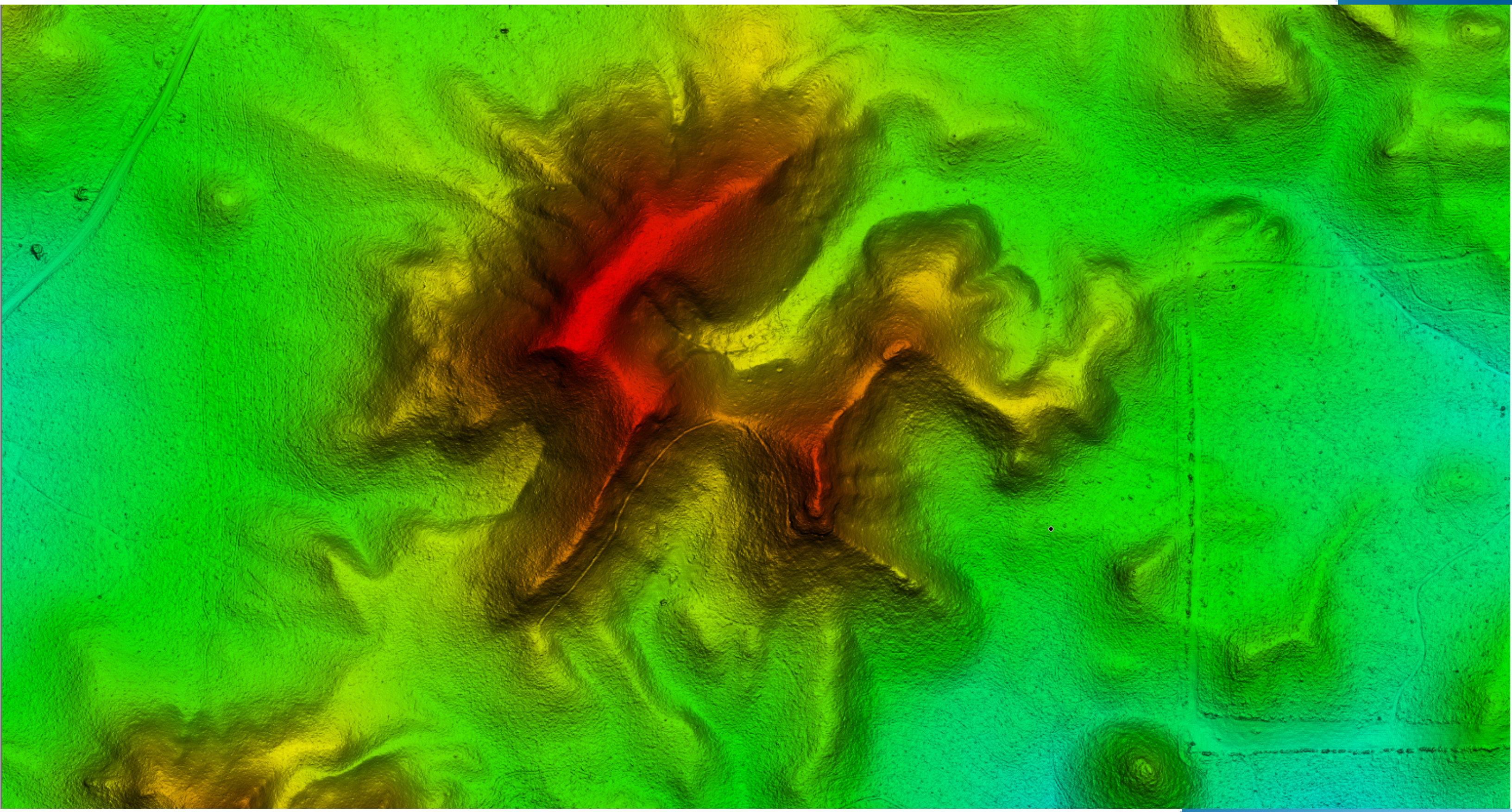
NV5 GEOSPATIAL



WI 12 County B22 Trempealeau LIDAR PROCESSING REPORT

2023

Submitted: August 31, 2023

Project ID: 23011
Work Unit: 300210

Prepared for:

USGS
science for a changing world

Prepared by:

NV5 GEOSPATIAL

National Map Help Desk: tnm_help@usgs.gov

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1. Summary / Scope

1.1. Summary

This report contains a summary of the WI 12 County B22 Trempealeau, Work Unit 300210 lidar acquisition task order, issued by USGS under their Contract 140G0221D0012 on March 28, 2022. The task order yielded a work unit area covering 750 square miles over Wisconsin at Quality Level 1. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

1.2. Scope

Aerial topographic lidar was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned Lidar Specifications

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
8 pts / m2	2,083 m	58.5°	20%	≤ 10 cm

1.3. Coverage

The work unit boundary covers 750 square miles over Wisconsin. Work unit extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from April 19, 2022 and April 27, 2022 in 2 total lifts. See “Section: 2.4. Time Period” for more details.

1.5. Issues

There are two empty tiles (784321 and 802308) due to water.

WI 12 County B22 Trempealeau Work Unit 300210 Projected Coordinate System: Wisconsin Coordinate Reference System - Trempeleau Horizontal Datum: NAD83 (2011) Vertical Datum: NAVD88 (GEOID 18) Units: Survey Feet	
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	• 1-foot Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format • 1-foot Intensity images in GeoTIFF format • 2-foot Maximum Surface Height Raster in GeoTIFF format • 2-foot Swath Seperation Images in GeoTIFF format
Vectors	Shapefiles (*.shp) • Project Boundary • Lidar Tile Index Geodatabase (*.gdb) • Continuous Hydro-flattened Breaklines • Flightlines Swath
Reports	Reports in PDF format • Focus on Delivery • Survey Report • Processing Report
Metadata	XML Files (*.xml) • Breaklines • Classified Point Cloud • DEM • Intensity Imagery

WI 12 County B22 Trempealeau
Work Unit 300210 Boundary

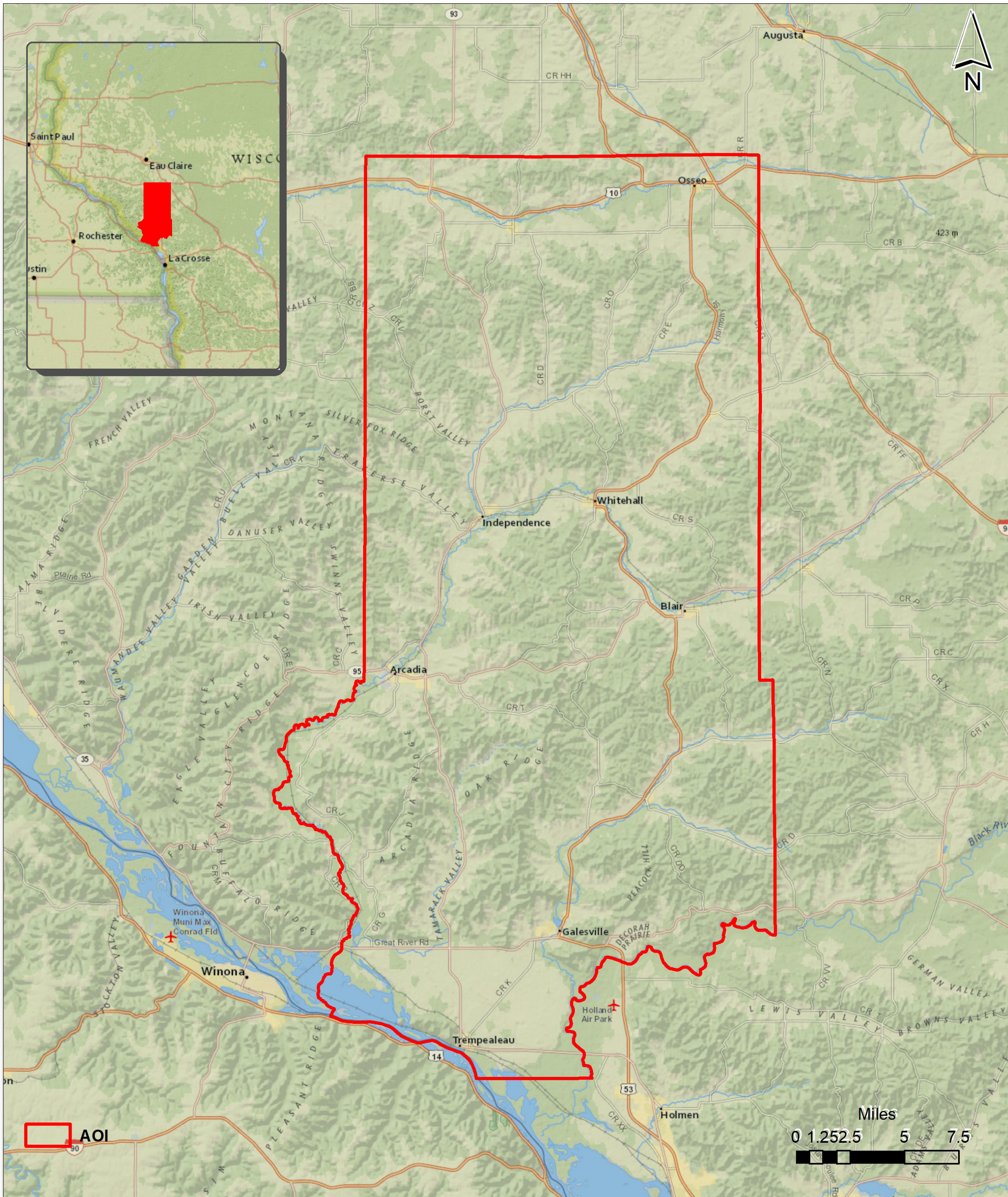


Figure 1. Work Unit Boundary

2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using RiPARAMETER planning software.

2.2. Lidar Sensor

NV5 Geospatial utilized Riegl VQ1560ii lidar sensors (Figure 2), serial number(s) 3543, for data acquisition.

The Riegl 1560ii system is a dual channel waveform processing airborne scanning system. It has a laser pulse repetition rate of up to 4 MHz resulting in up to 2.66 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA) and an integrated IMU/GNSS unit.

A brief summary of the aerial acquisition parameters for the project are shown in the lidar System Specifications in Table 2.

Table 2. Lidar System Specifications

		Riegl VQ1560ii (SN3543)
Terrain and Aircraft Scanner	Flying Height	1050 m
	Recommended Ground Speed	160 kts
Scanner	Field of View	60°
	Scan Rate Setting Used	295 Hz
Laser	Laser Pulse Rate Used	1000 kHz
	Multi Pulse in Air Mode	yes
Coverage	Full Swath Width	1846 m
	Line Spacing	1477 m
Point Spacing and Density	Average Point Spacing	0.35 m
	Average Point Density	8 pts / m^2

Figure 2. Riegl VQ1560ii Lidar Sensor

2.3. Aircraft

All flights for the project were accomplished through the use of customized aircraft. Plane type and tail numbers are listed below.

Lidar Collection Planes

- Piper PA-31, Tail Number(s): C-FFRY

These aircraft provided an ideal, stable aerial base for lidar acquisition. These aerial platforms have relatively fast cruise speeds, which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art lidar system. NV5 Geospatial's operating aircraft can be seen in Figure 3 below.

Figure 3. NV5 Geospatial's Aircraft

2.4. Time Period

Project specific flights were conducted between April 19, 2022 and April 27, 2022. Two aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
04192022A (SN3543,C-FFRY)	4/19/2022 5:08:58 PM	4/19/2022 9:51:19 PM
04272022A (SN3543,C-FFRY)	4/27/2022 12:26:03 PM	4/27/2022 5:44:25 PM

3. Processing Summary

3.1. Flight Logs

Flight logs were completed by Lidar sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.

3.2. Lidar Processing

Applanix + POSPac software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the lidar sensor during all flights. Applanix POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a "Smoothed Best Estimate Trajectory" (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the lidar missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

Point clouds in flightline swath format were created using the RiPROCESS software. The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Each flightline swath point cloud was calibrated using Strip Align software that corrects systematic geometric errors and improves the relative and absolute accuracy of the flightline swath point cloud. The calibrated point cloud swaths were imported into GeoCue distributive processing software and the imported data was then tiled so further processing could take place in TerraScan software. Using TerraScan, the vertical accuracy of the surveyed ground control was tested and any vertical bias was removed from the data. TerraScan and TerraModeler software packages were then used for automated data classification and manual cleanup. The data were manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

DEMs and Intensity Images are then generated using proprietary software. In the bare earth surface model, above-ground features are excluded from the data set. Global Mapper is used as a final check of the bare earth dataset.

Finally, proprietary software is used to perform statistical analysis of the LAS files.

Software	Version
Applanix + POSPac	8.6
RiPROCESS	1.8.6
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
Microstation Connect	10.16.02.34
TerraModeler	21.008
TerraScan	21.016
StripAlign	2.21

3.3. LAS Classification Scheme

The classification classes are determined by Lidar Base Specifications 2021, Revision A and are an industry standard for the classification of lidar point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

Table 3. LAS Classifications

	Classification Name	Description
1	Processed, but Unclassified	Laser returns that are not included in the bare earth class, or any other project classification
2	Bare earth	Laser returns that are determined to be bare earth using automated and manual cleaning algorithms
7	Low Noise	Laser returns that are often associated with scattering from reflective surfaces, or artificial points below the bare earth surface
9	Water	Laser returns that are found inside of hydro features
17	Bridge Deck	Laser returns falling on bridge decks
18	High Noise	Laser returns that are often associated with birds or artificial points above the bare earth surface
20	Ignored Ground	Bare earth points that fall within the given threshold of a collected hydro feature.
21	Snow	Bare earth points that fall on snow, where identifiable
22	Temporal Exclusion	Points that are excluded due to differences in collection dates

3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare- earth surface is finalized; it is then used to generate all hydro-breaklines through heads-up digitization.

All ground (ASPRS Class 2) lidar data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using proprietary tools. A buffer of 1.5 feet/0.5 meter was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 20). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 2) points were reclassified to the correct classification after the automated classification was completed.

Any noise that was identified either through manual review or automated routines was classified to the appropriate class (ASPRS Class 7 and/or ASPRS Class 18) followed by flagging with the withheld bit.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for all point cloud data. NV5 Geospatial's proprietary software was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

3.5. Hydro-Flattened Breakline Processing

Using heads-up digitization, all Lake-Ponds, Double Line Drains, and Islands are manually collected that are within the project size specification. This includes Lake-Ponds greater than 2 acres in size, Double Line Drains with greater than a 100 foot nominal width, and Islands greater than 1 acre in size within a collected hydro feature. Lidar intensity imagery and bare-earth surface models are used to ensure appropriate and complete collection of these features.

Elevation values are assigned to all collected hydro features via NV5 Geospatial's proprietary software. This software sets Lake-Ponds to an appropriate, single elevation to allow for the generation of hydro-flattened digital elevation models (DEM). Double Line Drain elevations are assigned based on lidar elevations and surrounding terrain feature to ensure all breaklines match the lidar within acceptable tolerances. Some deviation is expected between breakline and lidar elevations due to monotonicity, connectivity, and flattening rules that are enforced on the breaklines. Once complete, horizontal placement, and vertical variances are reviewed, all breaklines are evaluated for topological consistency and data integrity using a combination of proprietary tools and manual review of hydro-flattened DEMs.

Breaklines are combined into one seamless shapefile, clipped to the project boundary, and imported into an Esri file geodatabase for delivery.

3.6. Hydro-Flattened Raster DEM Processing

Hydro-Flattened DEMs (topographic) represent a lidar-derived product illustrating the grounded terrain and associated breaklines (as described above) in raster form. NV5 Geospatial's proprietary software was used to take all input sources (bare earth lidar points, bridge and hydro breaklines, etc.) and create a Triangulated Irregular Network (TIN) on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper triangulation can occur. From the TIN, linear interpolation is used to calculate the cell values for the raster product. The raster product is then clipped back to the tile edge so that no overlapping cells remain across the project area. A 32-bit floating point GeoTIFF DEM was generated for each tile with a pixel size of 1-foot. NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each DEM is reviewed in Global Mapper to check for any surface anomalies and to ensure a seamless dataset. NV5 Geospatial ensures there are no void or no-data values (-999999) in each derived DEM. This is achieved by using propriety software checking all cell values that fall within the project boundary. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.

3.7. Intensity Image Processing

Intensity images represent reflectivity values collected by the lidar sensor during acquisition. Proprietary software generates intensity images using first returns and excluding those flagged with a withheld bit. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written during product generation.

3.8. Swath Separation Raster Processing

Swath Separation Images are rasters that represent the interswath alignment between flight lines and provide a qualitative evaluation of the positional quality of the point cloud. NV5 Geospatial proprietary software generated 2-foot raster images in GeoTIFF format using last returns, excluding points flagged with the withheld bit, and using a point-in-cell algorithm. Images are generated with a 75% intensity opacity and (4) absolute 8-cm intervals, see below for interval coloring. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles. Appropriate horizontal projection information as well as applicable header values are written to the file during product generation. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the images against what is required before final delivery.

Green	0-8cm
Yellow	8-16cm
Orange	16-24cm
Red	>24cm

3.9. Maximum Surface Height Raster Processing

Maximum Surface Height rasters (topographic) represent a lidar-derived product illustrating natural and built-up features. NV5 Geospatial's proprietary software was used to take all classified lidar points, excluding those flagged with a withheld bit, and create a raster on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper gridding can occur. The raster is created by laying a 2-foot DEM cell size over the area and assigning the values to cells by using the maximum lidar point that intersects that grid cell. The raster product is then clipped back to the tile edge so that no overlapping cells remain across the project area. A 32-bit floating point GeoTIFF was then generated for each tile with a pixel size of 2-foot. There is no interpolation type being used in creating the raster product. NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each maximum surface height raster is reviewed in Global Mapper to check for any anomalies and to ensure a seamless dataset. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.

3.10. Point Density

The acquisition parameters were designed to acquire an average first-return density of 8 points/m2. First return density describes the density of pulses emitted from the laser that return at least one echo to the system. Multiple returns greater than 1 from a single pulse were not considered in first return density analysis. Some types of surfaces (e.g., breaks in terrain, water, and steep slopes) may have returned fewer pulses than originally emitted by the laser. First returns typically reflect off the highest feature on the landscape within the footprint of the pulse. In forested or urban areas, the highest feature could be a tree, building or power line, while in areas of unobstructed ground, the first return will be the only echo and represents the bare earth surface.

The density of ground-classified lidar returns was also analyzed for this project. Terrain character, land cover, and ground surface reflectivity all influenced the density of ground surface returns. In vegetated areas, fewer pulses may penetrate the canopy, resulting in lower ground density.

The average first-return density of lidar data for the project was 17.02 points/m2 while the average ground classified density was 15.40 points/m2. The statistical and spatial distributions of first return densities and classified ground return densities per 100 m x 100 m cell are portrayed in Figures 4 and 5.

WI 12 County B22 Trempealeau County
Work Unit 300210 First Return Density

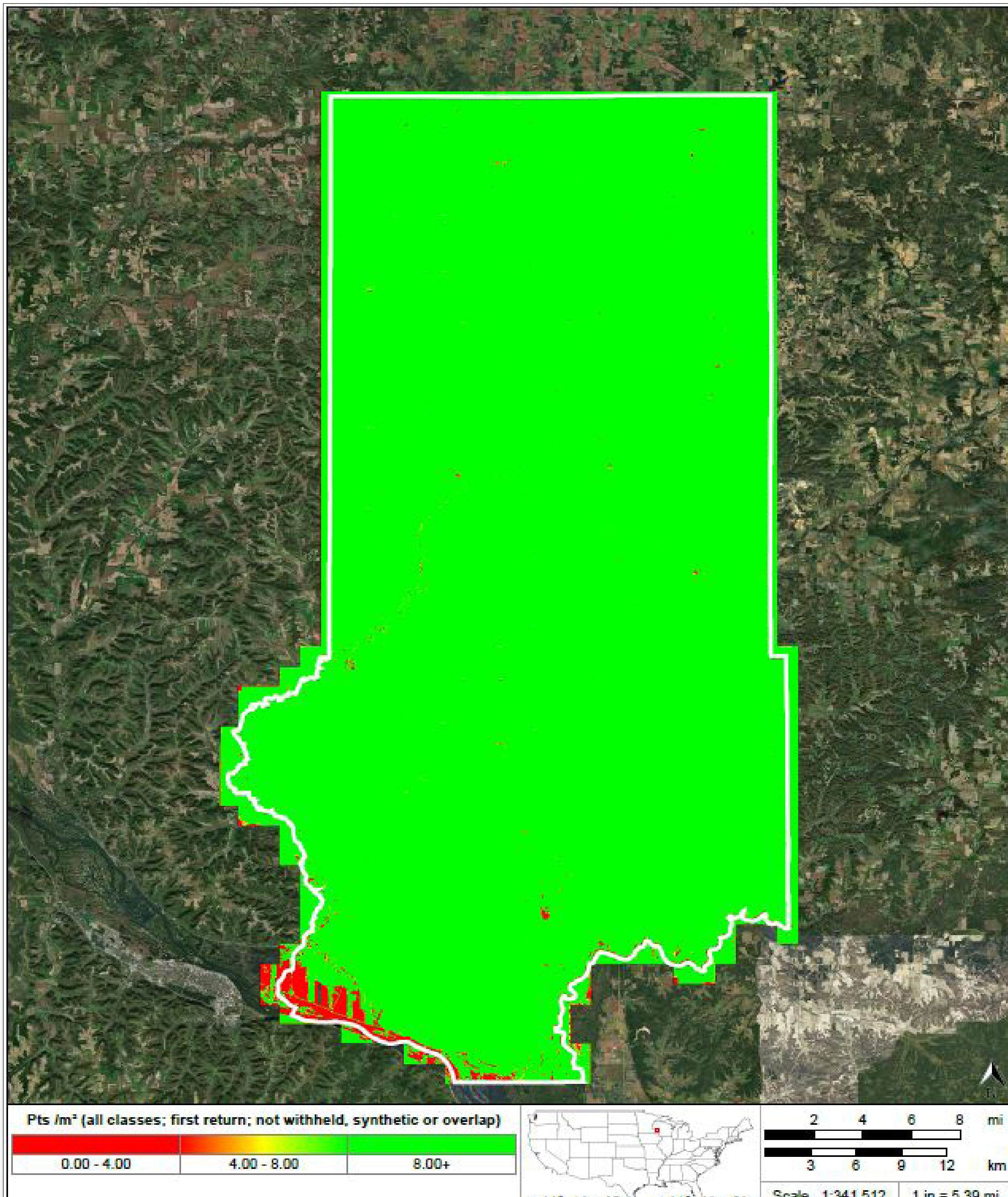


Figure 4. First Return Point Density

WI 12 County B22 Trempealeau County
Work Unit 300210 Ground Density

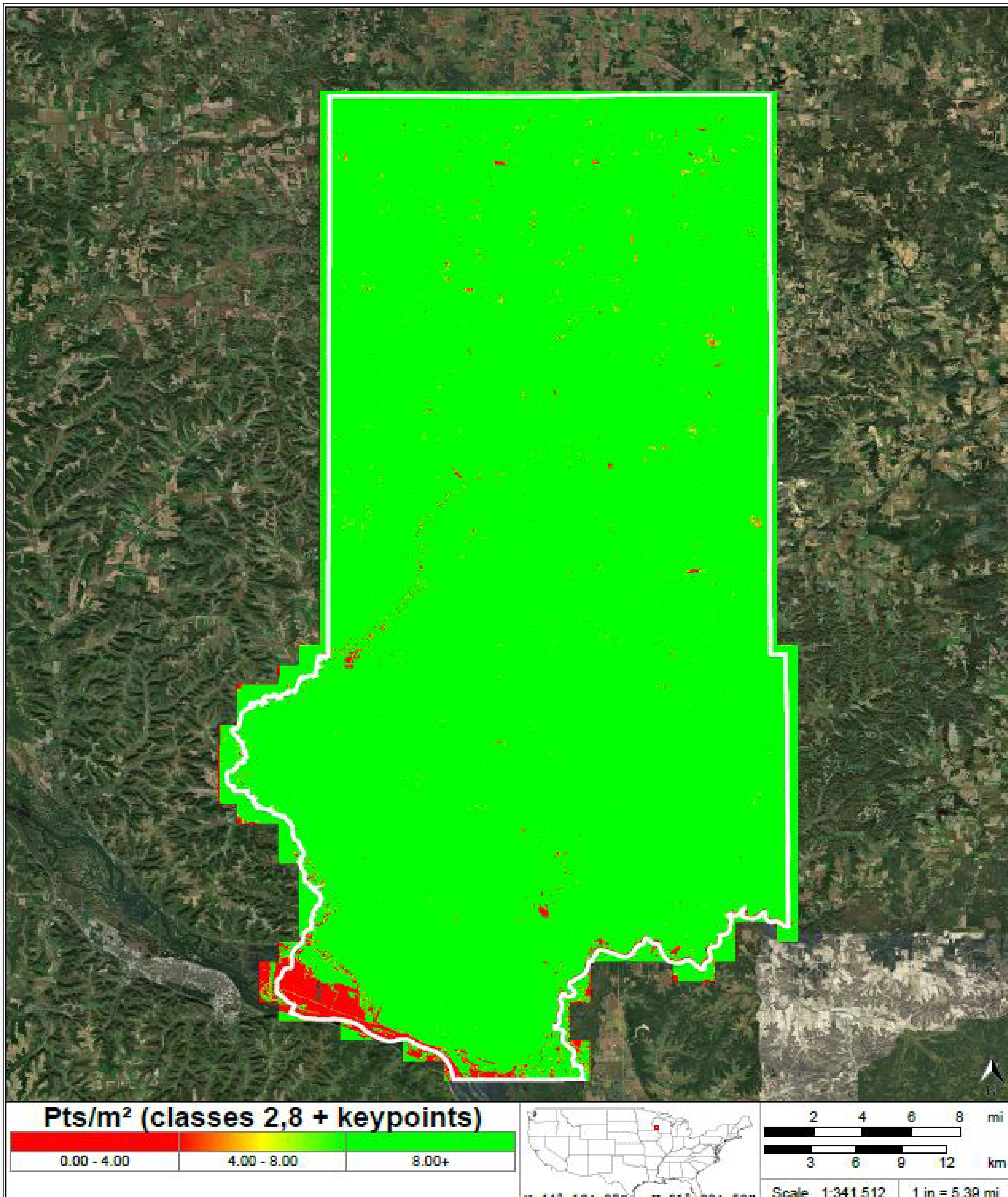


Figure 5. Ground Density

WI 12 County B22 Trempealeau
Work Unit 300210 Tile Layout

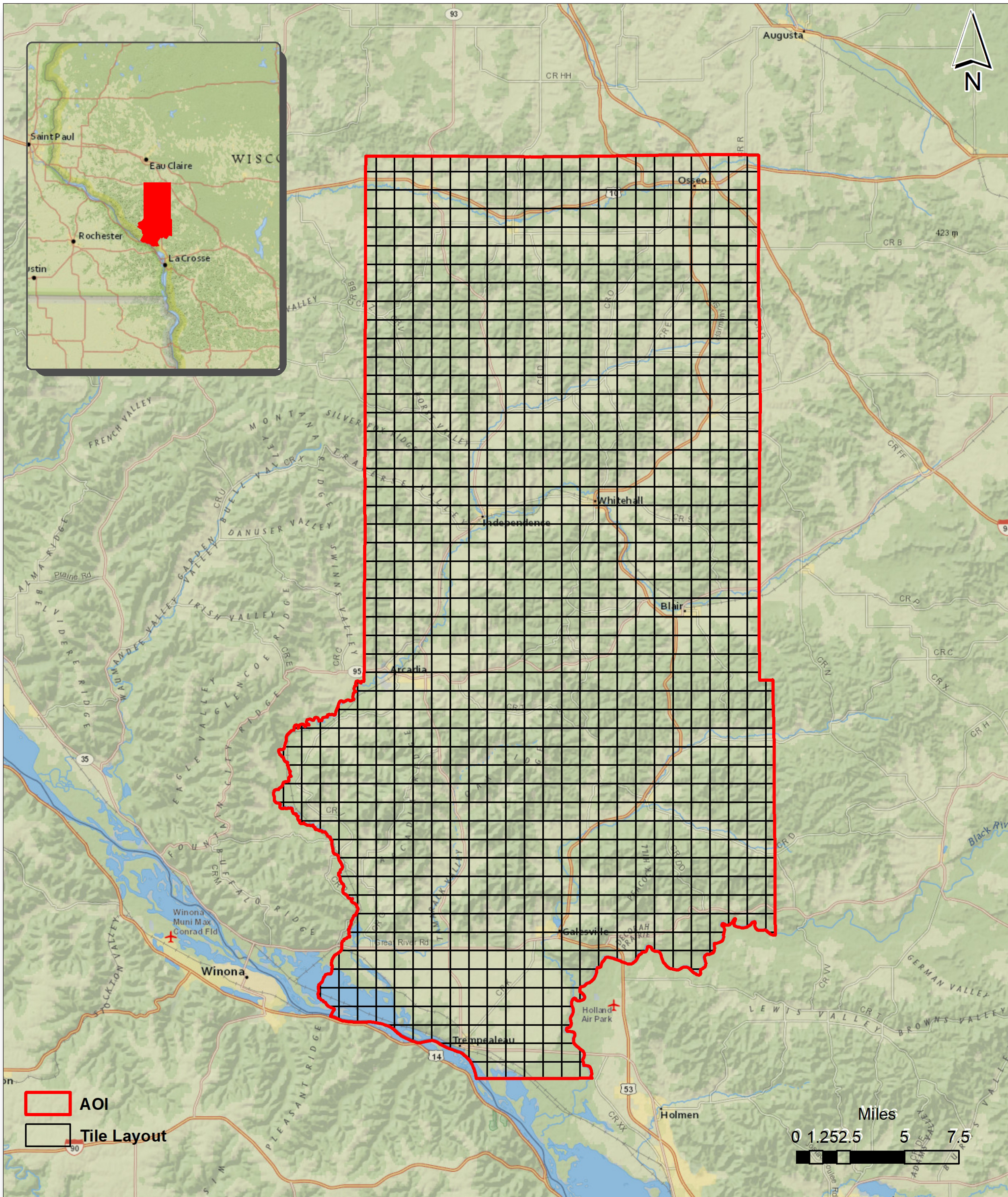


Figure 6. Lidar Tile Layout

4. Project Coverage Verification

A proprietary tool (FOCUS on Flight) produces grid-based polygons of each flightline, depicting exactly where lidar points exist. These swath polygons are reviewed against the project boundary to verify adequate project coverage. Please refer to Figure 5.

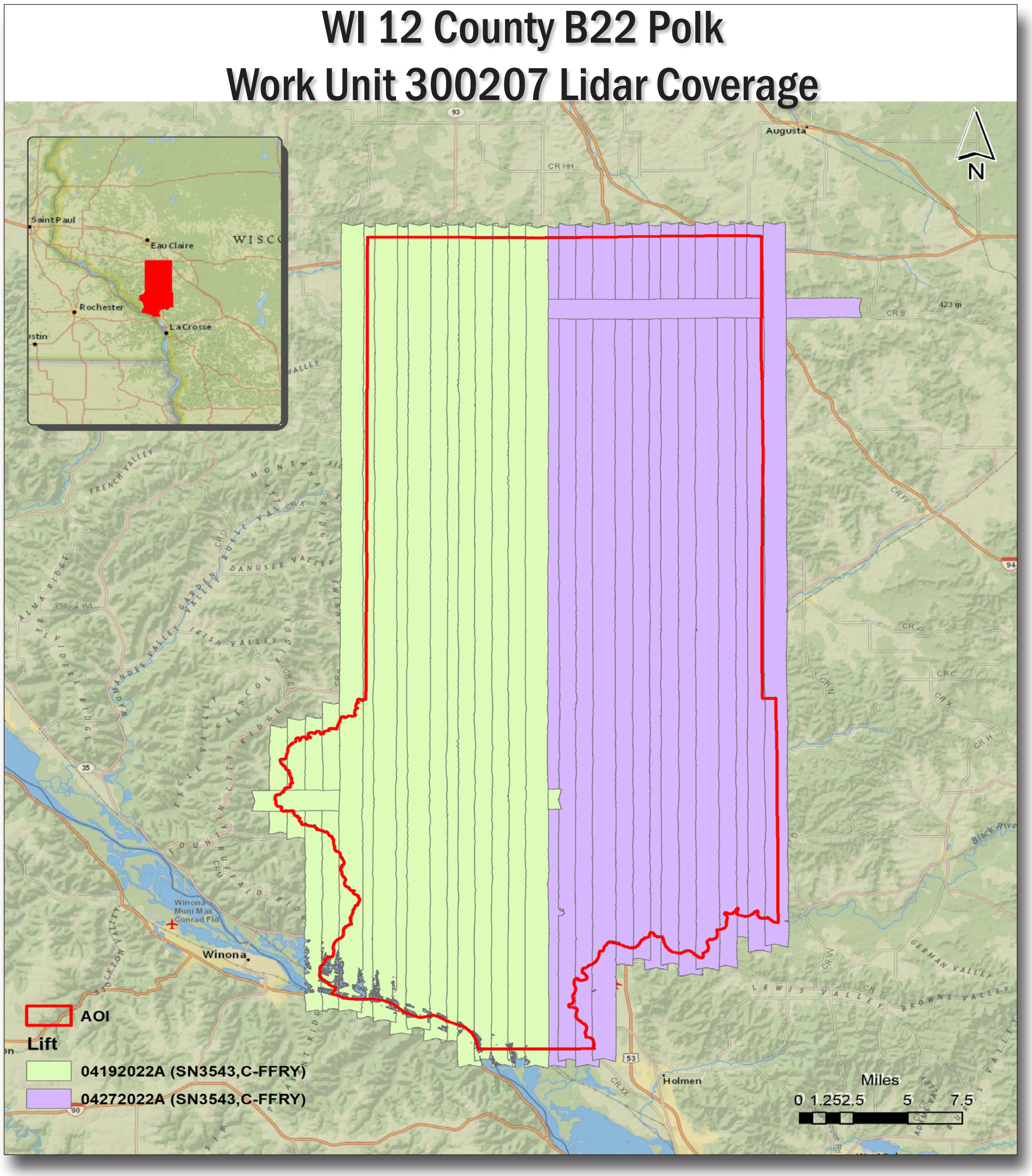


Figure 7. Lidar Coverage

5. Geometric Accuracy

5.1. Horizontal Accuracy

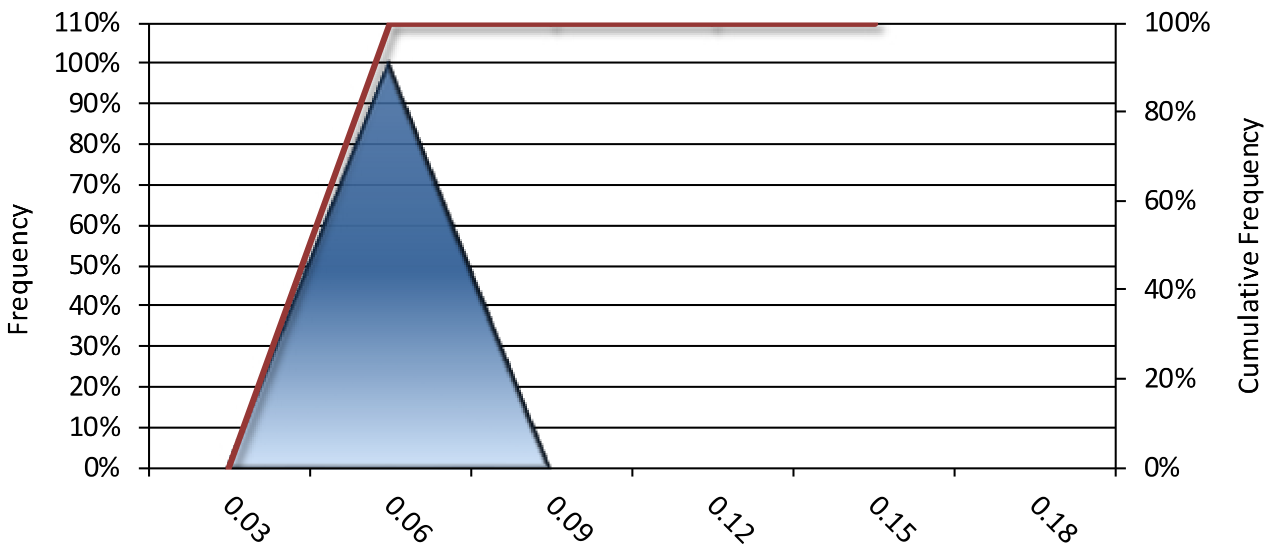
Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained $RMSE_r$ value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial Data Accuracy (NSSDA) reporting standard where a theoretical point will fall within the obtained radius 95% of the time. Based on a flying altitude of 1317 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.14 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

Horizontal Accuracy	
$RMSE_r$	0.27 ft
	0.08 m
ACC_r	0.47 ft
	0.14 m

5.2. Relative Vertical Accuracy

Relative vertical accuracy refers to the internal consistency of the data set as a whole: the ability to place an object in the same location given multiple flight lines, GPS conditions, and aircraft attitudes. When the lidar system is well calibrated, the swath-to-swath vertical divergence is low (<0.10 meters). The relative vertical accuracy was computed by comparing the ground surface model of each individual flight line with its neighbors in overlapping regions. The average (mean) line to line relative vertical accuracy for the WI 12 County B22 Trempealeau project was 0.043 feet (0.013 meters). A summary is shown below.

Relative Vertical Accuracy	
Sample	26 flight line surfaces
Average	0.043 ft
	0.013 m
Median	0.043 ft
	0.013 m
RMSE	0.043 ft
	0.013 m
Standard Deviation (1σ)	0.001 ft
	0.000 m
1.96σ	0.002 ft
	0.001 m



Wisconsin 12 County - Trempealeau, Wisconsin Relative Vertical Accuracy (ft)
Total Compared Points (n = 6,647,417,118)

5.3. Intraswath Precision (Smooth Surface Precision)

Intraswath Precision (smooth surface precision) is the measure of reliability of the lidar point cloud elevations along a planar surface. This measurement is performed on hard surfaces against a single flightline. NV5 digitized several large parking lots as polygons across the project area. These polygons were then used to calculate precision on a single FL basis using the below formula:

Precision = Range – (Slope x Cellsize x 1.414)

Range – Is the difference between the highest and lowest lidar points in each cell
Slope – is the maximum slope of the cell to its 8 neighbors
Cellsize – is set to the ANPS, rounded up to the next integer, and then doubled

NV5 calculated the RMSDz to be 2 cm, minimum slope-corrected range to be 0 cm, and the maximum slope-corrected range to be 8.2 cm.

Project Report Appendices

The following section contains the appendices as listed in the WI 12 County B22 Trempealeau Lidar Project Report.

Appendix A

Flight Logs

Julian Day 109 | Flight A

LIDAR Flight Log

AIRBORNE IMAGING — A Clean Harbors Company

Date	April 19, 2022	**Aircraft**	C-FFRY
Project	3238_NV5_WI3DEP_V3_QL	**Pilot**	Nick Hattie
Location	Eau Claire WI	**Operator**	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- 2C -Moderate Turbulence all flight
H- 69%
AMLS-278m
Hpa-1024

Time to next maintenance: ________ ⦿ 50 hr ○ 100 hr

Aircraft Block Time		
Engine On 16:21	**Takeoff** 16:42	
Engine Off 22:25	**Landing** 22:14	
Total 6.1 hrs	**Total** 5.5 hrs	

Mission Plan					
AGL Height	1584	m	**Pulse Rate**	1200 khz/ch	
Target Speed	160	kts	**Scan Rate**	186 hz/ch	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	1630	1635
Post Mission	2217	2222

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp	
F8			1650	1655				
3221	432210901		1708	1710			170857	
3222	432210902		1714	1716			171434	
3223	432210903		1720	1725			172014	
3224	432210904		1729	1735			172914	
3225	432210905		1745	1801			174532	
3226	432210906		1805	1818			180519	
3227	432210907		1822		1826		182221	Snapshoot lose conecction quit the line
3227	432210908		1835	1850			183501	Refly
3228	432210909		1853	1908			185355	
3229	432210910		1911	1926			191133	
3230	432210911		1930	1945			193001	
3231	432210912		1952	1906			195202	
3232	432210913		2010	2025			201021	
3233	432210914		2028	2043			202852	

Julian Day	109	Flight	A

LIDAR Flight Log

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A Clean Harbors Company

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Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1630	1635
Post Mission	2217	2222

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp	Comments
3234	432210915		2047	2102			204732	
3235	432210916		2106	2121			210639	
3236	432210917		2124	2139			212442	
X-tie	432210918		2146	2151			214626	
F8			2151	2154				

Julian Day 109	Flight A

LIDAR Flight Log

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A Clean Harbors Company

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Julian Day 109 | Flight A

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A Clean Harbors Company

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Julian Day 109	Flight A

LIDAR Flight Log

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Location	Eau Claire WI	**Operator**	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- 2C -Moderate Turbulence all flight
H- 69%
AMLS-278m
Hpa-1024

Time to next maintenance: ________ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	16:21	**Takeoff**	16:42	
Engine Off	22:25	**Landing**	22:14	
Total	6.1 hrs	**Total**	5.5 hrs	

Mission Plan					
AGL Height	1584	**m**	**Pulse Rate**	1200 khz/ch	
Target Speed	160	**kts**	**Scan Rate**	186 hz/ch	
Laser Current	100	**%**	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1630	1635
Post Mission	2217	2222

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp ________	

Julian Day	117	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 27, 2022	**Aircraft**	C-FFRY
Project	3238_NV5_WI3DEP_V3	**Pilot**	Nick H - Kane G
Location	Eau Claire WI	**Operator**	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- -2C
H- 74%
AMLS-278m
Hpa-1028

Time to next maintenance: ______ ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On 11:49	**Takeoff** 12:07			
Engine Off 18:10	**Landing** 18:00			
Total 6.4 hrs	**Total** 5.9 hrs			

Mission Plan				
AGL Height	1050	m	**Pulse Rate**	1000 khz/ch
Target Speed	160	kts	**Scan Rate**	295 hz/ch
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1157	1202
Post Mission	1804	1809

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp ______	Comments
F8			1217	1222				
3237	432211701		1226	1240			122602	
3238	432211702		1244	1259			124426	
3239	432211703		1303	1319			130359	
3240	432211704		1323	1338			132347	
3241	432211705		1343	1356			134327	
3242	432211706		1400	1413			140044	
3243	432211707		1418	1431			141803	
3244	432211708		1435	1448			144509	
3245	432211709		1451	1505			145152	
3246	432211710		1508	1521			150811	
3247	432211711		1525	1538			152527	
3248	432211712		1542	1554			154210	
3249	432211713		1558	1611			155841	
3250	432211714		1615	1628			161523	

Julian Day 117	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 27, 2022	Aircraft	C-FFRY
Project	3238_NV5_WI3DEP_V3	Pilot	Nick H - Kane G
Location	Eau Claire WI	Operator	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- -2C
H- 74%
AMLS-278m
Hpa-1028

Time to next maintenance: ________ ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	11:49	Takeoff	12:07	
Engine Off	18:10	Landing	18:00	
Total	6.4 hrs	Total	5.9 hrs	

Mission Plan					
AGL Height	1050	m	Pulse Rate	1000 khz/ch	
Target Speed	160	kts	Scan Rate	295 hz/ch	
Laser Current	100	%	FOV	60	degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1157	1202
Post Mission	1804	1809

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp	
3251	432211715		1632	1644			163215	
3252	432211716		1648	1701			164855	
3253	432211717		1705	1717			1705	
3254	432211718		1721	1734			172158	
Xtie	432211719		1739	1744			173915	
F8			1748	1753				

v 20200520

Julian Day 117	Flight A

LIDAR Flight Log

Date	April 27, 2022	Aircraft	C-FFRY
Project	3238_NV5_WI3DEP_V3	Pilot	Nick H - Kane G
Location	Eau Claire WI	Operator	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- -2C
H- 74%
AMLS-278m
Hpa-1028

Time to next maintenance: ________ ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On 11:49	Takeoff 12:07			
Engine Off 18:10	Landing 18:00			
Total 6.4 hrs	Total 5.9 hrs			

Mission Plan				
AGL Height	1050	m	Pulse Rate	1000 khz/ch
Target Speed	160	kts	Scan Rate	295 hz/ch
Laser Current	100	%	FOV	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1157	1202
Post Mission	1804	1809

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp ________	Comments

v 20200520

Julian Day 117	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	April 27, 2022	**Aircraft**	C-FFRY
Project	3238_NV5_WI3DEP_V3	**Pilot**	Nick H - Kane G
Location	Eau Claire WI	**Operator**	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- -2C
H- 74%
AMLS-278m
Hpa-1028

Time to next maintenance: ______ ⦿ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	11:49	**Takeoff**	12:07	
Engine Off	18:10	**Landing**	18:00	
Total	6.4 hrs	**Total**	5.9 hrs	

Mission Plan					
AGL Height	1050	m	**Pulse Rate**	1000 khz/ch	
Target Speed	160	kts	**Scan Rate**	295 hz/ch	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1157	1202
Post Mission	1804	1809

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID (Time Stamp ______)	Comments

v 20200520

Julian Day 117	Flight A

LIDAR Flight Log

AIRBORNE IMAGING — A Clean Harbors Company

Date	April 27, 2022	**Aircraft**	C-FFRY
Project	3238_NV5_WI3DEP_V3	**Pilot**	Nick H - Kane G
Location	Eau Claire WI	**Operator**	Daniel. A
Mission Objective			

System	Riegl VQ-1560ii
Unit	43
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T- -2C
H- 74%
AMLS-278m
Hpa-1028

Time to next maintenance: ________ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On 11:49	**Takeoff** 12:07			
Engine Off 18:10	**Landing** 18:00			
Total 6.4 hrs	**Total** 5.9 hrs			

Mission Plan				
AGL Height	1050	m	**Pulse Rate**	1000 khz/ch
Target Speed	160	kts	**Scan Rate**	295 hz/ch
Laser Current	100	%	**FOV**	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1157	1202
Post Mission	1804	1809

Flight Line	LiDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID (Time Stamp ________)	Comments

Appendix B

SBET and POSPAC Reports

General Information

Mission Information

Project name	04192022A_3543
Processing date	2022-04-21 17:01:17
Mission date	2022-04-19 16:33:34
Mission duration	05:47:34.986
Processing mode	IN-Fusion PP-RTX

Rover Hardware Information

Product	POS AV 610 VER6 HW2.5-12
Serial number	S/N9683
IMU type	57
Receiver type	BD982
Antenna type	AV59

Project File List

Rover Data Files

File name	File type
4322109a.001	POS Data
4322109a.002	POS Data
4322109a.003	POS Data
4322109a.004	POS Data
4322109a.005	POS Data
4322109a.006	POS Data
4322109a.007	POS Data
4322109a.008	POS Data
4322109a.009	POS Data
4322109a.010	POS Data
4322109a.011	POS Data
4322109a.012	POS Data
4322109a.013	POS Data
4322109a.014	POS Data
4322109a.015	POS Data
4322109a.016	POS Data
4322109a.017	POS Data
4322109a.018	POS Data
4322109a.019	POS Data
4322109a.020	POS Data
4322109a.021	POS Data
4322109a.022	POS Data
4322109a.023	POS Data
4322109a.024	POS Data
4322109a.025	POS Data
4322109a.026	POS Data
4322109a.027	POS Data
4322109a.028	POS Data
4322109a.029	POS Data
4322109a.030	POS Data
4322109a.031	POS Data
4322109a.032	POS Data
4322109a.033	POS Data
4322109a.034	POS Data
4322109a.035	POS Data
4322109a.036	POS Data
4322109a.037	POS Data
4322109a.038	POS Data
4322109a.039	POS Data
4322109a.040	POS Data
4322109a.041	POS Data
4322109a.042	POS Data
4322109a.043	POS Data
4322109a.044	POS Data
4322109a.045	POS Data
4322109a.046	POS Data
4322109a.047	POS Data
4322109a.048	POS Data
4322109a.049	POS Data
4322109a.050	POS Data
4322109a.051	POS Data
4322109a.052	POS Data
4322109a.053	POS Data
4322109a.054	POS Data
4322109a.055	POS Data
4322109a.056	POS Data
4322109a.057	POS Data
4322109a.058	POS Data
4322109a.059	POS Data

File name	File type
4322109a.060	POS Data
4322109a.061	POS Data
4322109a.062	POS Data
4322109a.063	POS Data
4322109a.064	POS Data

Input Files

File Name	File Type
Ephm1090.22g	GLONASS Broadcast Ephemeris
Ephm1090.22n	GPS Broadcast Ephemeris

