LiDAR Acquisition and Calibration Report – Florida Panhandle

Report Date: 07/17/2018

SUBMITTED BY:

Airborne Imaging Inc.
2700 – 61 Avenue SE
Calgary, AB T2C 4V2
403.215.2960

SUBMITTED TO:

Dewberry
1000 North Ashley Drive Suite 801
Tampa, FL 33602
813.225.1325

Overview

Dewberry elected to subcontract the LiDAR Acquisition and Calibration activities to Airborne Imaging Inc. A Clean Harbors Company (hereafter called Airborne Imaging). Airborne Imaging was responsible for providing LiDAR acquisition, calibration and delivery of LiDAR data files to Dewberry. Dewberry received calibrated swath data from Airborne Imaging in staged deliveries on May 22nd, June 26th, and July 11th, 2018

Project Area

The project area addressed by this report falls within the Florida Panhandle. The total size of the project was originally 7000 miles² but was reduced by 1048 miles² to 5952 miles² because of airspace restrictions over the Eglin Airforce Base (Area Not Acquired noted on the map below).

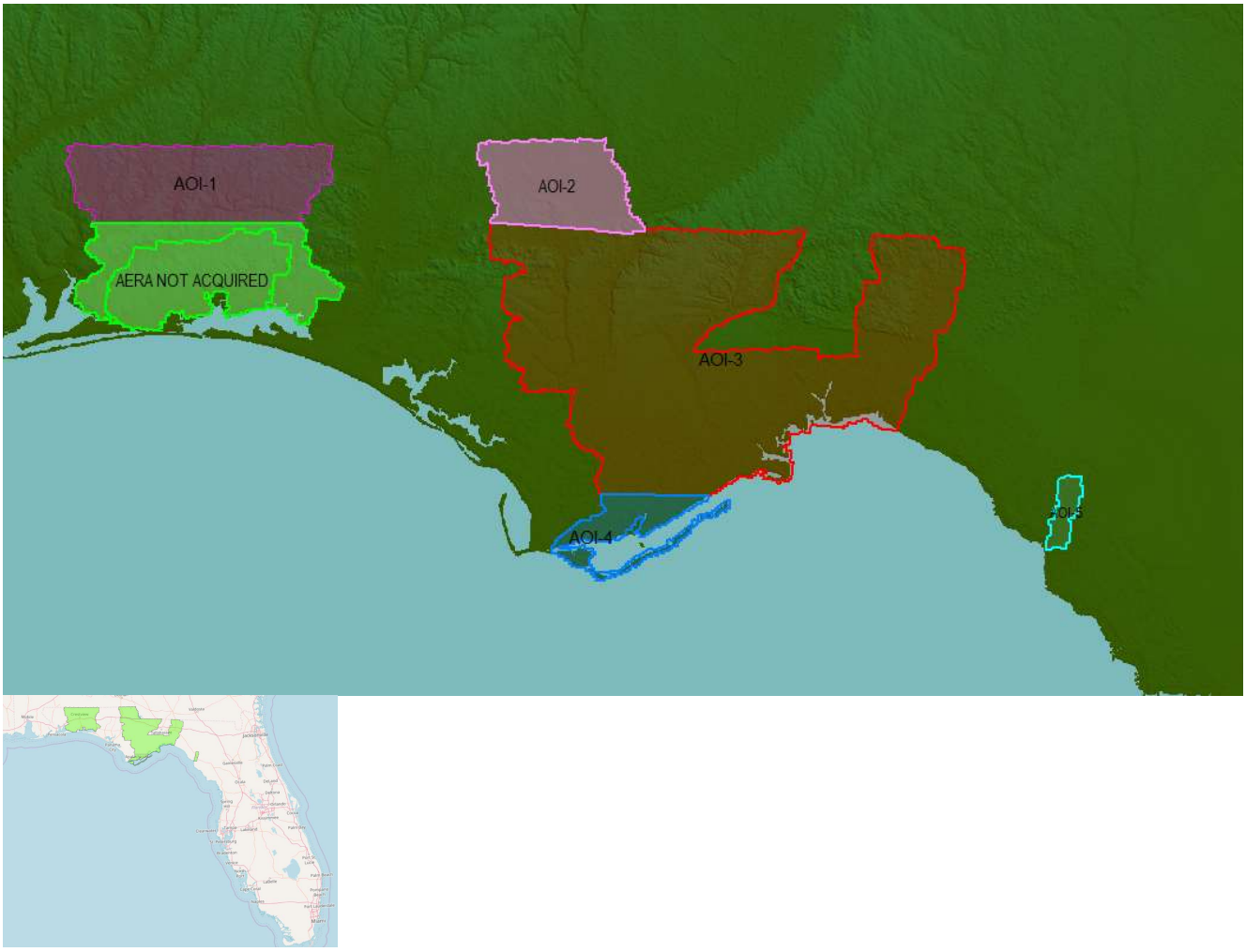


Figure 1 – Area of Interest

Acquisition Dates

The LiDAR survey was conducted between March 31st, 2018 and May 10th, 2018.

Datum Reference

Data produced for the project were delivered in the following reference system.
Horizontal Datum: The horizontal datum for the project is North American Datum of 1983 (NAD 83)
Vertical Datum: The vertical datum for the project is North American Vertical Datum of 1988 (NAVD88)
Coordinate System: Albers Conic Equal Area (CONUS) EPSG 6350

Units: Lidar data is provided in meters
Geoid Model: Geoid12B (Geoid12B was used to convert ellipsoid heights to orthometric heights)

LiDAR Acquisition Details

Airborne Imaging initially planned 275 passes for the project area as a series of parallel flight lines with cross flight lines for the purposes of quality control. On May 04 many of the lines within AOI-3 where re-orientated from north-south to east-west because of continuous cloud formation along the coast, thus allowing full lines to be flown as opposed to partial lines. The revision resulted in total 302 lines, however because of airspace access restrictions over the Eglin Airforce Base only 268 lines of the 302 were flown.

The flight plan included zigzag flight line collection as a result of the inherent IMU drift associated with all IMU systems. In order to reduce any margin for error in the flight plan, Airborne Imaging followed FEMA's Appendix A "guidelines" for flight planning and, at a minimum, includes the following criteria:

- Digital flight line layout using LEICA MISSION PRO flight design software for direct integration into the aircraft flight navigation system.
- Planned flight lines; flight line numbers; and coverage area.
- LiDAR coverage extended by a predetermined margin beyond all project borders to ensure necessary over-edge coverage appropriate for specific task order deliverables.
- Local restrictions related to air space and any controlled areas have been investigated so that required permissions can be obtained in a timely manner with respect to schedule.

Additionally, Airborne Imaging filed our flight plans as required by local Air Traffic Control (ATC) prior to each mission. Airborne Imaging monitored weather and atmospheric conditions and conducted LiDAR missions only when no conditions exist below the sensor that will affect the collection of data. These conditions include no snow, rain, fog, smoke, mist and low clouds. LiDAR systems are active sensors, not requiring light, thus missions may be conducted during night hours when weather restrictions do not prevent collection. Airborne Imaging accesses reliable weather sites and indicators (webcams) to establish the highest probability for successful collection in order to position our sensor to maximize successful data acquisition.

Within 72-hours prior to the planned day(s) of acquisition, Airborne Imaging closely monitored the weather, checking all sources for forecasts at least twice daily. As soon as weather conditions were conducive to acquisition, our aircraft mobilized to the project site to begin data collection. Once on site, the acquisition team took responsibility for weather analysis.

Airborne Imaging LiDAR sensors are calibrated at a designated site located at Red Deer, Alberta, Canada or St. Hubert, Quebec, Canada and are periodically checked and adjusted to minimize corrections at project sites.

LiDAR System parameters

Airborne Imaging operated two Piper PA-31 Navajo (Tail # C-GMEC, and # C-GKSX) outfitted with Riegl VQ-1560i LiDAR systems during the collection of the project area. Table 1 illustrates Airborne Imaging system parameters for LiDAR acquisition on this project.

A total of 22 flight missions where completed for this project, of which 11 were flown using an incorrect setting with the pulse rate at 2000 kHz (1000 kHz per channel). Although this did not affect data quality it does result in double the point density. Both sets of parameters are listed in the table below.

TABLE 1 SENSOR COLLECTION PARAMETERS	
Item	Parameter
Sensor System	Riegl VQ-1560i
Aircraft	Piper Navajo PA-31 Tail #: C-GKSX, #: C-GMEC
Altitude (AGL)	1600m
Approx. Flight Speed (kts)	160
Scanner Pulse Rate (KHz)	1000 kHz & 2000 kHz (true) 667 & 1333.3 kHz (effective)
Scan Frequency (lps)	239 & 361 Scanlines/s
Pulse Duration of the Scanner (microseconds)	3ns FWHM (0.003 us)
Pulse Width of the Scanner (m)	0.9m FWHM
Swath Width (m)	1848m
Central Wavelength of the Sensor Laser (nanometers)	1064nm
Will the Sensor Operate with Multiple Pulses in The Air? (yes/no)	Yes
Laser Beam Divergence (milliradians)	0.25mrad (1/e^2)
Nominal Swath Width on the Ground (m)	1793m
Swath Overlap (%)	30
Total Sensor Scan Angle (degree)	60
Computed Along Track Spacing (m)	0.67 per channel, 0.47 per channel
Computed Cross Track Spacing (m)	0.67 per channel, 0.47 per channel
Nominal Pulse Spacing (single swath), (m)	0.48 & 0.34
Nominal Pulse Density (single swath) (ppsm), (m)	4.3 ppsm & 8.7 ppsm
Aggregate Nominal Pulse Spacing (m)	< 0.60 m
Maximum Number of Returns per Pulse	7+
Line Spacing (m)	1255
Maximum Baseline Length (mi)	31

Table 1 – Airborne Imaging LiDAR System Parameters

Acquisition Status Report and Flight Lines

Upon notification to proceed, the flight crew loaded the flight plans and validated the flight parameters. The Acquisition Manager contacted air traffic control and coordinated flight pattern requirements. LiDAR acquisition began immediately upon notification that control base stations were in place. During flight operations, the flight crew monitored weather and atmospheric conditions. LiDAR missions were flown only when no condition existed below the sensor that would affect the collection of data. The pilot constantly monitored the aircraft course, position, pitch, roll, and yaw of the aircraft. The sensor operator monitored the sensor, the status of PDOPs, and performed the first Q/C review during acquisition. The flight crew constantly reviewed weather and cloud locations. Any flight lines impacted by unfavorable conditions were marked as invalid and re-flown immediately or at an optimal time. Figure 2 shows the planned trajectories of the flight lines and Figure 3 illustrates areas flown at 2000 k

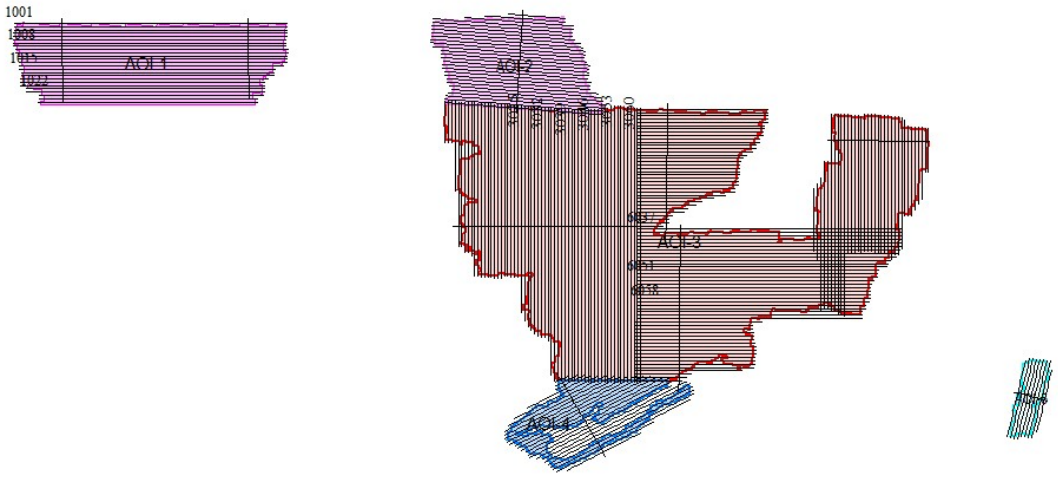


Figure 2 – Trajectories as flown by Airborne Imaging

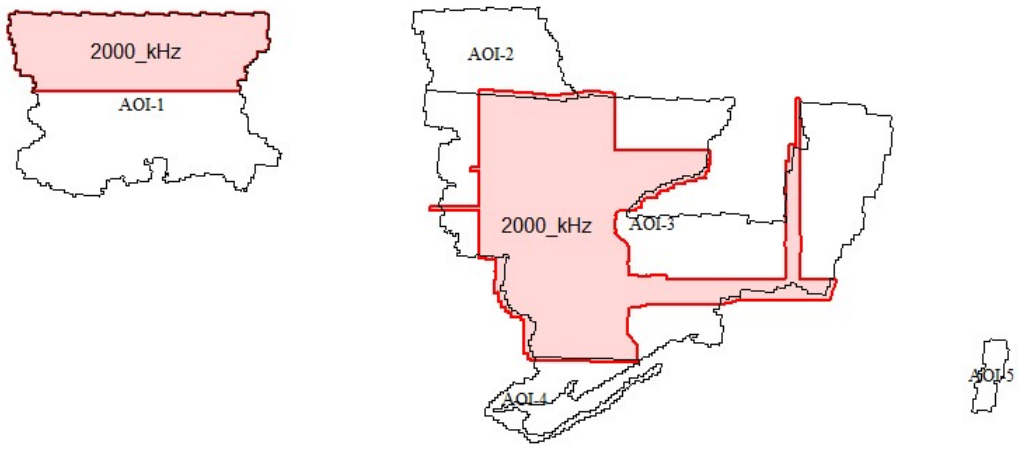


Figure 3 – Areas in red represent data acquired at 2000 kHz

LiDAR Control

Sixteen Florida DOT Permanent Reference Network (FPRN) stations, five existing NGS monuments, and nine newly established base stations (B160 to B163, B192 to B196) were used as control for the LiDAR acquisition and ground control surveys. Also, additional temporary points were set for ground control validation points. The coordinates of all used base stations are provided in the table below.

Name	NAD83 UTM16		Ellipsoid Ht (m)	Orthometric Ht (NAVD88 Geoid12B, m)
	Easting X (m)	Northing Y (m)		
ALEB	494693.290	3439738.415	14.897	42.548
AS0886	681913.980	3317375.711	-22.378	5.139
B160	672845.362	3309317.454	-21.612	5.782
B161	579293.786	3361938.113	-25.534	1.992
B162	615768.065	3357324.557	-11.580	16.236
B163	511856.156	3391266.404	15.528	42.857
B192	545495.379	3404707.655	22.340	49.643
B193	754142.941	3365770.682	-13.117	14.638
B194	791968.686	3365994.589	32.791	60.429
B195	692910.852	3368342.615	7.196	35.365
B196	674133.226	3408996.962	10.310	38.535
BE3768	614404.332	3391605.109	2.580	30.389
BG0447	500571.134	3388670.038	-4.408	22.961
BG1452	584006.922	3393146.721	36.366	63.928
BG5044	538984.329	3371984.615	-25.027	2.340
CRST	547279.052	3399348.394	33.971	61.274
DSTN	552012.702	3361973.218	-17.972	9.442
FLBF	894830.903	3321604.817	-13.265	14.622
FLBY	633393.240	3413226.790	7.452	35.289
FLCB	722678.147	3303573.946	-19.622	7.582
FLJL	762163.707	3386207.156	37.251	65.007
FLJO	665234.964	3299318.891	-19.483	7.747
FLMD	857990.859	3366119.857	0.118	28.150
FLMR	663218.544	3406291.235	41.831	69.914
PCLA	481818.038	3370773.340	3.366	30.786
PNMA	627713.830	3343284.269	-15.020	12.764
PRRY	830211.130	3332358.167	-12.953	14.815
SNED	693010.469	3391249.832	25.870	54.199
TALH	754047.178	3365692.073	-5.845	21.909
XCTY	876890.038	3284233.481	-13.819	13.925

Table 2 – Base Stations used to control LiDAR acquisition

Airborne GNSS Kinematic

Airborne GNSS data was processed using the Applanix POSPac MMS software suite and Novatel's GrafNav software. Flights were flown with a minimum of 6 satellites in view (13° above the horizon) and with a PDOP of better than 4. Distances from at least one base station to aircraft were kept to a maximum of 50km (31 miles). For all flights, the GNSS data can be classified as excellent, with GNSS residuals of 3cm average or better but no larger than 10cm being recorded. GNSS processing reports for each mission are included in Appendix A.

Generation and Calibration of Laser Points (raw data)

The initial step of calibration is to verify availability and status of all needed GNSS and Laser data against field notes and compile any data if not complete. Subsequently the mission points are output using Riegl's RiProcess, initially with default values calibration for the system. The initial point generation for each mission calibration is verified within Microstation/Terrascan for calibration errors. If a calibration error greater than specification is observed within the mission, the roll, pitch, and yaw corrections that need to be applied are calculated using Riegl's Scan Data Adjustment within RiProcess. The Scan Data Adjustment utility uses plane matching to determine roll, pitch, and yaw corrections for each swath. The missions with the new calibration values are regenerated and validated internally once again to ensure quality.

Data collected by the LiDAR unit is reviewed for completeness, acceptable density and to make sure all data is captured without errors or corrupted values. In addition, all GNSS, aircraft trajectory, mission information, and ground control files are reviewed and archived. On a project level, a supplementary coverage check is carried out to ensure no data voids unreported by field operations are present.

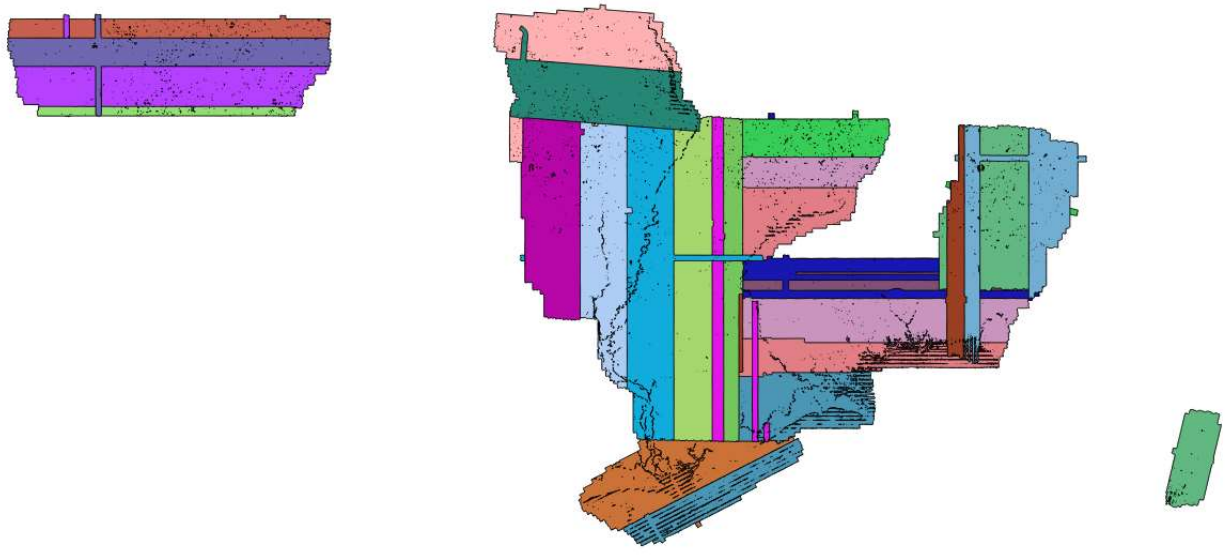
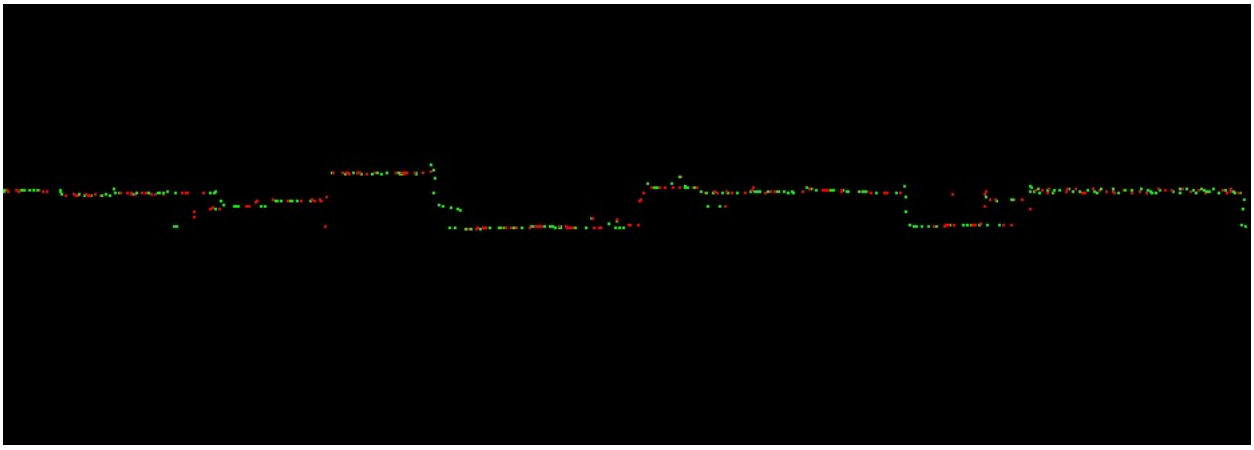


Figure 4 – LiDAR Swath output showing complete coverage.

Boresight and Relative accuracy

The initial points for each mission calibration are inspected for flight line errors, flight line overlap, slivers or gaps in the data, point data minimums, or issues with the LiDAR unit or GNSS. Roll, pitch and scanner scale are optimized during the calibration process until the relative accuracy is met. Relative accuracy and internal quality are checked using at least 3 regularly spaced QC blocks in which points from all lines are loaded and inspected. Vertical differences between ground surfaces of each line are displayed. Color scale is adjusted so that errors greater than the specifications are flagged. Cross sections are visually inspected across each block to validate point to point, flight line to flight line and mission to mission agreement.

For this project the specifications used are as follows:
Relative accuracy <= 6 cm maximum differences within individual swaths and <=8 cm RMSDz between adjacent and overlapping swaths.



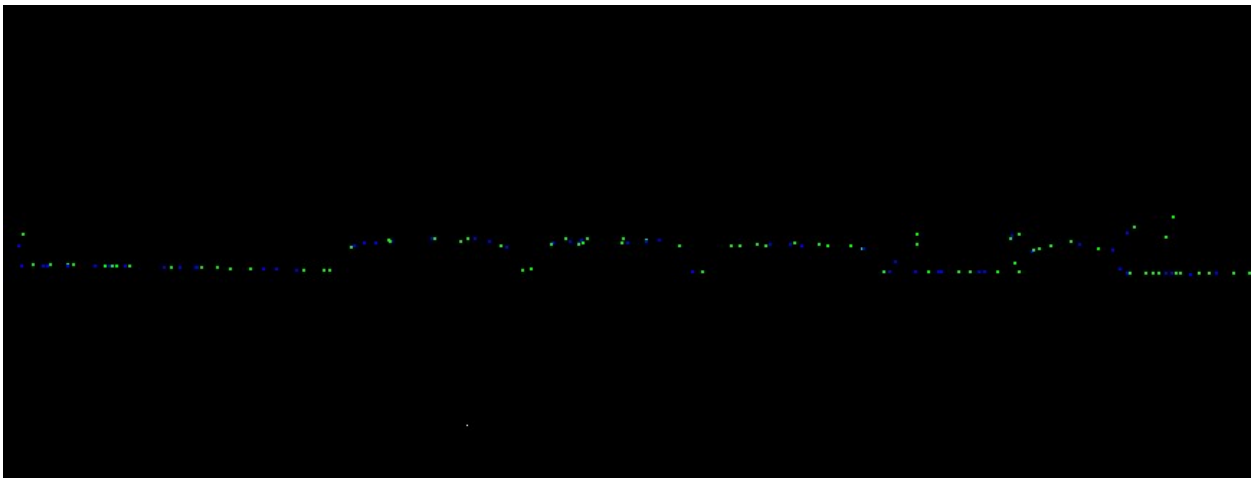


Figure 5 – Profile views showing correct roll and pitch adjustments.

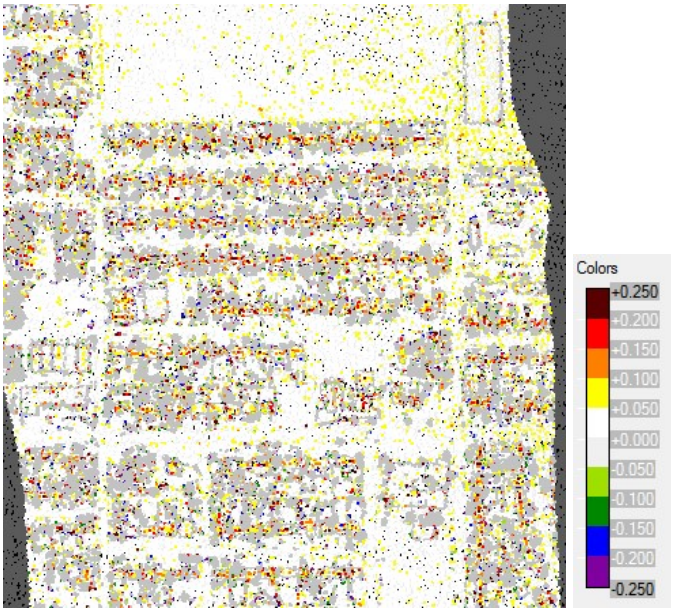


Figure 6 – QC block colored by distance to ensure accuracy at swath edges.

A different set of QC blocks are generated for final review after all transformations have been applied.

Preliminary Vertical Accuracy Assessment

A preliminary $RMSE_z$ error check is performed by Airborne Imaging at this stage of the project life cycle in the raw LiDAR dataset against GNSS static and kinematic data and compared to $RMSE_z$ project specifications. The LiDAR data is examined in non-vegetated, flat areas away from breaks. LiDAR ground points for each flight line generated by an automatic classification routine are used.

Prior to delivery to Dewberry, the elevation data was verified internally to ensure it met Non-vegetated Vertical Accuracy (NVA) requirements ($RMSE_z \leq 10$ cm and $Accuracy_z$ at the 95% confidence level ≤ 19.6 cm) when compared kinematic GNSS checkpoints.

Below is a summary for the test:
The calibrated Florida Panhandle LiDAR dataset was tested to 0.086 m vertical accuracy at 95% confidence level based on $RMSE_z$ (0.044 m x 1.9600) when compared to over 15000 GNSS kinematic check points collected on roads within the area. The following are the final statistics for the GNSS kinematic checkpoints used by Airborne Imaging to internally verify vertical accuracy after removing outlier points on slopes/obstructions/vehicles on the road.

