.797	4711832.567	117.878	117.919	ASPHALT	0.041
NVA038	368987.527	4691156.147	322.081	322.166	CONCRETE	0.085
NVA039	377171.404	4698127.662	267.549	267.494	SHORT GRASS	-0.055
NVA040	374066.530	4687225.952	285.680	285.725	GRAVEL	0.045
NVA041	358641.457	4683783.855	339.088	339.053	ASPHALT	-0.035
NVA042	377119.136	4698183.193	265.216	265.181	ASPHALT	-0.035
NVA043	389129.556	4694483.228	340.638	340.652	GRAVEL	0.014
NVA044	381537.077	4701256.640	275.948	276.000	GRAVEL	0.052
NVA045	379776.572	4704900.233	321.615	321.592	ASPHALT	-0.023
NVA046	375708.130	4710834.004	238.738	238.810	SHORT GRASS	0.072
NVA047	367031.134	4718337.540	221.882	222.045	BARE SOIL	0.163

NVA048	347431.588	4685040.230	172.628	172.701	GRAVEL	0.073
NVA049	342190.882	4691856.185	303.902	303.948	GRAVEL	0.046
NVA050	340995.342	4699505.187	379.542	379.502	SHORT GRASS	-0.040
NVA051	346111.035	4707052.198	257.855	257.824	ASPHALT	-0.031
NVA052	312335.841	4693948.375	334.687	334.653	ASPHALT	-0.034
NVA053	318348.577	4699930.862	426.535	426.519	BARE SOIL	-0.016
NVA054	326011.824	4704509.933	336.695	336.697	BARE SOIL	0.002
NVA055	322910.357	4718522.267	255.427	255.573	SHORT GRASS	0.146
NVA056	309503.776	4783920.296	151.035	150.975	SHORT GRASS	-0.060
NVA057	312426.536	4693779.115	339.585	339.525	ASPHALT	-0.060
NVA058	337698.603	4709881.284	301.204	301.130	BARE SOIL	-0.074
NVA059	339545.411	4727415.771	155.912	155.903	ASPHALT	-0.009
NVA060	321686.605	4710833.056	346.880	346.786	GRAVEL	-0.094
NVA061	332857.223	4719596.406	316.392	316.434	GRAVEL	0.042
NVA062	330993.088	4723968.281	224.191	224.280	ASPHALT	0.089
NVA063	321065.123	4725675.481	303.511	303.596	SHORT GRASS	0.085
NVA064	322873.758	4718540.704	256.473	256.599	BARE SOIL	0.126
NVA065	321686.909	4710777.154	346.571	346.491	ASPHALT	-0.080
NVA066	393302.437	4704980.734	331.659	331.661	ASPHALT	0.002
NVA067	387813.982	4716133.174	305.287	305.382	ASPHALT	0.095
NVA068	377219.658	4718833.823	305.056	305.115	ASPHALT	0.059
NVA069	379892.526	4704916.692	322.323	322.350	ASPHALT	0.027
NVA070	393425.596	4705078.090	333.071	333.046	ASPHALT	-0.025
NVA071	386227.937	4704580.326	309.723	309.760	SHORT GRASS	0.037
NVA072	330778.650	4731310.802	337.194	337.142	SHORT GRASS	-0.052
NVA073	322487.106	4787937.329	134.996	134.945	ASPHALT	-0.051

Table 16: Non-vegetated Vertical Accuracy (NVA) Bare Earth Check Point Assessment (Meters)

PointID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA001	330888.082	4775517.852	130.093	130.069	GRAVEL	-0.024
NVA002	328736.762	4767791.879	135.633	135.649	SHORT GRASS	0.016
NVA003	376539.486	4702332.885	117.579	117.603	SHORT GRASS	0.024
NVA004	352792.456	4688494.062	323.437	323.487	GRAVEL	0.050
NVA005	338807.787	4769828.856	120.938	120.889	ASPHALT	-0.049
NVA006	312639.083	4771459.276	141.094	141.096	SHORT GRASS	0.002
NVA007	328796.665	4767725.226	135.515	135.512	CONCRETE	-0.003
NVA008	320760.844	4769781.360	138.788	138.667	ASPHALT	-0.121
NVA009	339545.115	4727340.059	155.992	155.972	SHORT GRASS	-0.020
NVA010	349491.348	4758538.452	160.372	160.289	ASPHALT	-0.083
NVA011	347654.285	4771633.083	120.032	119.979	GRAVEL	-0.053
NVA012	356694.494	4769825.111	127.830	127.737	ASPHALT	-0.093
NVA013	318222.533	4779065.489	144.360	144.306	ASPHALT	-0.054
NVA014	338988.352	4786440.185	114.134	114.041	ASPHALT	-0.093
NVA015	310999.512	4773960.421	167.980	167.951	ASPHALT	-0.029
NVA016	340991.637	4749001.817	140.106	140.037	ASPHALT	-0.069
NVA017	349636.245	4752001.954	137.639	137.565	ASPHALT	-0.074
NVA018	354371.063	4751723.361	140.291	140.223	ASPHALT	-0.068
NVA019	357068.164	4745804.651	136.326	136.316	GRAVEL	-0.010
NVA020	352193.507	4742700.242	169.611	169.566	GRAVEL	-0.045
NVA021	347017.692	4713768.199	263.326	263.373	BARE SOIL	0.047
NVA022	362485.081	4712096.295	318.204	318.253	SHORT GRASS	0.049
NVA023	346148.583	4720161.273	136.947	136.965	ASPHALT	0.018
NVA024	344818.440	4738994.463	177.241	177.225	GRAVEL	-0.016
NVA025	346204.299	4783296.063	116.005	115.882	GRAVEL	-0.123
NVA026	352632.074	4786952.389	113.109	113.011	ASPHALT	-0.098
NVA027	339047.691	4757241.618	153.581	153.539	ASPHALT	-0.042
NVA028	352747.292	4786914.317	112.010	111.920	ASPHALT	-0.090
NVA029	349277.191	4734853.546	220.724	220.699	SHORT GRASS	-0.025
NVA030	350801.603	4726710.008	296.905	296.917	ASPHALT	0.012
NVA031	349745.343	4752040.615	137.848	137.831	ASPHALT	-0.017
NVA032	358836.879	4720082.547	262.087	262.116	ASPHALT	0.029
NVA033	337700.198	4709808.974	301.752	301.675	ASPHALT	-0.077
NVA034	347946.638	4698027.621	298.965	298.996	ASPHALT	0.031
NVA035	359293.649	4701291.438	366.262	366.314	GRAVEL	0.052
NVA036	365878.270	4699683.423	338.631	338.585	GRAVEL	-0.046
NVA037	368758.797	4711832.567	117.878	117.920	ASPHALT	0.042
NVA038	368987.527	4691156.147	322.081	322.151	CONCRETE	0.070
NVA039	377171.404	4698127.662	267.549	267.497	SHORT GRASS	-0.052
NVA040	374066.530	4687225.952	285.680	285.709	GRAVEL	0.029
NVA041	358641.457	4683783.855	339.088	339.057	ASPHALT	-0.031
NVA042	377119.136	4698183.193	265.216	265.189	ASPHALT	-0.027
NVA043	389129.556	4694483.228	340.638	340.647	GRAVEL	0.009
NVA044	381537.077	4701256.640	275.948	275.986	GRAVEL	0.038
NVA045	379776.572	4704900.233	321.615	321.588	ASPHALT	-0.027
NVA046	375708.130	4710834.004	238.738	238.815	SHORT GRASS	0.077
NVA047	367031.134	4718337.540	221.882	222.034	BARE SOIL	0.152

NVA048	347431.588	4685040.230	172.628	172.699	GRAVEL	0.071
NVA049	342190.882	4691856.185	303.902	303.945	GRAVEL	0.043
NVA050	340995.342	4699505.187	379.542	379.488	SHORT GRASS	-0.054
NVA051	346111.035	4707052.198	257.855	257.814	ASPHALT	-0.041
NVA052	312335.841	4693948.375	334.687	334.657	ASPHALT	-0.030
NVA053	318348.577	4699930.862	426.535	426.513	BARE SOIL	-0.022
NVA054	326011.824	4704509.933	336.695	336.684	BARE SOIL	-0.011
NVA055	322910.357	4718522.267	255.427	255.574	SHORT GRASS	0.147
NVA056	309503.776	4783920.296	151.035	150.971	SHORT GRASS	-0.064
NVA057	312426.536	4693779.115	339.585	339.527	ASPHALT	-0.058
NVA058	337698.603	4709881.284	301.204	301.127	BARE SOIL	-0.077
NVA059	339545.411	4727415.771	155.912	155.890	ASPHALT	-0.022
NVA060	321686.605	4710833.056	346.880	346.771	GRAVEL	-0.109
NVA061	332857.223	4719596.406	316.392	316.435	GRAVEL	0.043
NVA062	330993.088	4723968.281	224.191	224.280	ASPHALT	0.089
NVA063	321065.123	4725675.481	303.511	303.591	SHORT GRASS	0.080
NVA064	322873.758	4718540.704	256.473	256.588	BARE SOIL	0.115
NVA065	321686.909	4710777.154	346.571	346.483	ASPHALT	-0.088
NVA066	393302.437	4704980.734	331.659	331.653	ASPHALT	-0.006
NVA067	387813.982	4716133.174	305.287	305.376	ASPHALT	0.089
NVA068	377219.658	4718833.823	305.056	305.118	ASPHALT	0.062
NVA069	379892.526	4704916.692	322.323	322.353	ASPHALT	0.030
NVA070	393425.596	4705078.090	333.071	333.043	ASPHALT	-0.028
NVA071	386227.937	4704580.326	309.723	309.768	SHORT GRASS	0.045
NVA072	330778.650	4731310.802	337.194	337.142	SHORT GRASS	-0.052
NVA073	322487.106	4787937.329	134.996	134.931	ASPHALT	-0.065

Table 17: Non-vegetated Vertical Accuracy (NVA) DEM Check Point Assessment (Meters)

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ	ABS
VVA001	312442.906	4771515.088	141.301	141.358	FORESTED	0.057	0.057
VVA002	310973.330	4773977.541	167.431	167.439	FORESTED	0.008	0.008
VVA003	320871.064	4769841.857	138.910	138.778	BRUSH	-0.132	0.132
VVA004	338888.089	4769863.477	120.032	120.089	BRUSH	0.057	0.057
VVA005	338997.341	4786476.609	113.925	113.884	BRUSH	-0.041	0.041
VVA006	330911.188	4775508.269	129.796	129.898	BRUSH	0.102	0.102
VVA007	347513.729	4771709.703	119.837	119.792	FORESTED	-0.045	0.045
VVA008	356730.956	4769843.019	130.520	130.458	FORESTED	-0.062	0.062
VVA009	309406.641	4783873.794	156.056	155.866	FORESTED	-0.190	0.190
VVA010	322528.028	4787964.143	134.643	134.578	BRUSH	-0.065	0.065
VVA012	352630.776	4786986.232	113.280	113.288	TALL WEEDS	0.008	0.008
VVA013	318319.584	4779051.129	142.381	142.515	FORESTED	0.134	0.134
VVA014	328766.105	4767596.483	135.893	135.824	FORESTED	-0.069	0.069
VVA015	347029.180	4713814.149	263.819	263.898	FORESTED	0.079	0.079
VVA016	368773.174	4711782.632	117.668	117.714	FORESTED	0.046	0.046
VVA017	375702.799	4710849.679	238.364	238.487	FORESTED	0.123	0.123
VVA018	312461.121	4693942.116	333.224	333.254	FORESTED	0.030	0.030
VVA019	322230.756	4710493.624	316.480	316.391	FORESTED	-0.089	0.089
VVA020	326030.680	4704453.505	337.277	337.347	FORESTED	0.070	0.070
VVA021	318358.639	4699928.707	424.374	424.362	CROPS	-0.012	0.012
VVA022	376609.325	4702389.882	117.723	117.860	FORESTED	0.137	0.137
VVA023	358749.291	4683760.899	339.192	339.182	TALL WEEDS	-0.010	0.010
VVA024	352798.915	4688571.997	323.285	323.401	FORESTED	0.116	0.116
VVA025	347411.960	4685050.193	172.380	172.503	TALL WEEDS	0.123	0.123
VVA026	347934.414	4698026.658	298.707	298.727	FORESTED	0.020	0.020
VVA027	346096.768	4707055.923	257.483	257.435	FORESTED	-0.048	0.048
VVA028	359350.421	4701340.525	359.651	359.744	TALL WEEDS	0.093	0.093
VVA029	377146.243	4698195.261	263.812	263.845	FORESTED	0.033	0.033
VVA030	374054.123	4687198.624	283.613	283.592	BRUSH	-0.021	0.021
VVA031	393375.846	4705082.194	332.889	332.852	FORESTED	-0.037	0.037
VVA032	377236.904	4718823.798	304.413	304.476	FORESTED	0.063	0.063
VVA033	379747.691	4704918.551	322.628	322.609	FORESTED	-0.019	0.019
VVA034	365868.703	4699639.729	338.570	338.569	BRUSH	-0.001	0.001
VVA035	389112.144	4694488.948	340.444	340.540	BRUSH	0.096	0.096
VVA036	381524.101	4701264.546	275.682	275.690	BRUSH	0.008	0.008
VVA037	321141.317	4725669.822	305.519	305.578	FORESTED	0.059	0.059
VVA038	341007.099	4699491.227	379.485	379.480	BRUSH	-0.005	0.005
VVA039	337734.513	4709868.989	302.034	301.982	FORESTED	-0.052	0.052
VVA040	367049.945	4718362.751	224.546	224.763	BRUSH	0.217	0.217
VVA041	362506.940	4712051.535	317.905	317.977	TALL WEEDS	0.072	0.072
VVA042	346220.302	4720139.213	138.272	138.298	FORESTED	0.026	0.026
VVA043	330691.914	4731361.680	343.249	343.199	FORESTED	-0.050	0.050
VVA044	322889.249	4718581.149	255.560	255.682	FORESTED	0.122	0.122

VVA045	330958.097	4723941.984	223.041	223.173	FORESTED	0.132	0.132
VVA046	350911.187	4726710.969	296.406	296.439	FORESTED	0.033	0.033
VVA047	358827.755	4720061.055	260.971	261.041	FORESTED	0.070	0.070
VVA048	352188.917	4742660.216	169.837	169.813	TALL WEEDS	-0.024	0.024
VVA049	354388.498	4751595.089	141.595	141.505	FORESTED	-0.090	0.090
VVA050	349300.512	4734861.331	221.901	221.898	FORESTED	-0.003	0.003
VVA051	339486.999	4727259.329	153.523	153.516	FORESTED	-0.007	0.007
VVA052	344813.951	4739012.904	176.932	176.981	BRUSH	0.049	0.049
VVA053	349610.834	4752002.269	137.243	137.191	FORESTED	-0.052	0.052
VVA054	339027.963	4757249.526	152.658	152.681	BRUSH	0.023	0.023
VVA055	349507.544	4758384.482	159.537	159.500	BRUSH	-0.037	0.037
VVA056	342186.420	4691835.308	302.936	303.008	FORESTED	0.072	0.072
VVA057	369031.405	4691139.341	322.009	322.091	FORESTED	0.082	0.082
VVA300	357075.840	4745867.976	136.938	136.951	TALL WEEDS	0.013	0.013
VVA301	341013.557	4748955.273	141.950	141.954	BRUSH	0.004	0.004

Table 18: Vegetated Vertical Accuracy (VVA) Bare Earth Check Point Assessment (Meters)

PointID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ	ABS
VVA001	312442.906	4771515.088	141.301	141.333	FORESTED	0.032	0.032
VVA002	310973.330	4773977.541	167.431	167.420	FORESTED	-0.011	0.011
VVA003	320871.064	4769841.857	138.910	138.788	BRUSH	-0.122	0.122
VVA004	338888.089	4769863.477	120.032	120.079	BRUSH	0.047	0.047
VVA005	338997.341	4786476.609	113.925	113.883	BRUSH	-0.042	0.042
VVA006	330911.188	4775508.269	129.796	129.921	BRUSH	0.125	0.125
VVA007	347513.729	4771709.703	119.837	119.789	FORESTED	-0.048	0.048
VVA008	356730.956	4769843.019	130.520	130.457	FORESTED	-0.063	0.063
VVA009	309406.641	4783873.794	156.056	155.867	FORESTED	-0.189	0.189
VVA010	322528.028	4787964.143	134.643	134.569	BRUSH	-0.074	0.074
VVA012	352630.776	4786986.232	113.280	113.314	TALL WEEDS	0.034	0.034
VVA013	318319.584	4779051.129	142.381	142.519	FORESTED	0.138	0.138
VVA014	328766.105	4767596.483	135.893	135.838	FORESTED	-0.055	0.055
VVA015	347029.180	4713814.149	263.819	263.903	FORESTED	0.084	0.084
VVA016	368773.174	4711782.632	117.668	117.711	FORESTED	0.043	0.043
VVA017	375702.799	4710849.679	238.364	238.509	FORESTED	0.145	0.145
VVA018	312461.121	4693942.116	333.224	333.254	FORESTED	0.030	0.030
VVA019	322230.756	4710493.624	316.480	316.396	FORESTED	-0.084	0.084
VVA020	326030.680	4704453.505	337.277	337.355	FORESTED	0.078	0.078
VVA021	318358.639	4699928.707	424.374	424.344	CROPS	-0.030	0.030
VVA022	376609.325	4702389.882	117.723	117.863	FORESTED	0.140	0.140
VVA023	358749.291	4683760.899	339.192	339.186	TALL WEEDS	-0.006	0.006
VVA024	352798.915	4688571.997	323.285	323.400	FORESTED	0.115	0.115
VVA025	347411.960	4685050.193	172.380	172.501	TALL WEEDS	0.121	0.121
VVA026	347934.414	4698026.658	298.707	298.730	FORESTED	0.023	0.023
VVA027	346096.768	4707055.923	257.483	257.423	FORESTED	-0.060	0.060
VVA028	359350.421	4701340.525	359.651	359.750	TALL WEEDS	0.099	0.099
VVA029	377146.243	4698195.261	263.812	263.844	FORESTED	0.032	0.032
VVA030	374054.123	4687198.624	283.613	283.586	BRUSH	-0.027	0.027
VVA031	393375.846	4705082.194	332.889	332.855	FORESTED	-0.034	0.034
VVA032	377236.904	4718823.798	304.413	304.474	FORESTED	0.061	0.061
VVA033	379747.691	4704918.551	322.628	322.604	FORESTED	-0.024	0.024
VVA034	365868.703	4699639.729	338.570	338.563	BRUSH	-0.007	0.007
VVA035	389112.144	4694488.948	340.444	340.538	BRUSH	0.094	0.094
VVA036	381524.101	4701264.546	275.682	275.699	BRUSH	0.017	0.017
VVA037	321141.317	4725669.822	305.519	305.578	FORESTED	0.059	0.059
VVA038	341007.099	4699491.227	379.485	379.478	BRUSH	-0.007	0.007
VVA039	337734.513	4709868.989	302.034	301.984	FORESTED	-0.050	0.050
VVA040	367049.945	4718362.751	224.546	224.769	BRUSH	0.223	0.223
VVA041	362506.940	4712051.535	317.905	317.980	TALL WEEDS	0.075	0.075
VVA042	346220.302	4720139.213	138.272	138.303	FORESTED	0.031	0.031
VVA043	330691.914	4731361.680	343.249	343.211	FORESTED	-0.038	0.038
VVA044	322889.249	4718581.149	255.560	255.658	FORESTED	0.098	0.098
VVA045	330958.097	4723941.984	223.041	223.181	FORESTED	0.140	0.140
VVA046	350911.187	4726710.969	296.406	296.442	FORESTED	0.036	0.036
VVA047	358827.755	4720061.055	260.971	261.029	FORESTED	0.058	0.058
VVA048	352188.917	4742660.216	169.837	169.816	TALL WEEDS	-0.021	0.021

