NIVI5 GEOSPATIAL

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WI 12 County 6 B22 Winnebago LIDAR PROCESSING REPORT

Project ID: 23011 Work Unit: 300209

Prepared for:



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1. Summary / Scope

1.1. Summary

This report contains a summary of the WI 12 County B22 Winnebago County, Work Unit 300209 lidar acquisition task order, issued by USGS under their Contract 140G0221D0012 on March 28, 2022. The task order yielded a work unit area covering 585 square miles over Wisconsin at Quality Level 2. 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
2 pts / m2	2300 m	58.5°	20%	≤ 10 cm

1.3. Coverage

The work unit boundary covers 585 square miles over Winnebago County, Wisconsin. Work unit extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from April 12, 2022 and May 5, 2022 in 2 total lifts. See "Section: 2.4. Time Period" for more details.

1.5. Issues

Five tiles are empty due to being in water. Those tiles are 816507, 816471, 816492, 803467, and 816512.

WI 12 County B22 Winnebago County Work Unit 300209 Projected Coordinate System: WISCRS - Calumet, Fon du Lac, Outagamie & Winnebago Horizontal Datum: NAD83 (2011) Vertical Datum: NAVD88 (GEOID 18) Units: Survey Feet		
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format	
Rasters	 2-foot Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format 2-foot Intensity images in GeoTIFF format 4-foot Maximum Surface Height Raster 4-foot Swath Seperation Images 	
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 Winnebago County Work Unit 300209 Boundary Sey Black Creek WISCONSIN Lake Michigan New London WISCONSIN Milwaukee ville Rocket City Alrport Racine Waukegan Rockford •Little Chute Kimberly Kaukauna •Combined Lock *Appleton Outagamie Con Rgnl Airport Menash nah Hilbert, Oshkosh 21 Lake Winneba Chilton 151 Berlin New Holst Muni Airp Green Lake Ripon Fond Du Lac Co Airport Fond du Lac Miles AOI 0 1.5 3 CR 8 6 9 Oakfield,

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) 3062, 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.

		Riegl VQ1560ii (SN3062)
Terrain and	Flying Height	1584 m
Aircraft Scanner	Recommended Ground Speed	160 kts
	Field of View	60°
Scanner	Scan Rate Setting Used	191 lps
	Laser Pulse Rate Used	2400 kHz
Laser	Multi Pulse in Air Mode	yes
C	Full Swath Width	1827 m
Coverage	Line Spacing	1462 m
Point Spacing	Average Point Spacing	0.71 m
and Density	Average Point Density	2 pts / m ²

Table 2. Lidar System Specifications

Figure 2. Riegl VQ160ii Lidar Sensor



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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-GAYY, 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



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2.4. Time Period

Project specific flights were conducted between April 12, 2022 and May 5, 2022. Two aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
04122022A (SN3062,C-GAYY)	4/12/2022 2:48:09 PM	4/12/2022 5:18:44 PM
05052022A (SN3062,C-GAYY)	5/05/2022 2:13:11 PM	5/05/2022 4:24:02 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.

Each sensor is initially factory calibrated. Further adjustment is performed on each sensor by periodically flying boresight locations and using this data to update boresight values used in data processing. Various proprietary tools and methodologies are used during this process. Once all data has been processed with updated boresight values, FL to FL match is performed by using strip align and other proprietary tools/processes.

Point clouds were created using the RiPROCESS software. The generated point cloud is the mathematical threedimensional composite of all returns from all laser pulses as determined from the aerial mission. The flight line strips are calibrated using Strip Align software. This process involves correcting for systematic errors remaining in the dataset after the boresight values are applied to the dataset. Corrections are made from line to line as well as from lift to lift in order improve the relative accuracy of the dataset and exceed specifications. Each adjusted flight line channel is merged using proprietary software to form the final flight line strips. The point cloud data is then imported into GeoCue, where they are then cut into a tiled dataset. Automated ground macros are run, and the vertical accuracy of the calibrated point cloud is tested against the surveyed ground control and any bias is validated, and the remaining bias is removed from the data using a TerraScan macro that is run through the GeoCue distributive process.

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:

	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.

Table 3. LAS Classifications

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 3 feet/1 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. NV5 Geospatial's proprietary software was then used to create the deliverable industry-standard LAS files for all point cloud data and 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 2-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 proprietry 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 4-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.

0-8cm	
8-16cm	
16-24cm	
>24cm	

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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 4-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 4-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 2 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 3.25 points/m2 while the average ground classified density was 2.87 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 Oneida County Work Unit 300211 First Return Density

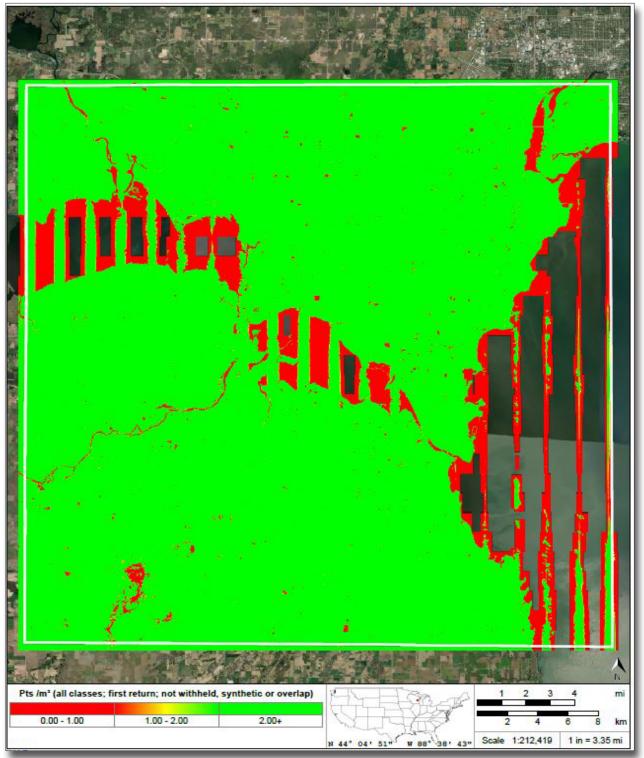


Figure 4. First Return Point Density

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WI 12 County B22 Oneida County Work Unit 300211 Ground Density

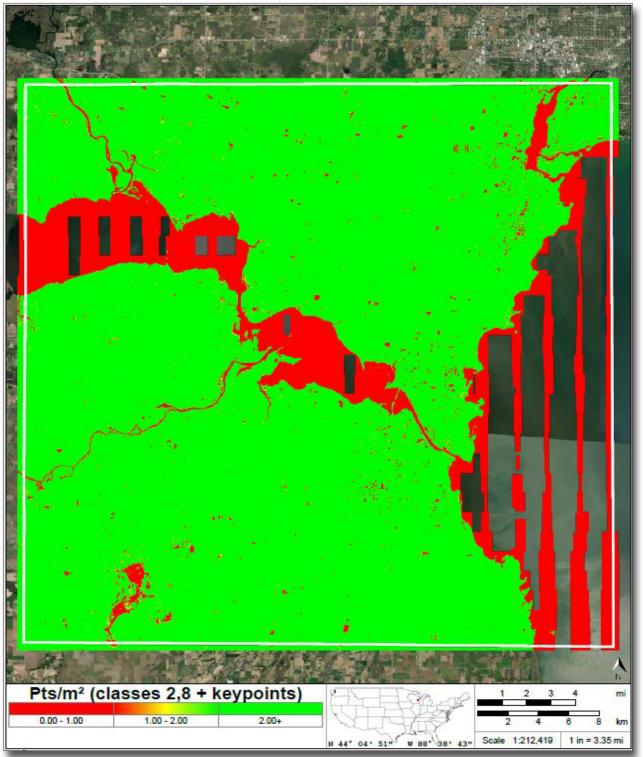


Figure 5. Ground Density

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WI 12 County B22 Winnebago County Work Unit 300209 Tile Layout Sey Ν Black Creek WISCONSIN Lake Michigan New London WISCONSIN Milwaukee ville Rocket City Airport Racine Waukegan Rockford •Little Chute Kimberly Kaukauna •Combined Lock Appleton Hilbert, Redgranit Chilton 151 Berlin New Holst Muni Airp Green Lake Ripon Fond du Lac Du Lac Co Ai AOI Miles **Tile Layout** 0 1.5 3 CR® 6 9 Oakfield

Figure 6. Lidar Tile Layout

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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.

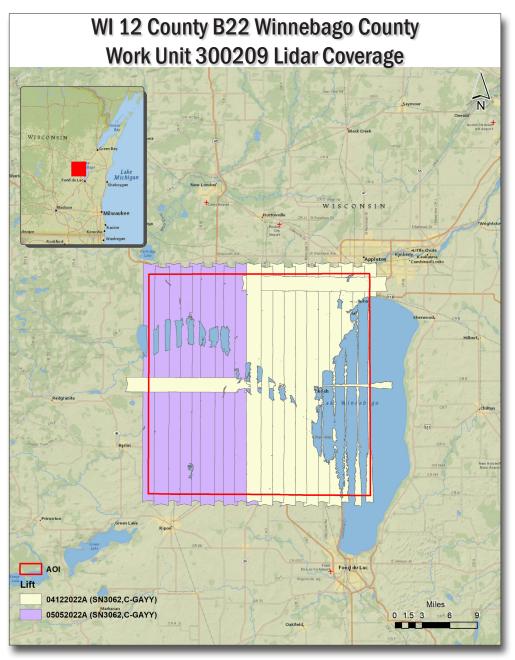


Figure 7. Lidar Coverage

5. Geometric Accuracy

5.1. Horizontal Accuracy

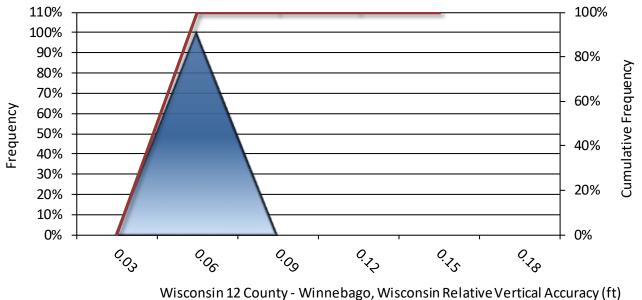
Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained RMSE, value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial 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 2300 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.25 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

Horizontal Accuracy		
RMSE,	0.47 ft	
	0.14 m	
ACC	0.82 ft	
ACC _r	0.25 m	

5.2. Relative Vertical Accuracy (Interswath Precision)

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 Winnebago County project was 0.054 feet (0.016 meters). A summary is shown below.

Relative Vertical Accuracy		
Sample	20 flight line surfaces	
	0.054 ft	
Average	0.016 m	
Madian	0.054 ft	
Median	0.016 m	
DNACE	0.054 ft	
RMSE	0.017 m	
Standard Deviation (1g)	0.002 ft	
Standard Deviation (1σ)	0.001 m	
1.05-	0.004 ft	
1.96σ	0.001 m	



Total Compared Points (n = 1,304,401,724)

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 4.1 cm, minimum slope-corrected range to be 0 cm, and the maximum slope-corrected range to be 15 cm.

Project Report Appendices

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

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Appendix A

Flight Logs

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August 31, 2023

$ \begin{array}{ $	Julian Day 102	Elight A			LIDA	LIDAR Flight Log	t Log				
KINSIN Operator R. Gemmel MU Applanix AP60 Alt e KINSIN Operator R. Gemmel Alt Timble GNS17 Timble GNS17 e Altcraft Block Time Alt Scanner 1 Drive Alt Time to next maintenance. 26.8 6 Takeoff 13:12 Mission Plan Mission Plan Altant 6 Lubak File Mission Pulse Rate 500 kHz Altant	A 3237	2022 3DFP	٦ aft	С-GAYY Зоодтар	System Unit	Reigl VQ		Additional Notes	AI C 117_158	A I R B I M A	0 R N G N G
Image Image <t< th=""><th></th><th></th><th>ator</th><th>2 Gemmel</th><th></th><th>Annlanix A</th><th></th><th>or o liajecioly riles.</th><th>ALO. 11/-130</th><th>A Clean Hai</th><th>A Clean Harbors Company</th></t<>			ator	2 Gemmel		Annlanix A		or o liajecioly riles.	ALO. 11/-130	A Clean Hai	A Clean Harbors Company
$ \ \ \ \ \ \ \ \ \ \ \ \ \ $	Obiective				GPS RX	Trimble G	NSS17				
Canner 2 Drive A Time to next maintenance: 26.8 Aircraft Block Time Aircraft Block Time Time to next maintenance: 26.8 Aircraft Block Time Mission Plan Static Static Aircraft Block Haight Scan Rate 500 kHz Aircraft Algument File Name Direction Start End Time Aborted Mission Direction Direction Direction Direction Direction Direction Direction Direction Direction	-2054-2056				Scanner 1	Drive	A1				
Aircraft Block Time Mission Plan Static 6 Takeoff 13:12 All Height 2300 Pulse Rate 500 kHz Alignment 6 Landing 17:57 All Height 2300 Pulse Rate 500 kHz Alignment 6 Landing 17:57 All Height 2300 Pulse Rate 500 kHz Alignment 7 Target Speed 160 ks For 60° 46gS Pre Mission 6 Landing 17:57 All Height All Hold Prov 60° 46gS Pre Mission 7 Total 4.8 hr Pre Anoted Mission ID Pre Mission 1 Efle Name Direction Start End Time Aborted Mission ID Pre Mission 6 22210201 183.2 13:46 Time Aborted Mission ID Pre Mission 6 22210202 093.1 13:36 13:46 Pre Mission Pre Mission 6	-2033-2033, WX Cal				Scanner 2	? Drive	A2	Time to next maintenance	26.8	O 50 hr 💿 100 hr	
		Aircraft Block Tin	ne			Missi			Static	GPS Time	me
					AGL Height				lignment	Start	End
I total 4.8 hrs Laser Current 100 % FOV 60° degs Post Mission LiDAR Flight CPS Time Lime Aborted Mission ID Mission ID 200412 130323 100					Target Speed		_		Vission	13:03	13:08
LiDAR Flight $\overline{\text{CPS Time}}$ $\overline{\text{Lime Aborted}}$ Mission ID File Name Direction Start End Time $\overline{\text{mison ID}}$ 220410 622210201 183.2 13:20 13:24 N 220412_130323 8199 622210201 183.2 13:30 13:46 N 220412_130328 8199 622210203 273.5 13:50 13:59 13:46 N 133828 8199 622210203 273.5 13:50 13:59 14:10 N 140240 N 622210204 092.8 14:02 14:10 N 140240 140240 N 622210205 093.5 14:41 14:15 N 140240 N N 140240 N <th>5.2</th> <th>4.8</th> <th></th> <th></th> <th>Laser Current</th> <th></th> <th></th> <th></th> <th>Mission</th> <th>17:59</th> <th>18:04</th>	5.2	4.8			Laser Current				Mission	17:59	18:04
File NameDirectionStartEndTimemin to End $T_{\text{ime stamp}}$ 220410 813:2013:2491220412130323813:2013:2413:3013:248199622210201183.213:2813:3613:3613:368622210203273.513:5013:5913:3613:38622210203273.513:5013:5914:1013:38622210203273.513:5014:1014:1014:02622210203273.514:1214:1614:1614:02622210203273.514:1214:1614:1614:02622210203092.814:1214:1614:1614:02622210205093.514:4814:5714:1614:05622210205093.514:4814:5715:1414:05622210205094.315:1715:2615:1415:05622210205094.315:1715:2615:1415:05622210205094.315:1715:2615:1415:05622210205094.315:1715:2615:1715:26622210205094.215:1715:2915:1715:29			Elizht	GPS	Time	Lin	e Aborted	Mission ID			
(13:20) (13:24) (20412_130323) (130323) 8 13:20 13:24 (20412_130323) (199) 622210201 183.2 13:28 13:30 (13:59) (13:30) 622210203 273.5 13:50 13:59 (13:59) (13:59) (13:69) 622210203 273.5 13:50 13:59 (13:59) (13:59) (13:69) 622210203 273.5 13:50 13:59 (13:59) (13:69) (13:69) 622210204 092.8 14:12 14:10 (14:10) (14:02) (14:10) (14:02) (14:10) (14:02) (14:12) (Flight Line)irection	Start	End	Time	nmi to End			Comments	
8 13:20 13:24 9 13:26 13:28 13:30 13:30 13:30 13:30 13:36 8199 622210201 183.2 13:38 13:46 13:30 13:38 8199 622210202 093.1 13:50 13:50 13:50 13:50 13:328 8199 622210203 273.5 13:50 14:10 14:10 14:02 14:10 14:02 14:10 14:0240 14:0250 14:0250 14:0250 14:0250 14:0250 14:0250 14:0250 14:0250 14:0250 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td> </td> <td></td> <td></td> <td></td>											
622210201 183.2 13:28 13:30 13:30 13:345 8199 622210202 093.1 13:38 13:46 13:328 133828 8193 622210203 273.5 13:50 13:50 13:59 13:50 135008 135008 135008 135008 135008 135008 140240	Figure 8		∞	13:20	13:24					8200 ft +/-	
622210202 093.1 13:38 13:46 13:328 13:328 622210203 273.5 13:50 13:59 13:59 13:59 13:59 622210204 092.8 14:102 14:10 14:02 14:10 140240 140240 8 14:12 14:15 14:16 14:16 140240 140240 140240 8 14:12 14:15 14:16 14:16 14:16 140240 140240 140240 8 14:41 14:15 14:16 14:16 14:16 140240 140240 14054 8 14:41 14:45 14:16 14:46 14:46 14:47 14:47 14:46 14:48 14:47 14:47 14:46 14:48 14:46 14:48 14:48 14:46 14:48 14:46 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 14:48 15:48 15:48			183.2	13:28	13:30				8199 ft, trir	ft, trimmed to 4.4 NM for X-Tie	M for X-Ti∈
622210203 273.5 13:50 13:59 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 13:50 14:02 14:10 14:02 14:11 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:15 14:16			093.1	13:38	13:46			133828		8301 ft	
622210204 092.8 14:02 14:10 14:10 14:0240 14:0240 8 14:12 14:15 14:15 14:16 14:02 14:0240 8 14:12 14:15 14:15 14:16 14:16 14:02 8 14:11 14:15 14:16 14:16 14:16 14:02 8 03:5 14:41 14:45 14:57 14:18 14:61 14:08 8199 ft, half o 622210206 004.3 15:05 15:14 15:26 15:14 15:0537 15:09 622210208 004.2 15:26 15:37 15:290 15:37 15:290			273.5	13:50	13:59			135008		8301 ft	
8 14:12 14:15 14:15 14:15 14:15 14:16 14:17 14:17 14:16 14:17 14:17 14:15 14:15 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 14:16 11:16 11:16 11:17 11:16 11:17 11:16 11:17 11:16 11:17 11:16 11:17 11:16 11:17 11:			092.8	14:02	14:10			140240		8301 ft	
8 14:41 14:45 9 14:40 8139 ft, half o 622210205 093.5 14:48 14:57 14:46 8139 ft, half o 622210206 004.3 15:05 15:14 15:26 15:14 15:77 622210207 184.3 15:17 15:26 15:17 15:26 151719 622210208 004.2 15:29 15:37 15:37 15209	Figure 8		8	14:12	14:15					8300 ft +/-	
622210205 093.5 14:48 14:57 14:480 8199 ft, half o 622210206 004.3 15:05 15:14 15:05 15:17 15:26 151719 151719 622210208 004.2 15:29 15:37 15:26 151719 15:26 151719	Figure 8		0	14:41	14:45					8250 ft +/-	
622210206 004.3 15:05 15:14 150537 622210207 184.3 15:17 15:26 151719 622210208 004.2 15:29 15:37 15:37			093.5	14:48	14:57			144808		half over lake, do	do X-Tie north
622210207 184.3 15:17 15:26 15:19 15:19 15:29 15:37 15:2909			004.3	15:05	15:14			150537		8199 ft	
622210208 004.2 15:29 15:37 1 15:29 15:37			184.3	15:17	15:26			151719		8199 ft	
	2050 6		004.2	15:29	15:37			152909		8199 ft	
2049 622210209 184.3 15:40 15:49 15:49 15:49 81			184.3	15:40	15:49			154052		8100 ft	
2048 622210210 004.2 15:52 16:01 15:52 81			004.2	15:52	16:01			155249		8100 ft	