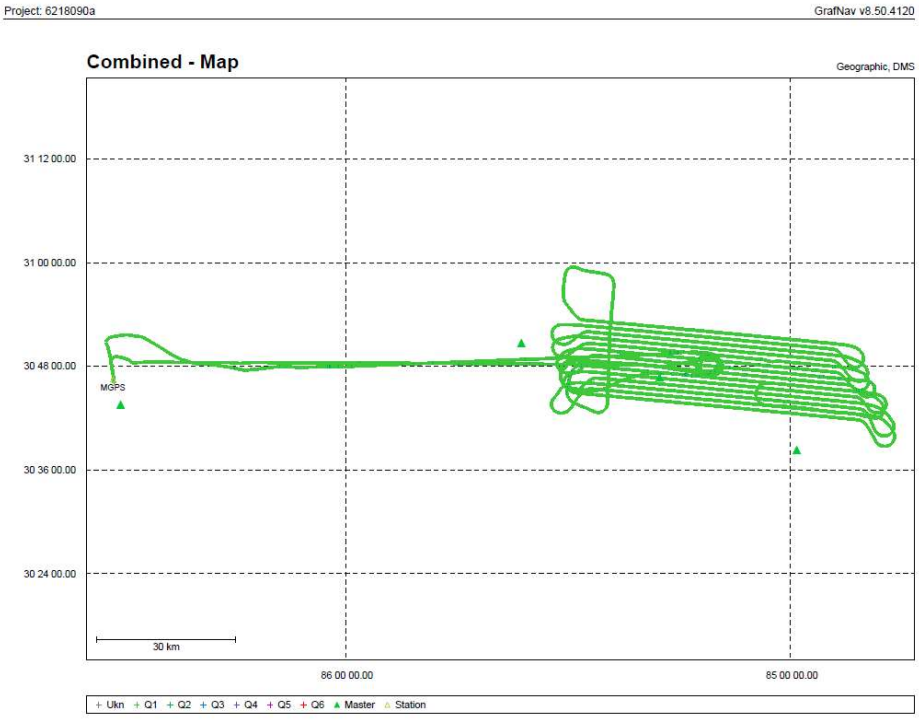
100 % of Totals	# of Points	RMSEz (nva) Spec=0.1 m	Spec=0.196m	Mean (m)	Std Dev (m)	Min (m)	Max (m)
Non-Vegetated Terrain	15470	0.044	0.086	0.001	0.044	-0.250	0.237

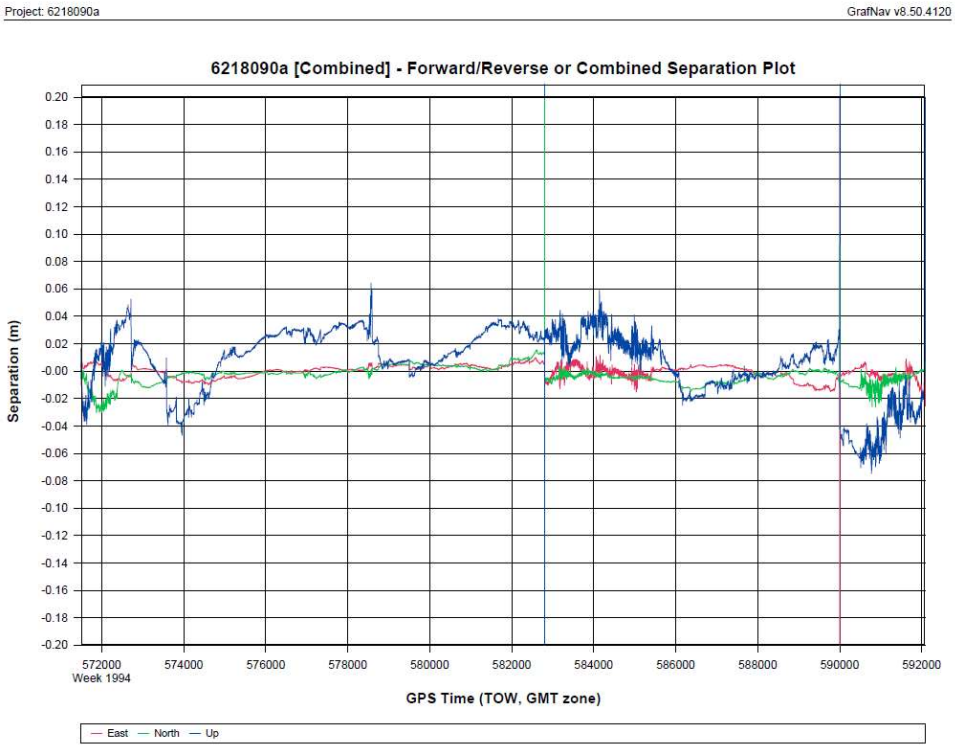
Table 3 – Kinematic GNSS Vertical Accuracy Results

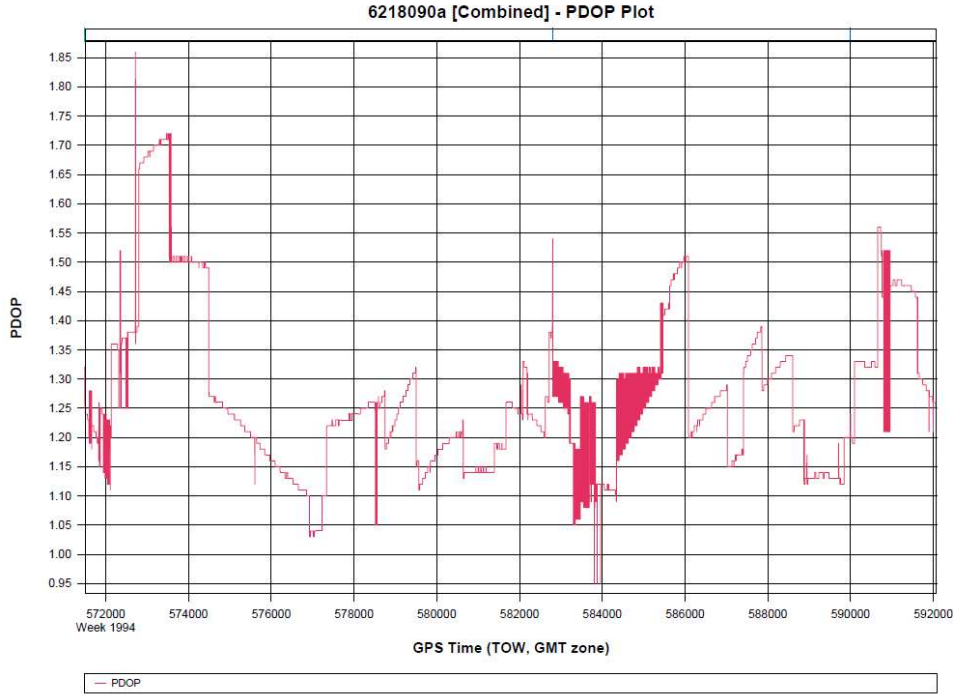
Overall the calibrated LiDAR data products collected by Airborne Imaging meet or exceed the requirements set out in the Statement of Work. The quality control requirements of Airborne Imaging quality management program were adhered to throughout the acquisition stage for this project to ensure product quality.

Appendix A: GNSS and IMU Processing Reports for Each Mission

Mission 1 – 6218090a GNSS Processing



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1.80
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1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
572000
Week 1994
574000
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584000
586000
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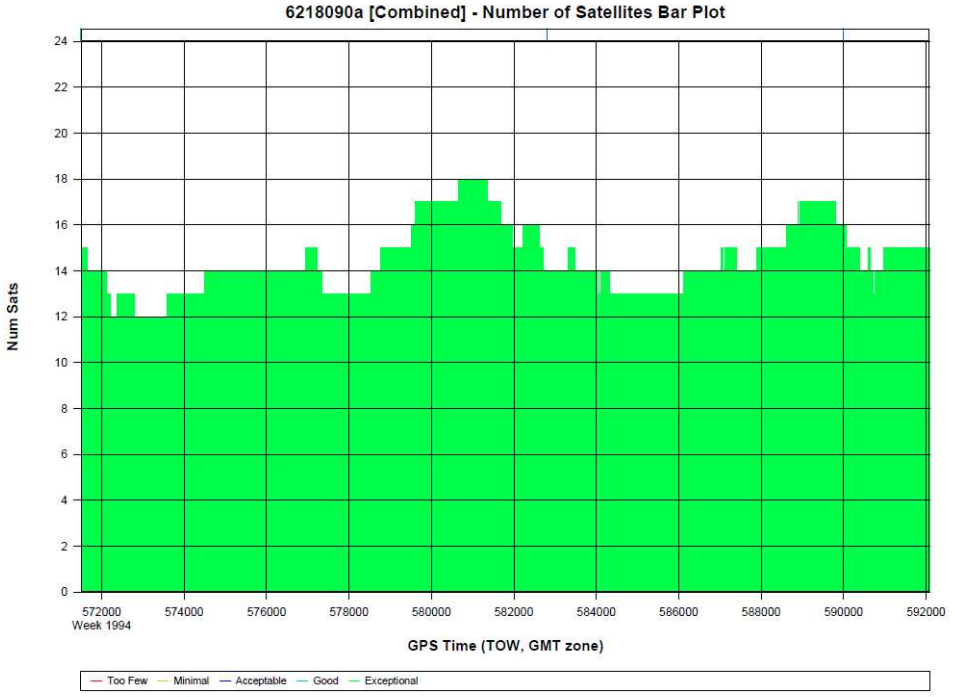
590000
592000
GPS Time (TOW, GMT zone)
PDOP


6218090a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
572000
Week 1994
574000
576000
578000
580000
582000
584000
586000
588000
590000
592000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

Processing Summary Information
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Version: 8.50.4120
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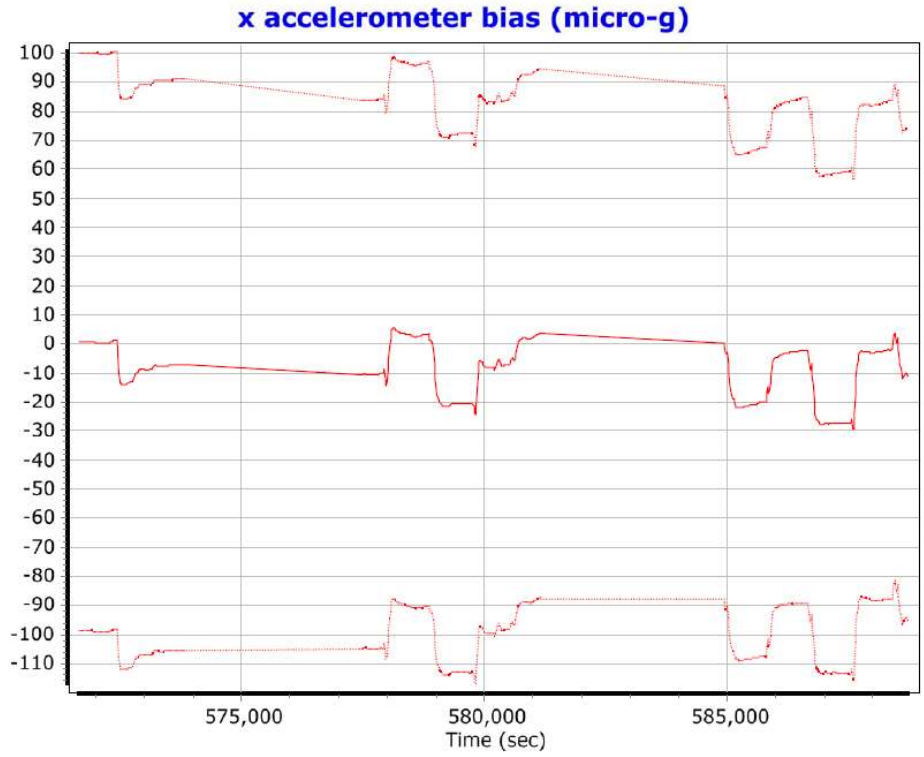
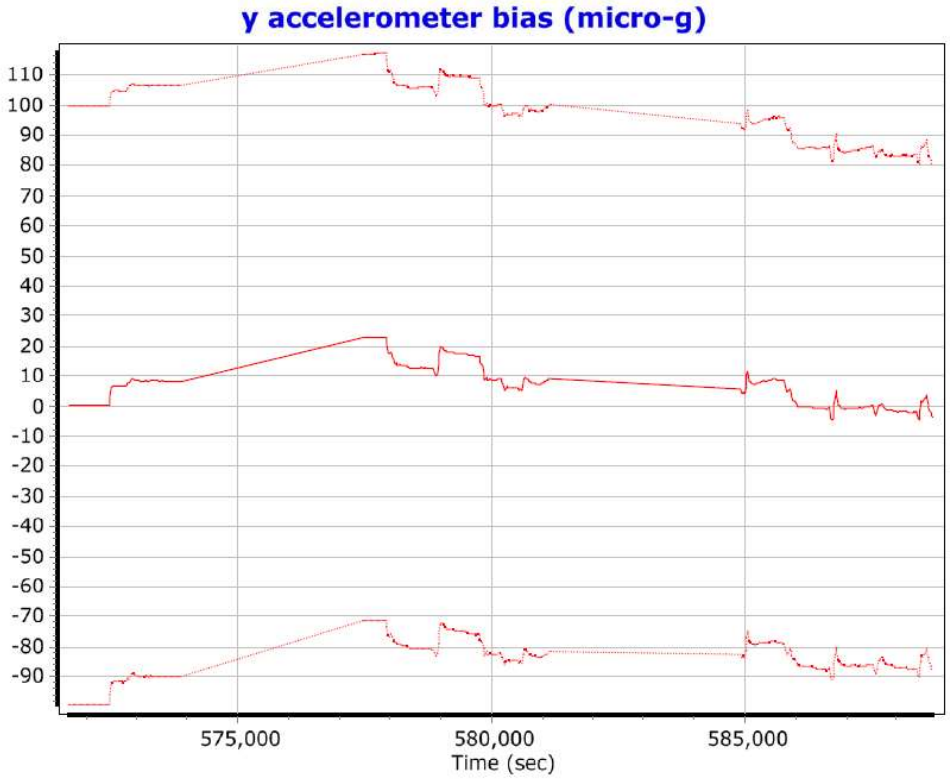
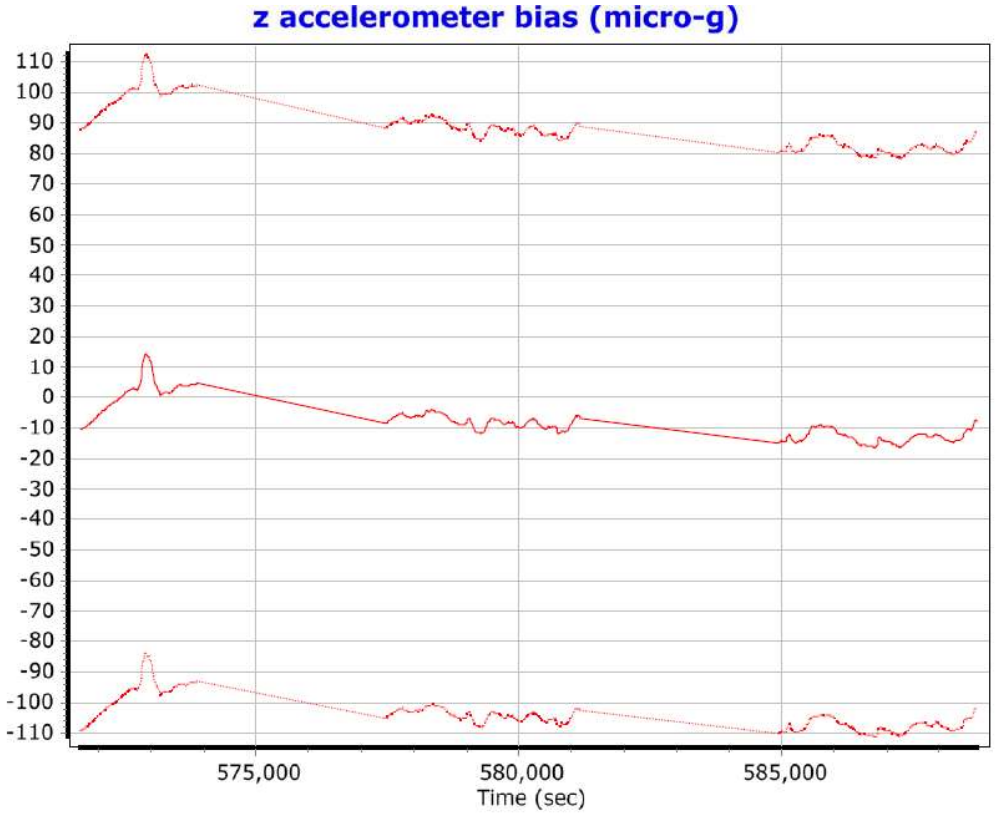
01_POS\6218090a\6218090a\GNSS\6218090a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 20603
No processed position: 2
Missing Fwd or Rev: 7
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0191 (m)
C/A Code: 0.64 (m)
L1 Doppler: 0.024 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.008 (m)
North: 0.008 (m)
Height: 0.027 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (20591 occurances):
East: 0.005 (m)
North: 0.007 (m)
Height: 0.025 (m)
Quality Number Percentages:
Q 1: 98.5 %
Q 2: 1.5 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 97.841 (km)
Minimum: 3.208 (km)
Average: 44.677 (km)
First Epoch: 86.964 (km)
Last Epoch: 85.726 (km)

Mission 1 – 6218090a Sensor Errors



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100
90
80
70
60
50
40
30
20
10
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-10
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-110
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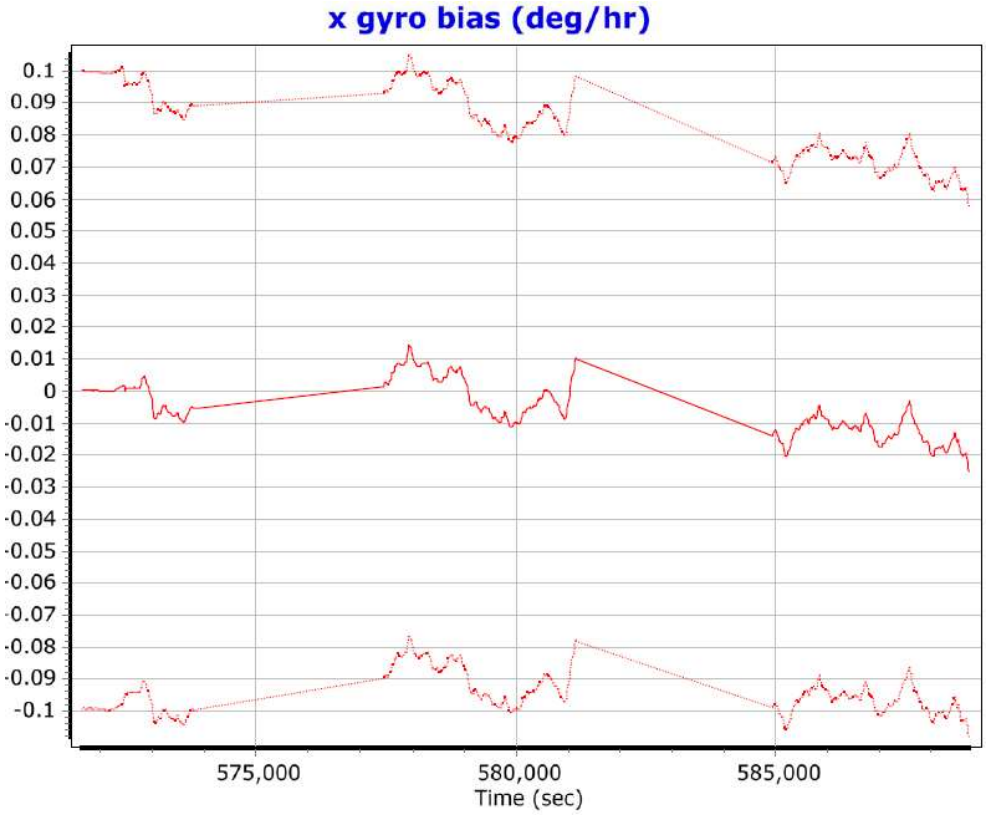
580,000
585,000
Time (sec)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0.08
0.07
0.06
0.05
0.04
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0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
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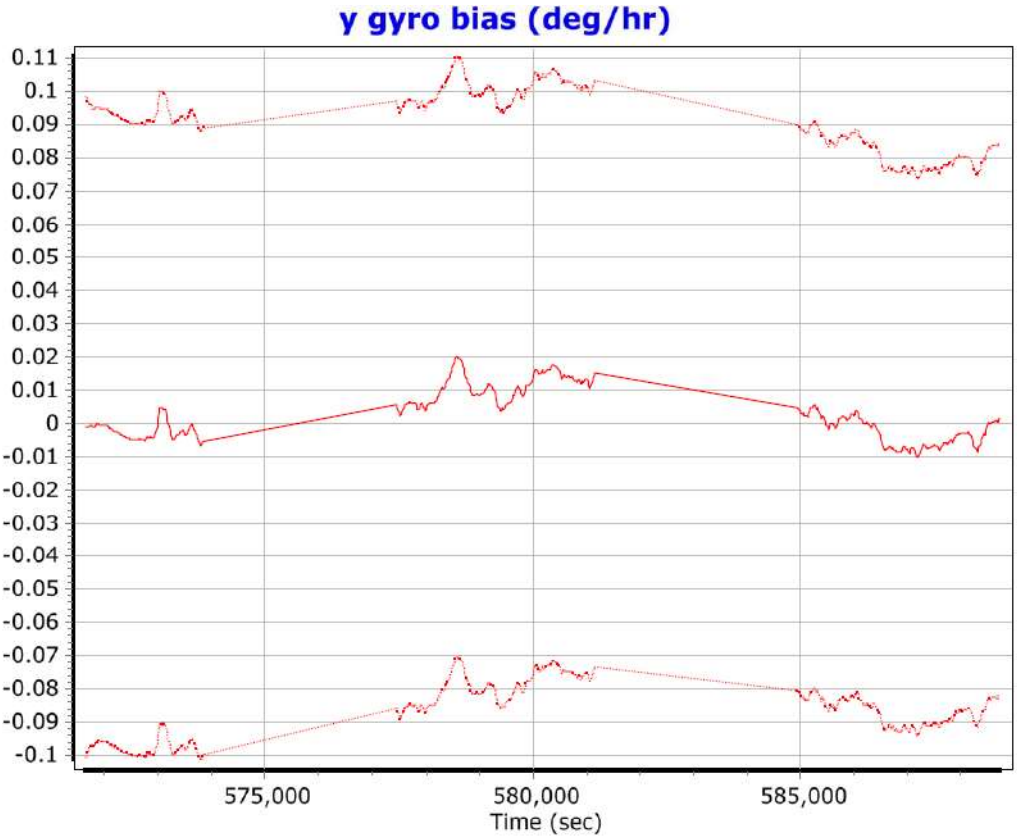
575,000
580,000
585,000
Time (sec)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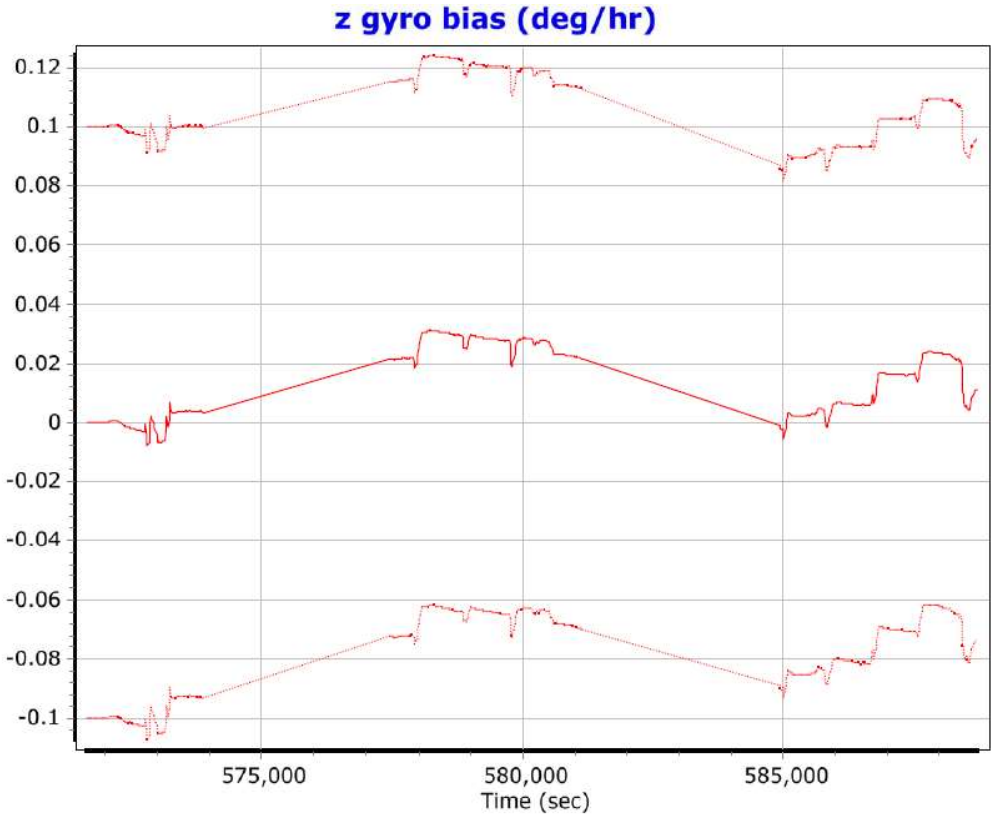
Time (sec)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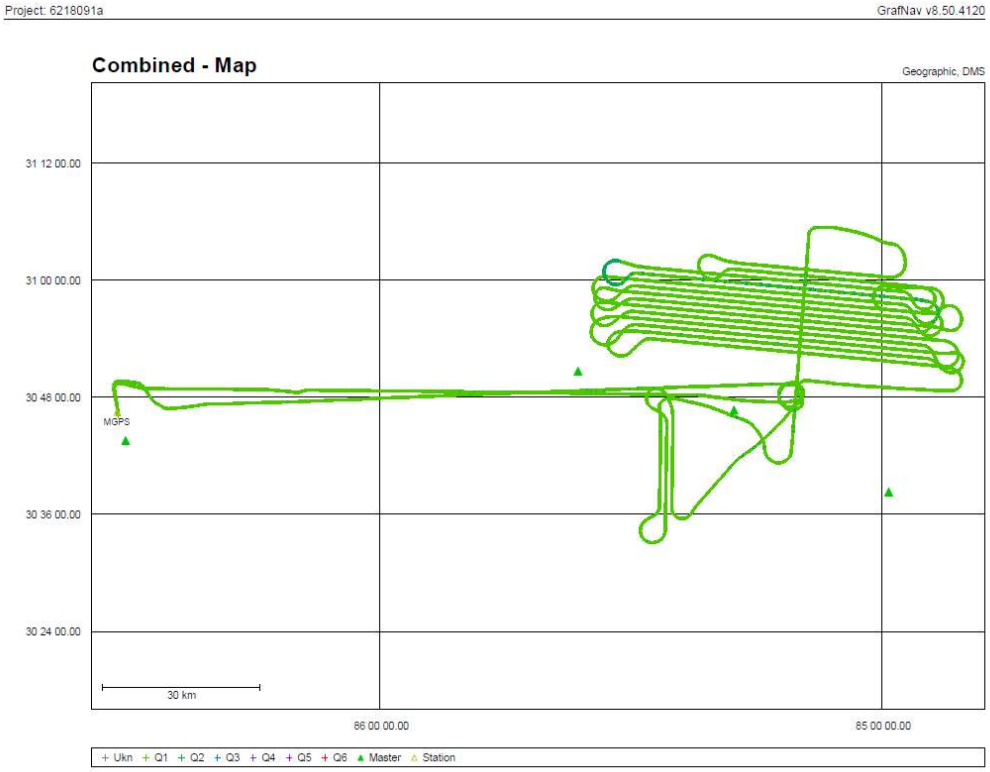
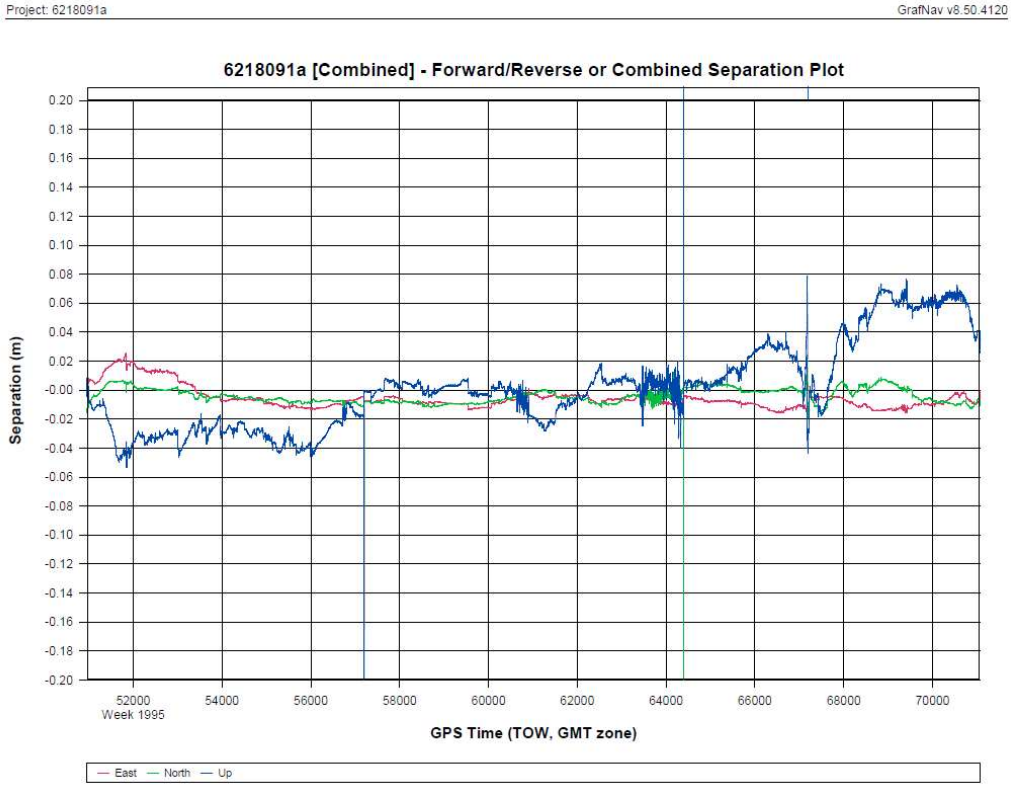
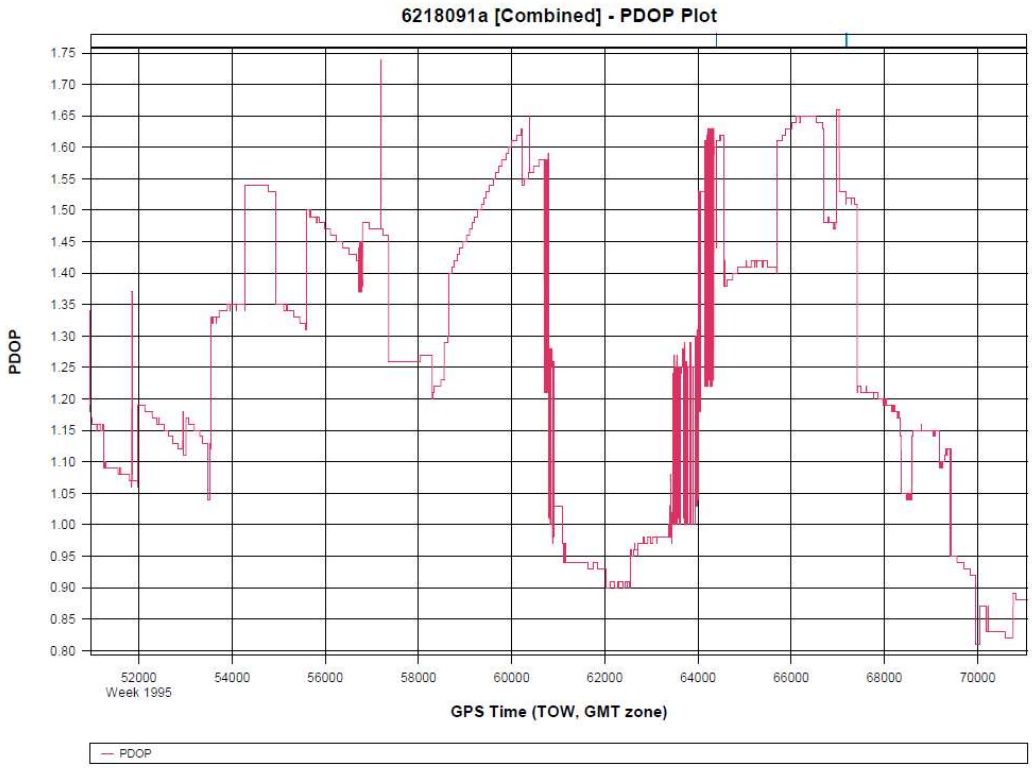
580,000
585,000
Time (sec)