VVA049	354388.498	4751595.089	141.595	141.507	FORESTED	-0.088	0.088
VVA050	349300.512	4734861.331	221.901	221.899	FORESTED	-0.002	0.002
VVA051	339486.999	4727259.329	153.523	153.514	FORESTED	-0.009	0.009
VVA052	344813.951	4739012.904	176.932	176.961	BRUSH	0.029	0.029
VVA053	349610.834	4752002.269	137.243	137.196	FORESTED	-0.047	0.047
VVA054	339027.963	4757249.526	152.658	152.677	BRUSH	0.019	0.019
VVA055	349507.544	4758384.482	159.537	159.502	BRUSH	-0.035	0.035
VVA056	342186.420	4691835.308	302.936	303.001	FORESTED	0.065	0.065
VVA057	369031.405	4691139.341	322.009	322.079	FORESTED	0.070	0.070
VVA300	357075.840	4745867.976	136.938	136.957	TALL WEEDS	0.019	0.019
VVA301	341013.557	4748955.273	141.950	141.962	BRUSH	0.012	0.012

Table 19: Vegetated Vertical Accuracy (VVA) DEM Check Point Assessment (Meters)

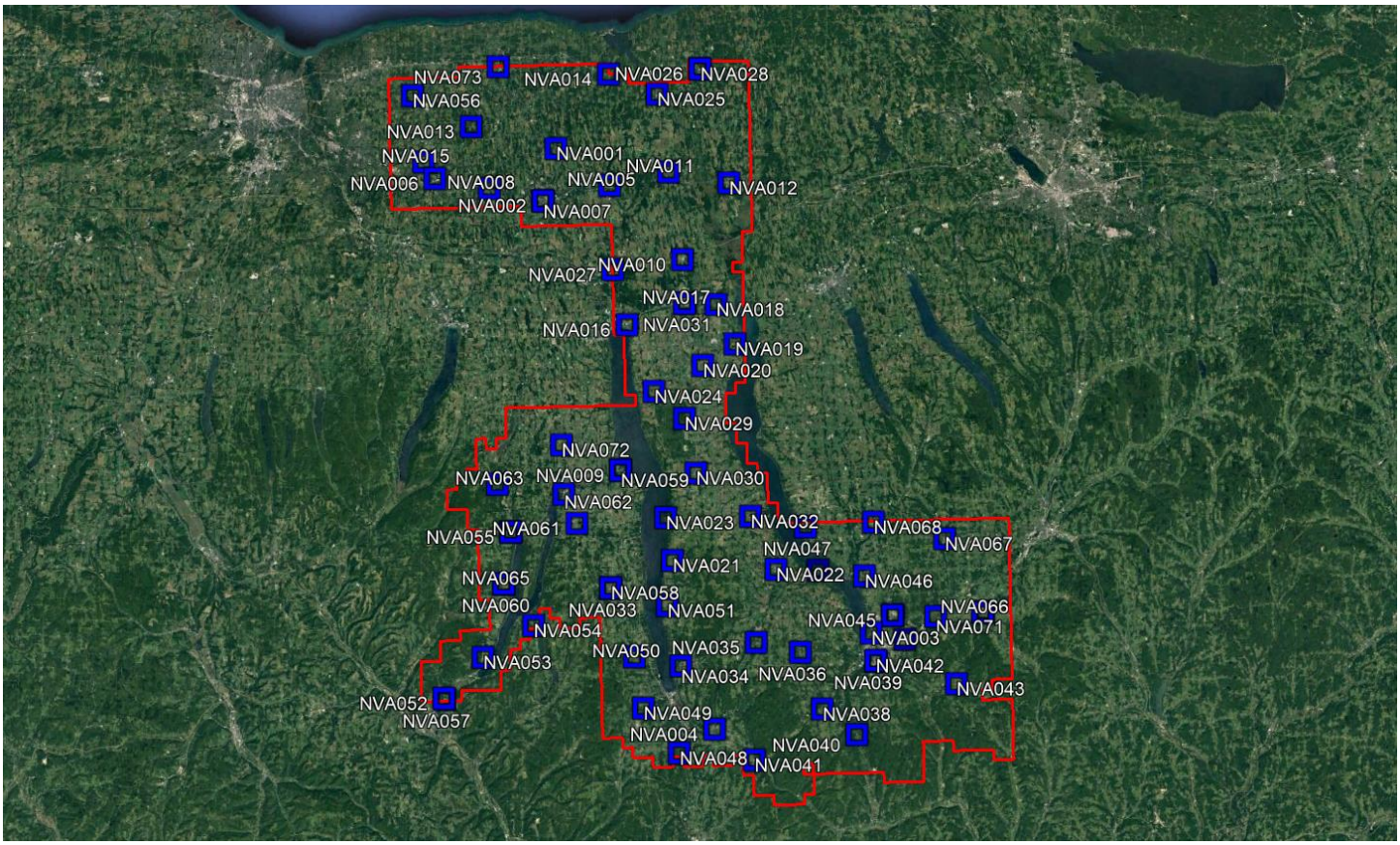


Figure 5: Non-vegetated Check Point Distribution

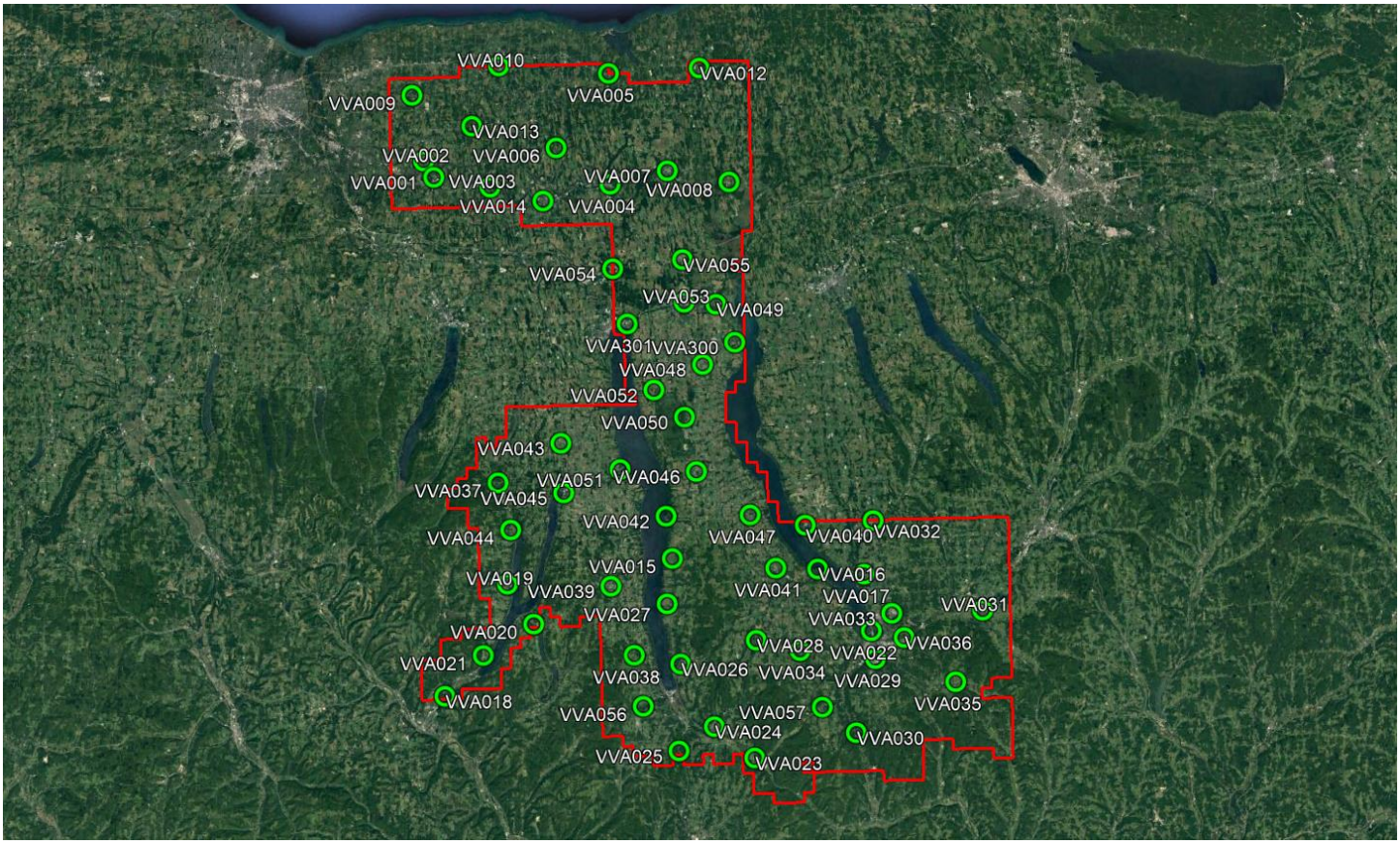


Figure 6: Vegetated Check Point Distribution

3.0 PRODUCT GENERATION

The following products were generated using the final coordinate system as defined in the contract:

Classified Point Cloud
The Classified Point Cloud, containing all returns, is delivered in LASv1.4 (*.las) format and meets project specifications. The Classified Point Cloud contains file names referencing the tile index.

Bare-Earth Digital Elevation Model
32-bit GeoTIFF (*.tif) elevation rasters were created from the bare-earth points in the processed lidar dataset and hydro-flattened breaklines. Each pixel contains an elevation.

Breaklines
Hydro-flattened breaklines (*.gdb) were created from digitized water features conflated to the elevations derived from the bare-earth points in the processed lidar dataset.

First-Return Digital Surface Model
32-bit GeoTIFF (*.tif) elevation rasters were created from the first-return points in the processed lidar dataset. All overlap classes were ignored during this process. Each pixel contains an elevation.

First-Return Intensity Images
8-bit GeoTIFF (*.tiff) intensity rasters were created from the first-return points in the processed lidar dataset. All overlap classes were ignored during this process.

Swath Separation Images
24-bit GeoTIFF (*.tif) height separation rasters modulated by intensity were created from the last-return points in the processed lidar dataset.

Swath Polygons
Polygons features representing either the convex or concave hull of swaths, where each record is an individual swath or channel within a swath. Delivered in Esri (*.shp) format.

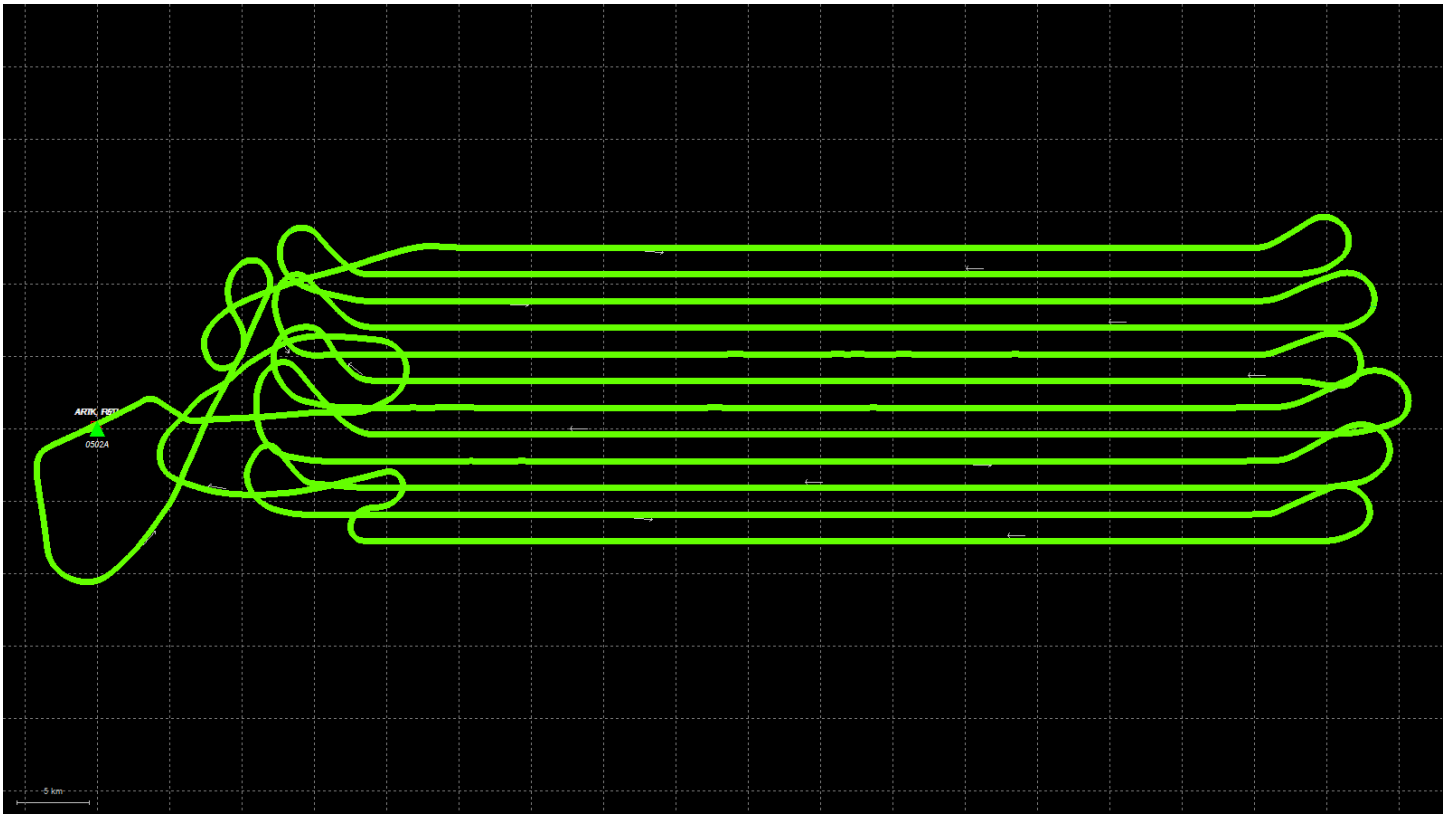
Other Deliverables
Metadata
Vertical Accuracy Report

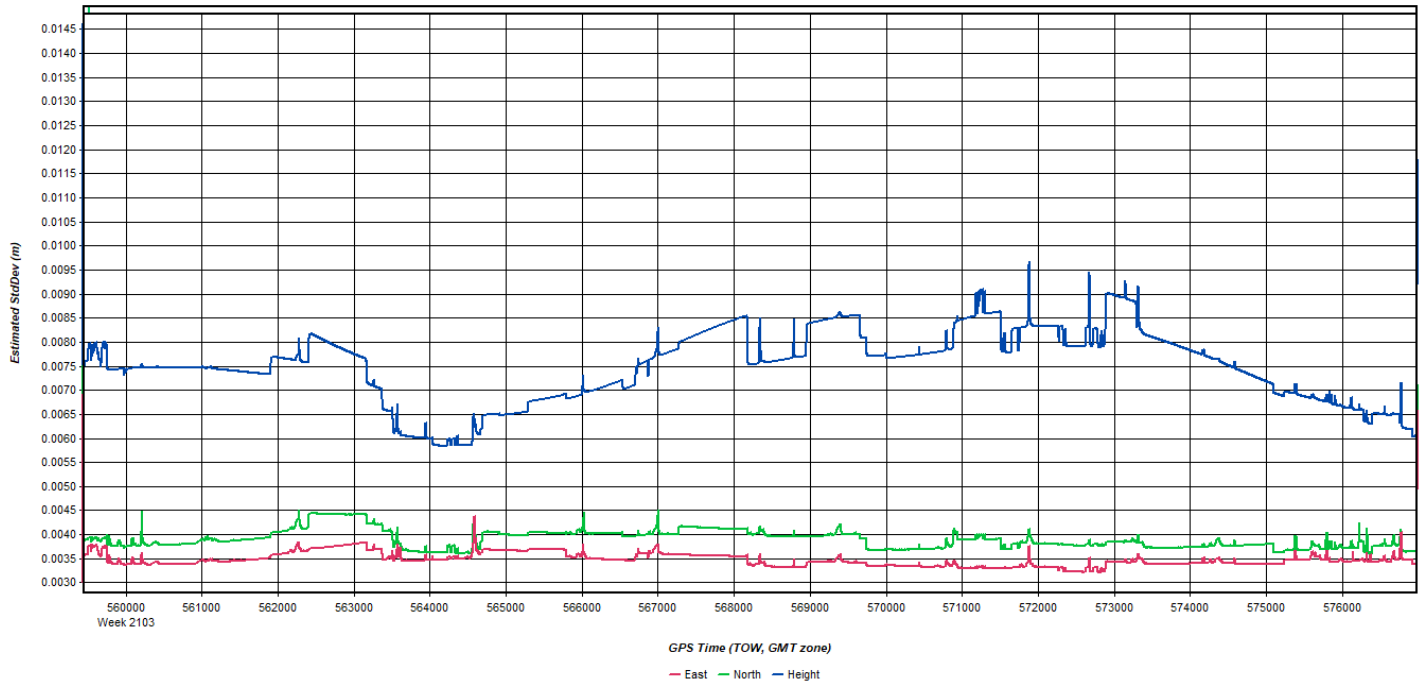
A final quality assurance process was undertaken to validate all deliverables for the project. Prior to release of data for delivery, Sanborn's Quality Control/Quality Assurance department reviews the data and then releases it for delivery.