	OR	IMAGING	A clean narbors company			● 50 hr O 100 hr	GPS Time	Start End	13:03 13:08	17:59 18:04		Comments	8199 ft	8100 ft	8100 ft, low cloud virga/rain coming in.	8199 ft	8199 ft Rain almost on us, 1 more line.	REFLY south 5 NM - rain, make it 7NM	8199 ft	south 5 NM - rain, make it 7NM	8200 ft +/-	more over land/less lake	8250 ft +/-			Page 2 of 2
		ALS.117-158				26.8	Static	Alignment	Pre Mission	Post Mission					8100 ft, low c		8199 ft Rain	REFLY south		REFLY south		Extra X-Tie,				
	Additional Notes	GPS trajectory Files: ALS.117-158	• •			Time to next maintenance:		500 kHz			Mission ID	Time Stamp 220410	220410_160407	161601	162727	163917	165035		170234		171325					
Log		0		VSS17	A1	A2 1	n Plan	Pulse Rate	Scan Rate100 (102 plane)	FOV 60 °	Line Aborted	nmi to End														
LIDAR Flight Log	Reigl VQ1560ii		Applanix AP60	Trimble GNSS17			Mission	2300 m	160 kts	100 %	Line	Time														
LIDA	System	Unit	IMU	GPS RX	Scanner 1 Drive	Scanner 2 Drive		AGL Height	Target Speed	Laser Current	Time	End	16:13	16:24	16:36	16:47	16:59		17:10		17:18		17:23			
	C-GAYY	Goodman	R. Gemmel								GPS Tim	Start	16:04	16:16	16:27	16:39	16:50		17:02		17:13		17:19			
	Aircraft	Pilot P.	Operator				me				Flight	Direction	184.3	004.1	184.2	004.1	184.2		004.1		095.0 +/-		8			
Flight A	ı, 2022	VI3DEP_QL2	KMSN				Aircraft Block Time	Takeoff 13:12	Landing 17:57	Total 4.8 hrs	I iDAR		622210211	622210212	622210213	622210214	622210215		622210216		622210217 0					
Julian Day 102	Date April 12th, 2022	Project 3237_NV5_WI3DEP	Location KM	Mission Objective	-2054-2056	-∠∪33-∠∪93, wx came	Air	Engine On 12:56 Ta	Engine Off 18:06 La	Total 5.2 hrs To		Flight Line Fil	2047 622	2046 622	2045 622	2044 622	2043 622		2042 622		X-Tie_42-52 622		Figure 8			v 20200520

	0 8	A Clean Ladver Community				• 50 hr O 100 hr	GPS Time	Start End	13:03 13:08	17:59 18:04		Comments								Page 3 of 2
		GPS trajectory Files: ALS.117-158				26.8	Static	Alignment	Pre Mission	Post Mission	OI C	220410								
	Additional Notes	GPS trajector	•			Time to next maintenance:		500 kHz) (102 plane)) ° degs	Mission ID	Time Stamp 2								
Log				VSS17	A1	A2	n Plan	Pulse Rate	Scan Rate 100 (102 plane)	FOV 60	Line Aborted	nmi to End								
LIDAR Flight Log	Reigl VQ1560ii		Applanix AP60	Trimble GNSS17			Mission	2300 m	160 kts	100 %	Line	Time								
LIDA	System	Unit	IMU	GPS Rx	Scanner 1 Drive	Scanner 2 Drive		AGL Height	Target Speed	Laser Current	ime	End								
	с-даүү	Goodman	R. Gemmel								GPS Time	Start								
	Aircraft	Pilot P.	Operator				ne				Fliaht	Direction								
Flight A	h, 2022	M3DEP_QL2	KMSN			eII	Aircraft Block Time	Takeoff 13:12	Landing 17:57	Total 4.8 hrs	Lidar	<u>е</u>								
Julian Day 102	Date April 12th, 2022	Project 3237_NV5_WI3DEP	Location KI	Mission Objective	-2054-2056	-∠033-∠033, WX Cam	Ai	Engine On 12:56 1	Engine Off 18:06 L	Total 5.2 hrs 1		Flight Line Fi								V 20200520

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			È																	l
	AIRBORN	A Clean United Standard and A					GPS Time	End	13:08	18:04		S								Page 4 of 2
	AI					• 50 hr O 100 hr	GP	Start	13:03	17:59		Comments								ă
		ALS.117-158				26.8	Static	Alignment	Pre Mission	Post Mission										
	s	y Files: ⊭				intenance:		A	Pre M	Post	Q	220410								1
	Additional Notes	GPS trajectory Files: ALS.117-158				Time to next maintenance:		500 kHz	Scan Rate 100 (102 plane)	° degs	Mission ID	Time Stamp 220410								
D	Ā						u	Pulse Rate	Rate 100	。09	ed	nmi to End								1
nt Lo <u>g</u>	Reigl VQ1560ii		AP60	Trimble GNSS17	A1	A2	Mission Plan	m Pulse	kts Scan		Line Aborted	ш Ш								1
LIDAR Flight Log	Reigl V		Applanix AP60	Trimble	Drive	Drive	Mis	2300	160 k	100		Time								1
LIDAF	System	Unit		GPS Rx	Scanner 1 Drive	Scanner 2 Drive		AGL Height	Target Speed	Laser Current	υ	End								
			-					AG	Tar	Las	GPS Time			 		 			 	l
	C-GAYY	P. Goodman	R. Gemmel								σ	Start								
	Aircraft	Pilot P	Operator				e				Eliaht	Direction								
Flight A	1, 2022	VI3DEP_QL2	KMSN				Aircraft Block Time	Takeoff 13:12	Landing 17:57	Total 4.8 hrs		е								
102	April 12th, 2022	NV5_WI3DEP	KR	ive		wx came	Air	12:56 Ta	18:06 L a	hrs To		- III								 1
Julian Day	Date A	Project 3237	Location	Mission Objective	-2054-2056	-2033-2033		Engine On 12	Engine Off 18	Total 5.2		Flight Line								v 20200520

•	Ш N	0							~	L L											
	O R	A Clean United Standard and A					GPS Time	End	13:08	18:04											Page 5 of 2
	AIRB					• 50 hr O 100 hr	GPS	Start	13:03	17:59		Comments									Pa
		S 117-15				26.8	tatic	Alignment	sion	ission											
		/ Files: AL				ntenance:	ö	Alig	Pre Mission	Post Mission	Q	20410									
	Additional Notes	GPS trajectory Files: ALS.117-158				Time to next maintenance:		500 kHz	Scan Rate 100 (102 plane)	° degs	Mission ID	Time Stamp 220410	-								
ວ				2			Plan	Pulse Rate	n Rate 100	° 09	ted	nmi to End									
LIDAR Flight Log	Reigl VQ1560ii		x AP60	Trimble GNSS17	A1	A2	Mission PI	m Puls		% FOV	Line Aborted										
.R Fliç	Reigl ¹		Applanix AP60	Trimble	1 Drive	2 Drive	M	2300	160	100		Time									
LIDA	System	Unit	IMU	GPS Rx	Scanner 1 Drive	Scanner 2 Drive		AGL Height	Target Speed	Laser Current	0	End									
		_	<u>_</u>					AGI	Tarç	Las	GPS Time								 		
	C-GAYY	P. Goodman	R. Gemmel								5	Start									
	Aircraft	Pilot P.	Operator				e				Cliabt	Direction									
Flight A	، 2022 کار ا	VI3DEP_QL2	KMSN				Aircraft Block Time	Takeoff 13:12	Landing 17:57	Total 4.8 hrs											
102	April 12th, 2022	7_NV5_WI3DEP.	Y	ctive		wx carn	Air	12:56 T	18:06 L	hrs T									 		
Julian Day	Date	Project 3237	Location	Mission Objective	-2054-2056	-2033-2033,		Engine On 1	Engine Off 1	Total 5.2		Flight Line									v 20200520

	BOR					● 50 hr O 100 hr	GPS Time	Start End	13:10 13:15	19:08 19:13			Comments		line aborted early	Data Recorder error, rebooted												
	Additional Notes					Time to next maintenance:	Static	500 khz/ch Alignment	102 lps/ch Pre Mission	degs Post Mission		Mission ID	Time Stamp 220505	-	141310	142407 Data	143431	144602	145737	150858	151955	153114	154202	155326	160427	161602		
LIDAR Flight Log	VQ-1560II Ad	S2223062	Applanix AP60	Trimble GNSS17	в		Mission Plan	m Pulse Rate	kts Scan Rate	0 % FOV 60			Time nmi to End															
LIDAR F	System	Unit	IMU Appl	GPS Rx Trir	Scanner 1 Drive	Scanner 2 Drive		AGL Height 2300	Target Speed 160	Laser Current 100	,		End T	14:11	14:17	14:28	14:43	14:54	15:06	15:17	15:28	15:39	15:50	16:01	16:13	16:24	16:28	
	C-GAYY	A. Hering	B.Eisenbart									6PS	Start	14:06	14:13	14:24	14:34	14:46	14:57	15:08	15:19	15:31	15:42	15:53	16:04	16:16	16:24	
	Aircraft	Pilot	Operator				me					Flight	Direction	-	94°	94°	184°	004°	184°	004°	184°	004°	184°	004°	184°	004°	I	
5 Flight A	April 5, 2022	NV5_QL2	Eau Claire, Wisconsin				Aircraft Block Time	Takeoff 13:20	Landing 19:06	Total 5.8 hrs			File Name			622212525	622212526	622212527	622212528	622212529	622212530	622212531	622212532	622212533	622212534	622212535		
Julian Day 125	Date April	Project 3237	Location Eau Cla	Mission Objective				Engine On 13:04	Engine Off 19:14	Total 6.2 hrs		-	Flight Line	figure 8	X-TIE	X-TIE 6	2042 6	2041 6	2040 6	2039 6	2038 6	2037 6	2036 6	2035 6	2034 6	2033 6	figure 8	

v 20200520

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	3 O R I					• 50 hr O 100 hr	GPS Time	nt Start End	13:10 13:15	19:08 19:13		Comments	changed scanner settings for 3238 QL1											
	I Notes					Time to next maintenance:	Static	ch Alignment	ch Pre Mission	degs Post Mission		220505			165855	171758	173657	175552	181515	•				
Бс	Additional Notes			17		Time to r	Plan	Pulse Rate 500 khz/ch	Scan Rate 102 lps/ch	V 60		i End												
LIDAR Flight Log	VQ-1560II	S2223062	Applanix AP60	Trimble GNSS17	1 Drive	2 Drive	Mission F	2300 m Pul	160 kts Sc	: 100 % FOV	l ine Ahorted	Time												
LIDA	System	Unit	NMI	GPS RX	Scanner 1 Drive	Scanner 2 Drive		AGL Height	Target Speed	Laser Current	GPS Time	End	i	16:58	17:14	17:33	17:52	18:11	18:17	18:21				
	C-GAYY	A. Hering	B.Eisenbart									Start		16:54	16:58	17:17	17:36	17:55	18:15	18:17				
	Aircraft	Pilot	Operator				ime					Flight Direction		1	004°	184°	004°	184°	096°	I				
5 Flight A	April 5, 2022	3237_NV5_QL2	Eau Claire, Wisconsin				Aircraft Block Time	Takeoff 13:20	Landing 19:06	Total 5.8 hrs		LiDAR File Name			622212536	622212537	622212538	622212539	622212540					
Julian Day 125	Date April	Project 3237	Location Eau Cla	Mission Objective				Engine On 13:04	Engine Off 19:14	Total 6.2 hrs		Flight Line		Figure 8	3055 6	3054 (3053 (3052 (X-TIE (figure 8				

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O O O 0 0 0 13:10 13:10 19:08 Comments			Page 3 of 5
Additional Notes Time to next maintenance: 500 khz/ch 102 lps/ch 103 lps/ch 104 lp			
R Flight Log VQ-1560II VQ-1560II S2223062 Applanix AP60 Trimble GNSS17 1 Drive 2 Drive 2 Drive 100 % FOV 100 % FOV 100 % Init o End 100 % Init o End			
tr A. Hering A. Hering A. Hering C-GAYY S. S. S			
Julian Day 125 Flight A Date April 5, 2022 Aircraf Project 3237_NV5_0L2 Pilot Properative Aircraft Block Time Aircraft Block Time Engine Off 19:14 Landling 19:06 Protal 6.2 hrs Pilot Flight Line LiDAR File Name Pirection			

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	~					• 50 hr O 100 hr	GPS Time	int Start End	13:10 13:15	n 19:08 19:13			Comments								Page 4 of 5
	Additional Notes					Time to next maintenance:	Ctatic C	500 khz/ch Alignment	102 lps/ch Pre Mission	60 degs Post Mission		MISSI	Time Stamp 220505								
LIDAR Flight Log	System VQ-1560II	Unit S2223062	IMU Applanix AP60	GPS Rx Trimble GNSS17	Scanner 1 Drive	Scanner 2 Drive	Mission Plan	leight 2300 m Pulse Rate	Target Speed 160 kts Scan Rate	Laser Current 100 % FOV	l ine Ahorted		End Time nmi to End								
	Aircraft C-GAYY	Pilot A. Hering I	Operator B.Eisenbart			55		AGL Height	Target	Laser	GDS Time		Start								
Julian Day 125 Flight A	Date April 5, 2022	Project 3237_NV5_QL2	nsin	Mission Objective			Aircraft Block Time	Engine On 13:04 Takeoff 13:20	Engine Off 19:14 Landing 19:06	Total 6.2 hrs Total 5.8 hrs		LIDAR	File Name Dir						 		

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	~	D N G						End	13:15	19:13											
	AIRBOR	A Closed and a G I N G				● 50 hr O 100 hr	GPS Time	Start	13:10	19:08		Comments									
							Static	Alignment	Pre Mission	Post Mission			I								-
	Notes					Time to next maintenance:				ß	Mission ID	220505 mm									
	Additional Notes					Time to ne		500 khz/ch	102 lps/ch	60 d	Σ	Time S									
Log			60	SS17			n Plan	Pulse Rate	Scan Rate	FOV	Line Aborted	nmi to End									
LIDAR Flight Log	VQ-1560II	S2223062	Applanix AP60	Trimble GNSS17)rive	Irive	Mission	2300 m	160 kts	100 %	Line	Time									-
LIDAR	System	Unit	A UMI	GPS Rx	Scanner 1 Drive	Scanner 2 Drive		iL Height 2	ъ	Laser Current		End									
		 						AGL	Targ	Lase	GPS Time										-
	C-GAYY	A. Hering	B.Eisenbart								9	Start									
	Aircraft	Pilot /	Operator				e				Clickt	Direction									
Flight A	2022	3237_NV5_QL2	Eau Claire, Wisconsin				Aircraft Block Time	Takeoff 13:20	Landing 19:06	Total 5.8 hrs		<u>е</u>									-
y 125	April 5, 2022	3237_N	Eau Claire	jective			A	13:04		hrs											
Julian Day	Date	Project	Location	Mission Objective				Engine On	Engine Off 19:14	Total 6.2		Flight Line									

Appendix B

SBET and POSPAC Reports

WI 12 County - Winnebago Lidar Project - Work Unit 300209

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August 31, 2023

General Information

Mission Information

Project name	04122022A_3062
Processing date	2022-04-13 16:31:37
Mission date	2022-04-12 13:03:42
Mission duration	05:01:14.285
Processing mode	IN-Fusion PP-RTX

Rover Hardware Information

Product	POS AV 610 VER6 HW2.5-12
Serial number	S/N8708
IMU type	57
Receiver type	BD982
Antenna type	Bilinmeyen harici

Project File List

Rover Data Files

File name	File type
220412_130323_INS-GPS_1.raw	POS Data

Input Files

File Name	File Type
Ephm1020.22g	GLONASS Broadcast Ephemeris
Ephm1020.22n	GPS Broadcast Ephemeris

Output Files

Filename	File type
sbet_04122022A_3062.out	SBET Trajectory File

Rover Data Summary

First raw data file	220412_130323_INS-GPS_1.raw			
Last raw data file	220412_130323_INS-GPS_1.raw			
Start GPS week	2205			
Start time	219803.592 (4/12/2022 1:03:23 PM)			
End time	237877.877 (4/12/2022 6:04:37 PM)			
Start of fine alignment	220157.284 (4/12/2022 1:09:17 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)	0.000	0.000	0.000	
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000	
Gimbal to Primary GNSS lever arm (m)	0.142	-0.236	-1.269	
Gimbal to Primary GNSS lever arm std dev (m)	-1.000			
Aircraft to Reference mounting angles (deg)	0.000	0.000	0.000	

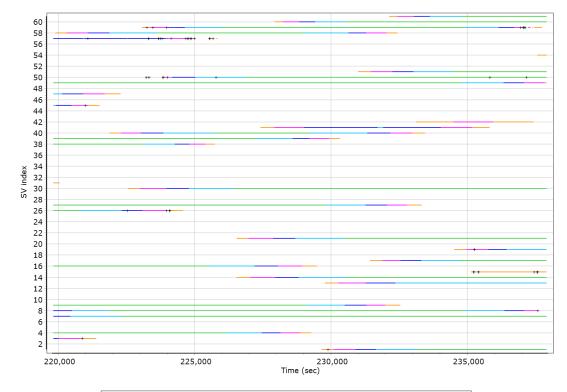
Rover Data QC

Raw IMU Import QC Summary

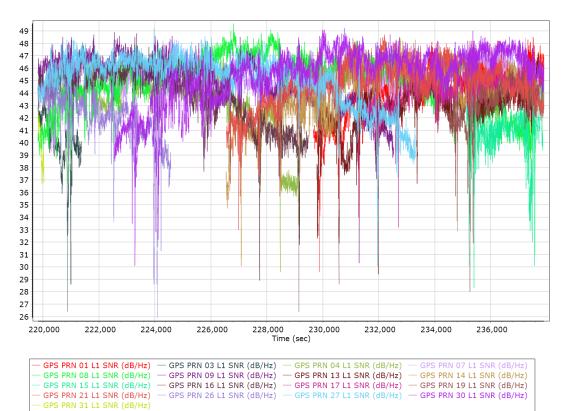
IMU data input file	imu_Mission 1.dat
IMU data check log file	imudt_04122022A_3062.log
IMU Records Processed	3614360
Termination Status	Normal
IMU Anomalies	0