Output Files

Filename	File type
sbet_04192022A_3543.out	SBET Trajectory File

Rover Data Summary

First raw data file	4322109a.001		
Last raw data file	4322109a.064		
Start GPS week	2206		
Start time	232396.025 (4/19/2022 4:33:16 PM)		
End time	253251.011 (4/19/2022 10:20:51 PM)		
Start of fine alignment	232626.908 (4/19/2022 4:37:06 PM)		
Available subsystems	Primary GNSS, Gimbal, IMU		
POS Event Input	None		
Correction data	None		
IMU Installation Lever Arms & Mounting Angles			
Gimbal to IMU lever arm (m)	-0.034	-0.010	-0.374
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000
Gimbal to Primary GNSS lever arm (m)	0.717	-0.178	-1.265
Gimbal to Primary GNSS lever arm std dev (m)	-1.000		
Aircraft to Reference mounting angles (deg)	0.000	0.000	0.000

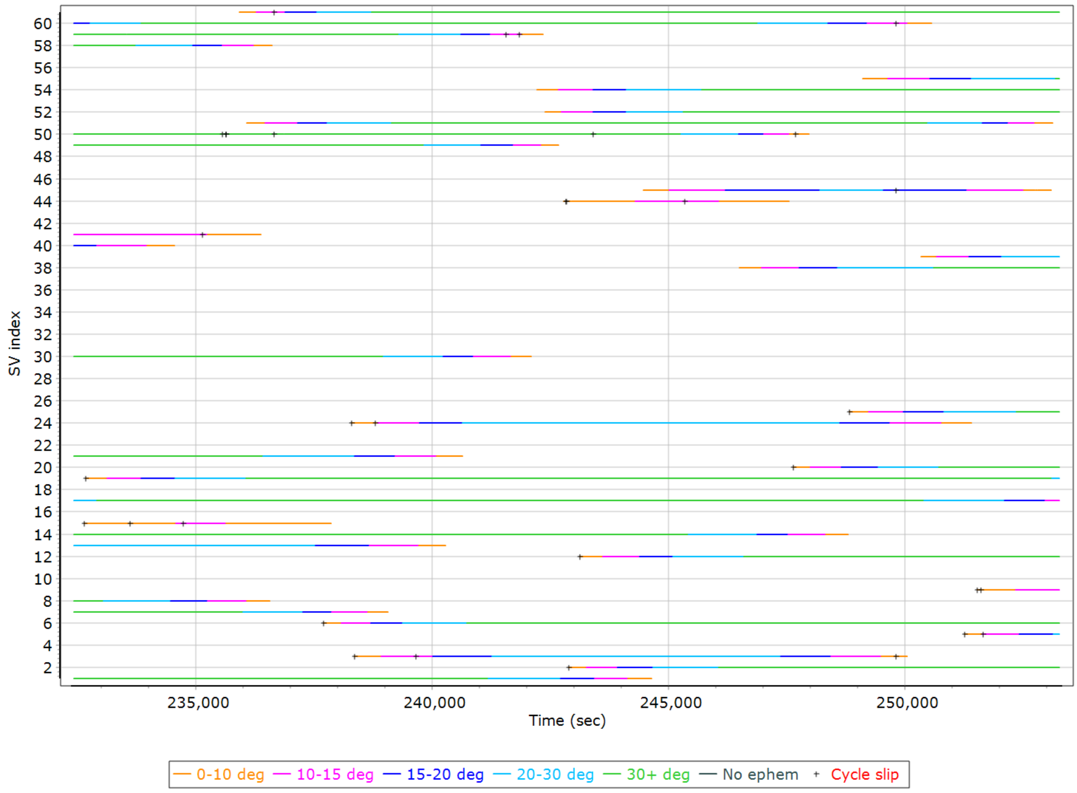
Rover Data QC

Raw IMU Import QC Summary

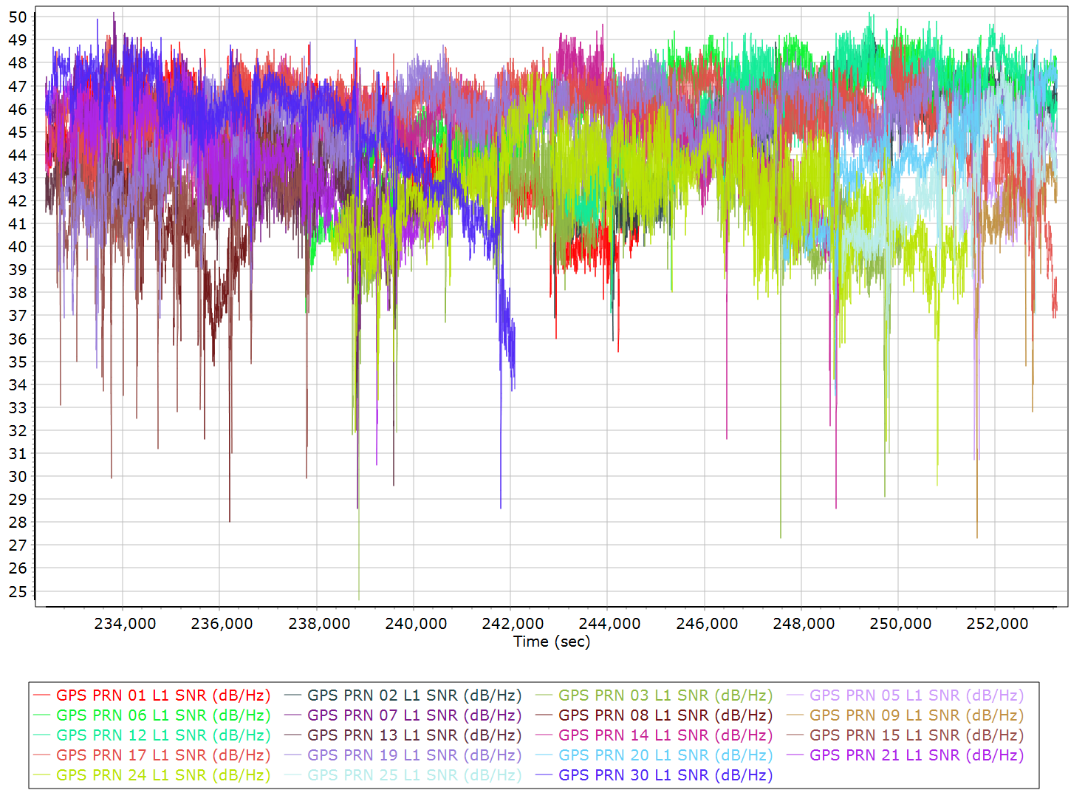
IMU data input file	imu_Mission 1.dat
IMU data check log file	imudt_04192022A_3543.log
IMU Records Processed	4171826
Termination Status	Normal
IMU Anomalies	0

Primary Observables & Satellite Data

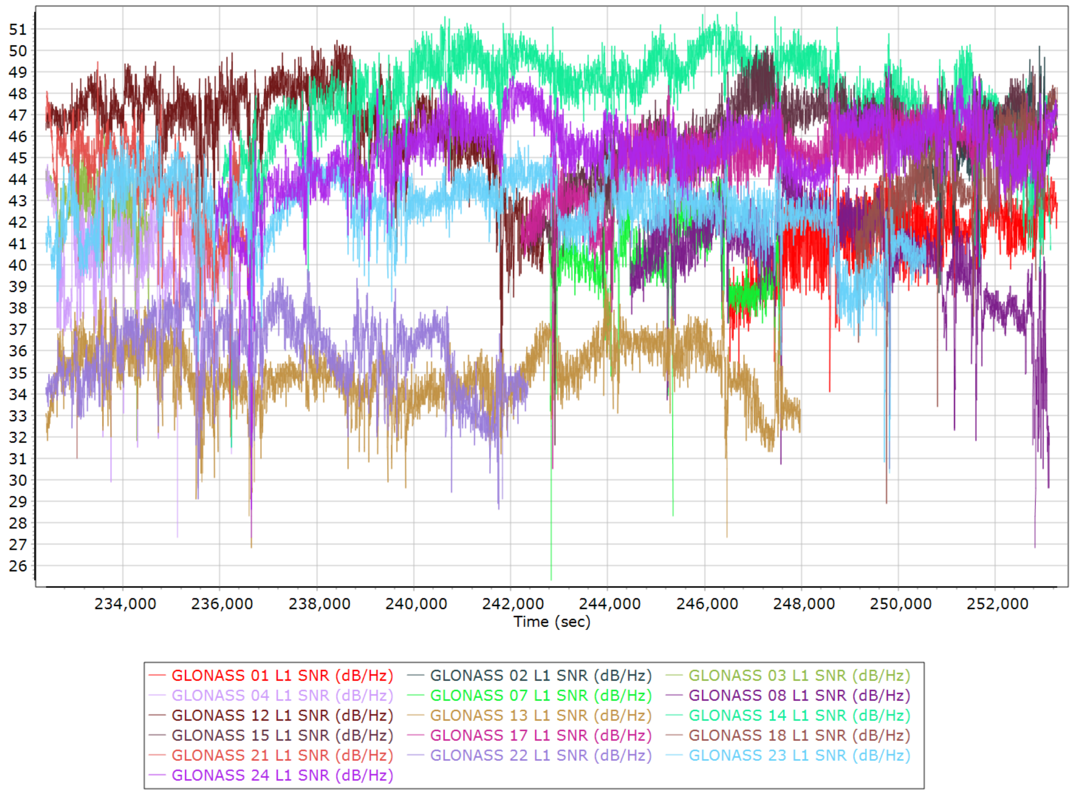
GPS/GLONASS L1 Satellite Lock/Elevation



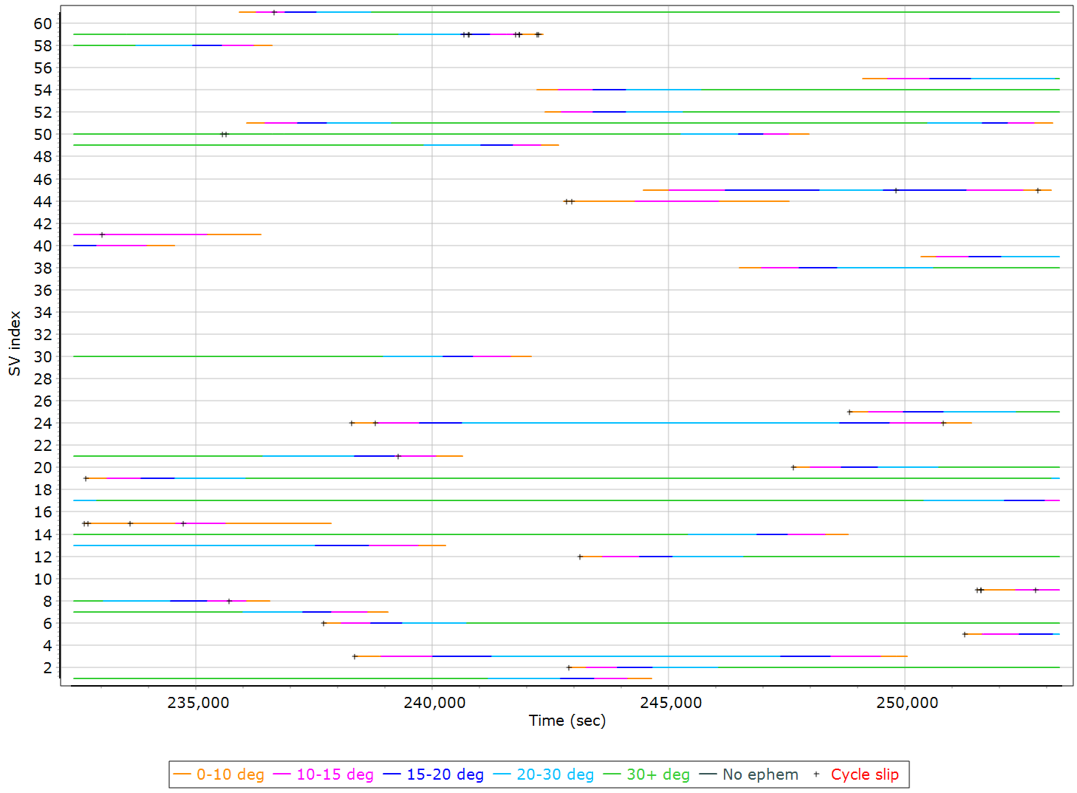
GPS L1 SNR



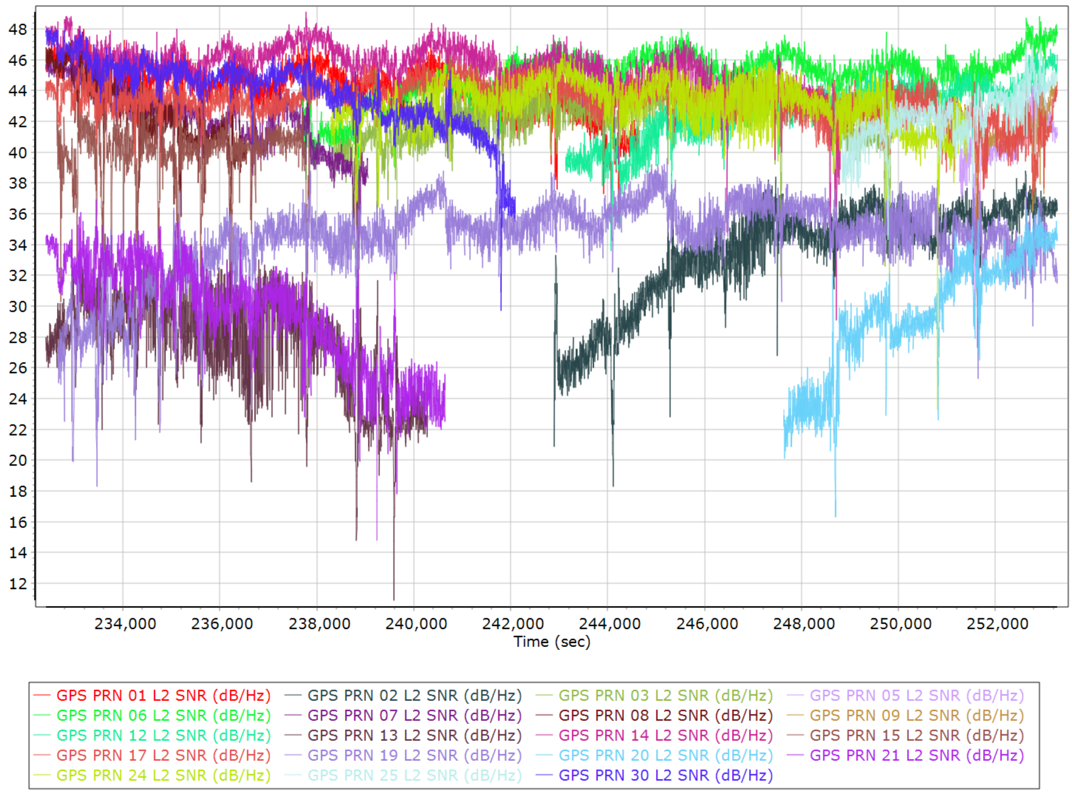
GLONASS L1 SNR



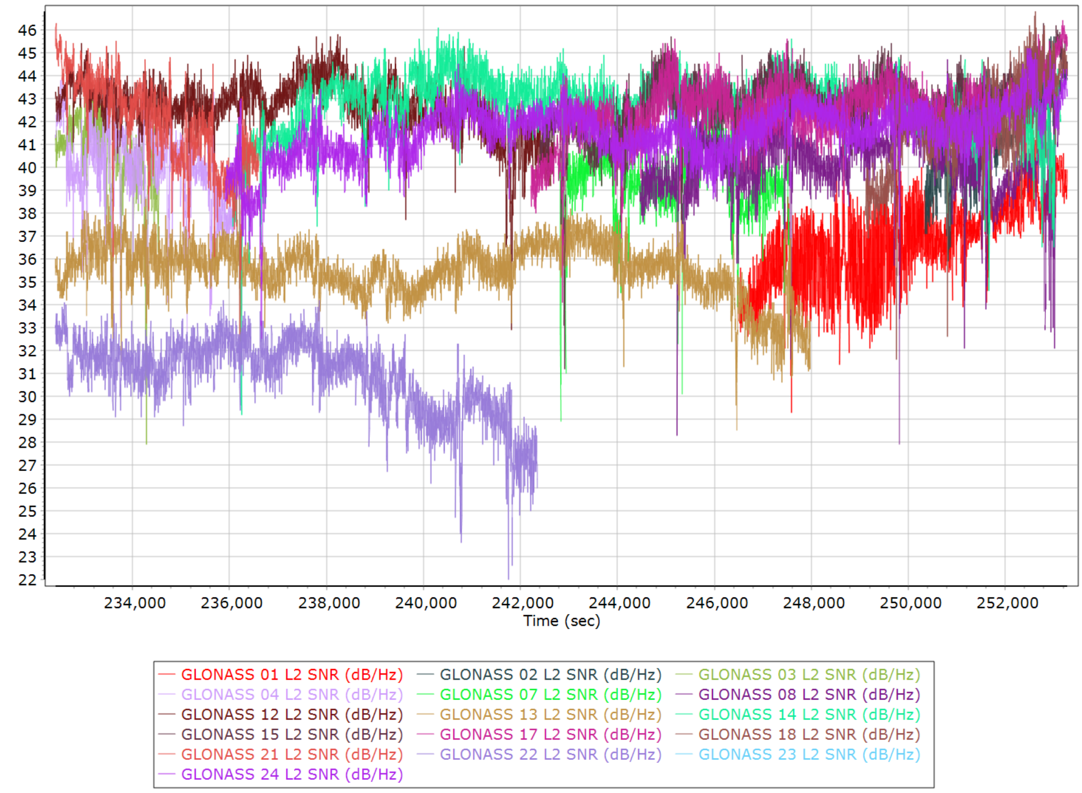
GPS/GLONASS L2 Satellite Lock/Elevation



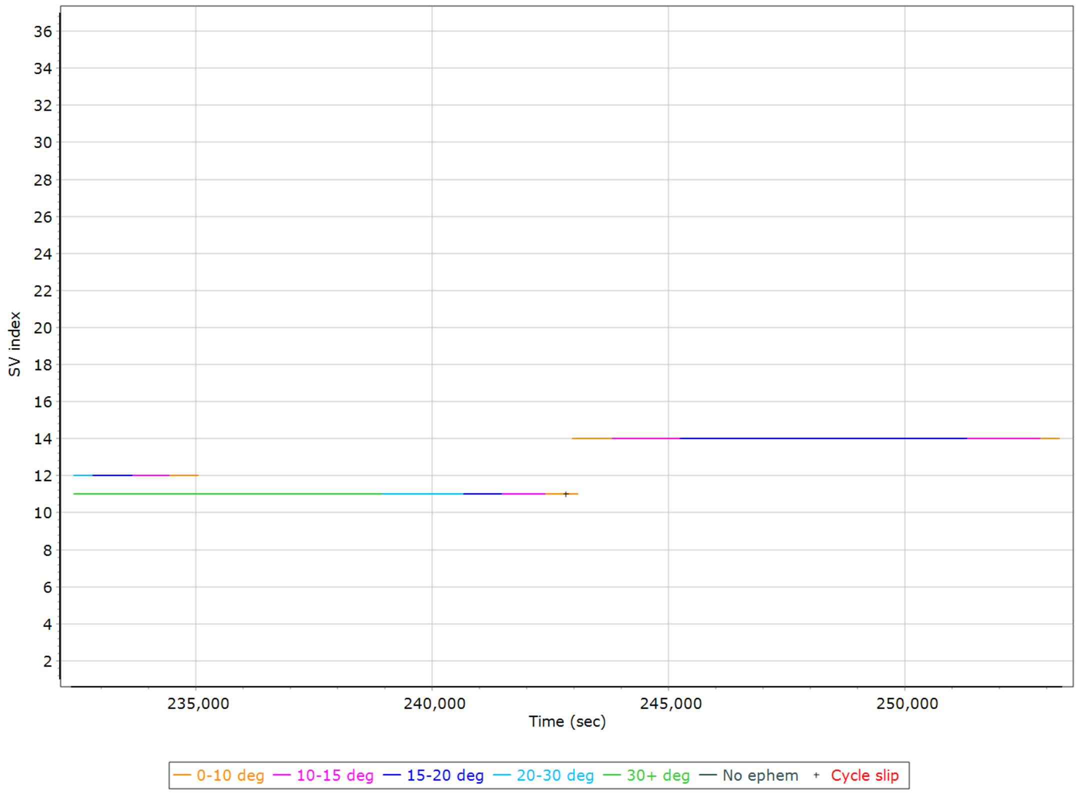
GPS L2 SNR



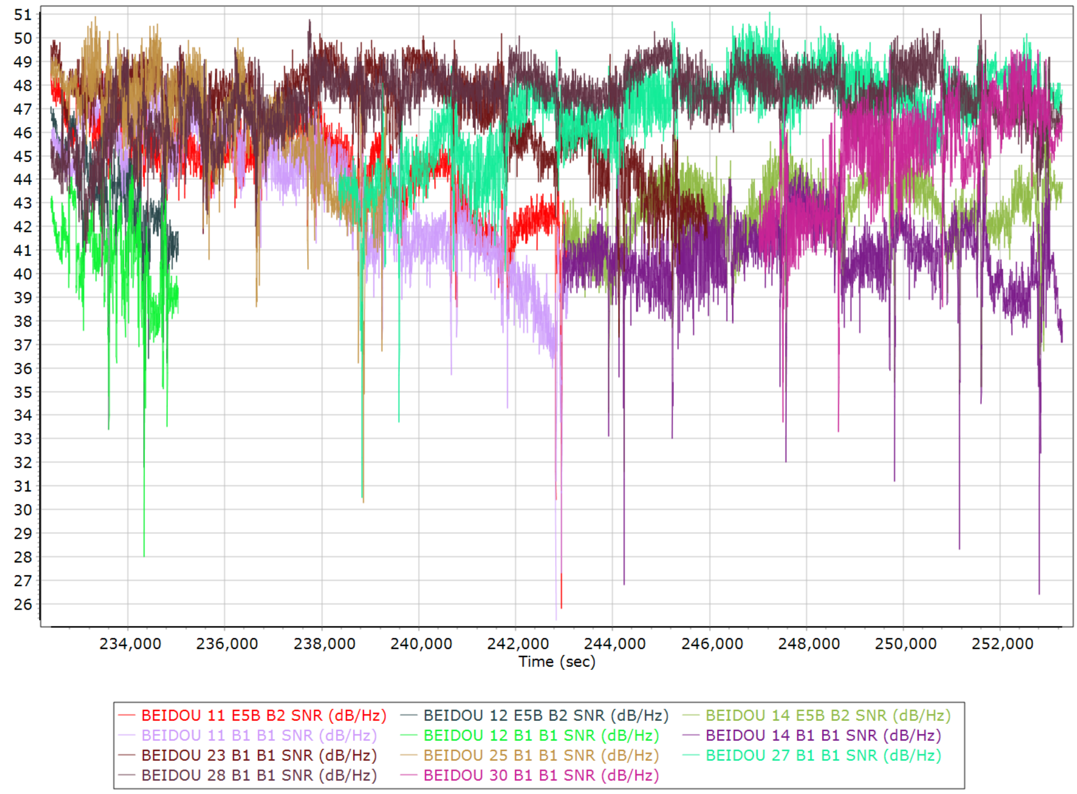
GLONASS L2 SNR



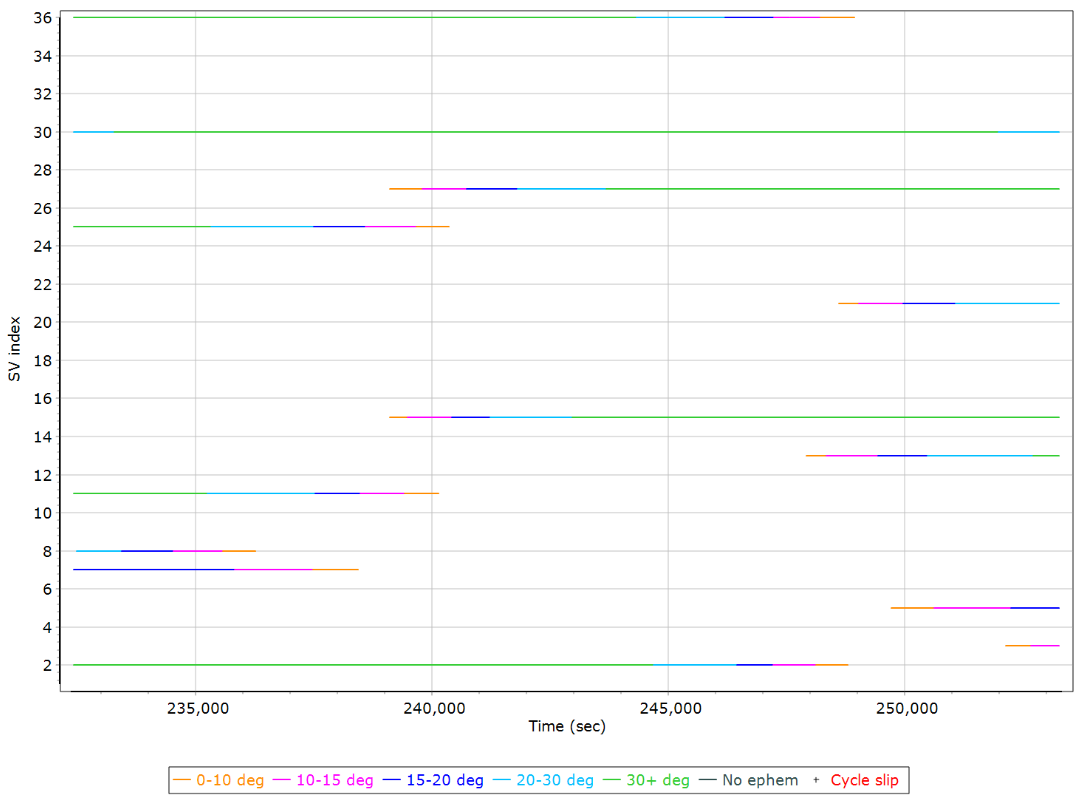
BEIDOU Satellite Lock/Elevation



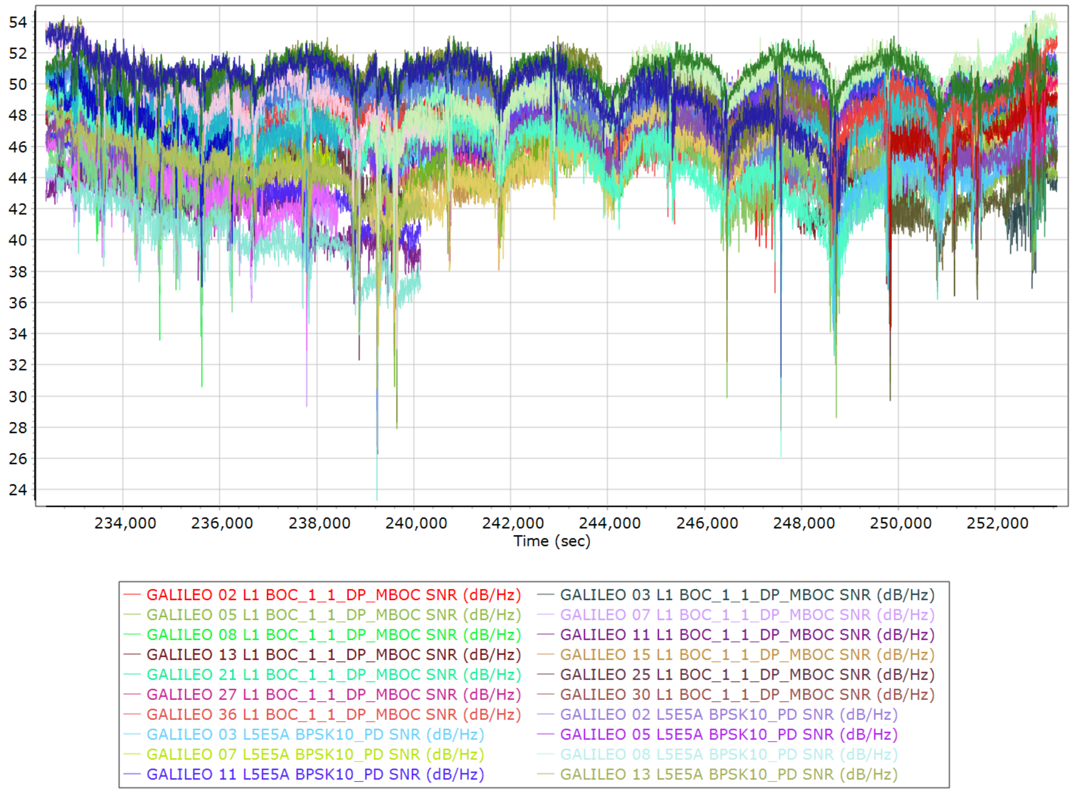
BEIDOU SNR



GALILEO Satellite Lock/Elevation



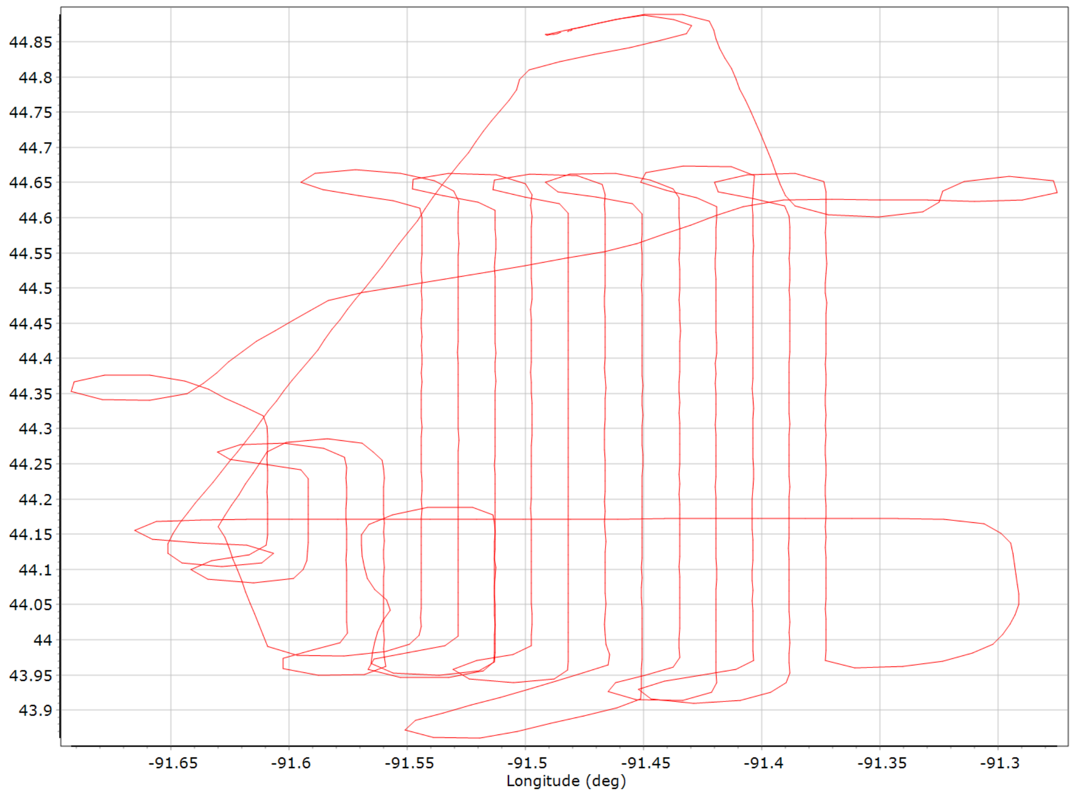
GALILEO SNR



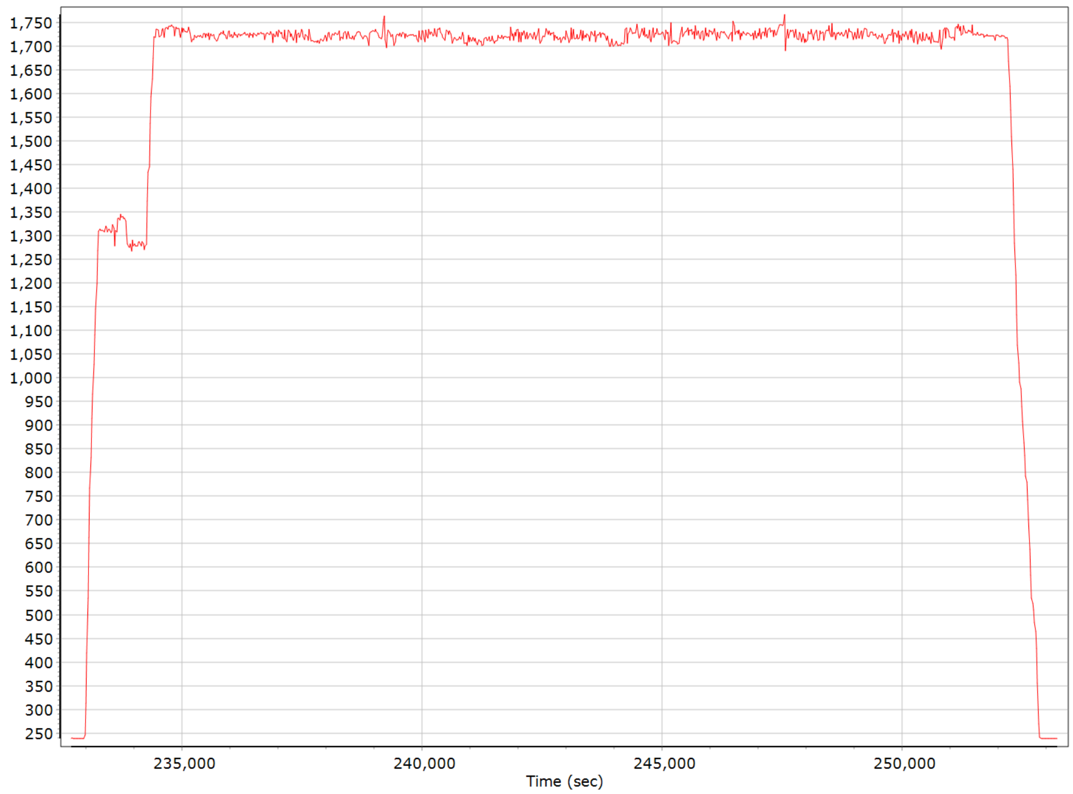
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
234,000
236,000
238,000
240,000
242,000
244,000
246,000
248,000
250,000
252,000
Time (sec)
GALILEO 02 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 03 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 05 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 07 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 08 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 11 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 13 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 15 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 21 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 25 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 27 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 30 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 36 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 02 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 03 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 05 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 07 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 08 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 11 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 13 L5E5A BPSK10_PD SNR (dB/Hz)

Smoothed Trajectory Information

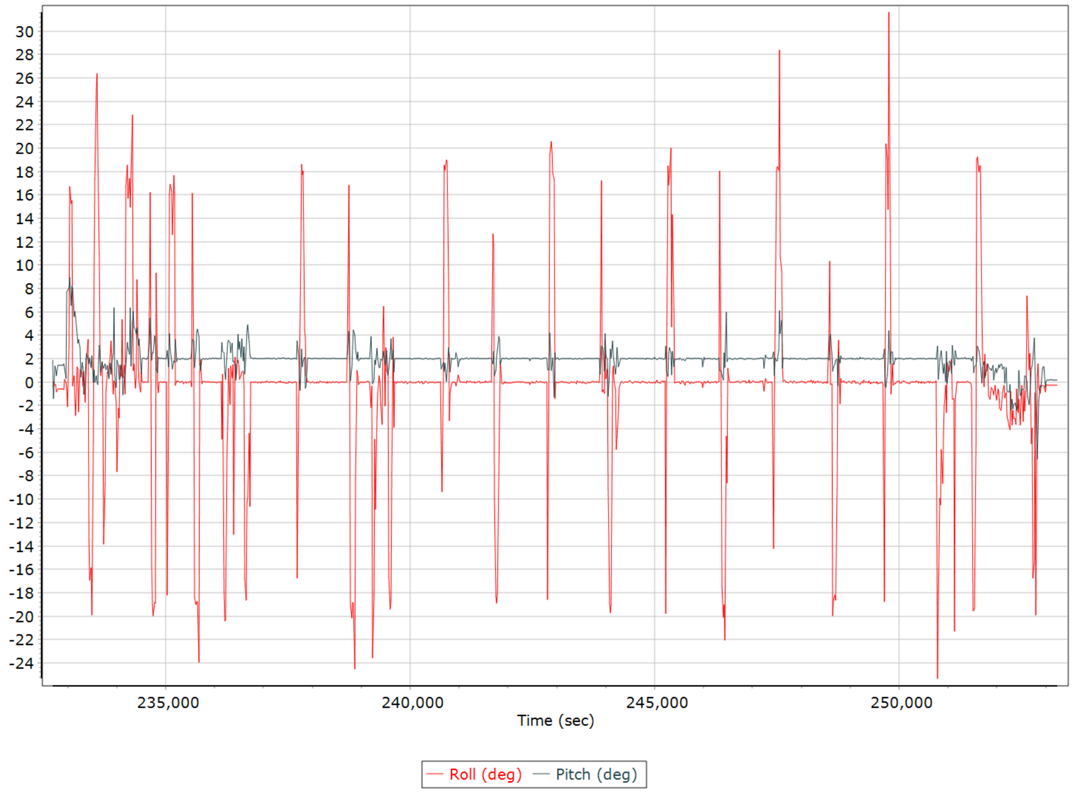
Top View



Altitude



Roll/Pitch



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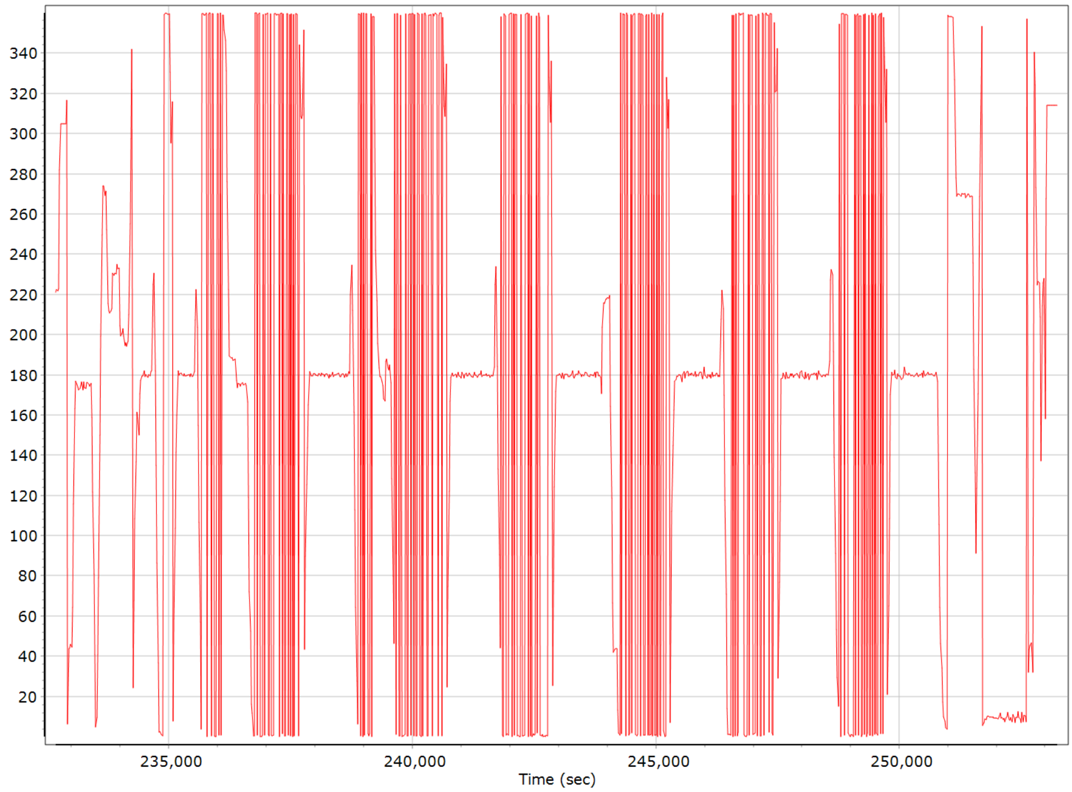
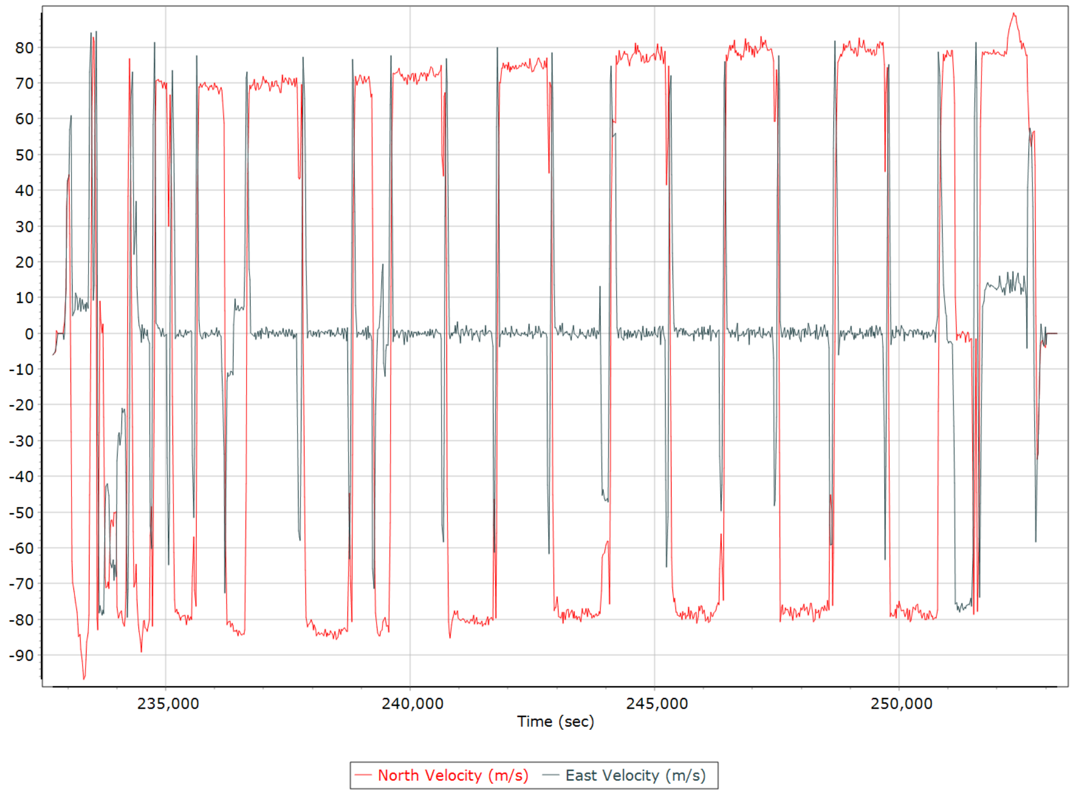
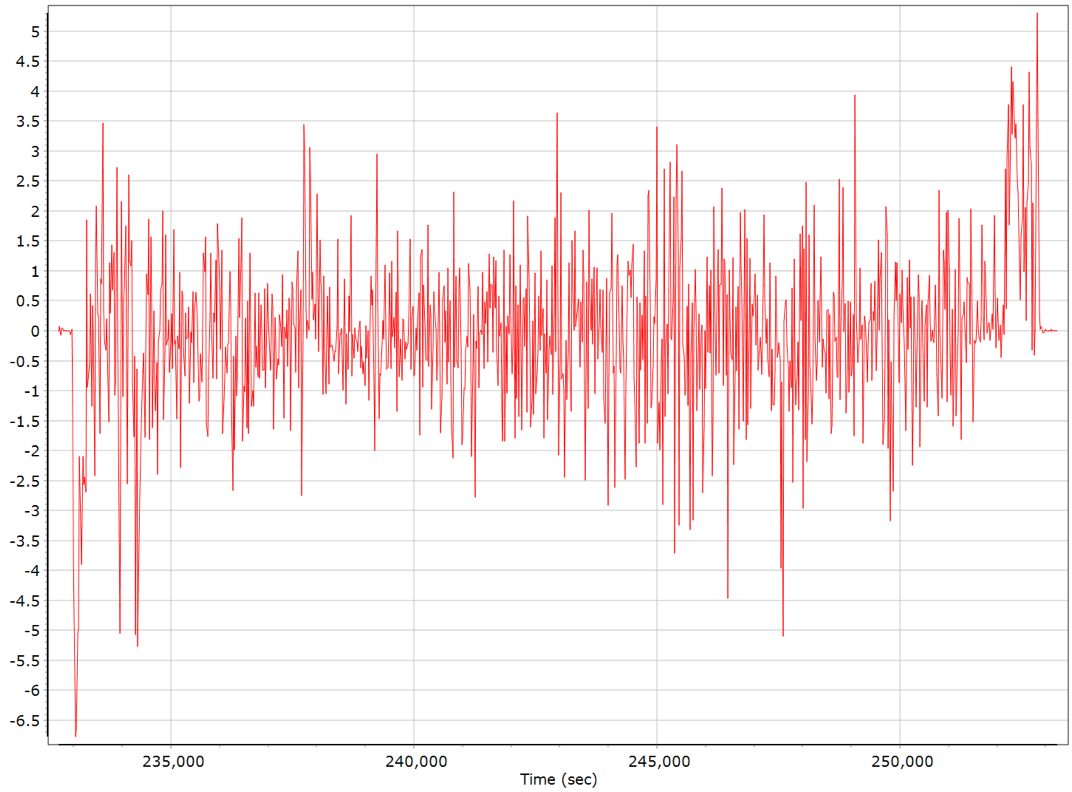