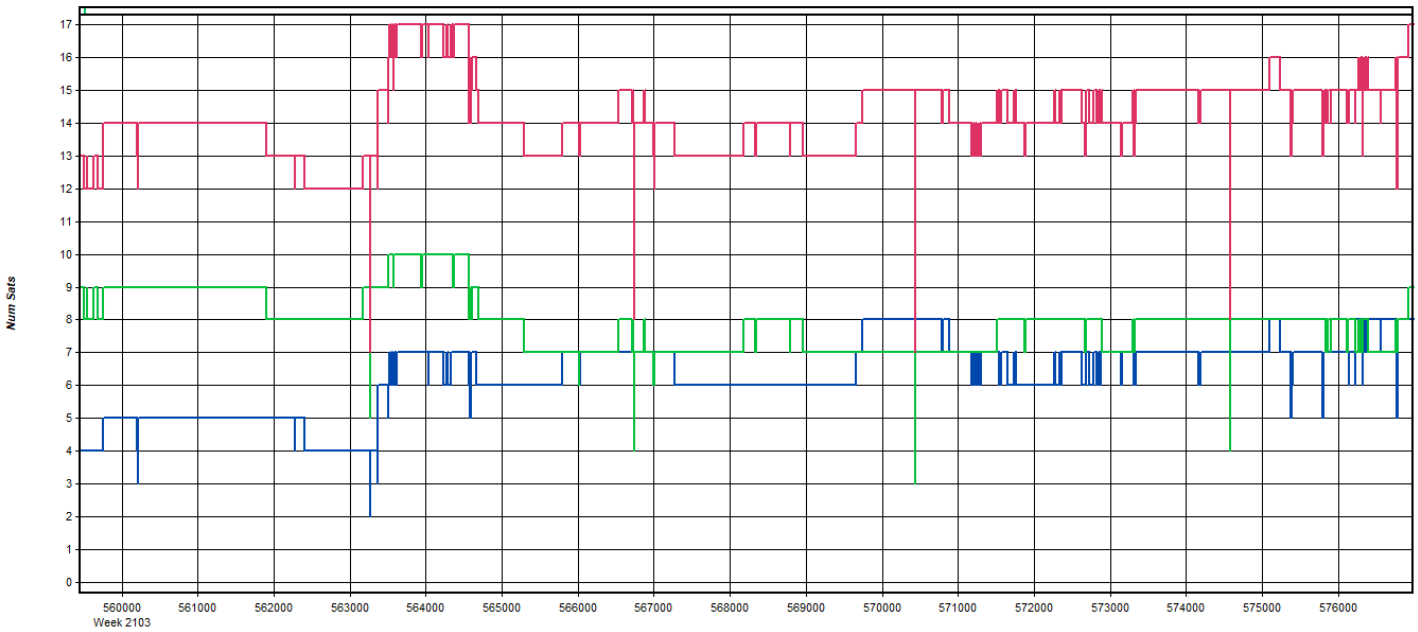
APPENDIX A – ABGNSS/IMU PLOTS

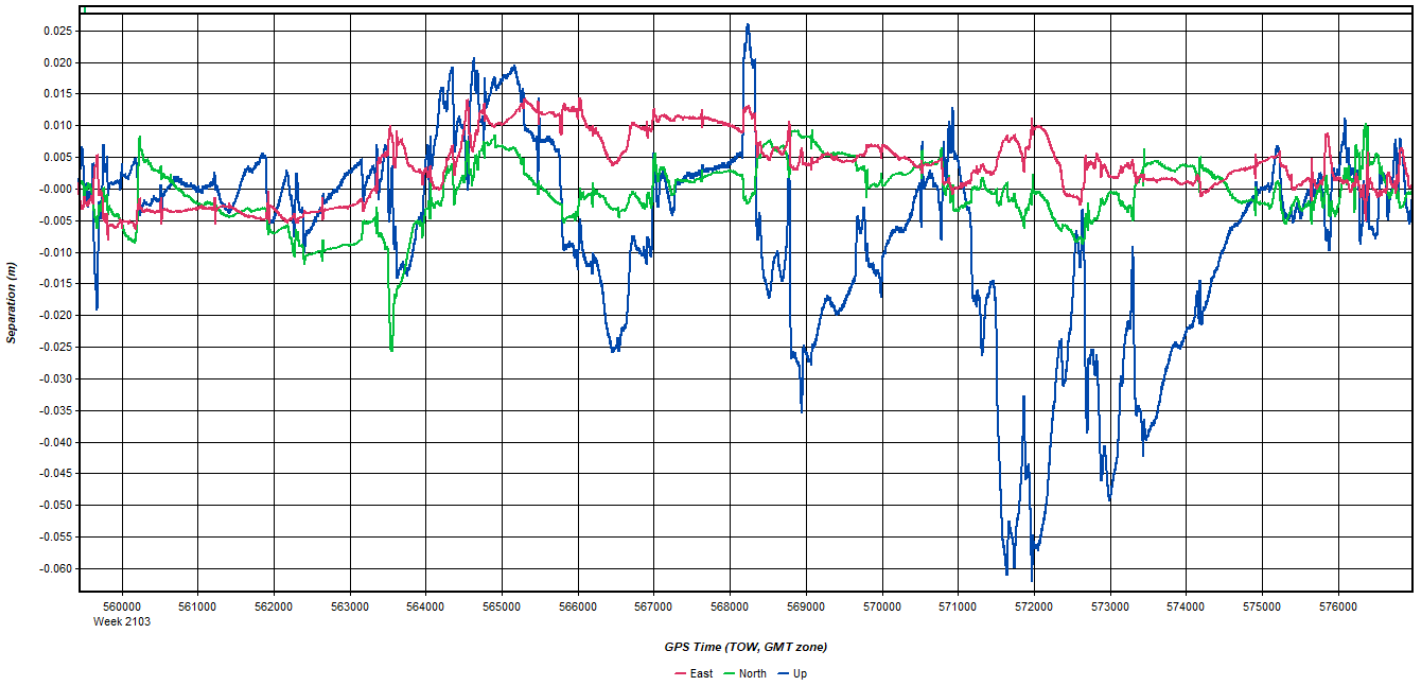
Coverage Map	Plots the Aircraft GNSS-IMU Trajectory in reference to localized GNSS Reference Stations.
Estimated Position Accuracy	Plots the standard deviations of the east, north, and up directions versus time for the solution. The total standard deviation with a distance dependent component is also plotted.
Number of Satellites	Plots the number of satellites used in the solution as a function of time. The number of GPS, GLONASS, and the total number of satellites are distinguished with separate color coded lines.
Combined Separation	Plots the north, east, and height position difference between any two solutions loaded into the project. These are 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.
PDOP	PDOP is a unitless 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. PDOP spikes can occur on aircraft turns were the antenna angle is unfavorable; these spikes while aesthetically unfavorable do not generally reduce the accuracy of the acquired data.

20200502A_N603ET_TM91520






Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
560000
Week 2103
561000
562000
563000
564000
565000
566000
567000
568000
569000
570000
571000
572000
573000
574000
575000
576000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS


Separation (m)
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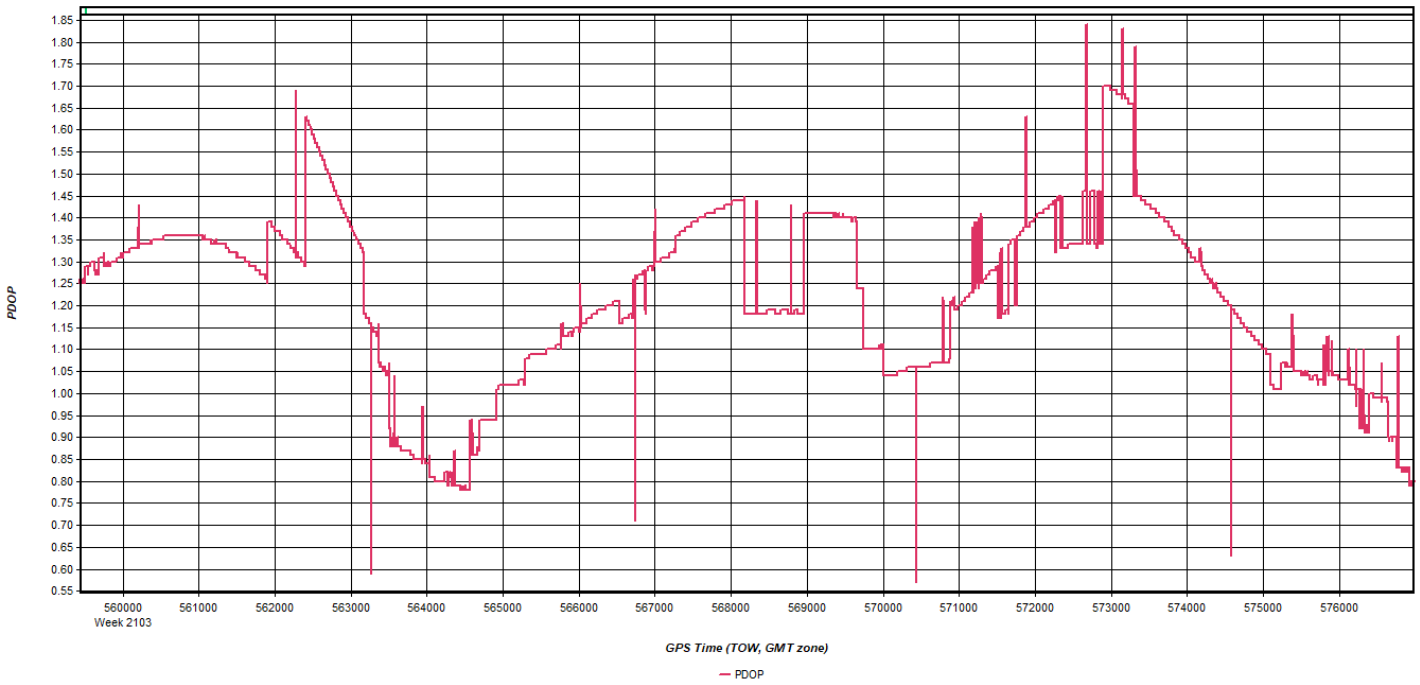
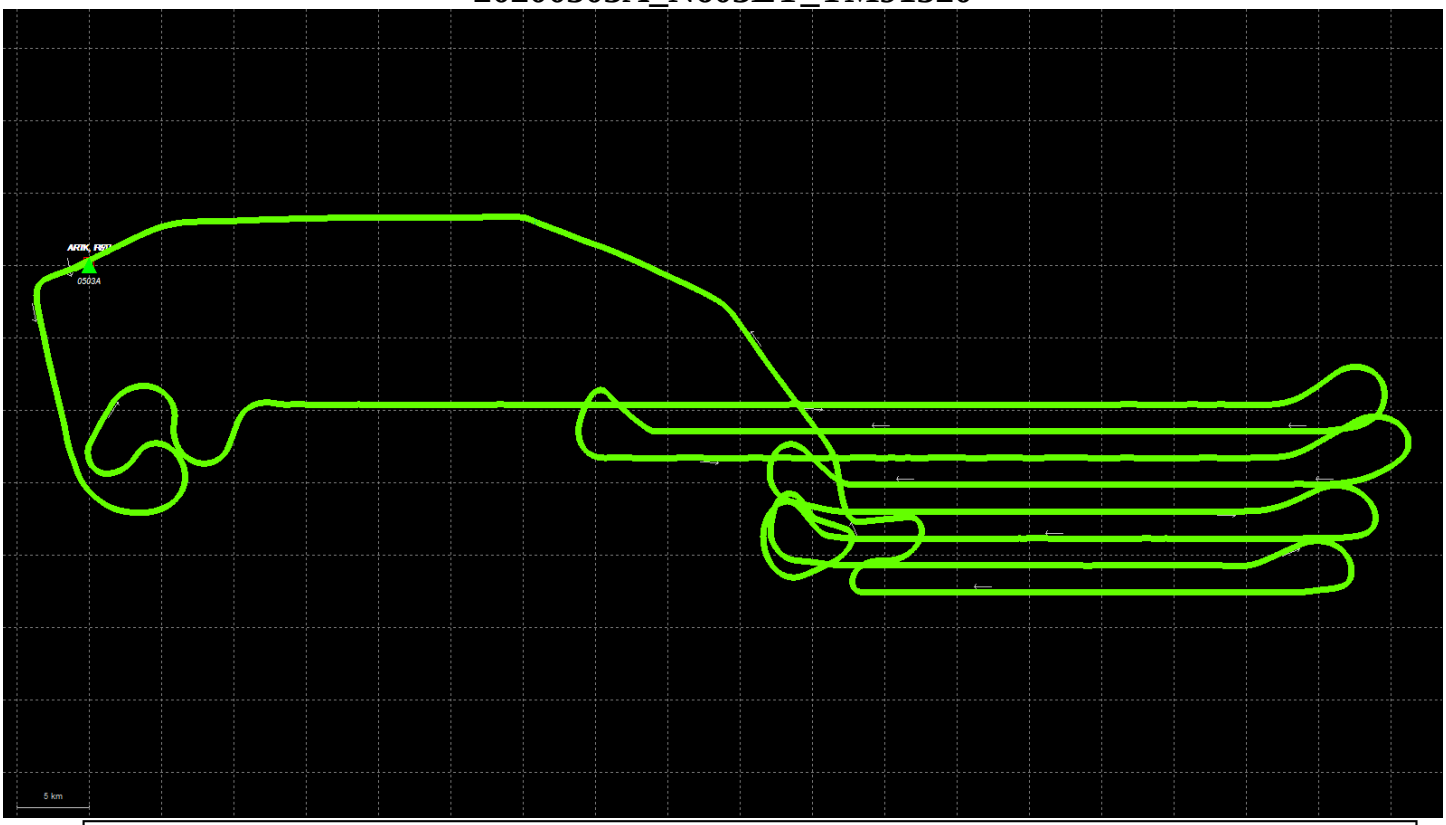
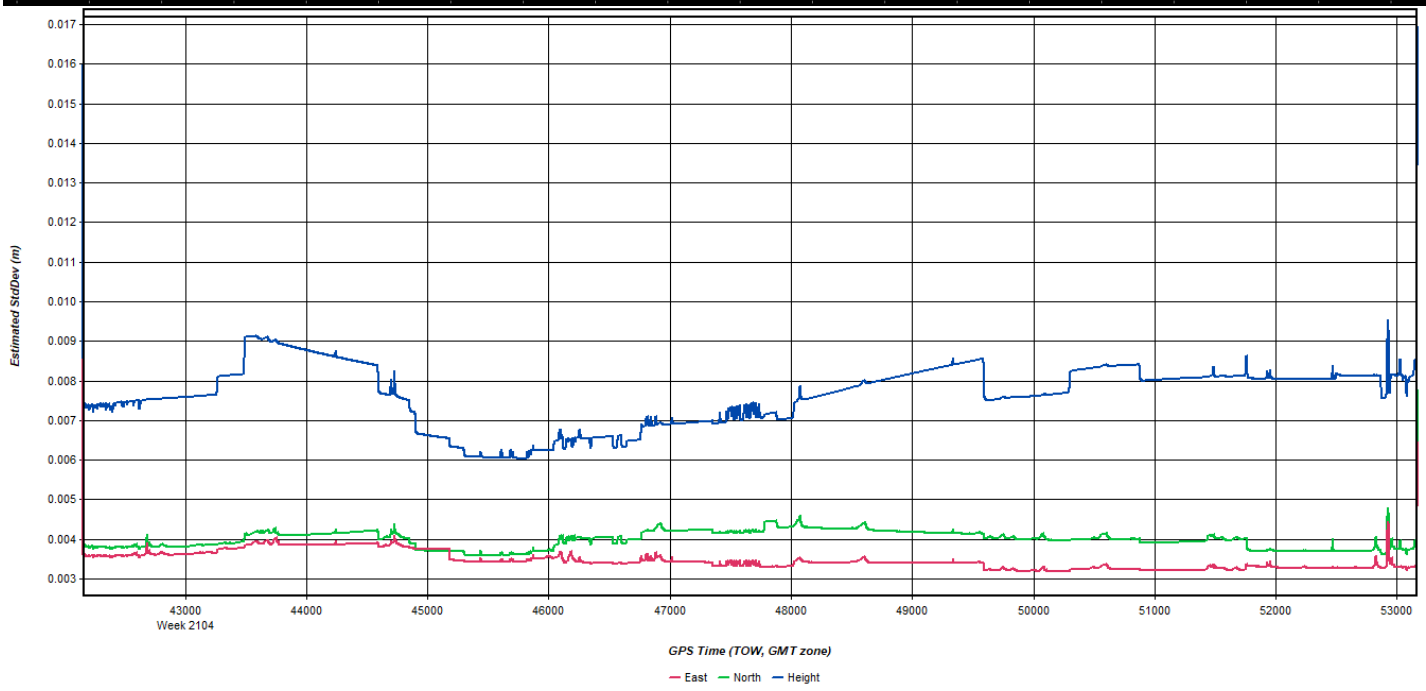
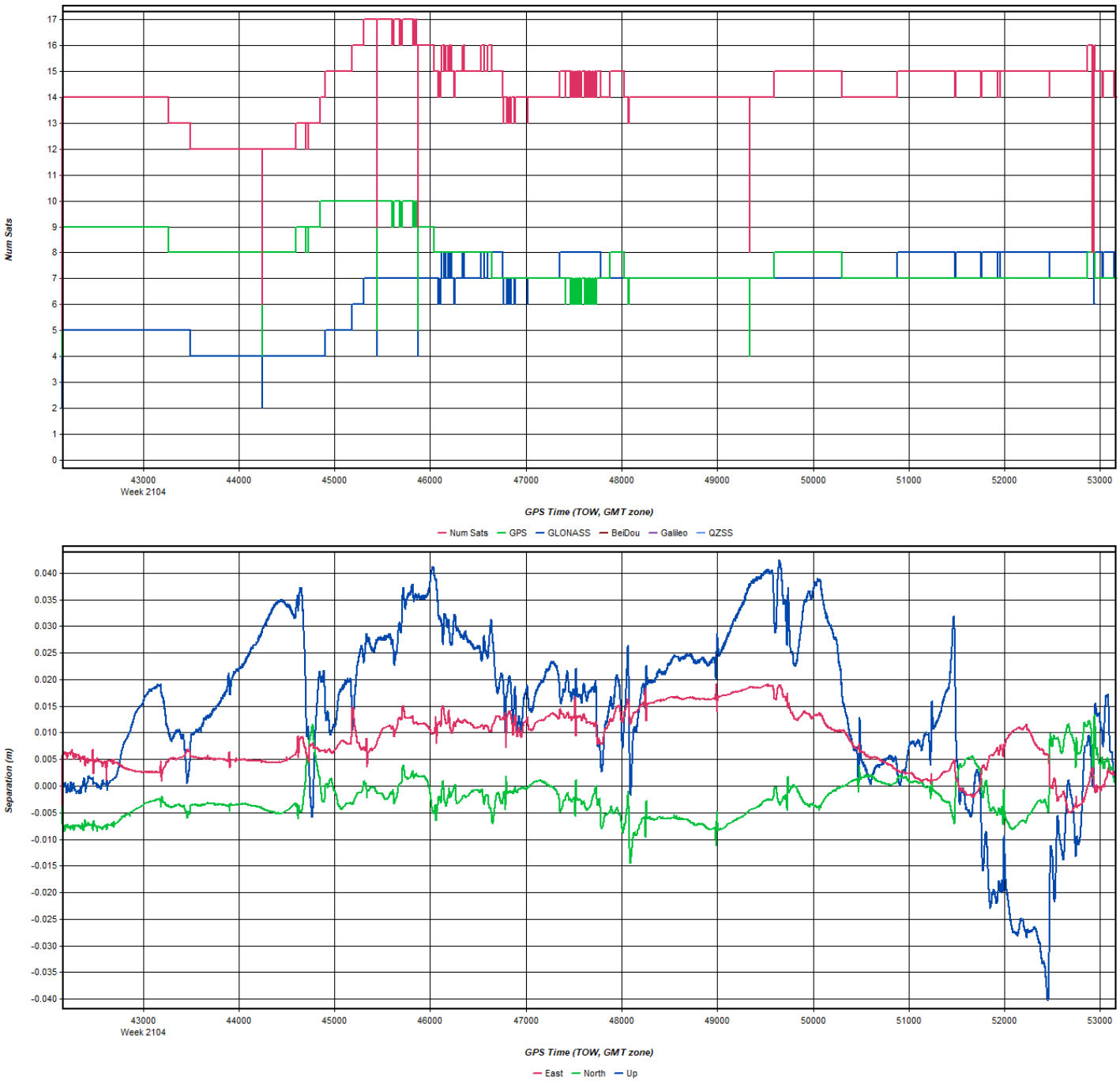
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
560000
Week 2103
561000
562000
563000
564000
565000
566000
567000
568000
569000
570000
571000
572000
573000
574000
575000
576000
GPS Time (TOW, GMT zone)
East
North
Up