Mission 2 – 6218091a GNSS Processing



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PDOP
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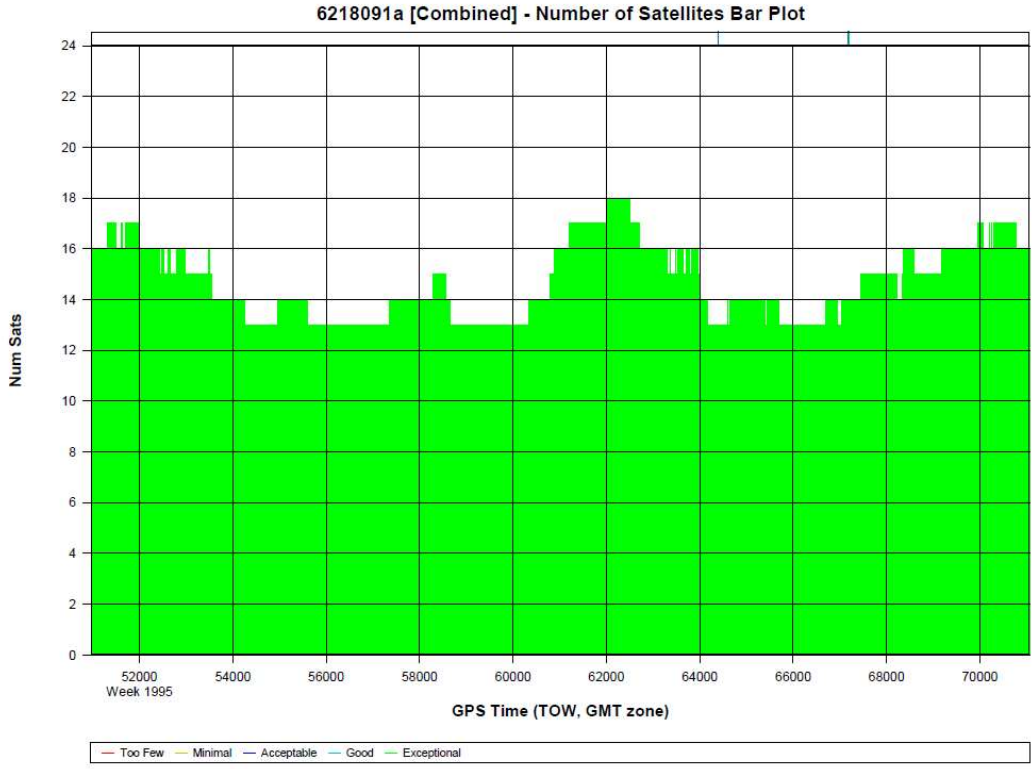
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
52000
Week 1995
54000
56000
58000
60000
62000
64000
66000
68000
70000
GPS Time (TOW, GMT zone)
PDOP


6218091a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
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Week 1995
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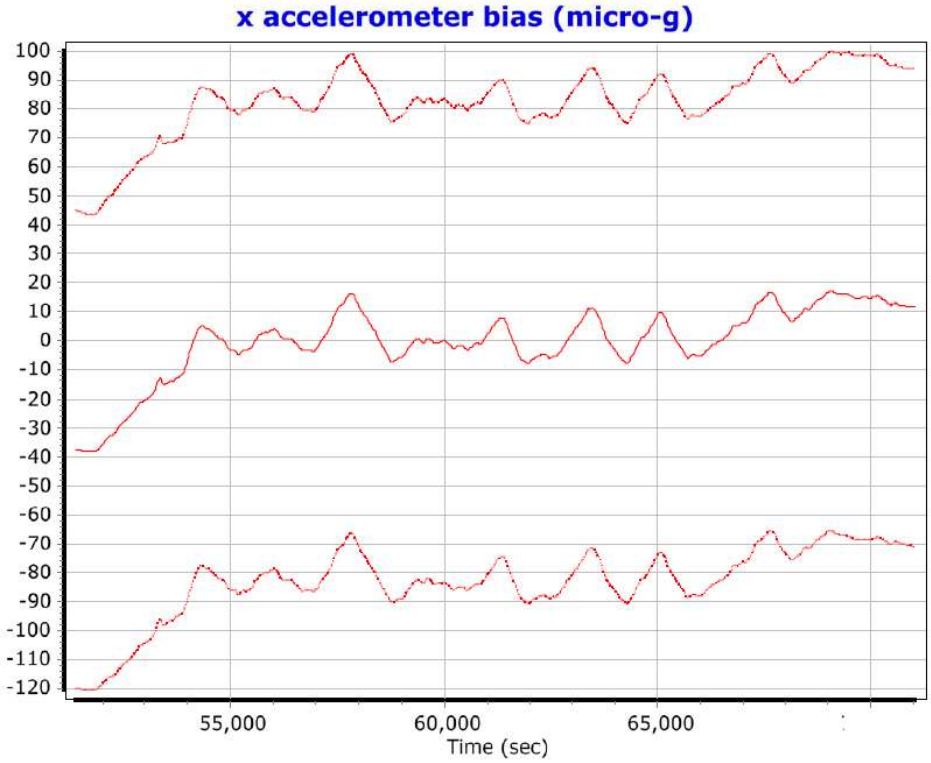
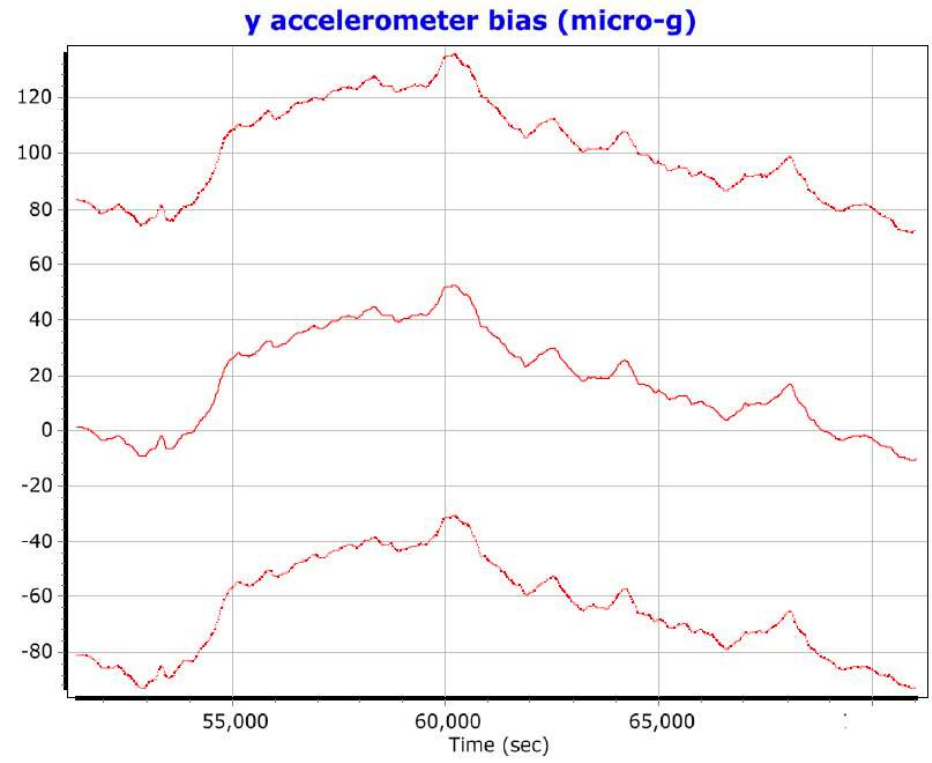
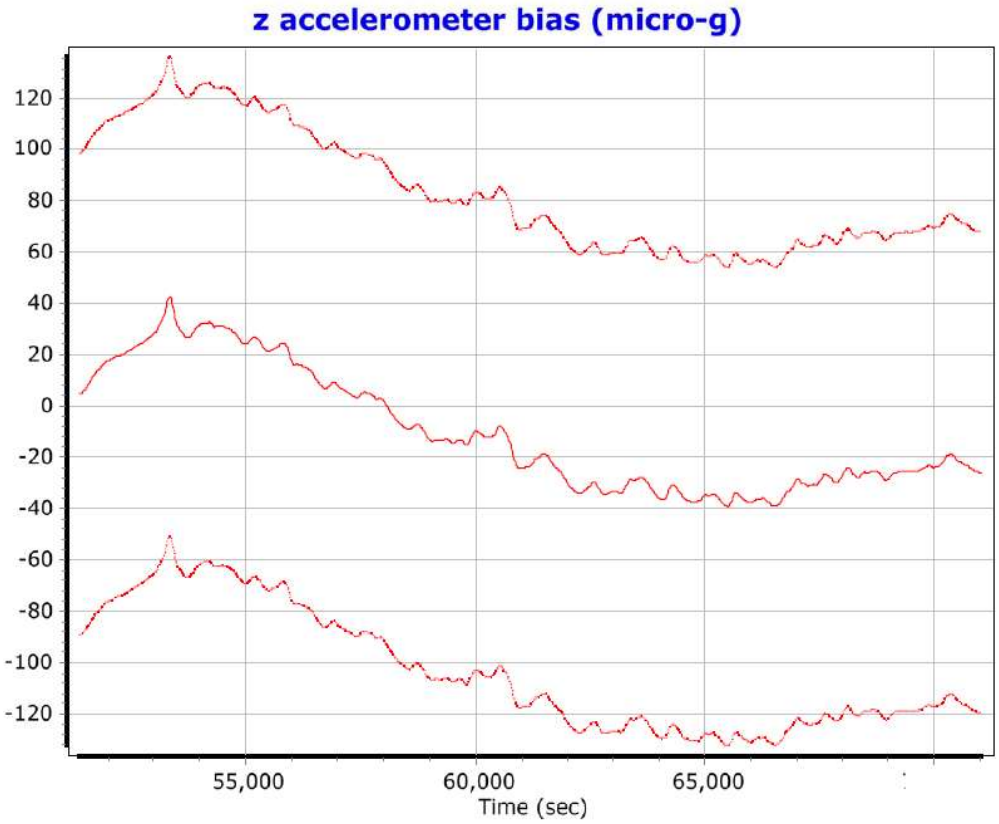
56000
58000
60000
62000
64000
66000
68000
70000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

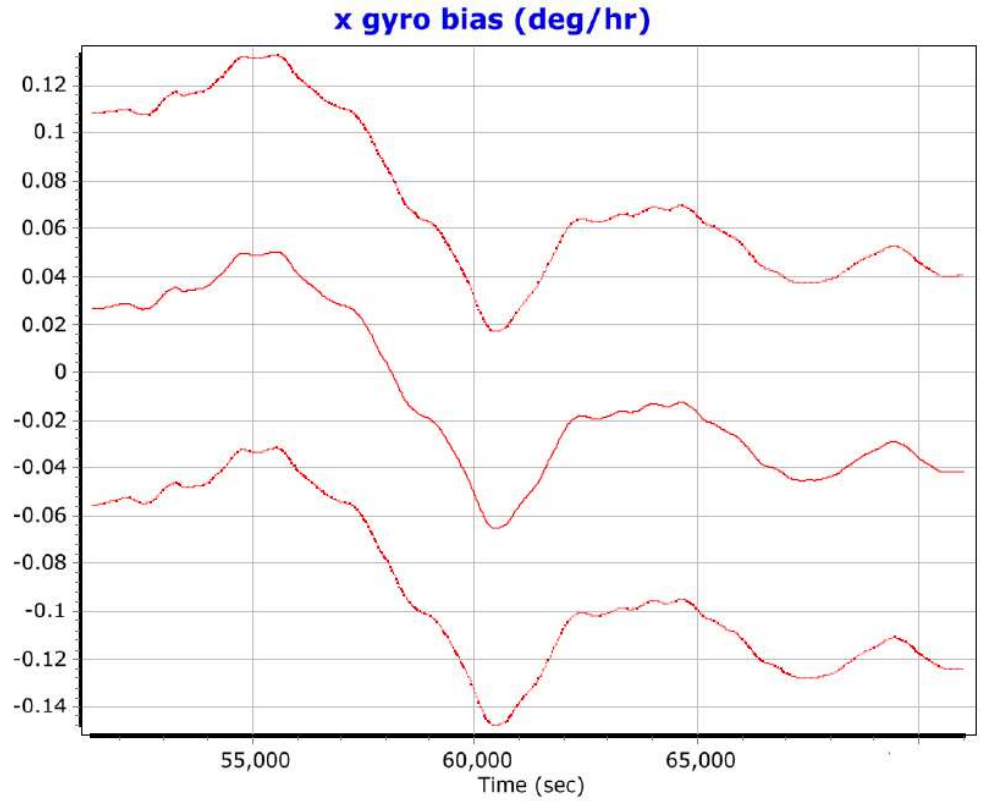
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218091a\05_INS-GPS_PROC\01_POS\6218091a\6218091a\GNSS\6218091a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 20123
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0177 (m)
C/A Code: 0.69 (m)
L1 Doppler: 0.026 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.010 (m)
North: 0.007 (m)
Height: 0.031 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (20116 occurances):
East: 0.009 (m)
North: 0.006 (m)
Height: 0.031 (m)
Quality Number Percentages:
Q 1: 96.9 %
Q 2: 3.1 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 93.234 (km)
Minimum: 6.616 (km)
Average: 45.732 (km)
First Epoch: 89.329 (km)
Last Epoch: 88.634 (km)

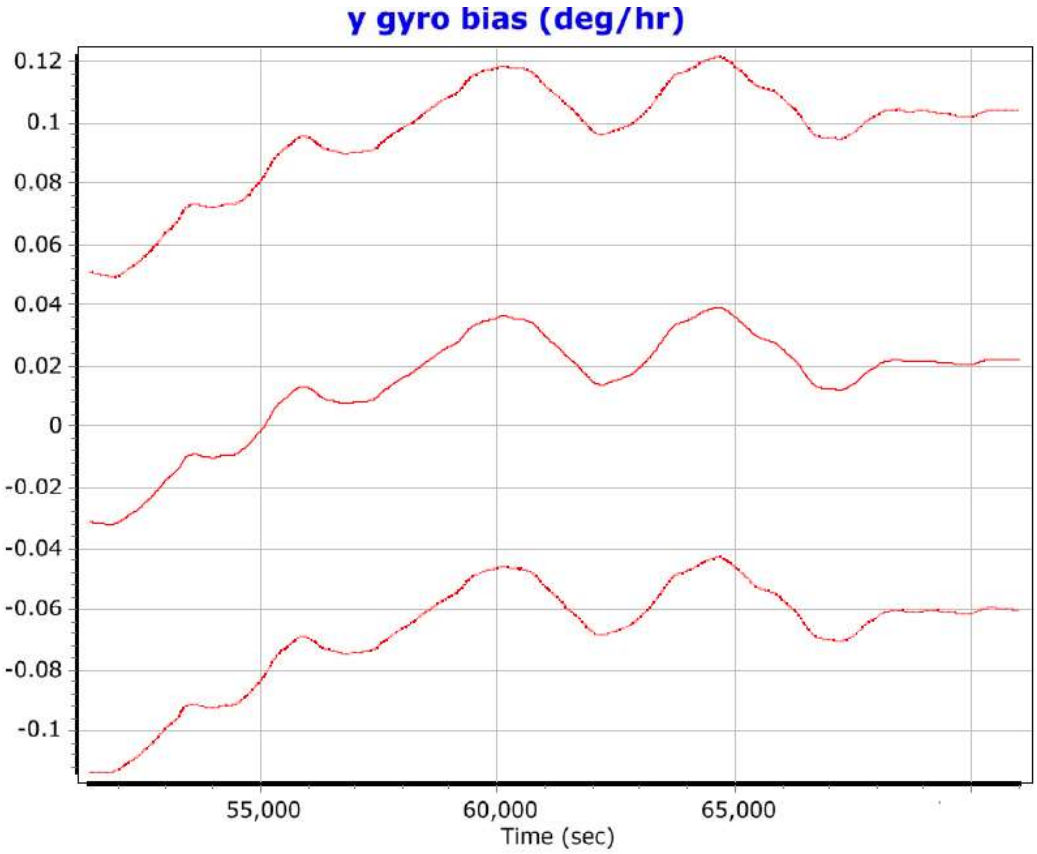
Mission 2 – 6218091a Sensor Errors

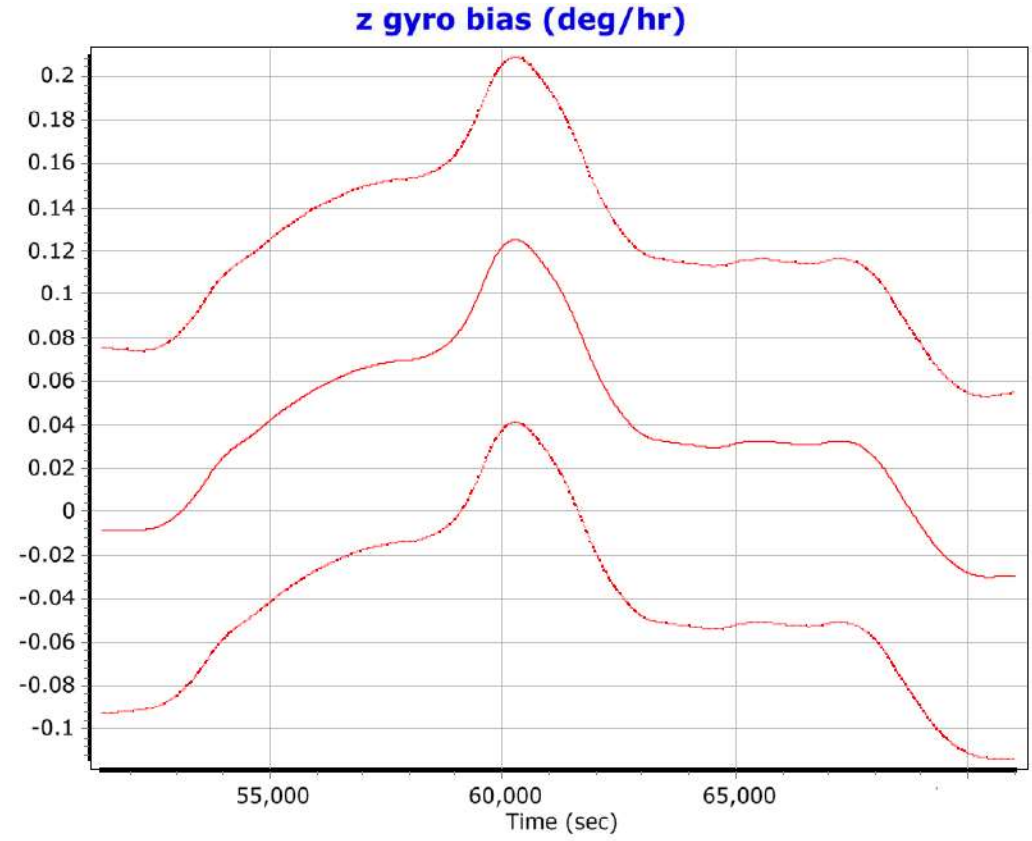




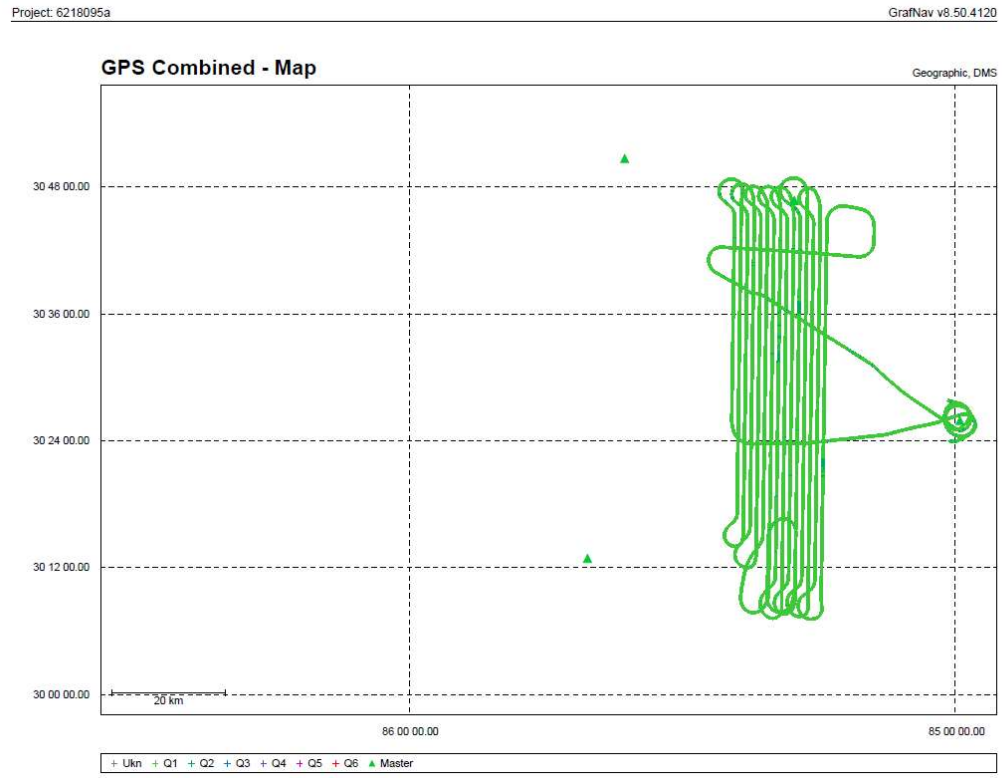

z accelerometer bias (micro-g)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
55,000
60,000
65,000
Time (sec)

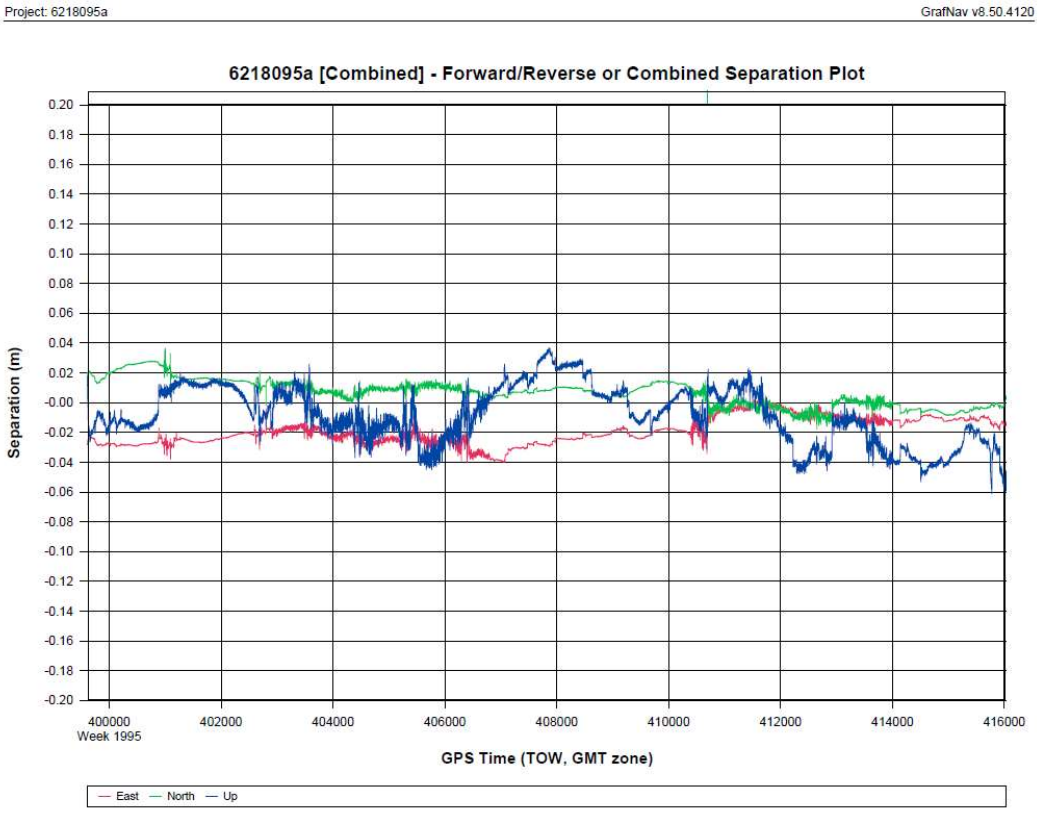

x gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
55,000
60,000
65,000
Time (sec)

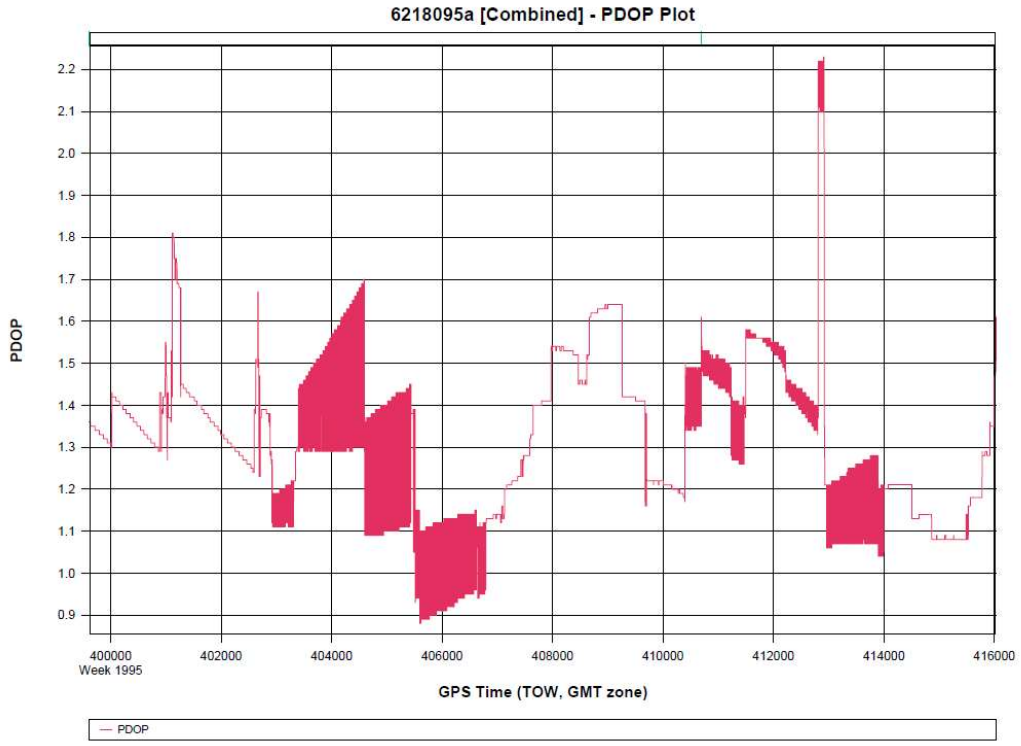

y gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
55,000
60,000
65,000
Time (sec)