Primary Observables & Satellite Data

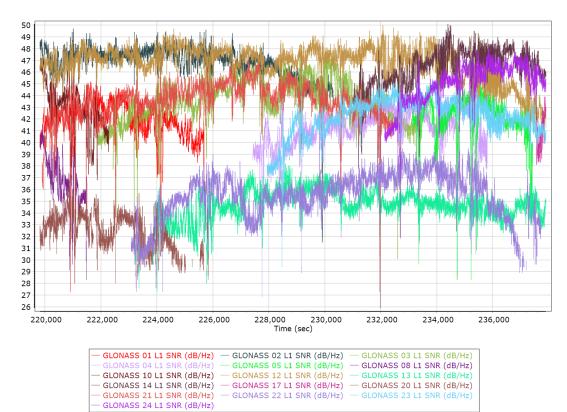
GPS/GLONASS L1 Satellite Lock/Elevation





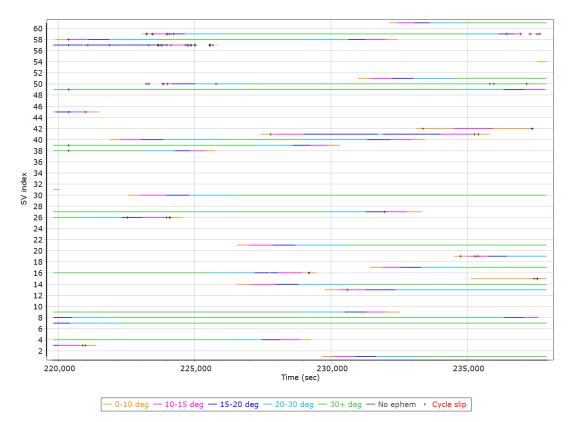


GLONASS L1 SNR

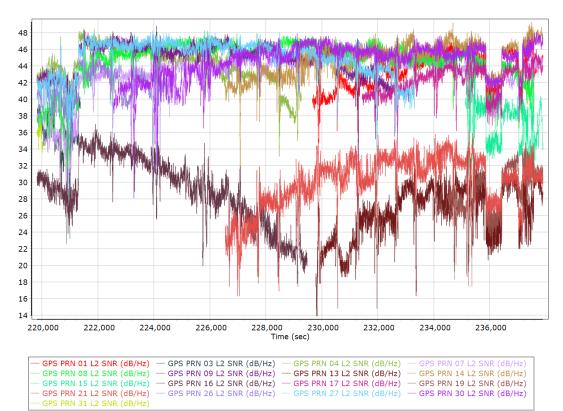


5

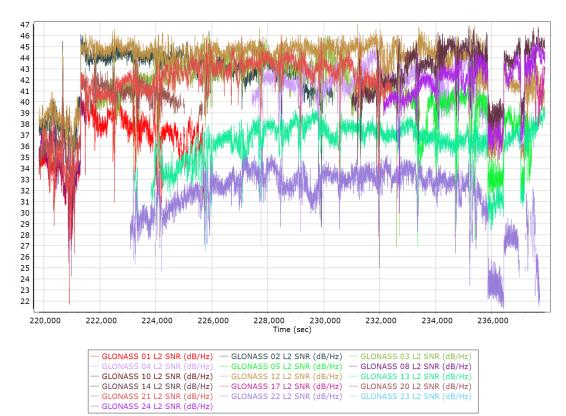
GPS/GLONASS L2 Satellite Lock/Elevation



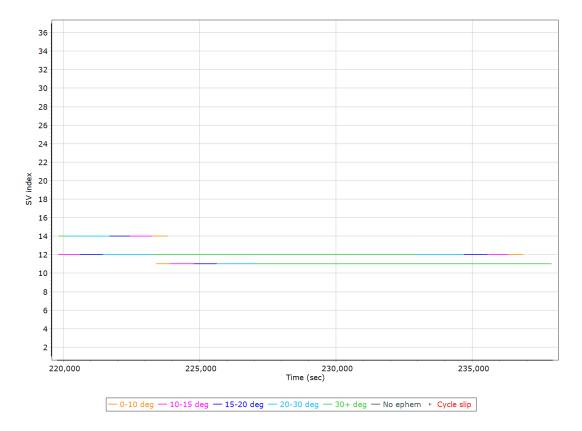
GPS L2 SNR



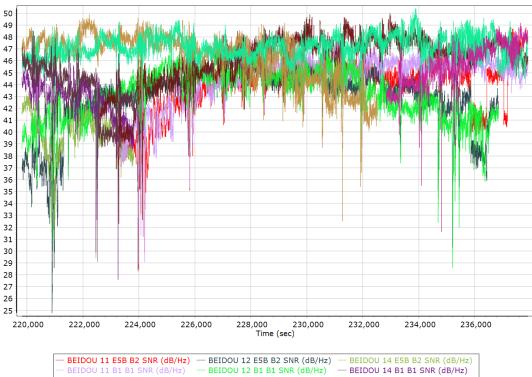
GLONASS L2 SNR



BEIDOU Satellite Lock/Elevation

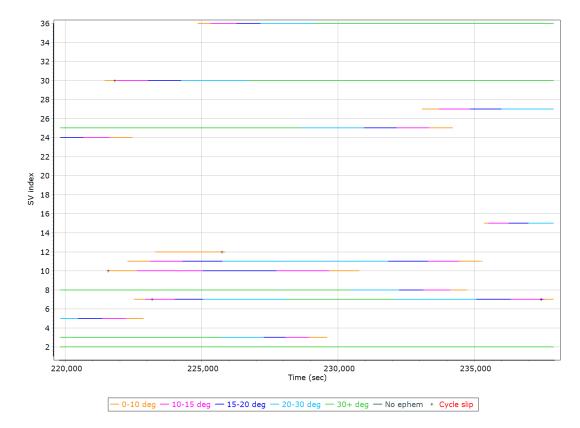


BEIDOU SNR



DEIDOO II DI DI SMA (UD/112)		DEIDOO 14 DI DI SMR (UD/112)
- BEIDOU 23 B1 B1 SNR (dB/Hz)	— BEIDOU 24 B1 B1 SNR (dB/Hz)	- BEIDOU 25 B1 B1 SNR (dB/Hz

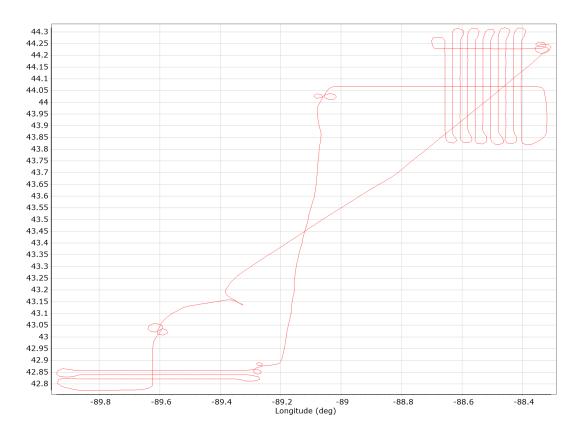
— BEIDOU 26 B1 B1 SNR (dB/Hz) — BEIDOU 28 B1 B1 SNR (dB/Hz)



GALILEO Satellite Lock/Elevation

GALILEO SNR

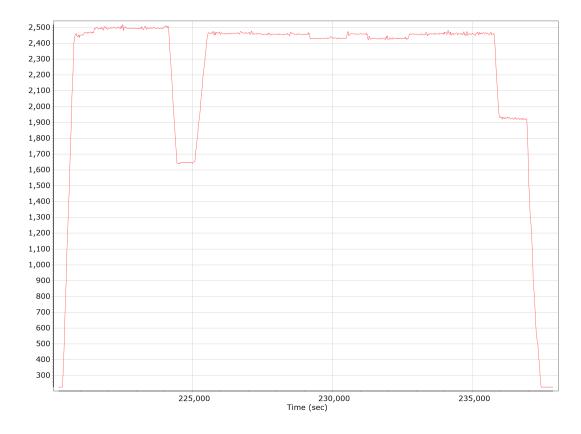




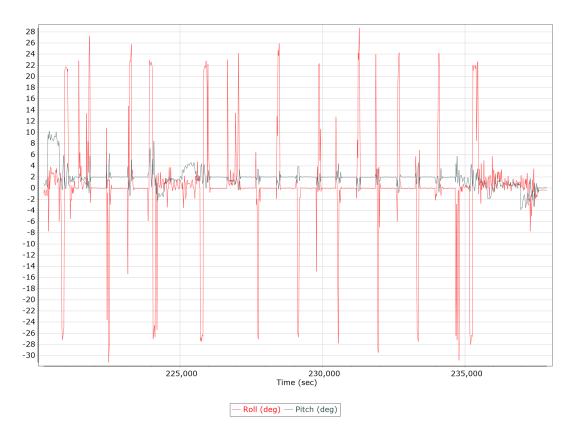
Smoothed Trajectory Information

Top View

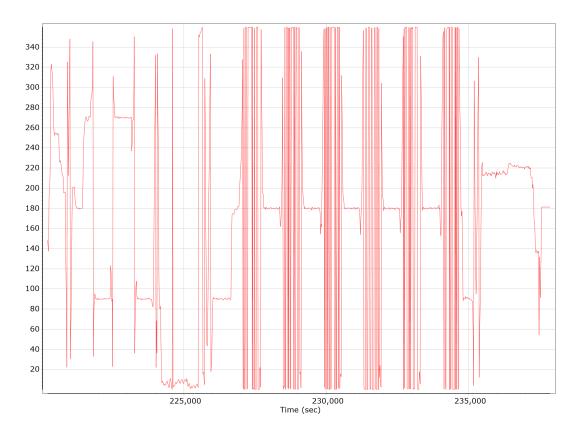
Altitude



Roll/Pitch



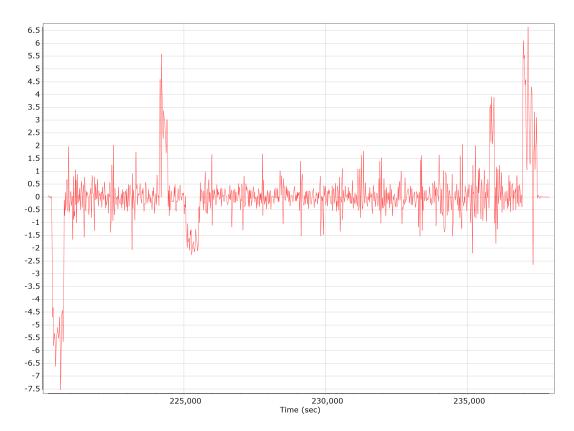
Heading



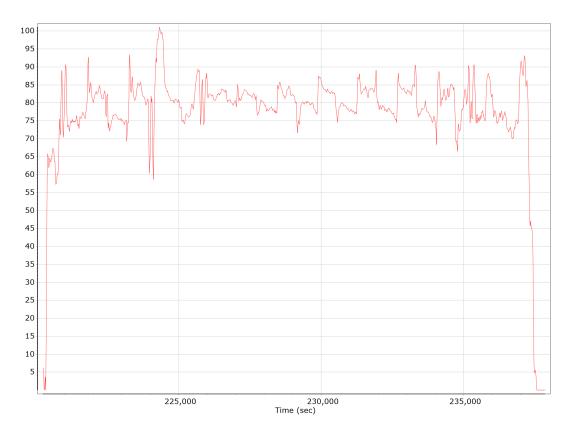
North/East Velocity



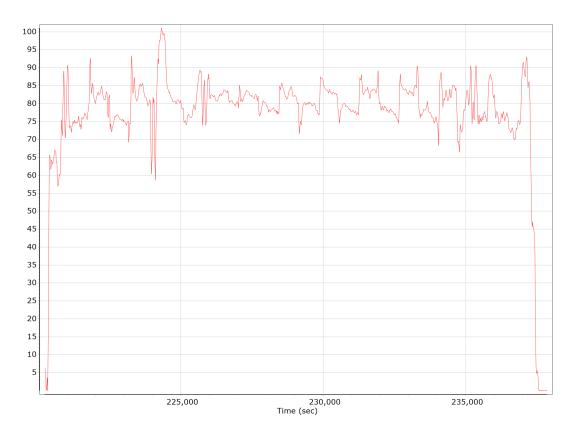
Down Velocity

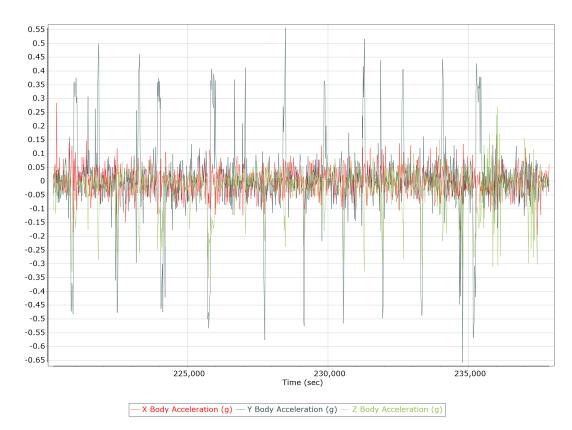


Total Speed



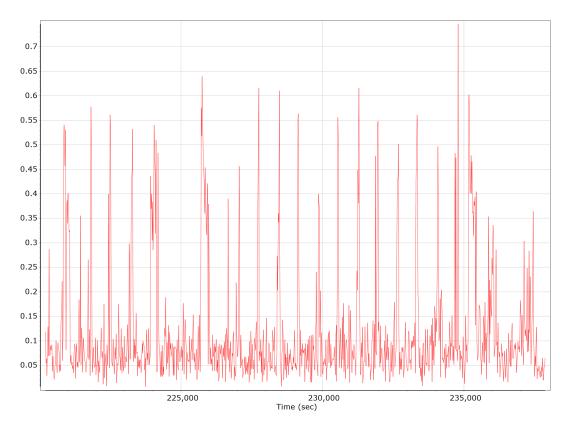
Ground Speed



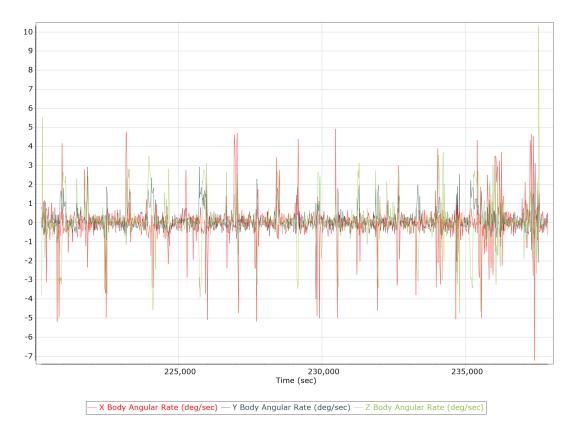


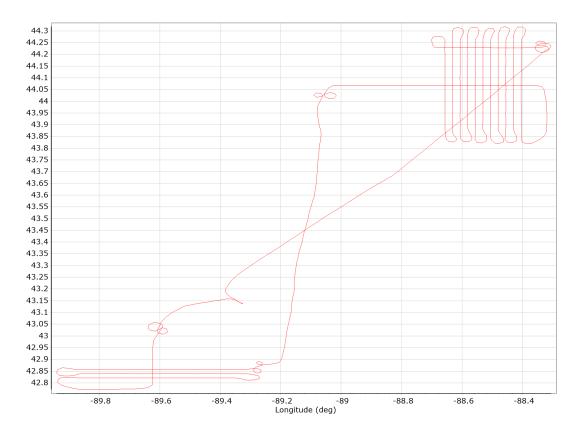
Body Acceleration





Body Angular Rate

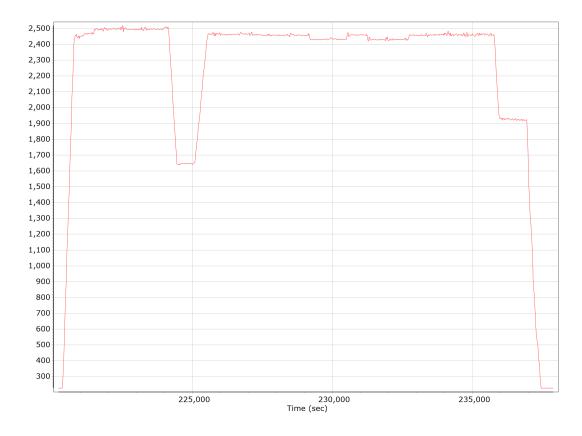




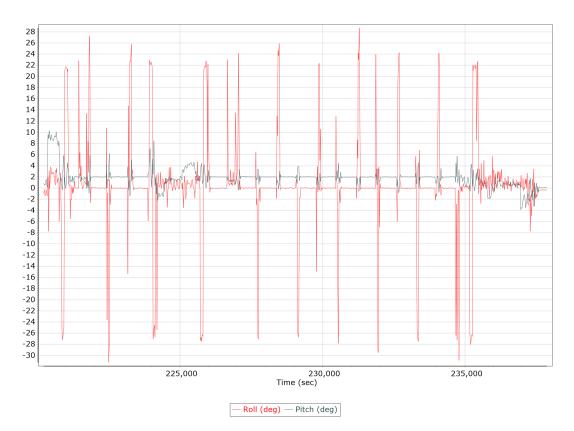
Forward Processed Trajectory Information