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
0.85
0.80
0.75
0.70
0.65
0.60
0.55
560000
Week 2103
561000
562000
563000
564000
565000
566000
567000
568000
569000
570000
571000
572000
573000
574000
575000
576000
GPS Time (TOW, GMT zone)
PDOP

20200503A_N603ET_TM91520



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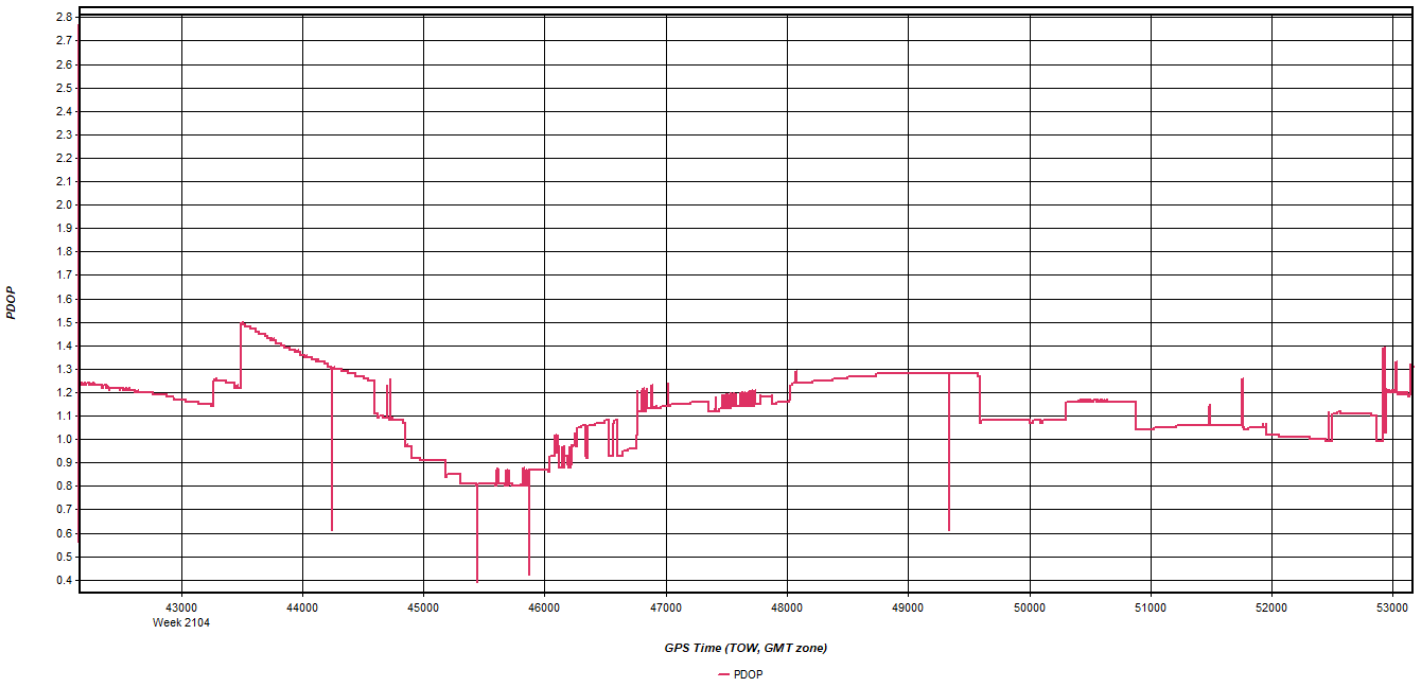
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
43000
Week 2104
44000
45000
46000
47000
48000
49000
50000
51000
52000
53000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

Separation (m)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
43000
Week 2104
44000
45000
46000
47000
48000
49000
50000
51000
52000
53000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
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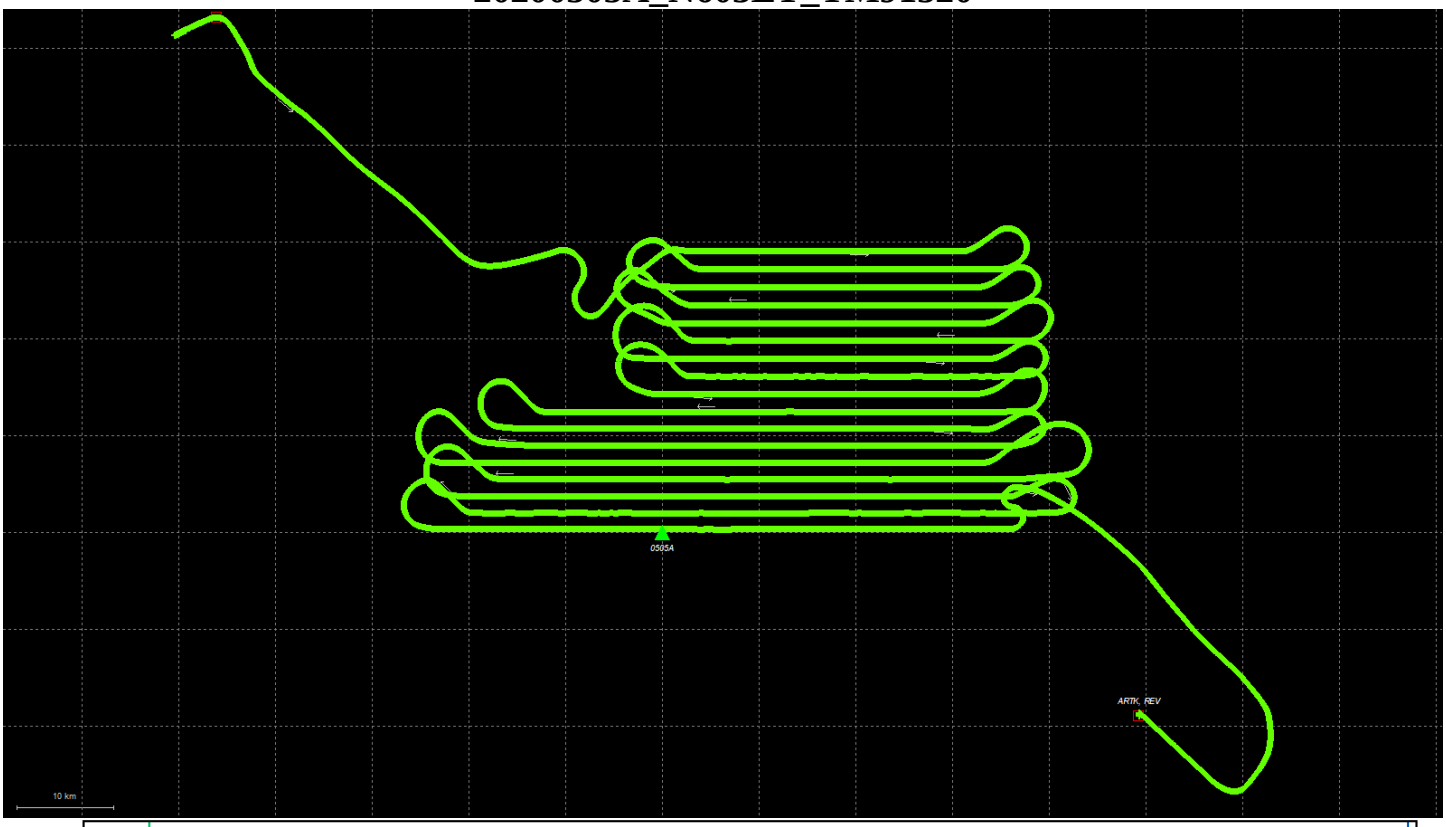
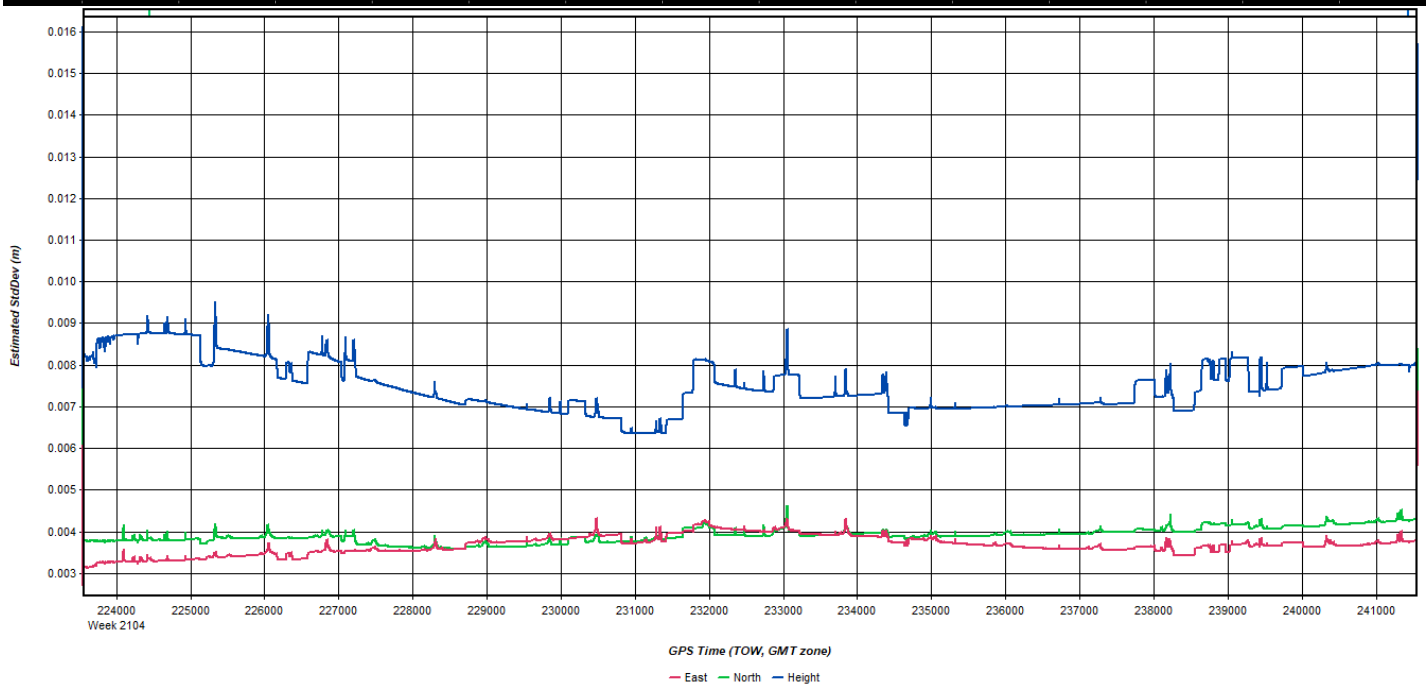
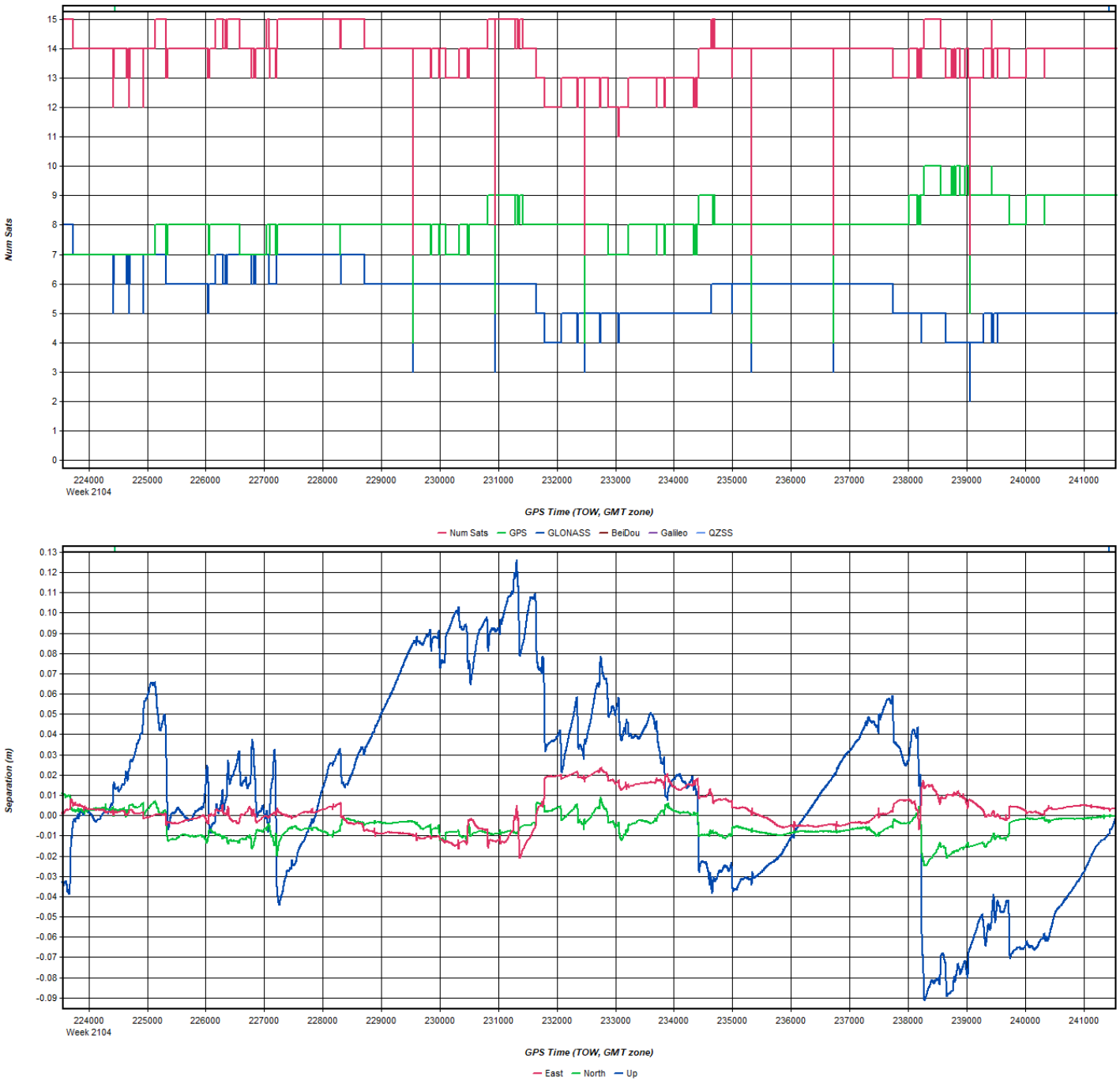
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
43000
Week 2104
44000
45000
46000
47000
48000
49000
50000
51000
52000
53000
GPS Time (TOW, GMT zone)
PDOP