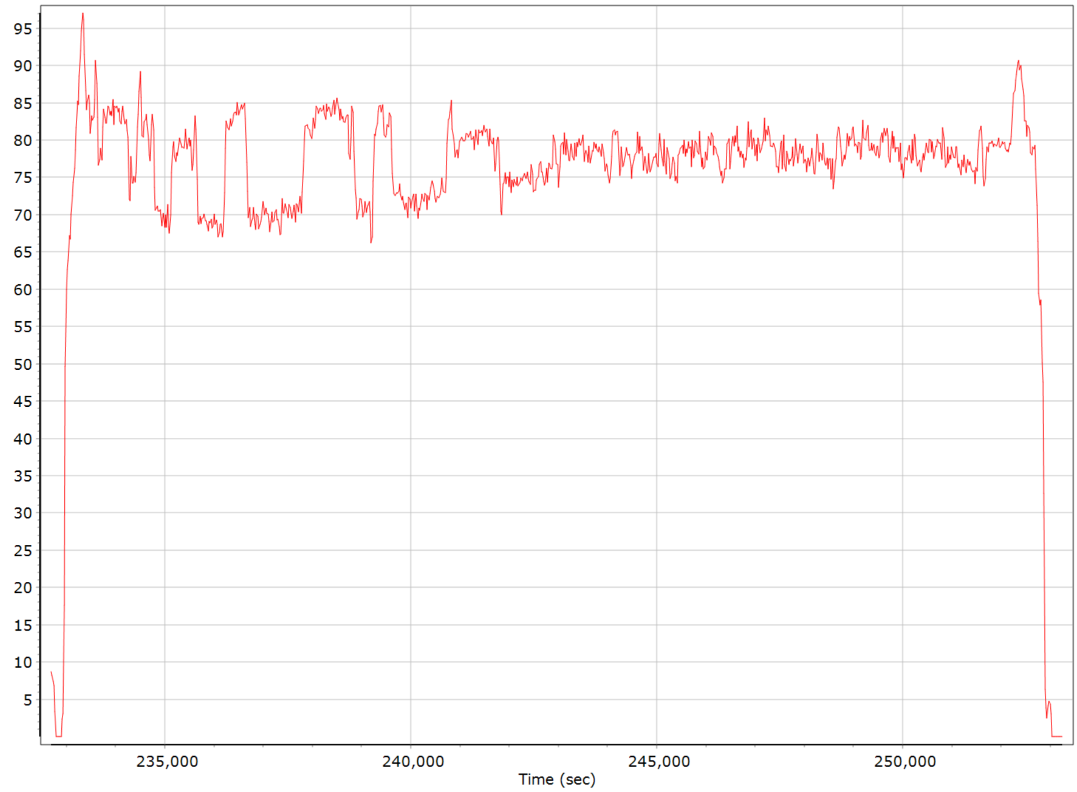
North/East Velocity



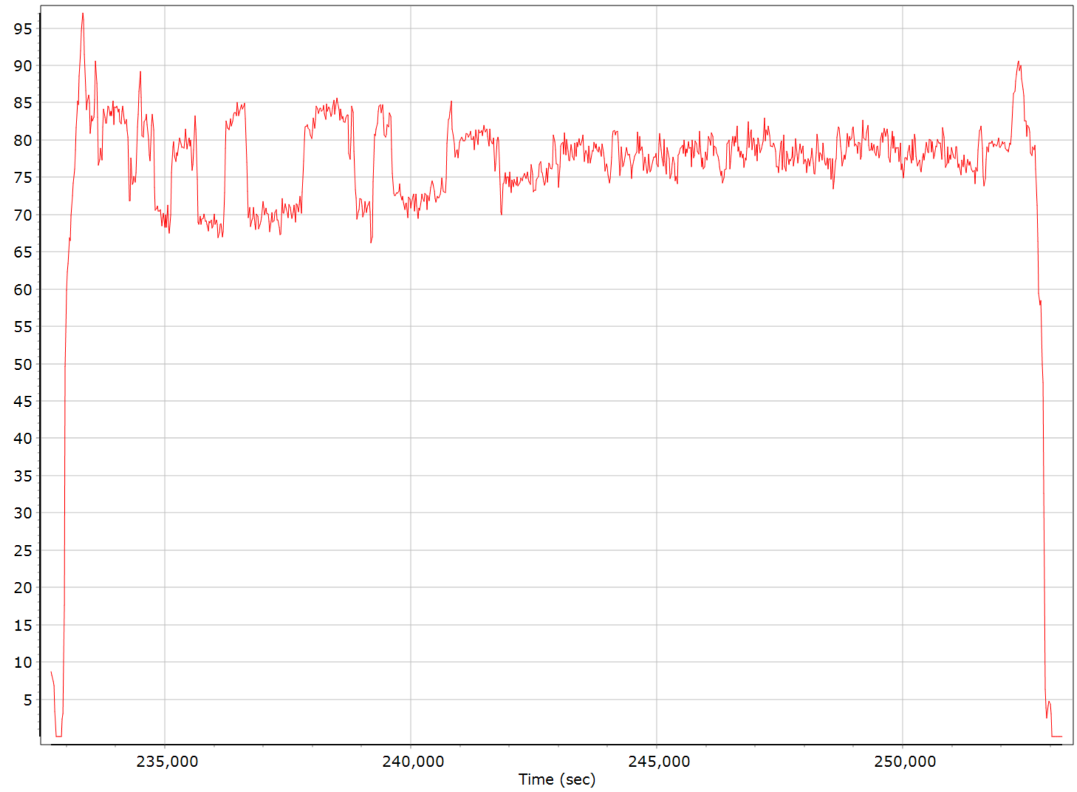
Down Velocity



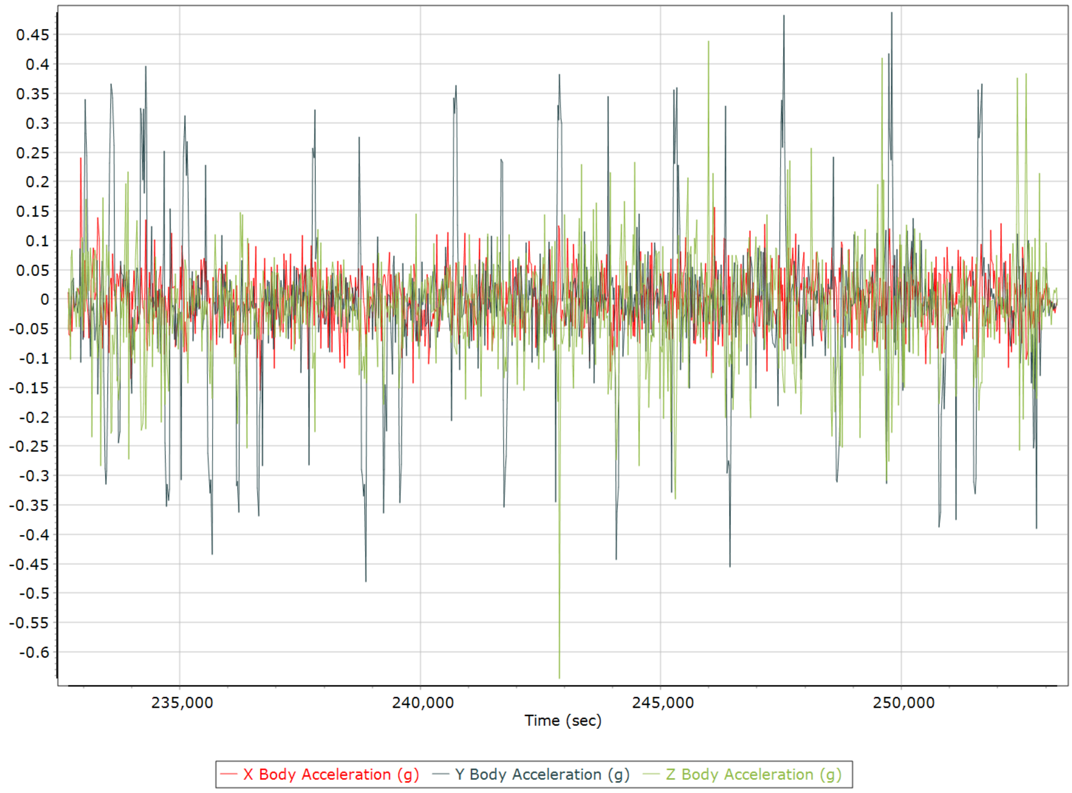
Total Speed



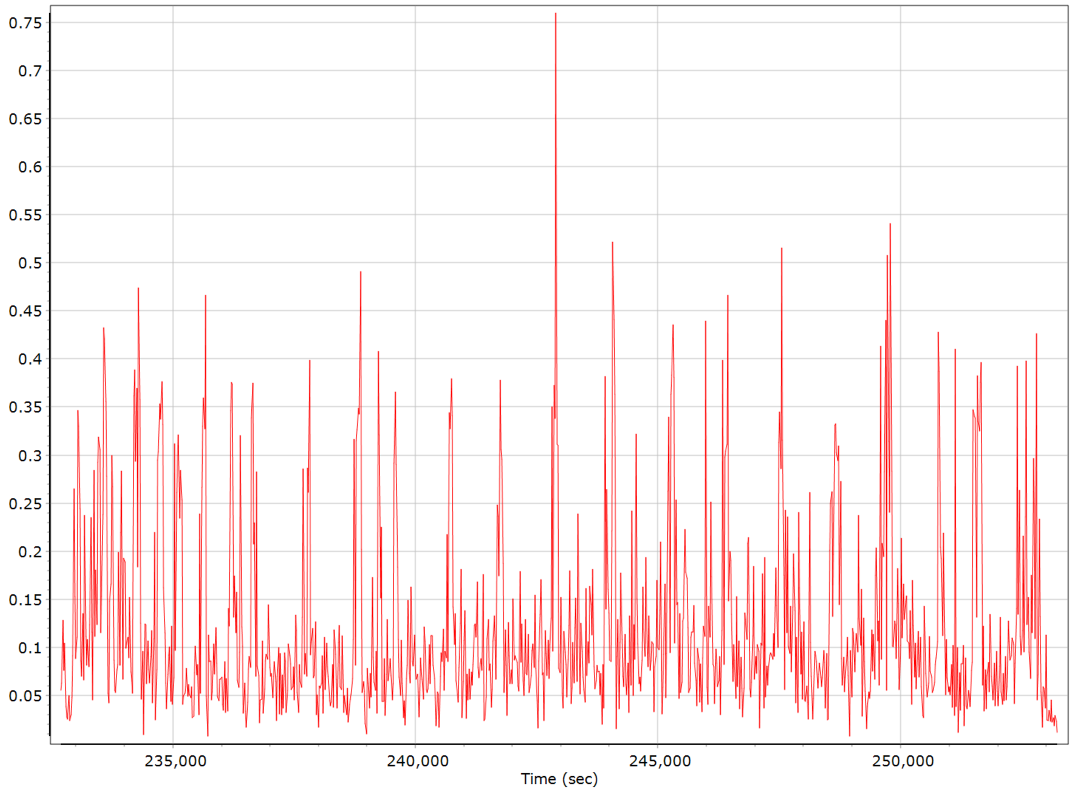
Ground Speed



Body Acceleration



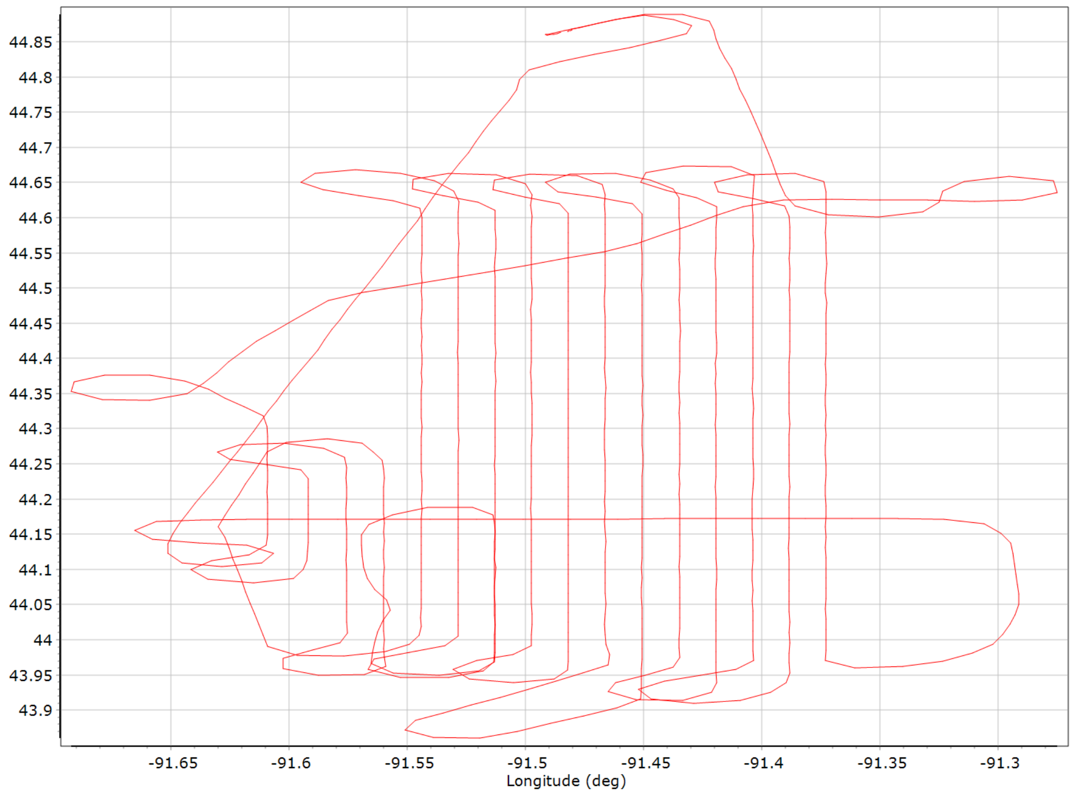
Total Body Acceleration



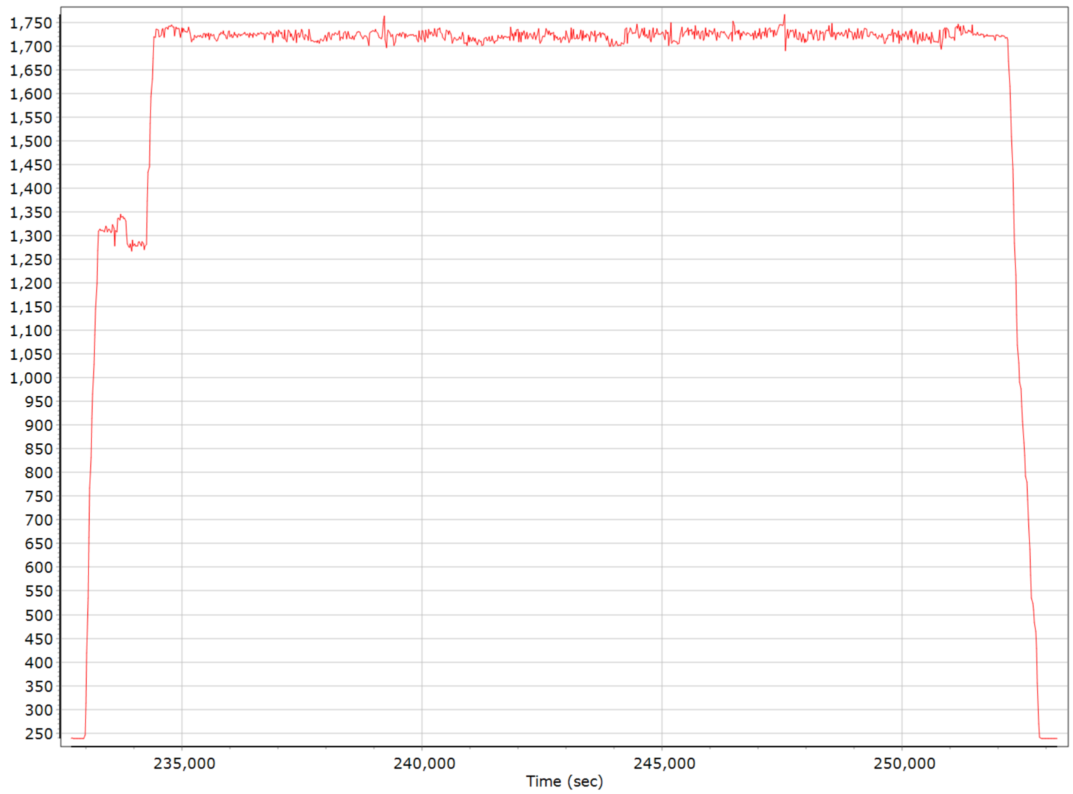
Body Angular Rate

Forward Processed Trajectory Information

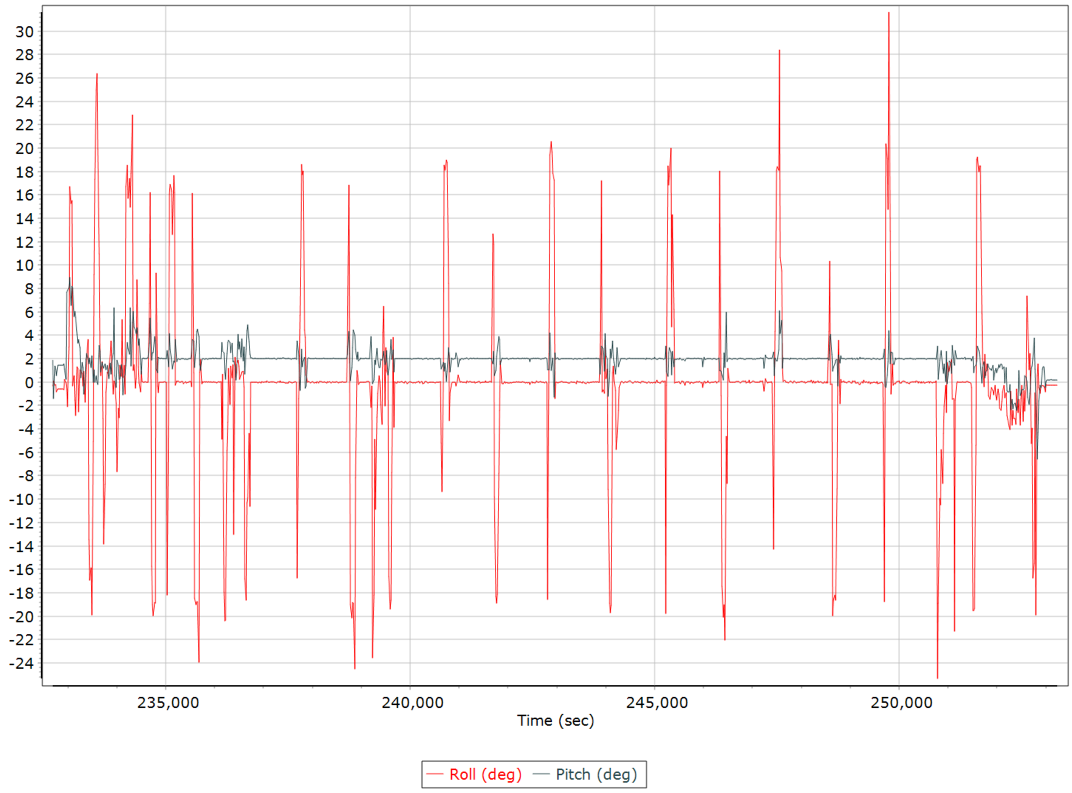
Top View



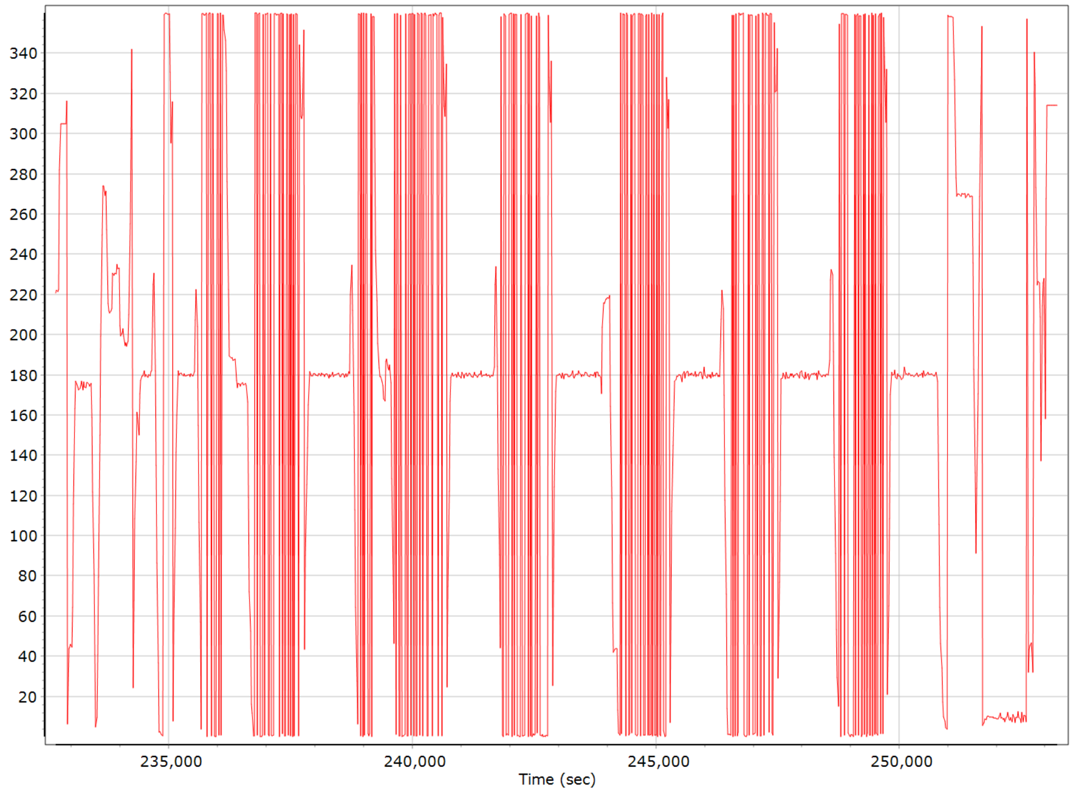
Altitude



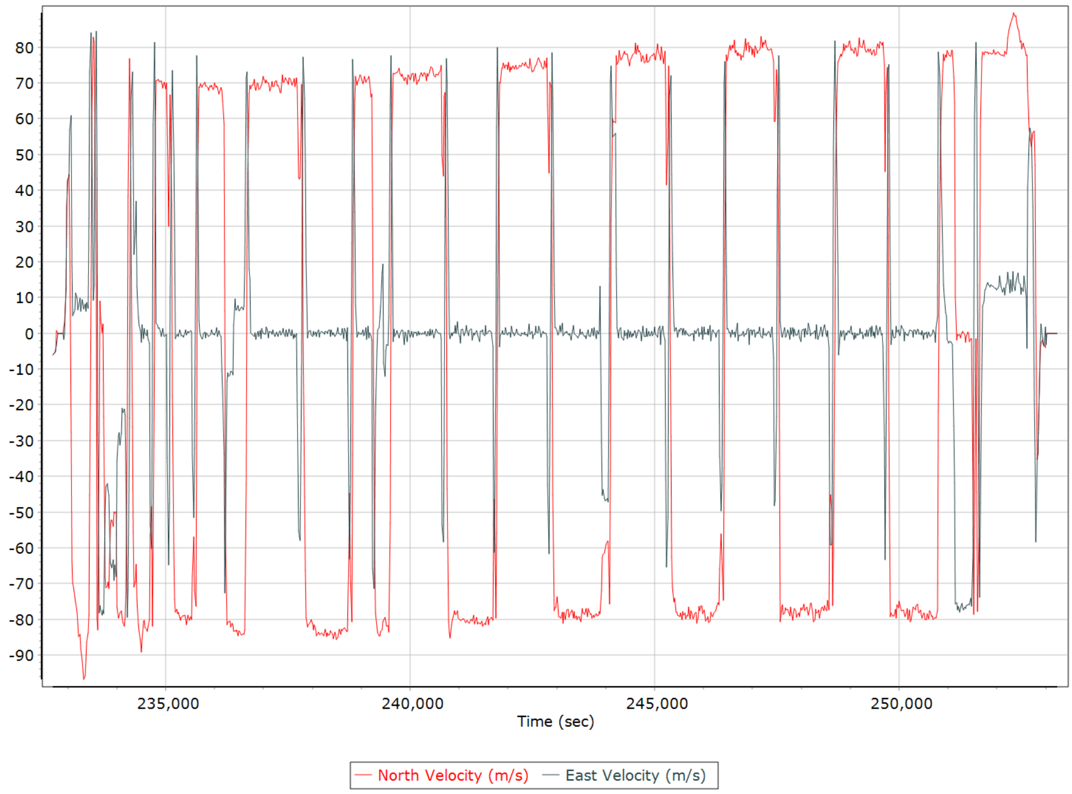
Roll/Pitch



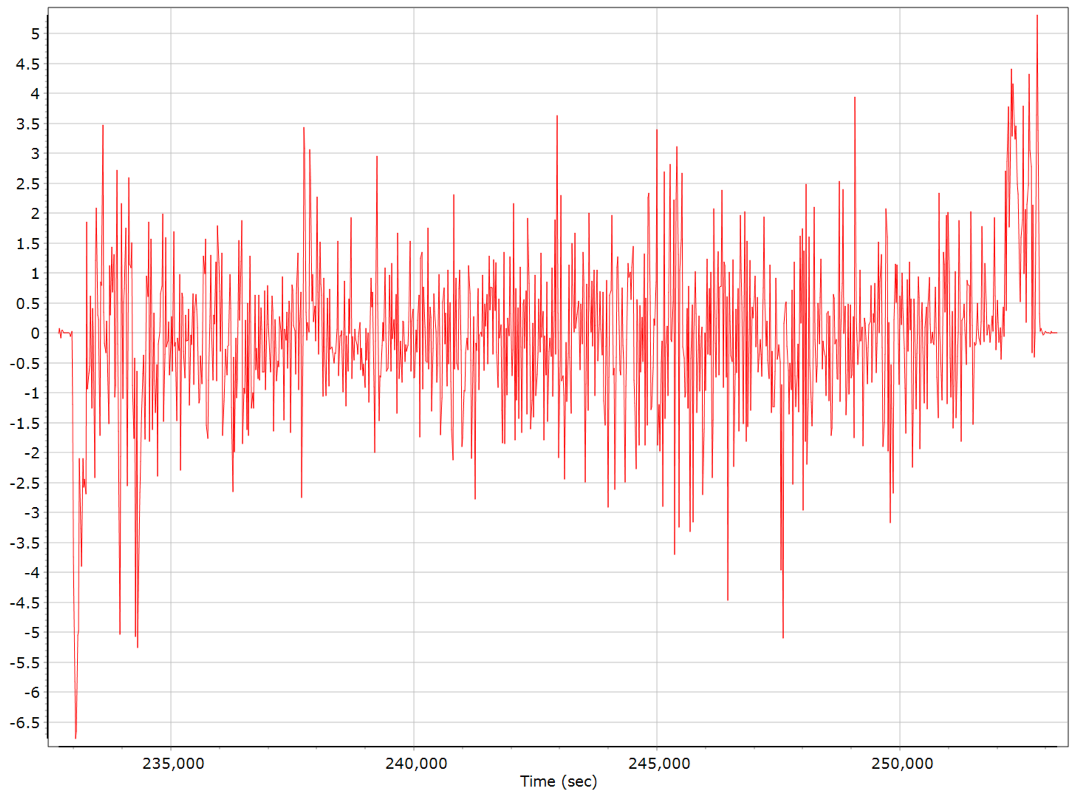
Heading



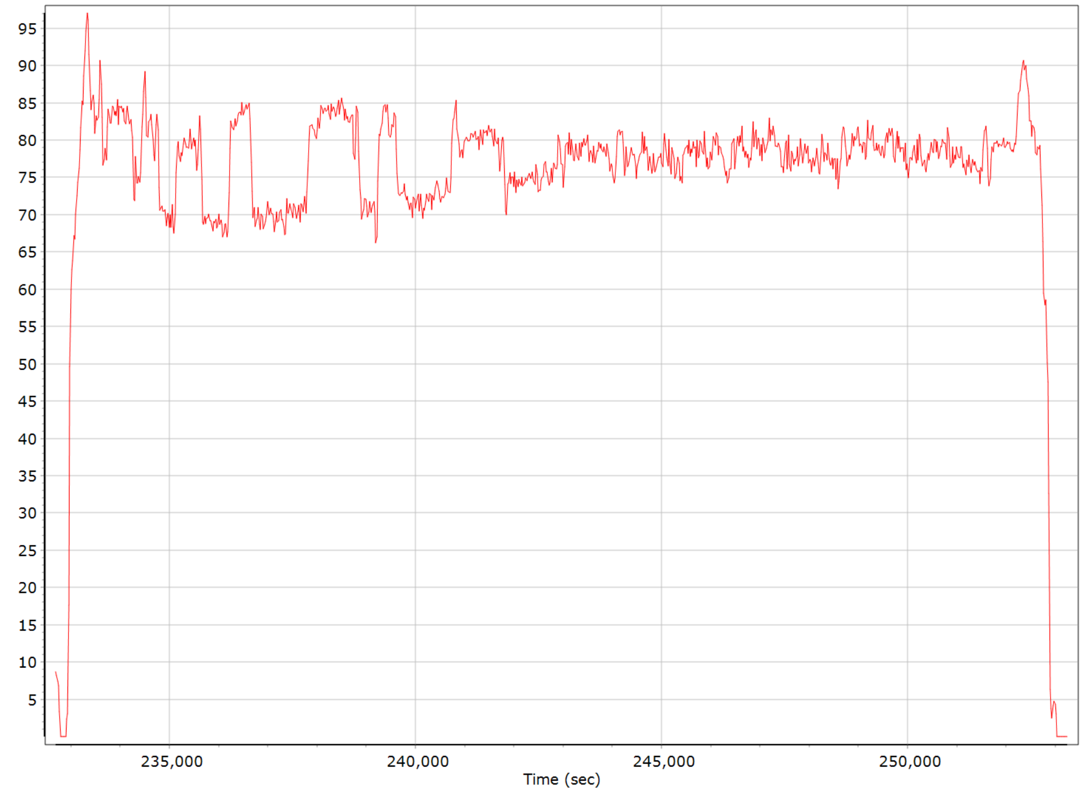
North/East Velocity



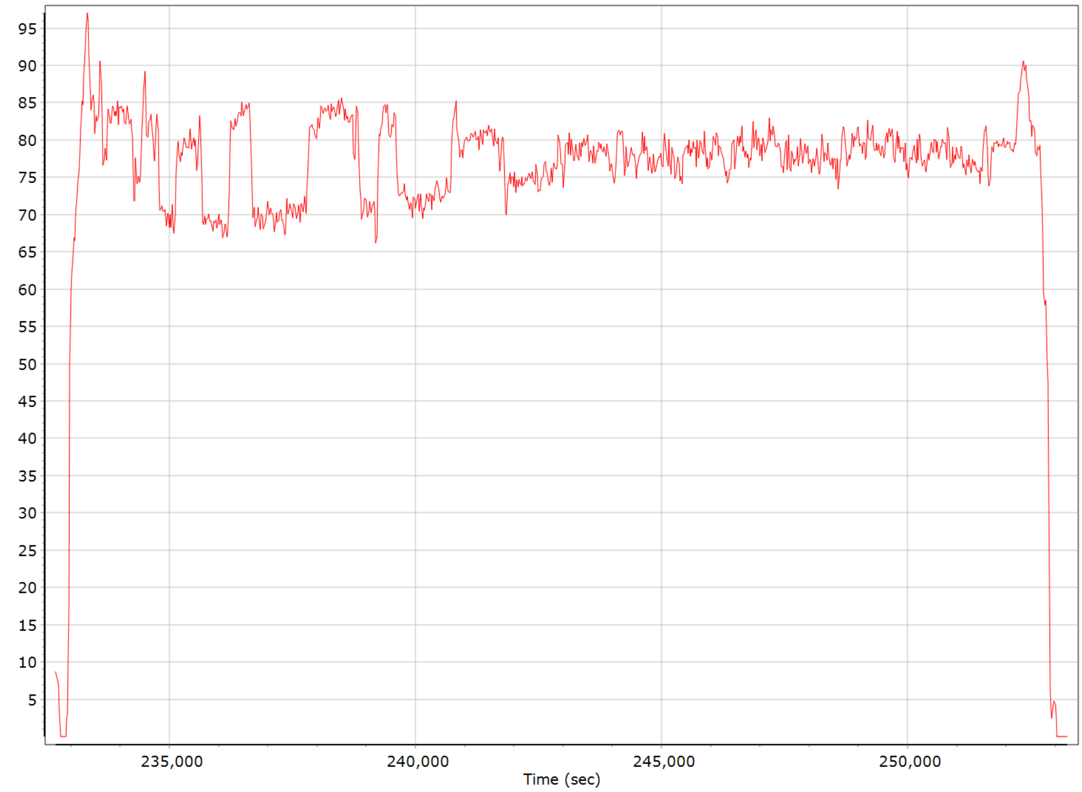
Down Velocity



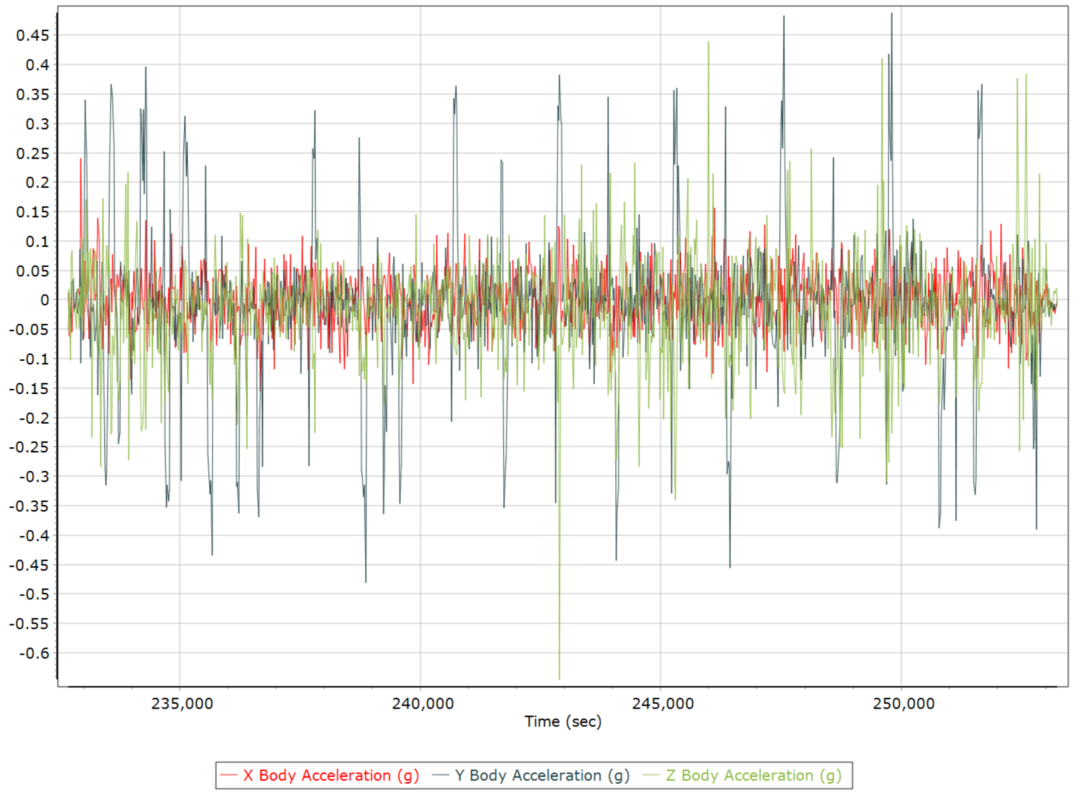
Total Speed



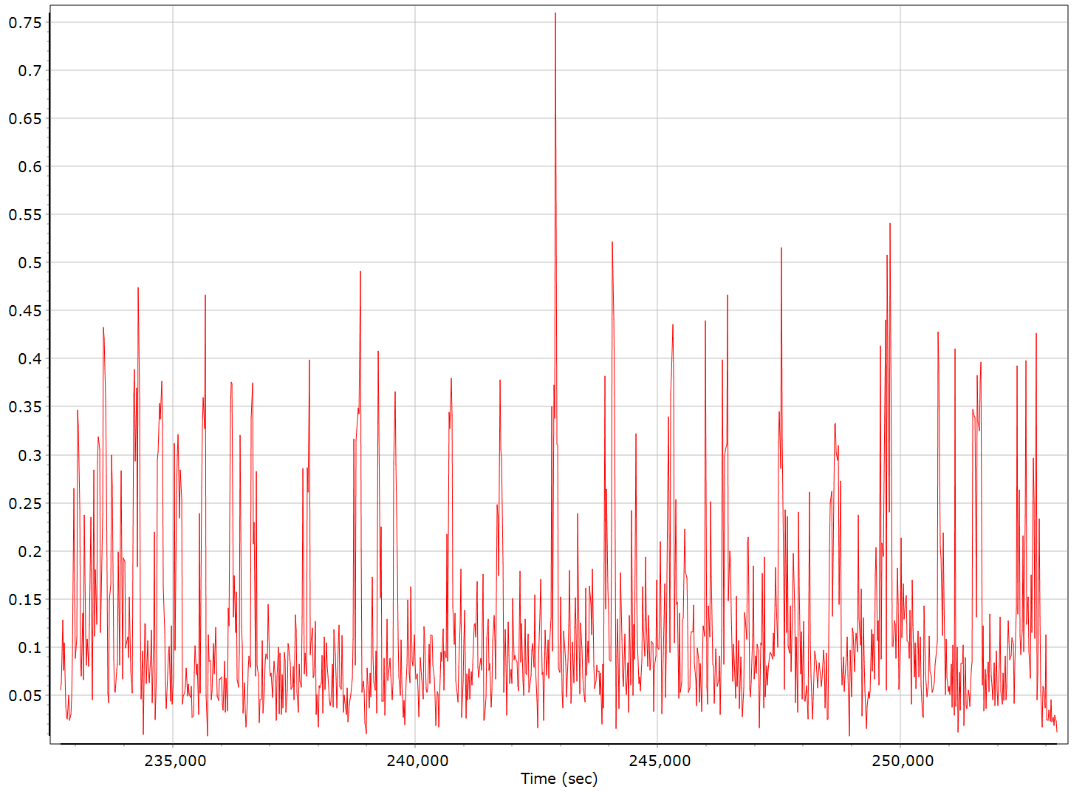
Ground Speed



Body Acceleration



Total Body Acceleration



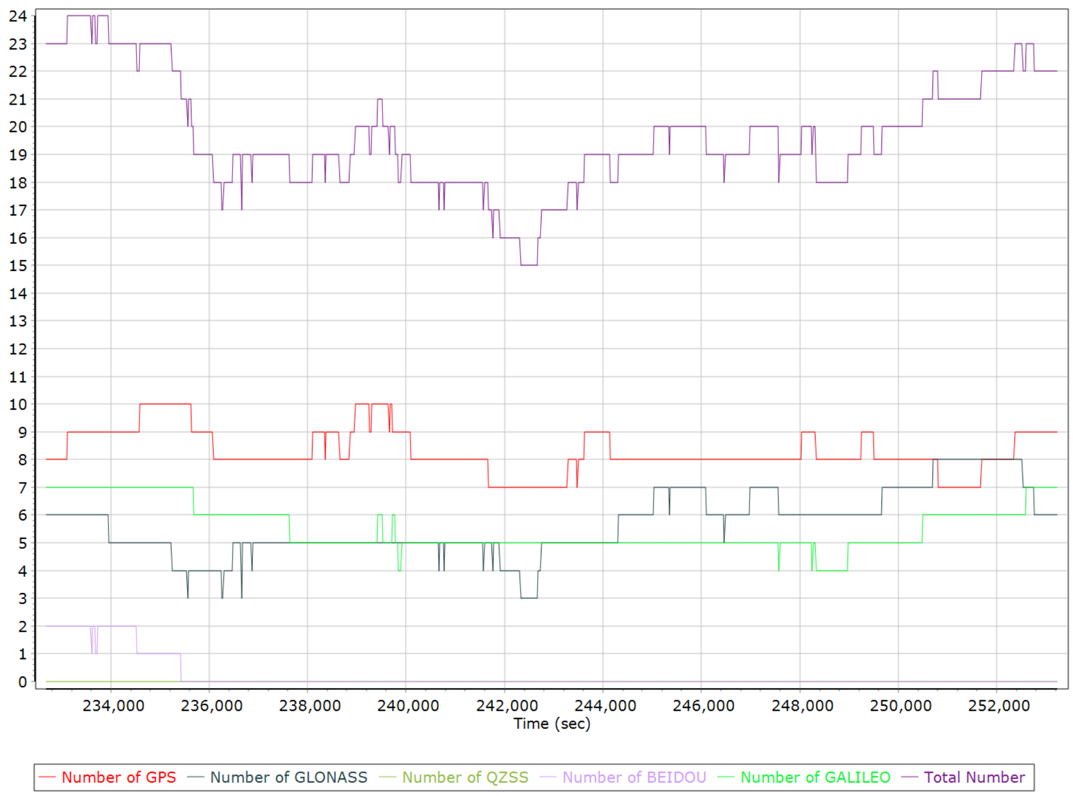
Body Angular Rate

GNSS QC

GNSS QC Statistics

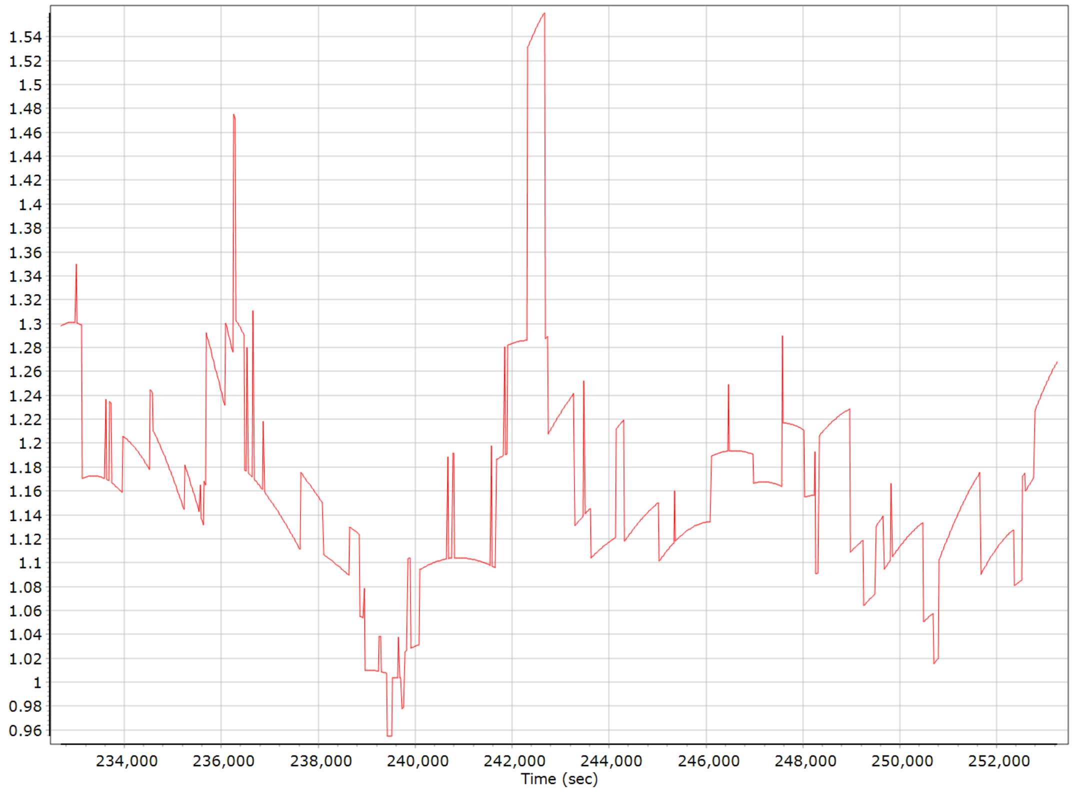
Statistics	Min	Max	Mean
Baseline length (km)	0.00	0.00	
Number of GPS SV	7	10	8
Number of GLONASS SV	3	8	6
Number of QZSS SV	0	0	0
Number of BEIDOU SV	0	2	0
Number of GALILEO SV	4	7	6
Total number of SV	15	24	20
PDOP	0.95	1.56	1.16
QC Solution Gaps	0.00	0.00	
Solution Type	Fixed	Float	No solution
Epoch (sec)	20816.00	0.00	0.00
Percentage	100.00	0.00	0.00