Top View

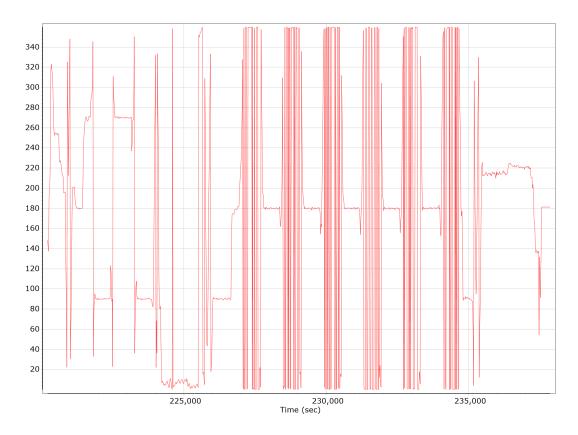
Altitude



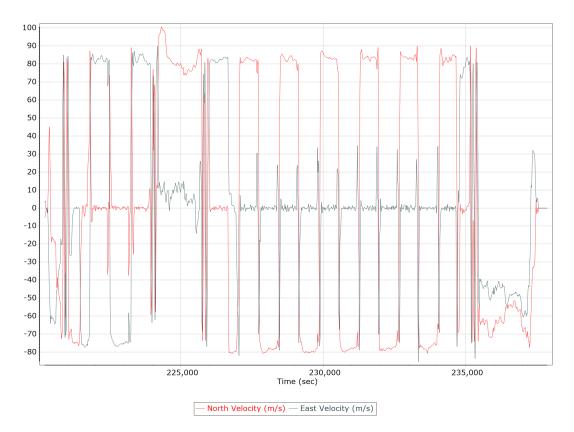
Roll/Pitch



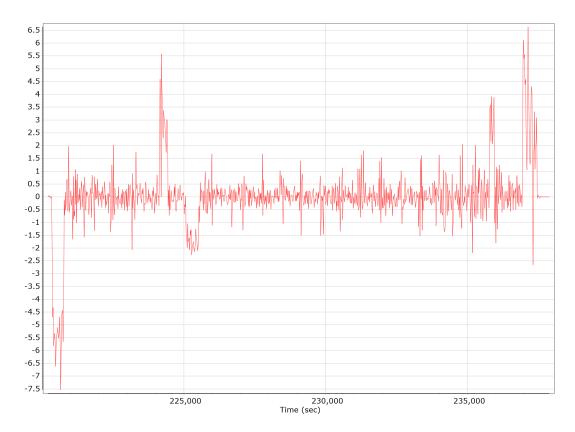
Heading



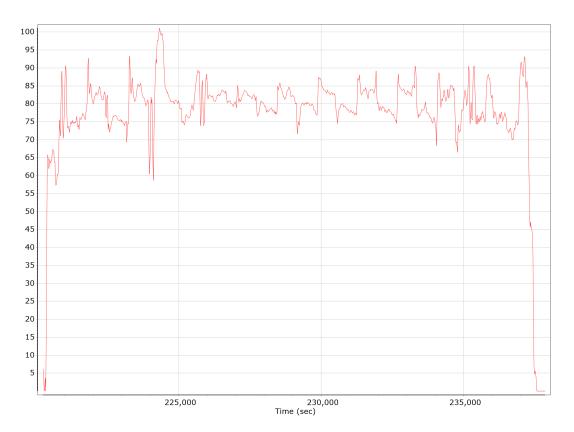
North/East Velocity



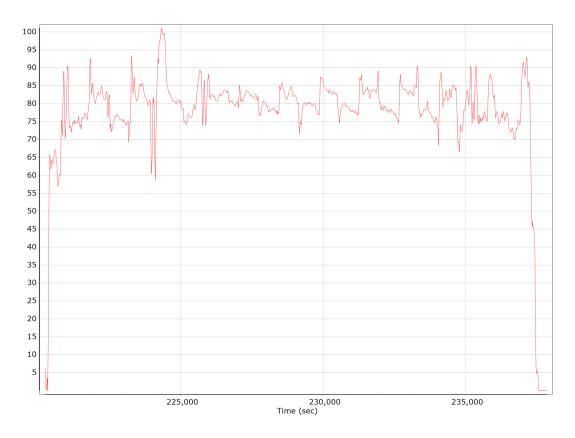
Down Velocity

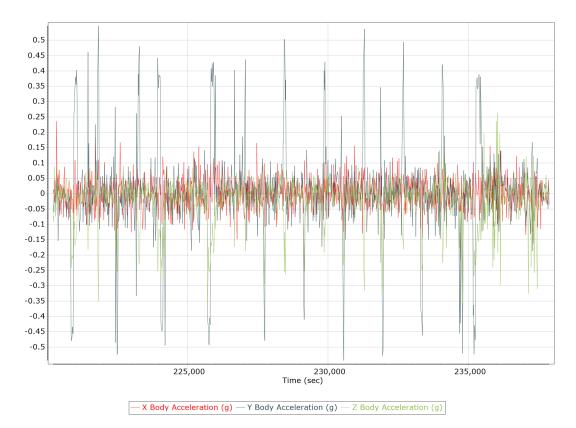


Total Speed

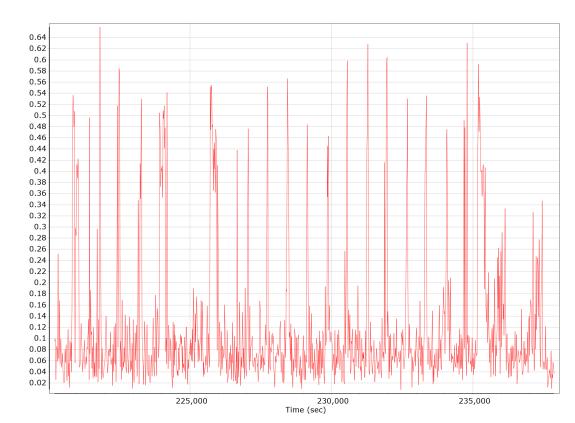


Ground Speed



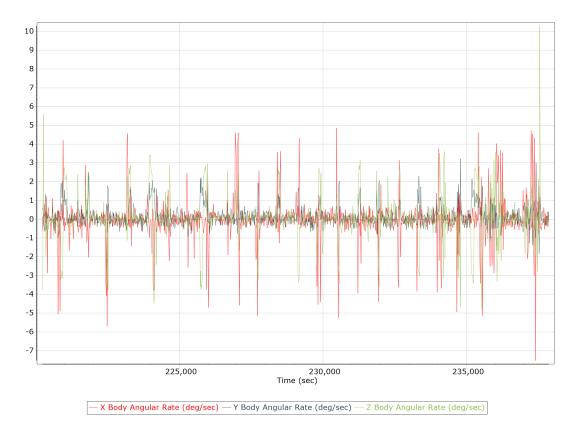


Body Acceleration



Total Body Acceleration

Body Angular Rate

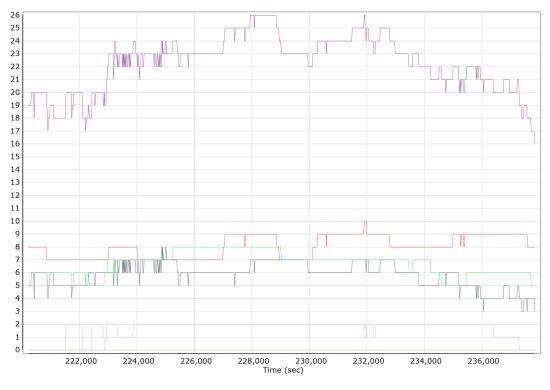


GNSS QC

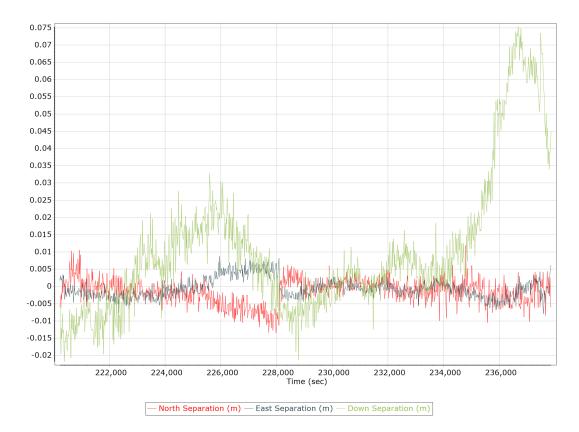
GNSS QC Statistics

Statistics	Min	Max	Mean
Baseline length (km)	0.00	0.00	
Number of GPS SV	4	10	8
Number of GLONASS SV	0	8	6
Number of QZSS SV	0	0	0
Number of BEIDOU SV	0	2	2
Number of GALILEO SV	5	8	7
Total number of SV	14	26	22
PDOP	0.95	1.82	1.17
QC Solution Gaps	1.00	1.00	
Solution Type	Fixed	Float	No solution
Epoch (sec)	18028.00	0.00	2.00
Percentage	99.99	0.00	0.01

Num SVs in solution

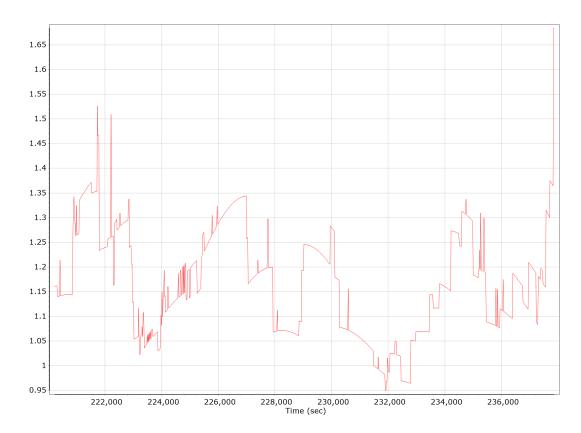


- Number of GPS - Number of GLONASS - Number of QZSS - Number of BEIDOU - Number of GALILEO - Total Number

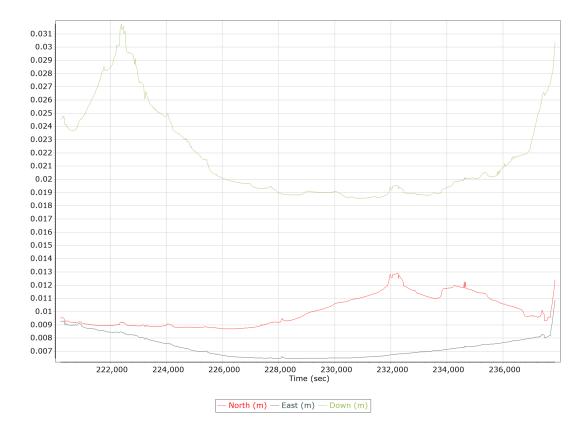


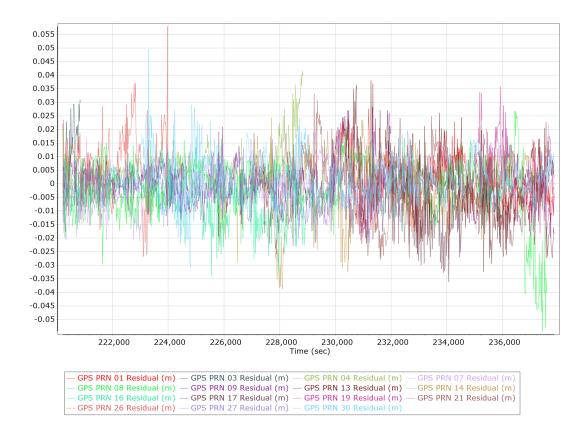
Forward/Reverse Separation





Estimated Position Accuracy

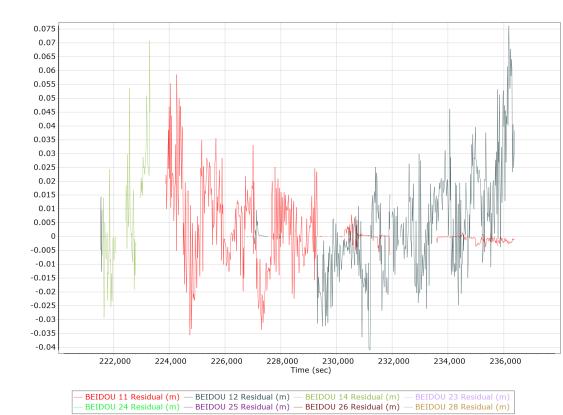




GPS Residuals



GLONASS Residuals



BEIDOU Residuals



GALILEO Residuals

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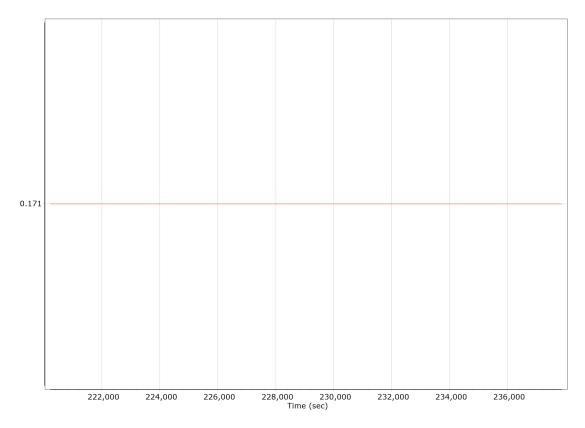
GNSS-Inertial Processor Configuration

Processing mode	IN-Fusion PP-RTX			
Stabilized mount	True	True		
Processing start time	219804.000 (4	219804.000 (4/12/2022 1:03:24 PM)		
Processing end time	237879.000 (4/12/2022 6:04:39 PM)			
Initial attitude source	Real-Time VNAV/RNAV Attitude			
IMU Sensor Context	Processing wi	Processing with Onboard IMU		
Gimbal to IMU lever arm (m)	0.000	0.000	0.000	
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000	
Gimbal to Primary GNSS lever arm (m)	0.171	-0.238	-1.273	
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	

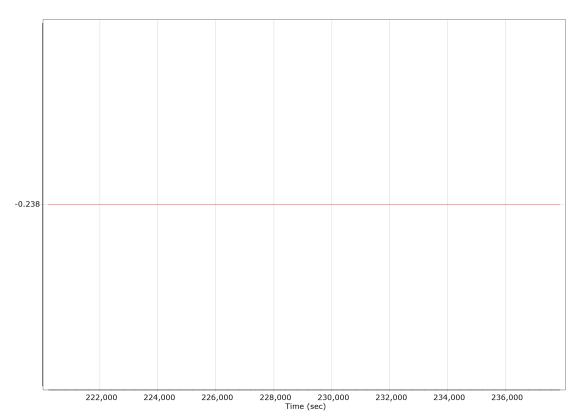
Calibrated Installation Parameters

Reference-Primary GNSS Lever Arm (m)

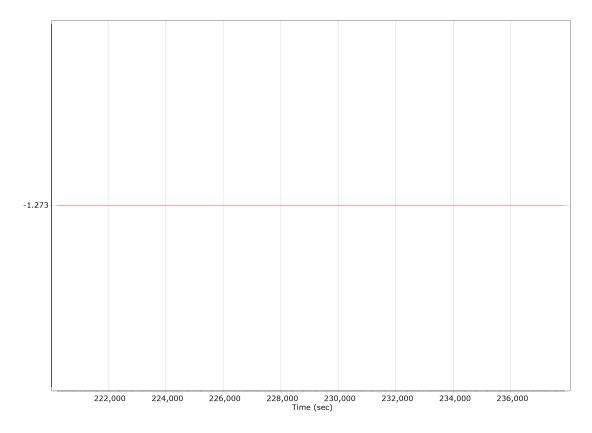
X Reference-Primary GNSS Lever Arm (m)



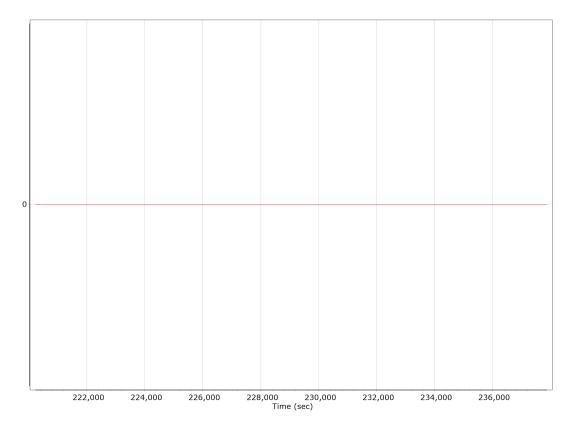
Y Reference-Primary GNSS Lever Arm (m)



Z Reference-Primary GNSS Lever Arm (m)

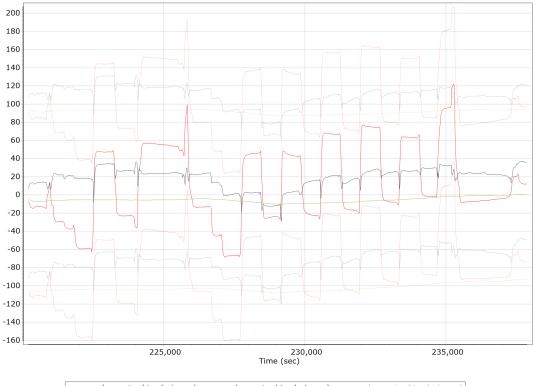


Reference-Primary GNSS Lever Arm Figure of Merit

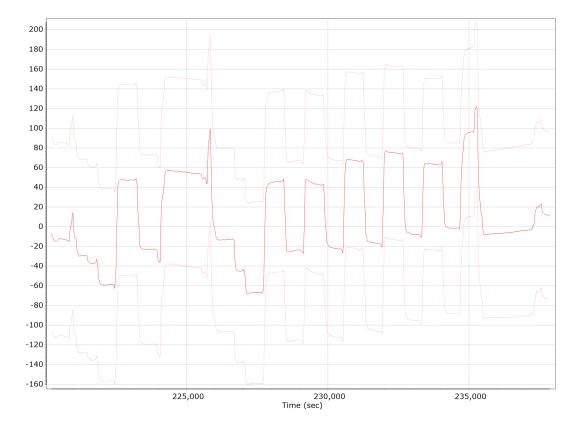


IN-Fusion QC

Forward Processed Estimated Errors, Reference Frame Accelerometer Bias (micro-g)

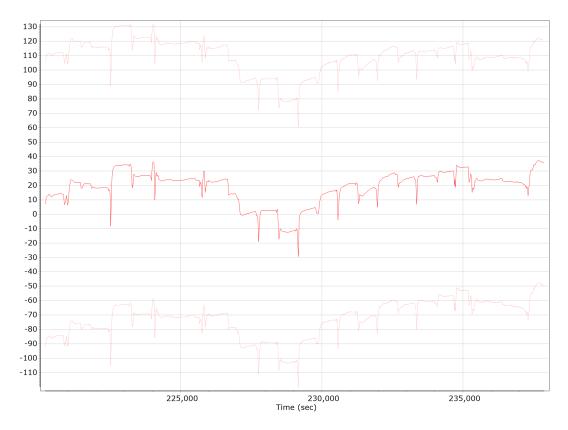




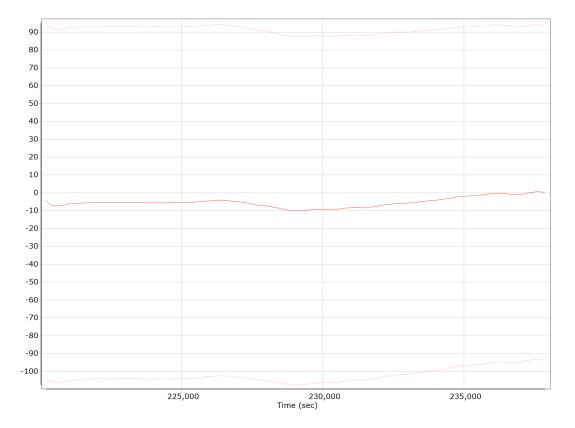


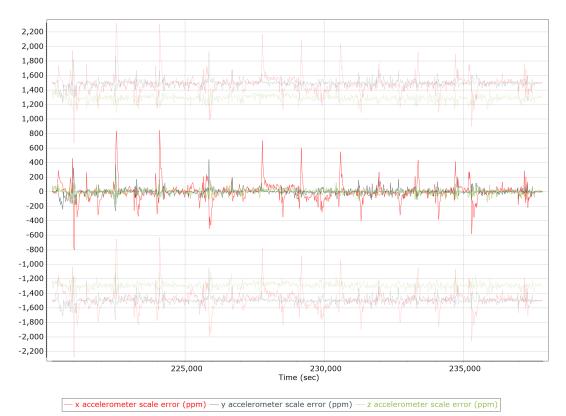
X Accelerometer Bias (micro-g)