20200505A_N603ET_TM91520






Num Sats
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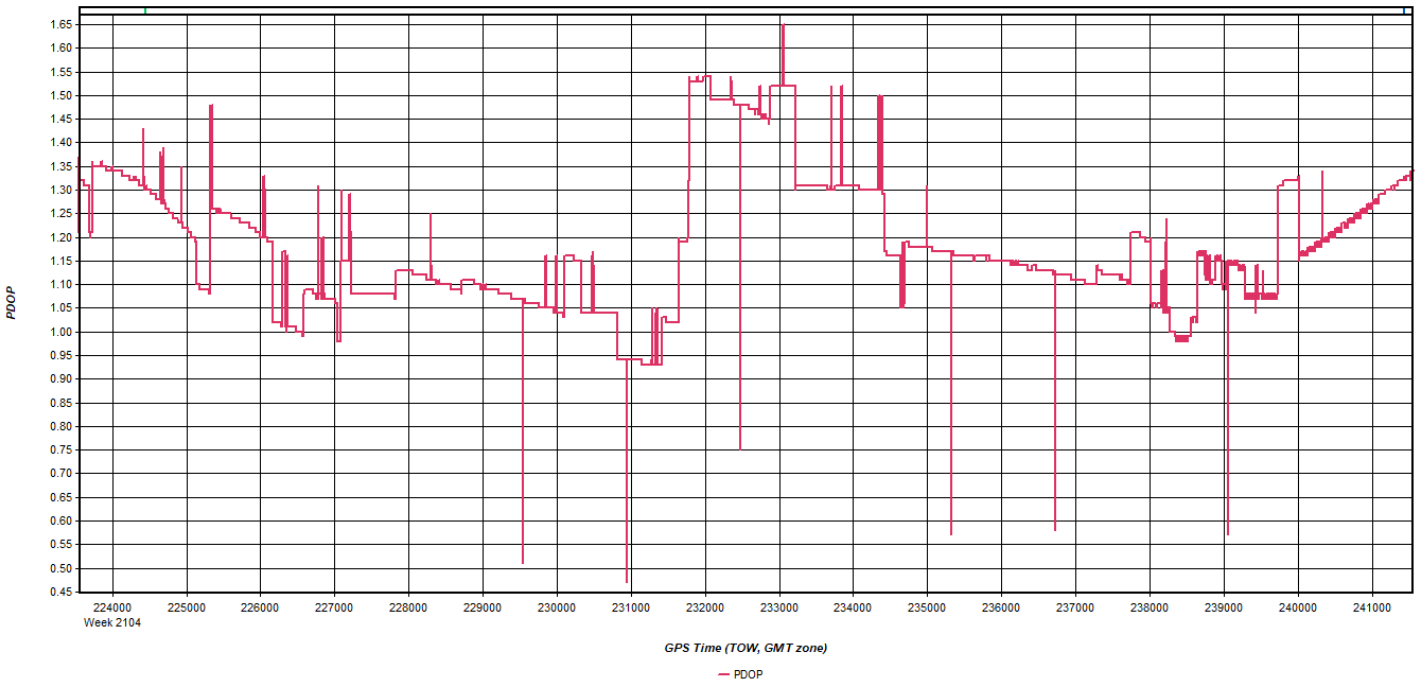
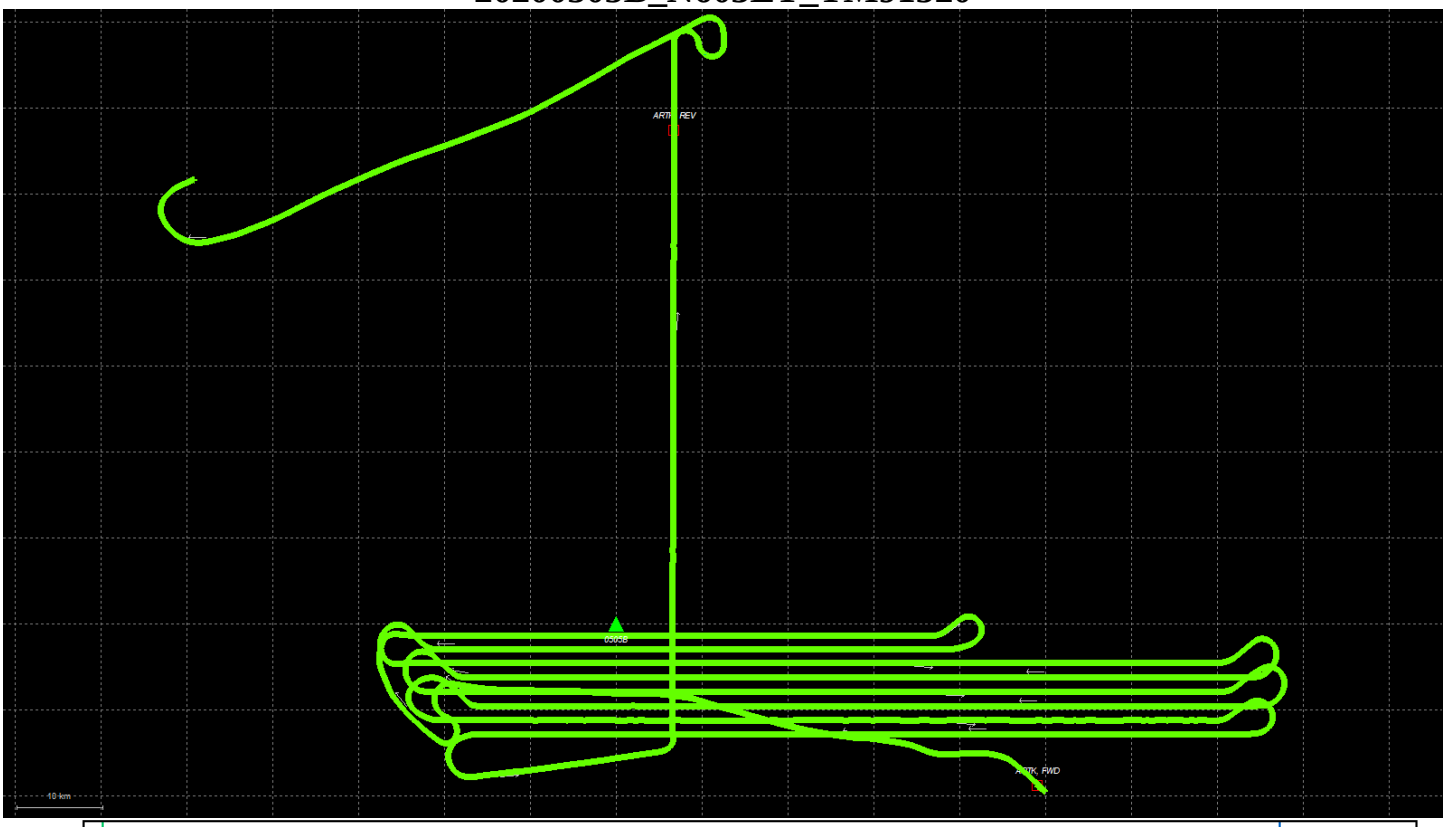
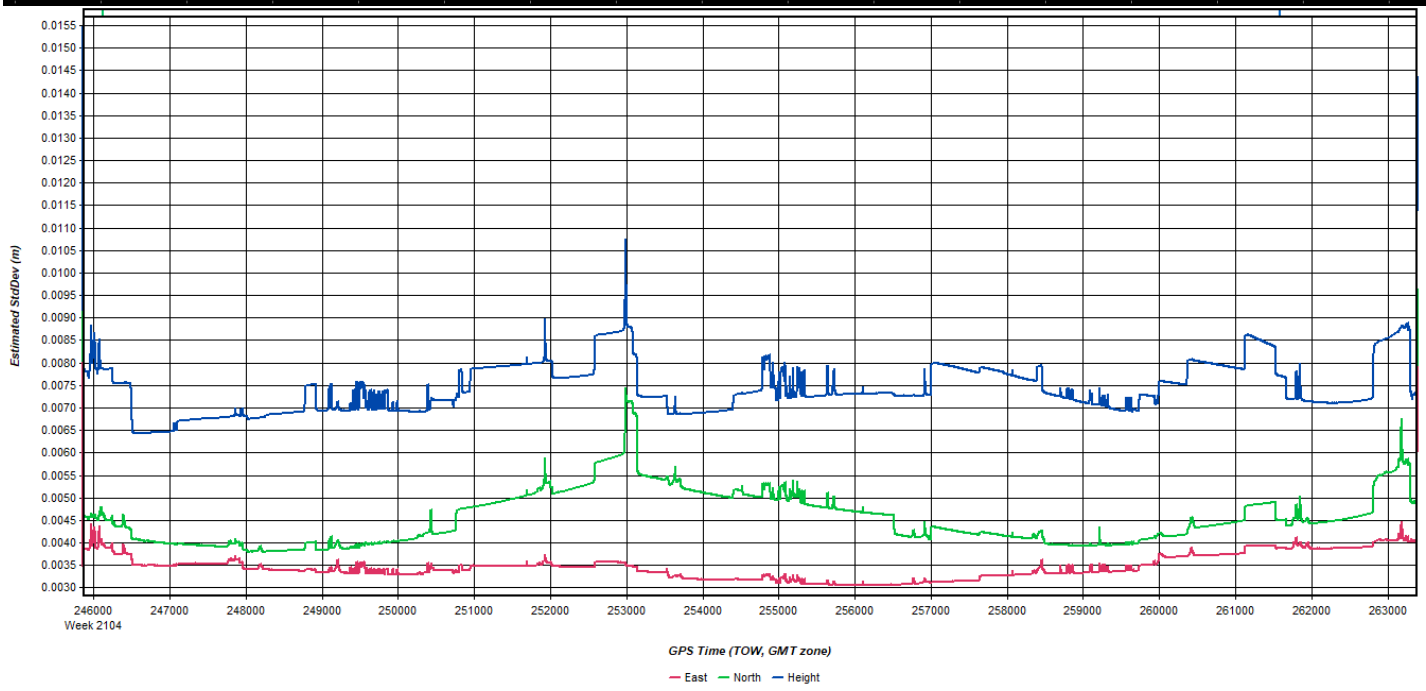
13
12
11
10
9
8
7
6
5
4
3
2
1
0
224000
Week 2104
225000
226000
227000
228000
229000
230000
231000
232000
233000
234000
235000
236000
237000
238000
239000
240000
241000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

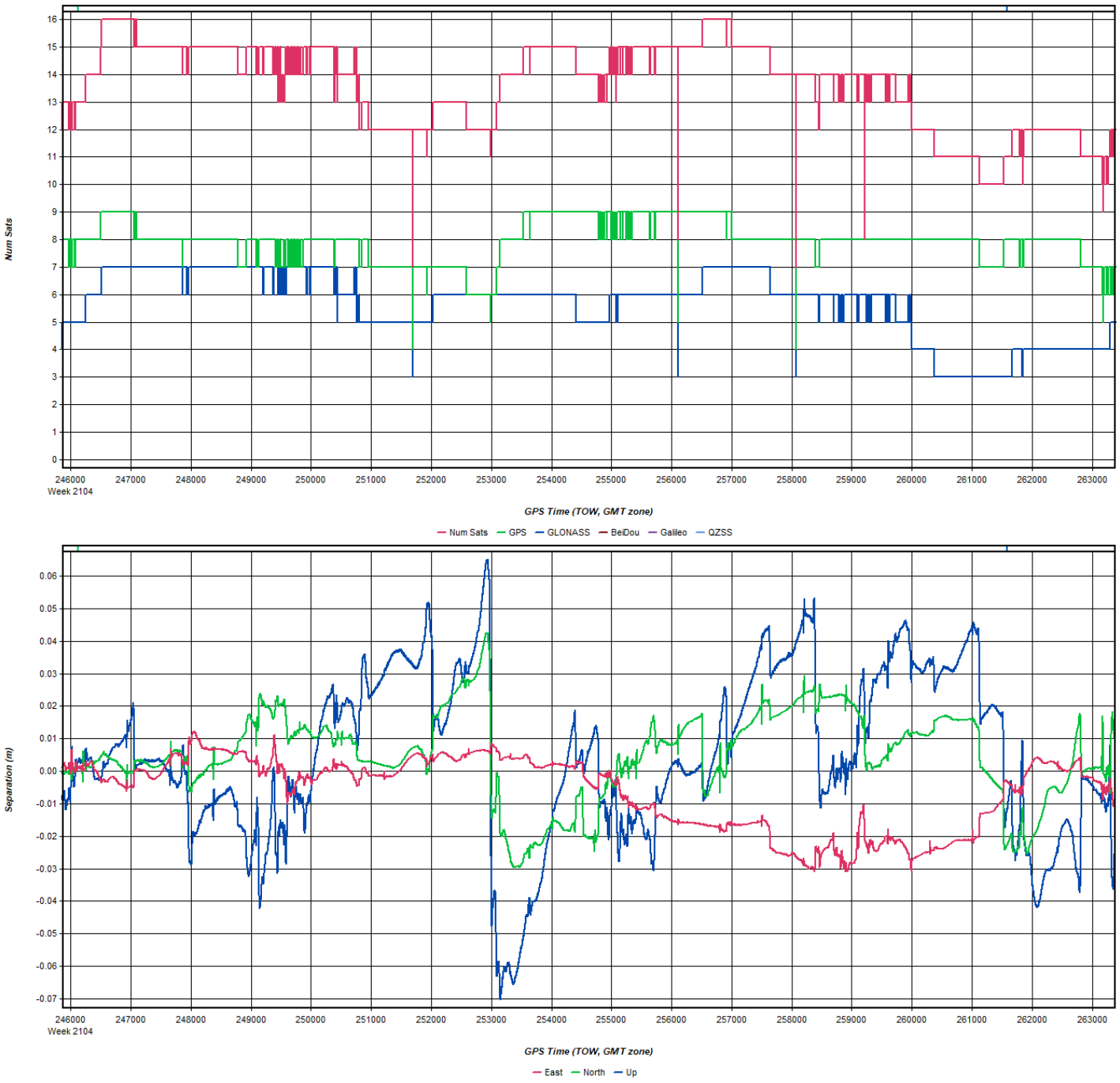
Separation (m)
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
224000
Week 2104
225000
226000
227000
228000
229000
230000
231000
232000
233000
234000
235000
236000
237000
238000
239000
240000
241000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
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
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
224000
Week 2104
225000
226000
227000
228000
229000
230000
231000
232000
233000
234000
235000
236000
237000
238000
239000
240000
241000
GPS Time (TOW, GMT zone)
PDOP

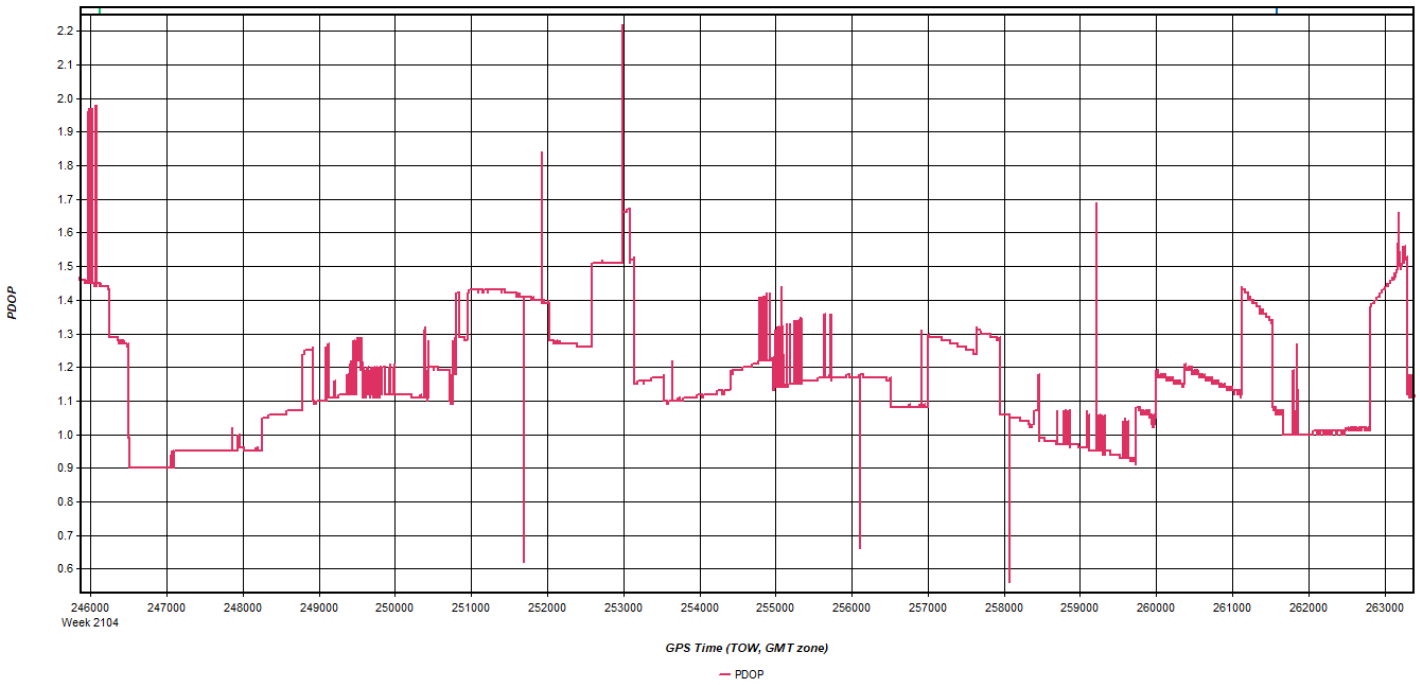
20200505B_N603ET_TM91520






Num Sats
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
246000
Week 2104
247000
248000
249000
250000
251000
252000
253000
254000
255000
256000
257000
258000
259000
260000
261000
262000
263000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