Num SVs in solution

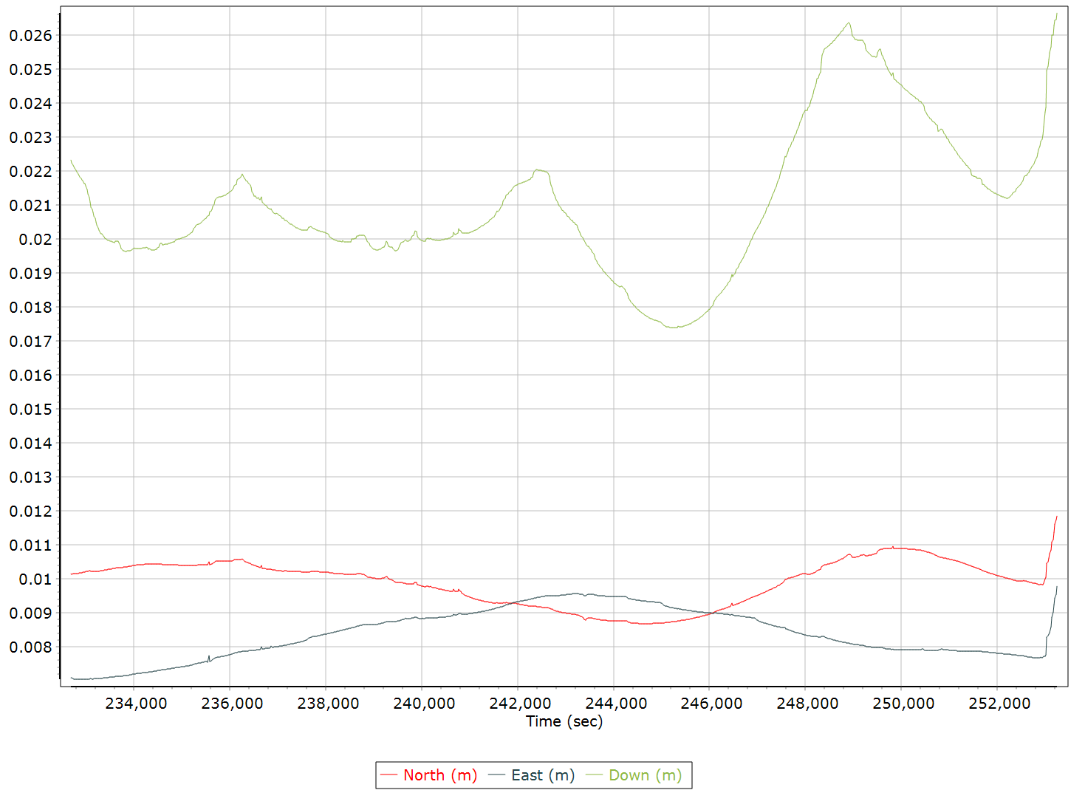


Forward/Reverse Separation

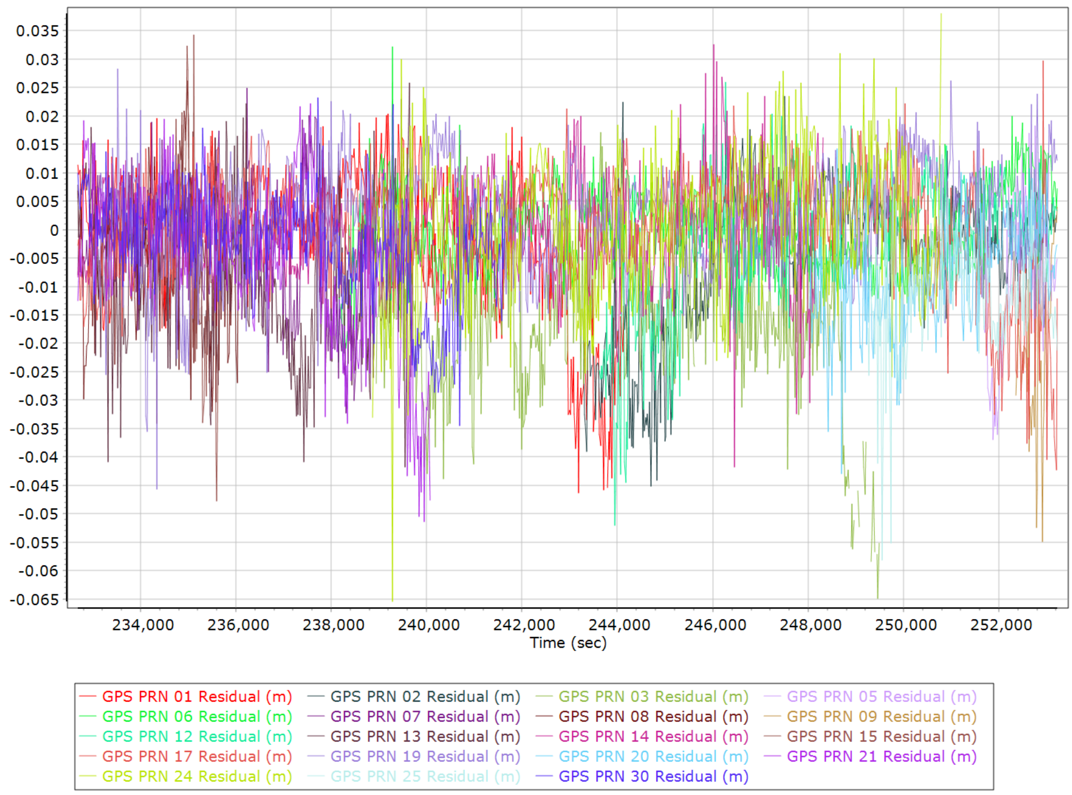
PDOP



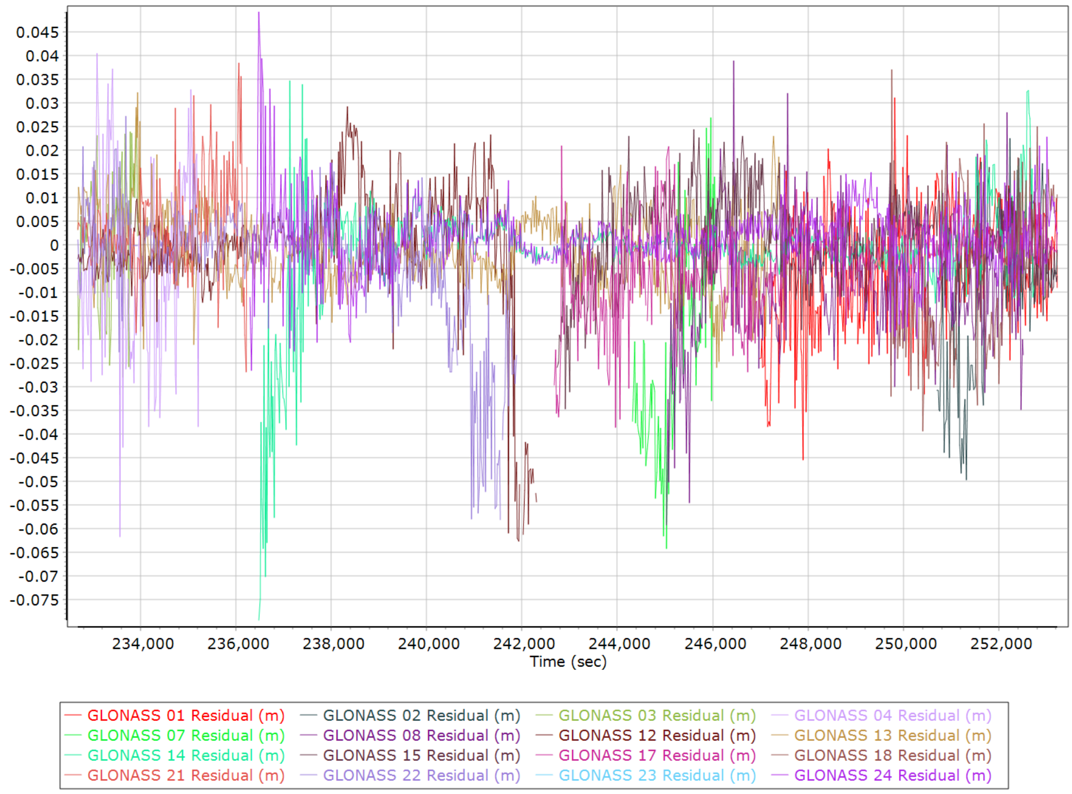
Estimated Position Accuracy



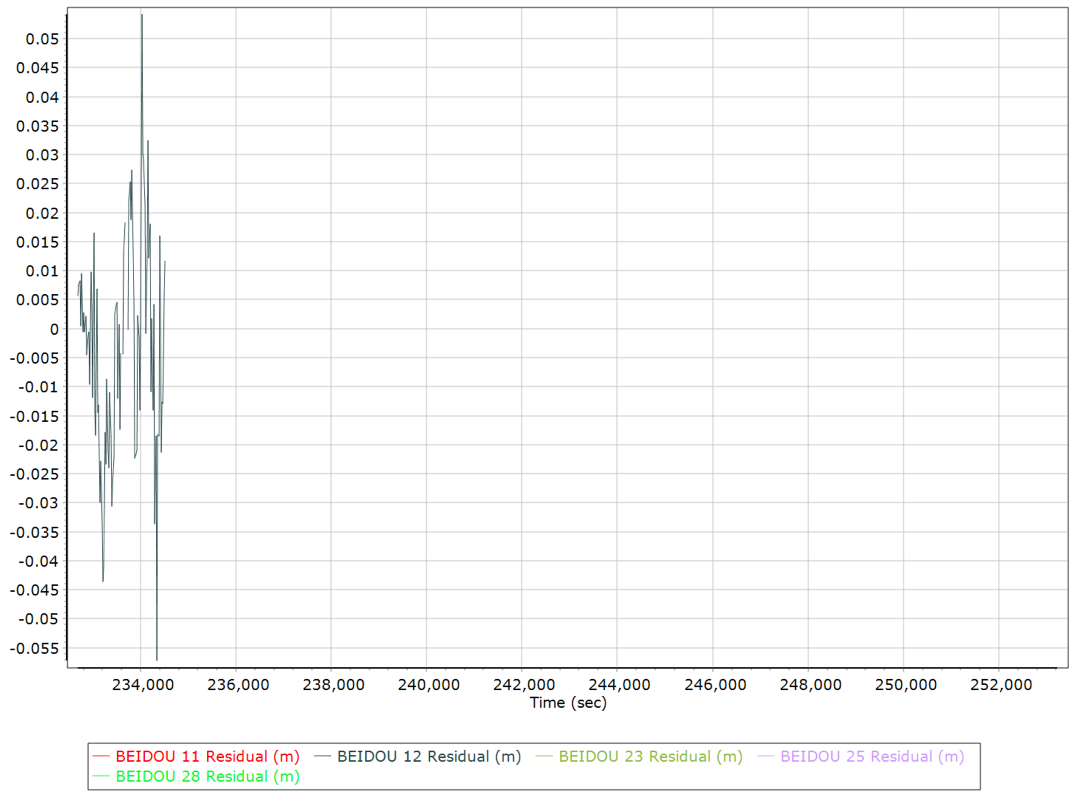
GPS Residuals



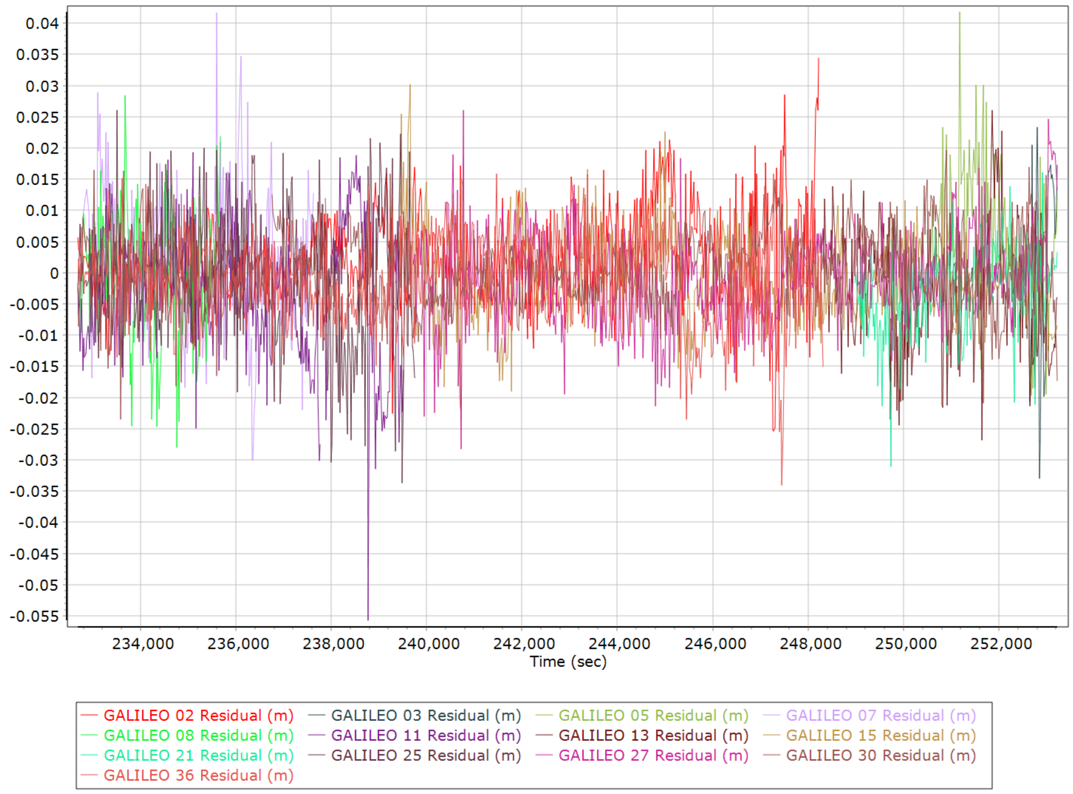
GLONASS Residuals



BEIDOU Residuals



GALILEO Residuals



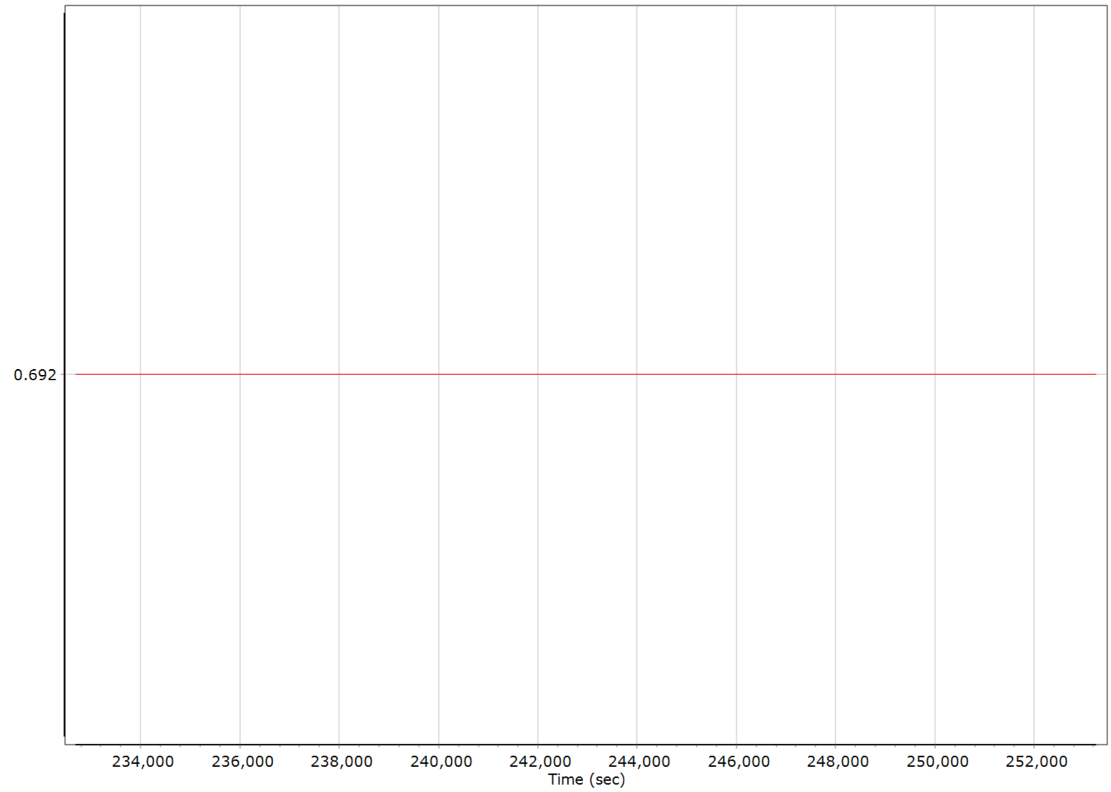
GNSS-Inertial Processor Configuration

Processing mode	IN-Fusion PP-RTX		
Stabilized mount	True		
Processing start time	232396.025 (4/19/2022 4:33:16 PM)		
Processing end time	253259.000 (4/19/2022 10:20:59 PM)		
Initial attitude source	Real-Time VNAV/RNAV Attitude		
IMU Sensor Context	Processing with Onboard IMU		
Gimbal to IMU lever arm (m)	-0.034	-0.010	-0.374
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000
Gimbal to Primary GNSS lever arm (m)	0.692	-0.181	-1.276
Gimbal to Primary GNSS lever arm std dev (m)	0.030	0.030	0.030
Aircraft to Reference mounting angles (deg)	0.000	0.000	0.000

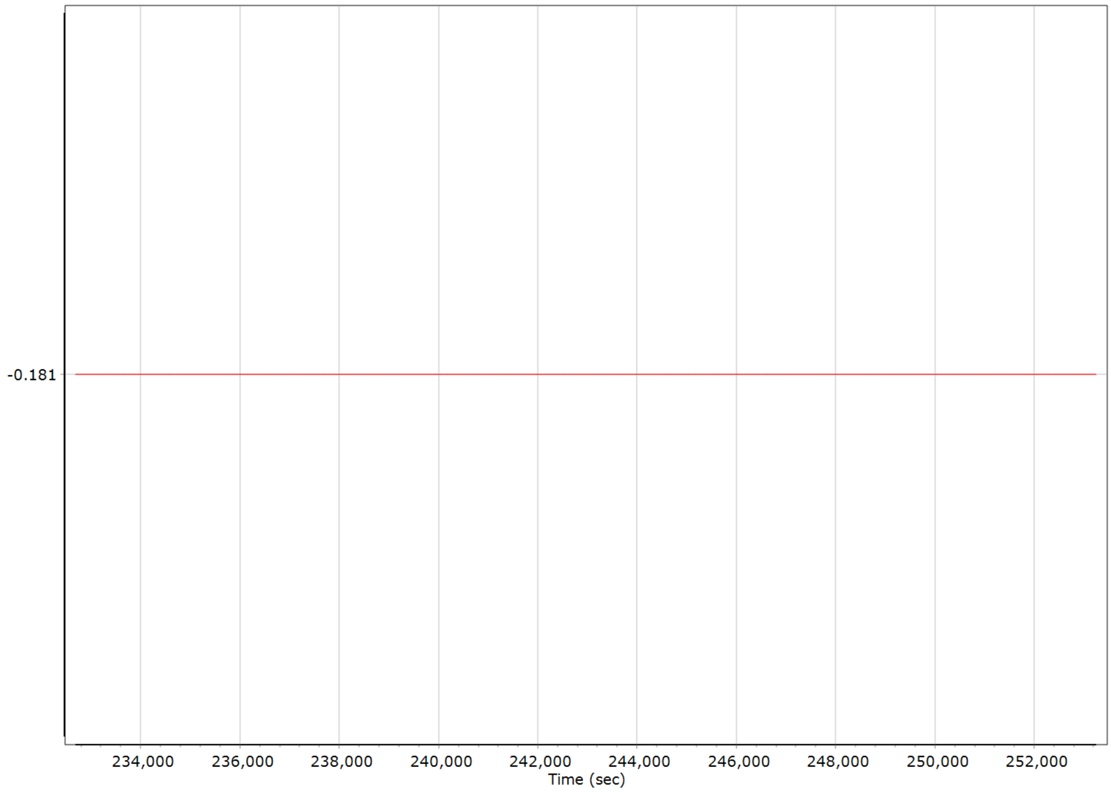
Calibrated Installation Parameters

Reference-Primary GNSS Lever Arm (m)

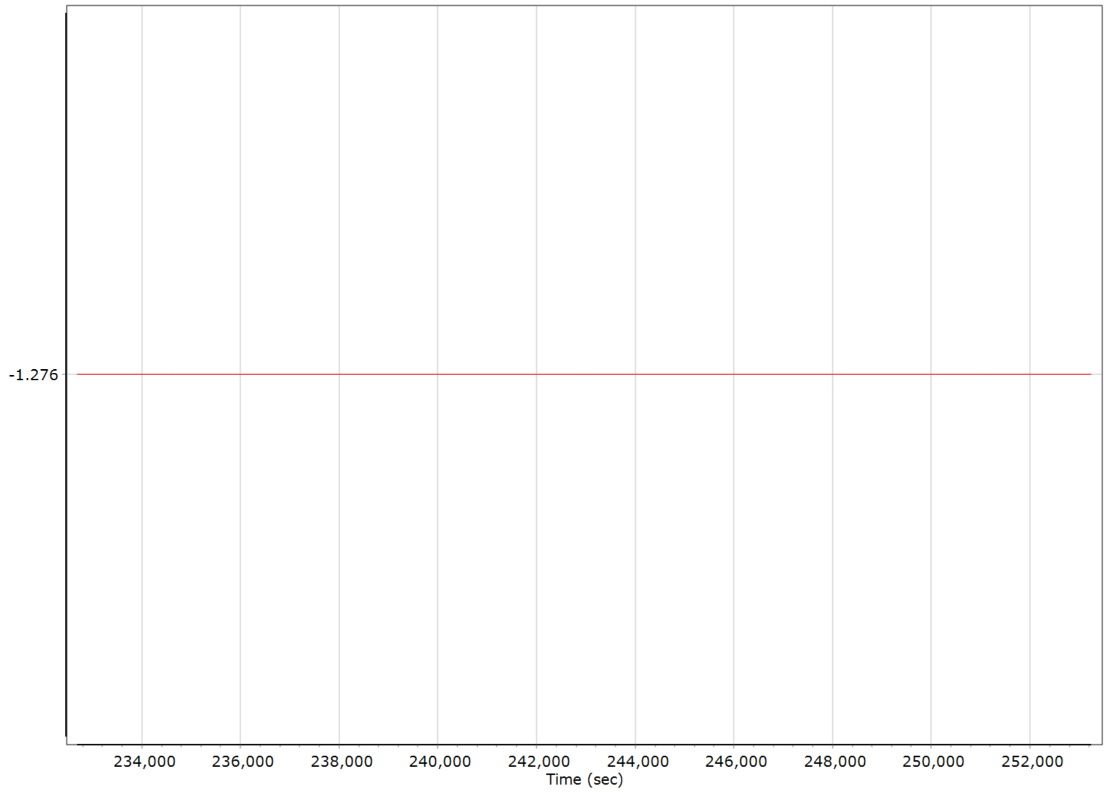
X Reference-Primary GNSS Lever Arm (m)



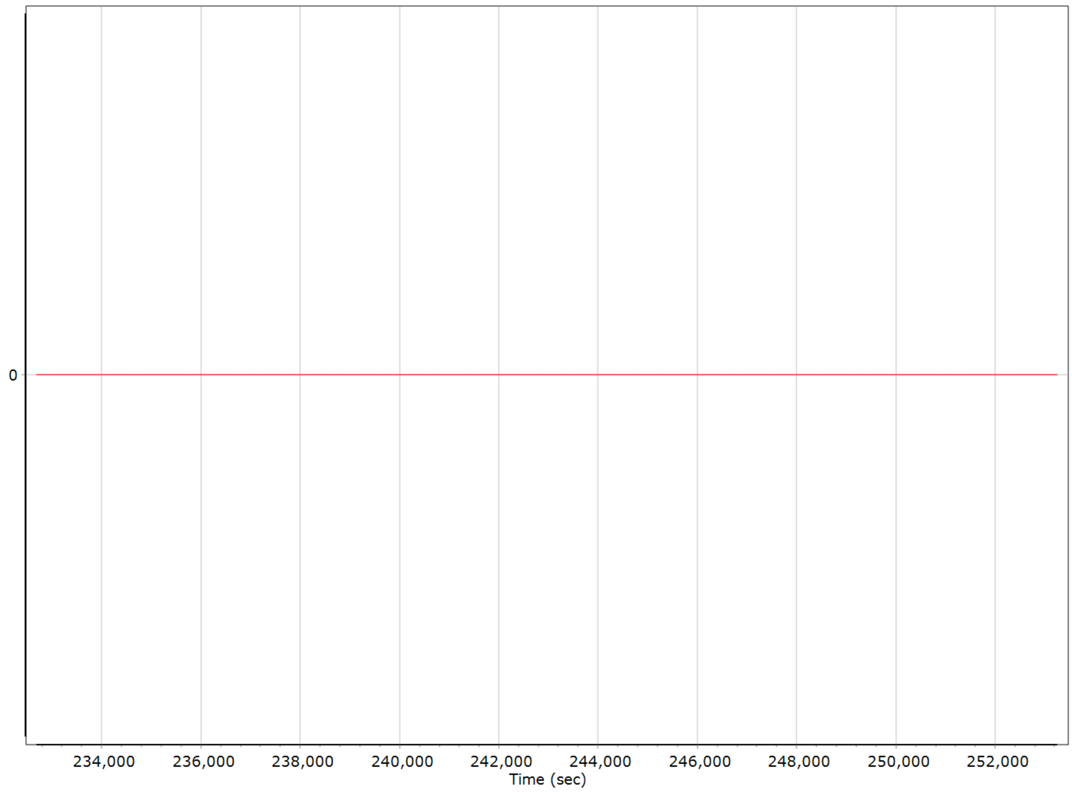
Y Reference-Primary GNSS Lever Arm (m)



Z Reference-Primary GNSS Lever Arm (m)



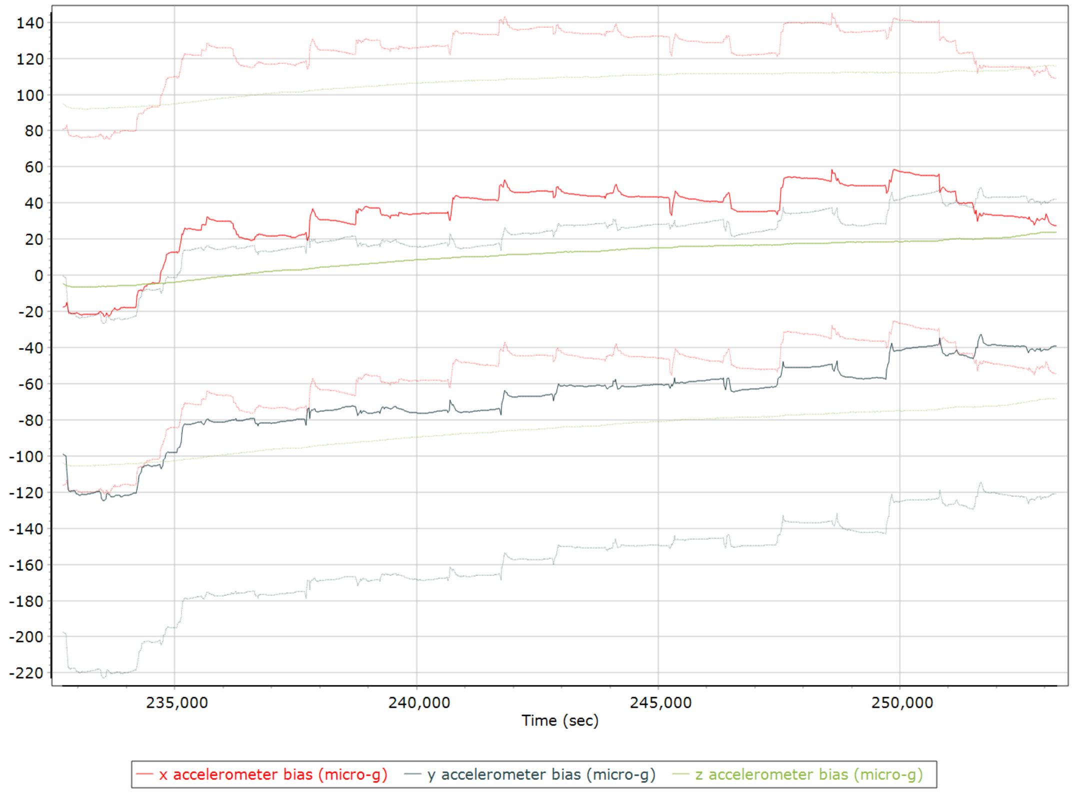
Reference-Primary GNSS Lever Arm Figure of Merit



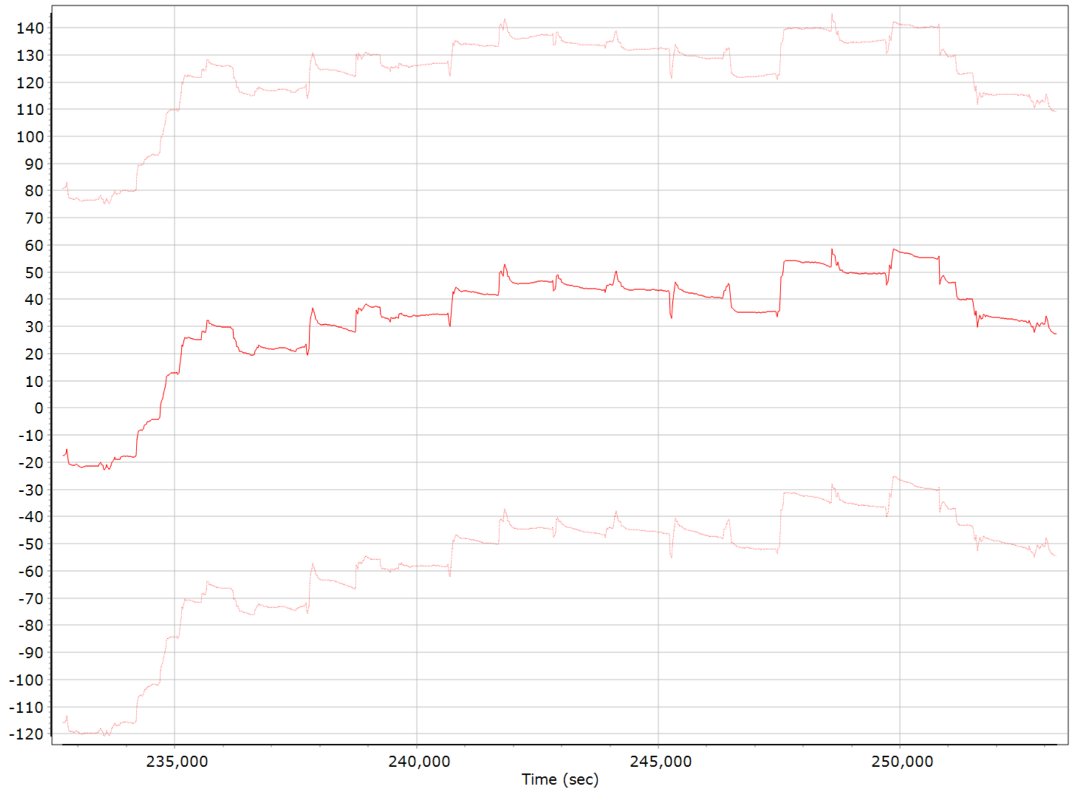
IN-Fusion QC

Forward Processed Estimated Errors, Reference Frame

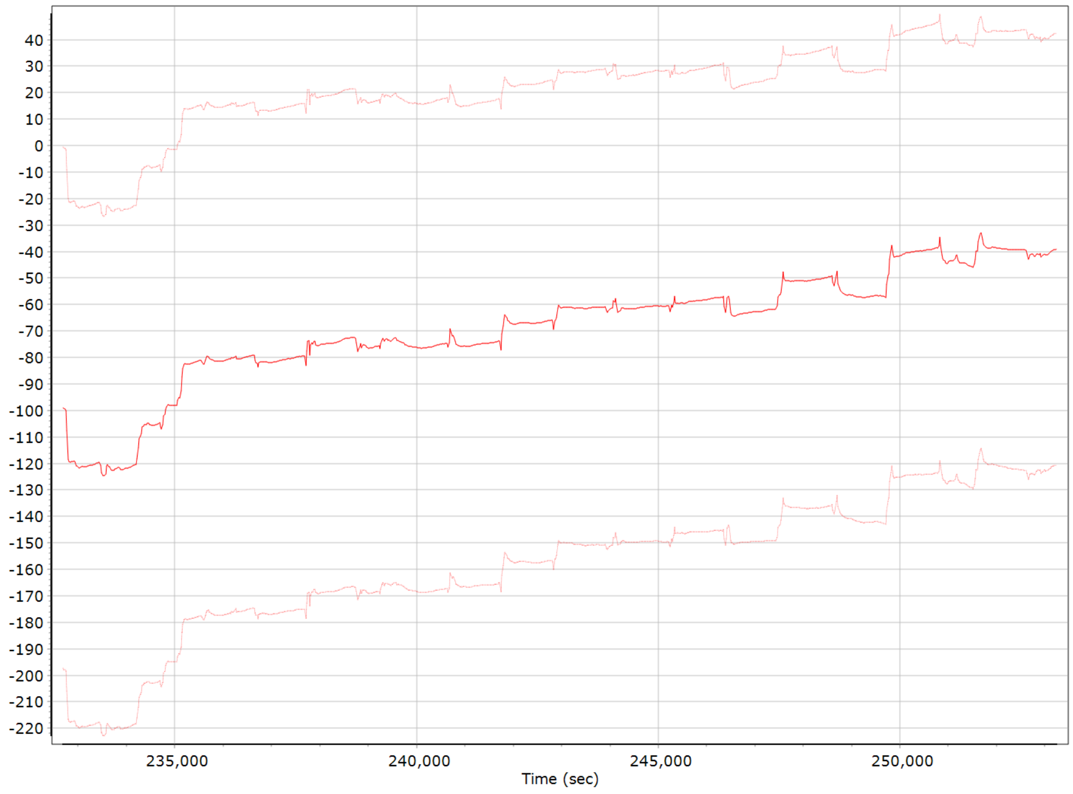
Accelerometer Bias (micro-g)



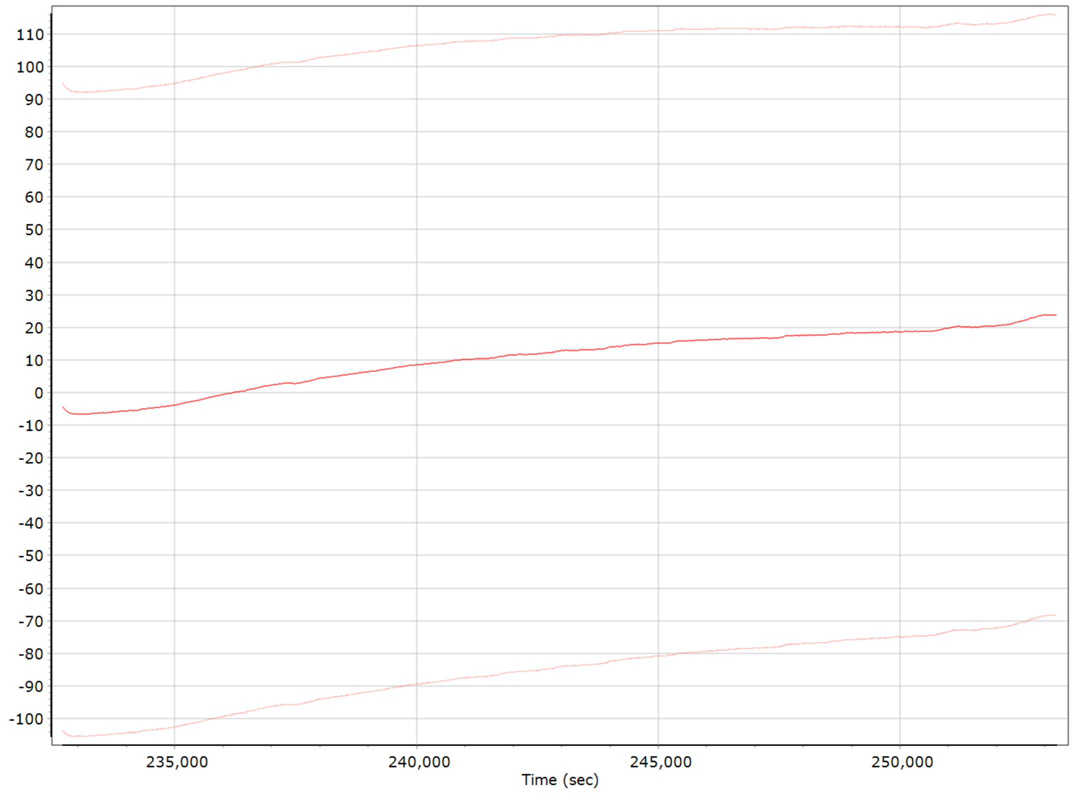
X Accelerometer Bias (micro-g)



Y Accelerometer Bias (micro-g)



Z Accelerometer Bias (micro-g)

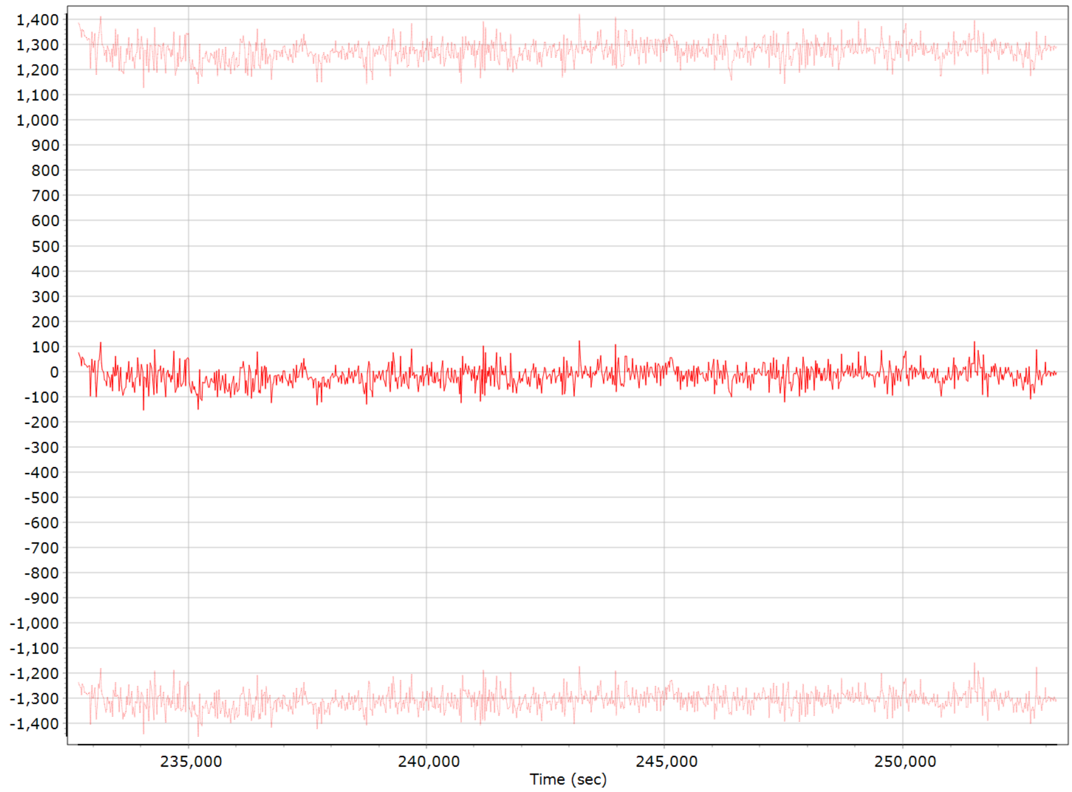


Accelerometer Scale Error (ppm)

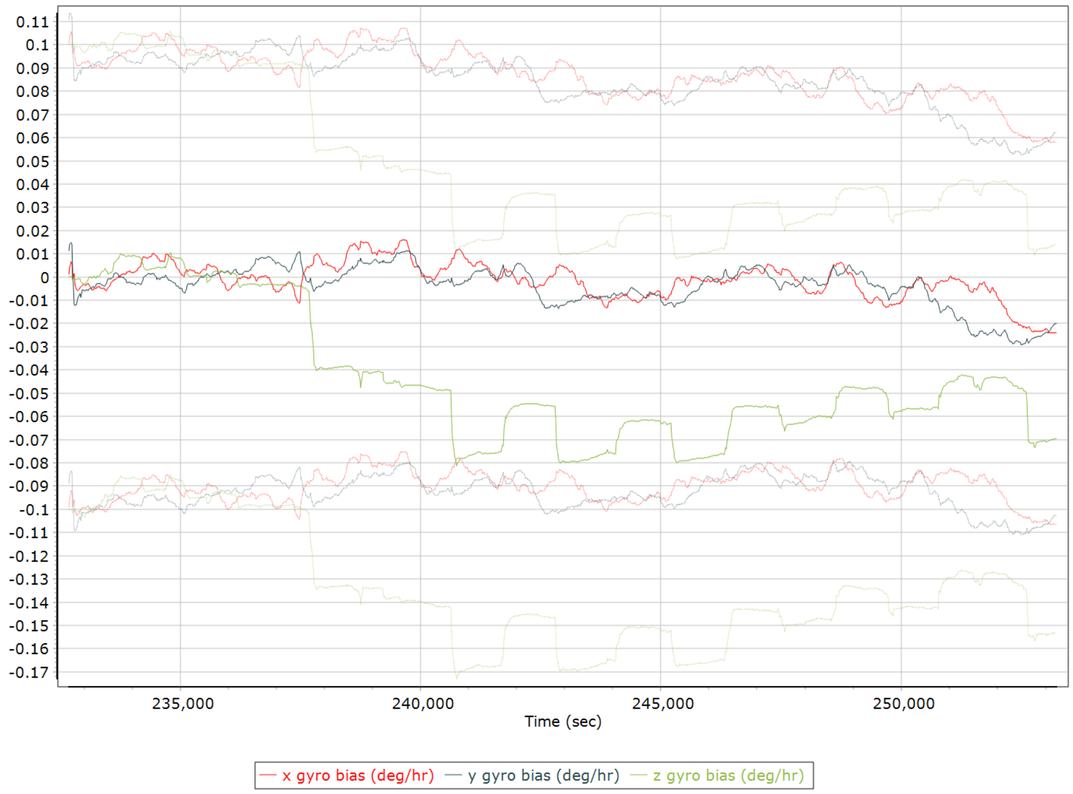
X Accelerometer Scale Error (ppm)

Y Accelerometer Scale Error (ppm)

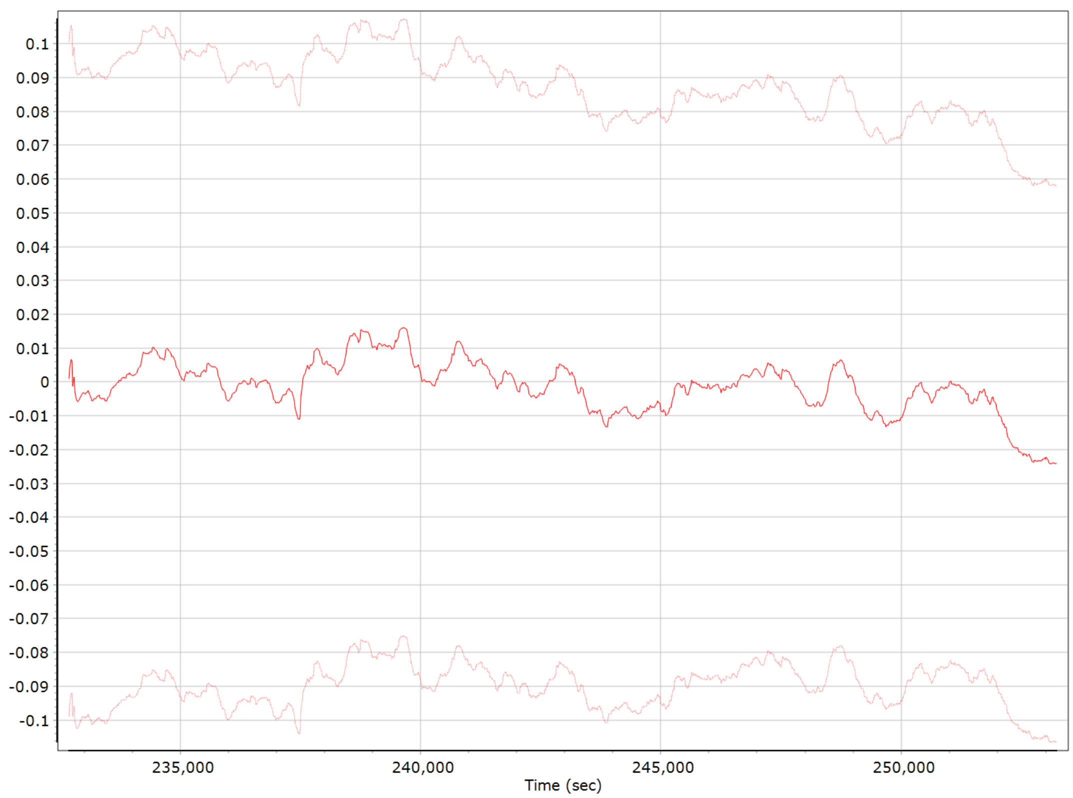
Z Accelerometer Scale Error (ppm)



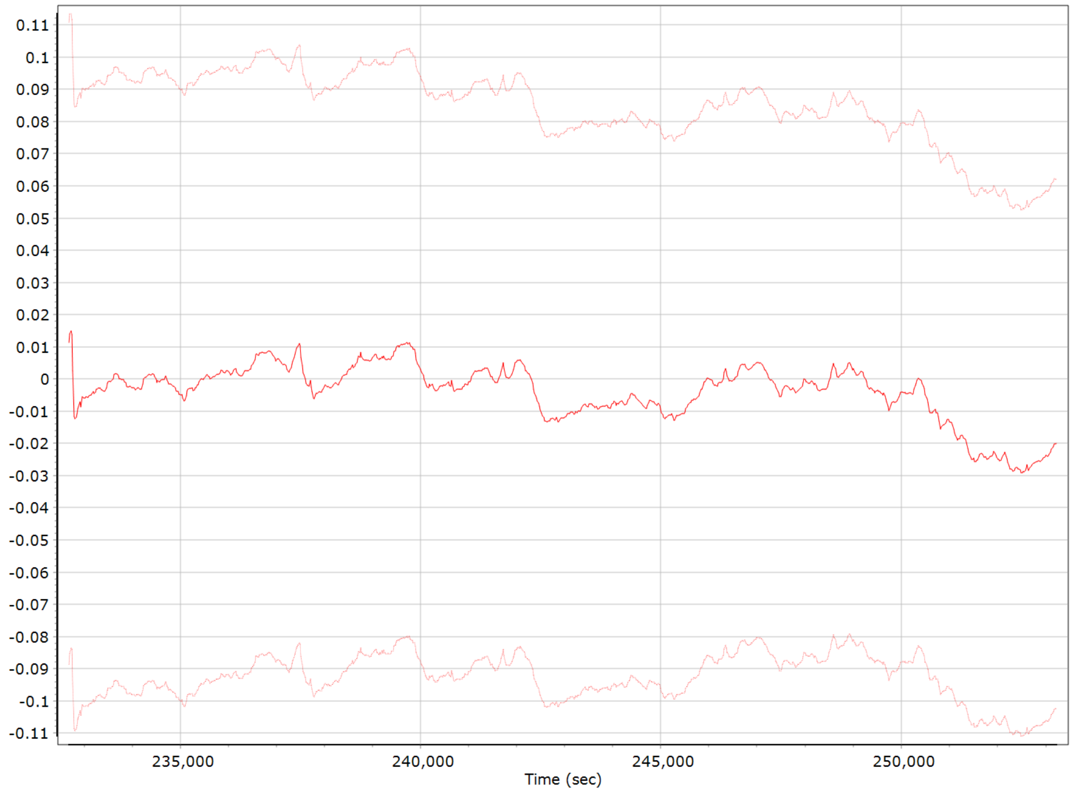
Gyro Bias (deg/h)



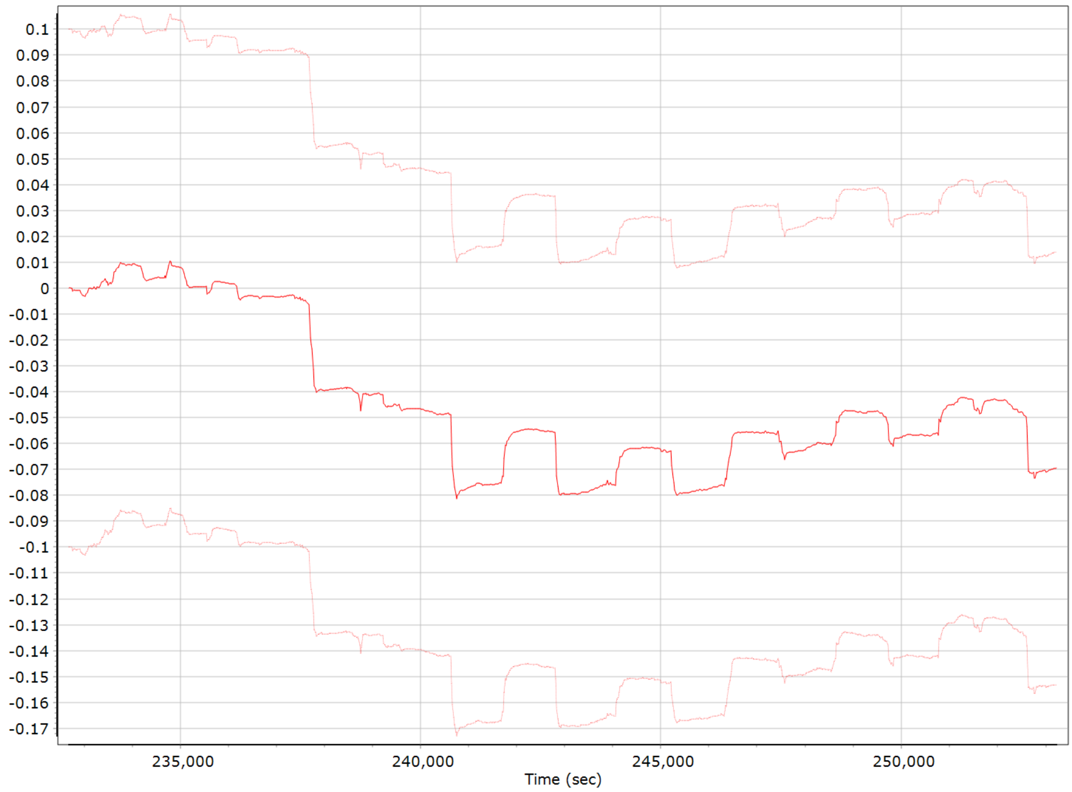
X Gyro Bias (deg/h)



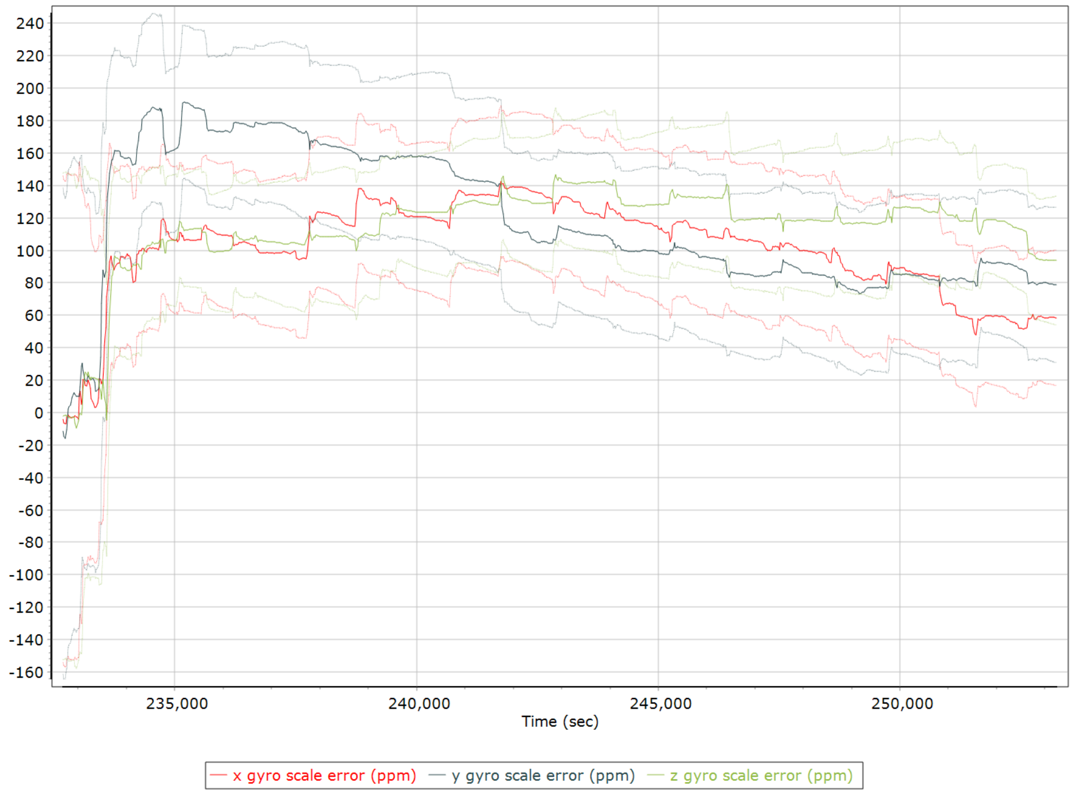
Y Gyro Bias (deg/h)



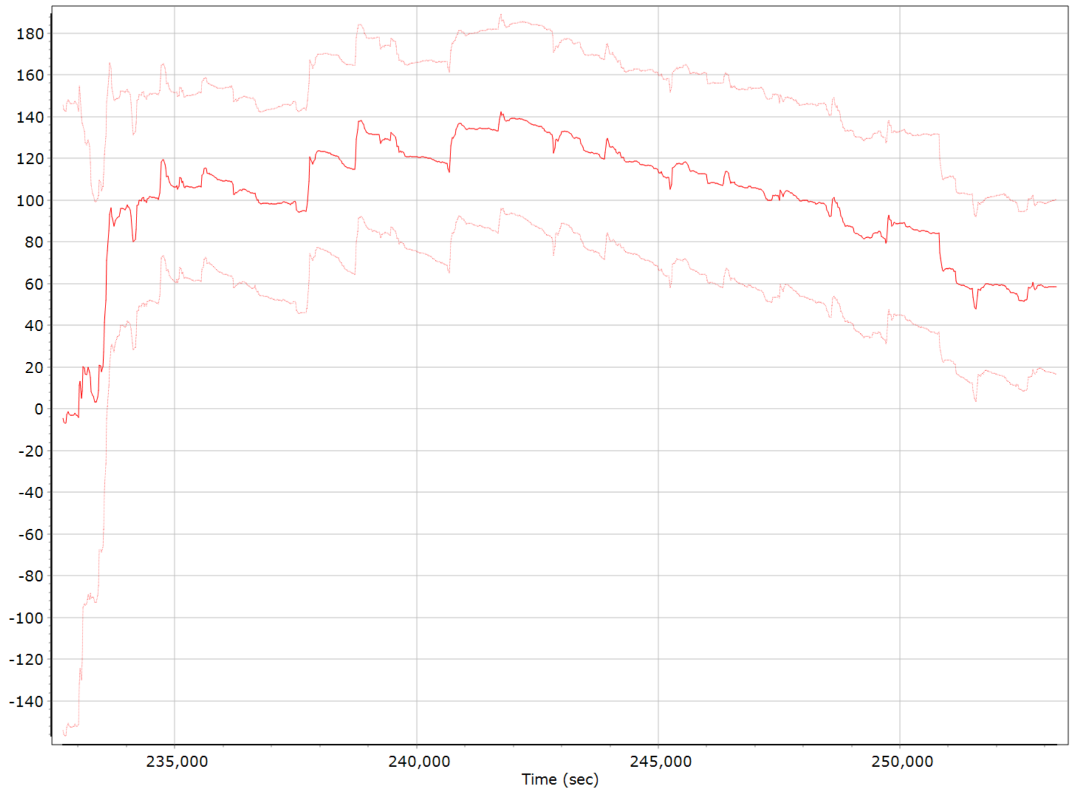
Z Gyro Bias (deg/h)