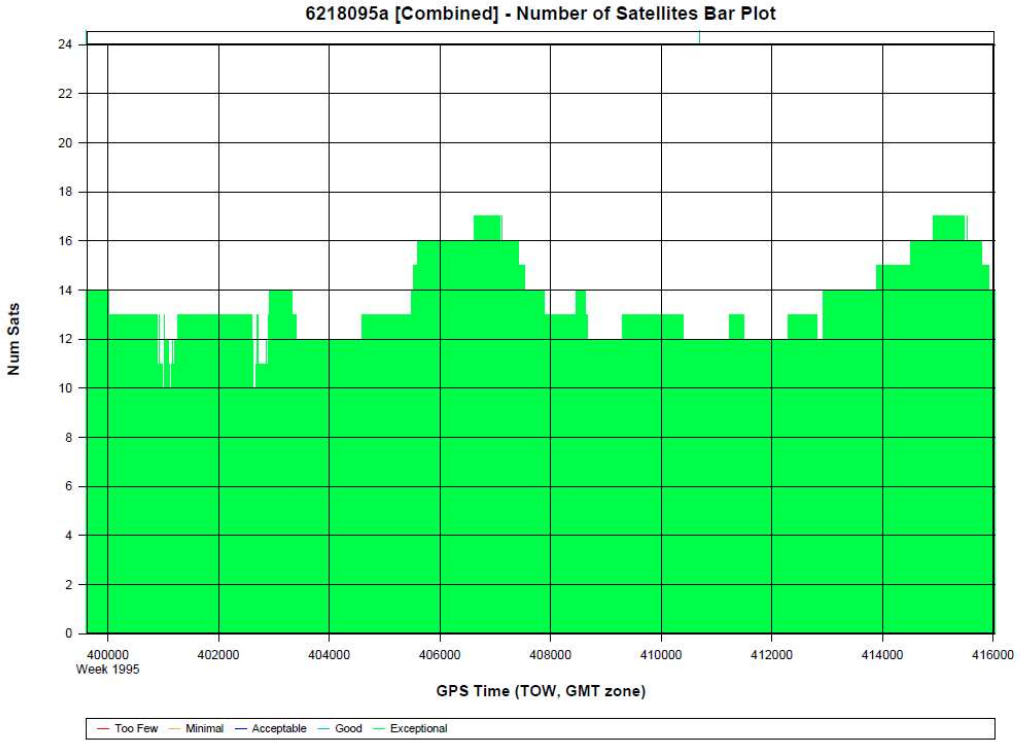

z gyro bias (deg/hr)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
55,000
60,000
65,000
Time (sec)

Mission 3 – 6218095a GNSS Processing



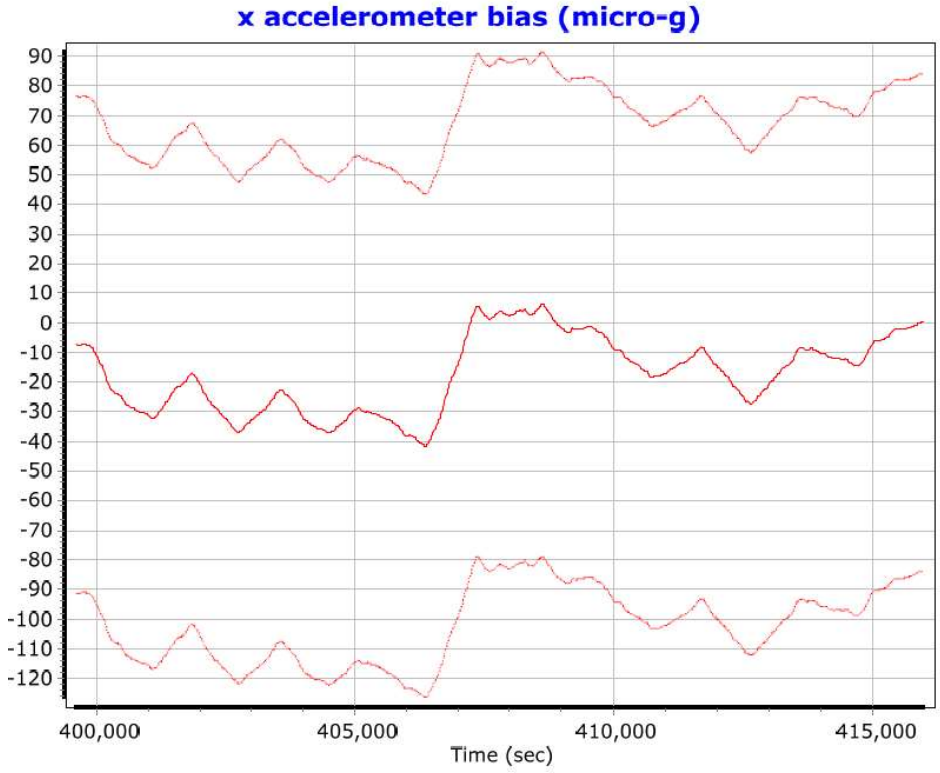


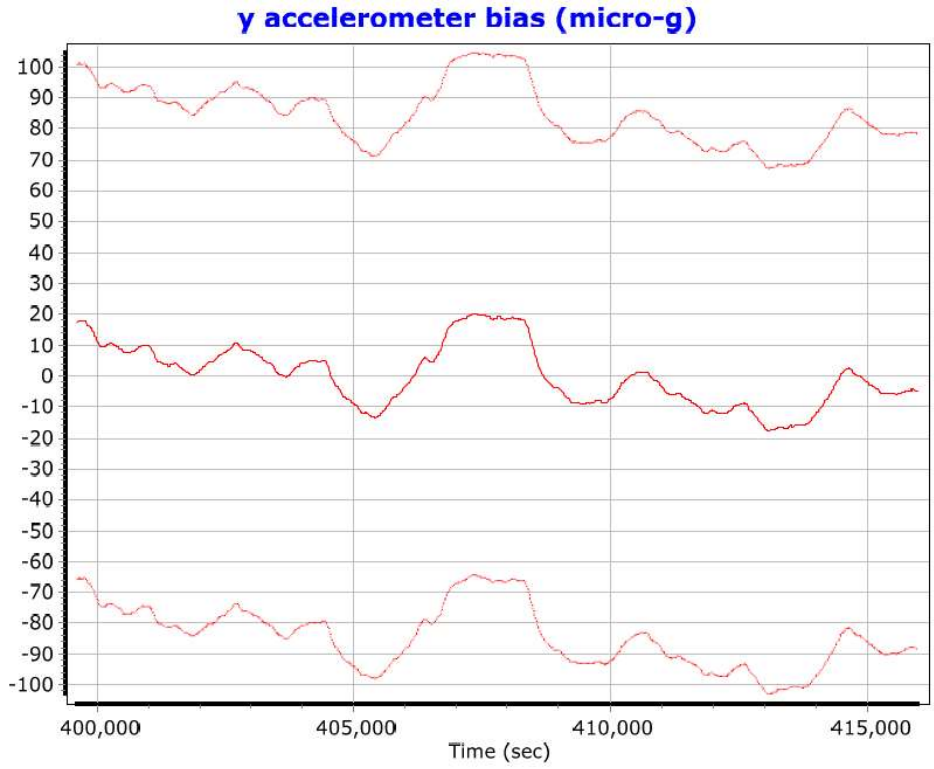

6218095a [Combined] - PDOP Plot
PDOP
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
400000
Week 1995
402000
404000
406000
408000
410000
412000
414000
416000
GPS Time (TOW, GMT zone)
PDOP

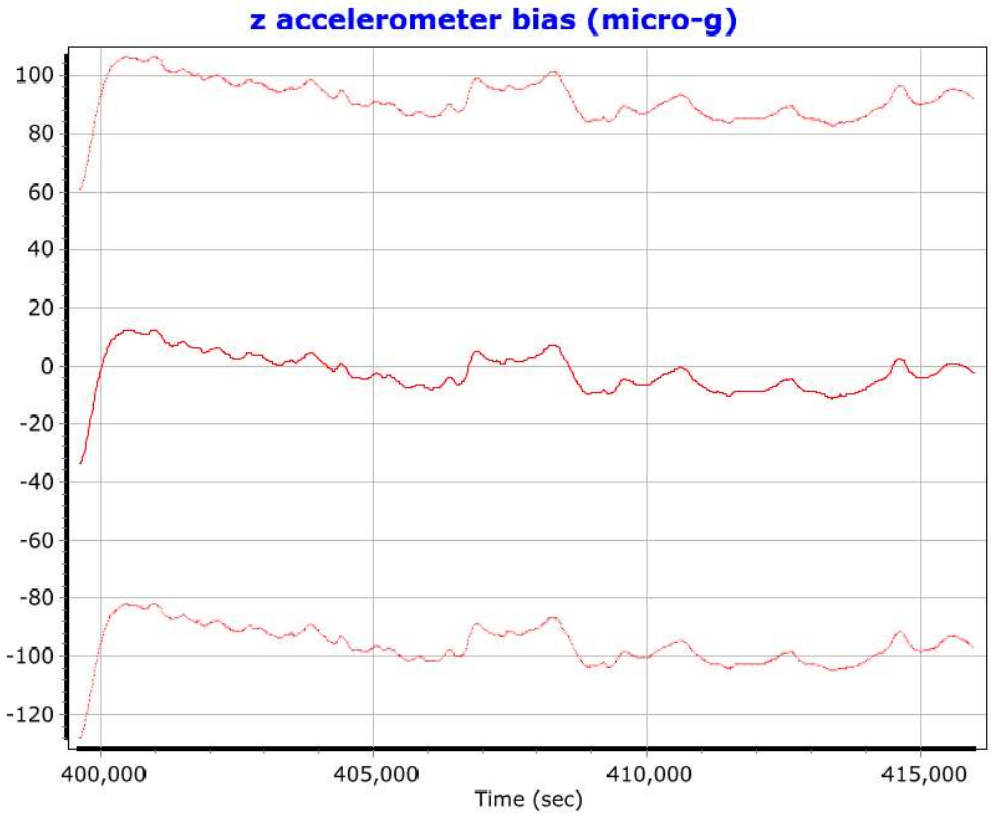

6218095a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
400000
Week 1995
402000
404000
406000
408000
410000
412000
414000
416000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

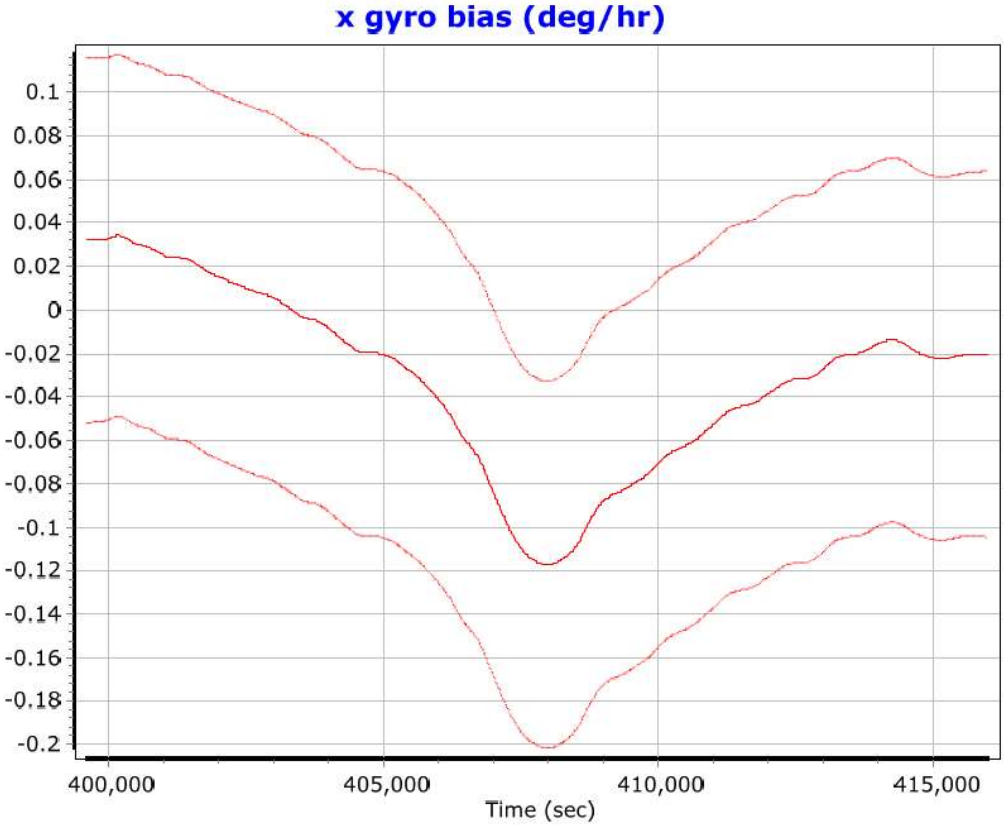
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218095a\05_INS-GPS_PROC\
01_POS\6218095a\6218095a\GNSS\6218095a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 21491
No processed position: 5069
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0183 (m)
C/A Code: 0.68 (m)
L1 Doppler: 0.518 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.021 (m)
North: 0.011 (m)
Height: 0.021 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (16418 occurances):
East: 0.021 (m)
North: 0.011 (m)
Height: 0.021 (m)
Quality Number Percentages:
Q 1: 98.3 %
Q 2: 1.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 51.147 (km)
Minimum: 1.677 (km)
Average: 23.518 (km)
First Epoch: 40.864 (km)
Last Epoch: 38.996 (km)

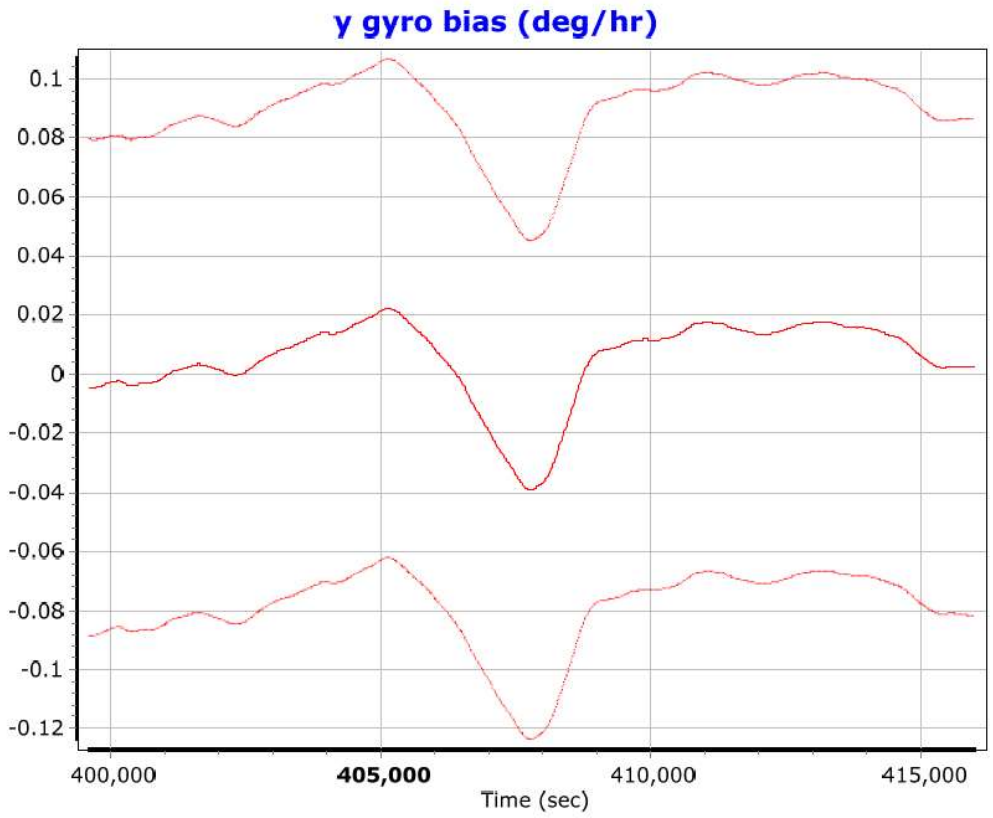
Mission 3 – 6218095a Sensor Errors

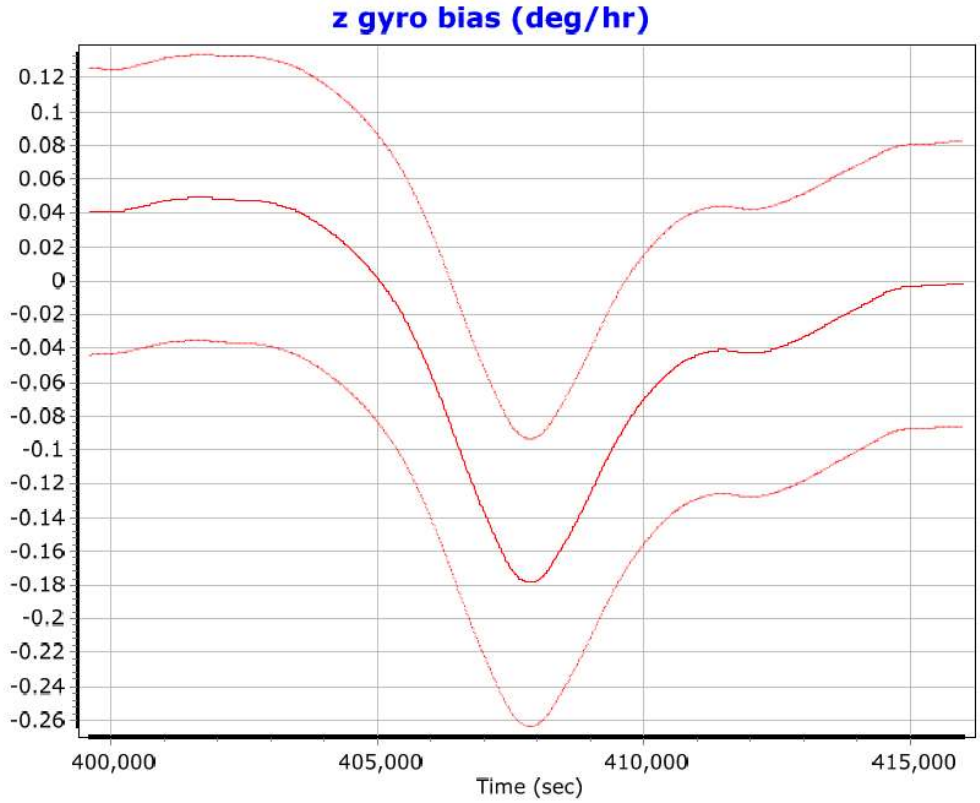




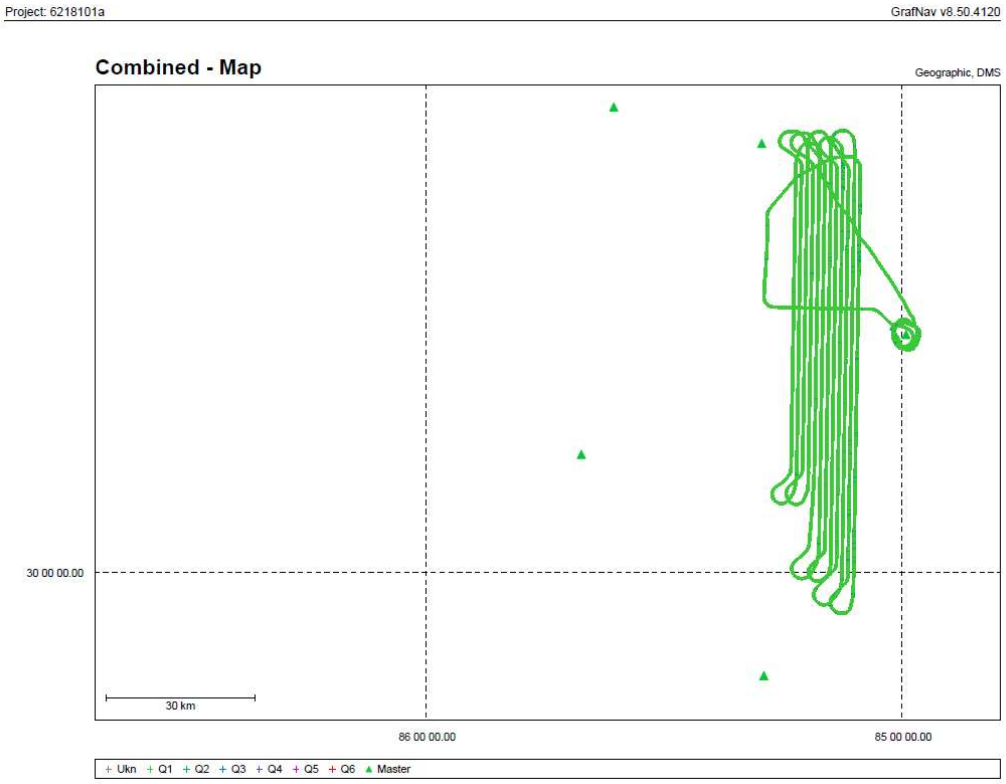

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
400,000
405,000
410,000
415,000
Time (sec)

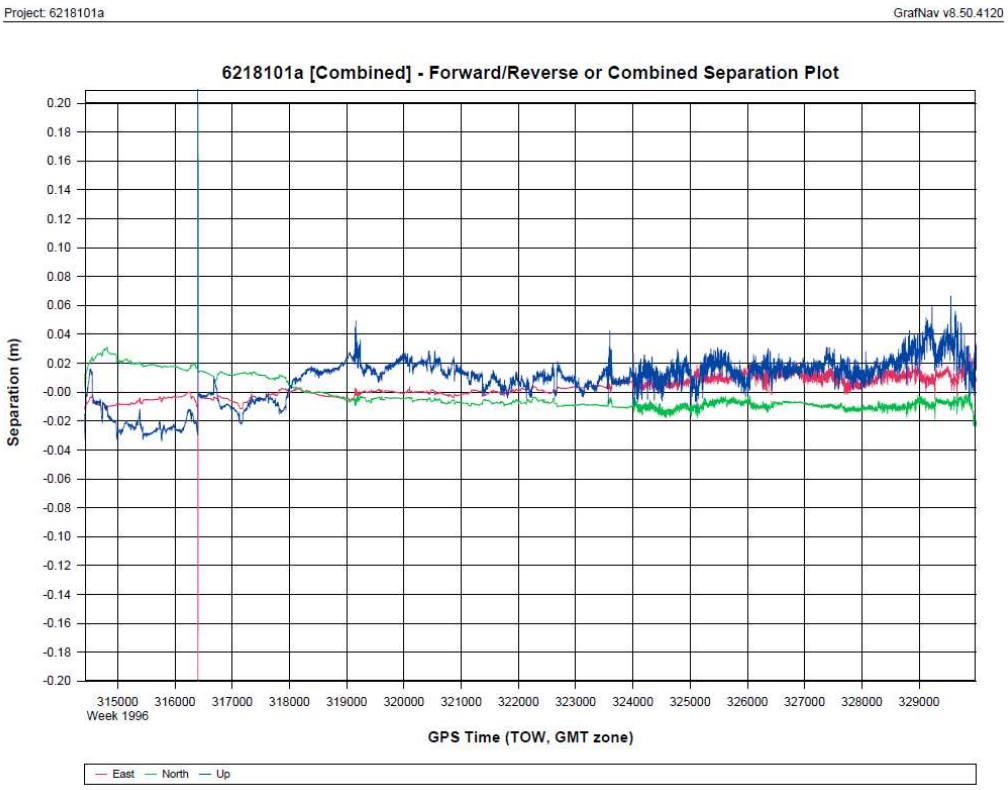

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
400,000
405,000
410,000
415,000
Time (sec)

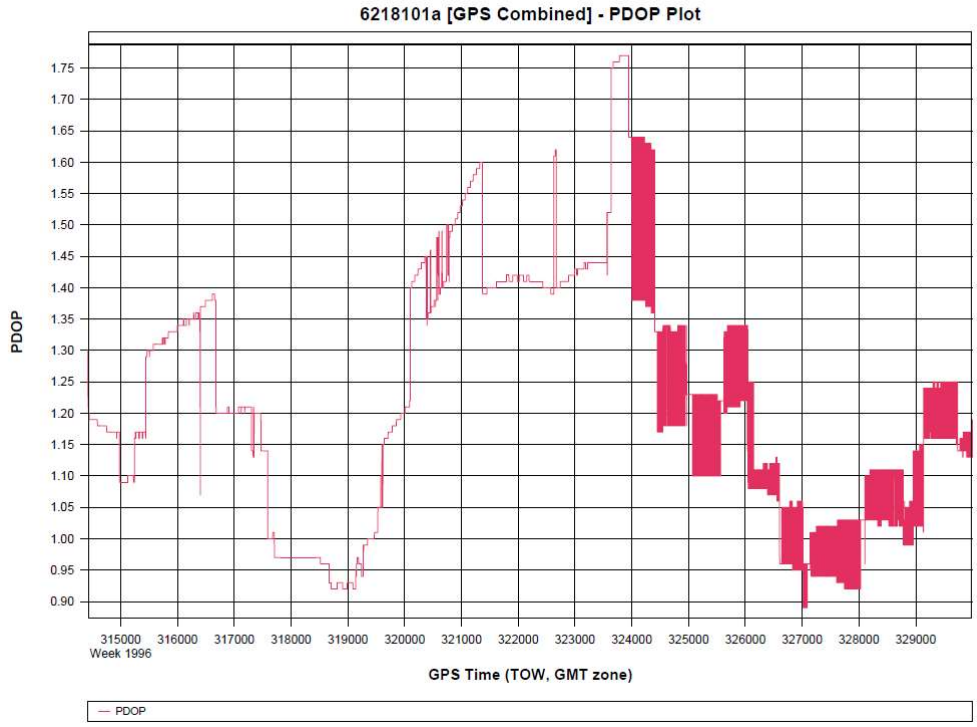

y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
400,000
405,000
410,000
415,000
Time (sec)

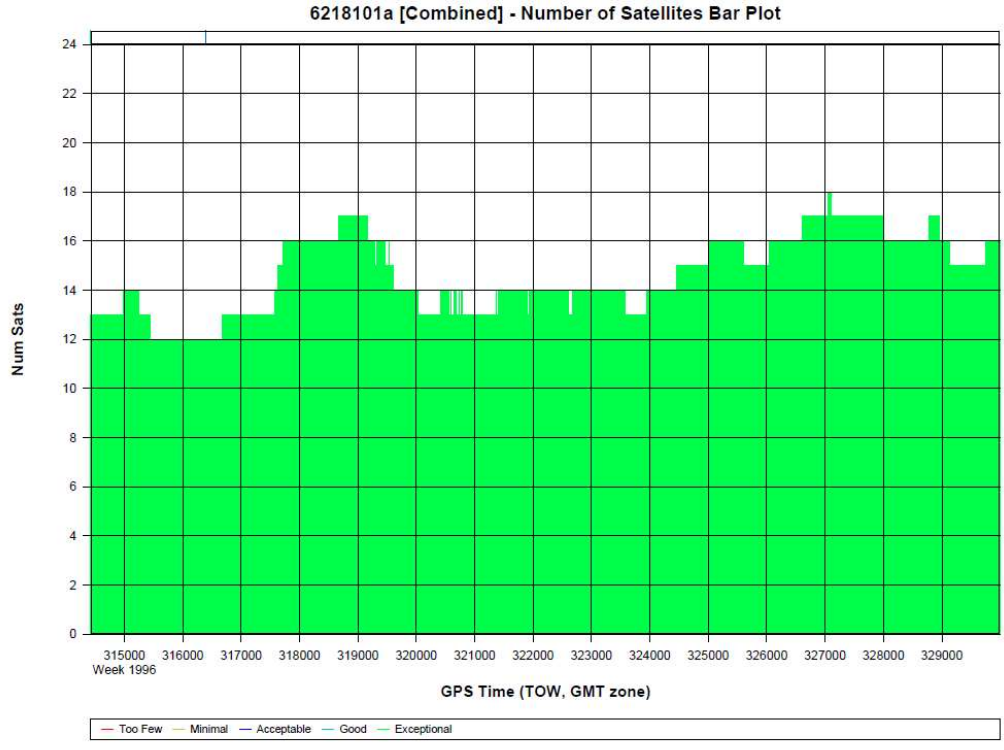

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
-0.22
-0.24
-0.26
400,000
405,000
410,000
415,000
Time (sec)