Separation (m)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
246000
Week 2104
247000
248000
249000
250000
251000
252000
253000
254000
255000
256000
257000
258000
259000
260000
261000
262000
263000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
246000
Week 2104
247000
248000
249000
250000
251000
252000
253000
254000
255000
256000
257000
258000
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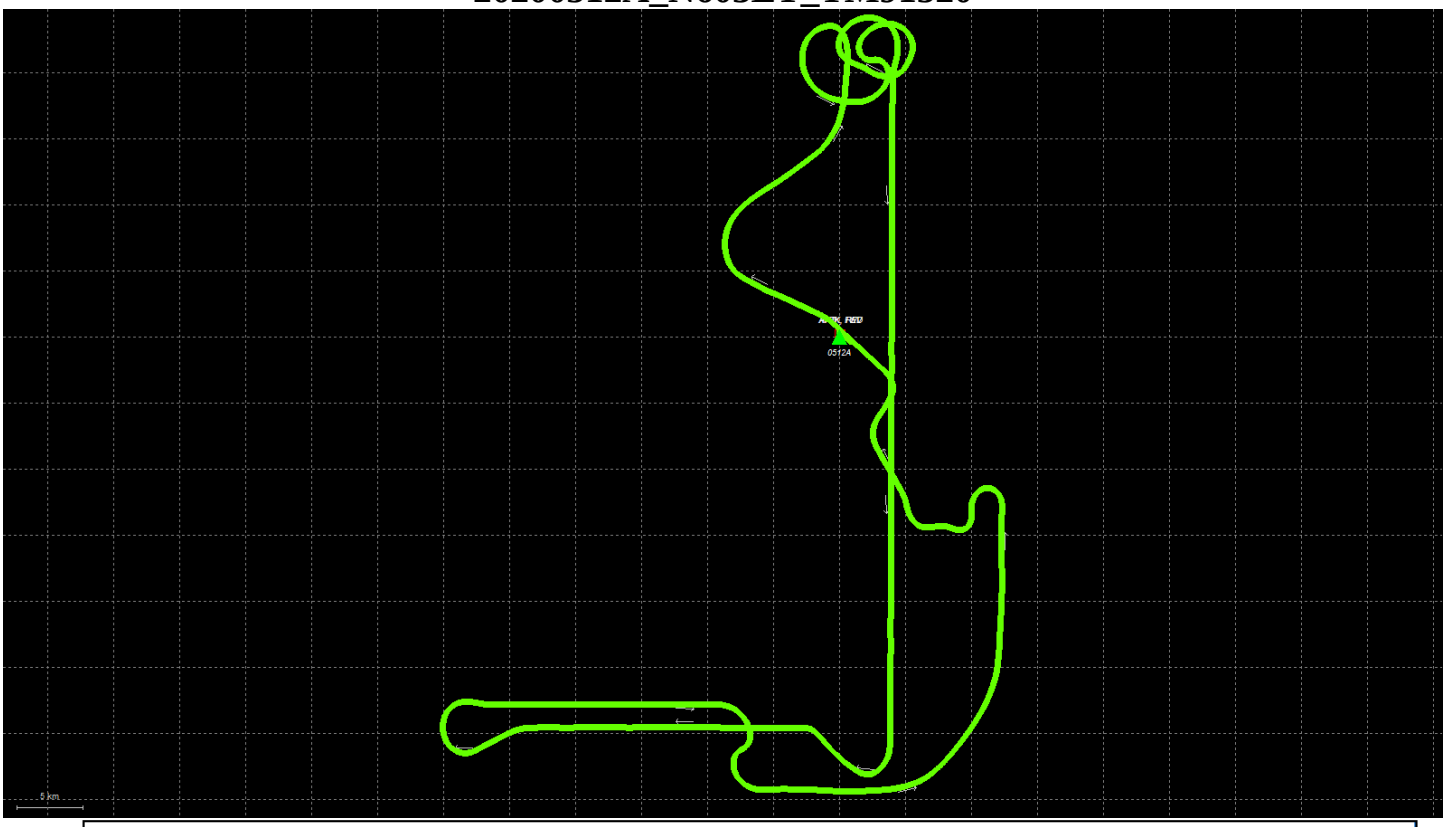
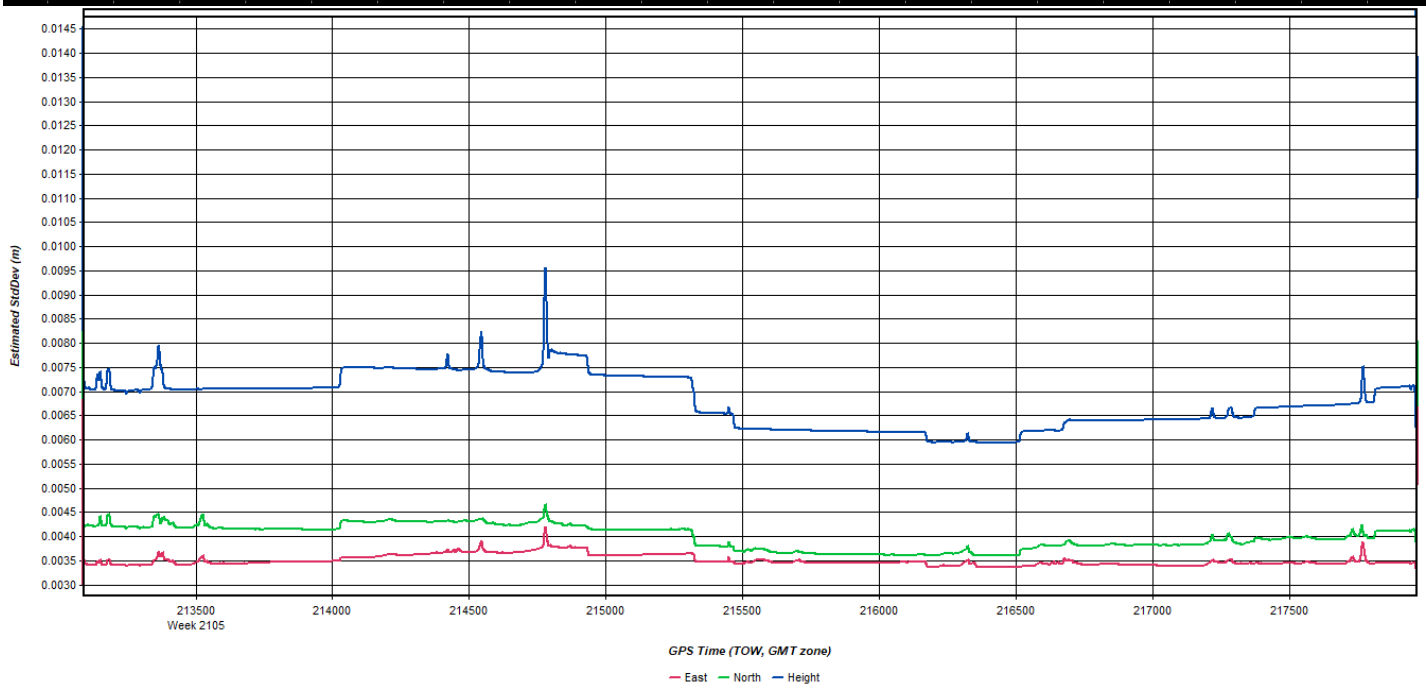
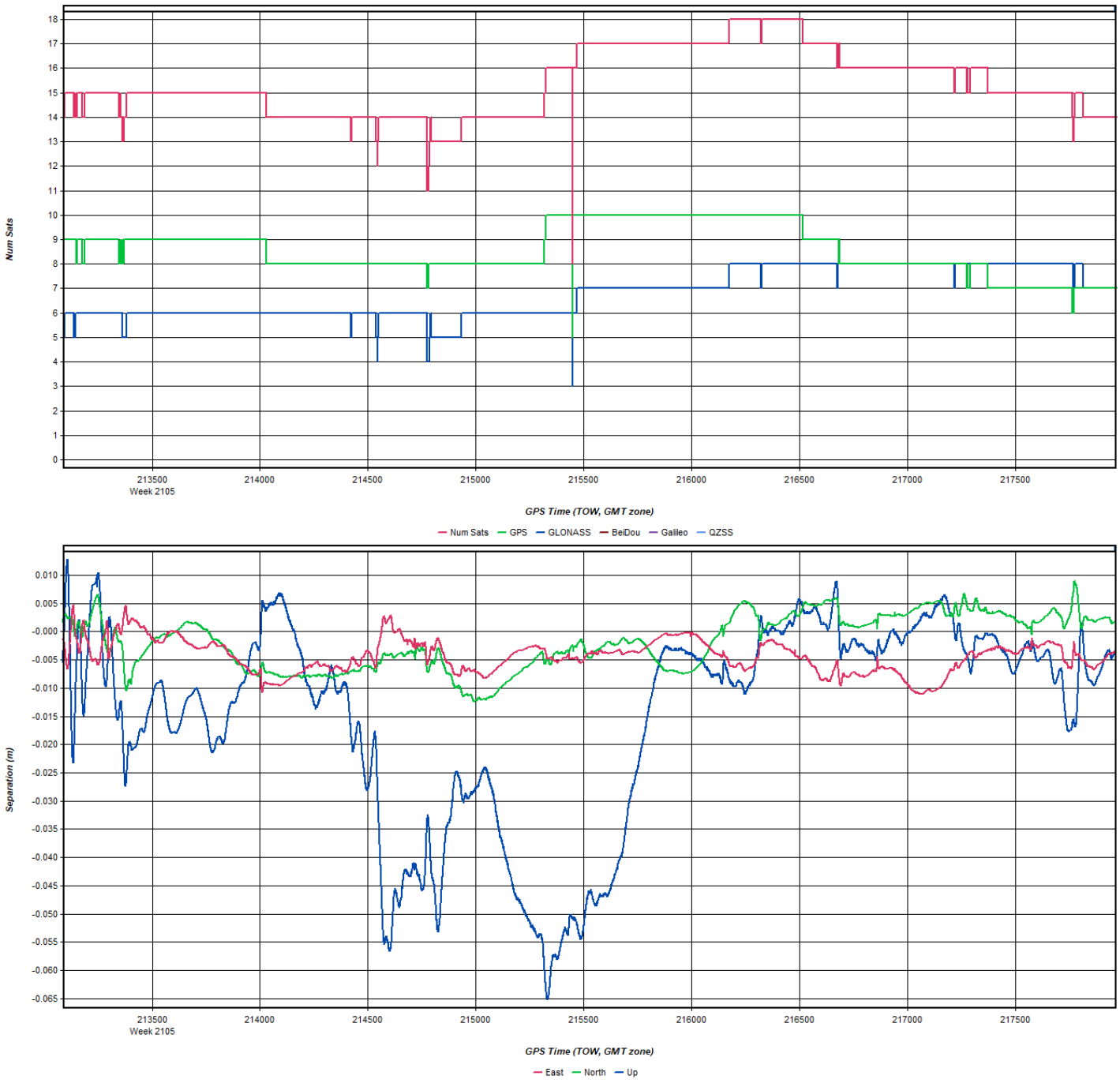
260000
261000
262000
263000
GPS Time (TOW, GMT zone)
PDOP