Y Accelerometer Bias (micro-g)



Z Accelerometer Bias (micro-g)



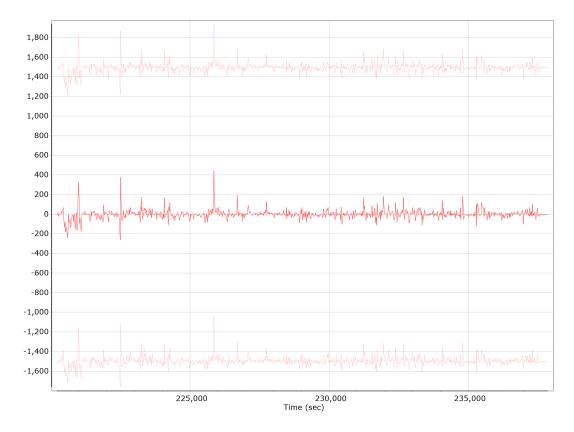


Accelerometer Scale Error (ppm)

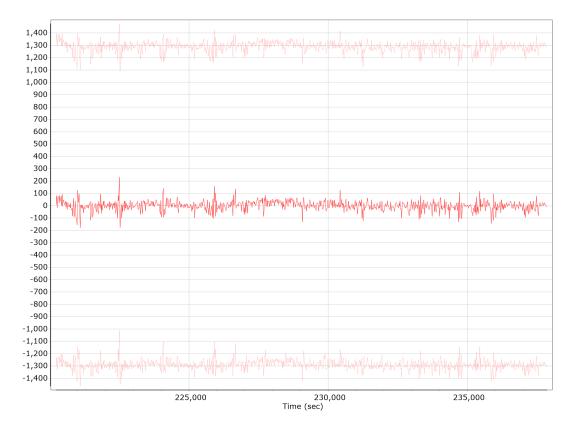


X Accelerometer Scale Error (ppm)

Y Accelerometer Scale Error (ppm)



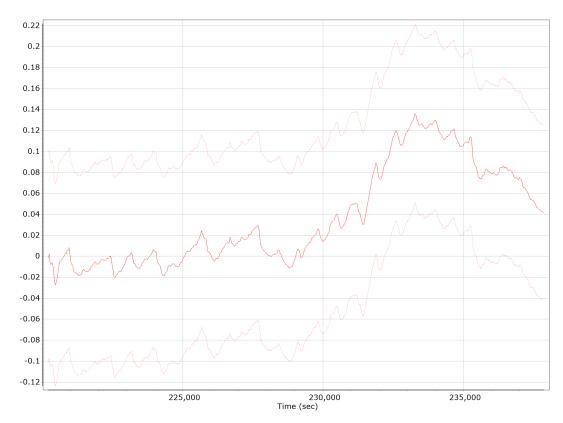
Z Accelerometer Scale Error (ppm)



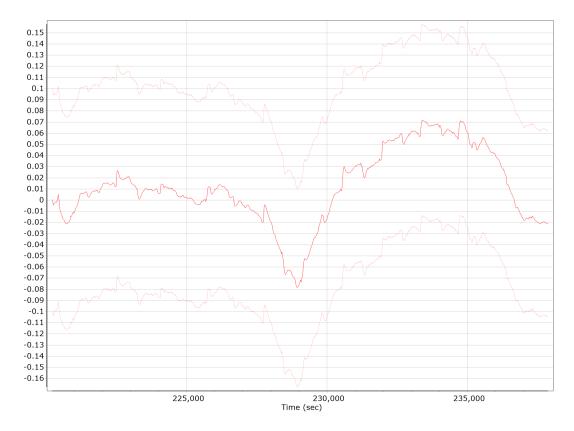


Gyro Bias (deg/h)

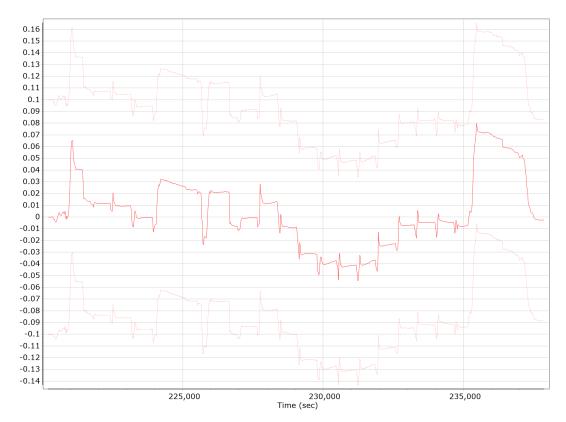




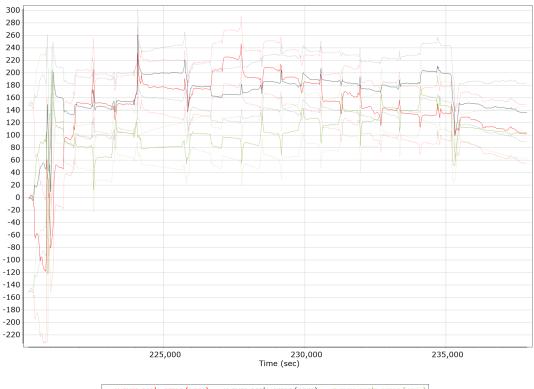
Y Gyro Bias (deg/h)



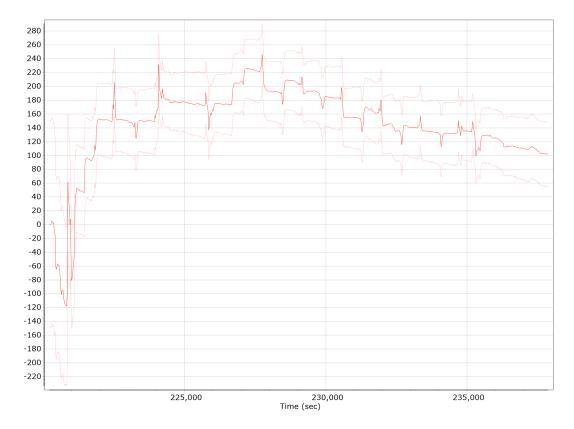
Z Gyro Bias (deg/h)



Gyro Scale Error (ppm)

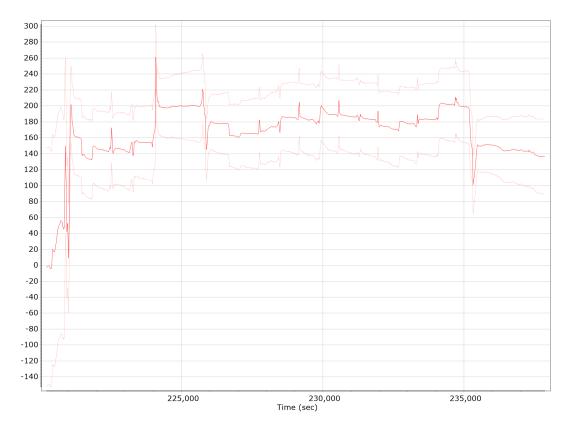


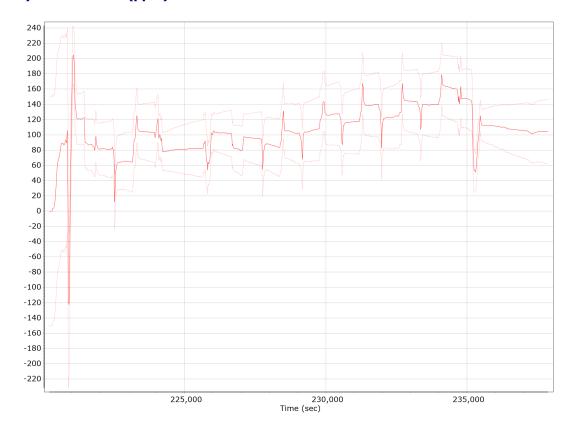




X Gyro Scale Error (ppm)

Y Gyro Scale Error (ppm)



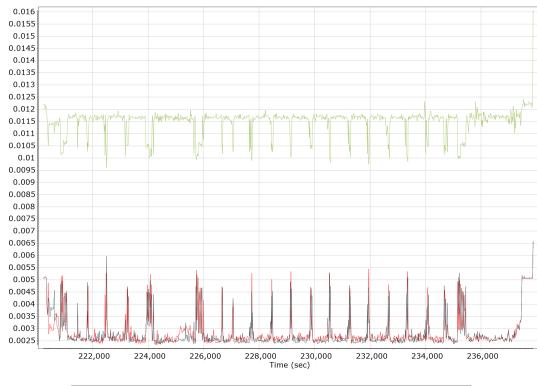


Z Gyro Scale Error (ppm)



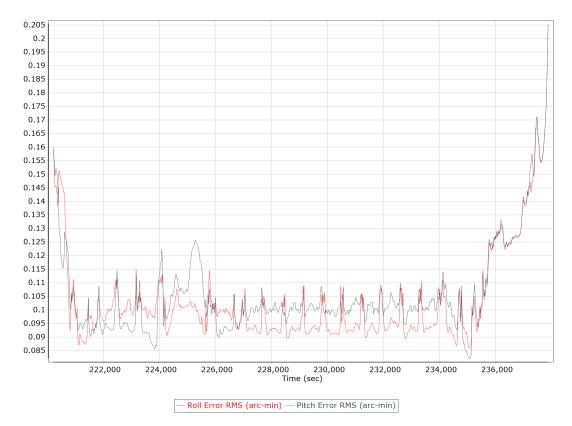
Position Error RMS (m)





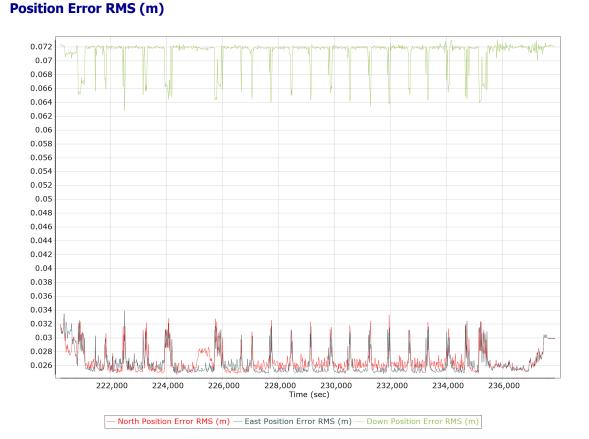
Velocity Error RMS (m/s)

Roll/Pitch Error RMS (arc-min)



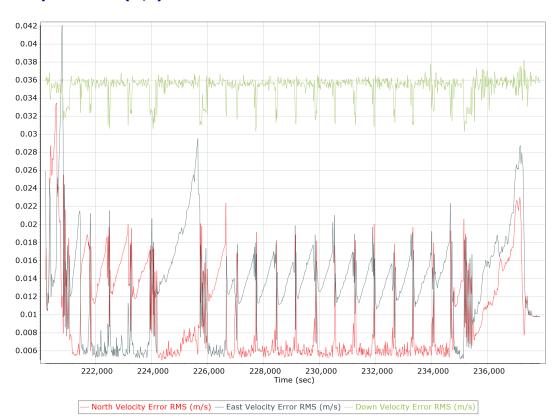
1.1 1.05 1 0.95 0.9 0.85 0.8 0.75 0.7 0.65 0.6 0.55 0.5 0.45 0.4 0.35 0.3 0.25 0.2 228,000 230,000 Time (sec) 222,000 224,000 226,000 232,000 234,000 236,000

Heading Error RMS (arc-min)

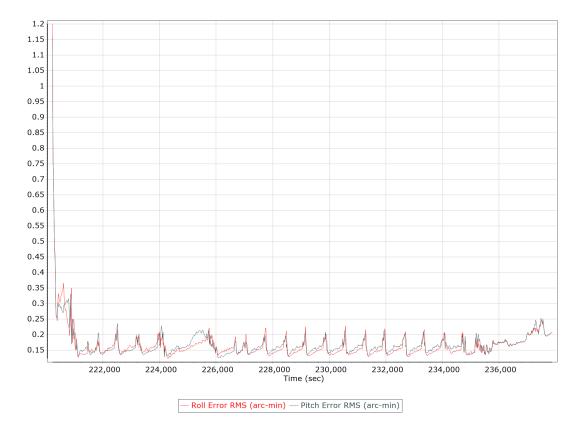


Forward Processed Performance Metrics

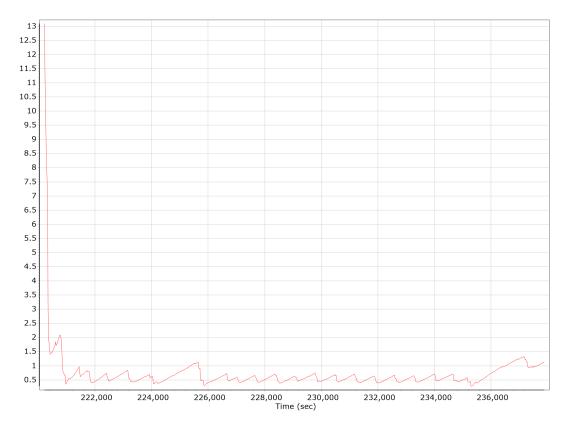
Velocity Error RMS (m/s)



Roll/Pitch Error RMS (arc-min)

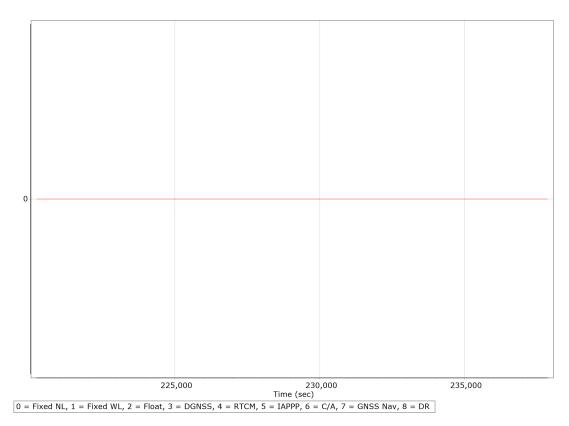


Heading Error RMS (arc-min)

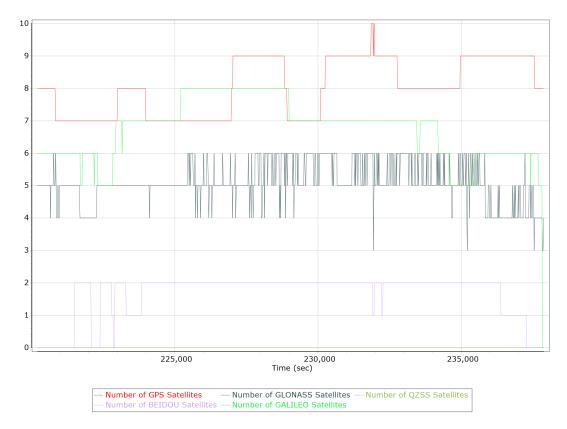


Forward Processed Solution Status

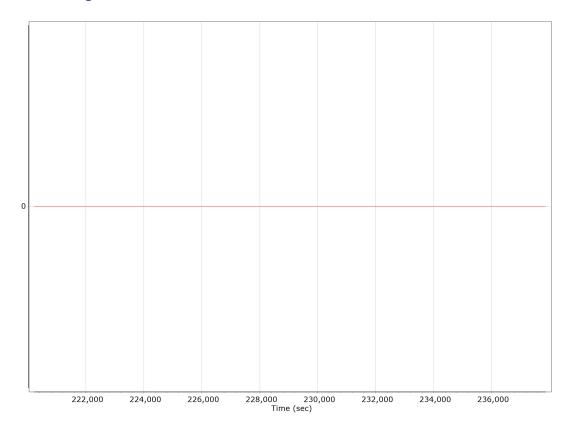
Processing Mode



Number of Satellites



Baseline Length



General Information

Mission Information

Project name	05052022A_3062
Processing date	2022-05-10 18:17:00
Mission date	2022-05-05 13:11:16
Mission duration	06:03:05.156
Processing mode	IN-Fusion PP-RTX

Rover Hardware Information

Product	POS AV 610 VER6 HW2.5-12
Serial number	S/N8708
IMU type	57
Receiver type	BD982
Antenna type	AV59

Project File List

Rover Data Files

File name	File type
220505_131057_INS-GPS_1.raw	POS Data

Input Files

File Name	File Type
Ephm1250.22g	GLONASS Broadcast Ephemeris
Ephm1250.22n	GPS Broadcast Ephemeris

Output Files

Filename	File type	
sbet_05052022A_3062.out	SBET Trajectory File	

Rover Data Summary

First raw data file	220505_131	220505_131057_INS-GPS_1.raw			
Last raw data file	220505_131	220505_131057_INS-GPS_1.raw			
Start GPS week	2208	2208			
Start time	393057.478	393057.478 (5/5/2022 1:10:57 PM)			
End time	414842.634	414842.634 (5/5/2022 7:14:02 PM)			
Start of fine alignment	393197.219	393197.219 (5/5/2022 1:13:17 PM)			
Available subsystems	Primary GN	Primary GNSS, Gimbal, IMU			
POS Event Input	None	None			
Correction data	None	None			
IMU Installation Lever Arms & Mounting Angles					
Gimbal to IMU lever arm (m)	0.000	0.000	0.000		
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000		
Gimbal to Primary GNSS lever arm (m)	0.142	-0.236	-1.269		
Gimbal to Primary GNSS lever arm std dev (m)	-1.000	-1.000			
Aircraft to Reference mounting angles (deg)	0.000	0.000 0.000 0.000			

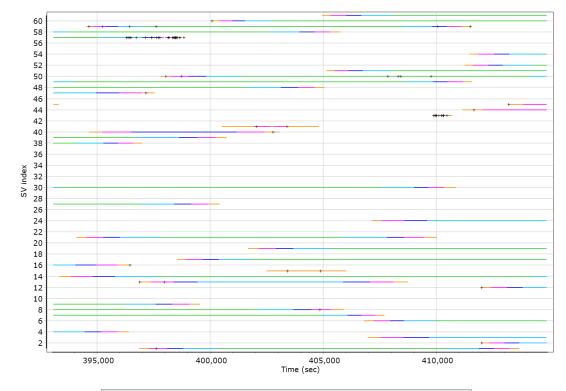
Rover Data QC

Raw IMU Import QC Summary

IMU data input file	imu_Mission 1.dat
IMU data check log file	imudt_05052022A_3062.log
IMU Records Processed	4356266
Termination Status	Normal
IMU Anomalies	0