Mission 4 – 6218101a GNSS Processing



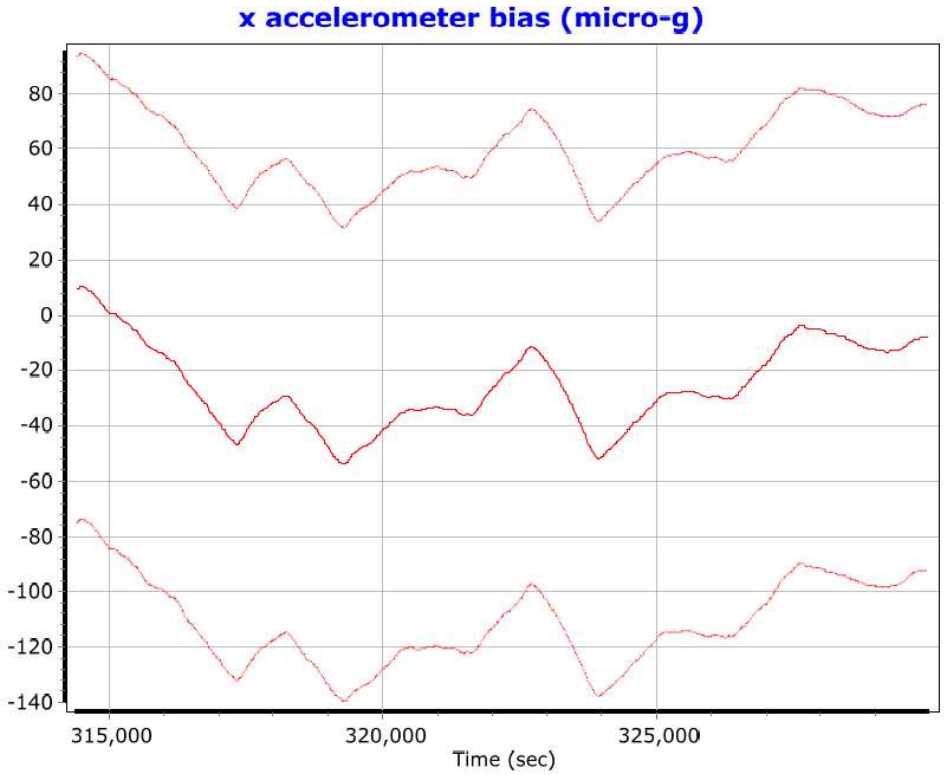


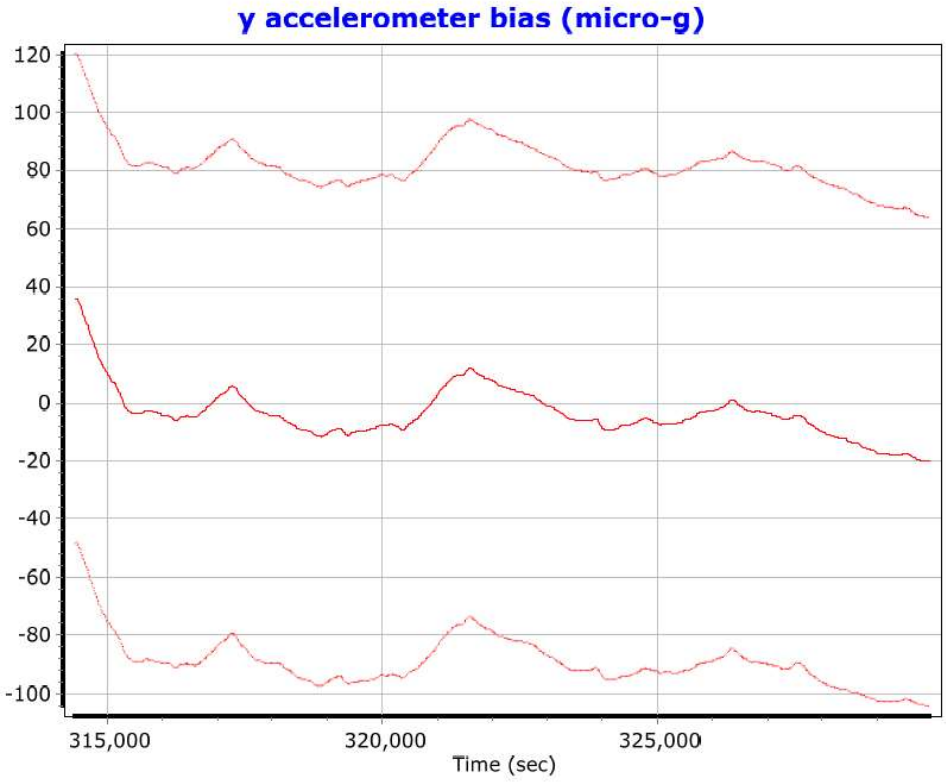

6218101a [GPS Combined] - PDOP Plot
PDOP
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
315000
316000
317000
318000
319000
320000
321000
322000
323000
324000
325000
326000
327000
328000
329000
Week 1996
GPS Time (TOW, GMT zone)
PDOP

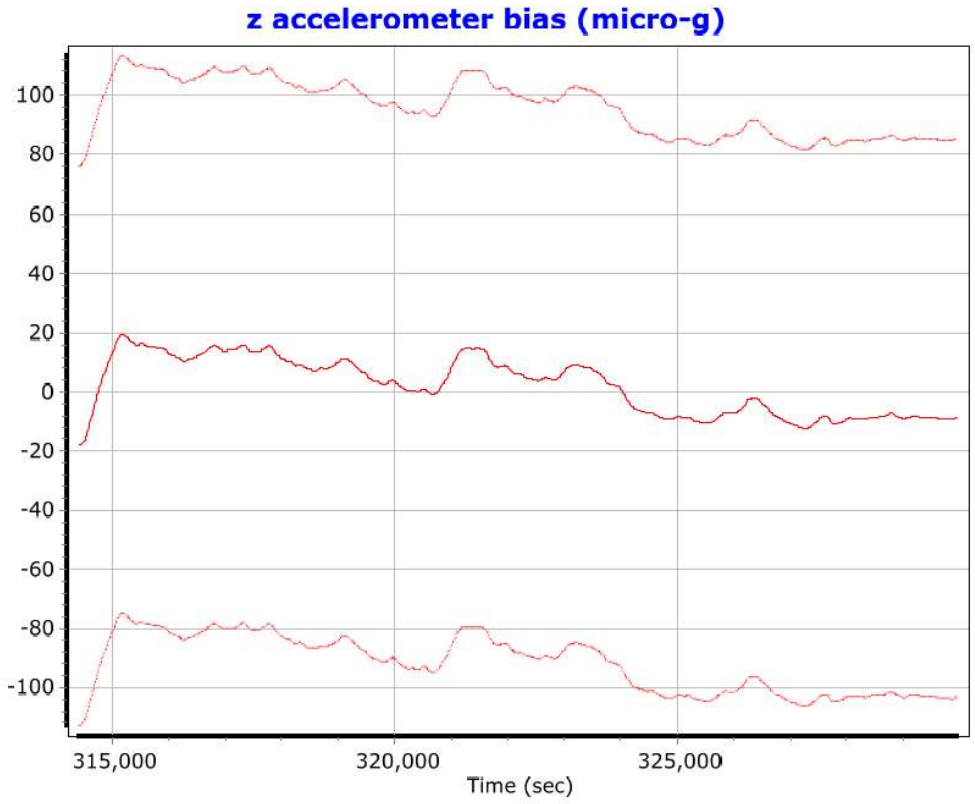

6218101a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
315000
316000
317000
318000
319000
320000
321000
322000
323000
324000
325000
326000
327000
328000
329000
Week 1996
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

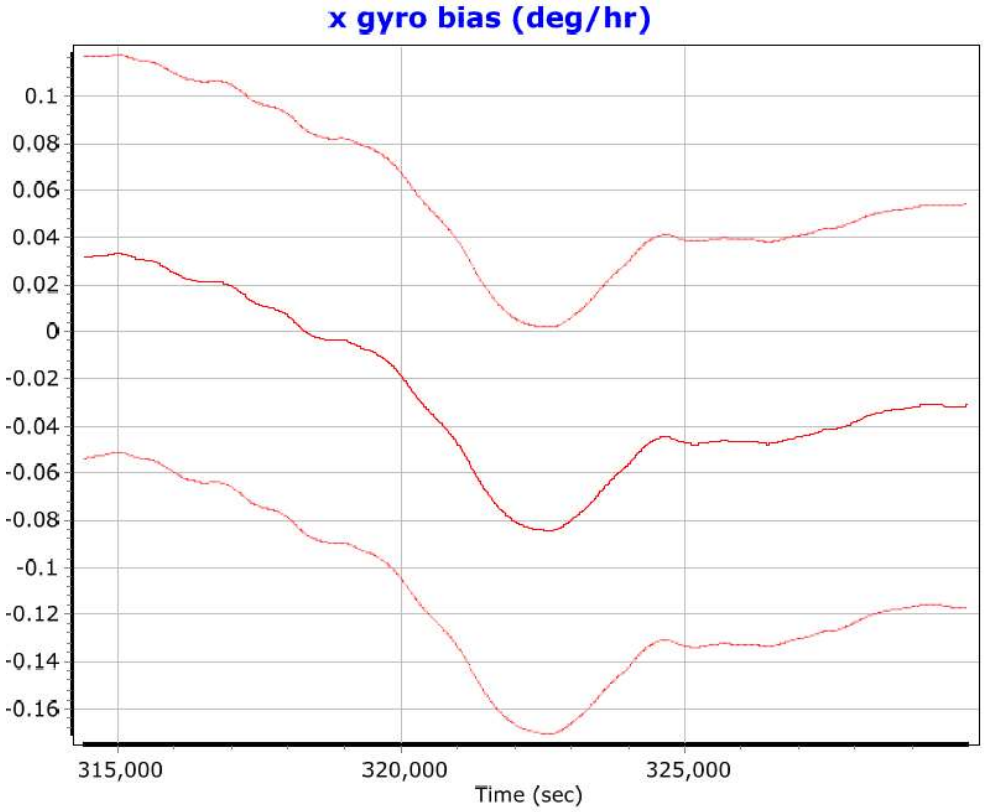
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218101a\05_INS-GPS_PROC\
01_POS\6218101a\6218101a\GNSS\6218101a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 21089
No processed position: 5511
Missing Fwd or Rev: 5
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0179 (m)
C/A Code: 0.73 (m)
L1 Doppler: 0.029 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.009 (m)
North: 0.011 (m)
Height: 0.019 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (15572 occurances):
East: 0.007 (m)
North: 0.011 (m)
Height: 0.017 (m)
Quality Number Percentages:
Q 1: 98.0 %
Q 2: 2.0 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 59.307 (km)
Minimum: 11.557 (km)
Average: 33.734 (km)
First Epoch: 37.447 (km)
Last Epoch: 33.794 (km)

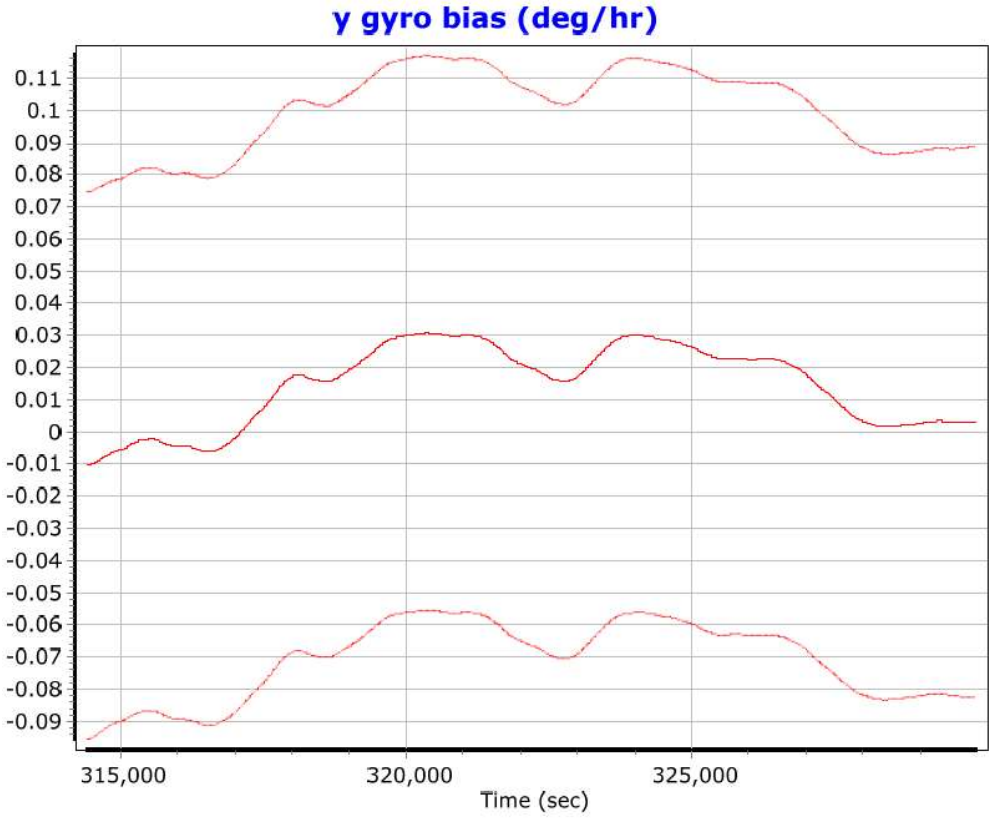
Mission 4 – 6218101a Sensor Errors





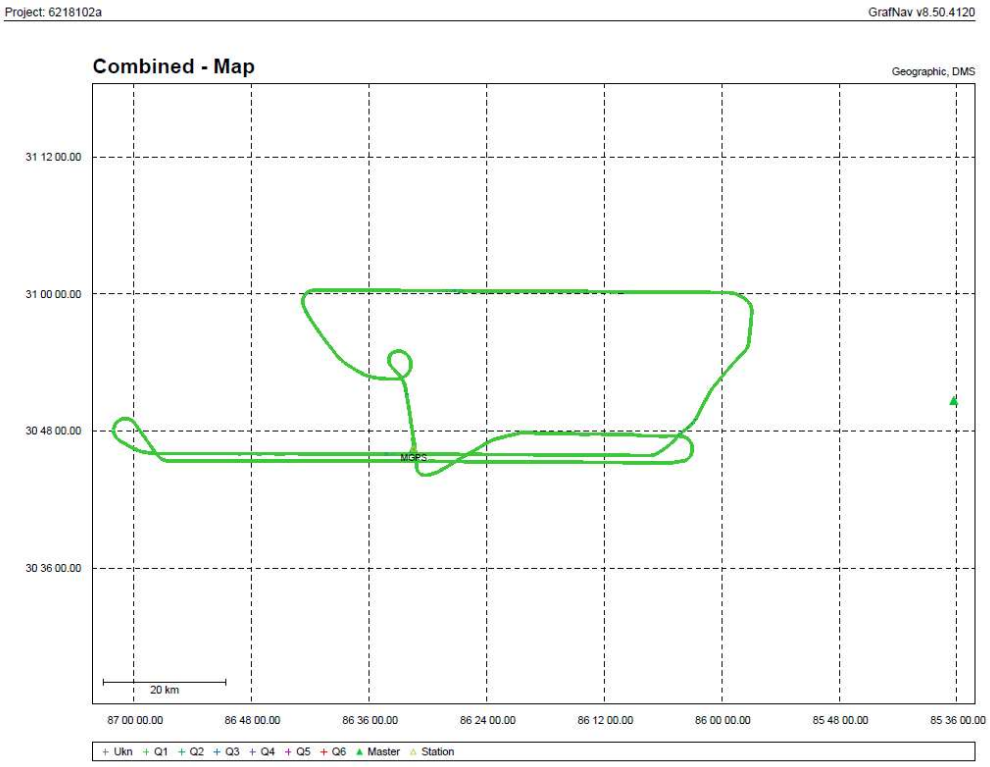

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
315,000
320,000
325,000
Time (sec)

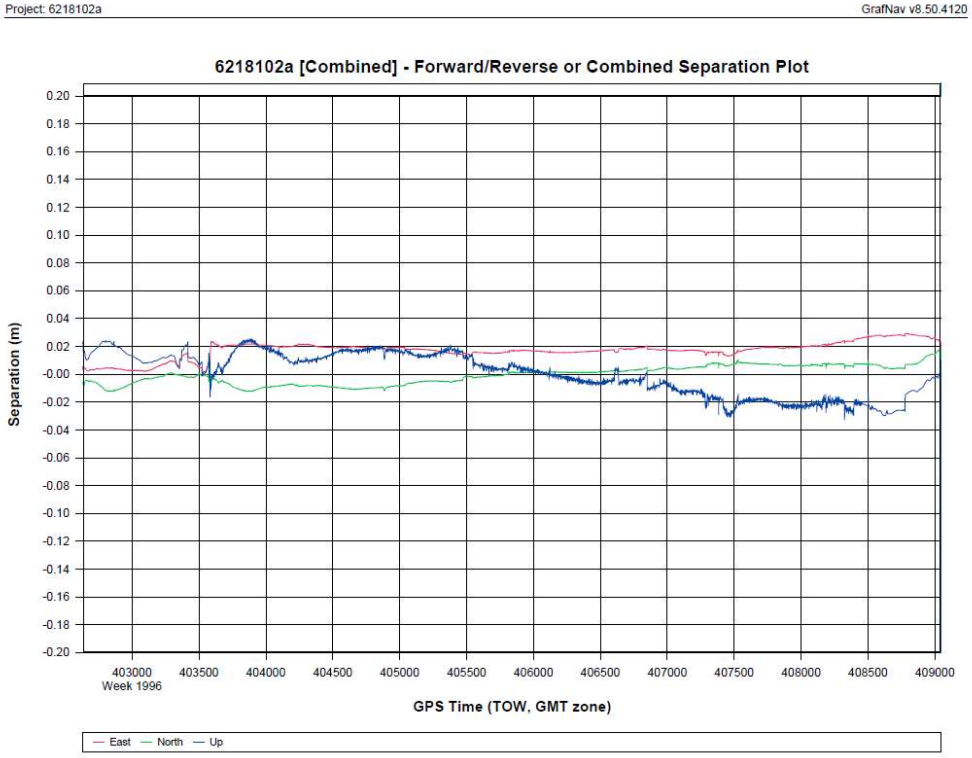

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
315,000
320,000
325,000
Time (sec)

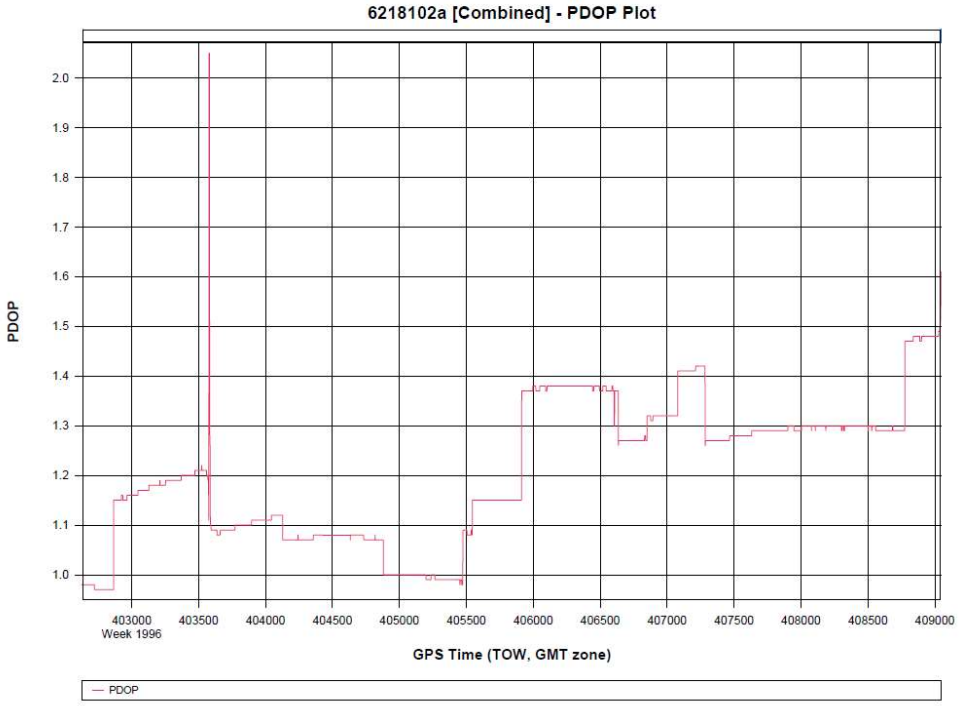

y gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
315,000
320,000
325,000
Time (sec)

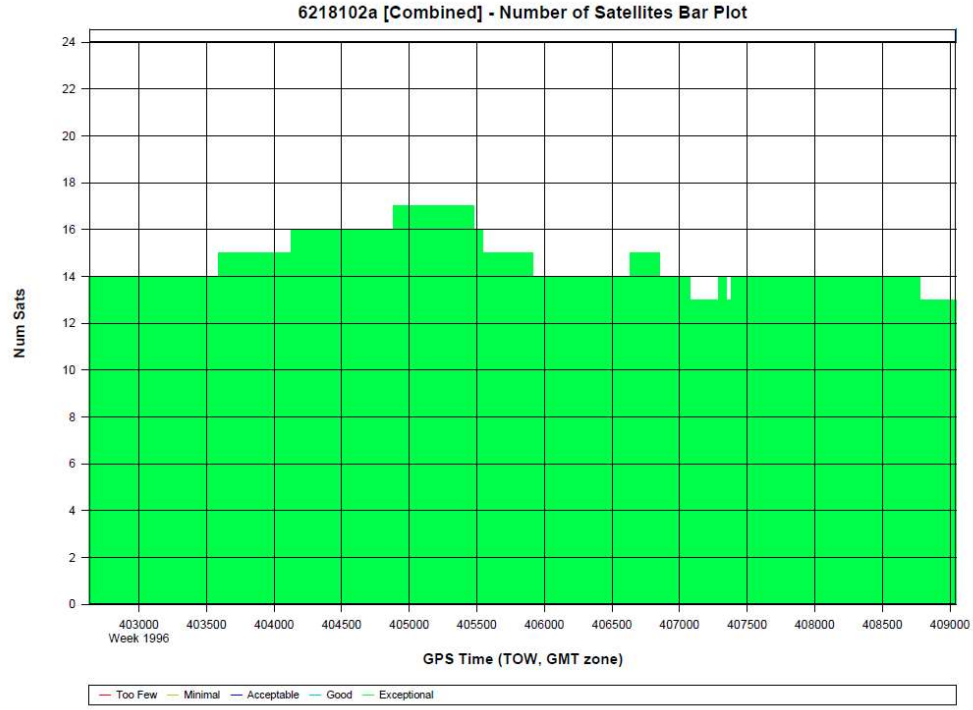

z gyro bias (deg/hr)
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
315,000
320,000
325,000
Time (sec)

Mission 5 – 6218102a GNSS Processing



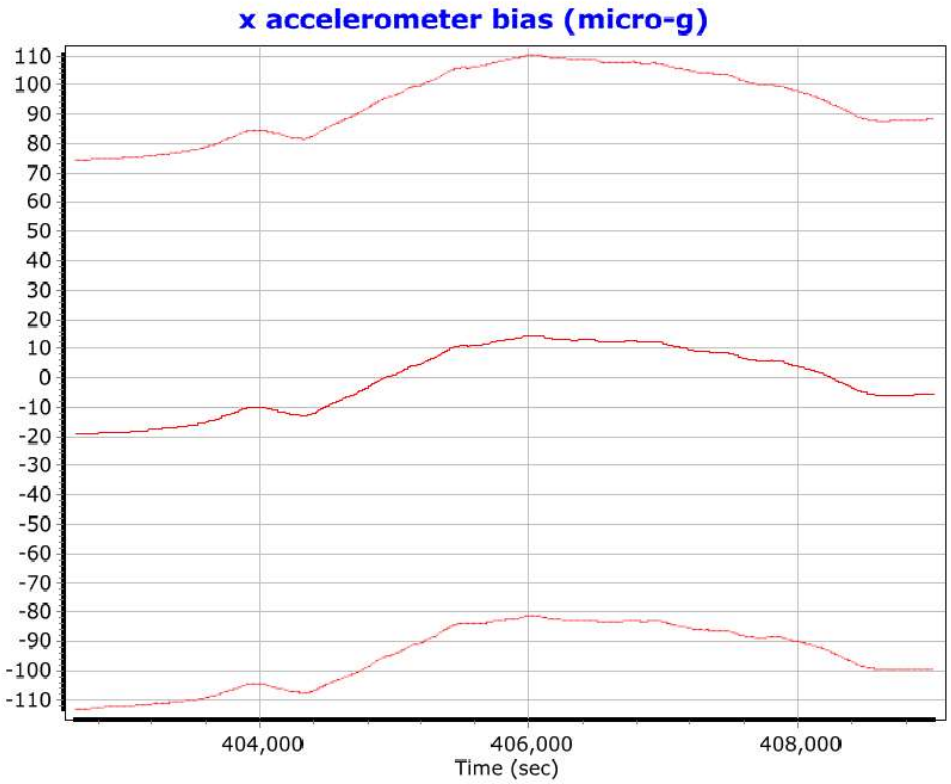


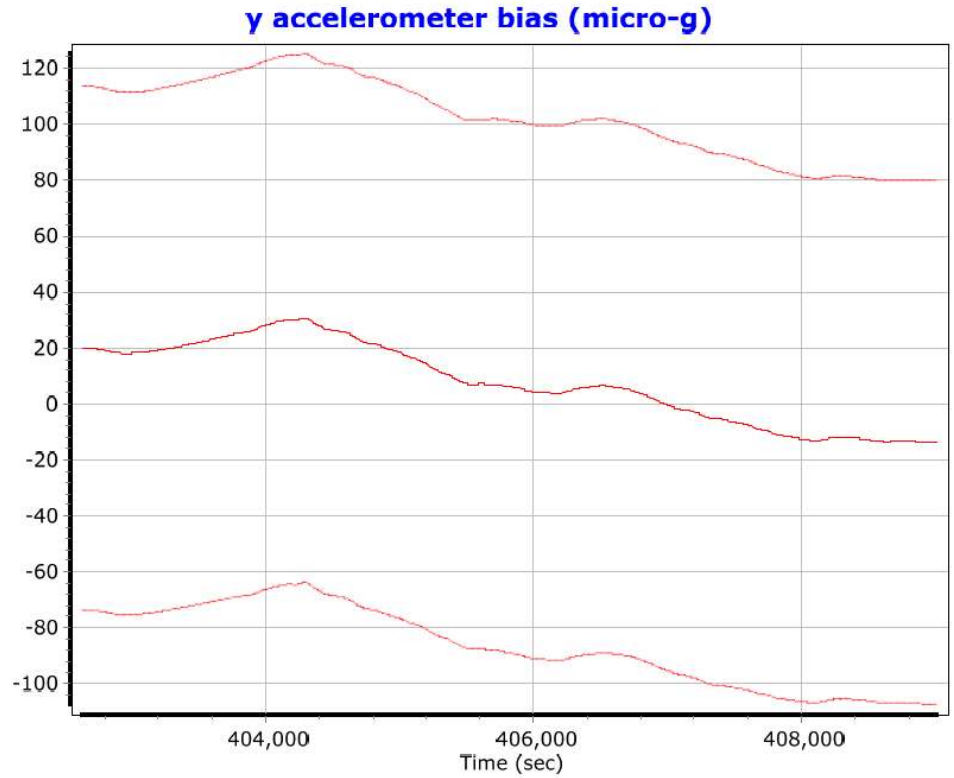

6218102a [Combined] - PDOP Plot
PDOP
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
403000
Week 1996
403500
404000
404500
405000
405500
406000
406500
407000
407500
408000
408500
409000
GPS Time (TOW, GMT zone)
PDOP