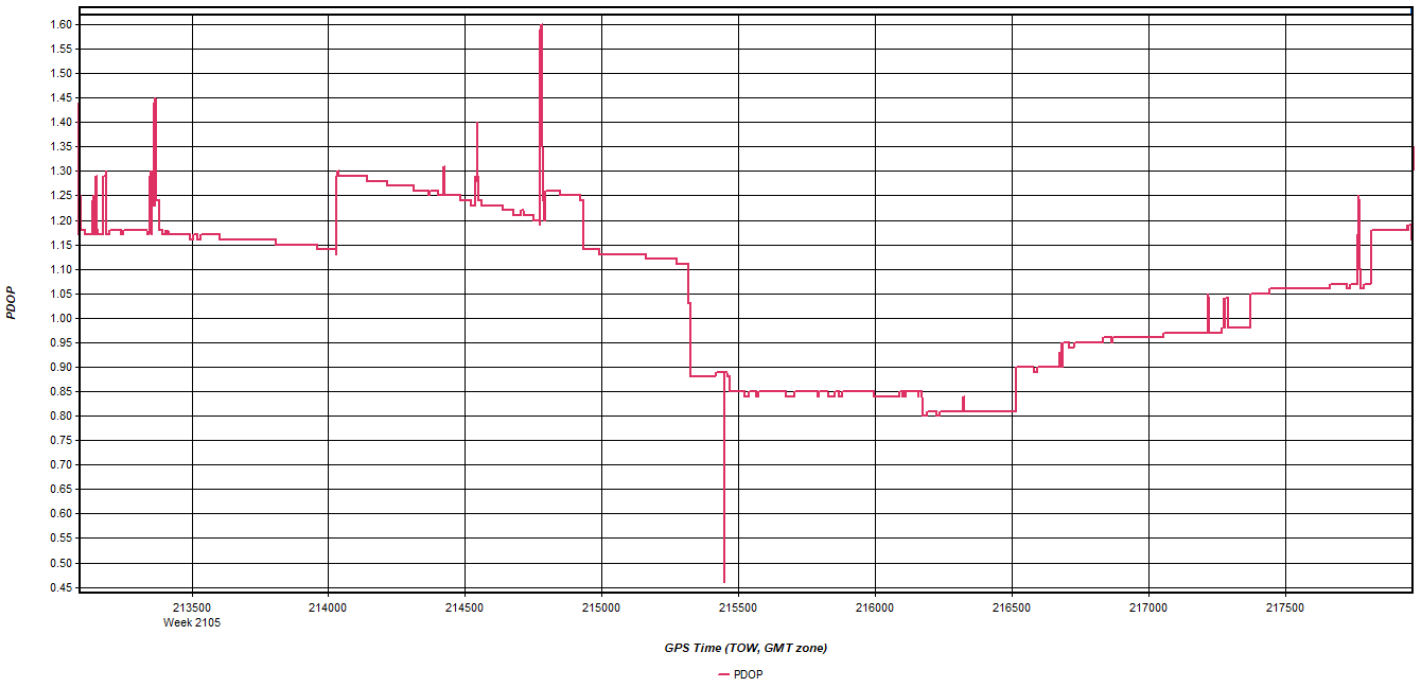
20200512A_N603ET_TM91520



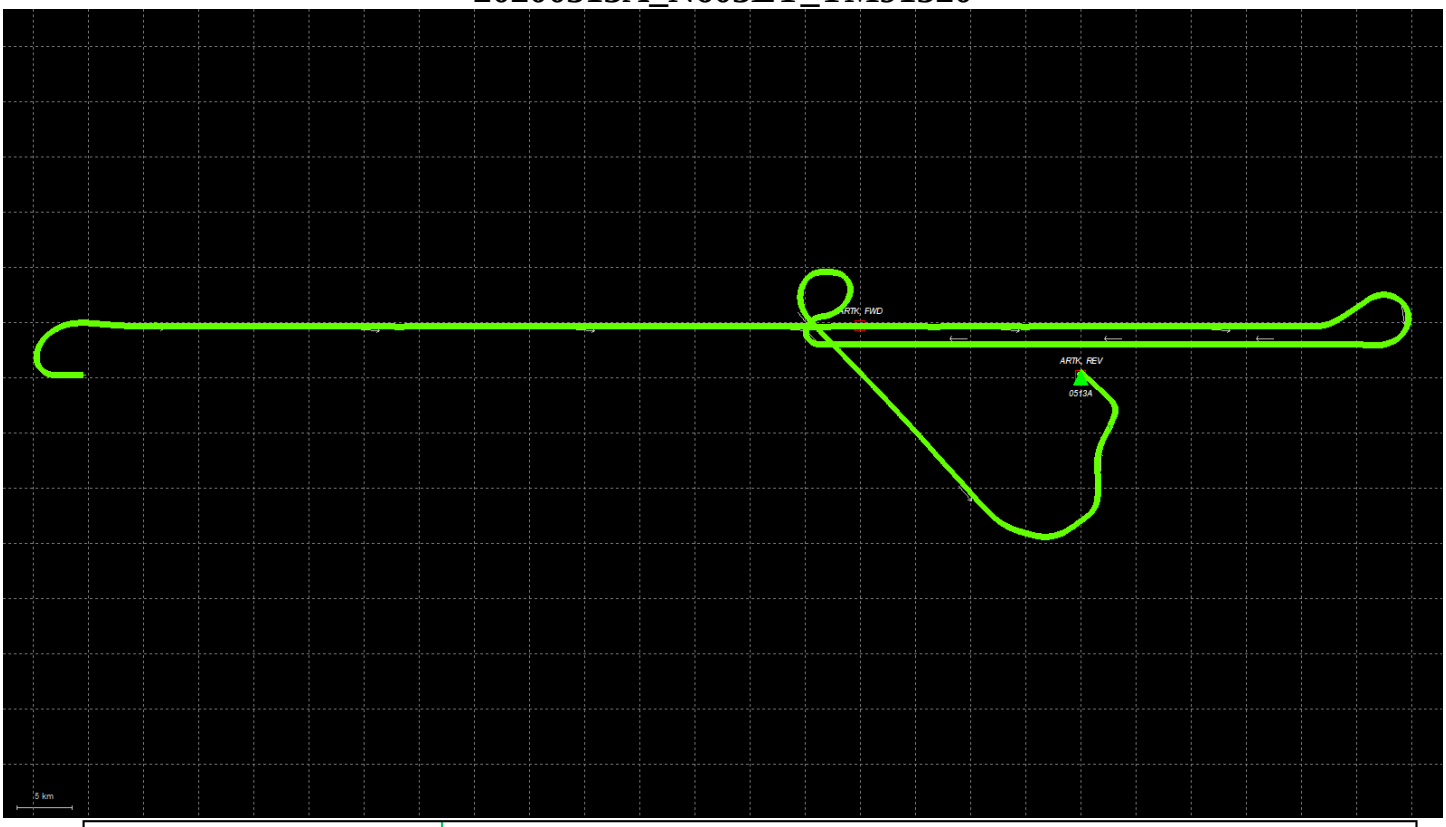


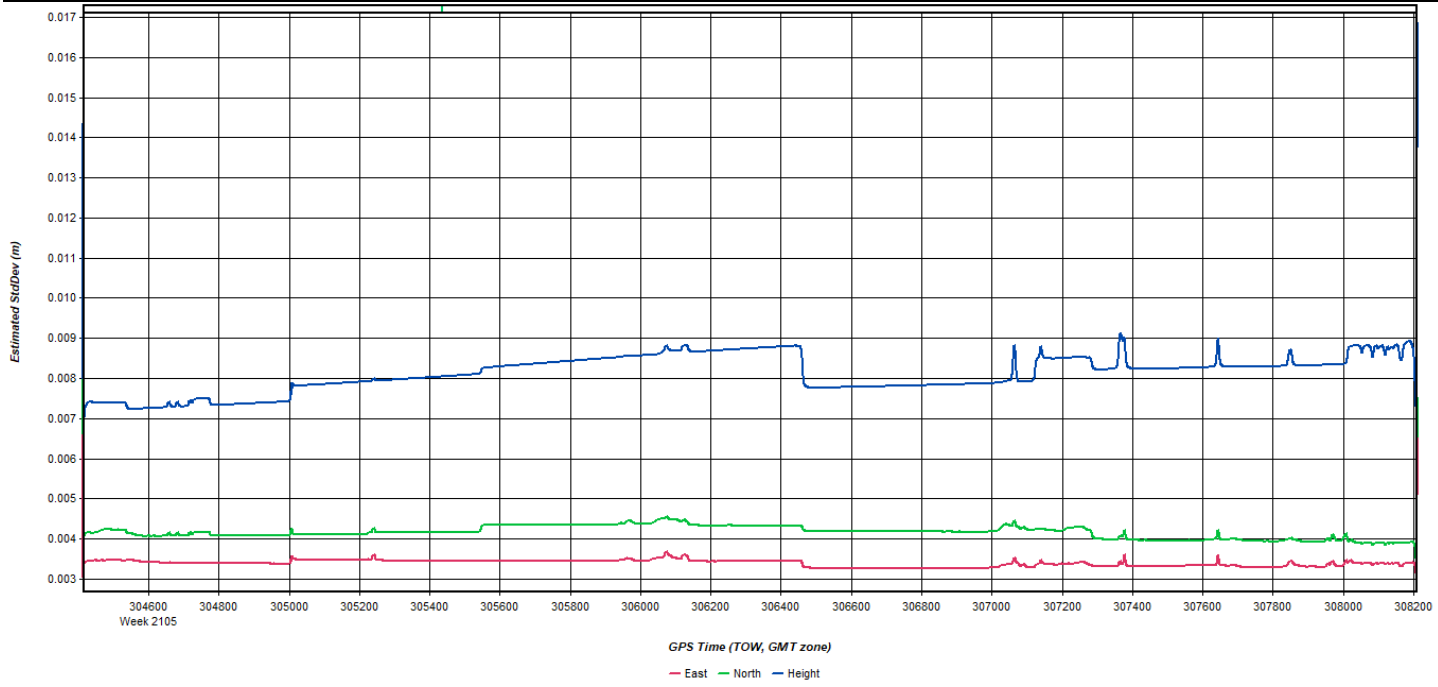

Num Sats
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
213500
Week 2105
214000
214500
215000
215500
216000
216500
217000
217500
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

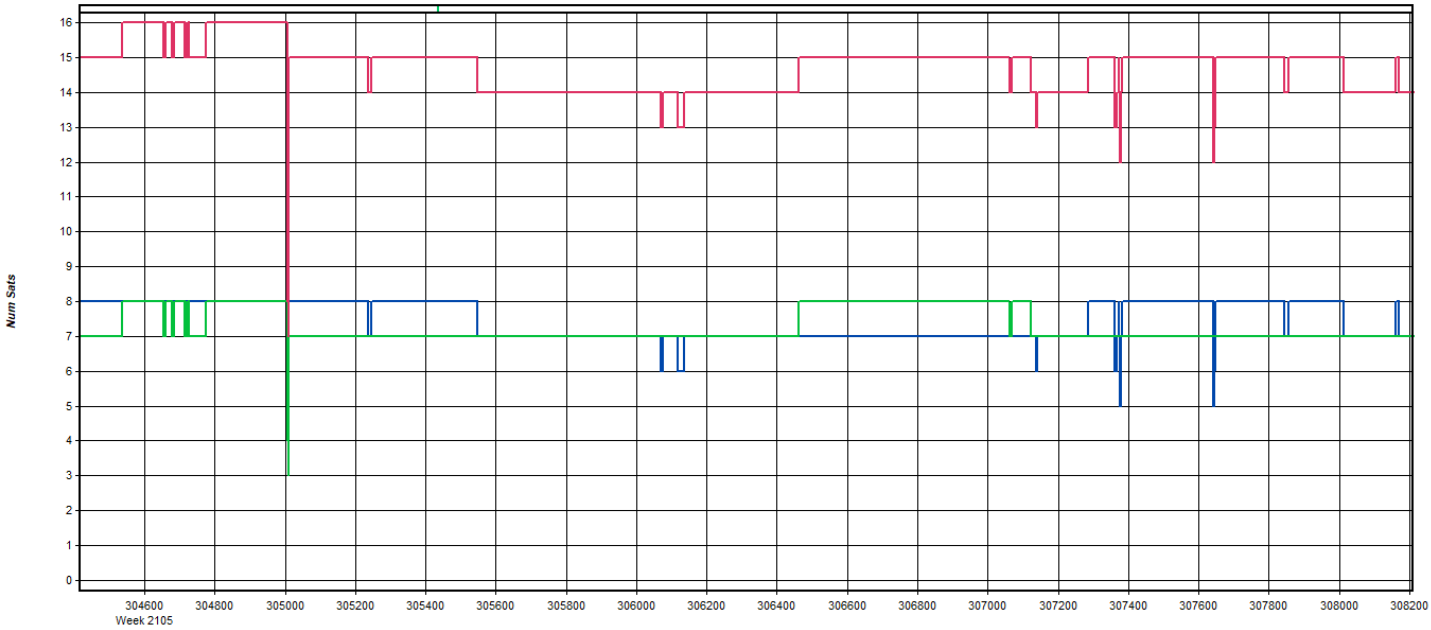
Separation (m)
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
-0.065
213500
Week 2105
214000
214500
215000
215500
216000
216500
217000
217500
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
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
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
213500
Week 2105
214000
214500
215000
215500
216000
216500
217000
217500
GPS Time (TOW, GMT zone)
PDOP

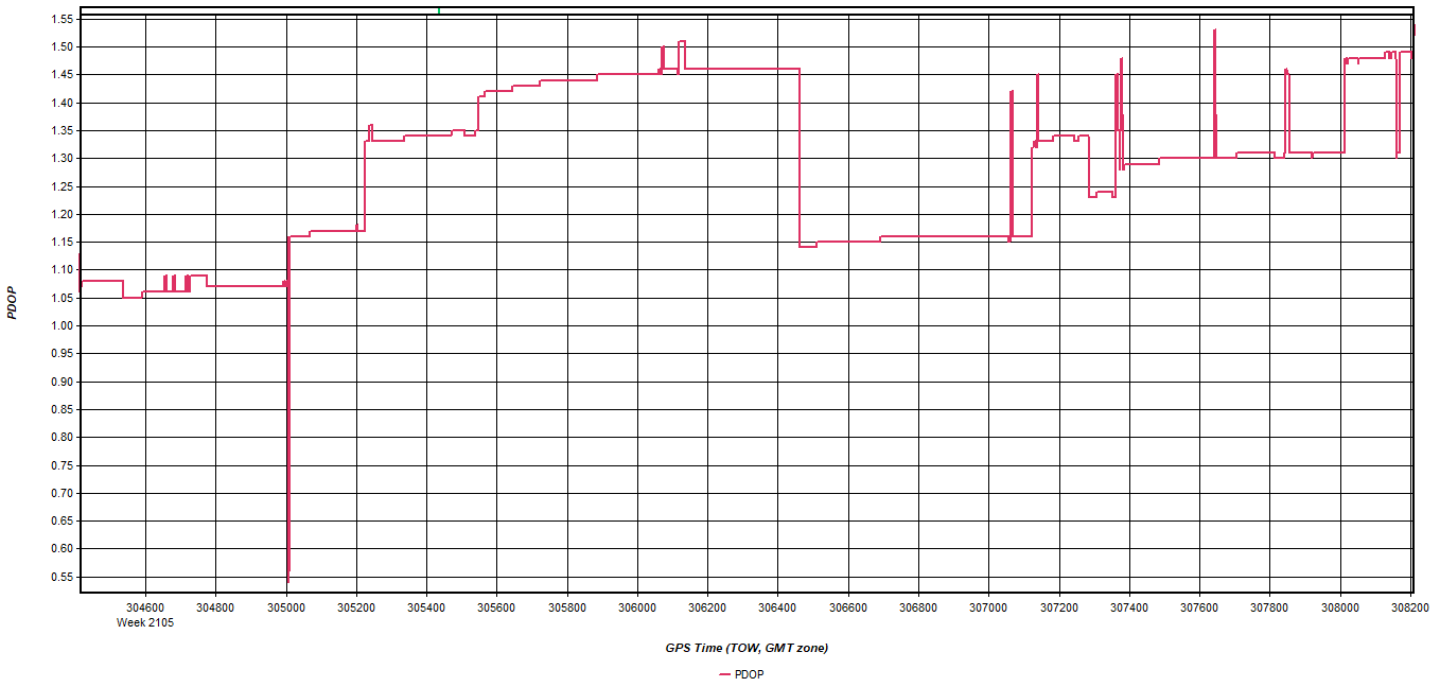
20200513A_N603ET_TM91520



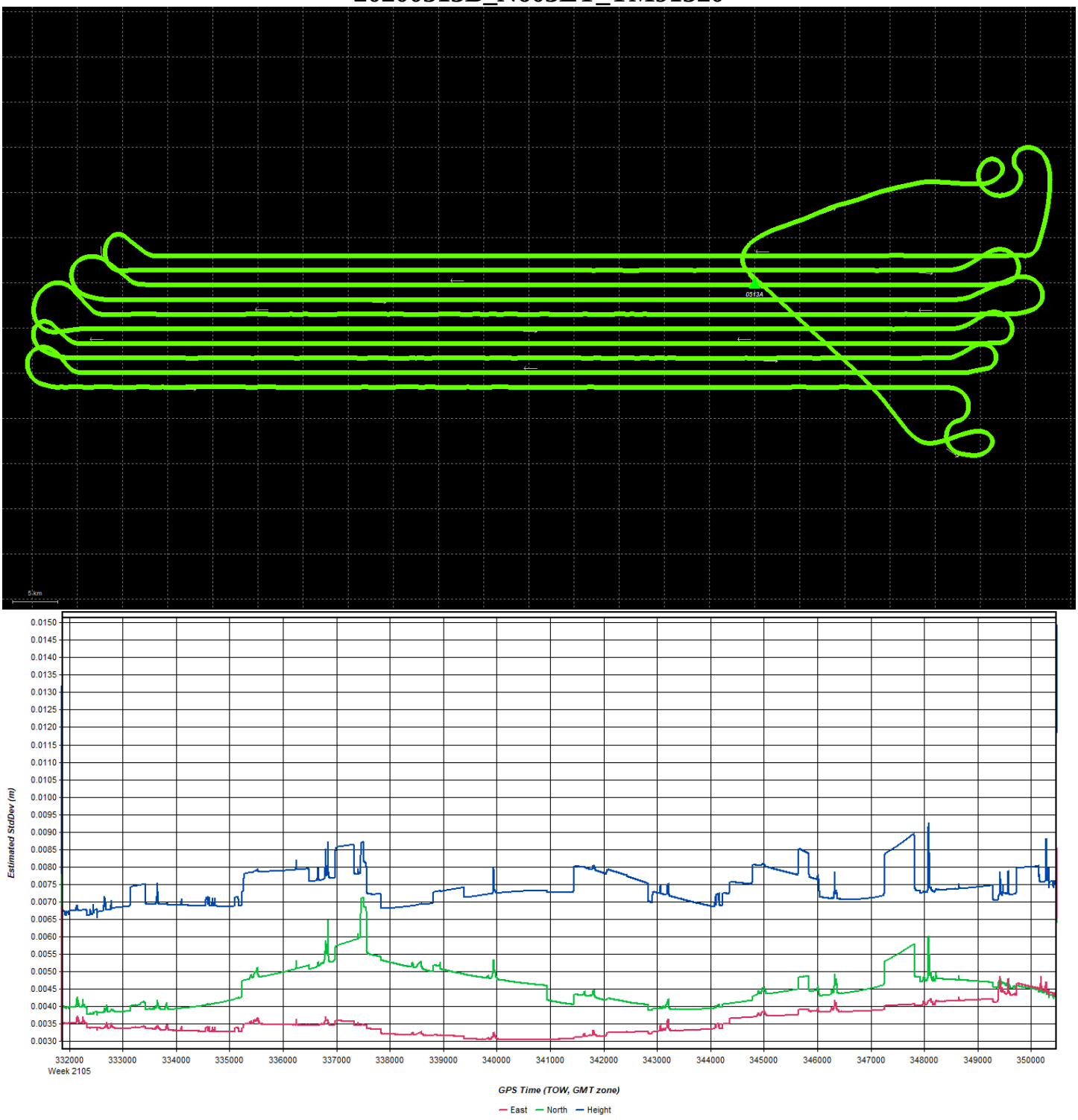


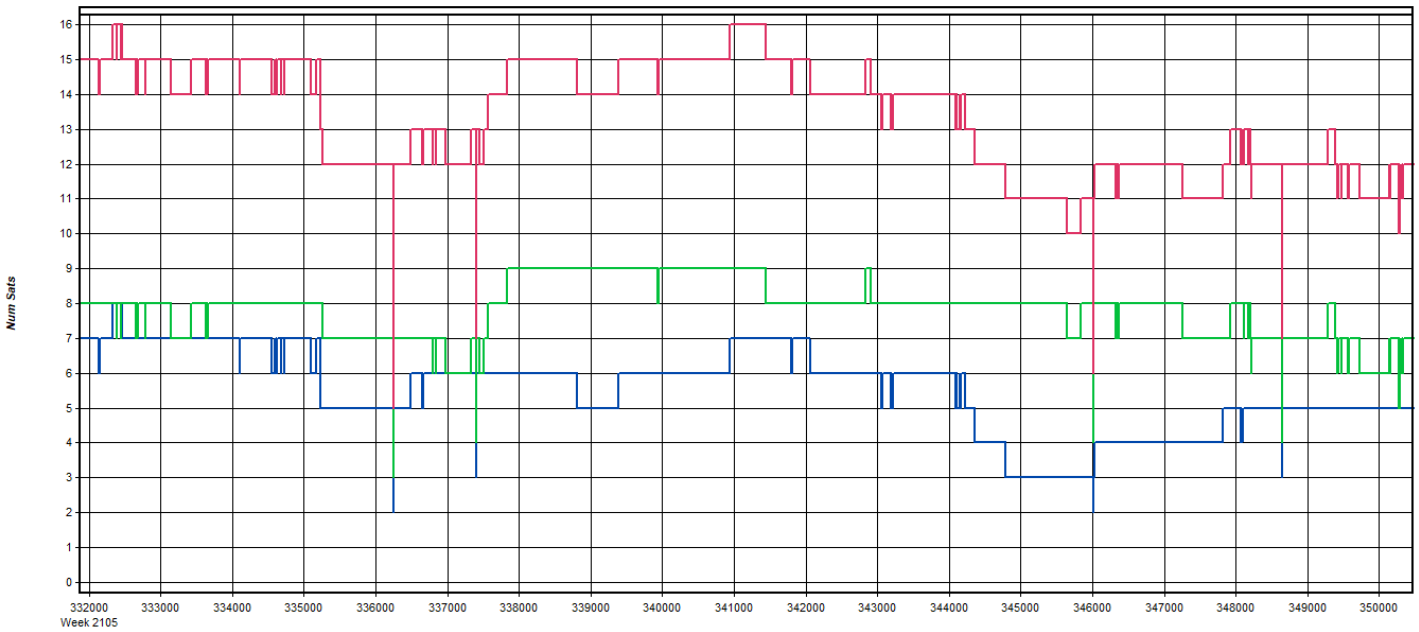

Num Sats
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
304600
Week 2105
304800
305000
305200
305400
305600
305800
306000
306200
306400
306600
306800
307000
307200
307400
307600
307800
308000
308200
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS


Separation (m)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
304600
Week 2105
304800
305000
305200
305400
305600
305800
306000
306200
306400
306600
306800
307000
307200
307400
307600
307800
308000
308200
GPS Time (TOW, GMT zone)
East
North
Up