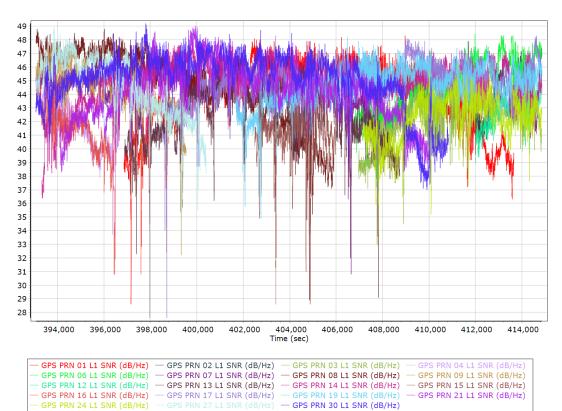
Primary Observables & Satellite Data

GPS/GLONASS L1 Satellite Lock/Elevation

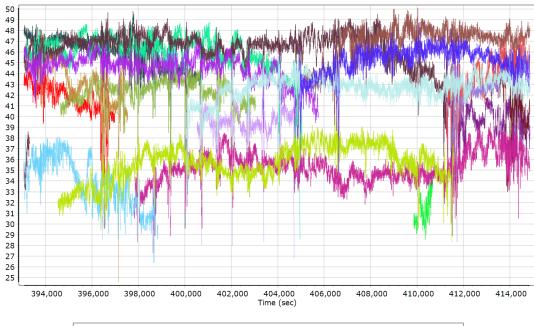


- 0-10 deg - 10-15 deg - 15-20 deg - 20-30 deg - 30+ deg - No ephem + Cycle slip



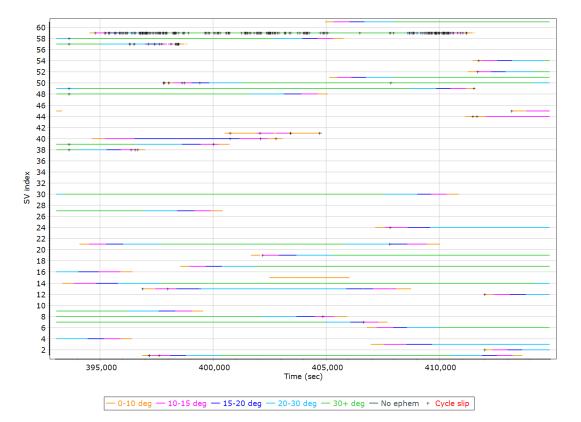


GLONASS L1 SNR

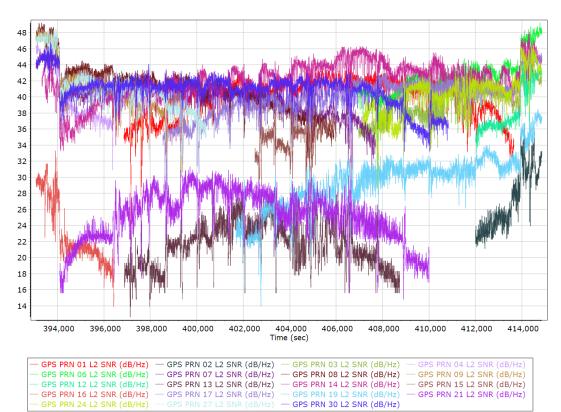


GLONASS 01 L1 SNR (dB/Hz) - GLONASS 02 L1 SN	R (dB/Hz) — GLONASS 03 L1 SNR (dB/Hz)
- GLONASS 04 L1 SNR (dB/Hz) - GLONASS 06 L1 SN	R (dB/Hz) — GLONASS 07 L1 SNR (dB/Hz)
GLONASS 08 L1 SNR (dB/Hz) - GLONASS 10 L1 SNI	R (dB/Hz) — GLONASS 11 L1 SNR (dB/Hz)
GLONASS 12 L1 SNR (dB/Hz) - GLONASS 13 L1 SN	R (dB/Hz) — GLONASS 14 L1 SNR (dB/Hz)
GLONASS 15 L1 SNR (dB/Hz) - GLONASS 17 L1 SN	R (dB/Hz) — GLONASS 20 L1 SNR (dB/Hz)
GLONASS 21 L1 SNR (dB/Hz) - GLONASS 22 L1 SNI	R (dB/Hz) — GLONASS 23 L1 SNR (dB/Hz)
— GLONASS 24 L1 SNR (dB/Hz)	

GPS/GLONASS L2 Satellite Lock/Elevation



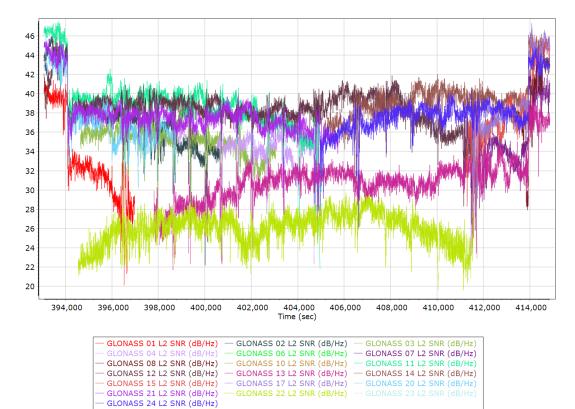
GPS L2 SNR



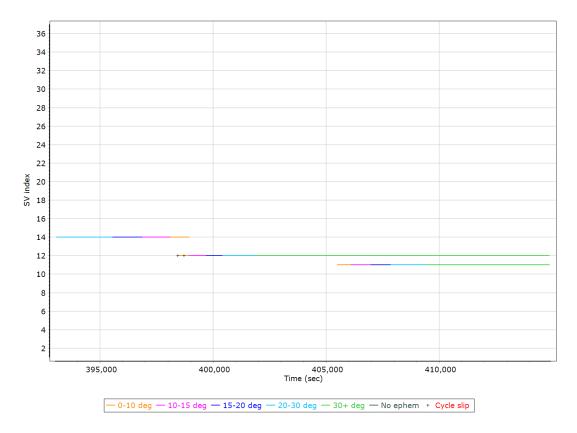
6

GPS PRN 30 L2 SNR (dB/Hz)

GLONASS L2 SNR

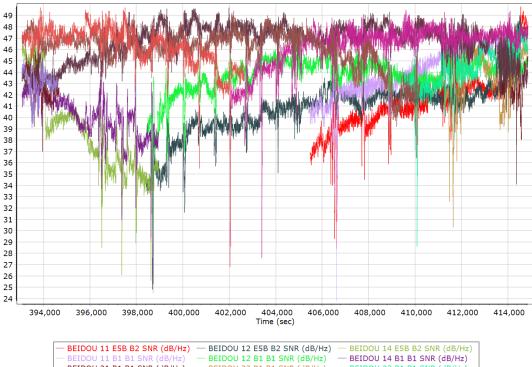


BEIDOU Satellite Lock/Elevation



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BEIDOU SNR



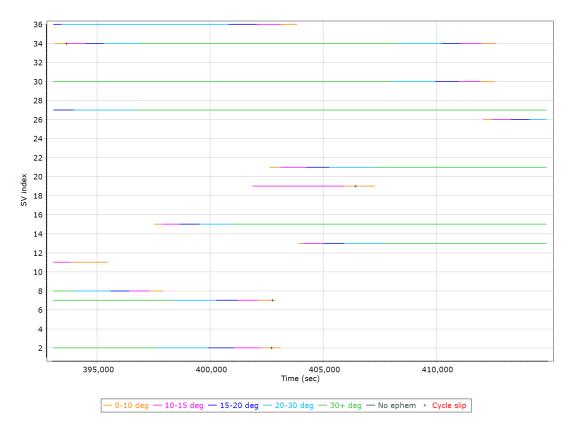
 BEIDOU 12 B1 B1 SNR (dB/Hz)
 BEIDOU 22 B1 B1 SNR (dB/Hz)
 BEIDOU 22 B1 B1 SNR (dB/Hz)

 BEIDOU 24 B1 B1 SNR (dB/Hz)
 BEIDOU 25 B1 B1 SNR (dB/Hz)
 BEIDOU 26 B1 B1 SNR (dB/Hz)

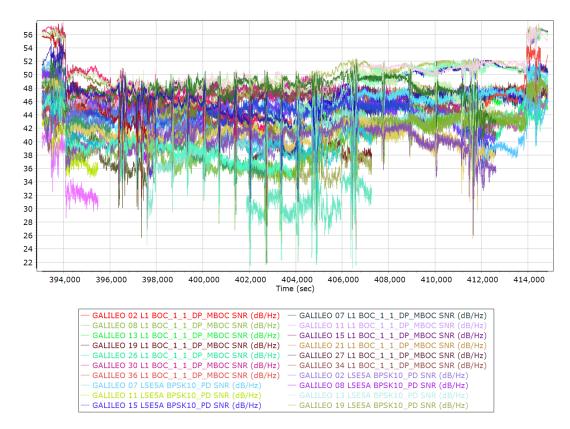
 BEIDOU 24 B1 B1 SNR (dB/Hz)
 BEIDOU 25 B1 B1 SNR (dB/Hz)
 BEIDOU 26 B1 B1 SNR (dB/Hz)

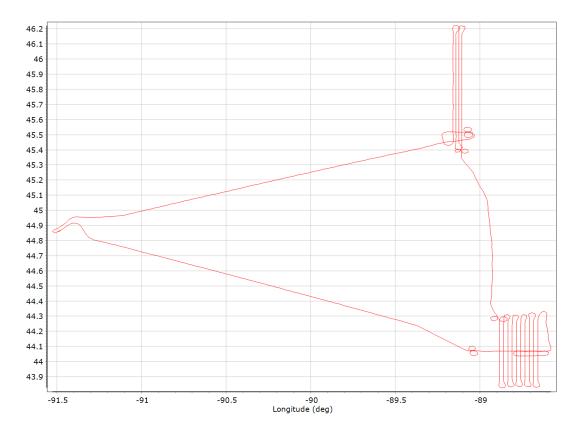
 BEIDOU 29 B1 B1 SNR (dB/Hz)
 BEIDOU 30 B1 B1 SNR (dB/Hz)
 BEIDOU 26 B1 B1 SNR (dB/Hz)

GALILEO Satellite Lock/Elevation



GALILEO SNR

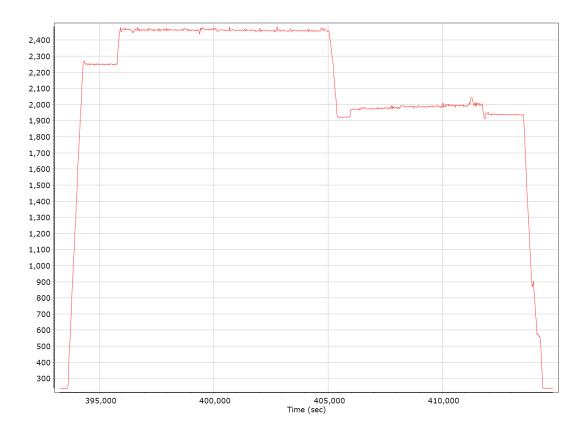




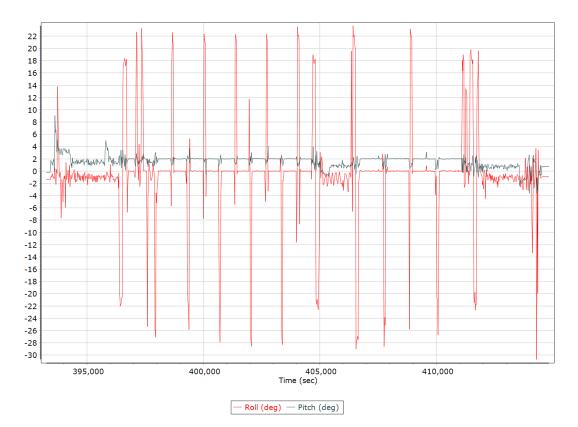
Smoothed Trajectory Information

Top View

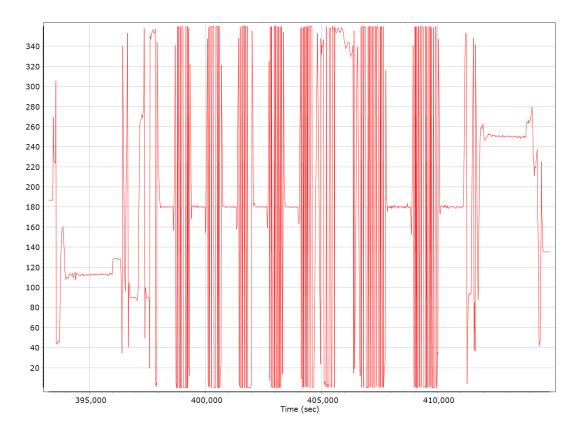
Altitude

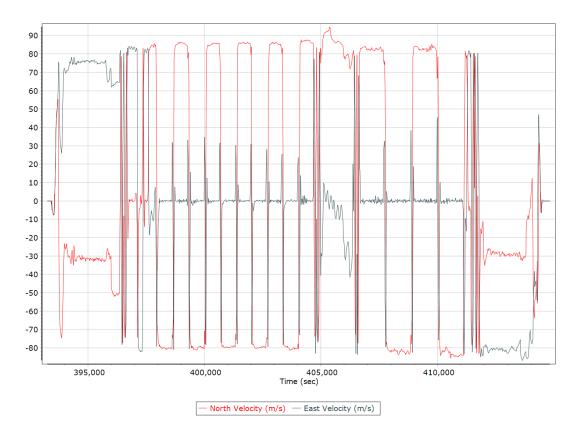


Roll/Pitch



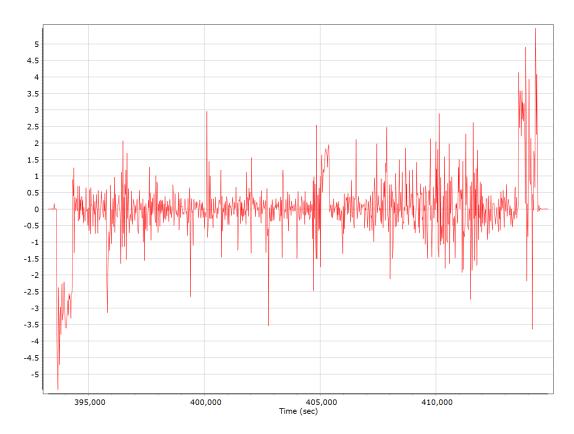
Heading



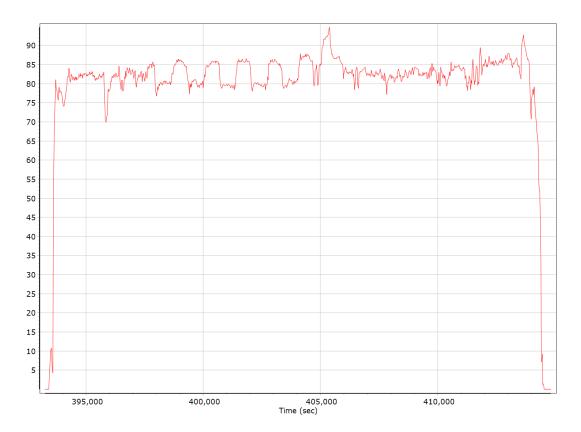


North/East Velocity

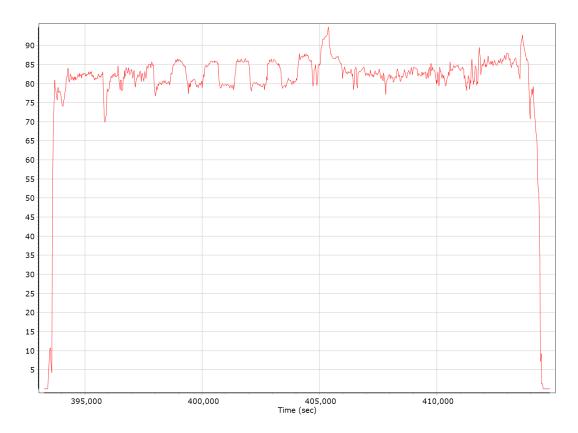
Down Velocity



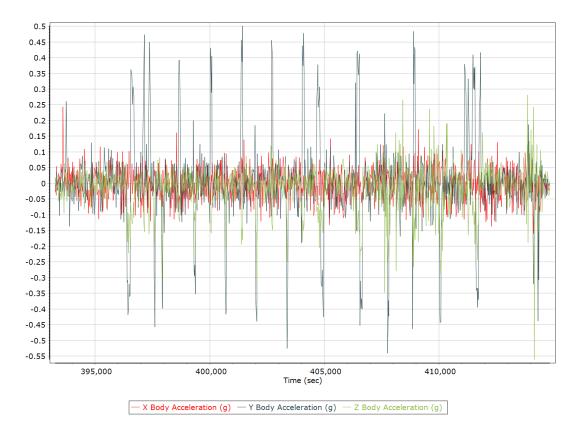
Total Speed



Ground Speed

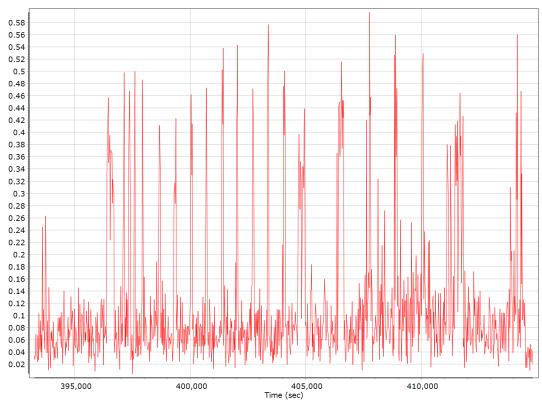


13

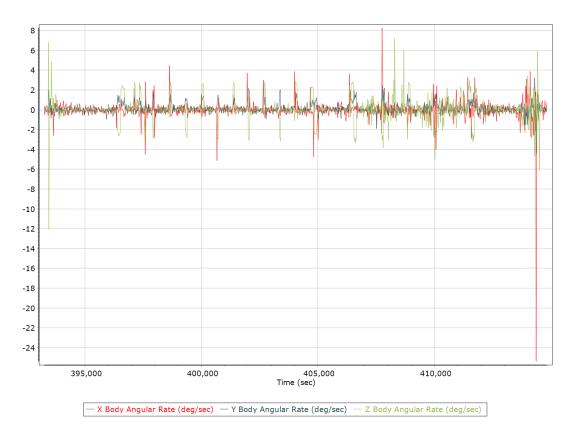


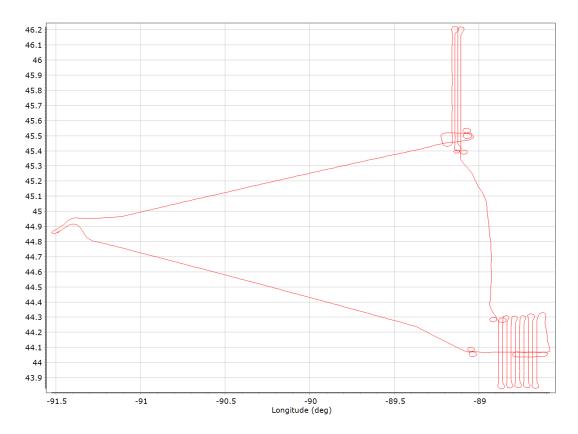
Body Acceleration

Total Body Acceleration



Body Angular Rate

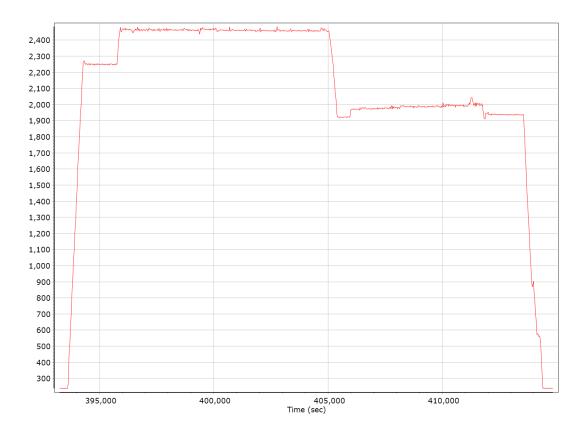




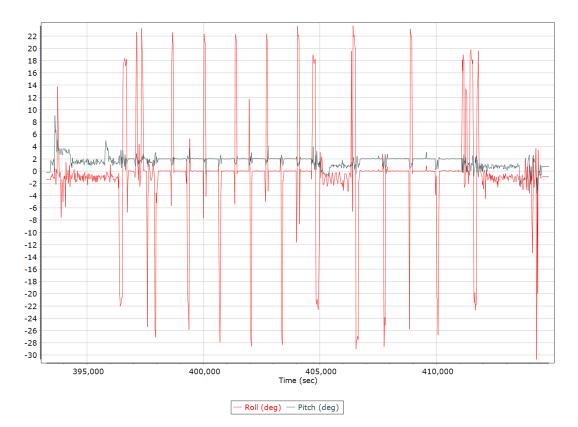
Forward Processed Trajectory Information