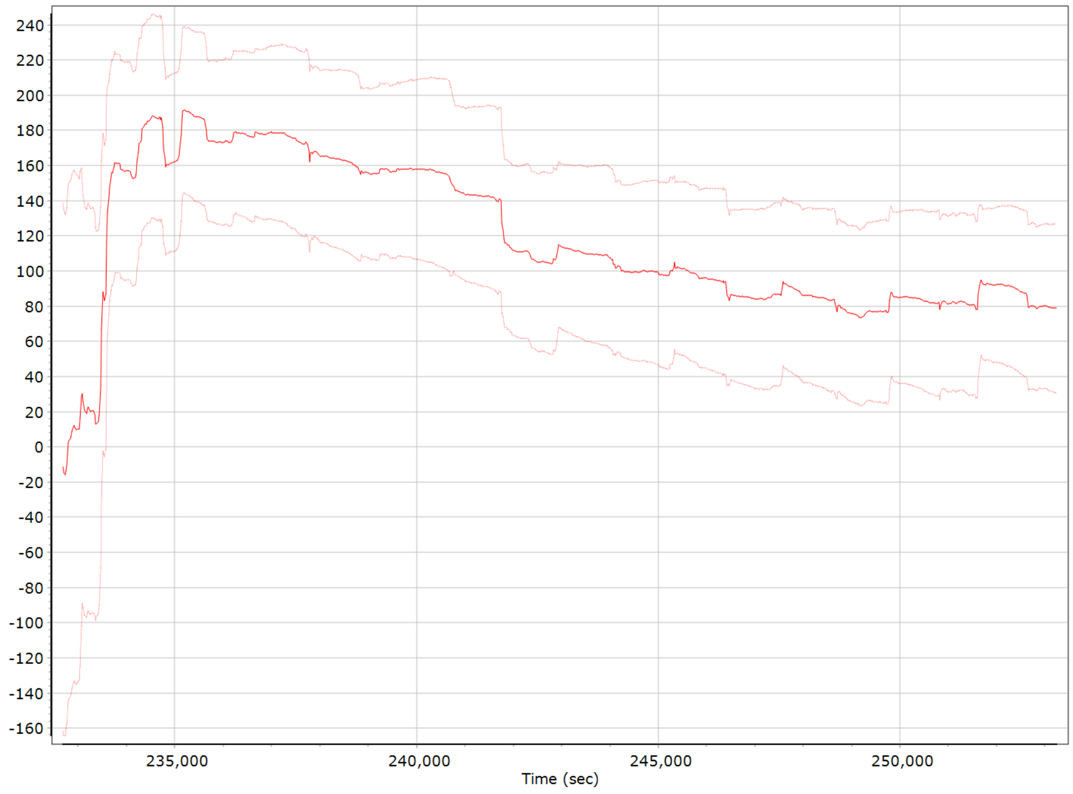
Gyro Scale Error (ppm)



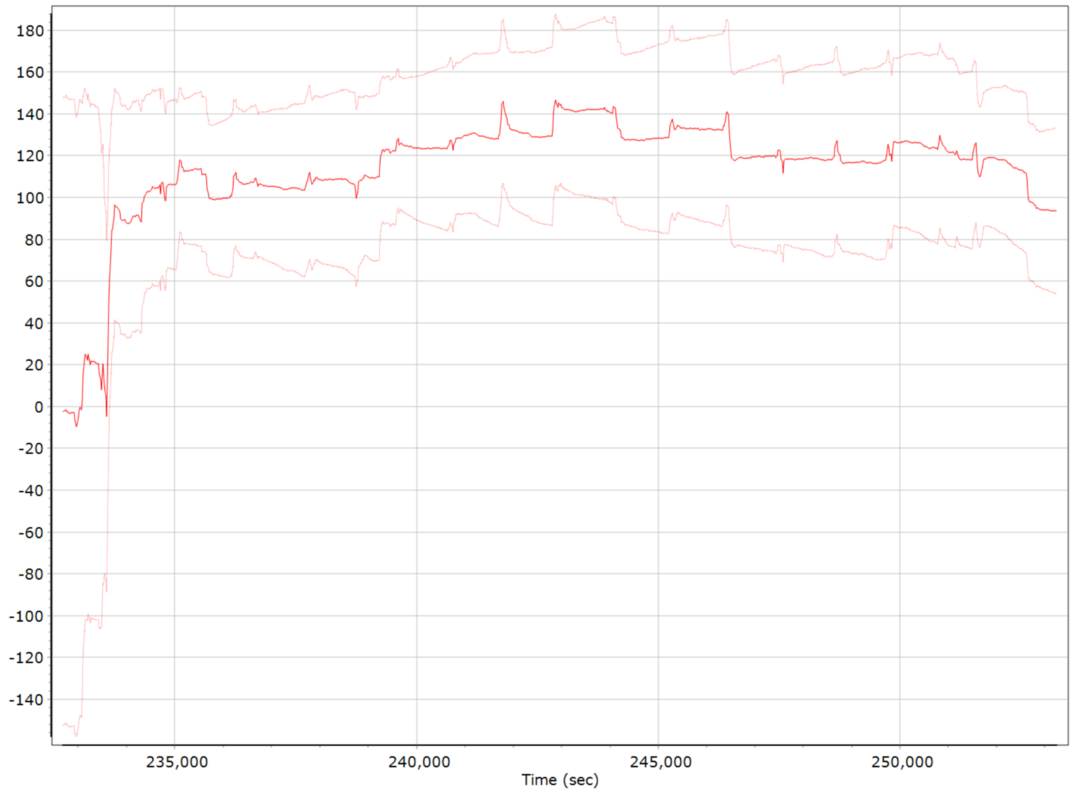
X Gyro Scale Error (ppm)



Y Gyro Scale Error (ppm)

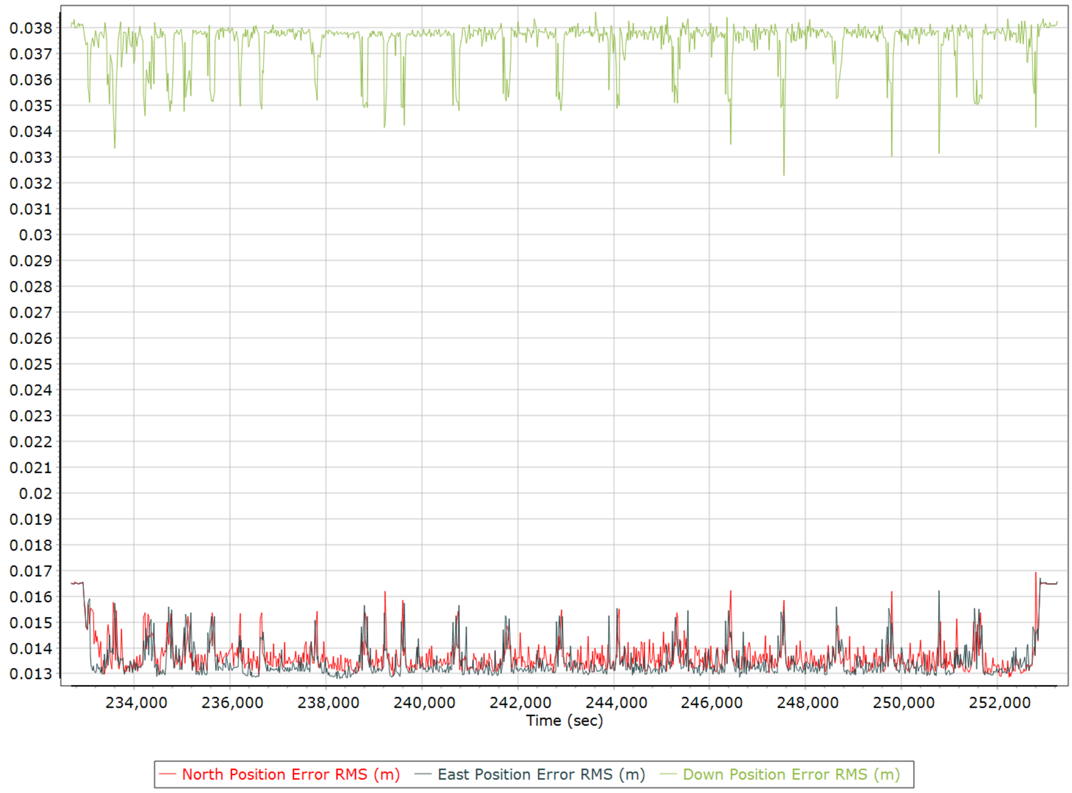


Z Gyro Scale Error (ppm)

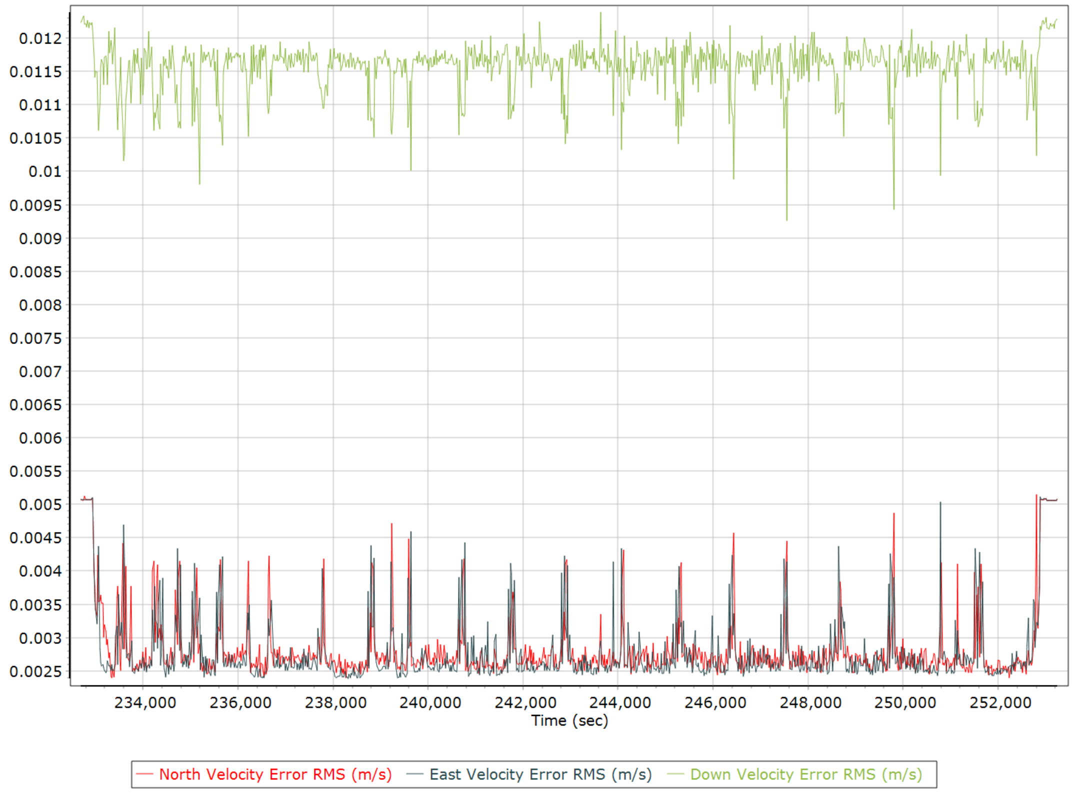


Smoothed Performance Metrics

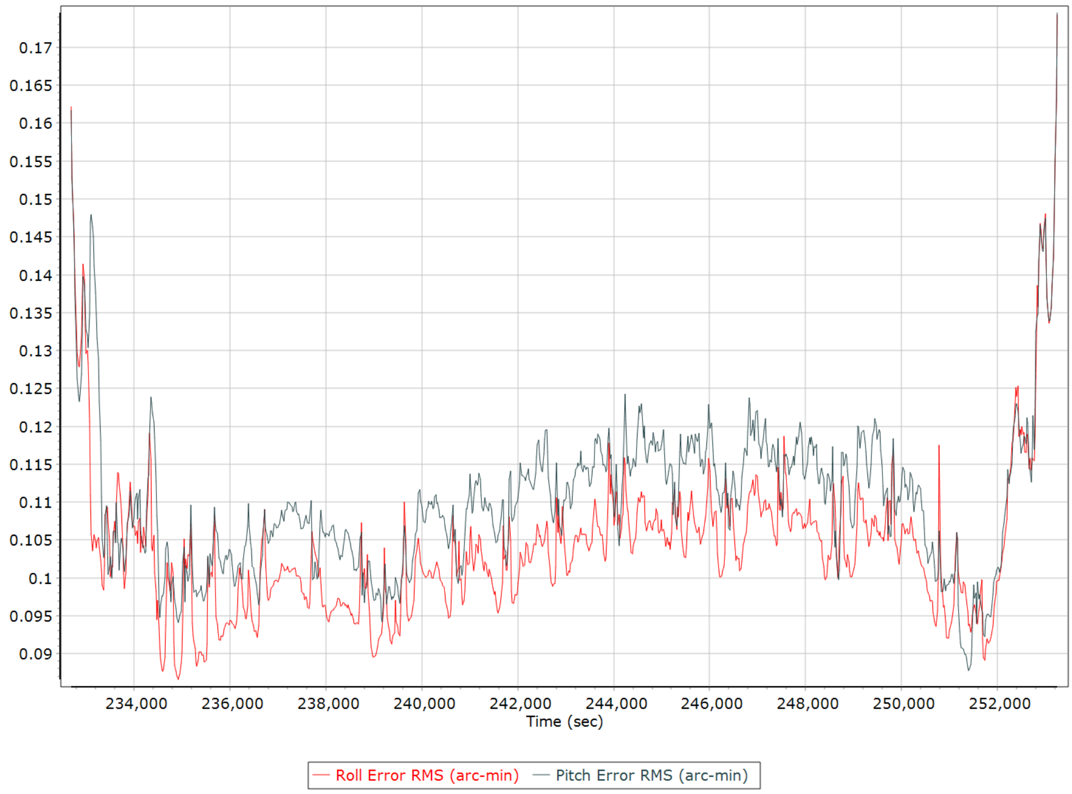
Position Error RMS (m)



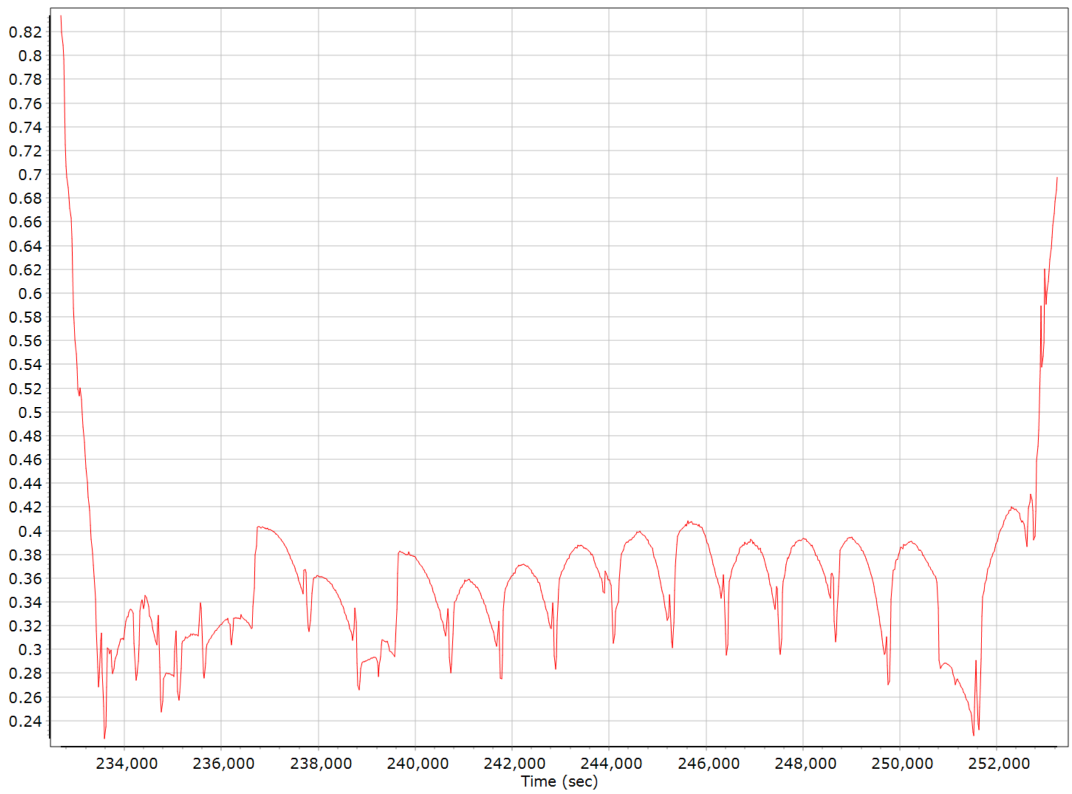
Velocity Error RMS (m/s)



Roll/Pitch Error RMS (arc-min)

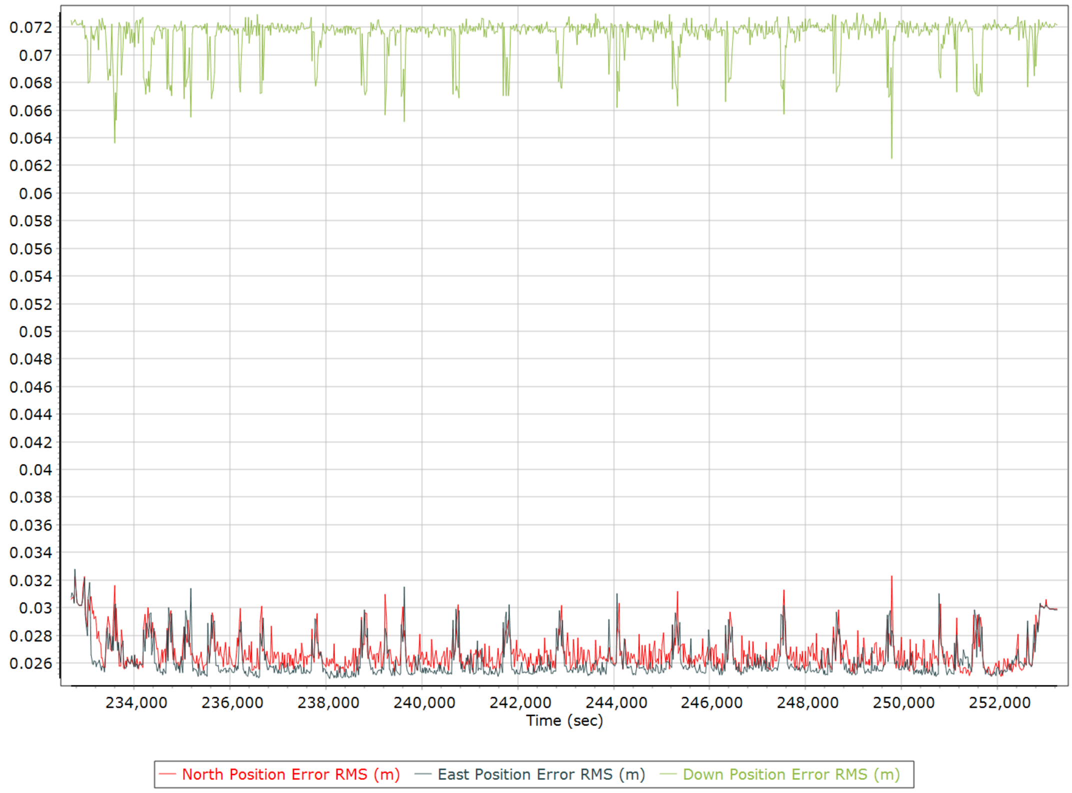


Heading Error RMS (arc-min)



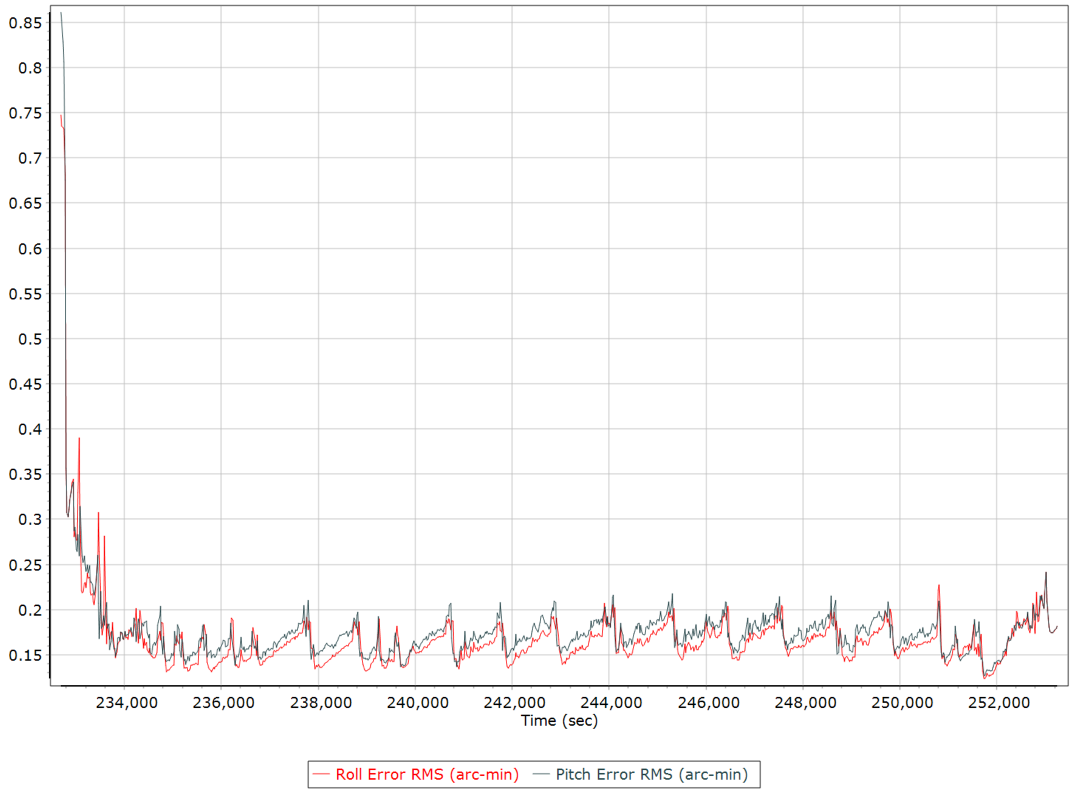
Forward Processed Performance Metrics

Position Error RMS (m)

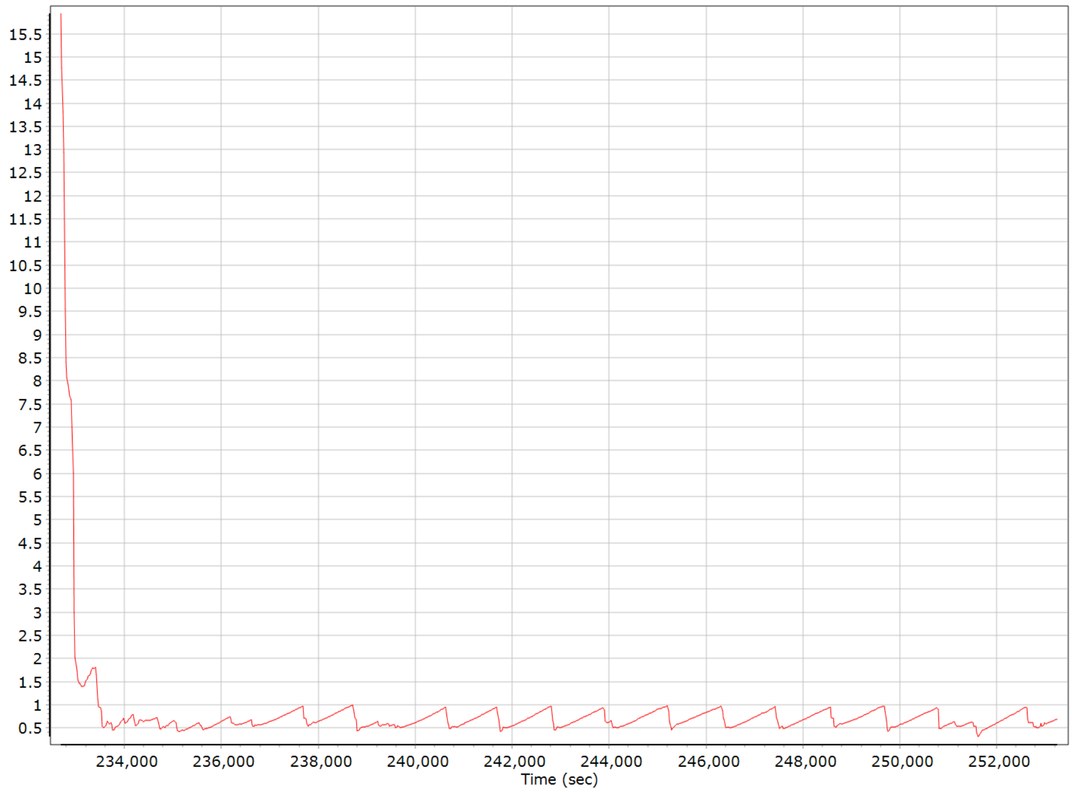


Velocity Error RMS (m/s)

Roll/Pitch Error RMS (arc-min)

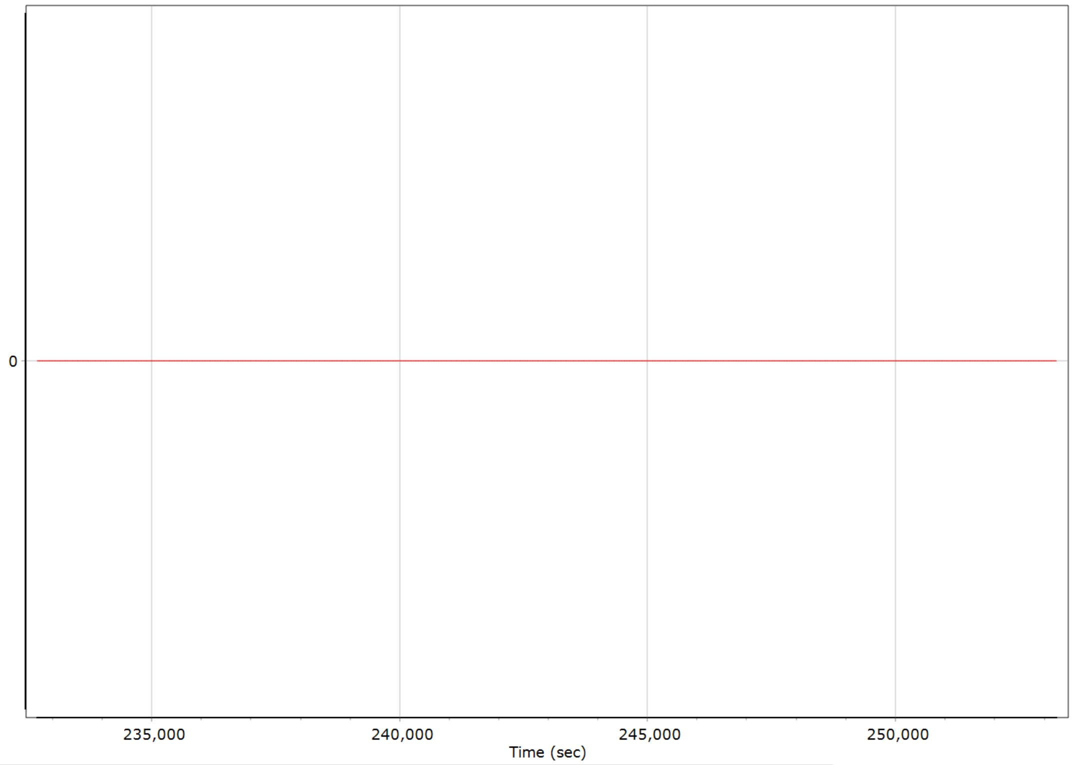


Heading Error RMS (arc-min)



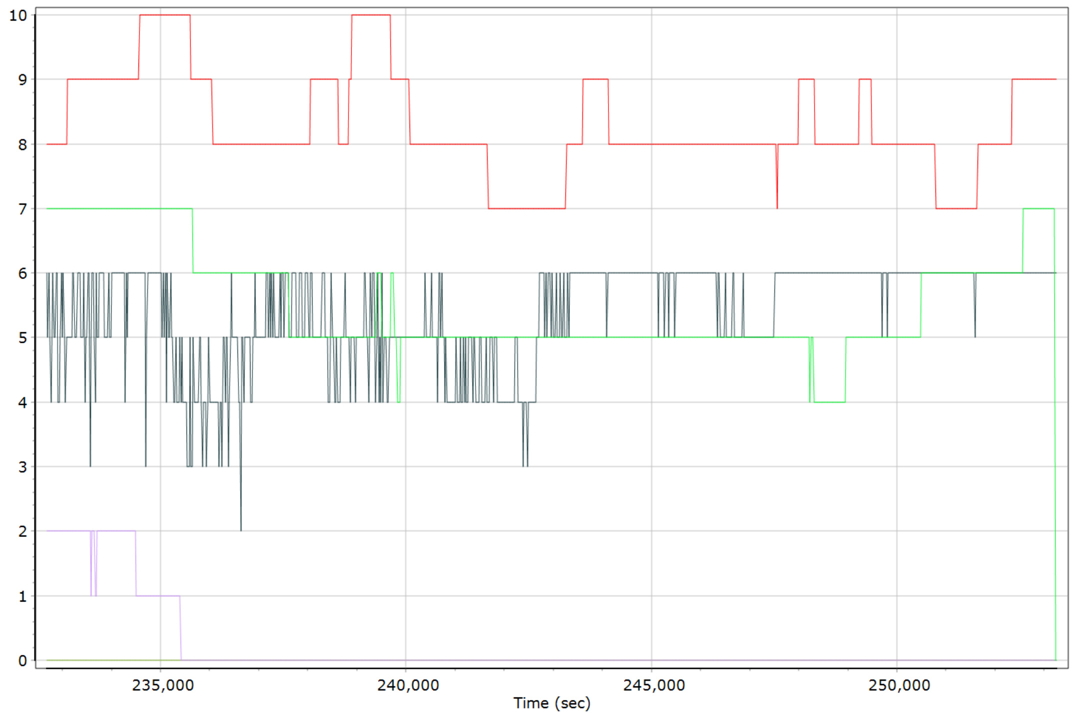
Forward Processed Solution Status

Processing Mode



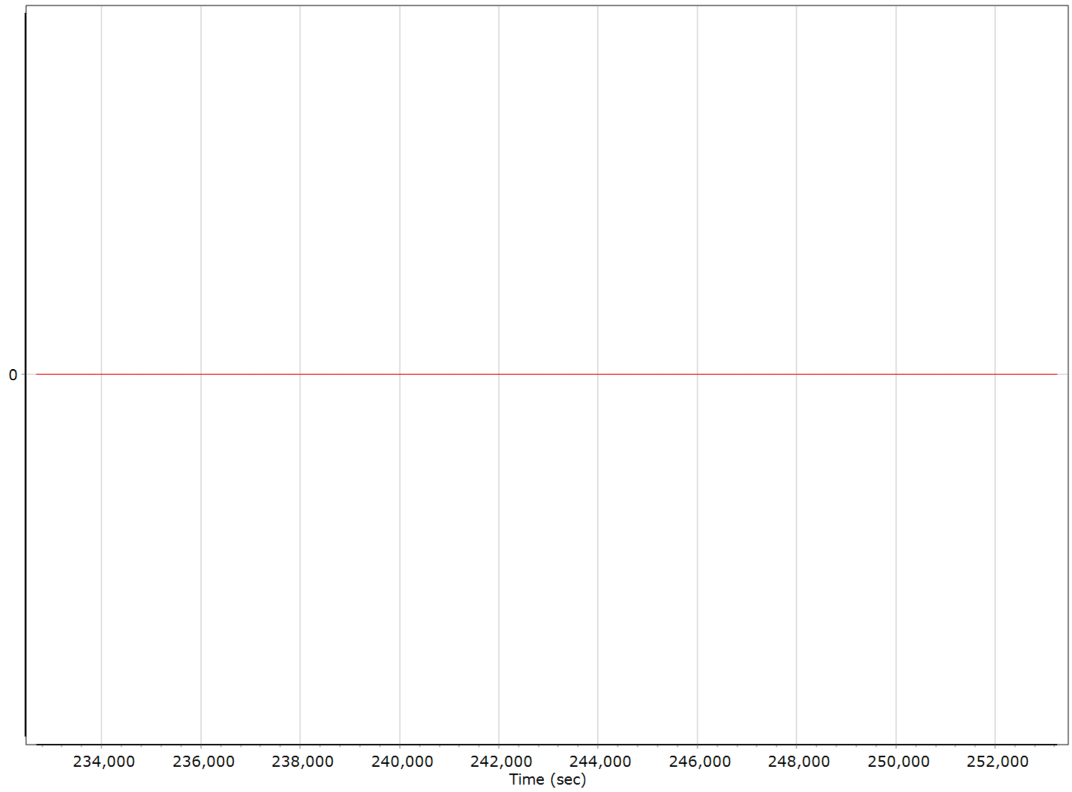
0 = Fixed NL, 1 = Fixed WL, 2 = Float, 3 = DGNSS, 4 = RTCM, 5 = IAPPP, 6 = C/A, 7 = GNSS Nav, 8 = DR

Number of Satellites



Number of GPS Satellites — Number of GLONASS Satellites — Number of QZSS Satellites
Number of BEIDOU Satellites — Number of GALILEO Satellites

Baseline Length



General Information

Mission Information

Project name	04272022A_3543
Processing date	2022-04-29 15:20:15
Mission date	2022-04-27 11:57:27
Mission duration	06:11:55.348
Processing mode	IN-Fusion PP-RTX

Rover Hardware Information

Product	POS AV 610 VER6 HW2.5-12
Serial number	S/N9683
IMU type	57
Receiver type	BD982
Antenna type	Bilinmeyen harici

Project File List

Rover Data Files

File name	File type
220427_115708_INS-GPS_1.raw	POS Data

Input Files

File Name	File Type
Ephm1170.22g	GLONASS Broadcast Ephemeris
Ephm1170.22n	GPS Broadcast Ephemeris

Output Files

Filename	File type
sbet_04272022A_3543.out	SBET Trajectory File

Rover Data Summary

First raw data file	220427_115708_INS-GPS_1.raw		
Last raw data file	220427_115708_INS-GPS_1.raw		
Start GPS week	2207		
Start time	302228.891 (4/27/2022 11:57:08 AM)		
End time	324544.239 (4/27/2022 6:09:04 PM)		
Start of fine alignment	302577.175 (4/27/2022 12:02:57 PM)		
Available subsystems	Primary GNSS, Gimbal, IMU		
POS Event Input	None		
Correction data	None		
IMU Installation Lever Arms & Mounting Angles			
Gimbal to IMU lever arm (m)	-0.034	-0.010	-0.374
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000
Gimbal to Primary GNSS lever arm (m)	0.717	-0.178	-1.265
Gimbal to Primary GNSS lever arm std dev (m)	-1.000		
Aircraft to Reference mounting angles (deg)	0.000	0.000	0.000

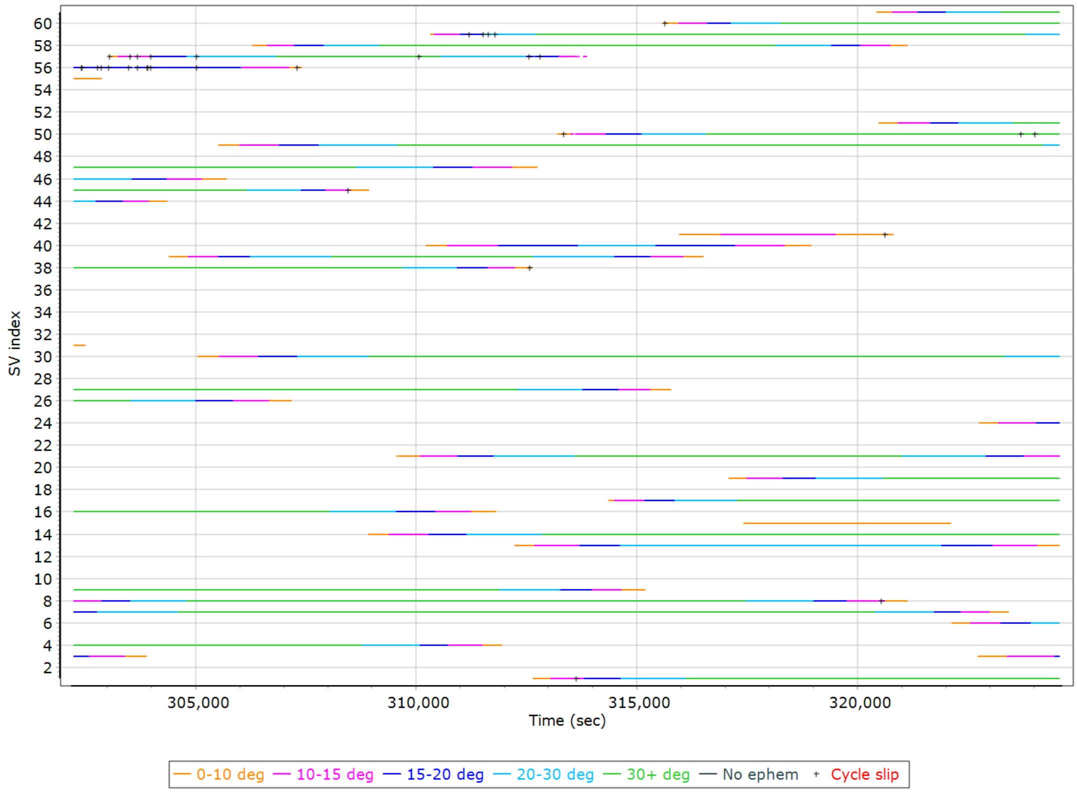
Rover Data QC

Raw IMU Import QC Summary

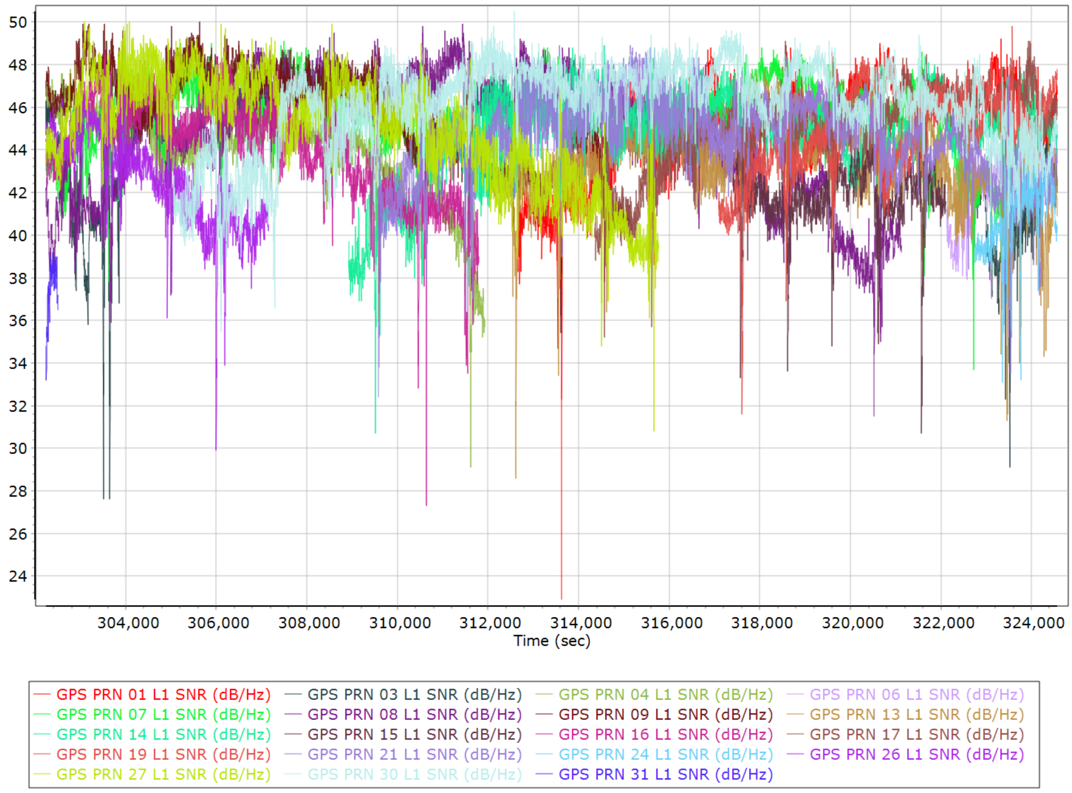
IMU data input file	imu_Mission 1.dat
IMU data check log file	imudt_04272022A_3543.log
IMU Records Processed	4462893
Termination Status	Normal
IMU Anomalies	0