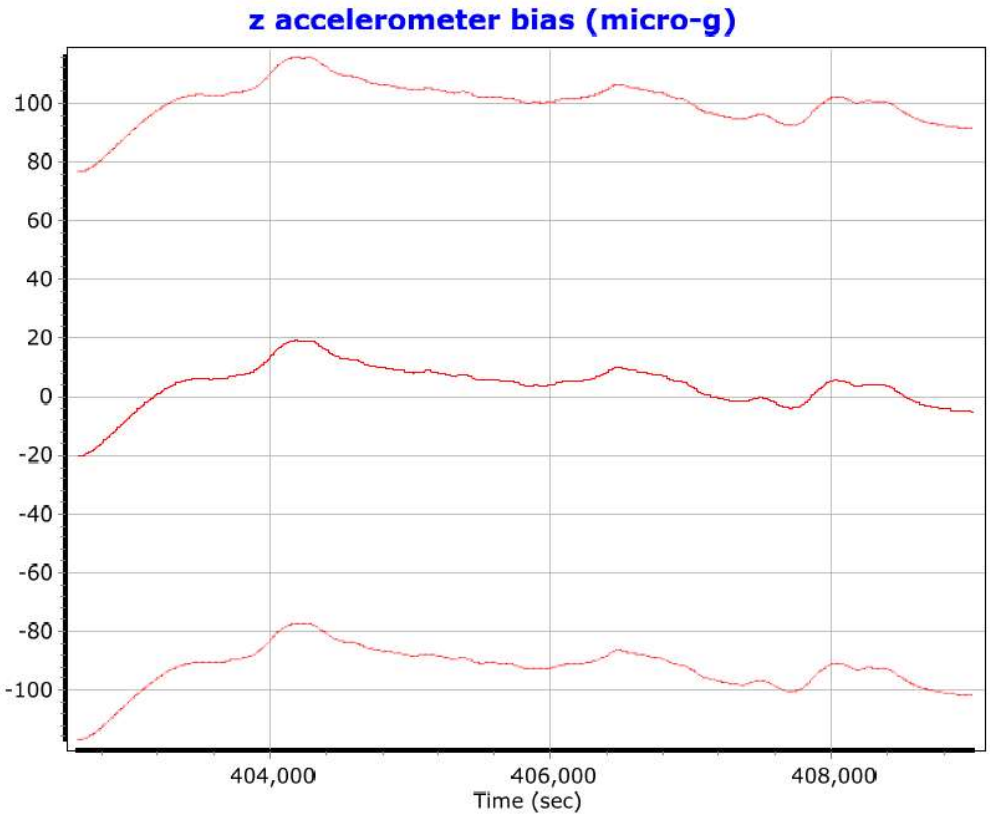

6218102a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
403000
Week 1996
403500
404000
404500
405000
405500
406000
406500
407000
407500
408000
408500
409000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

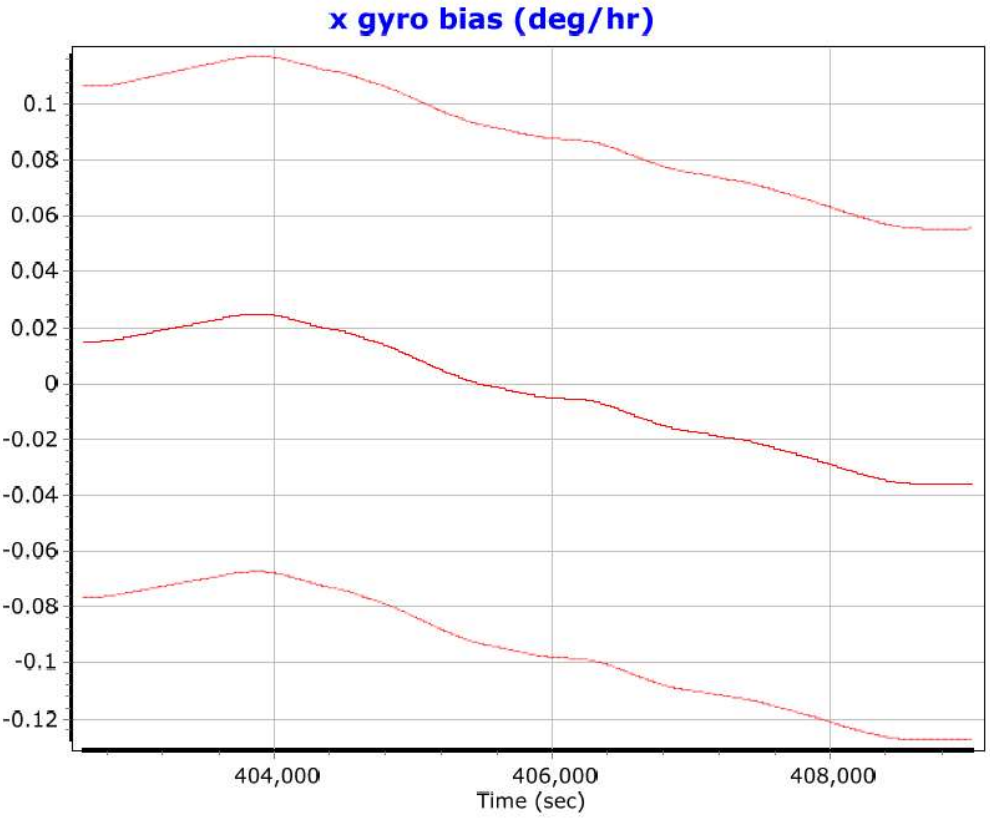
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218102a\05_INS-GPS_PROC\
01_POS\6218102a\6218102a\GNSS\6218102a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 6418
No processed position: 0
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0174 (m)
C/A Code: 0.78 (m)
L1 Doppler: 0.026 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.020 (m)
North: 0.009 (m)
Height: 0.018 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (6413 occurances):
East: 0.018 (m)
North: 0.007 (m)
Height: 0.015 (m)
Quality Number Percentages:
Q 1: 99.3 %
Q 2: 0.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 92.082 (km)
Minimum: 2.023 (km)
Average: 40.021 (km)
First Epoch: 43.700 (km)
Last Epoch: 43.727 (km)

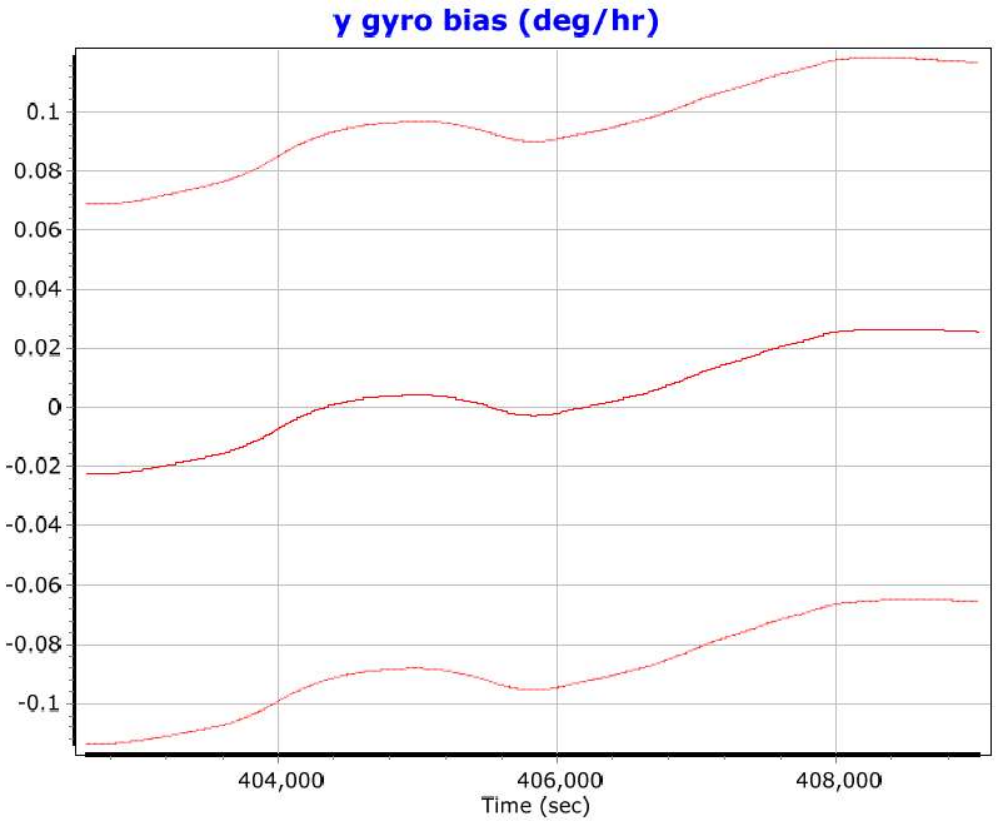
Mission 5 – 6218102a Sensor Errors





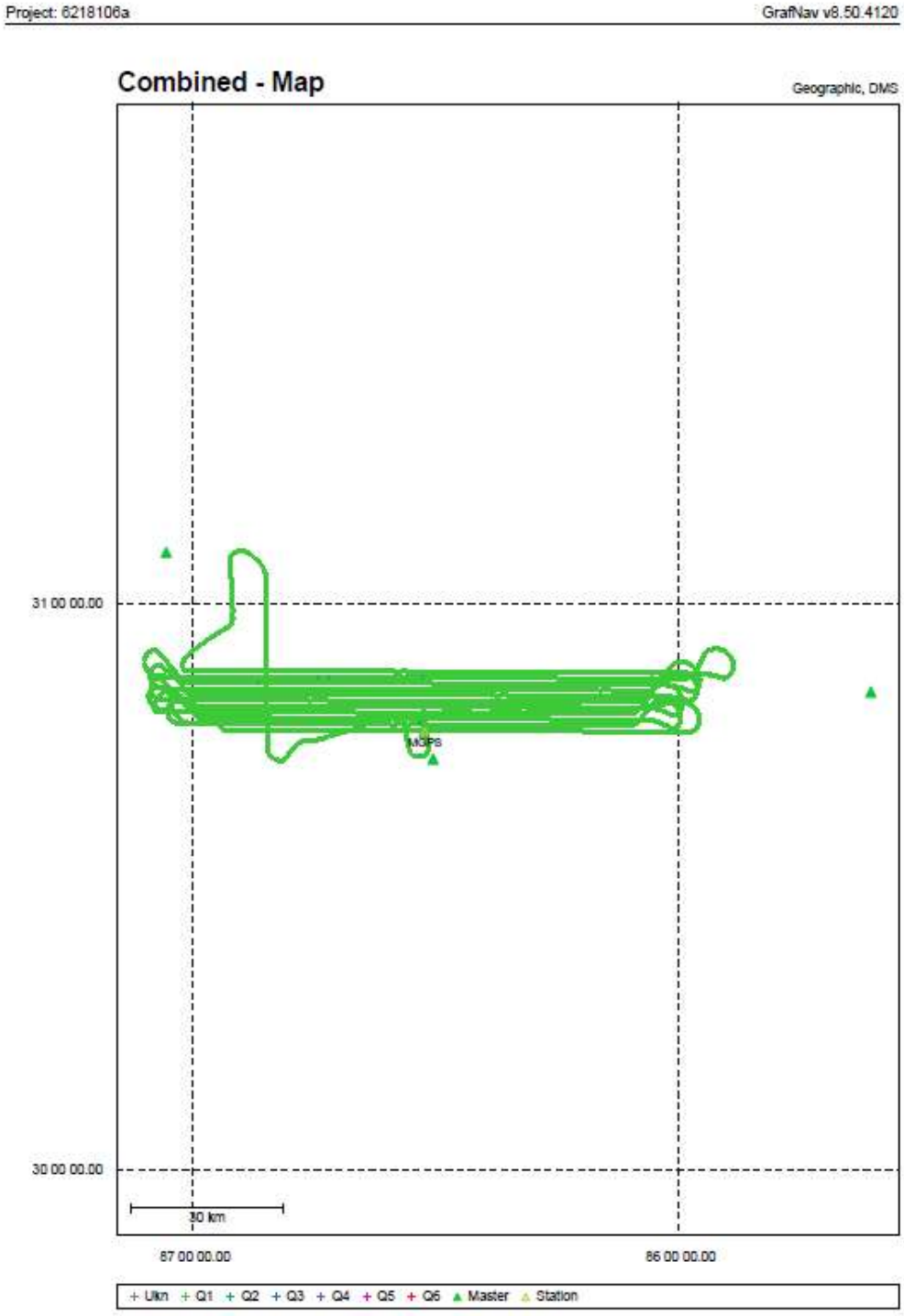

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
404,000
406,000
408,000
Time (sec)

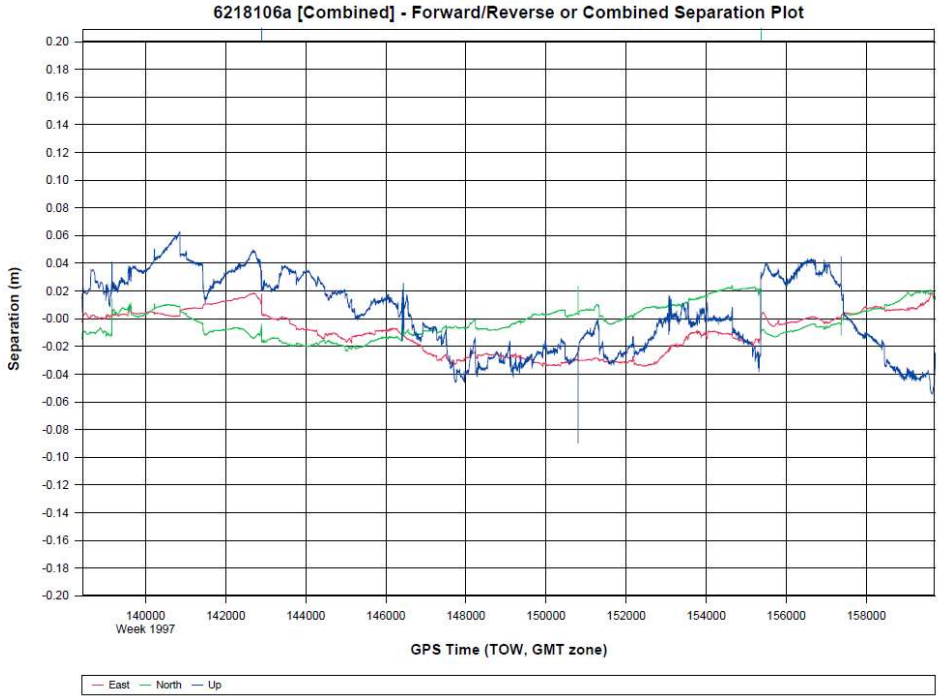

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
404,000
406,000
408,000
Time (sec)

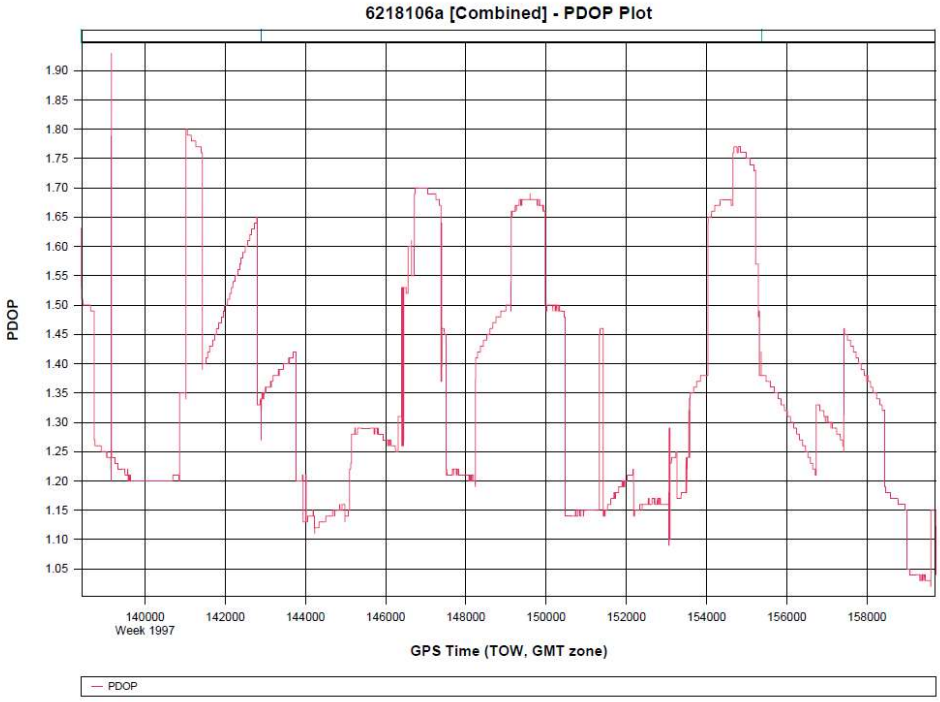

y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
404,000
406,000
408,000
Time (sec)

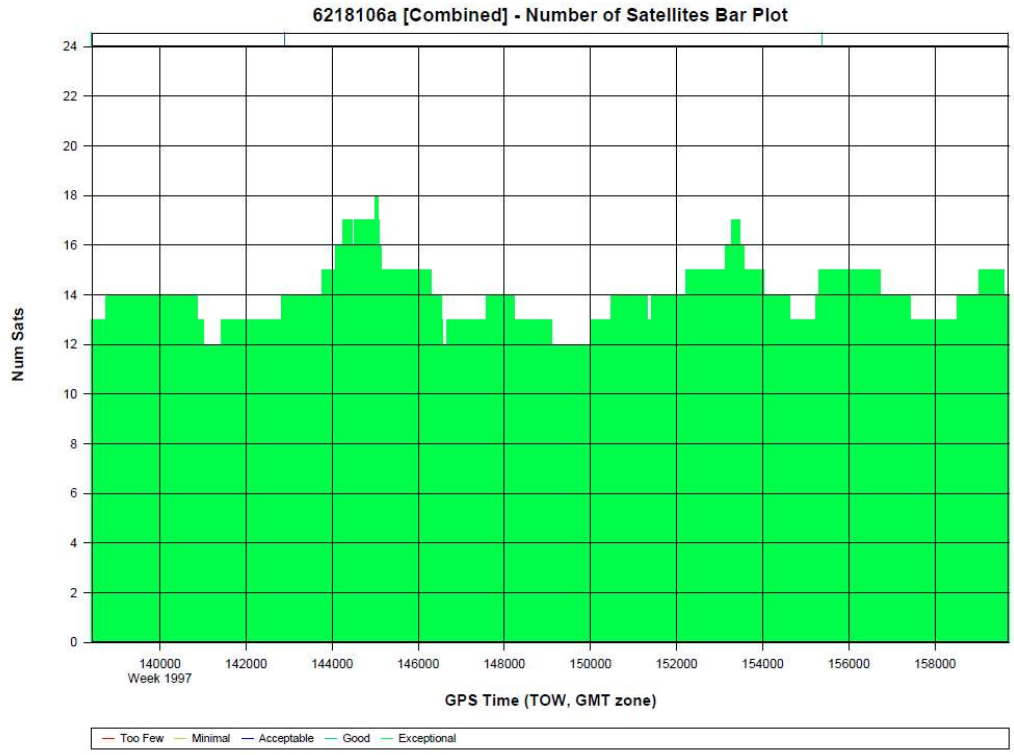

z gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
404,000
406,000
408,000
Time (sec)

Mission 6 – 6218106a GNSS Processing



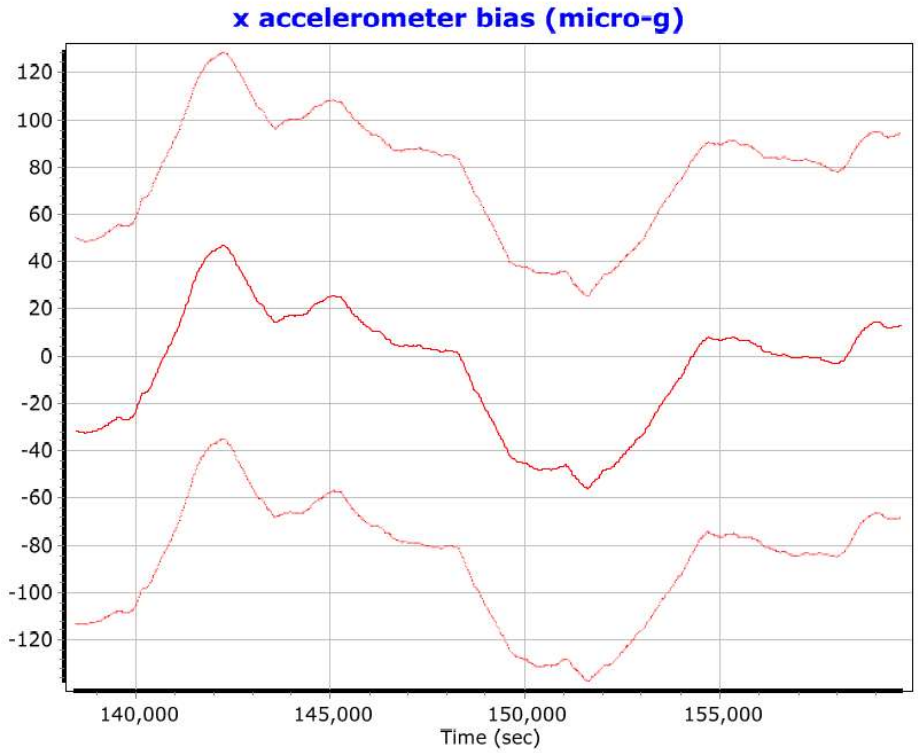

6218106a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
140000
Week 1997
142000
144000
146000
148000
150000
152000
154000
156000
158000
GPS Time (TOW, GMT zone)
East
North
Up

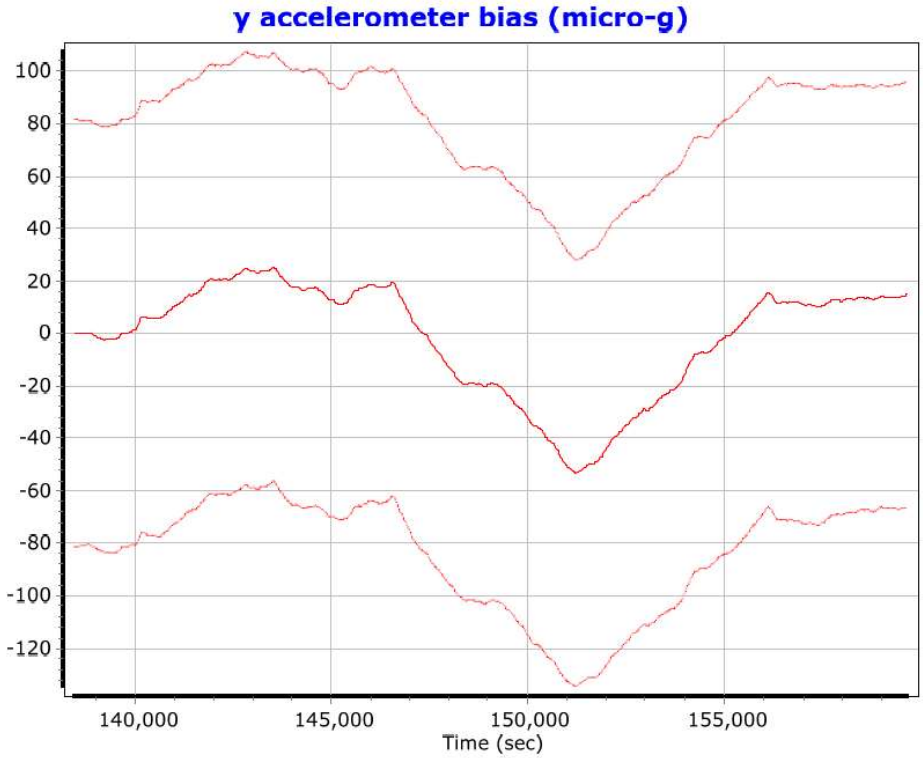

6218106a [Combined] - PDOP Plot
PDOP
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
140000
Week 1997
142000
144000
146000
148000
150000
152000
154000
156000
158000
GPS Time (TOW, GMT zone)
PDOP

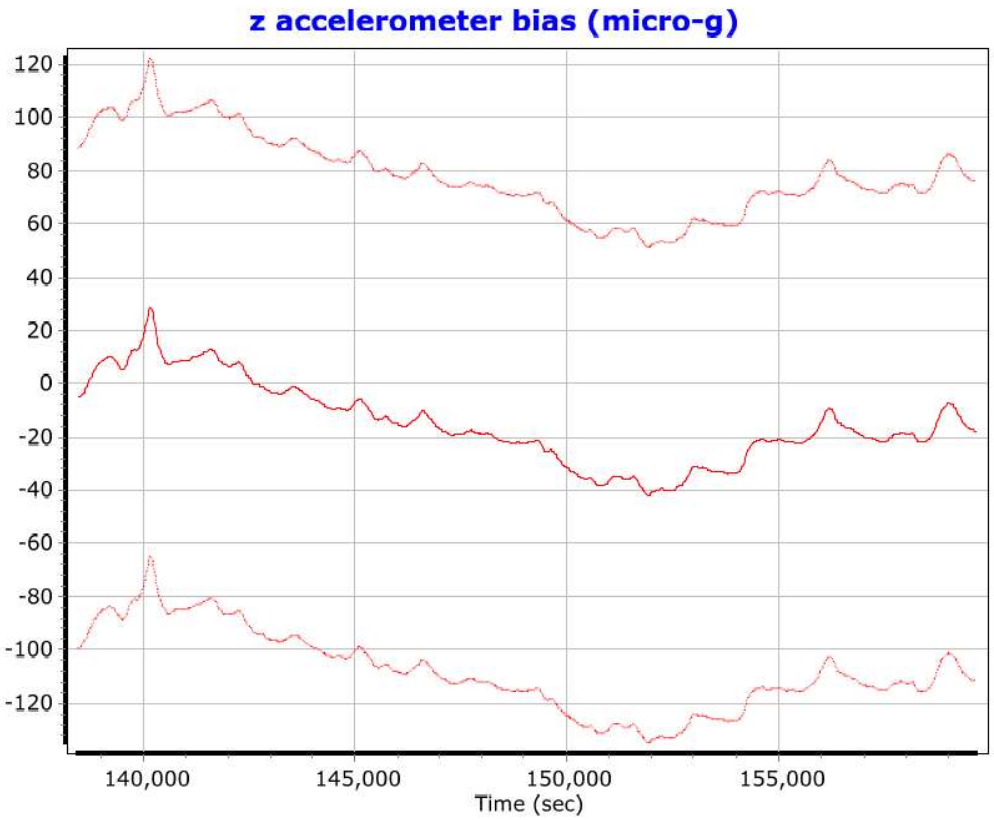

6218106a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
140000
Week 1997
142000
144000
146000
148000
150000
152000
154000
156000
158000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

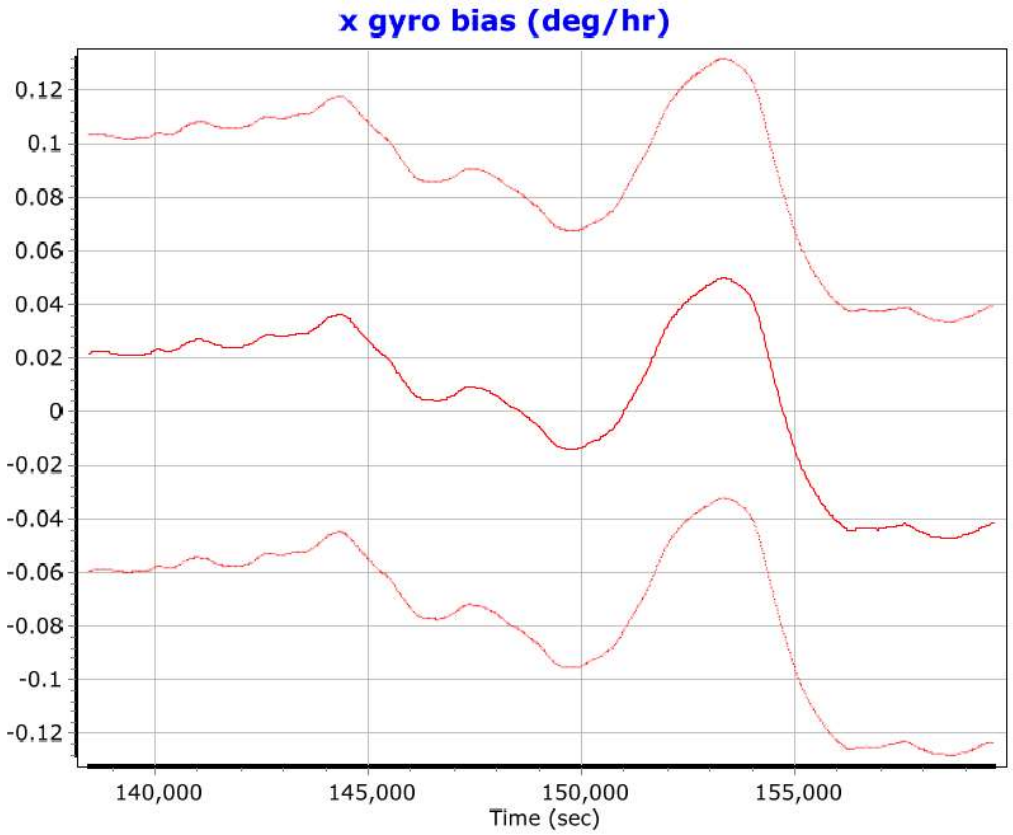
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218106a\05_INS-GPS_PROC\
01_POS\GNSS\6218106a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 21311
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0216 (m)
C/A Code: 0.73 (m)
L1 Doppler: 0.023 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.018 (m)
North: 0.012 (m)
Height: 0.028 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (21305 occurances):
East: 0.018 (m)
North: 0.012 (m)
Height: 0.028 (m)
Quality Number Percentages:
Q 1: 99.7 %
Q 2: 0.3 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 64.312 (km)
Minimum: 1.715 (km)
Average: 29.288 (km)
First Epoch: 13.381 (km)
Last Epoch: 12.620 (km)