Top View

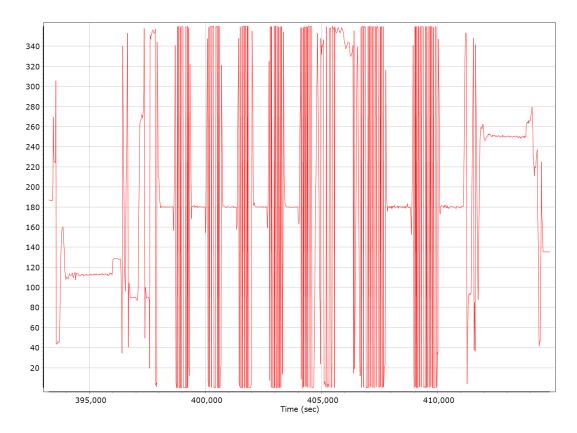
Altitude

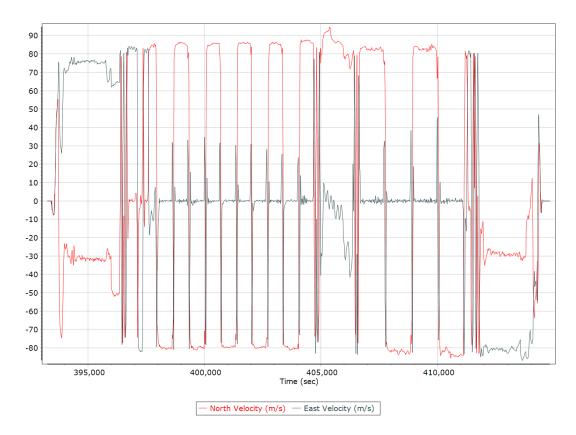


Roll/Pitch



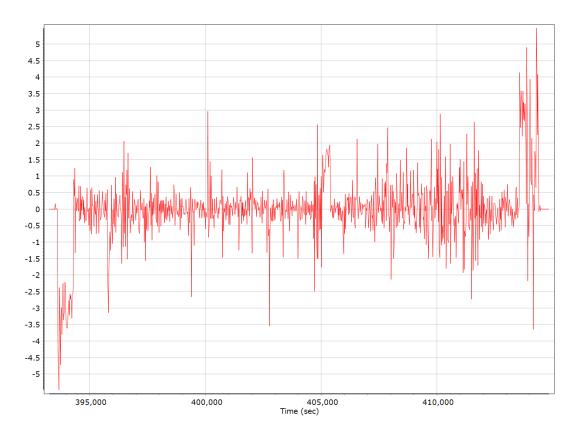
Heading



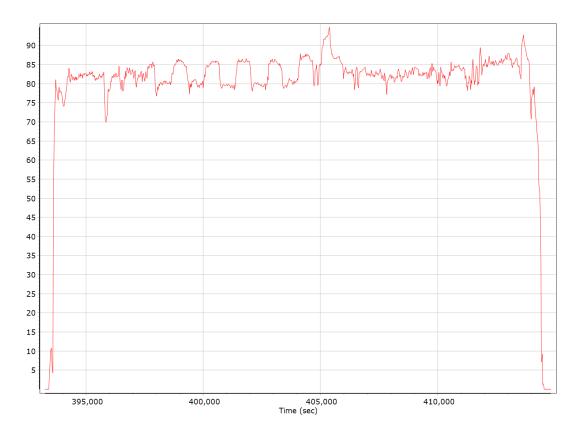


North/East Velocity

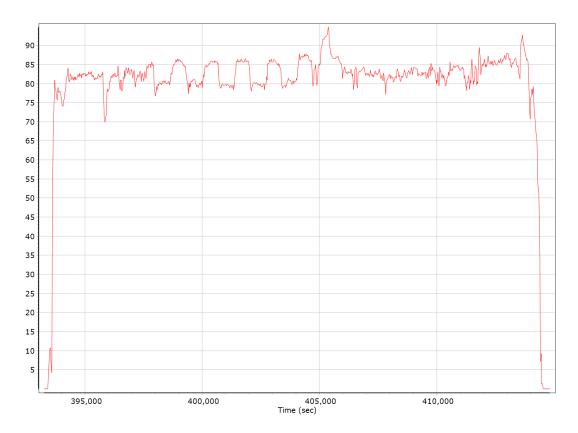
Down Velocity



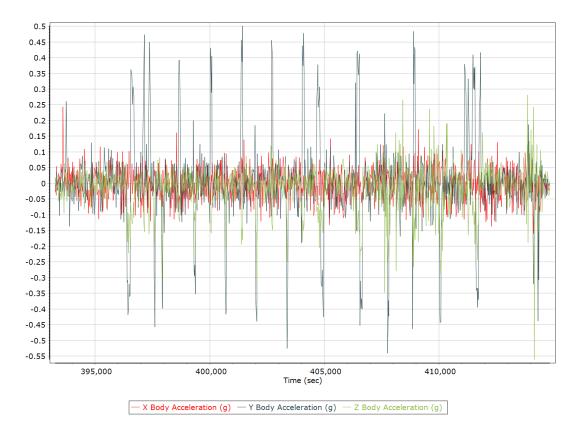
Total Speed



Ground Speed

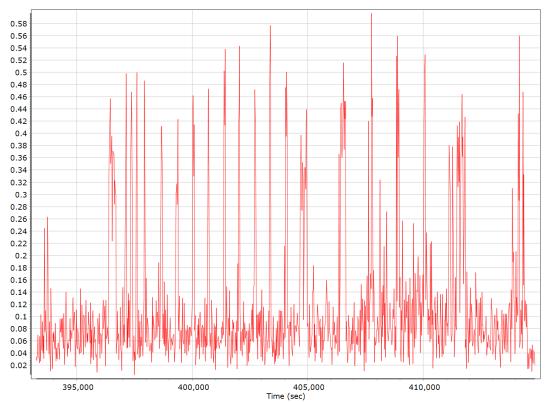


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Body Acceleration

Total Body Acceleration



Body Angular Rate

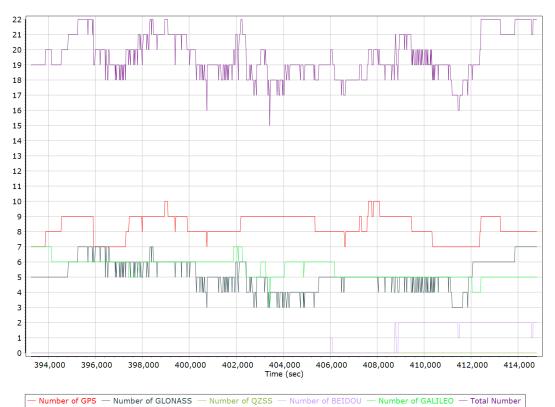


GNSS QC

GNSS QC Statistics

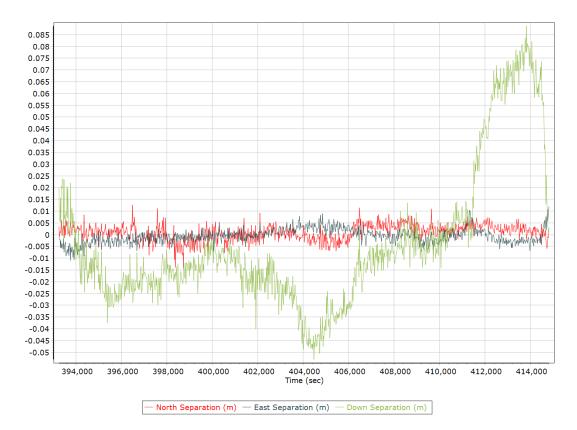
Statistics	Min	Max	Mean
Baseline length (km)	0.00	0.00	
Number of GPS SV	2	10	8
Number of GLONASS SV	0	7	5
Number of QZSS SV	0	0	0
Number of BEIDOU SV	0	2	1
Number of GALILEO SV	1	7	6
Total number of SV	10	22	20
PDOP	1.00	5.42	1.20
QC Solution Gaps	1.00	1.00	
Solution Type	Fixed	Float	No solution
Epoch (sec)	21726.00	0.00	3.00
Percentage	99.99	0.00	0.01

Num SVs in solution



umber of GPS — Number of GLONASS — Number of Q2SS — Number of BEIDOO — Number of GALLEO — Total Numb

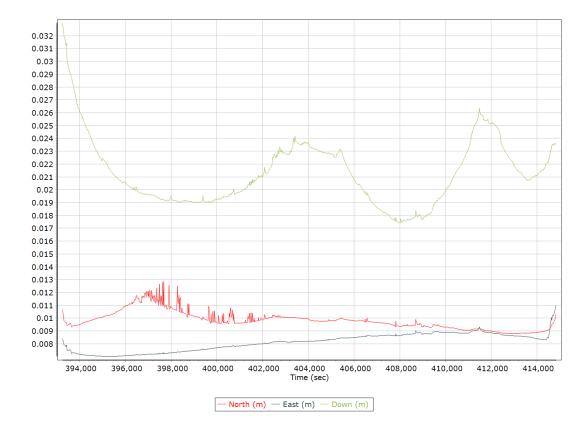


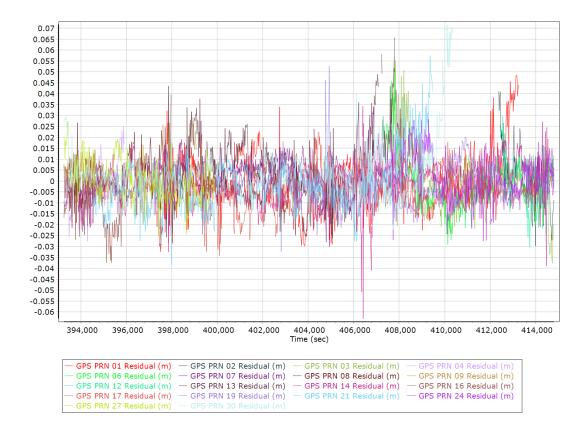


PDOP

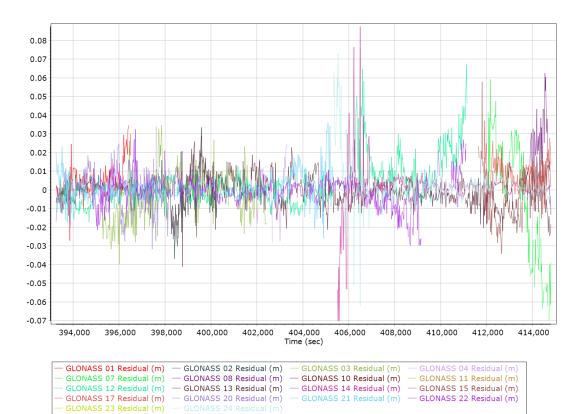


Estimated Position Accuracy



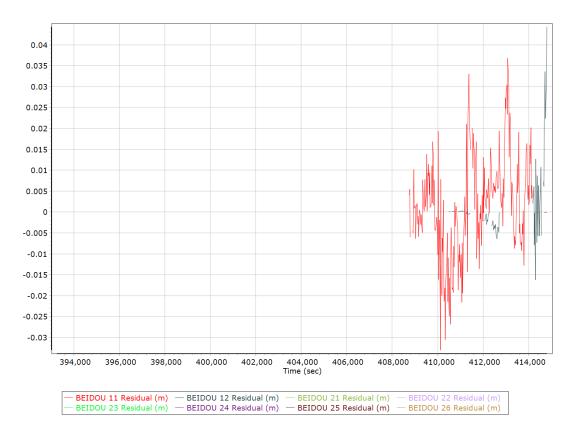


GPS Residuals



GLONASS Residuals

BEIDOU Residuals





GALILEO Residuals

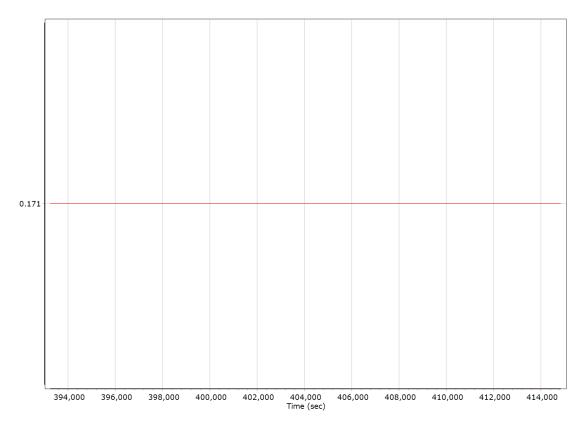
GNSS-Inertial Processor Configuration

Processing mode	IN-Fusion PP-	IN-Fusion PP-RTX			
Stabilized mount	True				
Processing start time	393058.000 (5	393058.000 (5/5/2022 1:10:58 PM)			
Processing end time	414843.000 (5/5/2022 7:14:03 PM)				
Initial attitude source	Real-Time VNAV/RNAV Attitude				
IMU Sensor Context	Processing wi	Processing with Onboard IMU			
Gimbal to IMU lever arm (m)	0.000	0.000	0.000		
Gimbal to IMU mounting angles (deg)	0.000	0.000	0.000		
Gimbal to Primary GNSS lever arm (m)	0.171	-0.238	-1.273		
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		

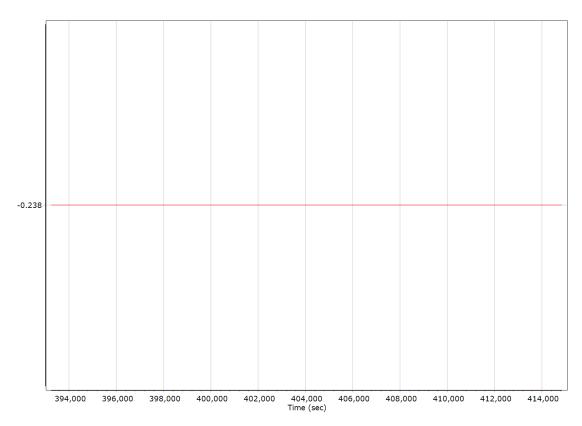
Calibrated Installation Parameters

Reference-Primary GNSS Lever Arm (m)

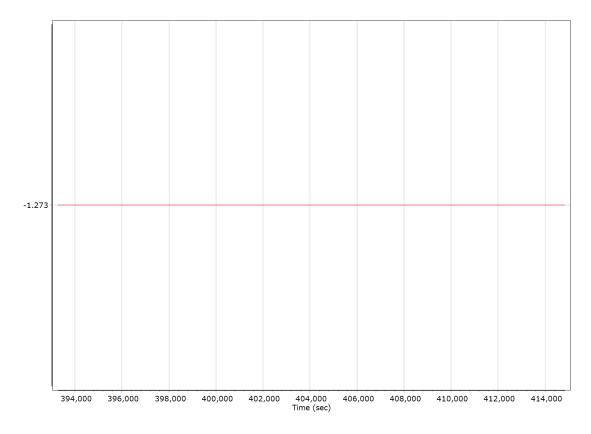
X Reference-Primary GNSS Lever Arm (m)



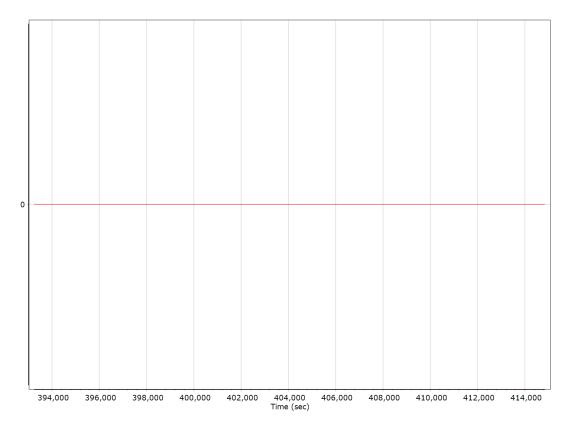
Y Reference-Primary GNSS Lever Arm (m)



Z Reference-Primary GNSS Lever Arm (m)

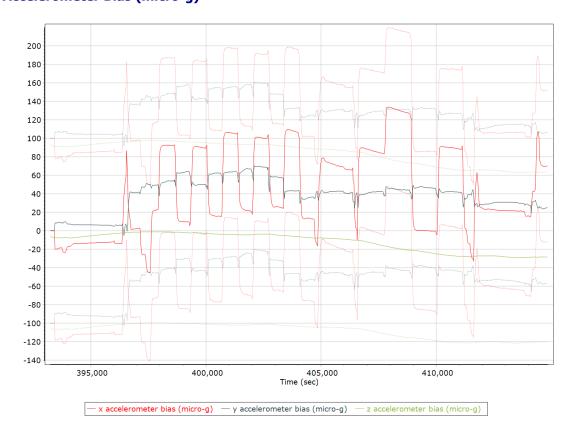


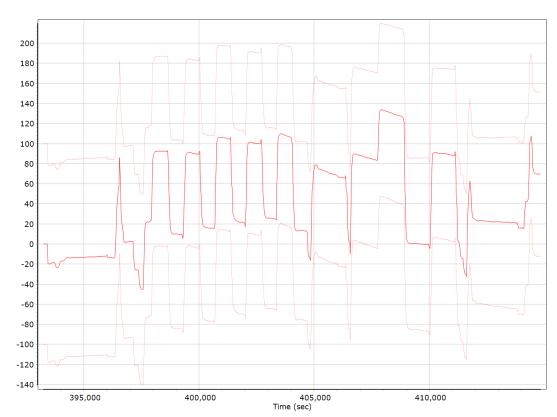
Reference-Primary GNSS Lever Arm Figure of Merit