Primary Observables & Satellite Data

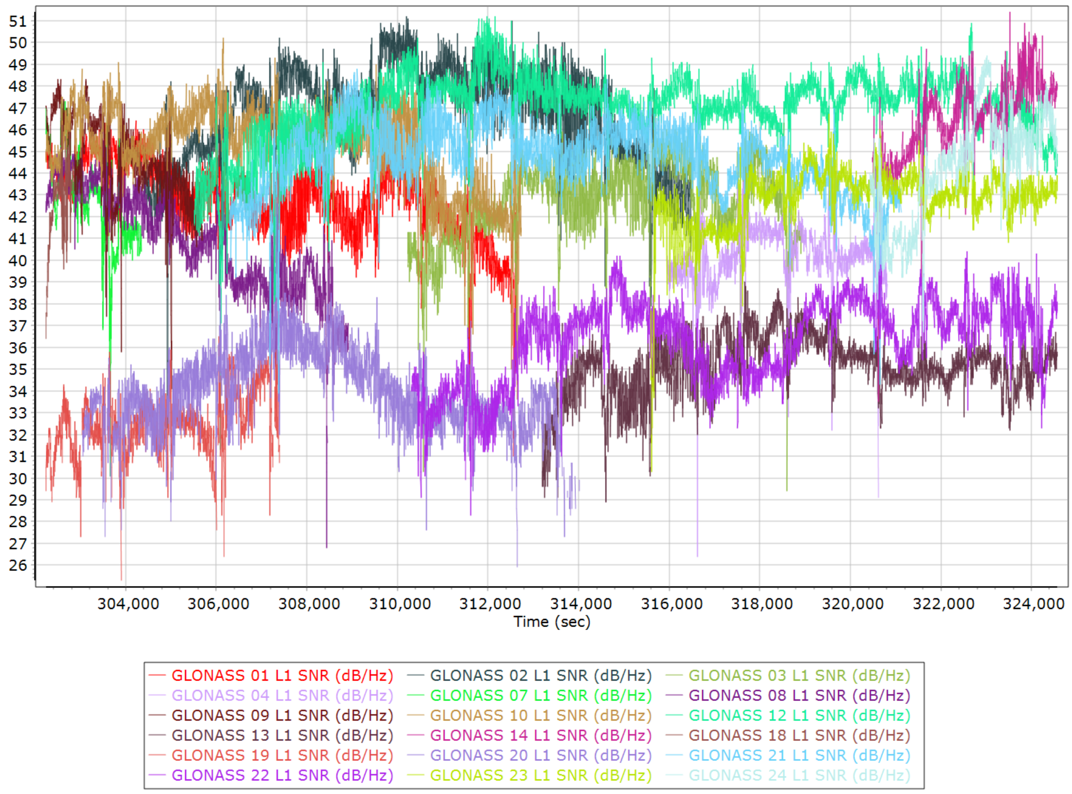
GPS/GLONASS L1 Satellite Lock/Elevation



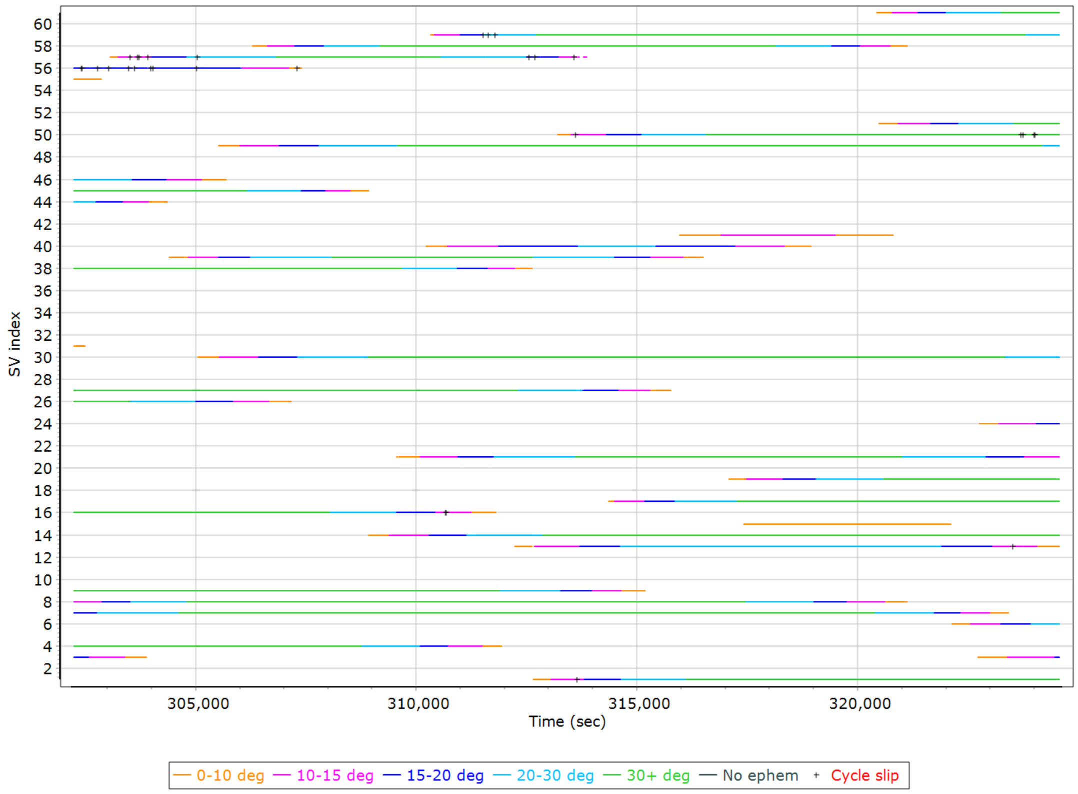
GPS L1 SNR



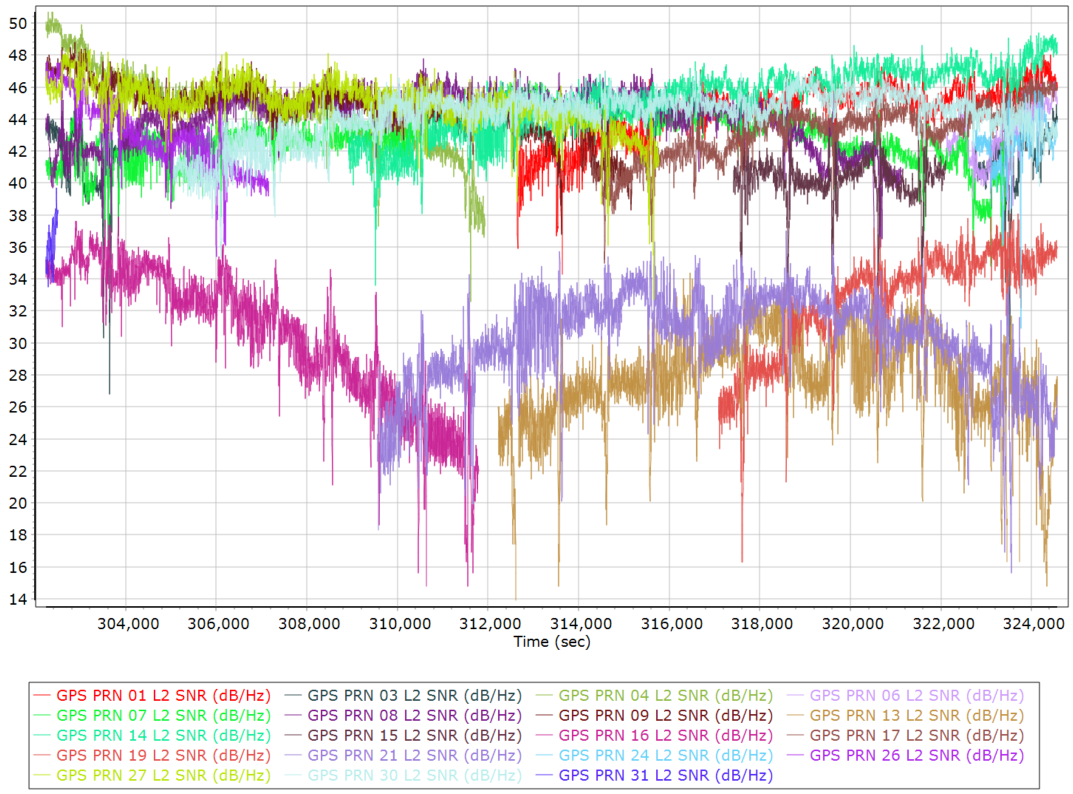
GLONASS L1 SNR



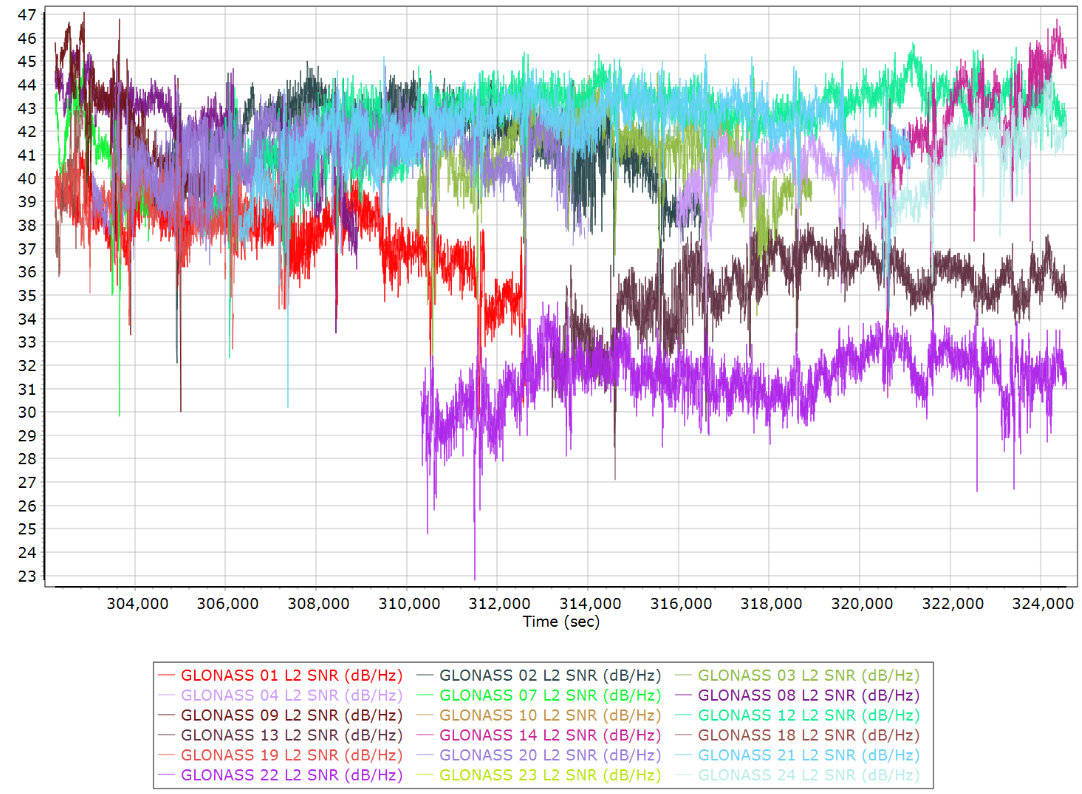
GPS/GLONASS L2 Satellite Lock/Elevation



GPS L2 SNR

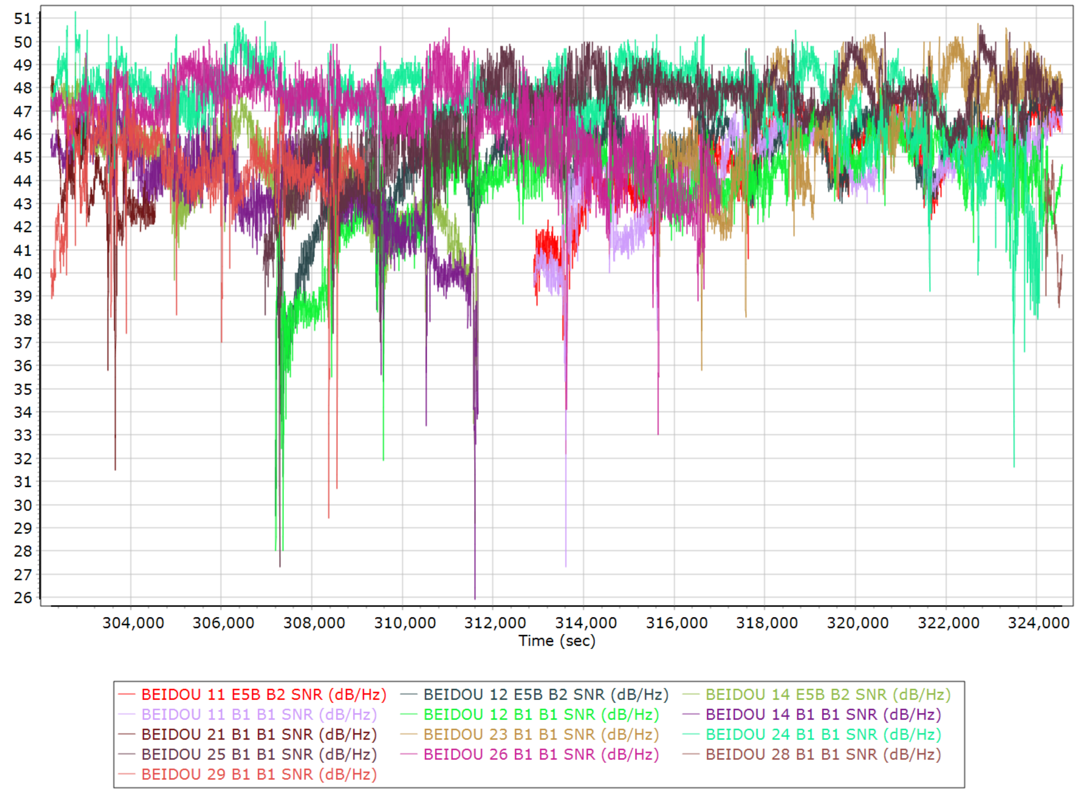


GLONASS L2 SNR

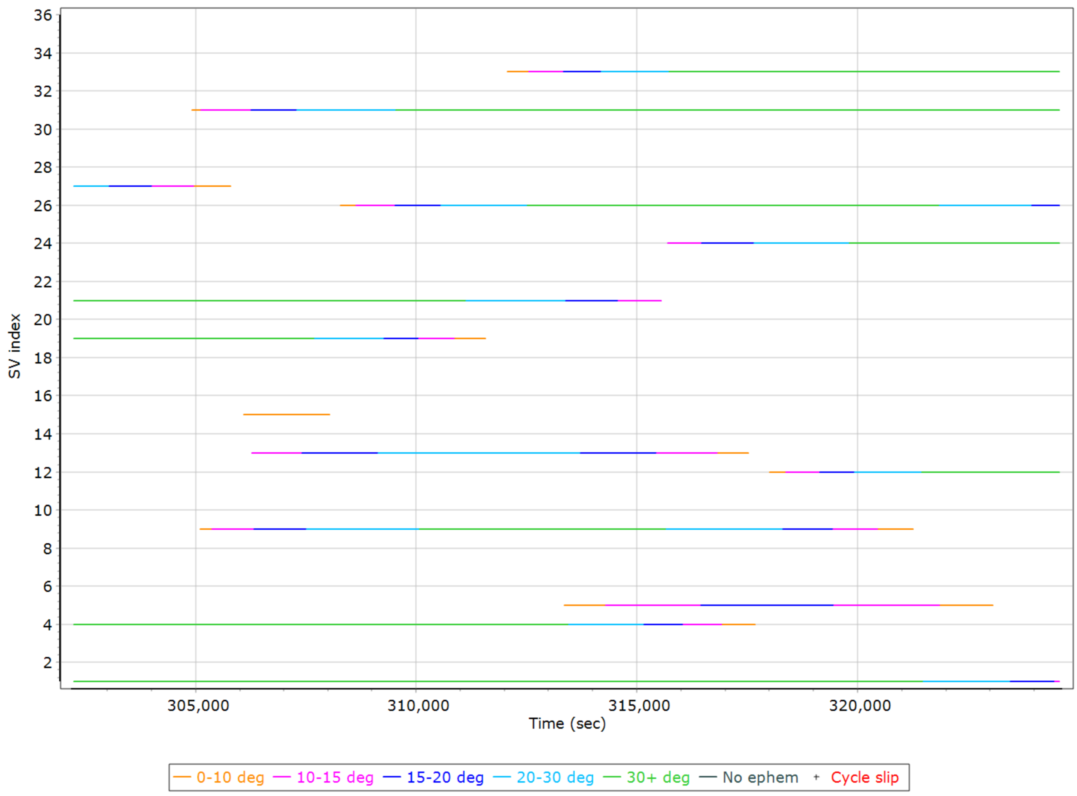


BEIDOU Satellite Lock/Elevation

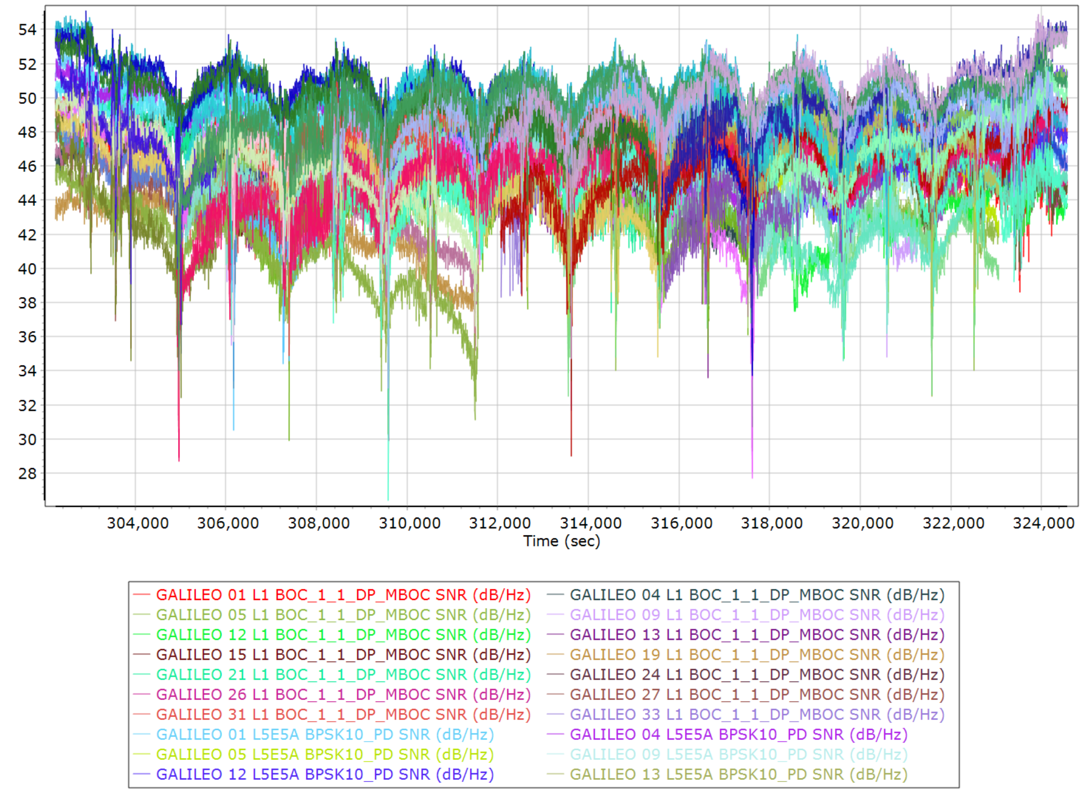
BEIDOU SNR



GALILEO Satellite Lock/Elevation

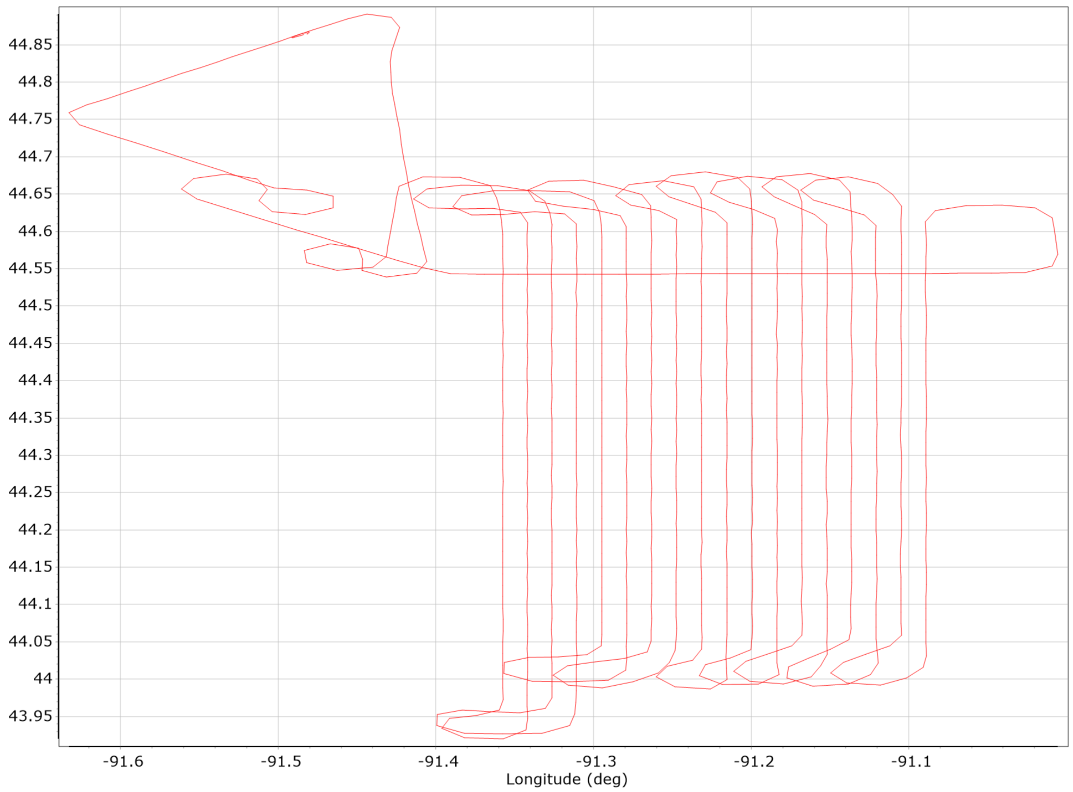


GALILEO SNR


54
52
50
48
46
44
42
40
38
36
34
32
30
28
304,000
306,000
308,000
310,000
312,000
314,000
316,000
318,000
320,000
322,000
324,000
Time (sec)
GALILEO 01 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 04 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 05 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 09 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 12 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 13 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 15 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 19 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 21 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 24 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 26 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 27 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 31 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 33 L1 BOC_1_1_DP_MBOC SNR (dB/Hz)
GALILEO 01 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 04 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 05 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 09 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 12 L5E5A BPSK10_PD SNR (dB/Hz)
GALILEO 13 L5E5A BPSK10_PD SNR (dB/Hz)

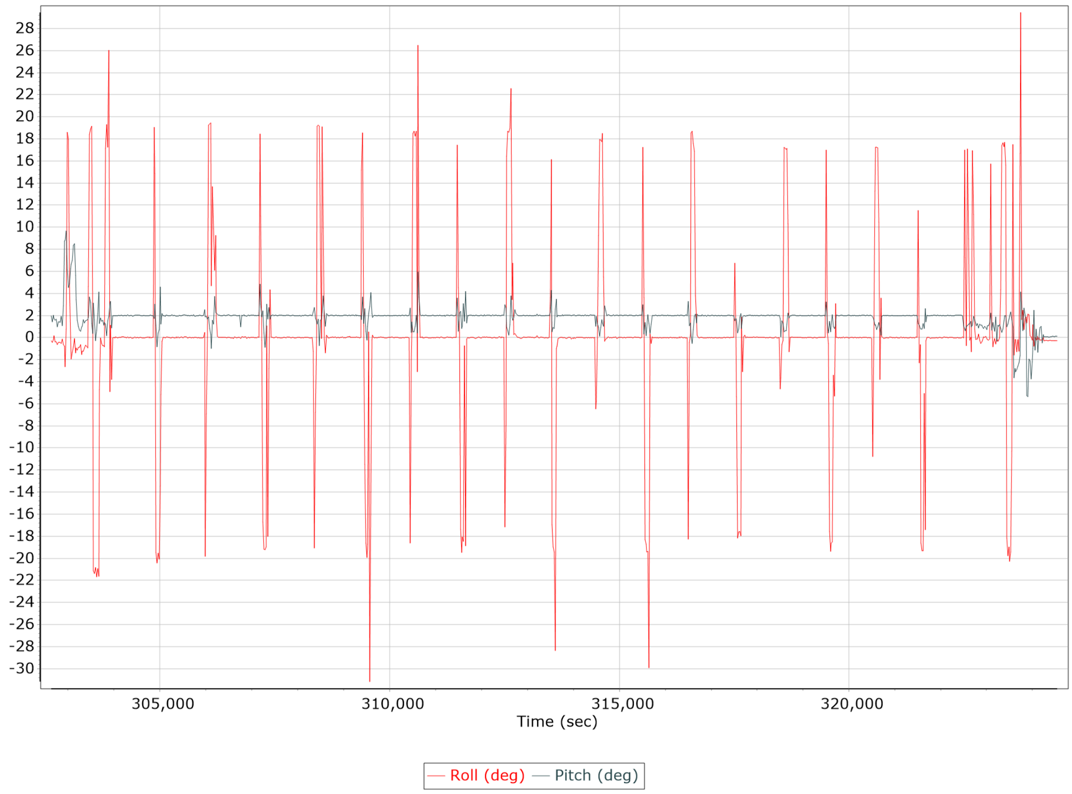
Smoothed Trajectory Information

Top View

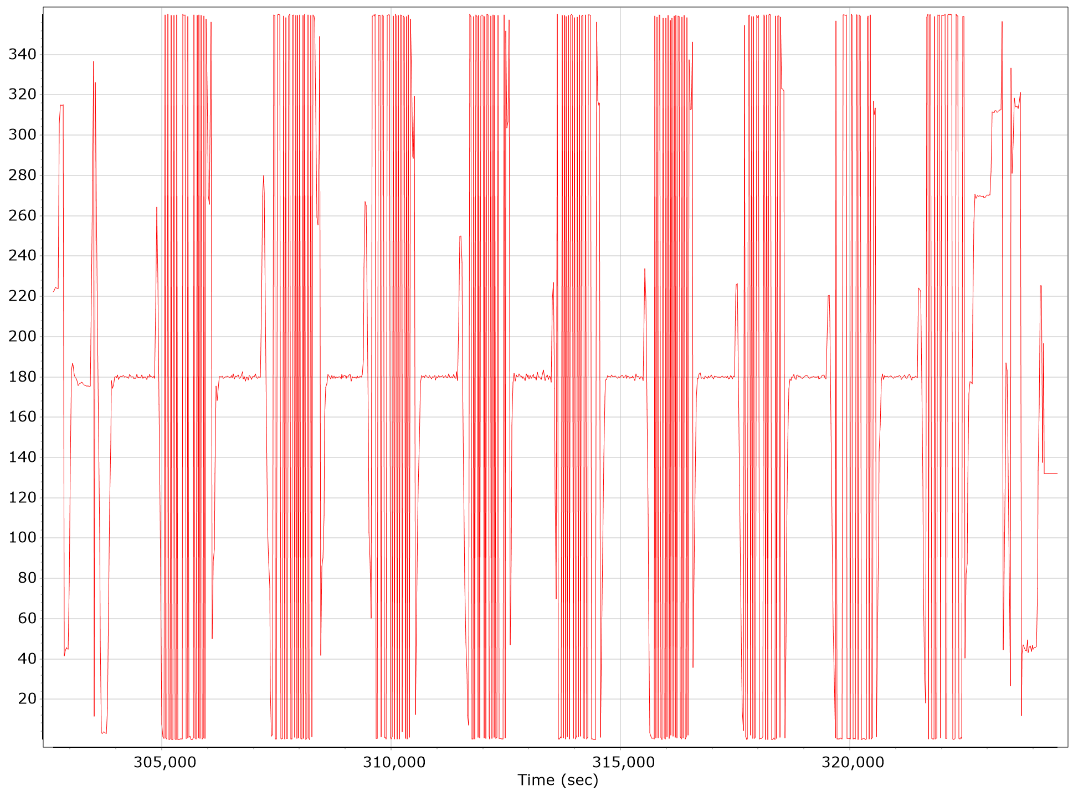


Altitude

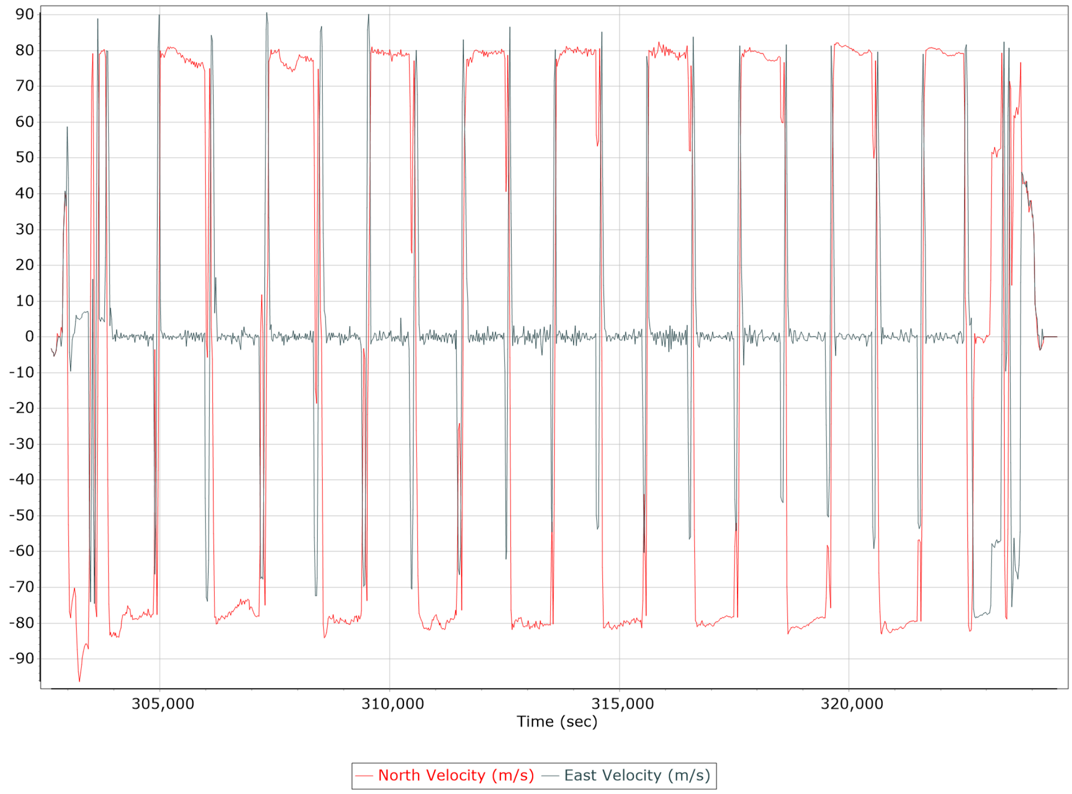
Roll/Pitch



Heading

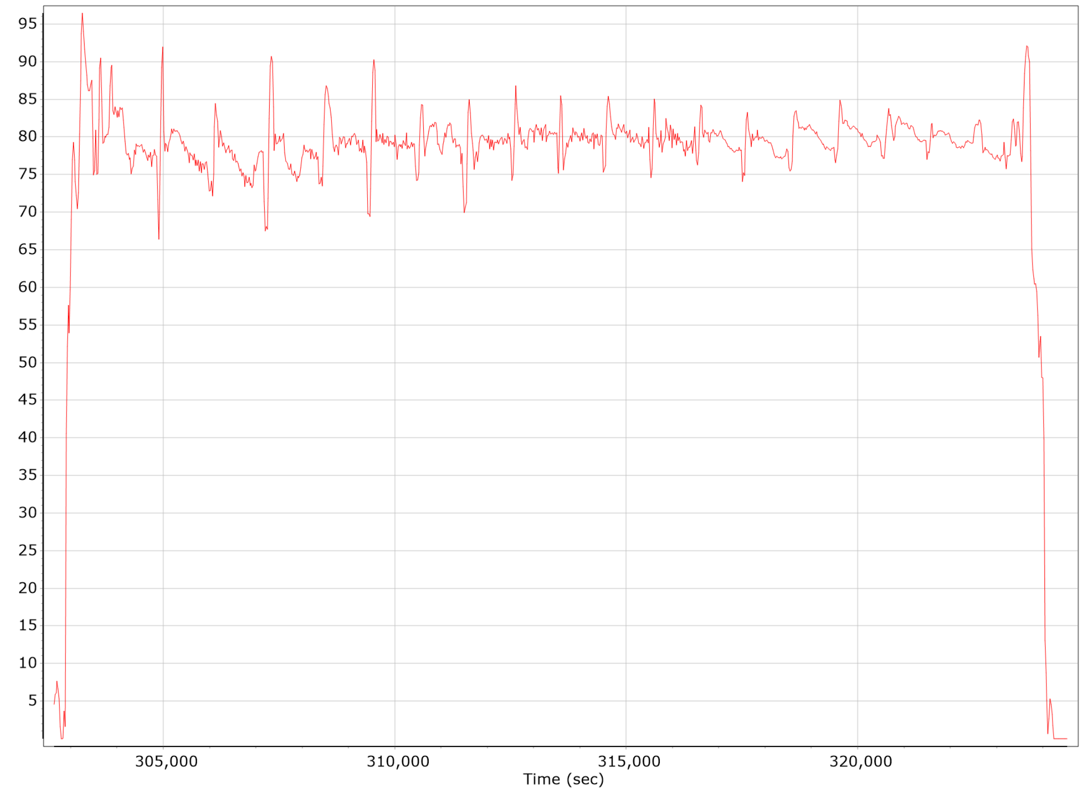


North/East Velocity

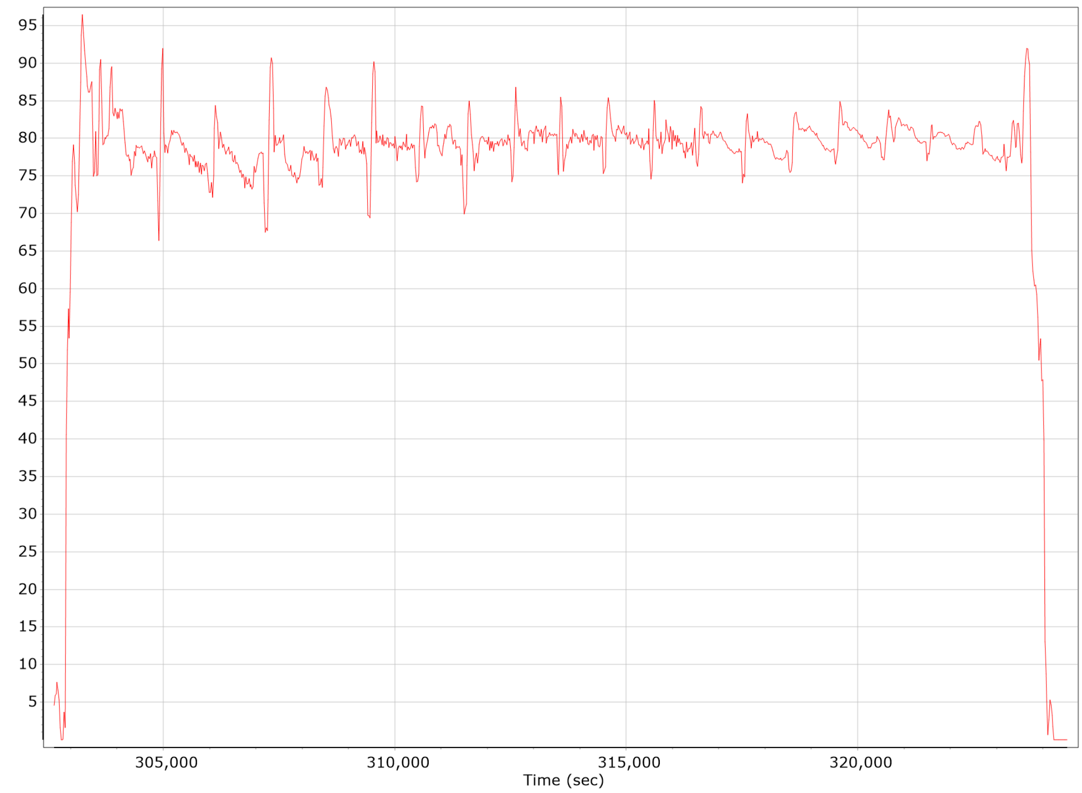


Down Velocity

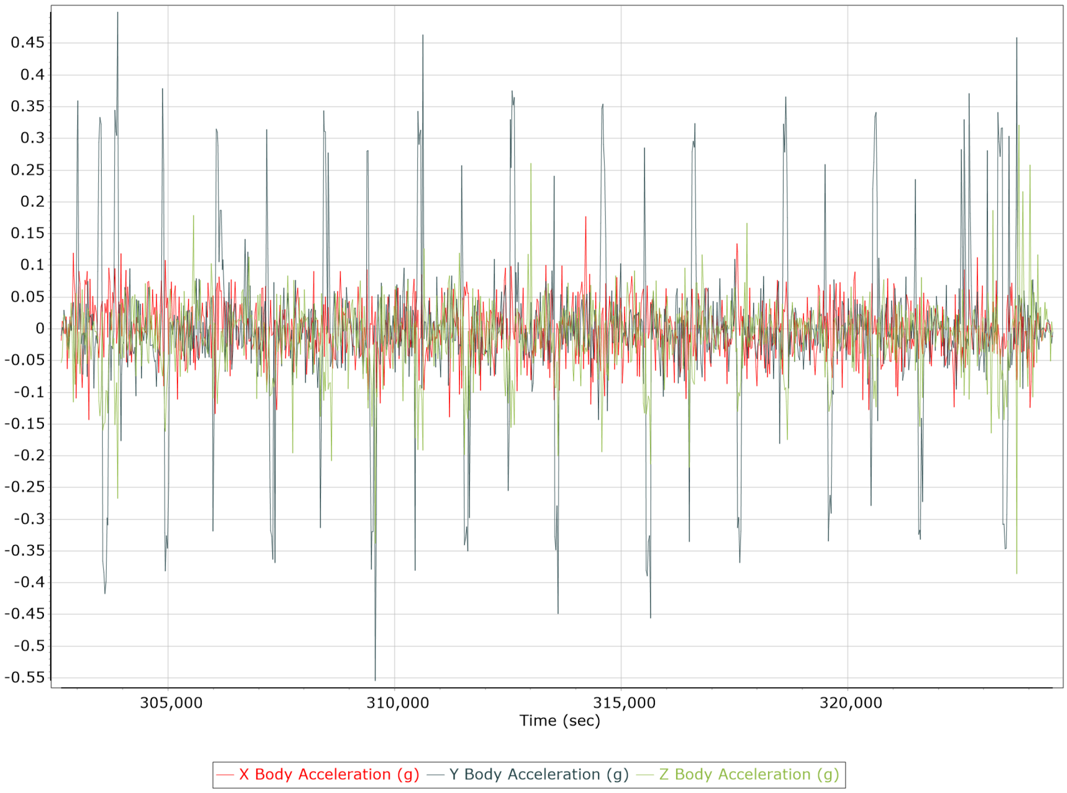
Total Speed



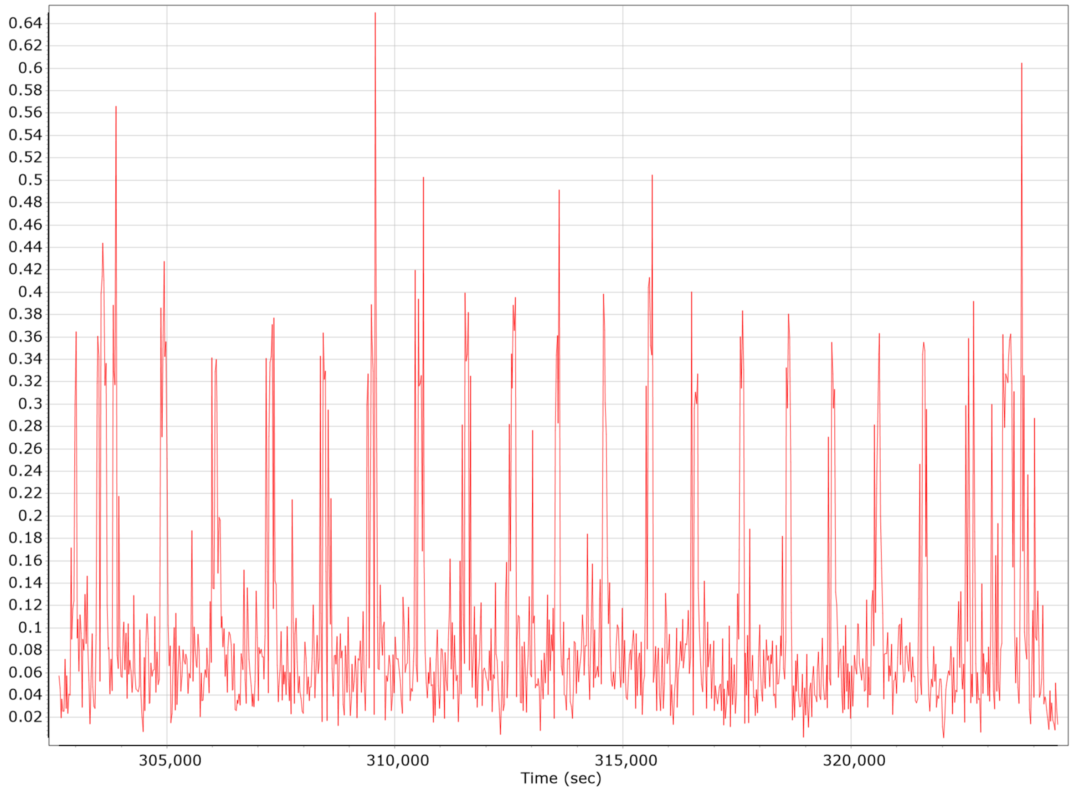
Ground Speed



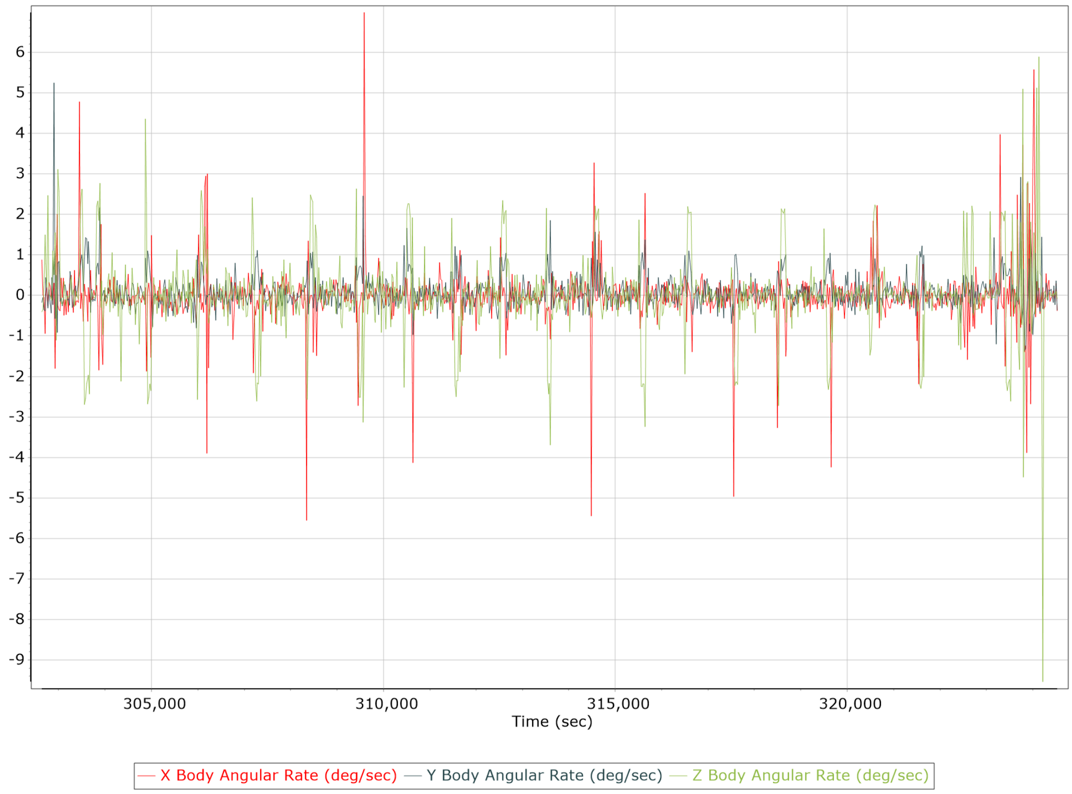
Body Acceleration



Total Body Acceleration

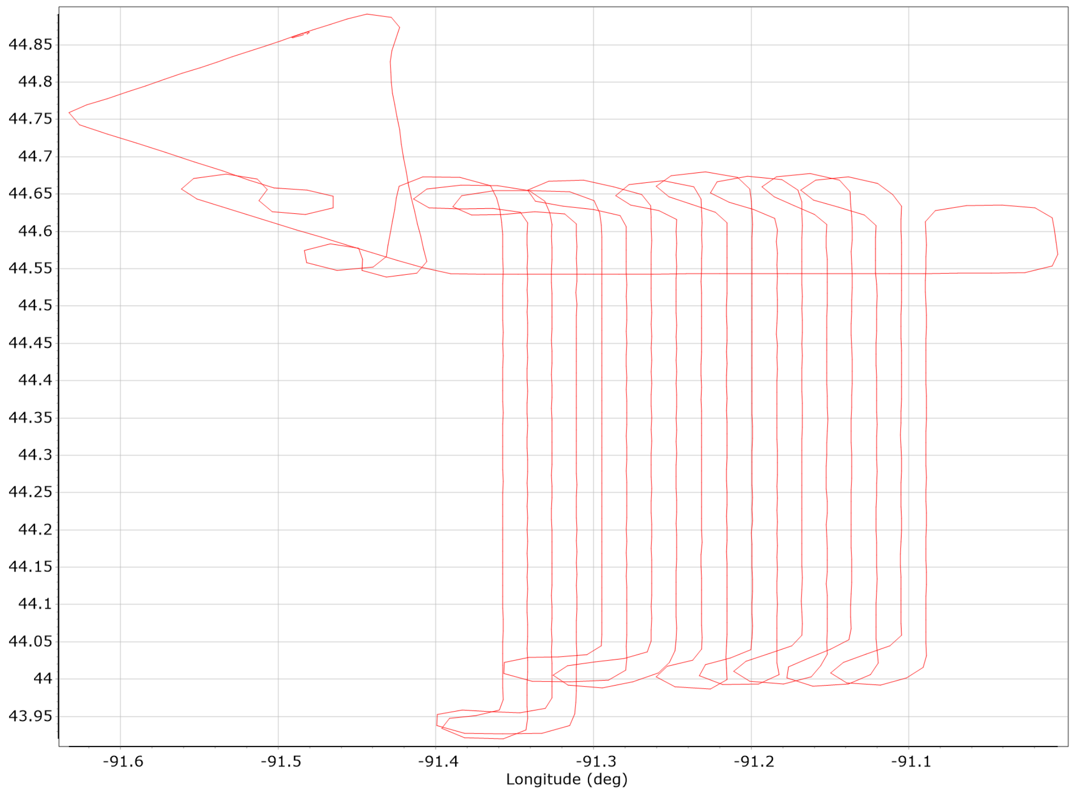


Body Angular Rate



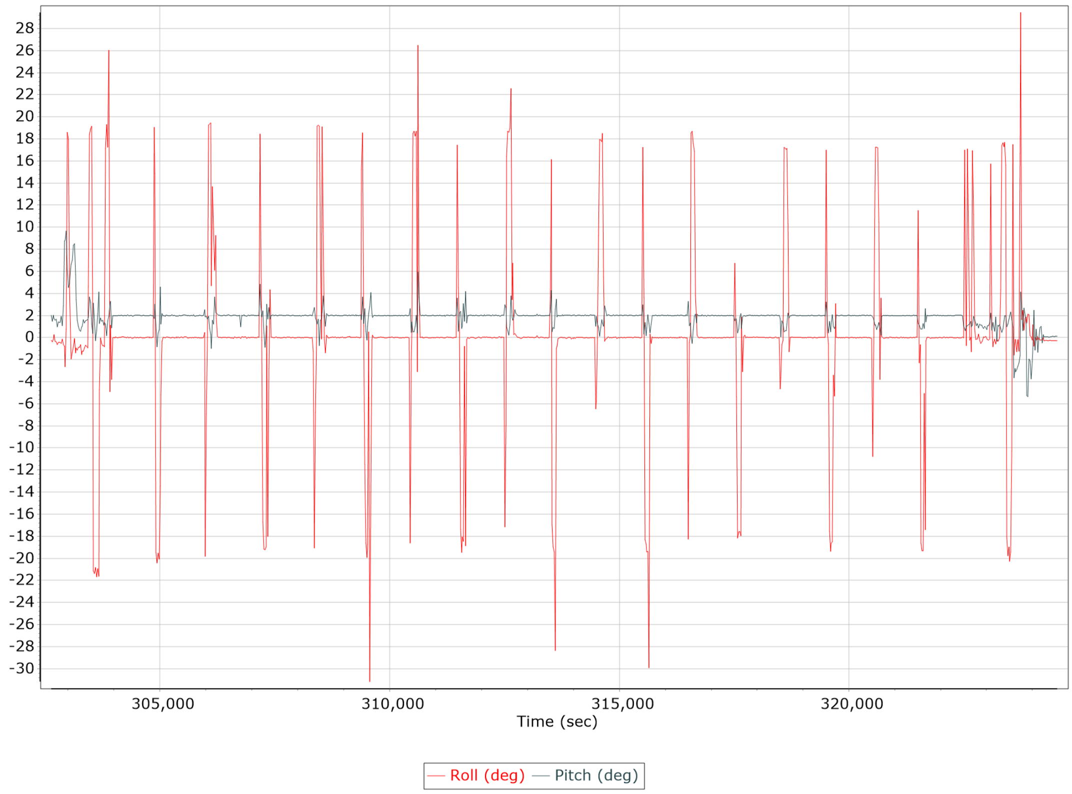
Forward Processed Trajectory Information