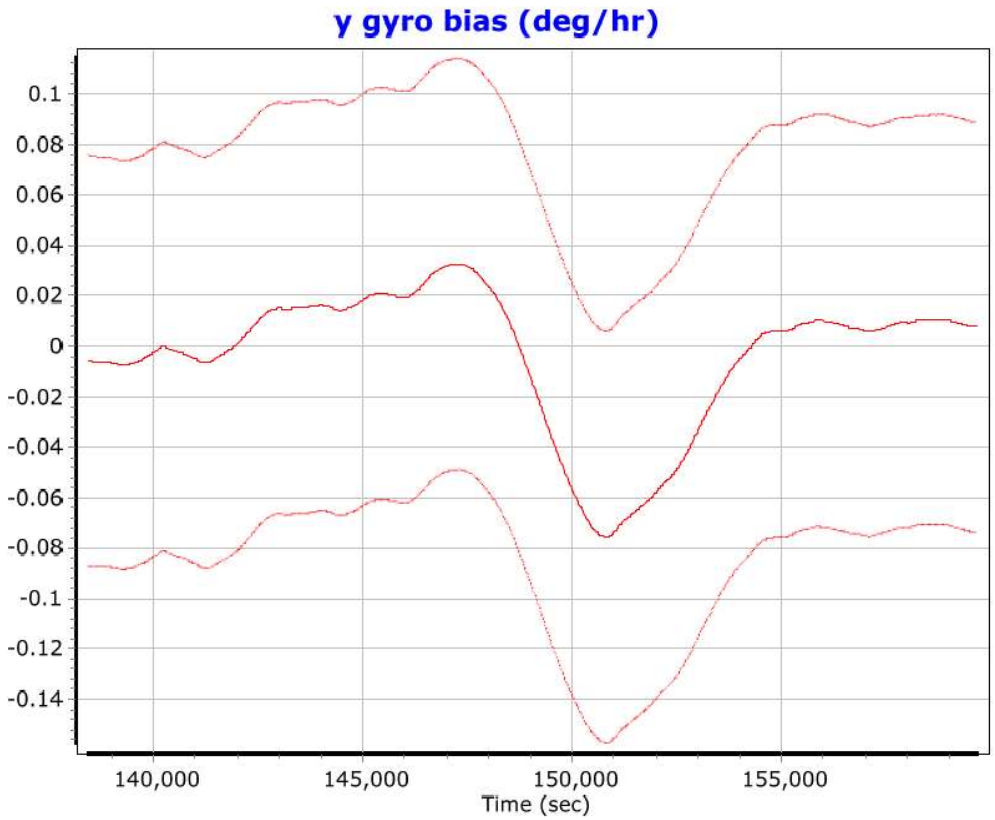
Mission 6 – 6218106a Sensor Errors





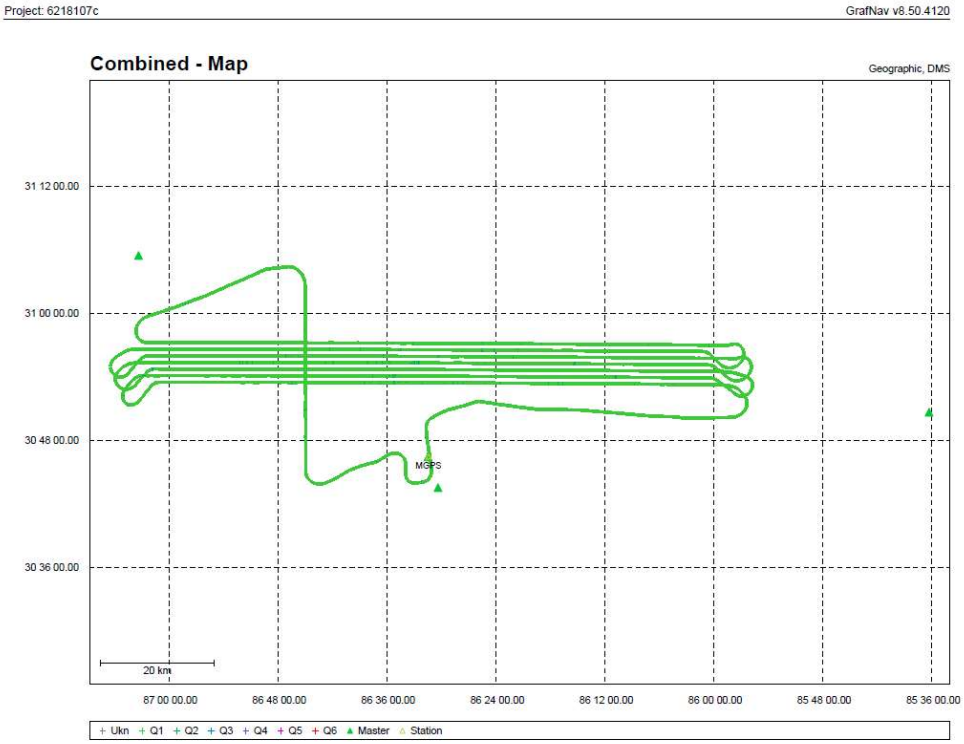

z accelerometer bias (micro-g)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
140,000
145,000
150,000
155,000
Time (sec)

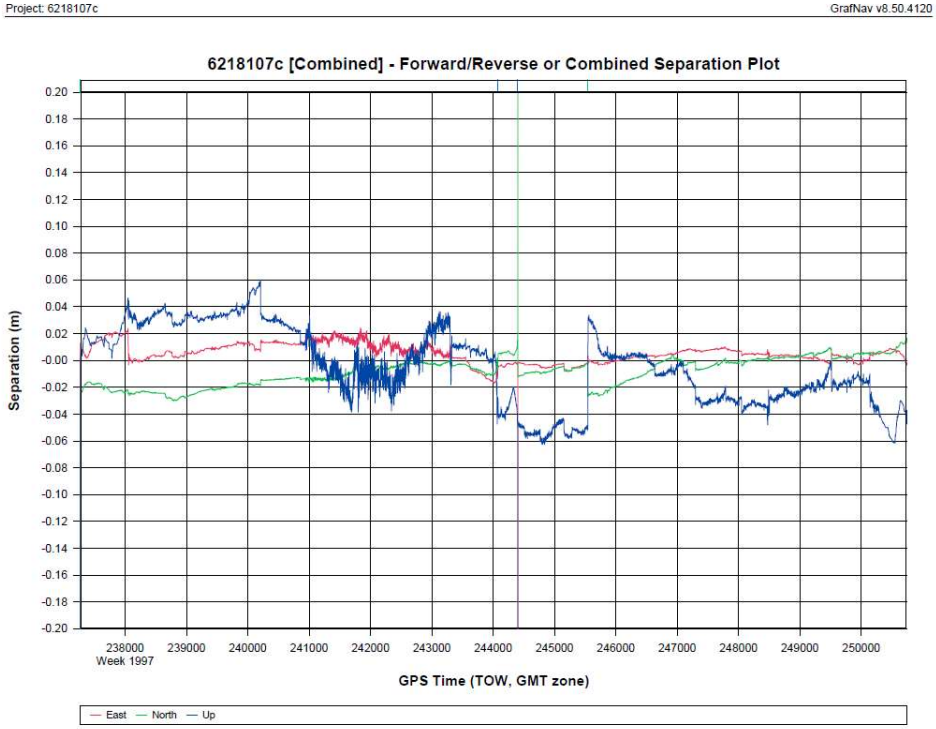

x gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
140,000
145,000
150,000
155,000
Time (sec)

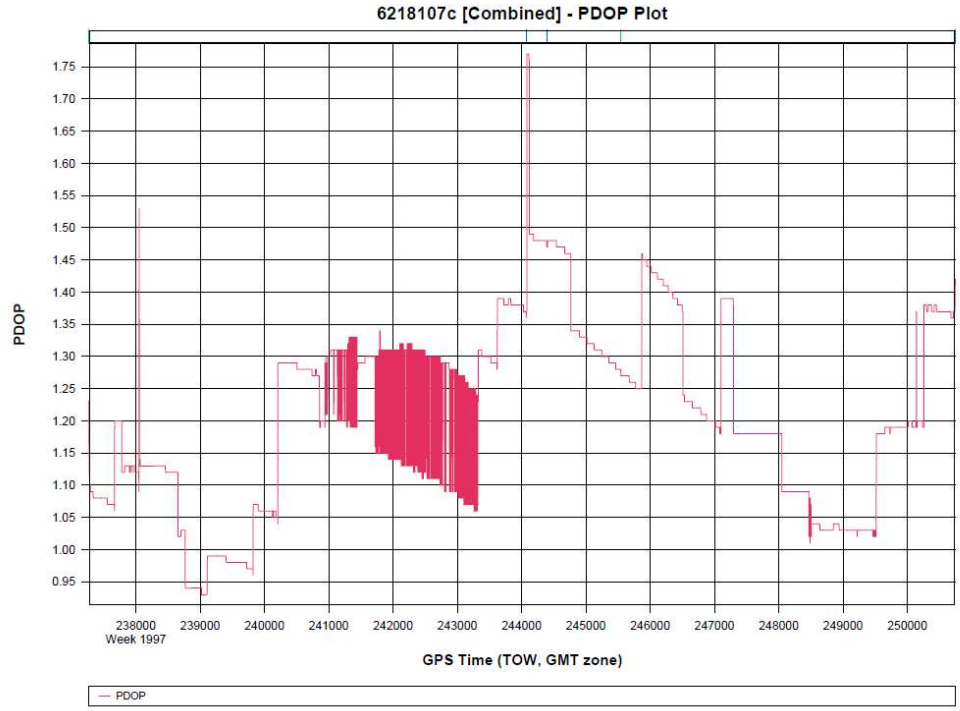

y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
140,000
145,000
150,000
155,000
Time (sec)

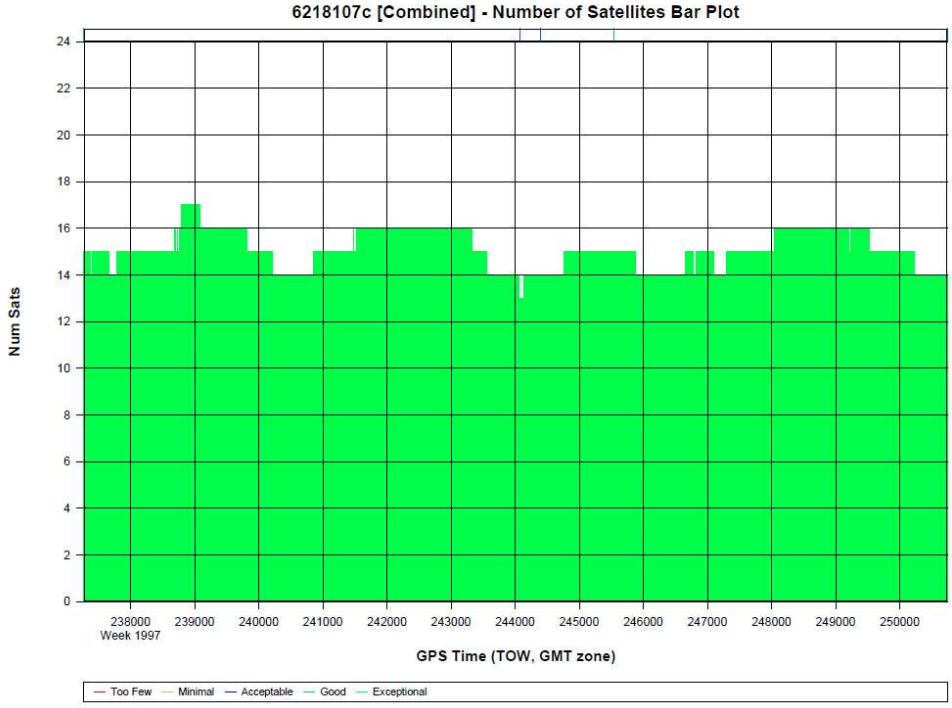

z gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
140,000
145,000
150,000
155,000
Time (sec)

Mission 7 – 6218107c GNSS Processing



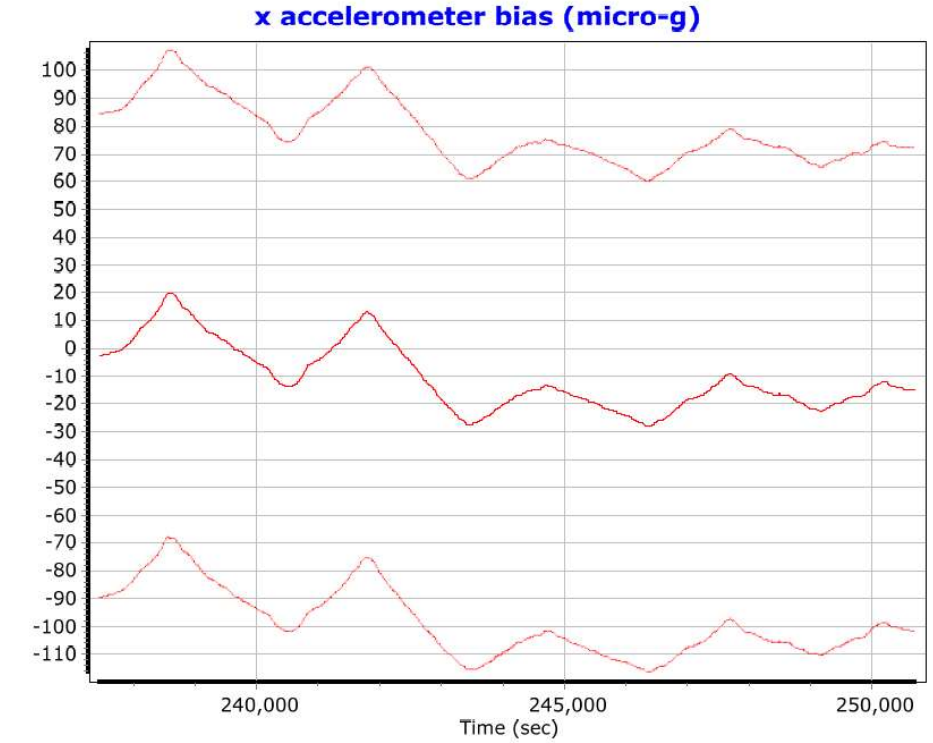


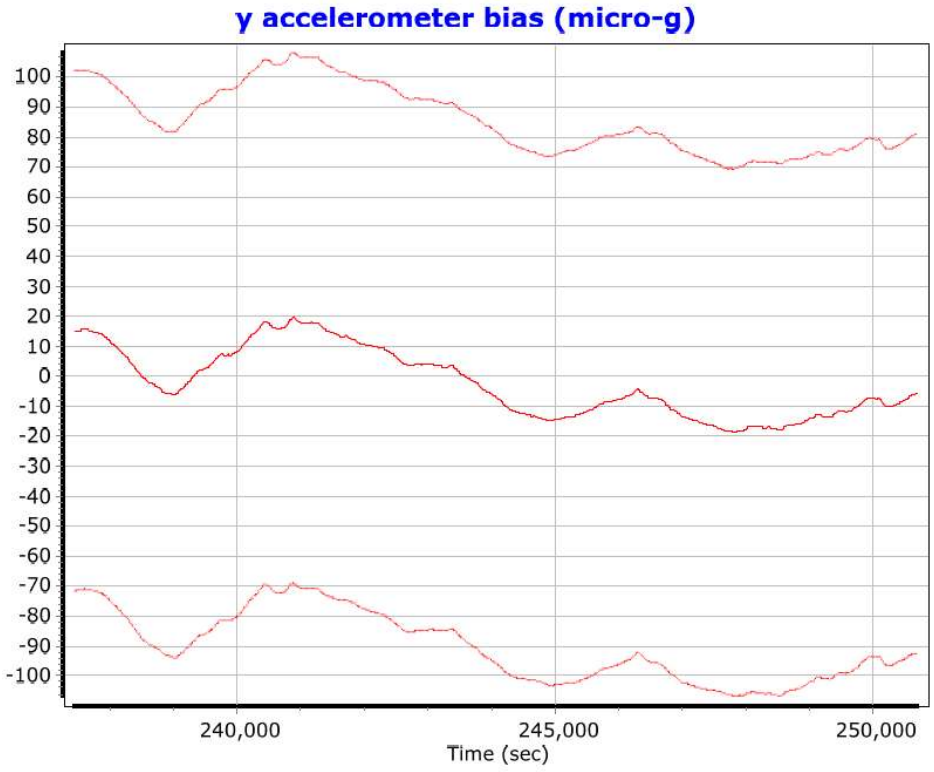

6218107c [Combined] - PDOP Plot
PDOP
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
238000
Week 1997
239000
240000
241000
242000
243000
244000
245000
246000
247000
248000
249000
250000
GPS Time (TOW, GMT zone)
PDOP

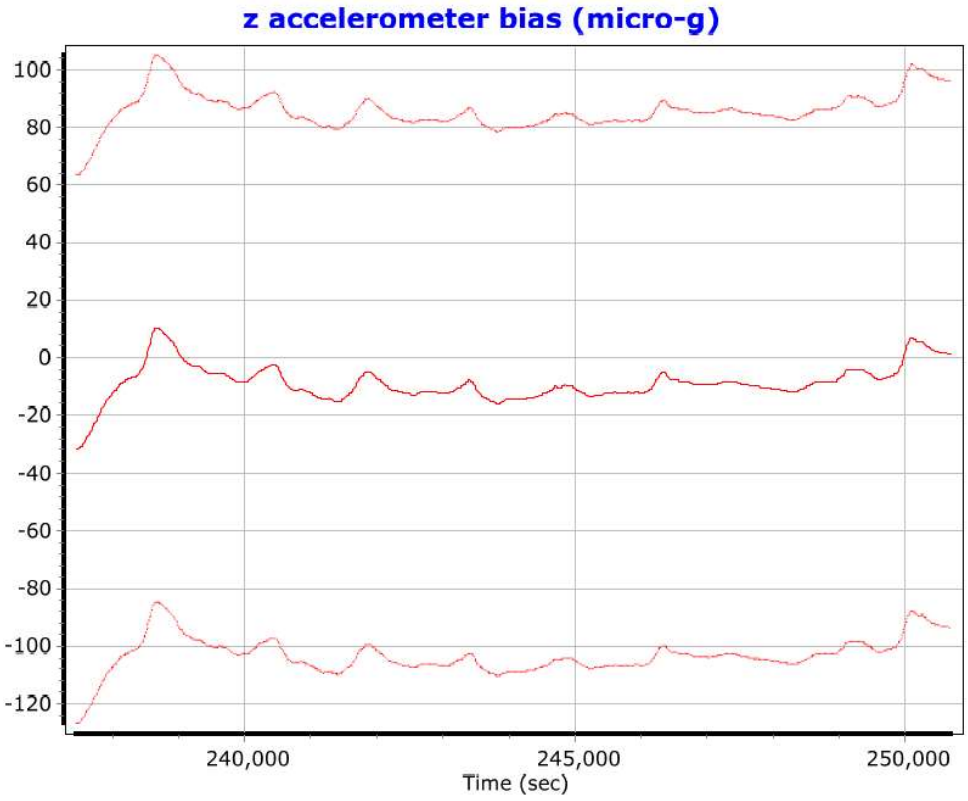

6218107c [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
238000
Week 1997
239000
240000
241000
242000
243000
244000
245000
246000
247000
248000
249000
250000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

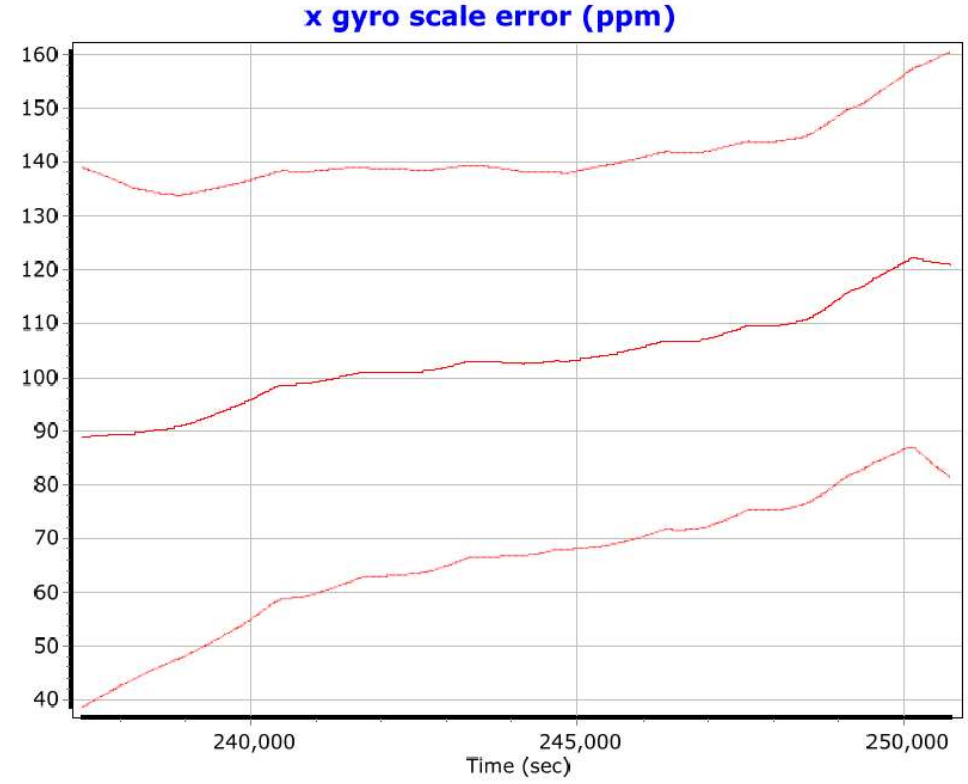
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218107a\05_INS-GPS_PROC\
01_POS\GNSS\6218107c.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 13480
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0213 (m)
C/A Code: 0.70 (m)
L1 Doppler: 0.685 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.010 (m)
North: 0.014 (m)
Height: 0.031 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (13472 occurances):
East: 0.009 (m)
North: 0.013 (m)
Height: 0.029 (m)
Quality Number Percentages:
Q 1: 98.4 %
Q 2: 1.6 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 65.003 (km)
Minimum: 1.250 (km)
Average: 28.118 (km)
First Epoch: 11.991 (km)
Last Epoch: 12.088 (km)

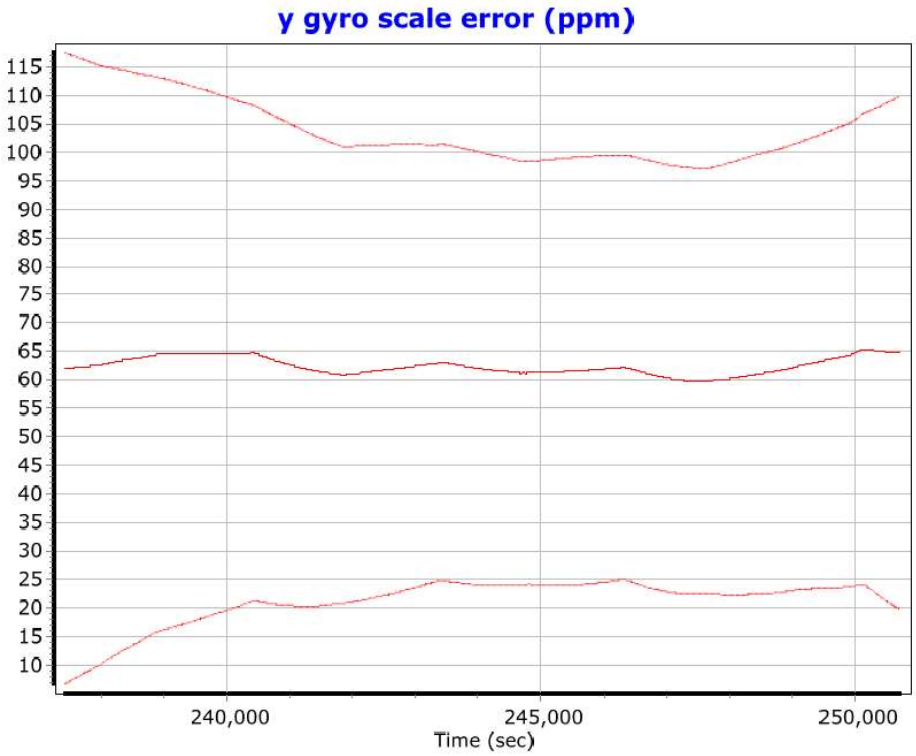
Mission 7 – 6218107c Sensor Errors

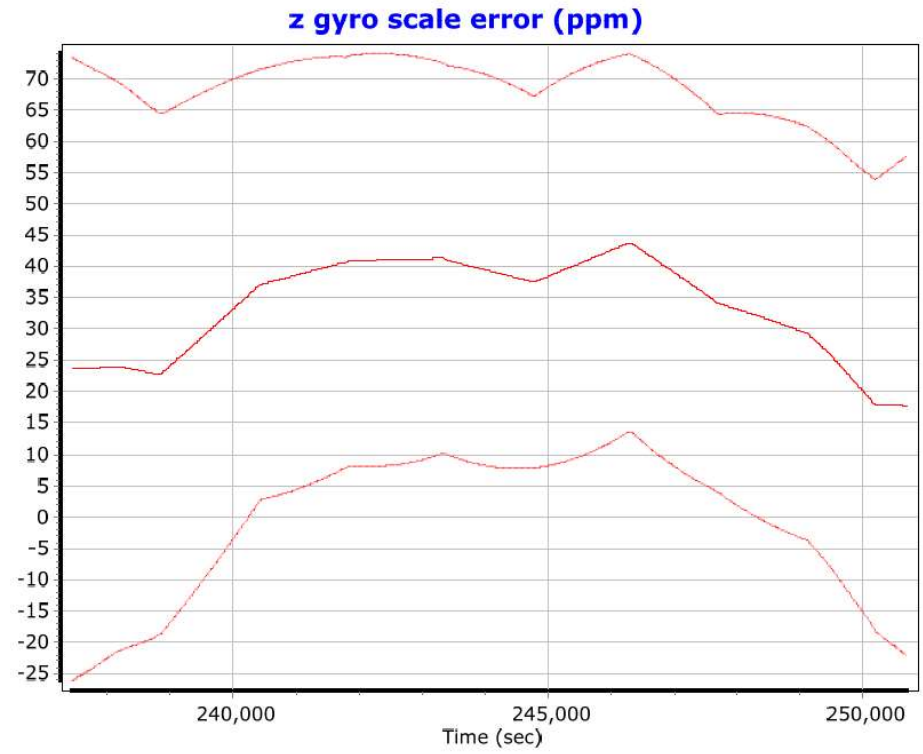





z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
240,000
245,000
250,000
Time (sec)