IN-Fusion QC

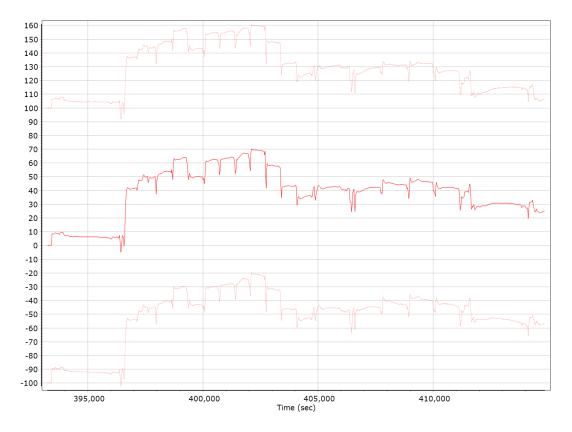
Forward Processed Estimated Errors, Reference Frame Accelerometer Bias (micro-g)



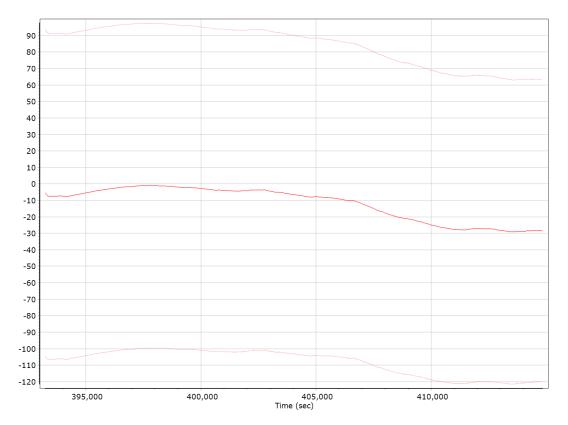


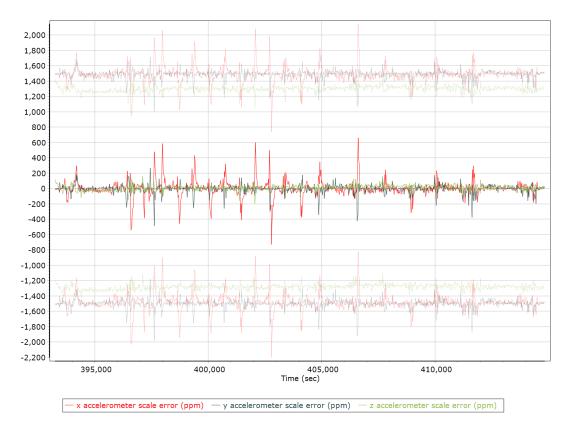
X Accelerometer Bias (micro-g)

Y Accelerometer Bias (micro-g)

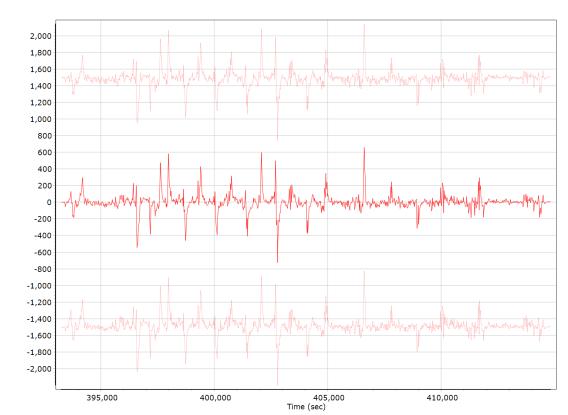


Z Accelerometer Bias (micro-g)

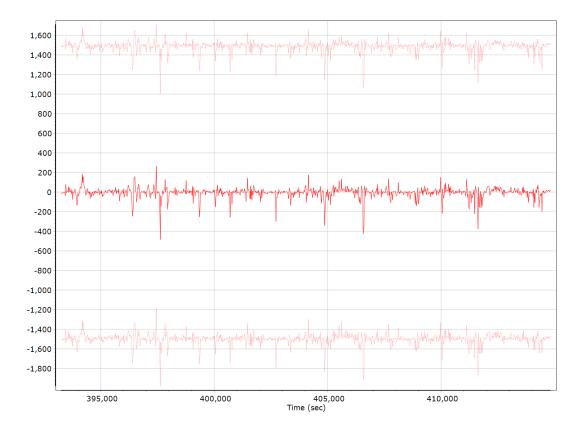




Accelerometer Scale Error (ppm)



X Accelerometer Scale Error (ppm)



Y Accelerometer Scale Error (ppm)

1,400 1,300 1,200 1,100 1,000 900 800 700 600 500 400 300 200 100 0 -100 -200 -300 -400 -500 -600 -700 -800 -900 -1,000 -1,100 -1,200 Multimaningupul -1,300 -1,400 395,000 400,000 405,000 410,000

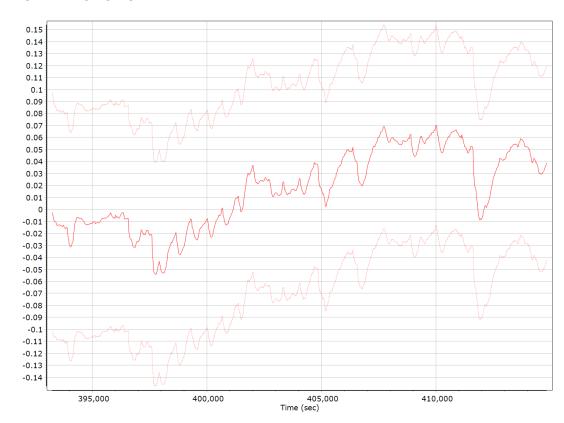
Z Accelerometer Scale Error (ppm)

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Time (sec)

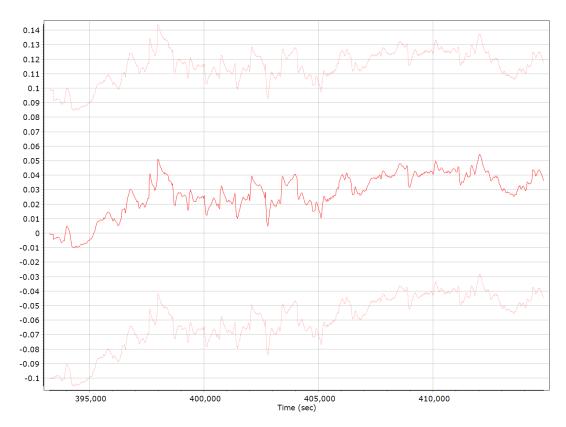




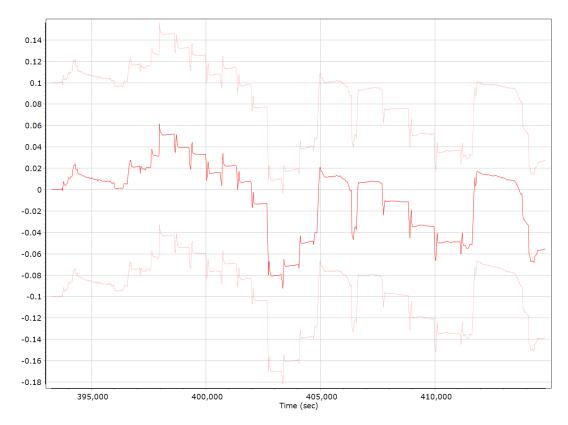


X Gyro Bias (deg/h)

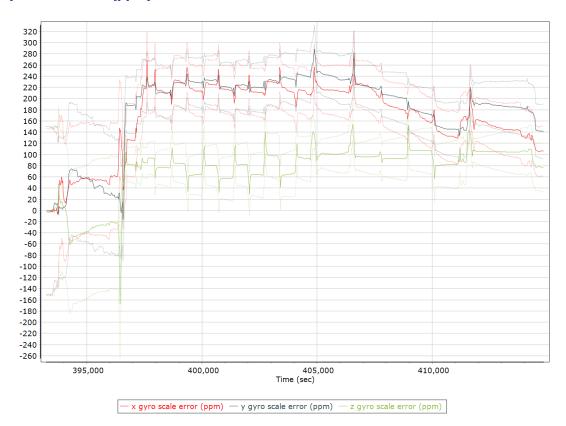
Y Gyro Bias (deg/h)

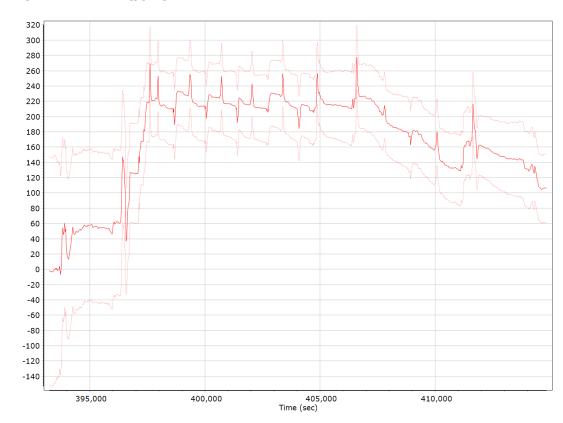


Z Gyro Bias (deg/h)



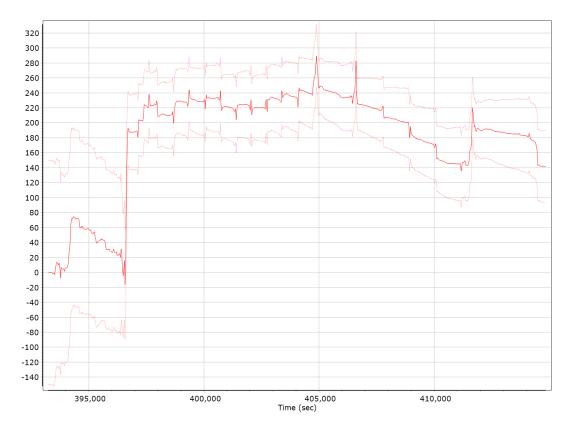
Gyro Scale Error (ppm)

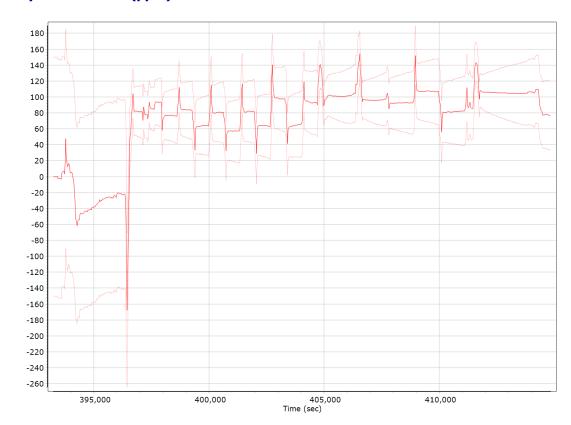




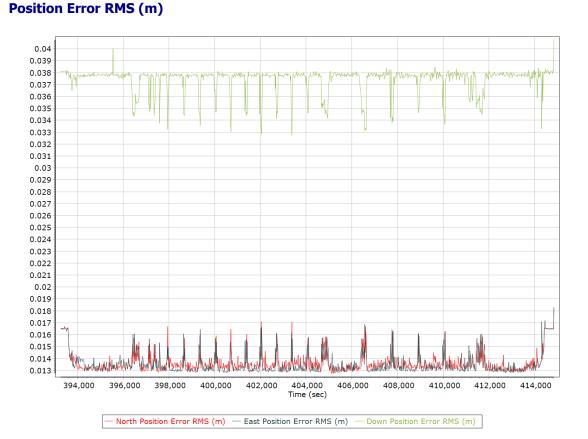
X Gyro Scale Error (ppm)

Y Gyro Scale Error (ppm)



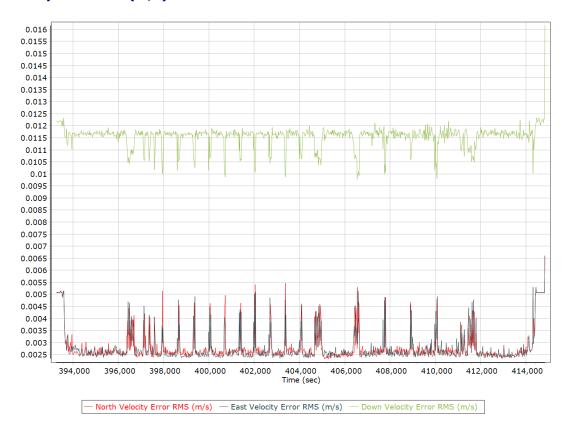


Z Gyro Scale Error (ppm)



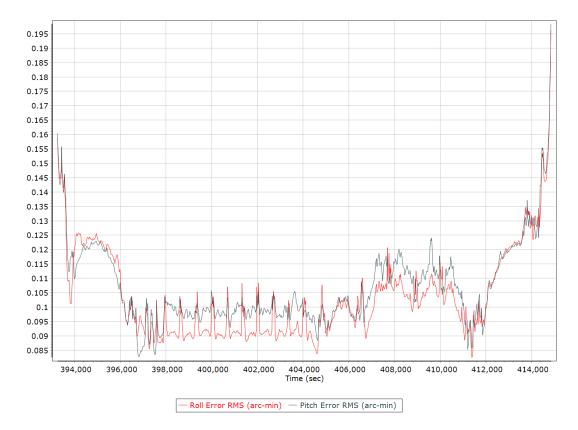
Smoothed Performance Metrics

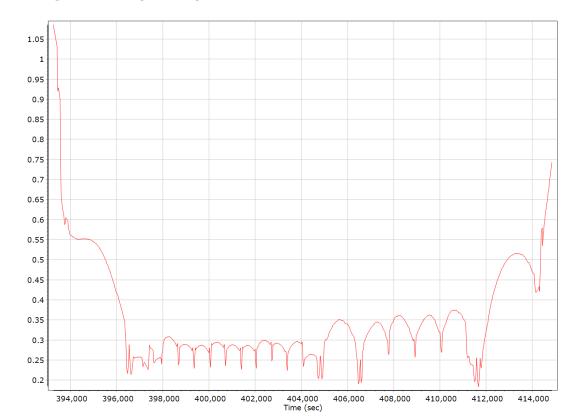
Velocity Error RMS (m/s)



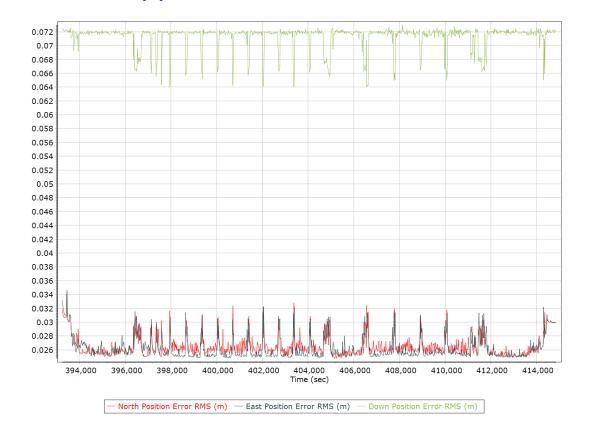
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Roll/Pitch Error RMS (arc-min)





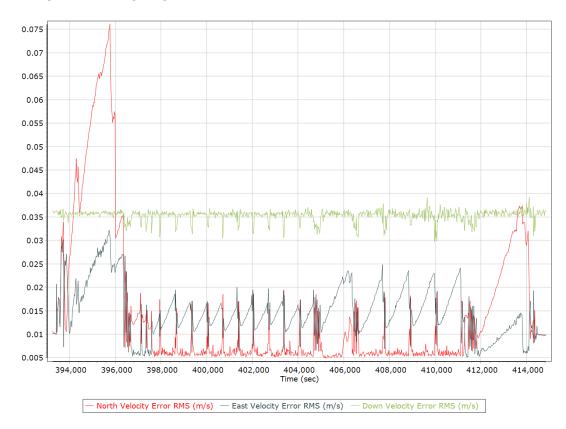
Heading Error RMS (arc-min)



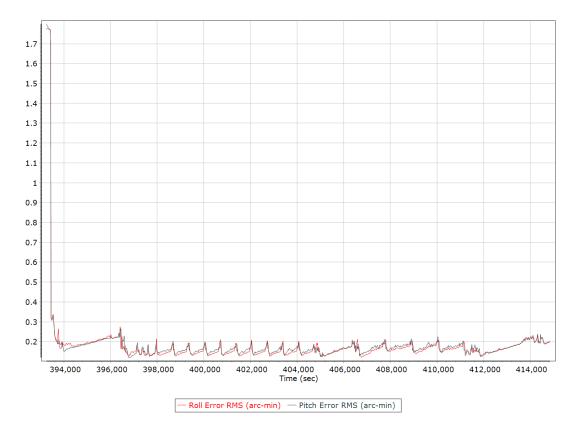
Forward Processed Performance Metrics

Position Error RMS (m)

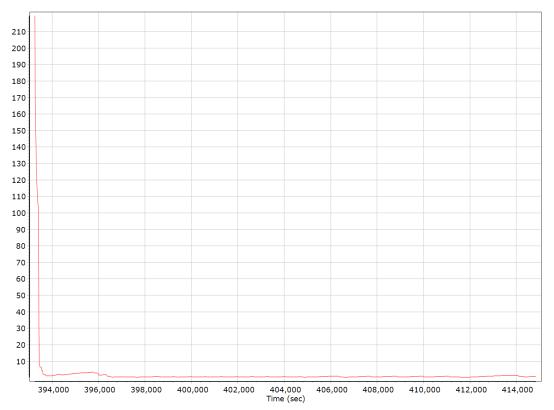
Velocity Error RMS (m/s)



Roll/Pitch Error RMS (arc-min)

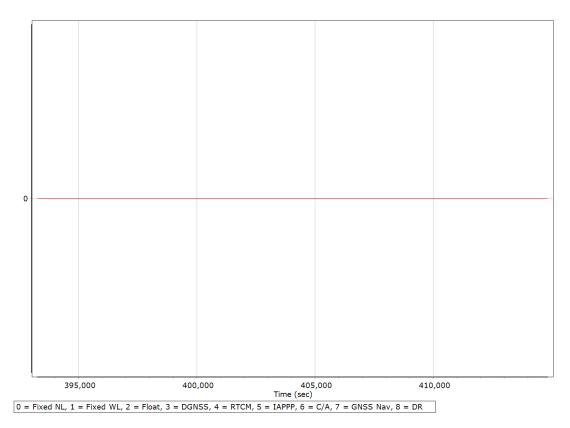


Heading Error RMS (arc-min)

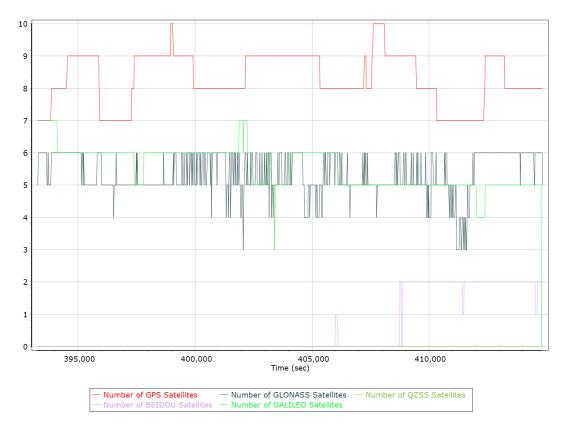


Forward Processed Solution Status

Processing Mode



Number of Satellites



Baseline Length