Top View

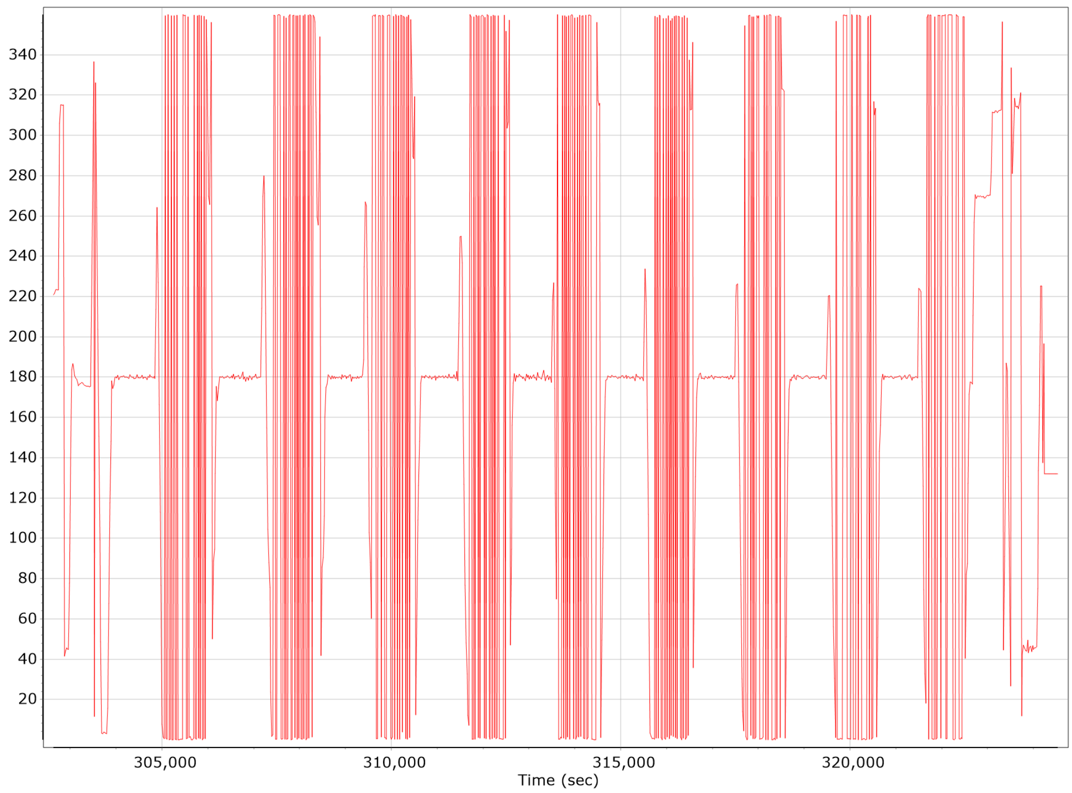


Altitude

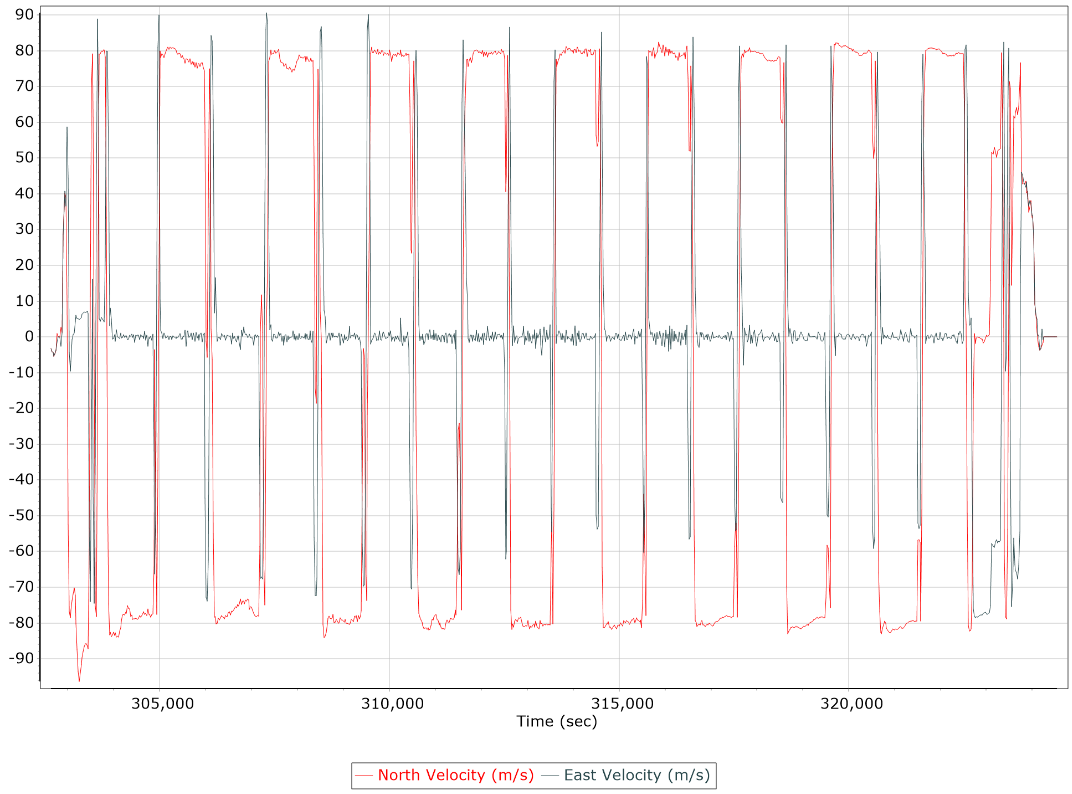
Roll/Pitch



Heading

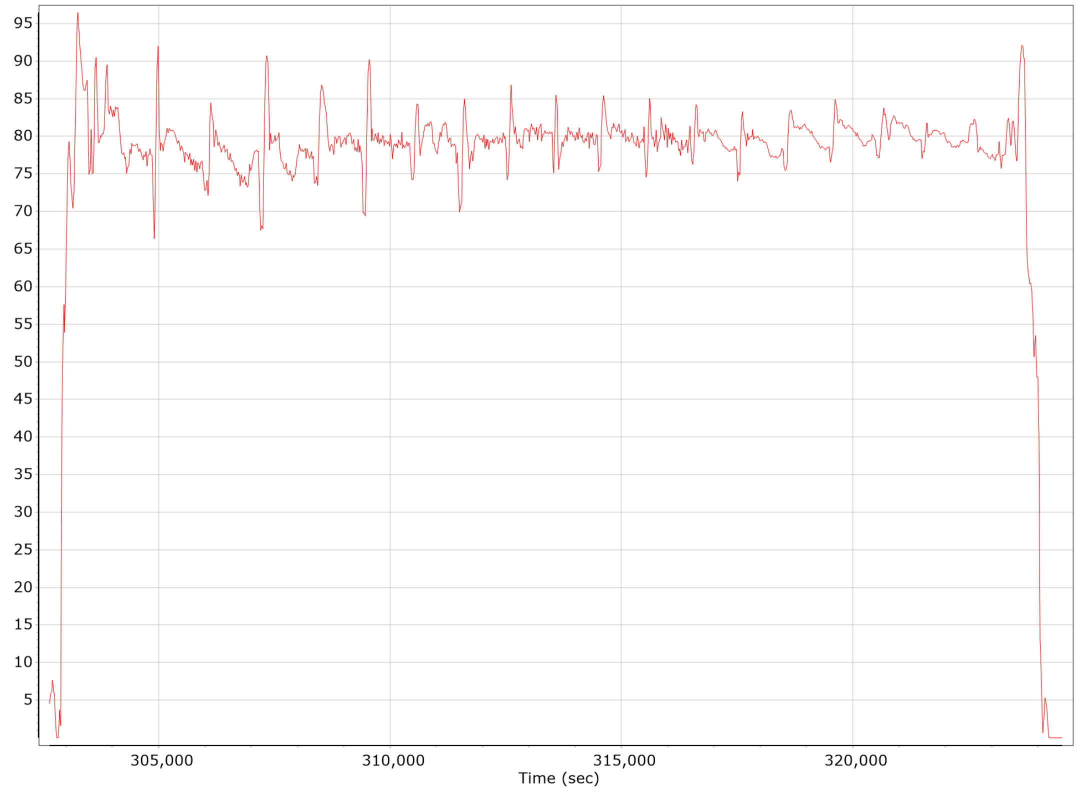


North/East Velocity

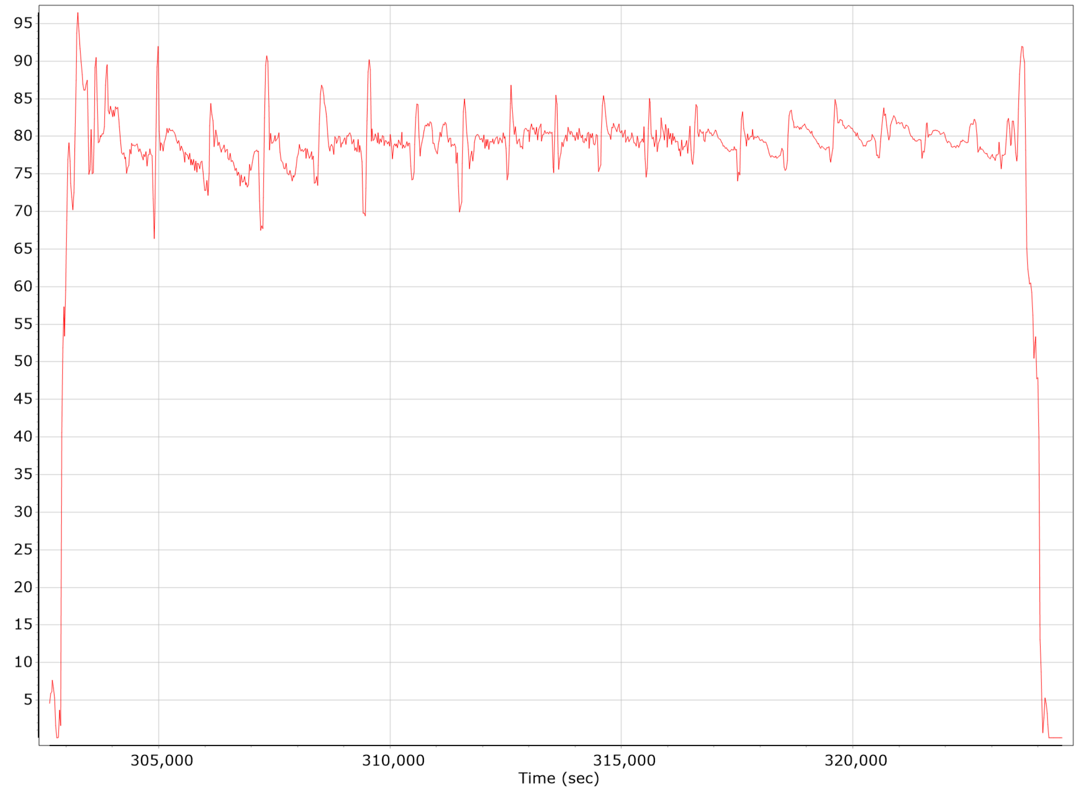


Down Velocity

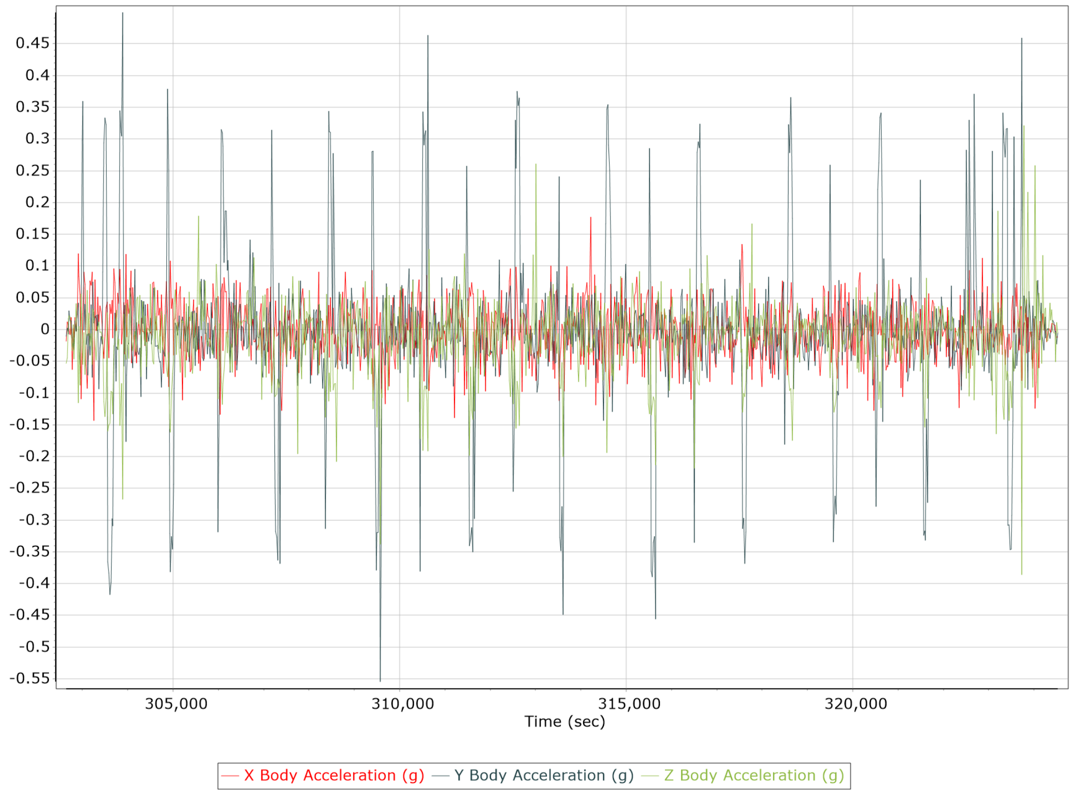
Total Speed



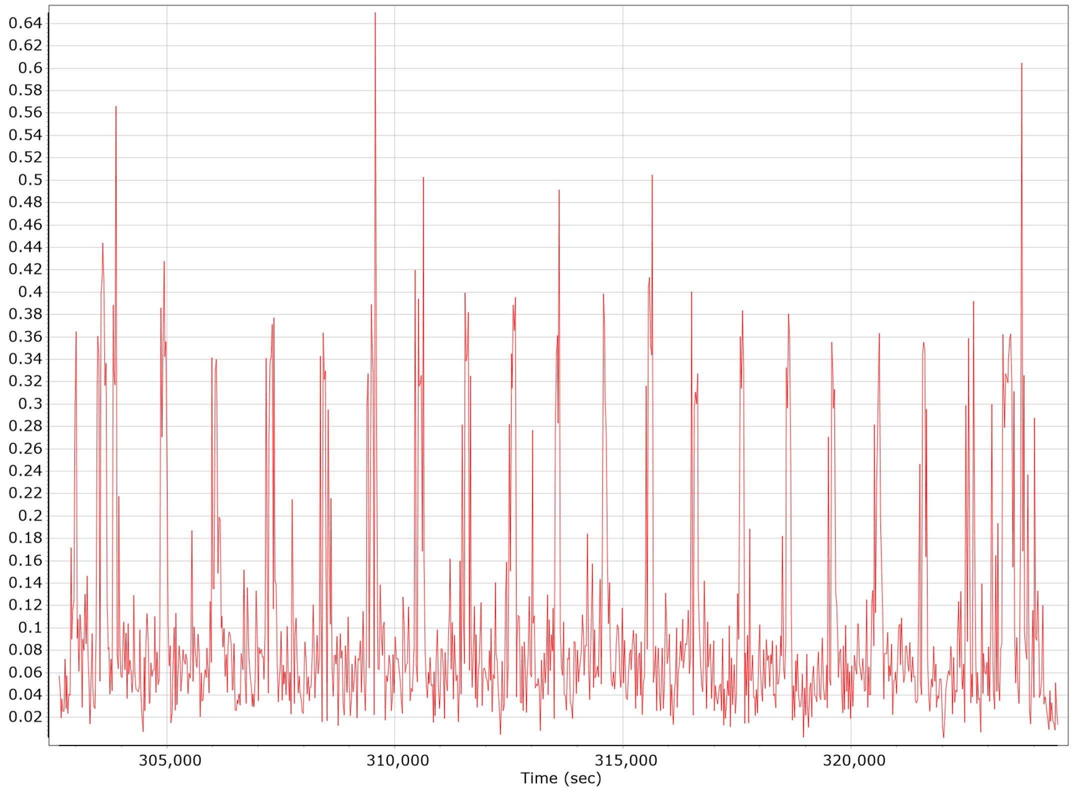
Ground Speed



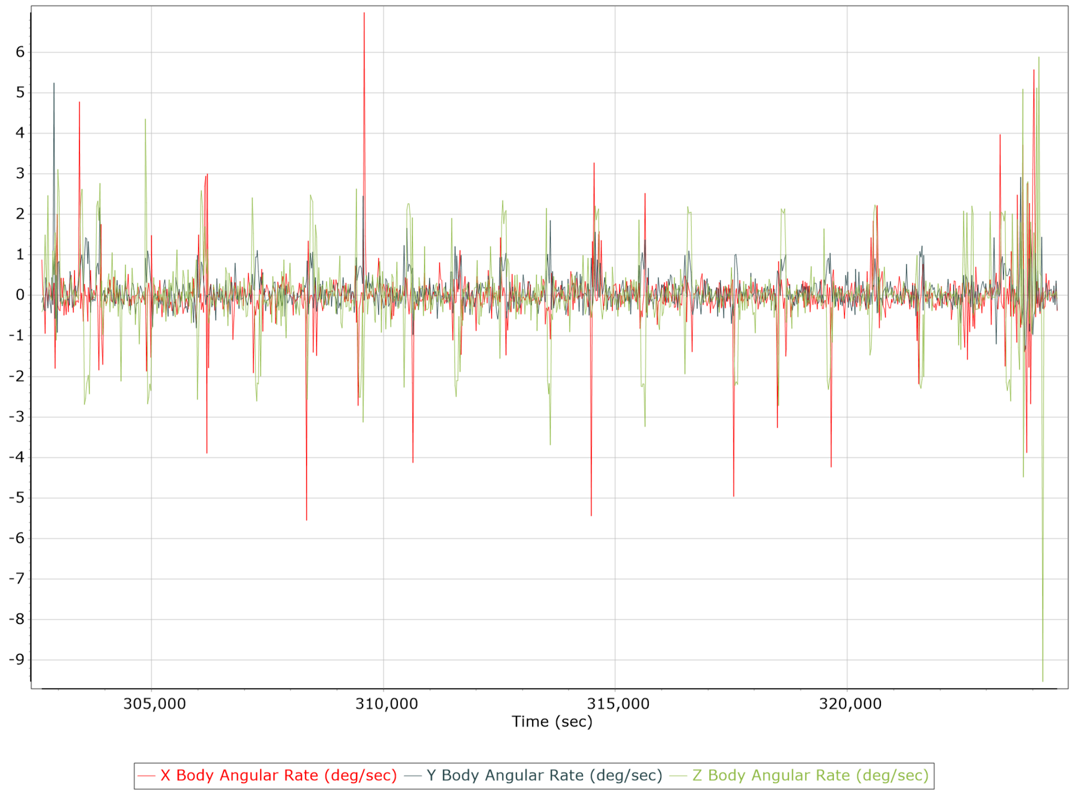
Body Acceleration



Total Body Acceleration



Body Angular Rate

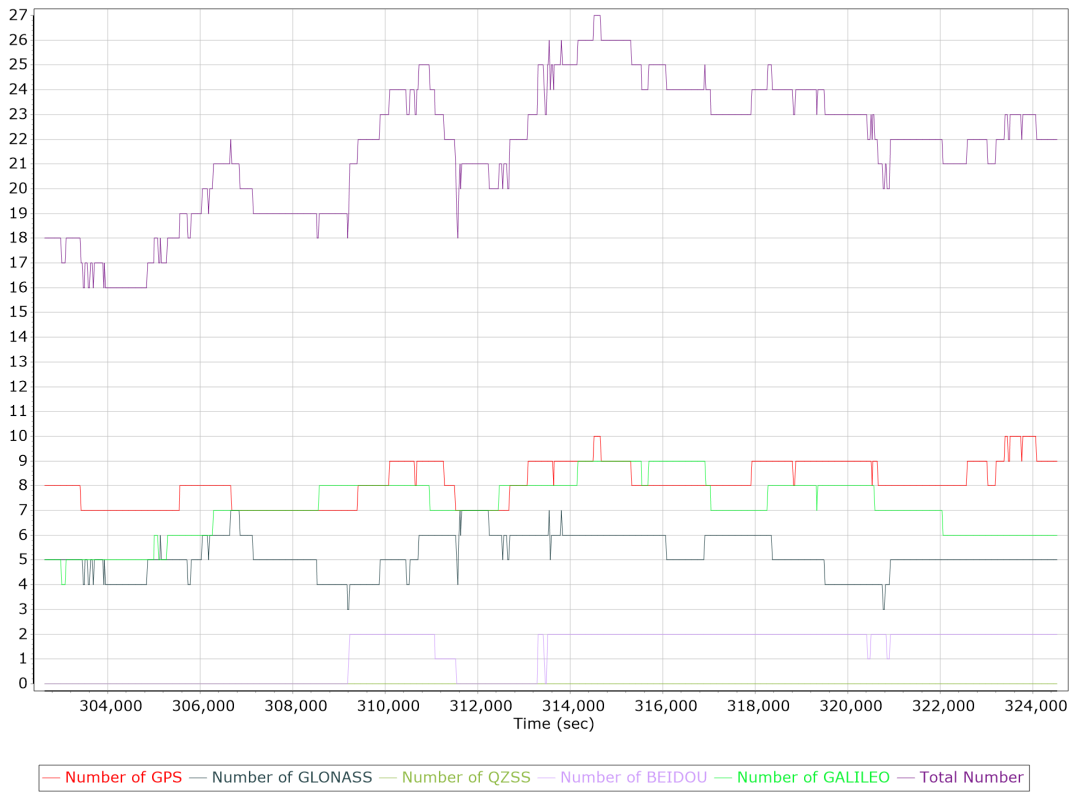


GNSS QC

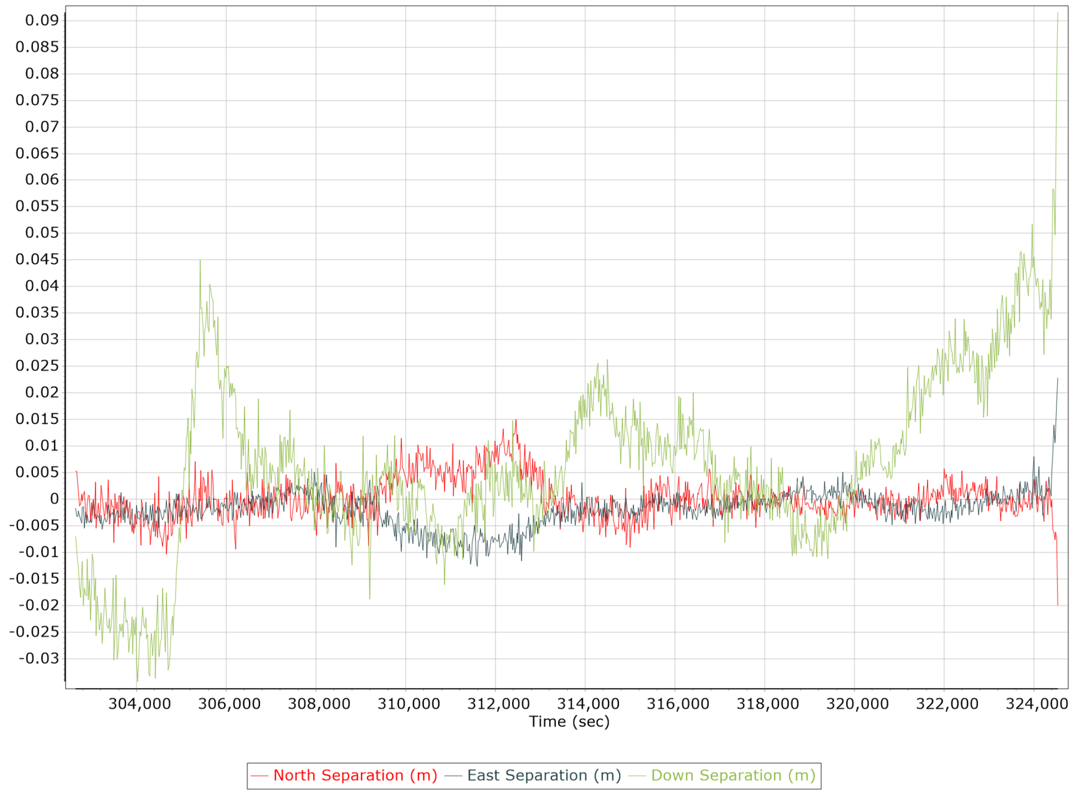
GNSS QC Statistics

Statistics	Min	Max	Mean
Baseline length (km)	0.00	0.00	
Number of GPS SV	7	10	8
Number of GLONASS SV	3	7	5
Number of QZSS SV	0	0	0
Number of BEIDOU SV	0	2	1
Number of GALILEO SV	4	9	7
Total number of SV	15	27	22
PDOP	0.93	1.68	1.20
QC Solution Gaps	0.00	0.00	
Solution Type	Fixed	Float	No solution
Epoch (sec)	22295.00	0.00	0.00
Percentage	100.00	0.00	0.00

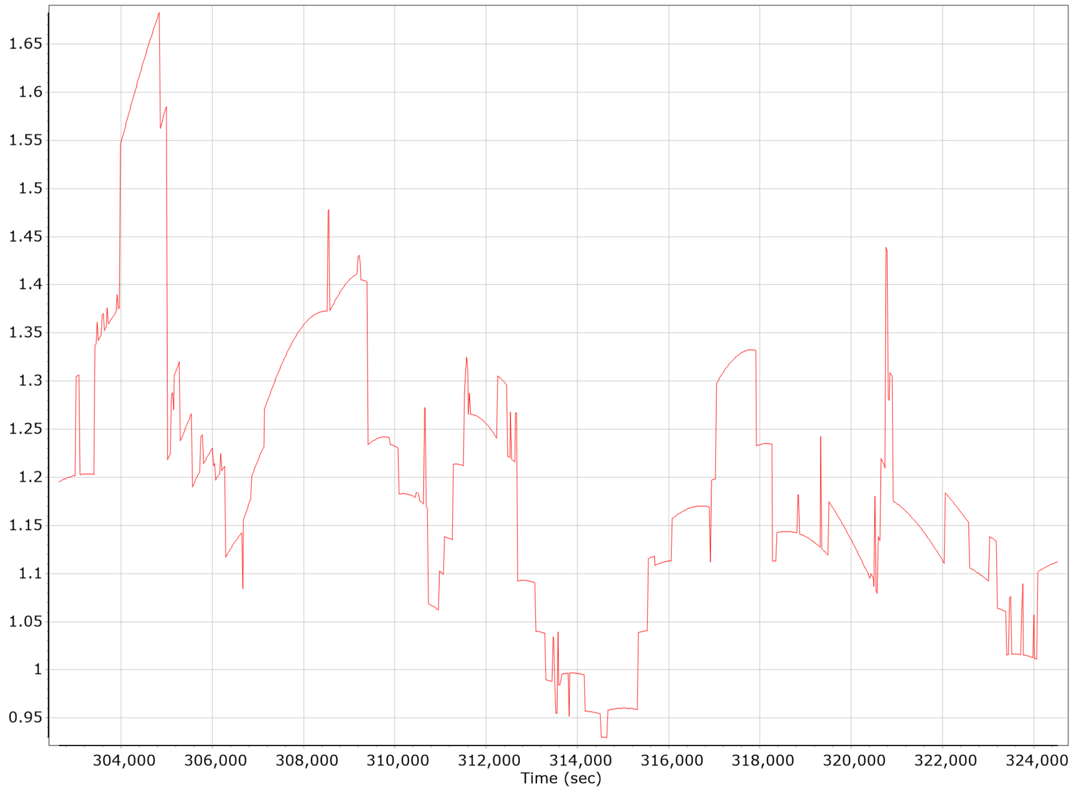
Num SVs in solution



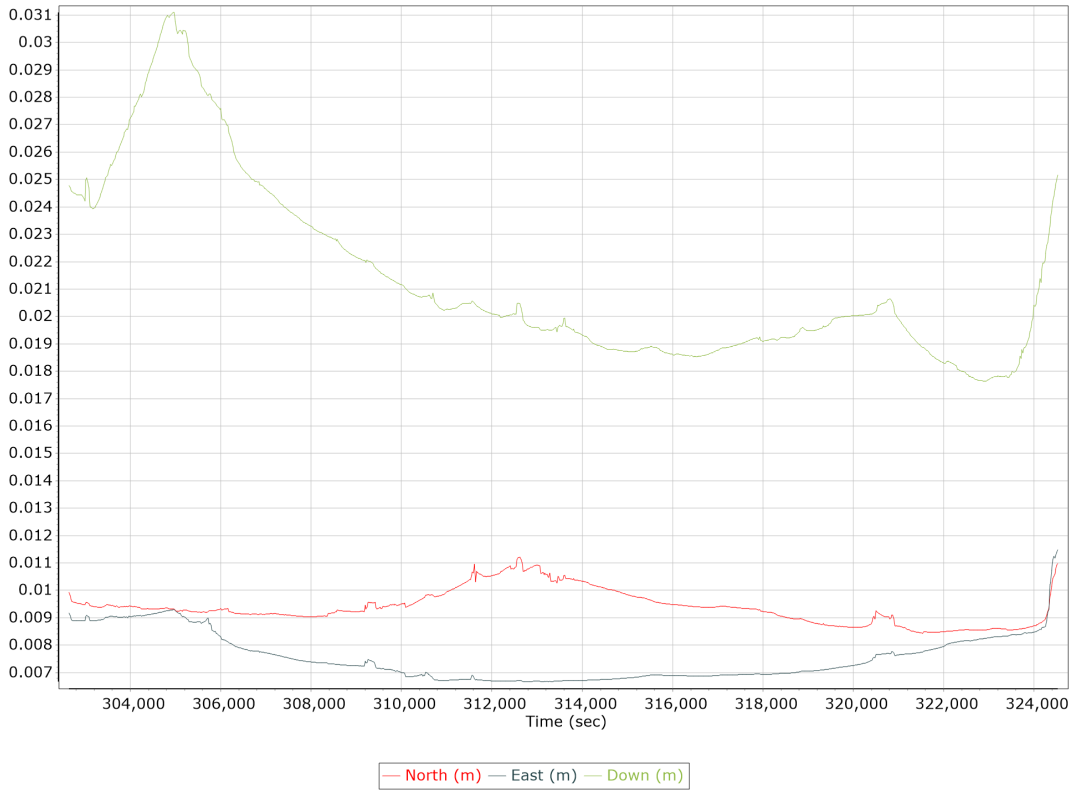
Forward/Reverse Separation



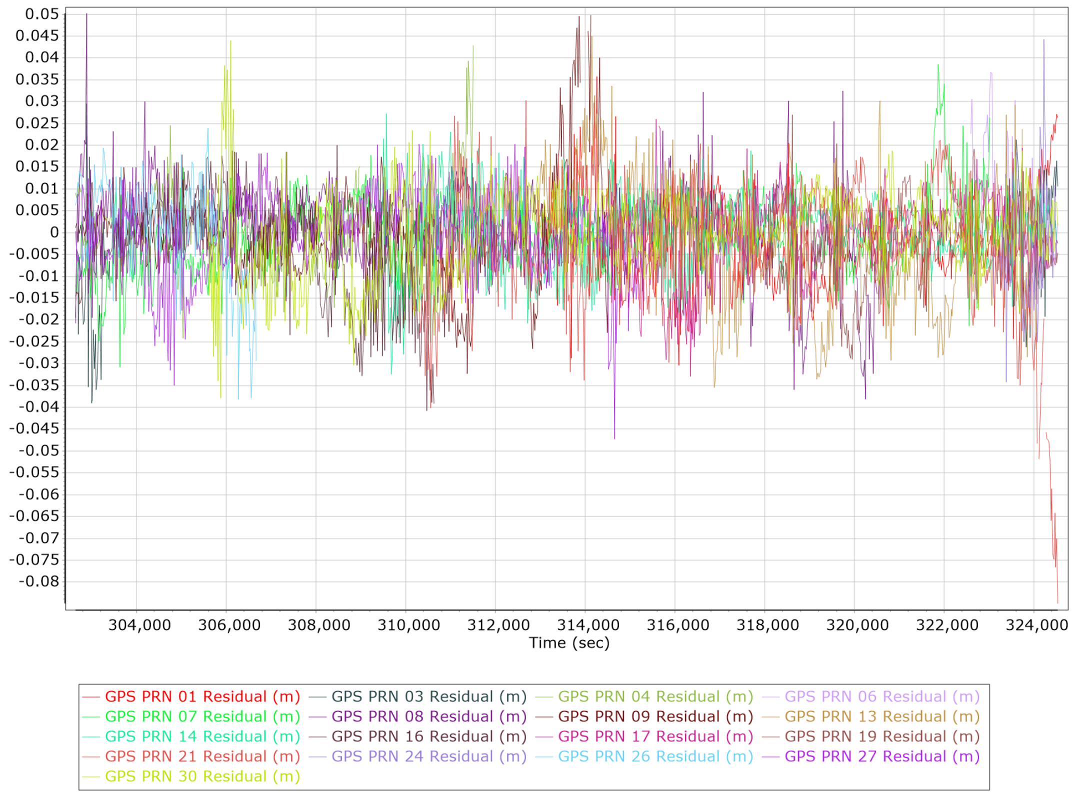
PDOP



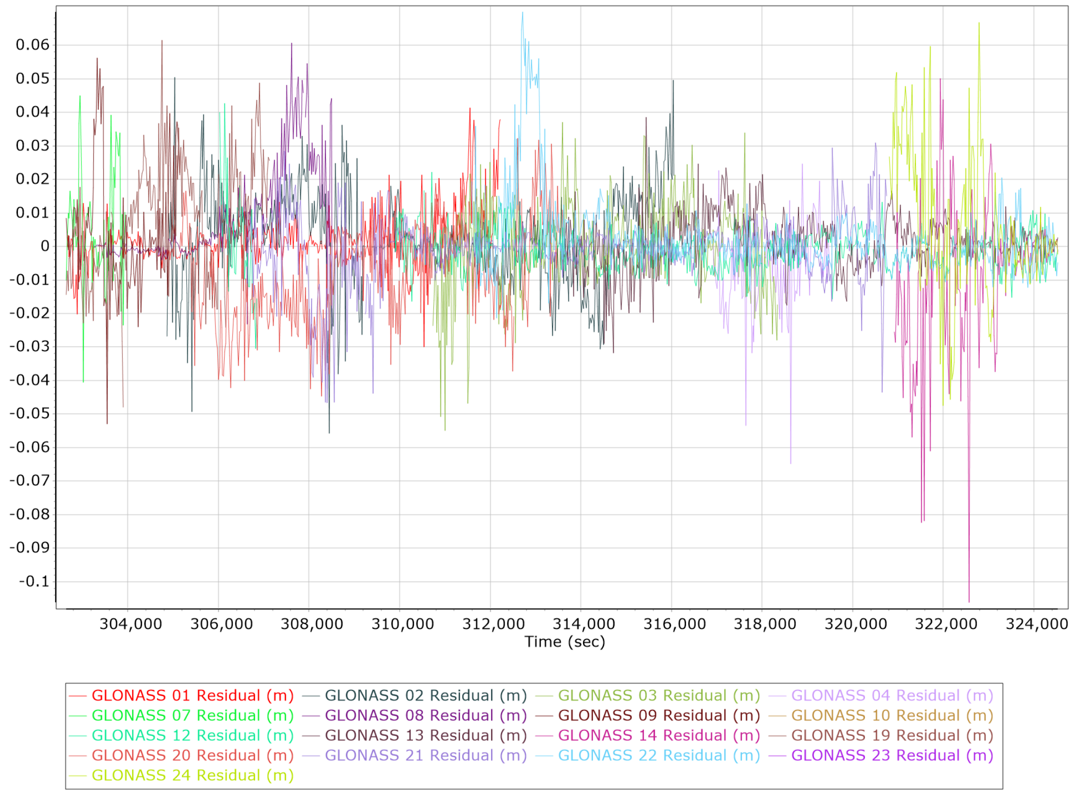
Estimated Position Accuracy



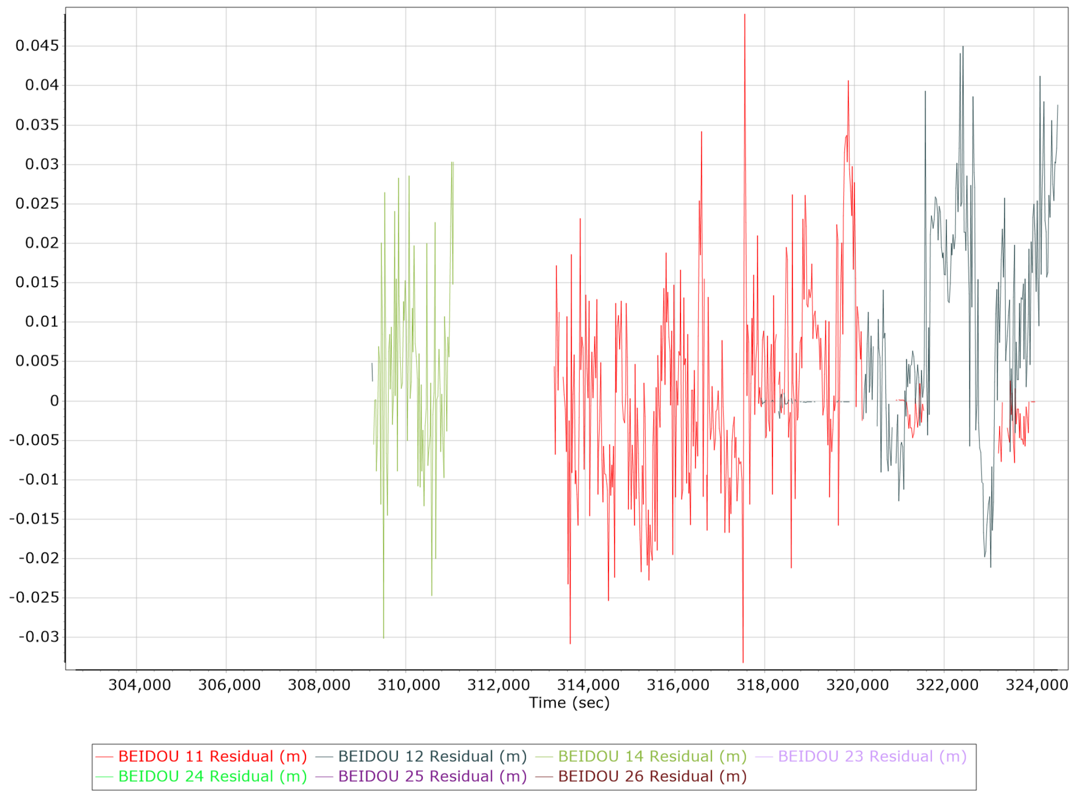
GPS Residuals



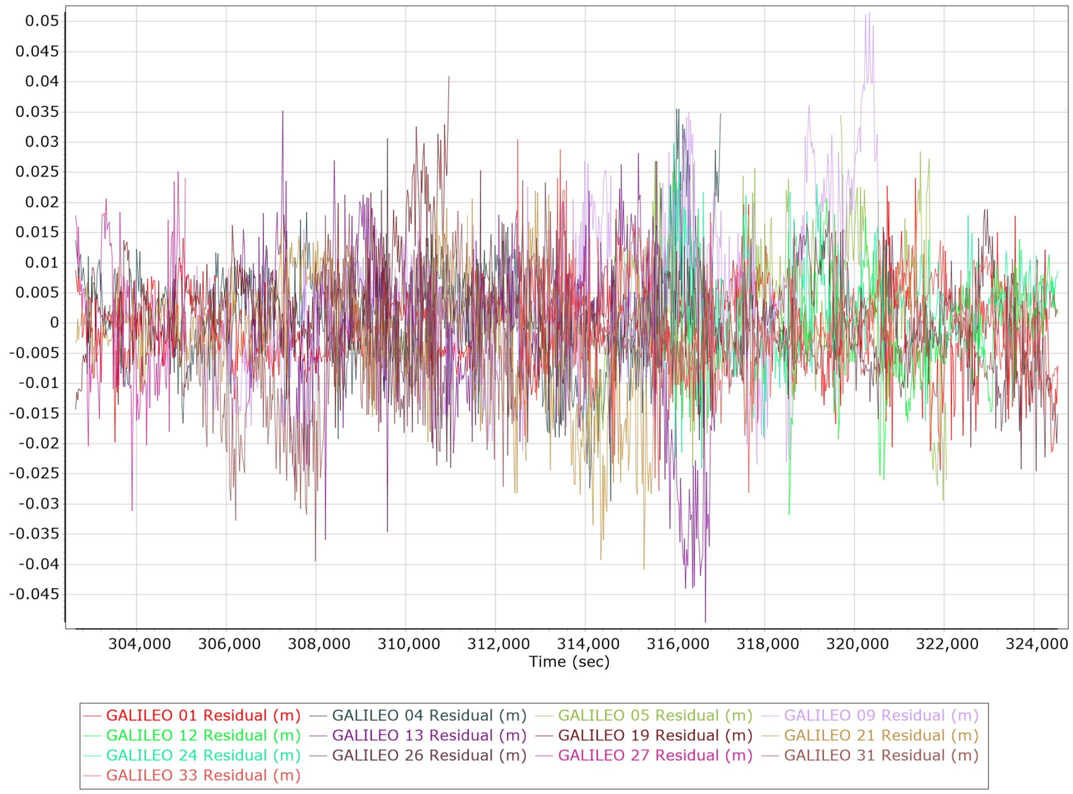
GLONASS Residuals



BEIDOU Residuals



GALILEO Residuals



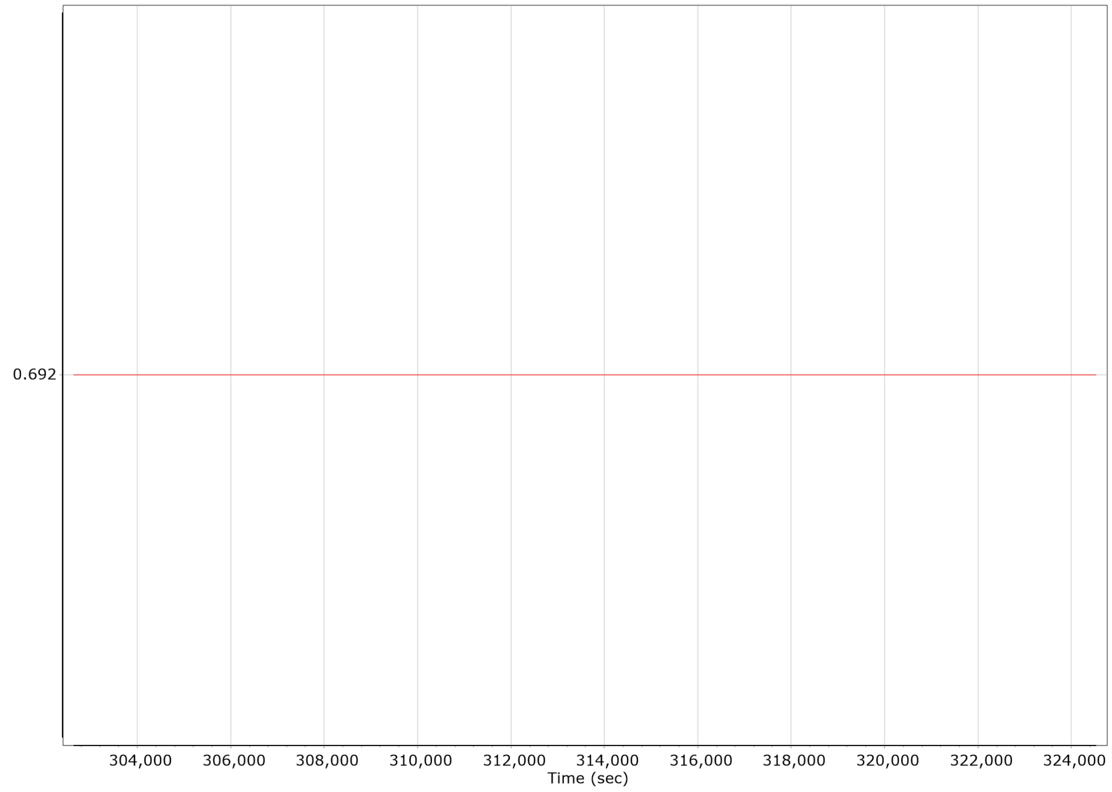
GNSS-Inertial Processor Configuration

Processing mode	IN-Fusion PP-RTX		
Stabilized mount	True		
Processing start time	302229.000 (4/27/2022 11:57:09 AM)		
Processing end time	324548.000 (4/27/2022 6:09:08 PM)		
Initial attitude source	Real-Time VNAV/RNAV Attitude		
IMU Sensor Context	Processing with Onboard IMU		
Gimbal to IMU lever arm (m)	-0.034	-0.010	-0.374
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000
Gimbal to Primary GNSS lever arm (m)	0.692	-0.181	-1.276
Gimbal to Primary GNSS lever arm std dev (m)	0.030	0.030	0.030
Aircraft to Reference mounting angles (deg)	0.000	0.000	0.000

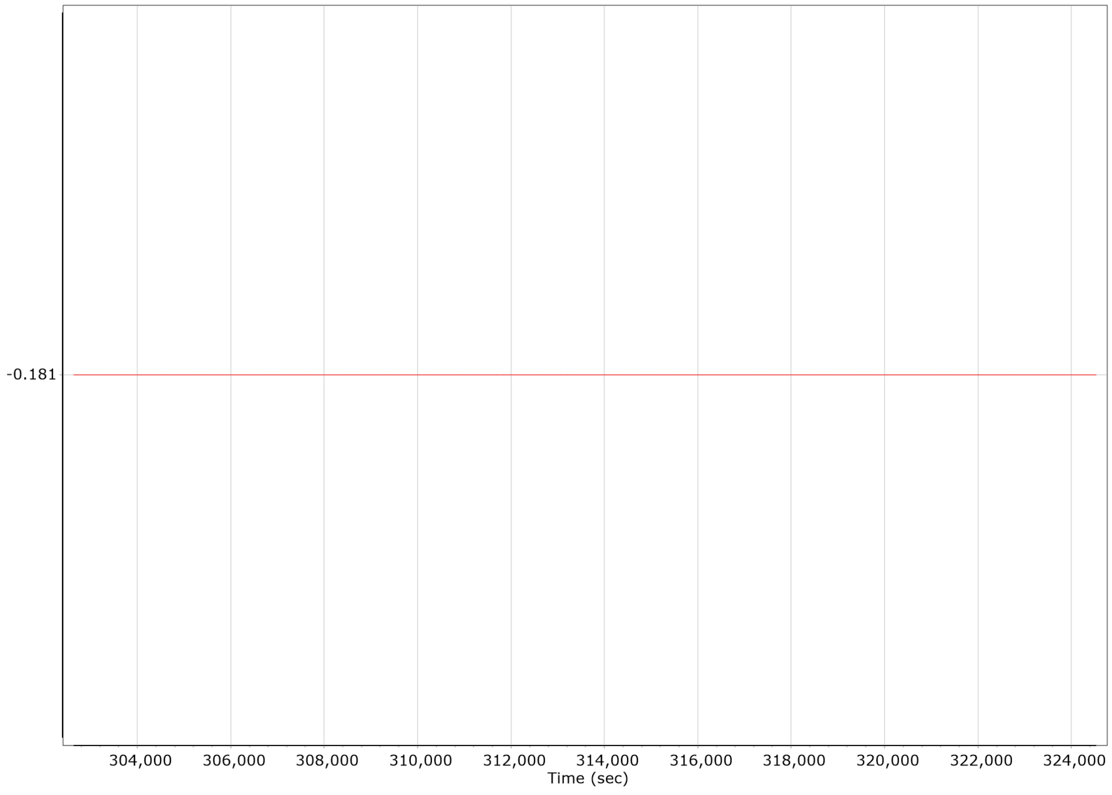
Calibrated Installation Parameters

Reference-Primary GNSS Lever Arm (m)

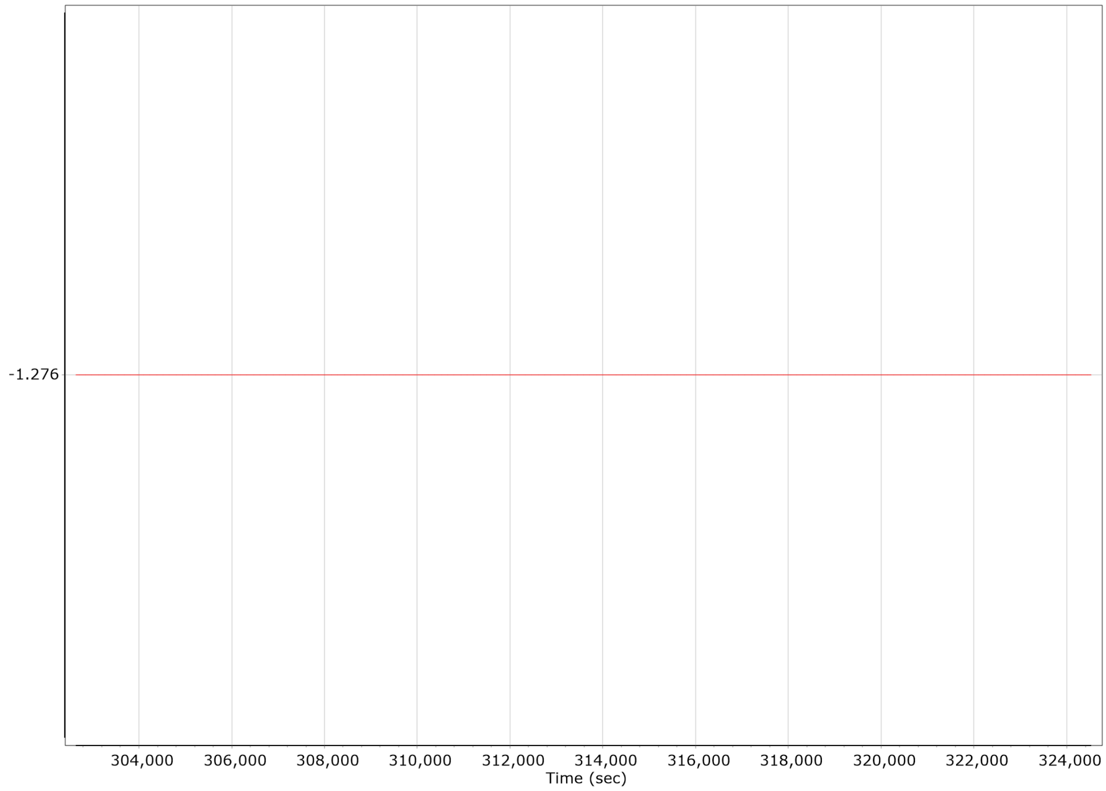
X Reference-Primary GNSS Lever Arm (m)



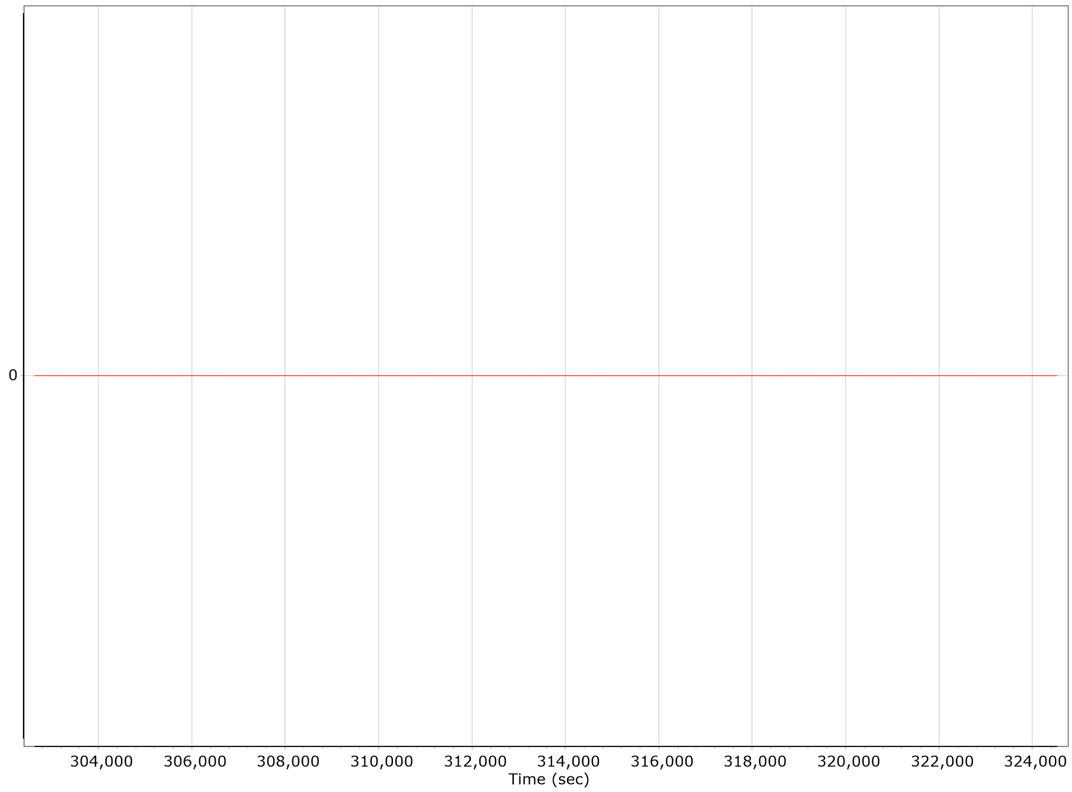
Y Reference-Primary GNSS Lever Arm (m)



Z Reference-Primary GNSS Lever Arm (m)



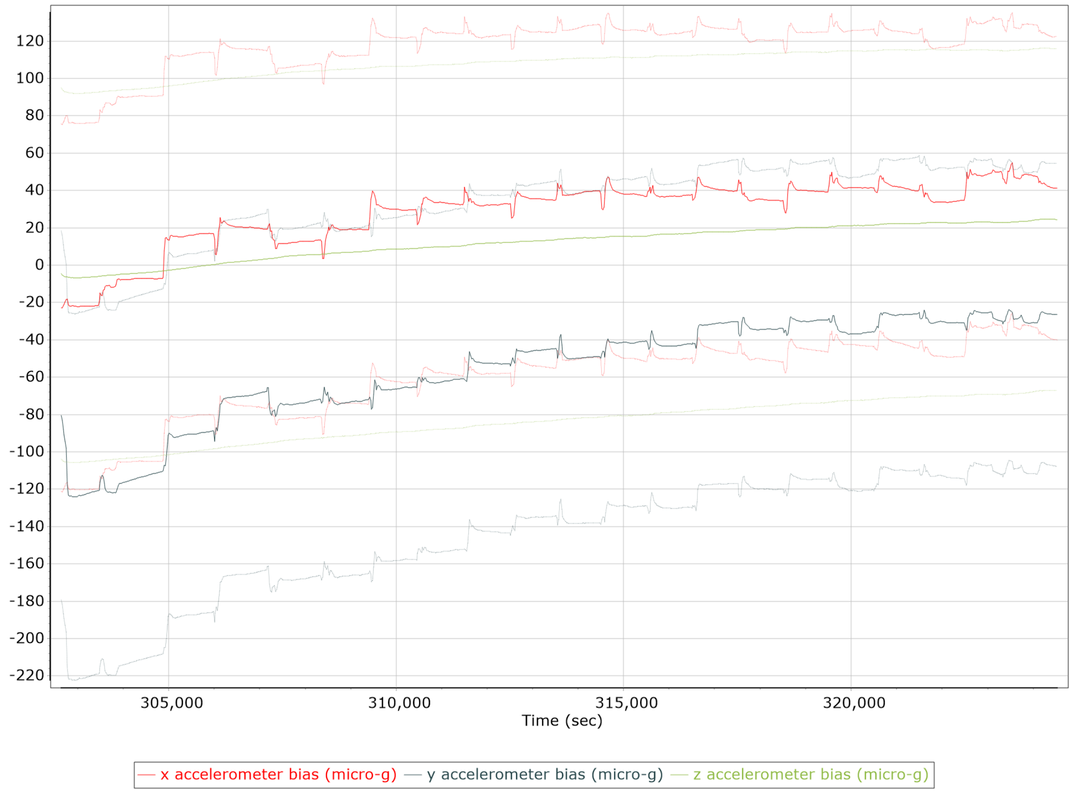
Reference-Primary GNSS Lever Arm Figure of Merit