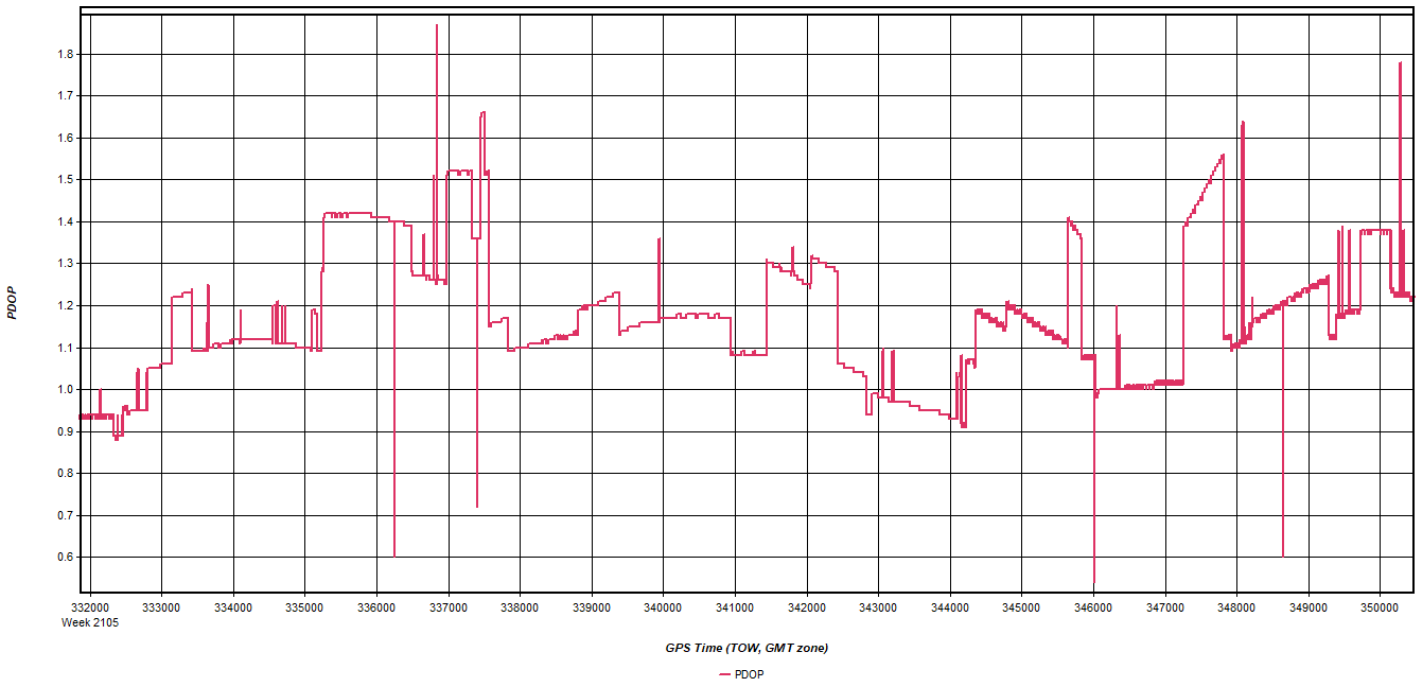

PDOP
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
304600
Week 2105
304800
305000
305200
305400
305600
305800
306000
306200
306400
306600
306800
307000
307200
307400
307600
307800
308000
308200
GPS Time (TOW, GMT zone)
PDOP

20200513B_N603ET_TM91520

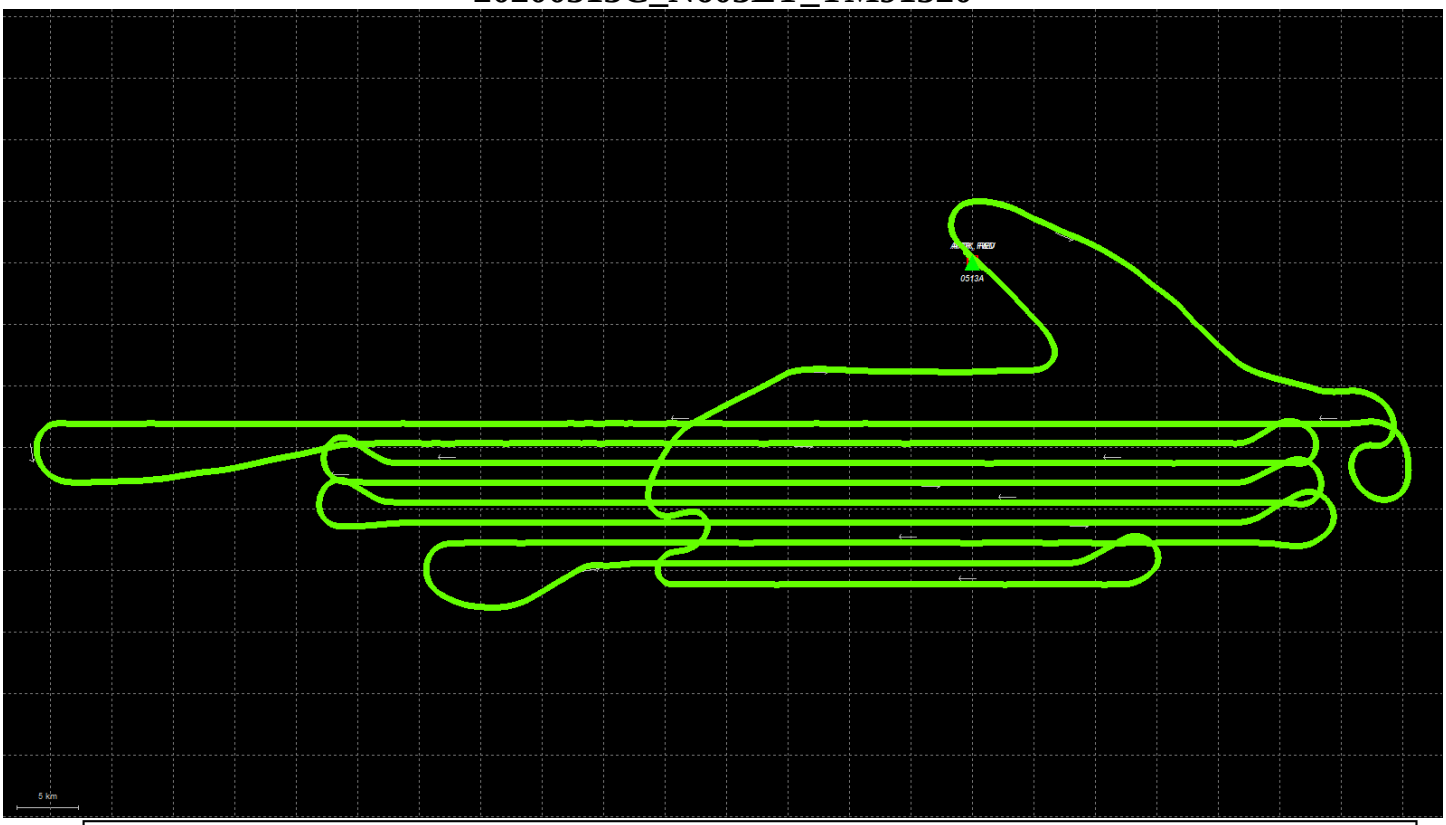


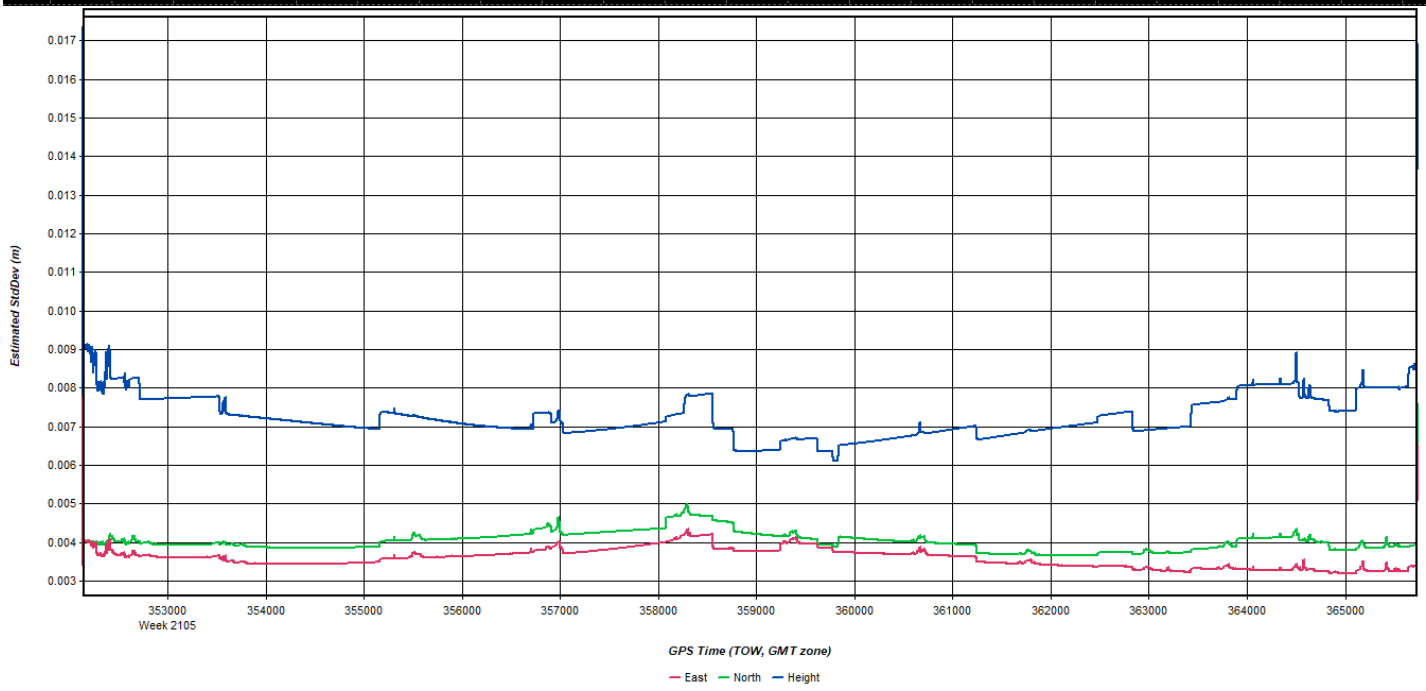

Num Sats
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
332000
Week 2105
333000
334000
335000
336000
337000
338000
339000
340000
341000
342000
343000
344000
345000
346000
347000
348000
349000
350000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

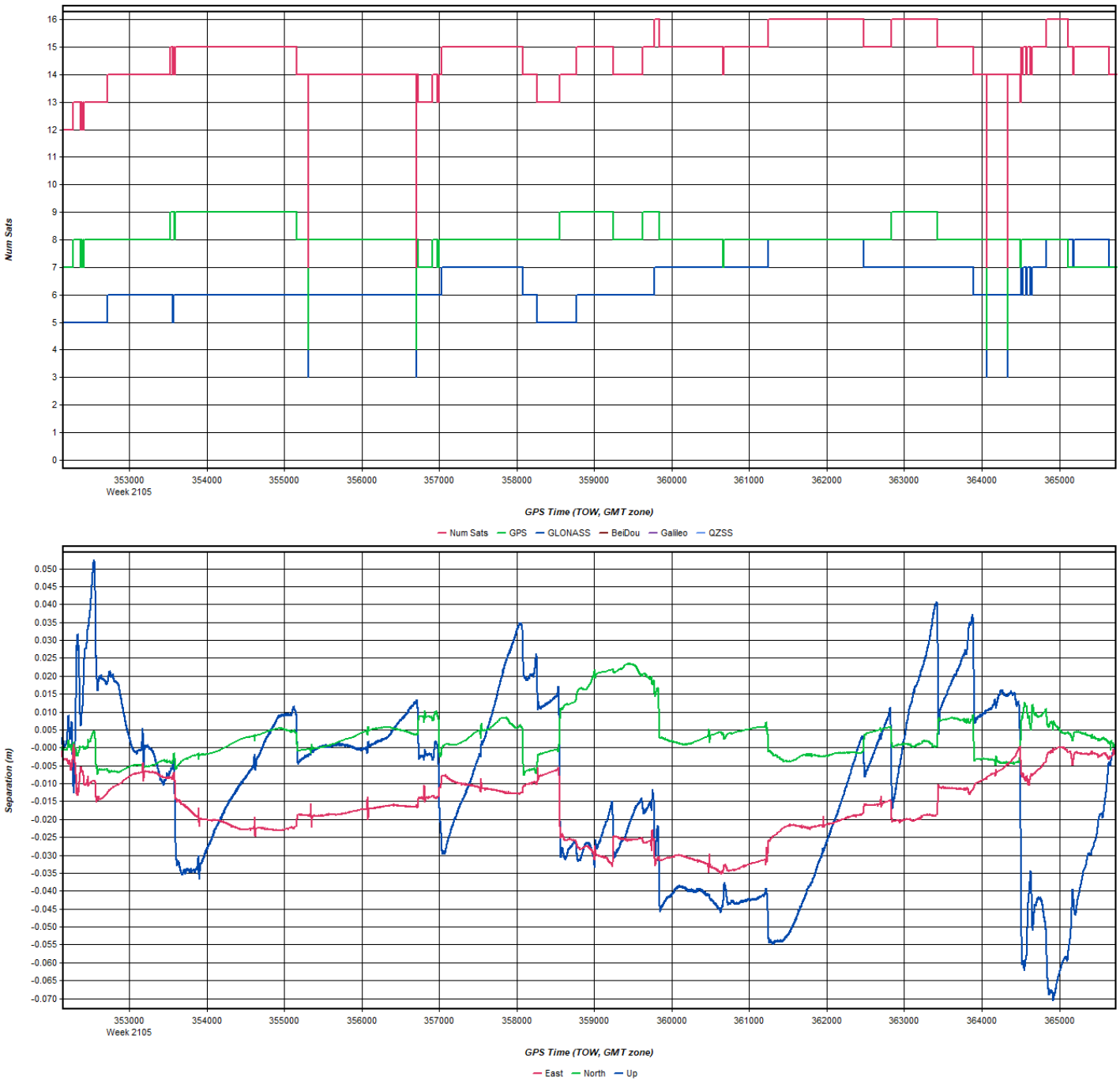

Separation (m)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
332000
Week 2105
333000
334000
335000
336000
337000
338000
339000
340000
341000
342000
343000
344000
345000
346000
347000
348000
349000
350000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
332000
Week 2105
333000
334000
335000
336000
337000
338000
339000
340000
341000
342000
343000
344000
345000
346000
347000
348000
349000
350000
GPS Time (TOW, GMT zone)
PDOP

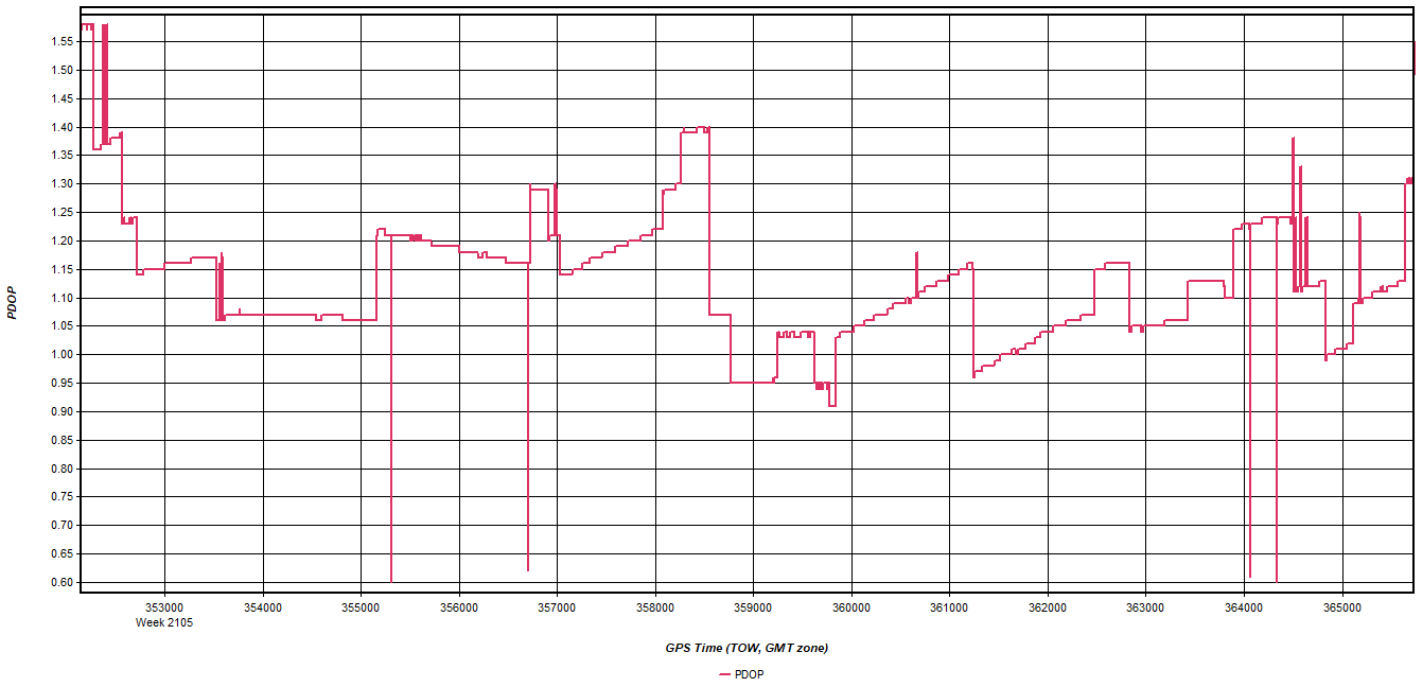
20200513C_N603ET_TM91520






Num Sats
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
353000
Week 2105
354000
355000
356000
357000
358000
359000
360000
361000
362000
363000
364000
365000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

Separation (m)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
-0.065
-0.070
353000
Week 2105
354000
355000
356000
357000
358000
359000
360000
361000
362000
363000
364000
365000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
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
0.85
0.80
0.75
0.70
0.65
0.60
353000
Week 2105
354000
355000
356000
357000
358000
359000
360000
361000
362000
363000
364000
365000
GPS Time (TOW, GMT zone)
PDOP