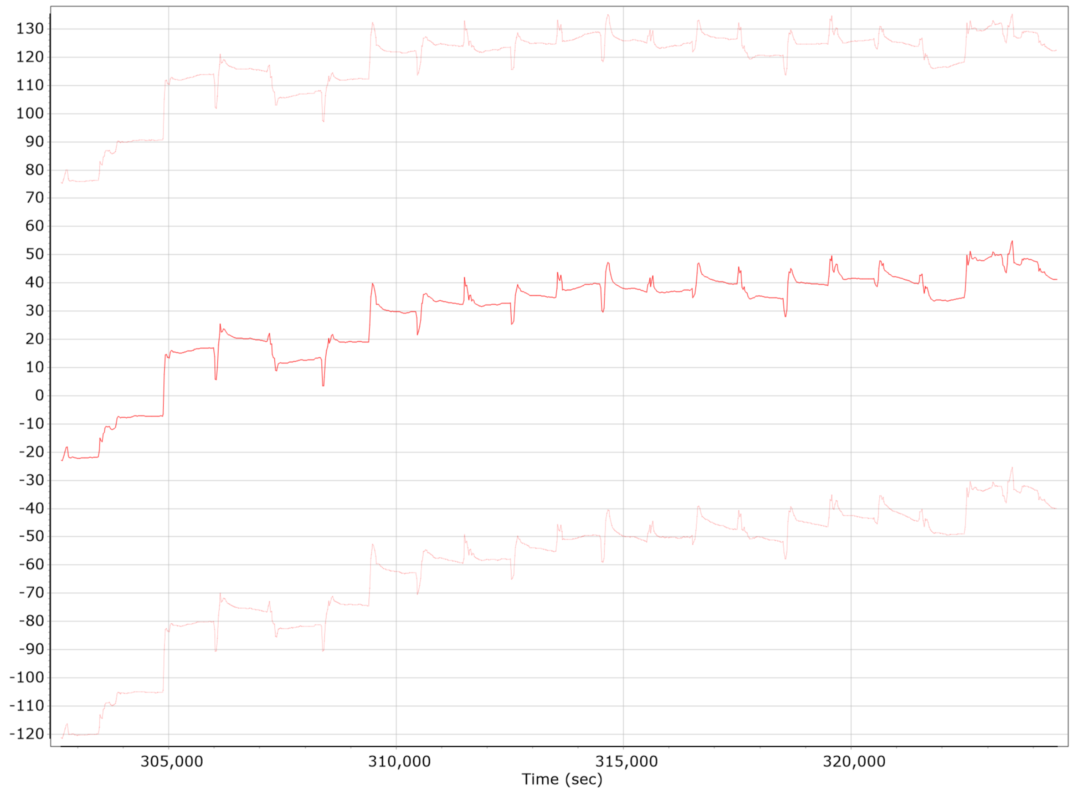
IN-Fusion QC

Forward Processed Estimated Errors, Reference Frame

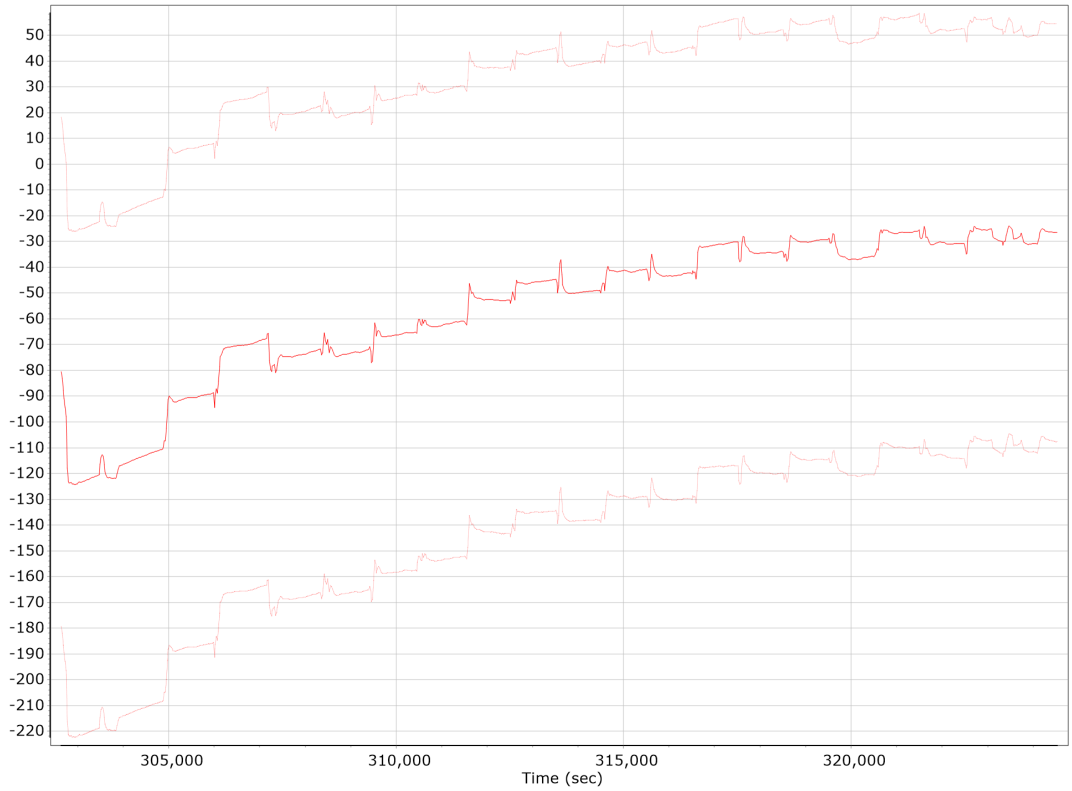
Accelerometer Bias (micro-g)



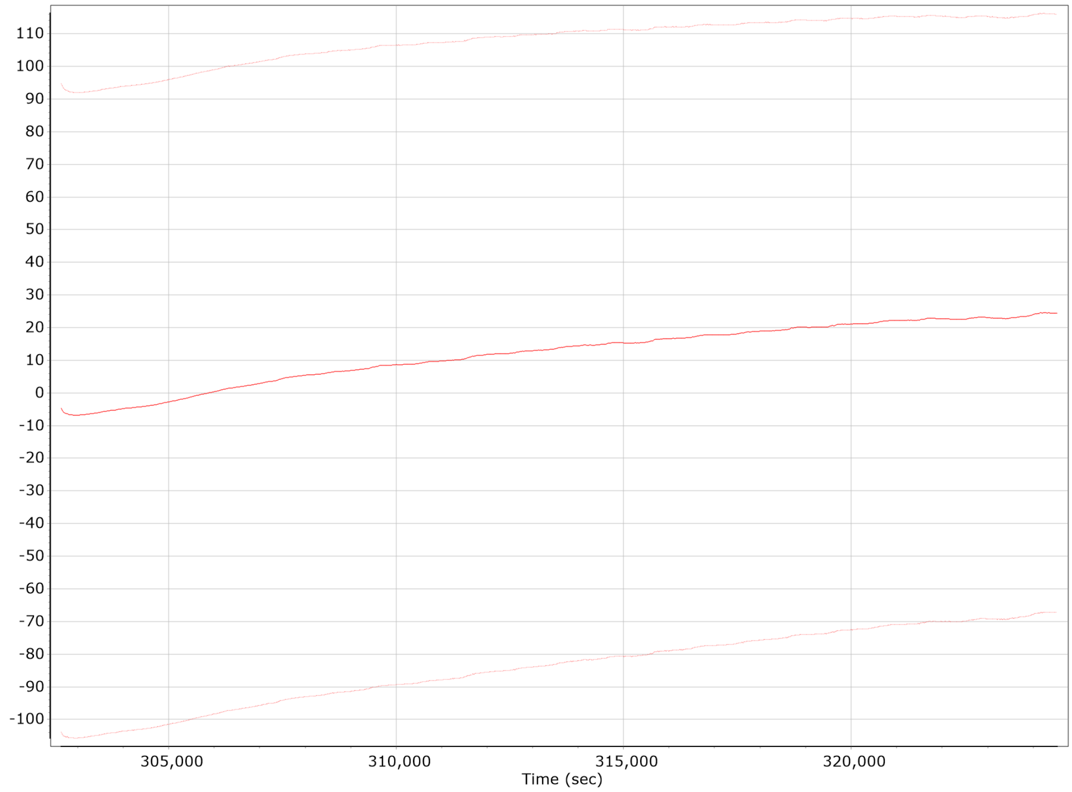
X Accelerometer Bias (micro-g)



Y Accelerometer Bias (micro-g)



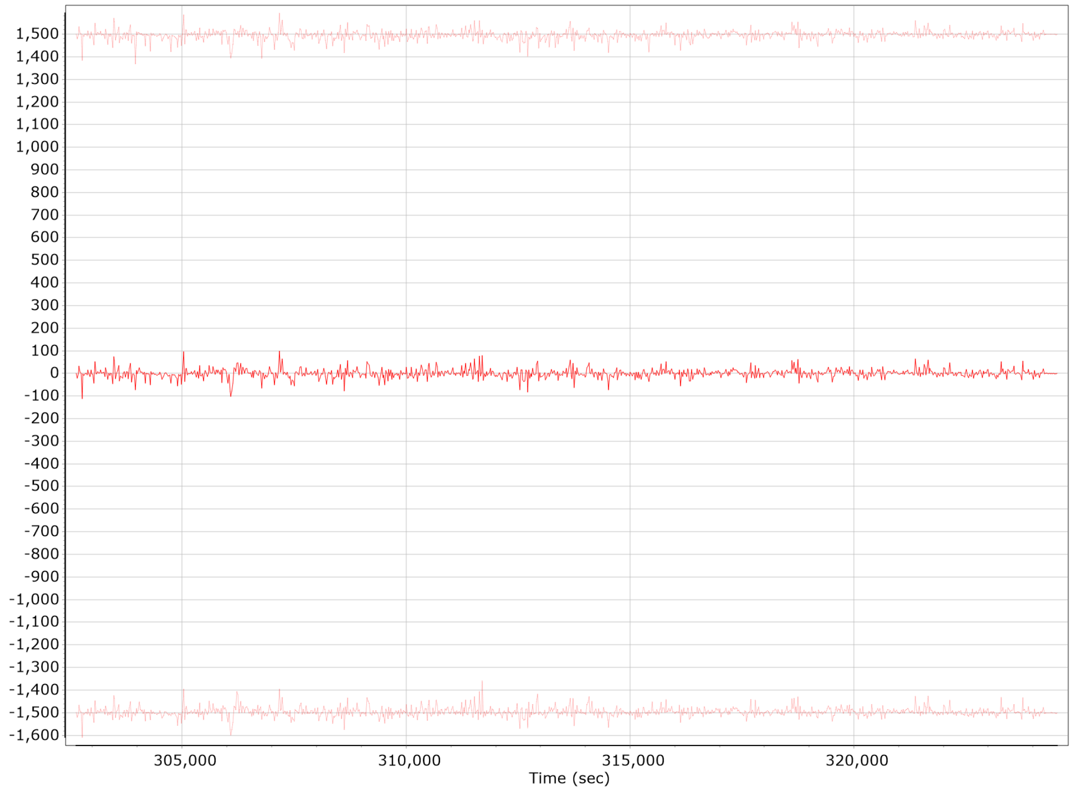
Z Accelerometer Bias (micro-g)



Accelerometer Scale Error (ppm)

X Accelerometer Scale Error (ppm)

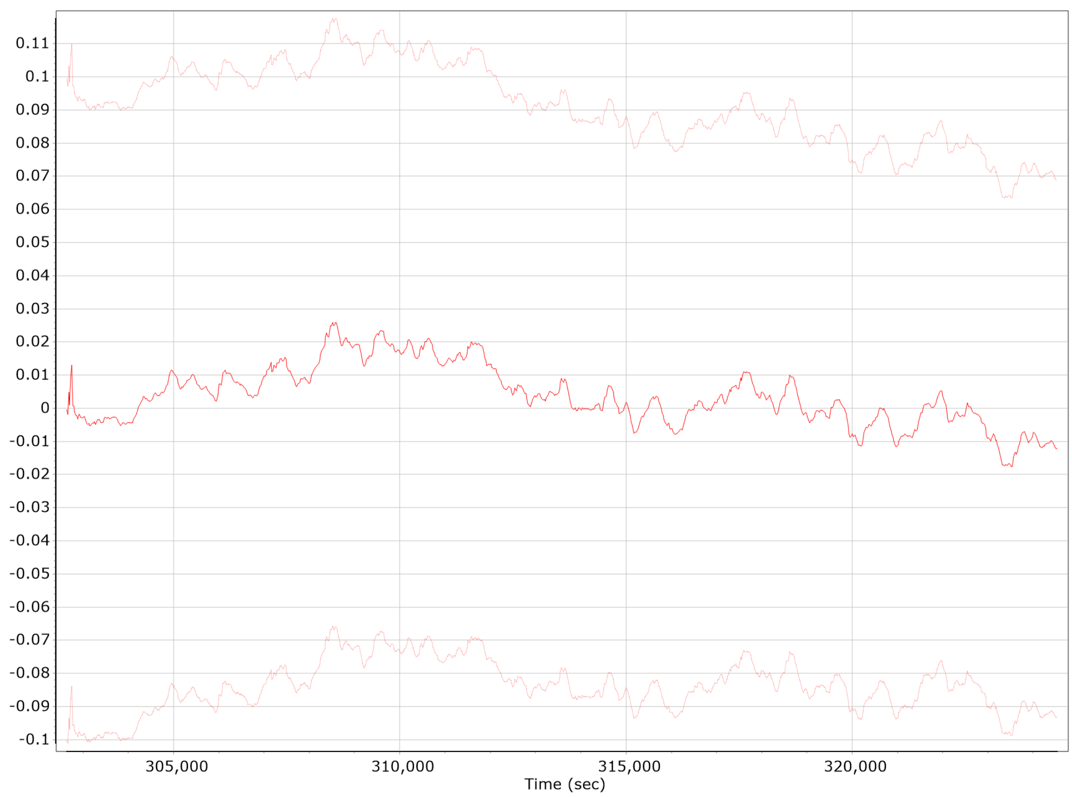
Y Accelerometer Scale Error (ppm)



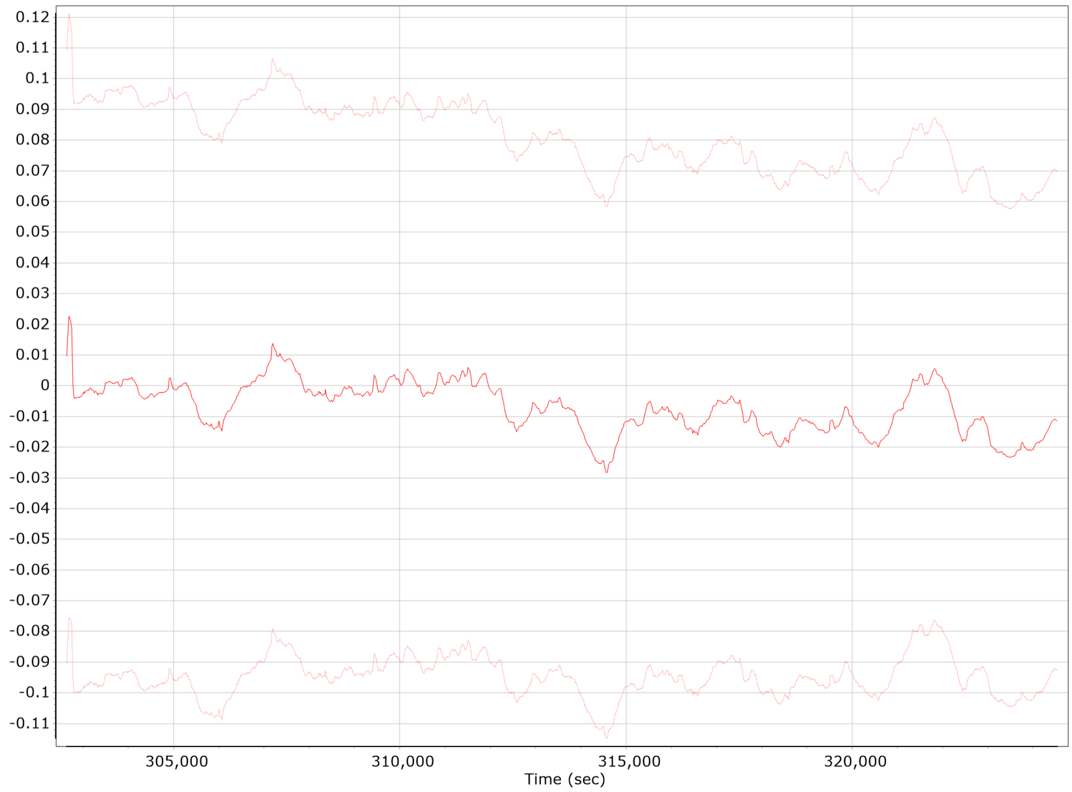
Z Accelerometer Scale Error (ppm)

Gyro Bias (deg/h)

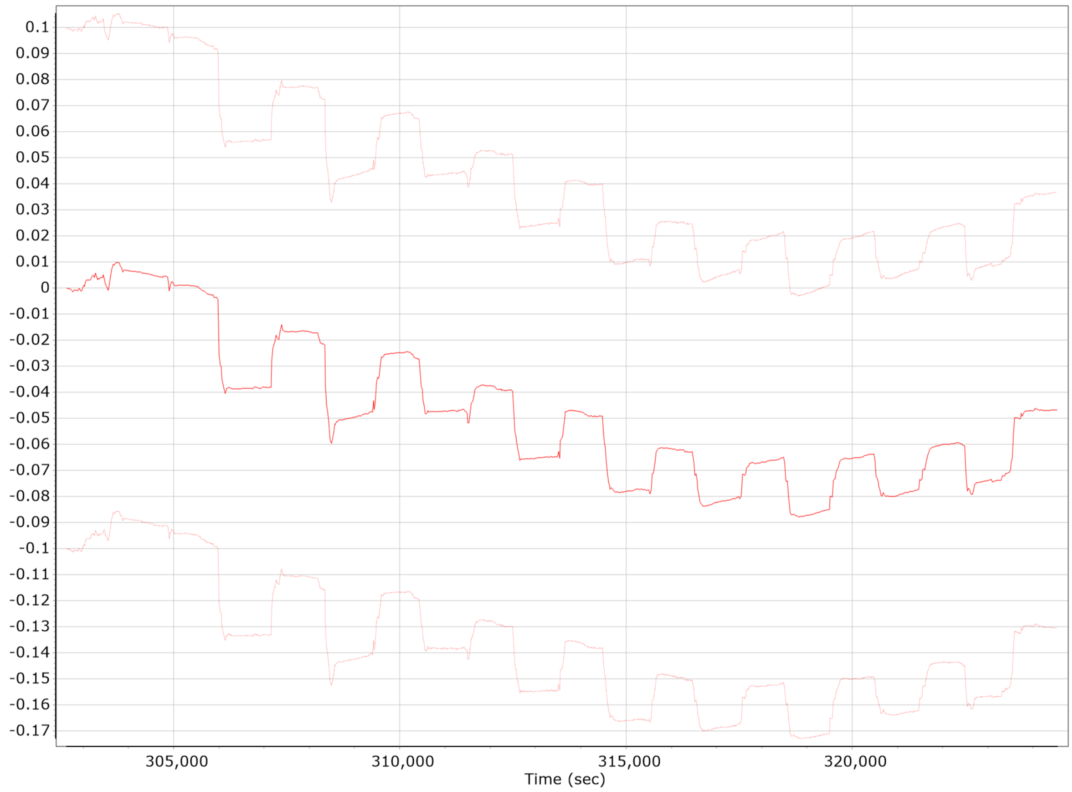
X Gyro Bias (deg/h)



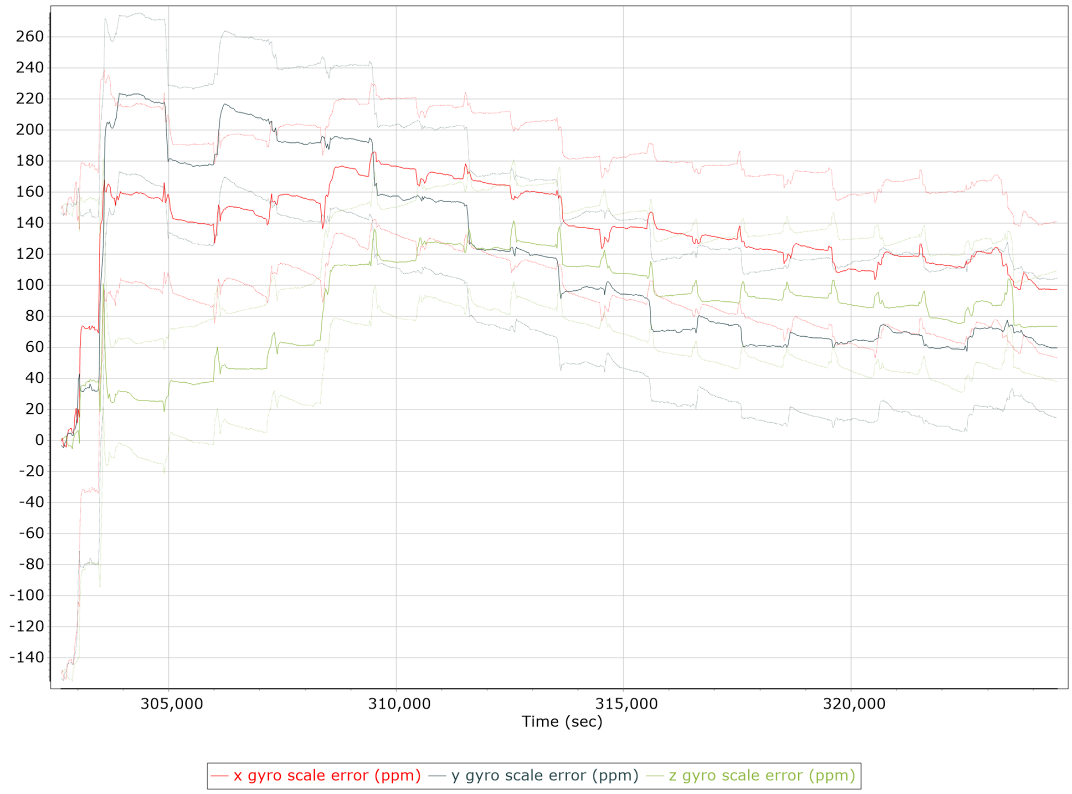
Y Gyro Bias (deg/h)



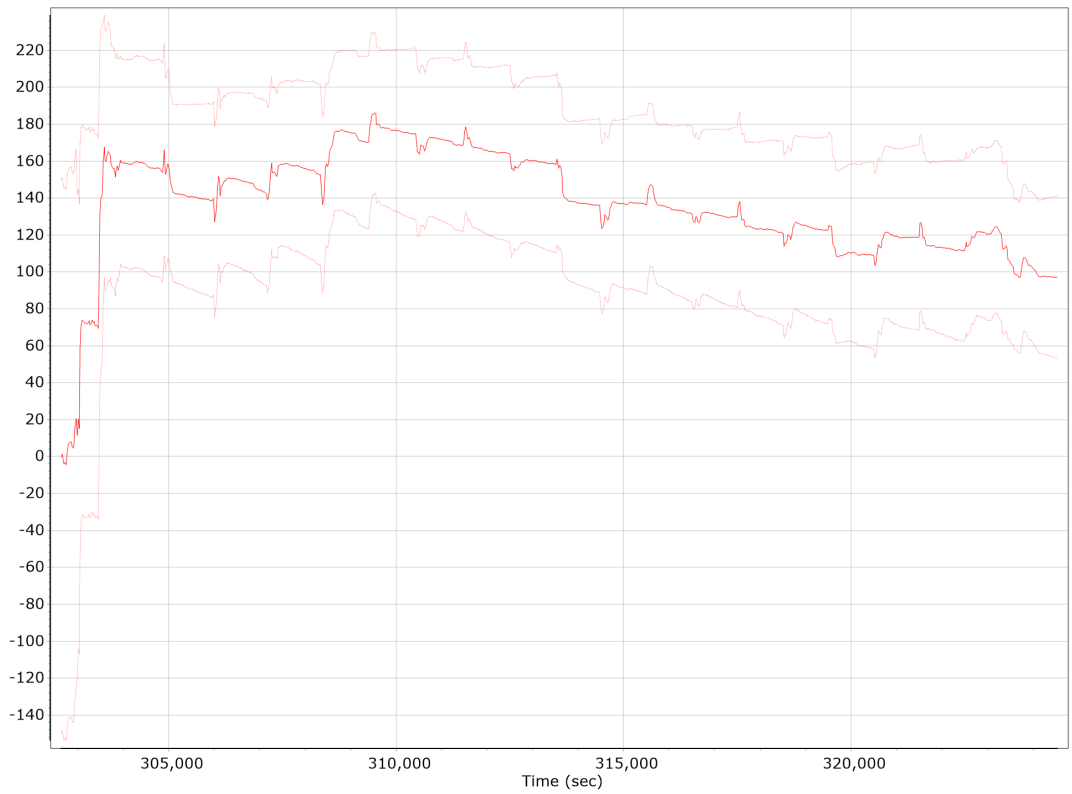
Z Gyro Bias (deg/h)



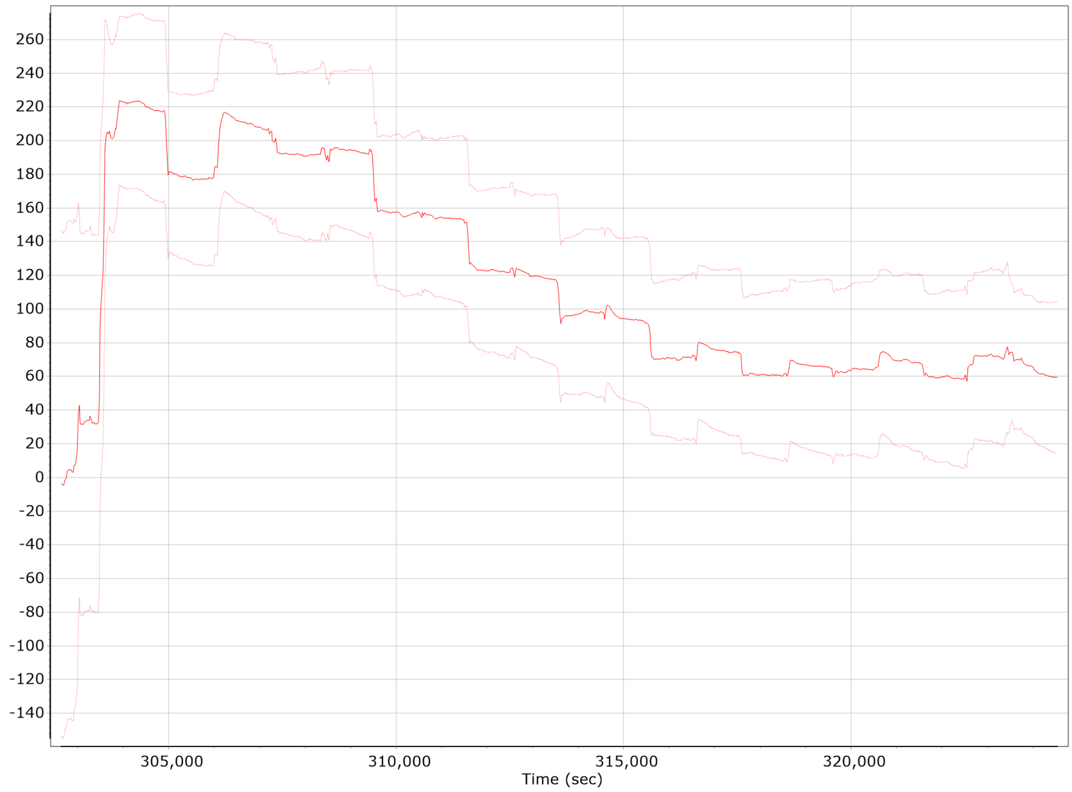
Gyro Scale Error (ppm)



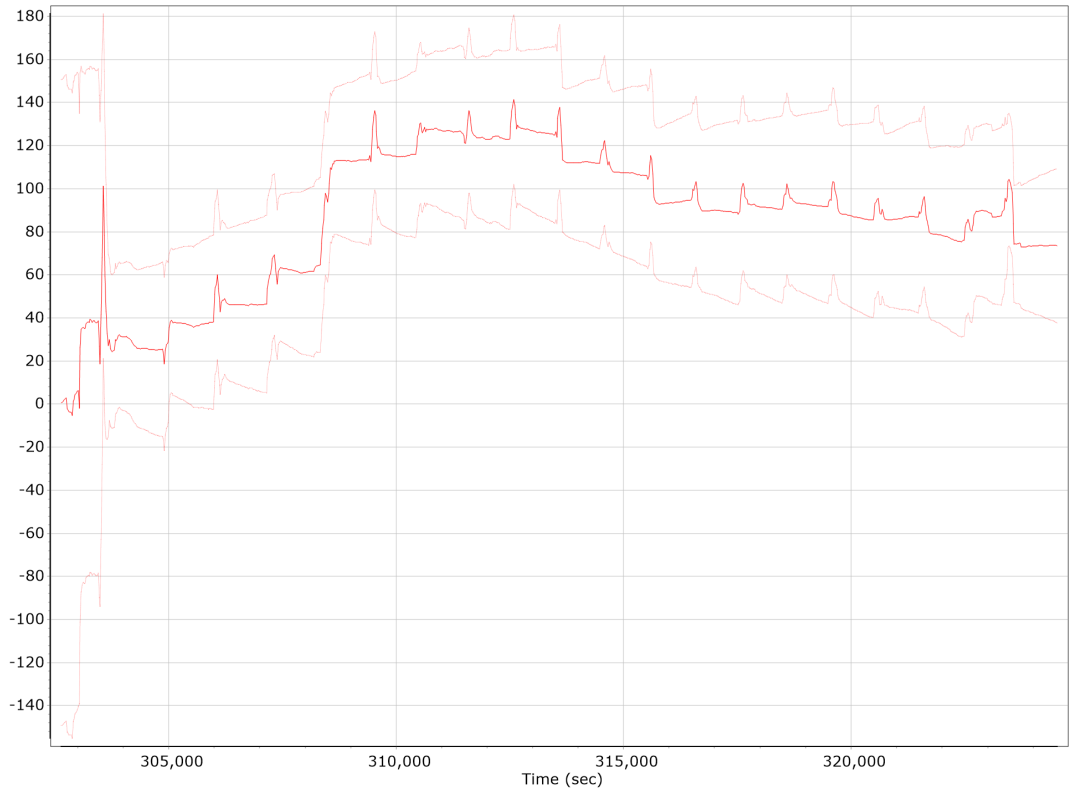
X Gyro Scale Error (ppm)



Y Gyro Scale Error (ppm)

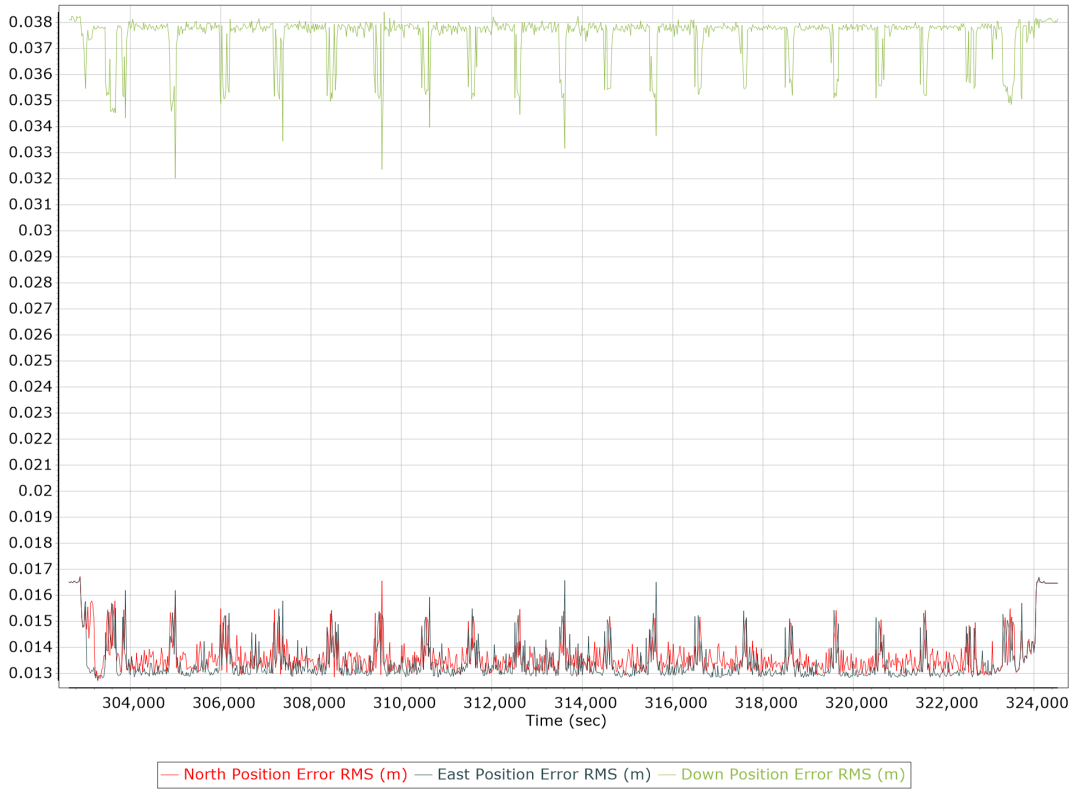


Z Gyro Scale Error (ppm)



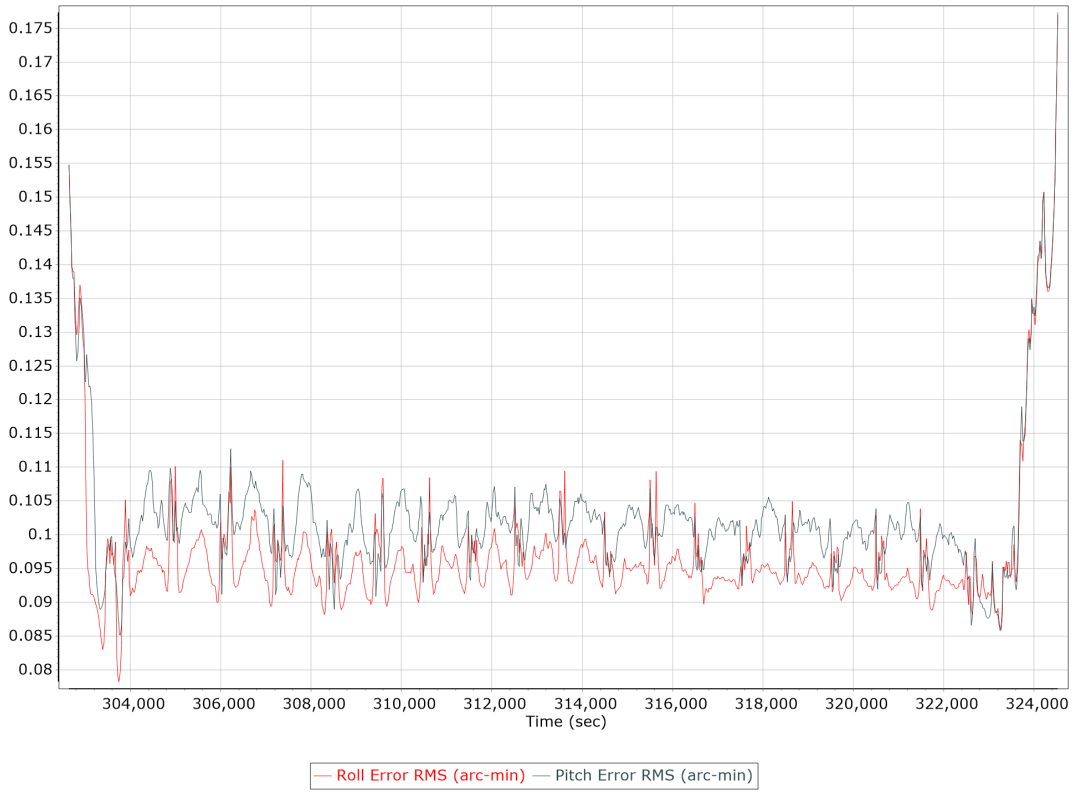
Smoothed Performance Metrics

Position Error RMS (m)

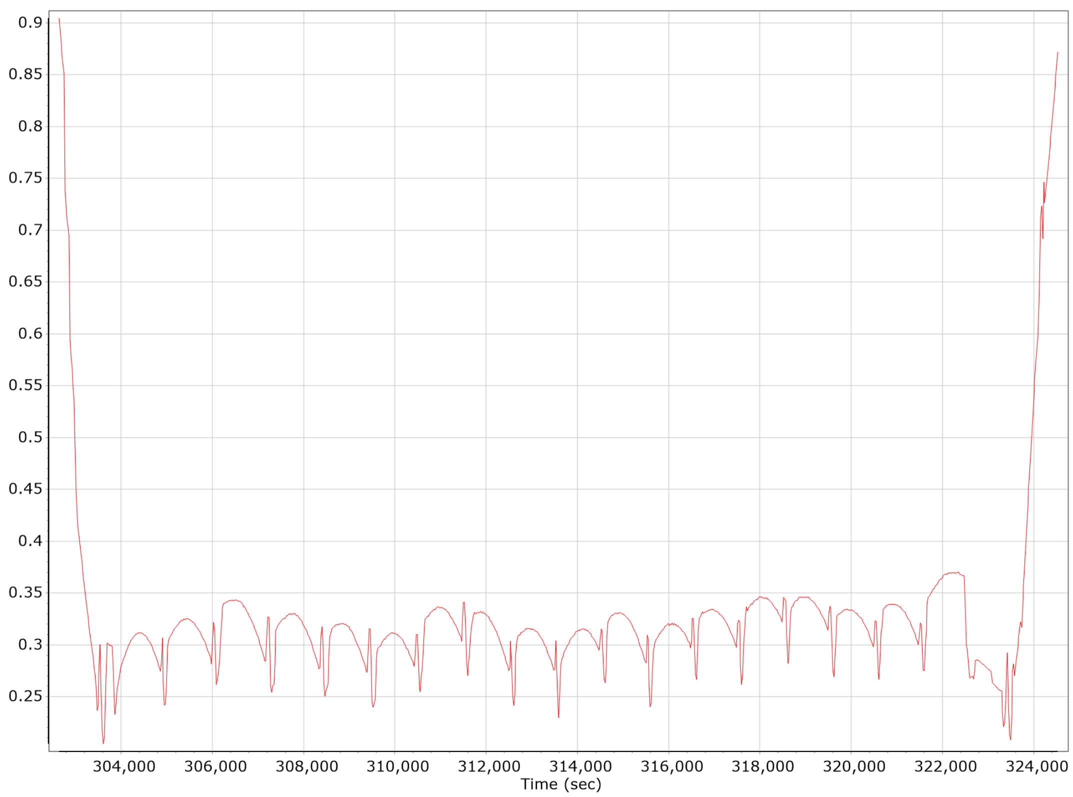


Velocity Error RMS (m/s)

Roll/Pitch Error RMS (arc-min)



Heading Error RMS (arc-min)

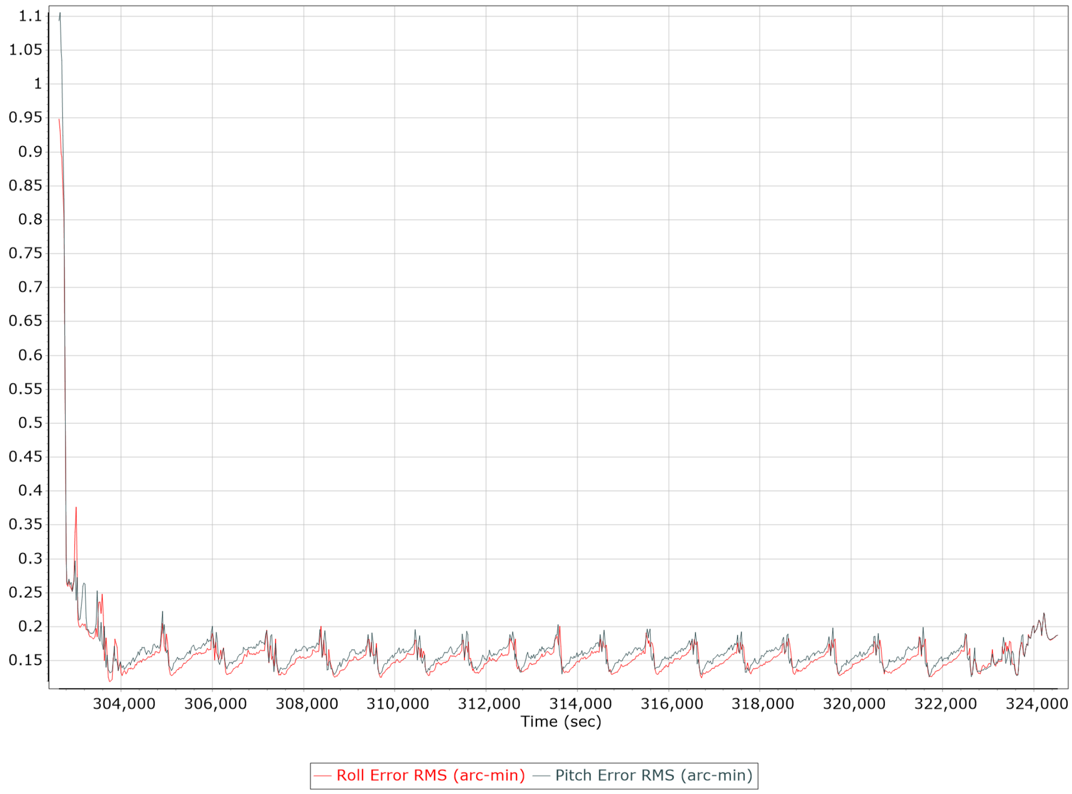


Forward Processed Performance Metrics

Position Error RMS (m)

Velocity Error RMS (m/s)

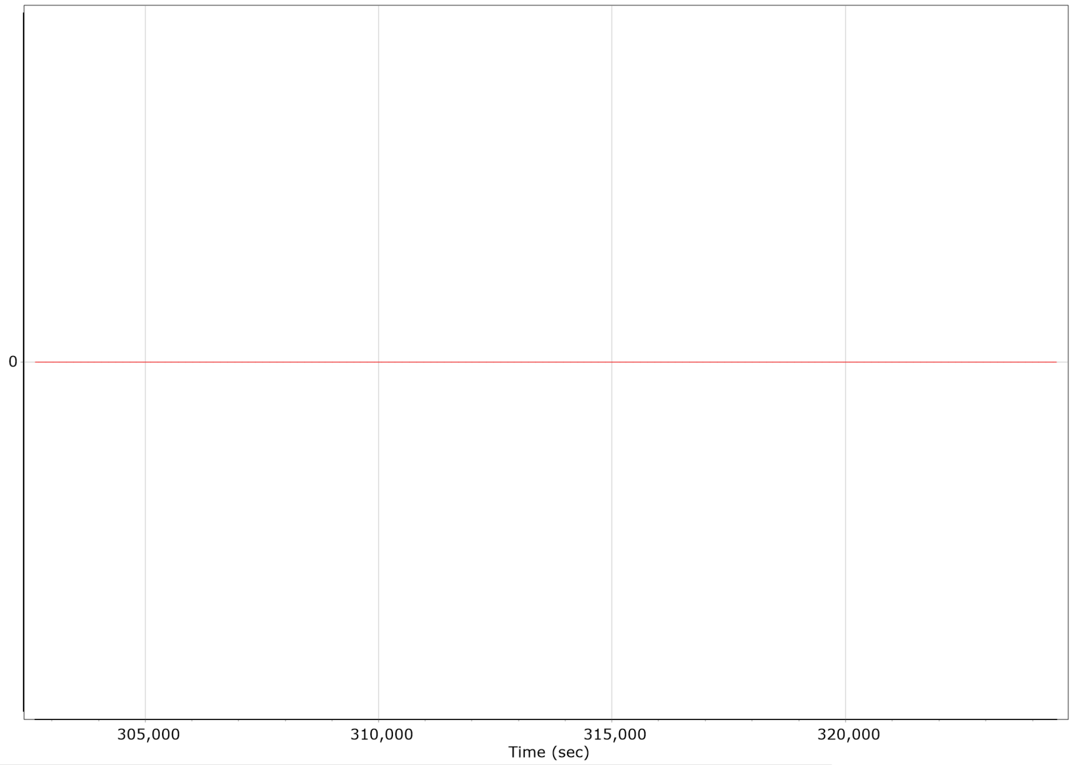
Roll/Pitch Error RMS (arc-min)



Heading Error RMS (arc-min)

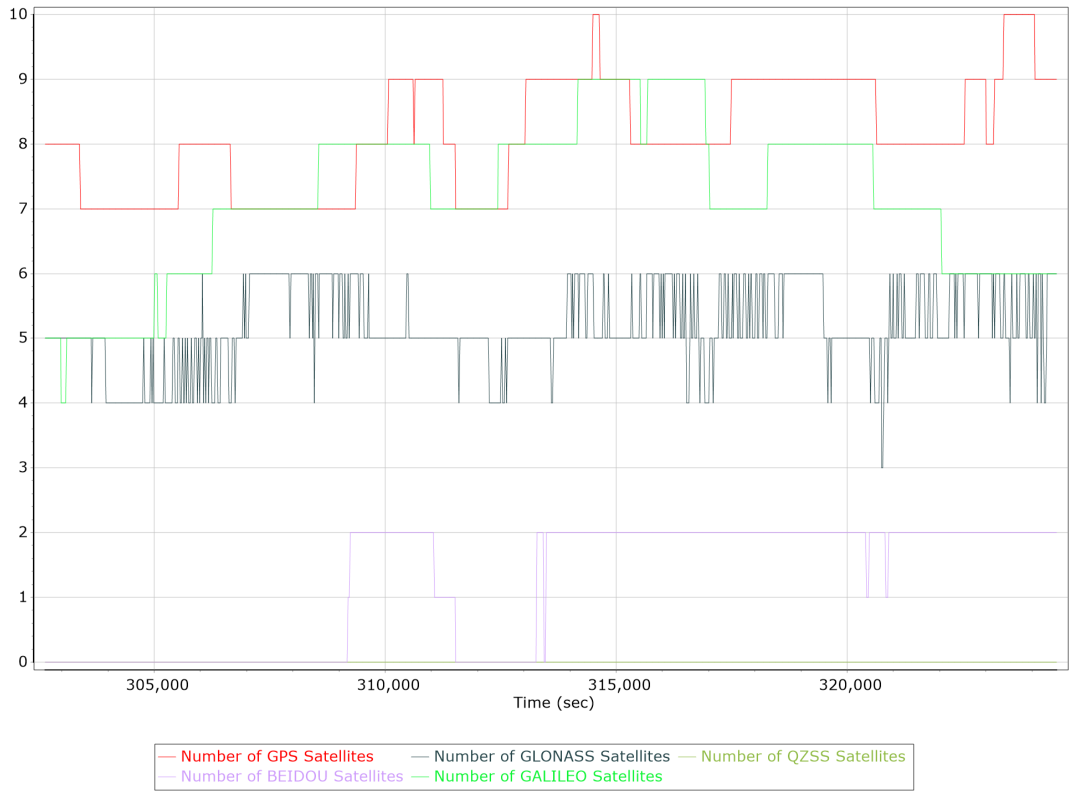
Forward Processed Solution Status

Processing Mode



0 = Fixed NL, 1 = Fixed WL, 2 = Float, 3 = DGNSS, 4 = RTCM, 5 = IAPPP, 6 = C/A, 7 = GNSS Nav, 8 = DR

Number of Satellites



Baseline Length