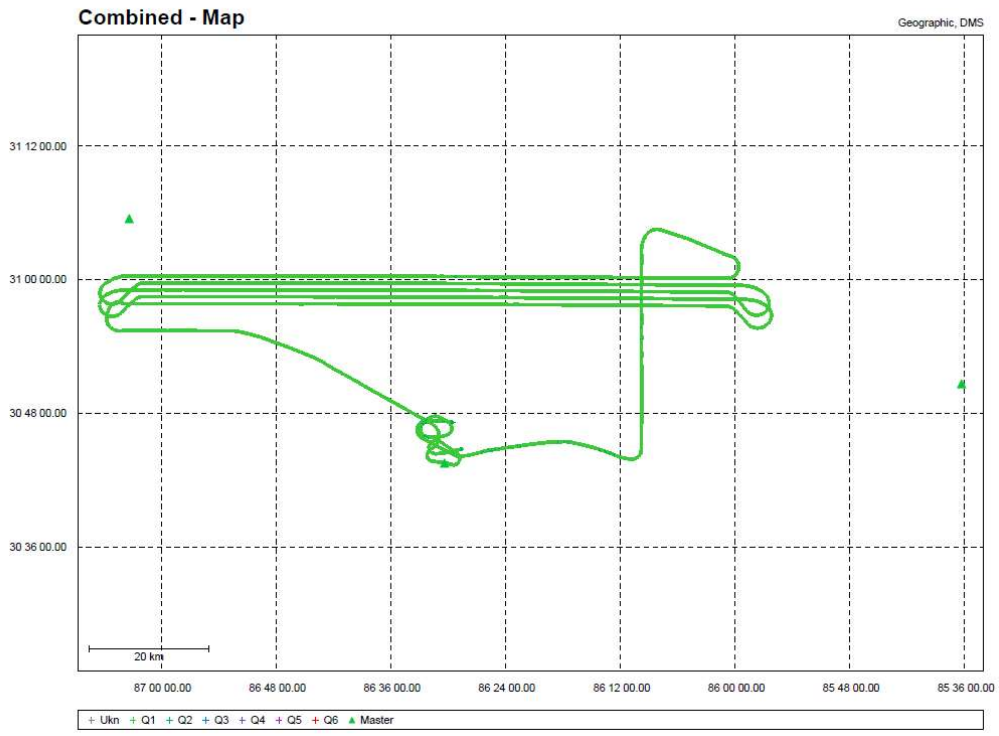

x gyro scale error (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
240,000
245,000
250,000
Time (sec)


y gyro scale error (ppm)
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
240,000
245,000
250,000
Time (sec)

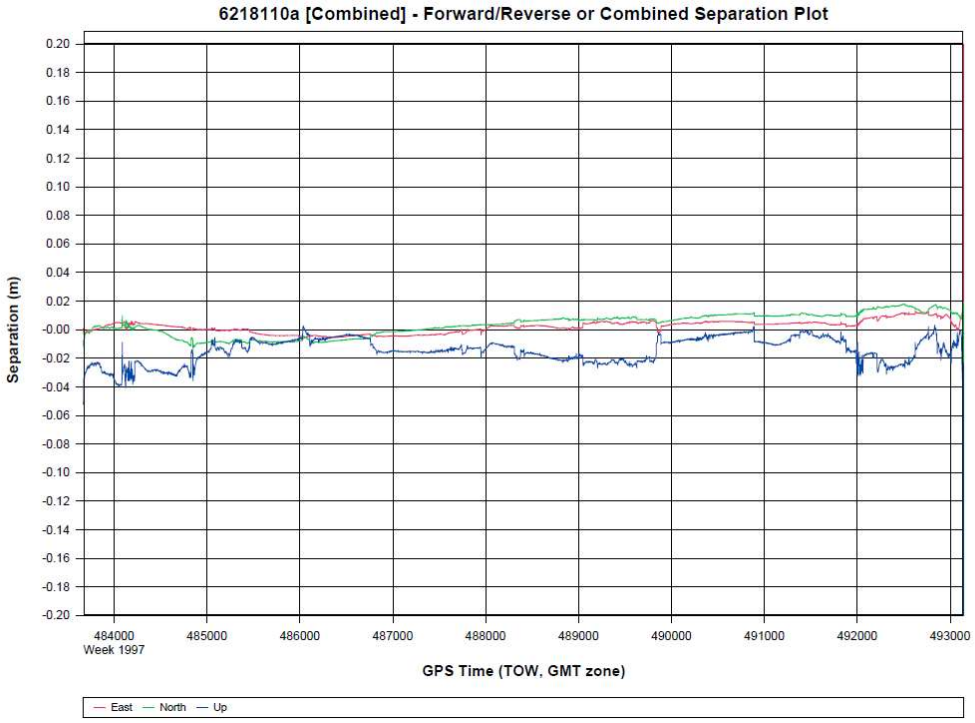

z gyro scale error (ppm)
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
240,000
245,000
250,000
Time (sec)

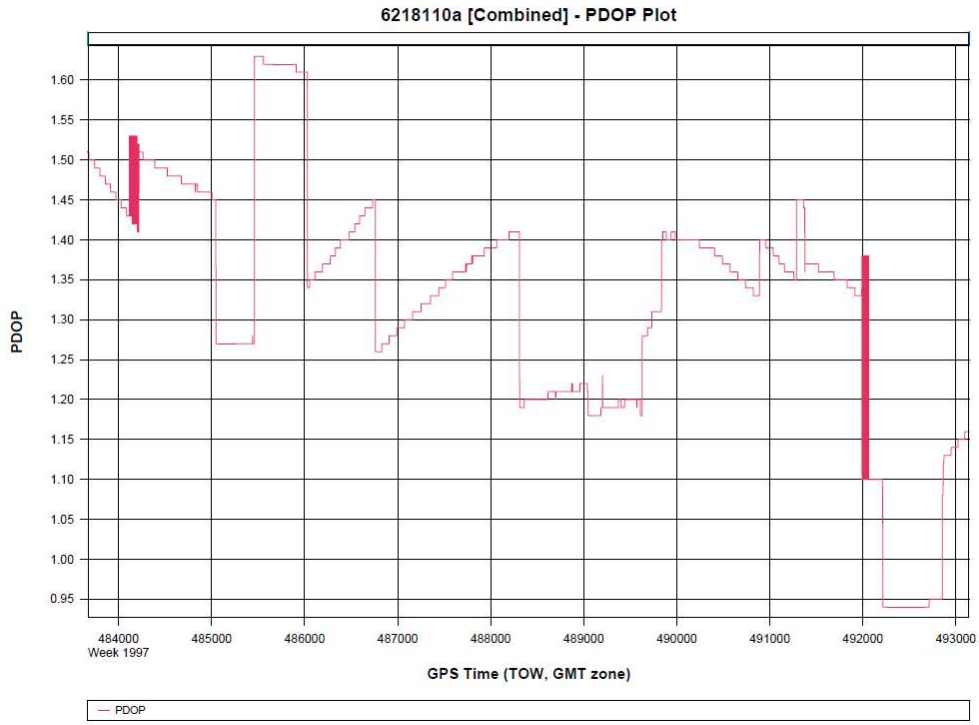
Mission 8 – 6218110a GNSS Processing

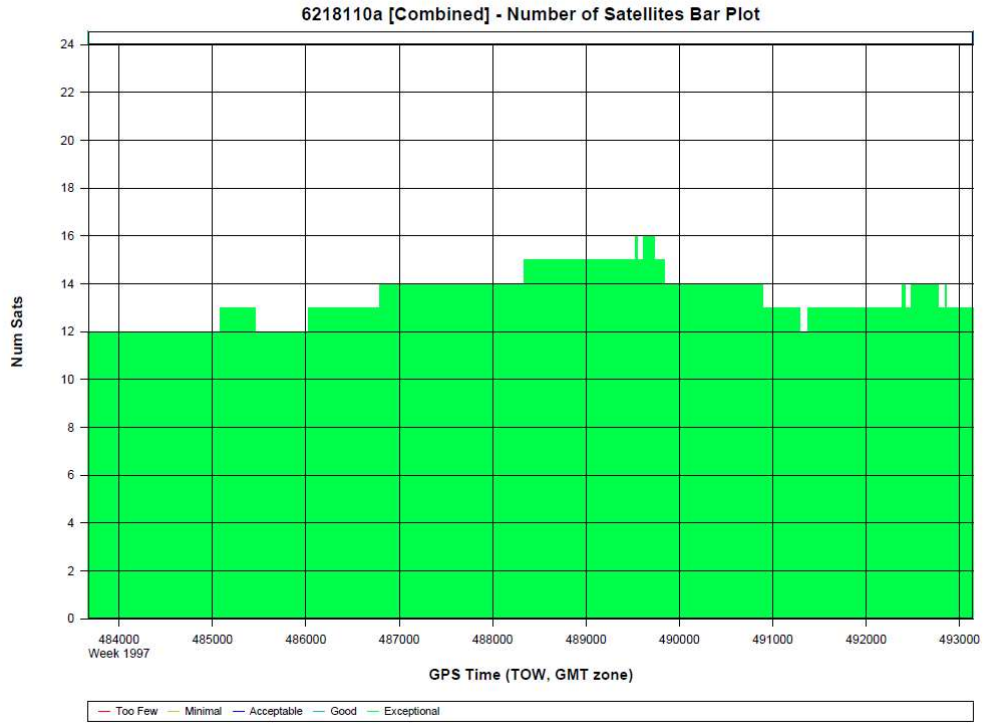
Project: 6218110a GrafNav v8.50.4120



Project: 6218110a GrafNav v8.50.4120



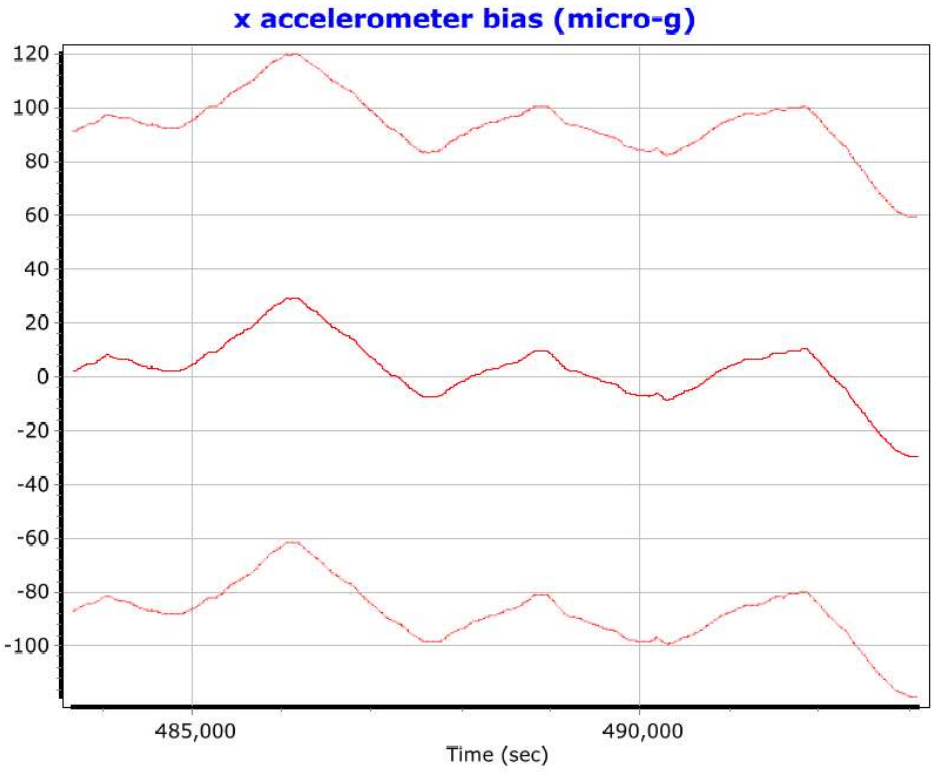


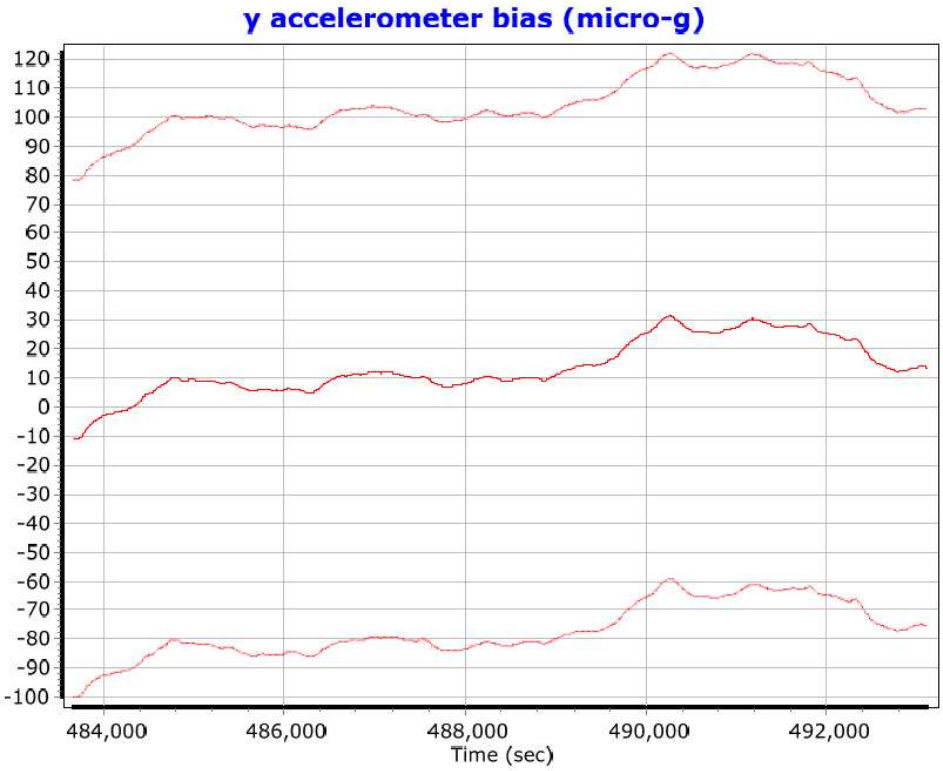


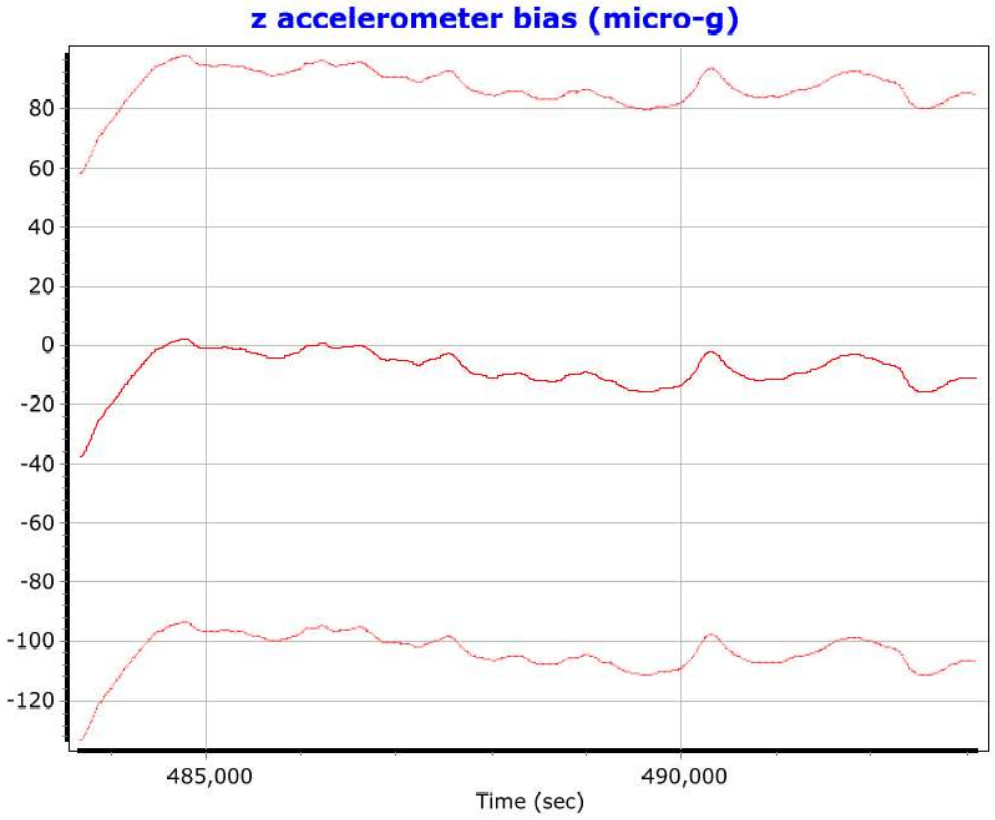
Processing Summary Information

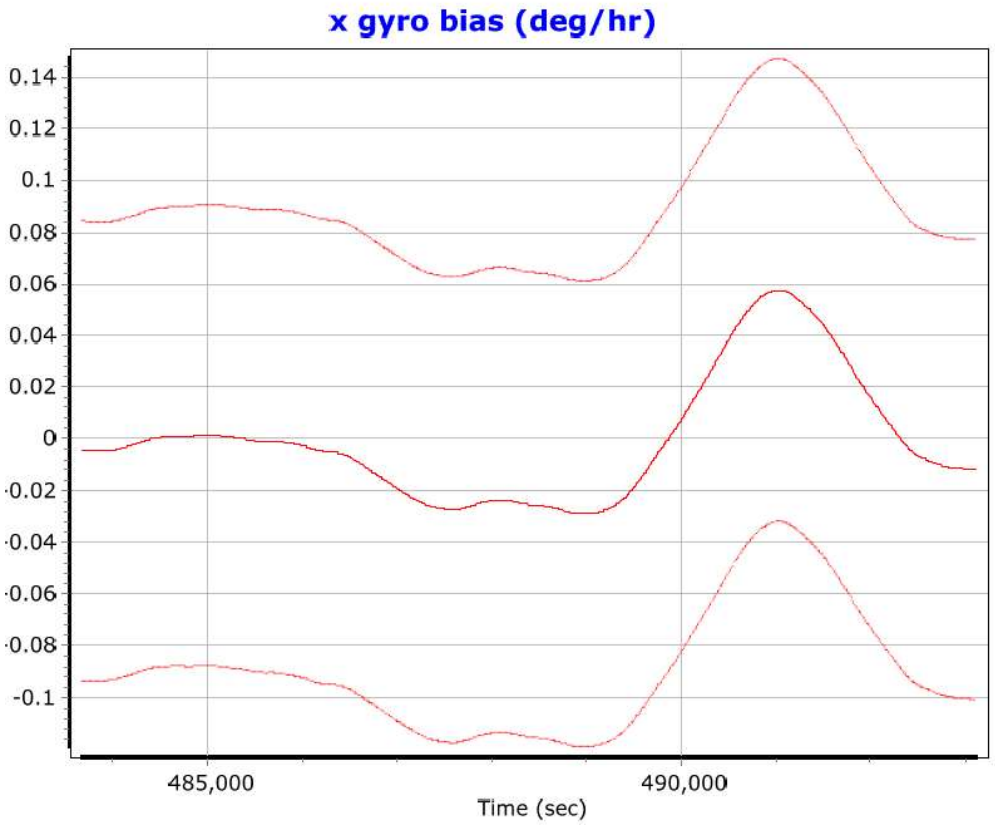
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218110a\05_INS-GPS_PROC\
01_POS\6218110a\GNSS\6218110a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 17309
No processed position: 7829
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0158 (m)
C/A Code: 0.68 (m)
L1 Doppler: 0.021 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.006 (m)
North: 0.009 (m)
Height: 0.018 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (9475 occurances):
East: 0.005 (m)
North: 0.008 (m)
Height: 0.017 (m)
Quality Number Percentages:
Q 1: 99.3 %
Q 2: 0.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 68.443 (km)
Minimum: 8.404 (km)
Average: 30.969 (km)
First Epoch: 17.809 (km)
Last Epoch: 15.401 (km)

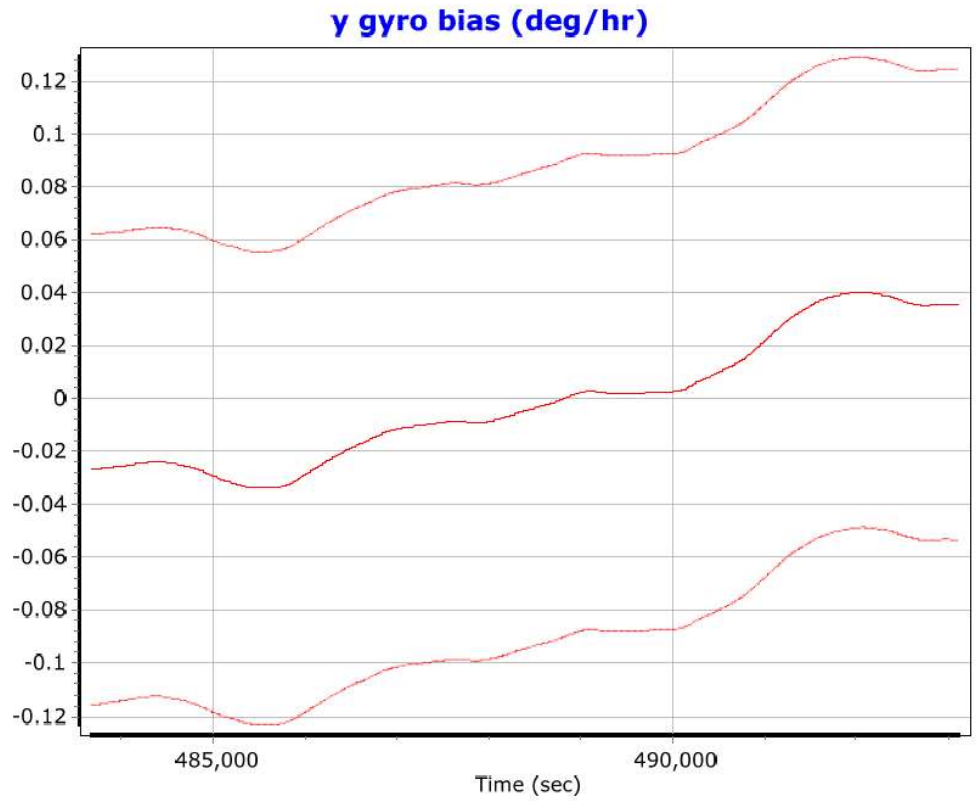
Mission 8 – 6218110a Sensor Errors





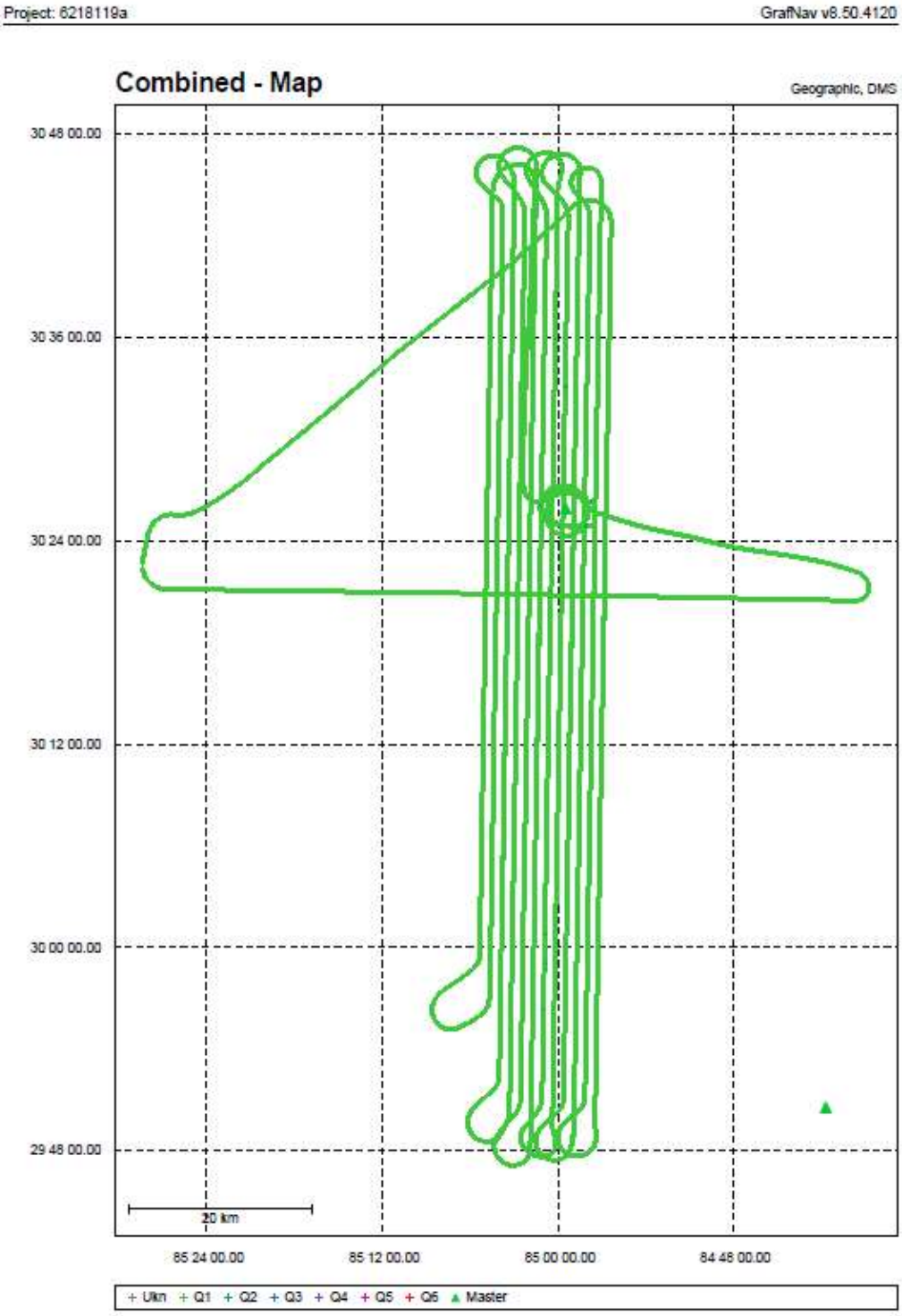

z accelerometer bias (micro-g)
80
60
40
20
0
-20
-40
-60
-80
-100
-120
485,000
490,000
Time (sec)

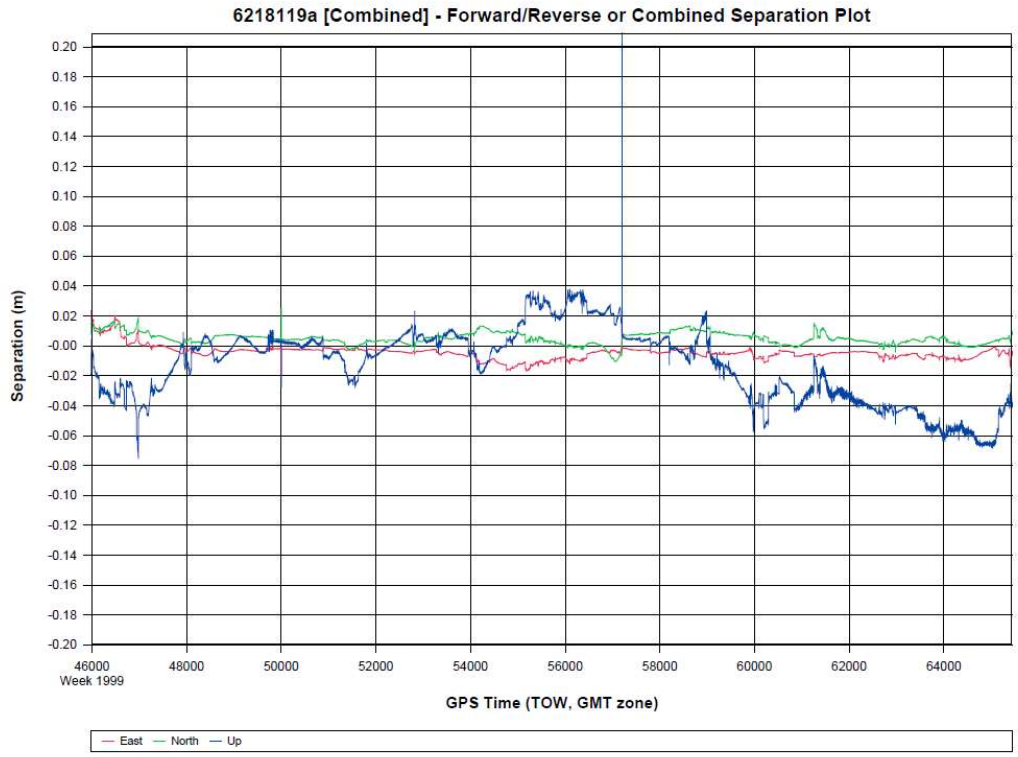

x gyro bias (deg/hr)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
485,000
490,000
Time (sec)

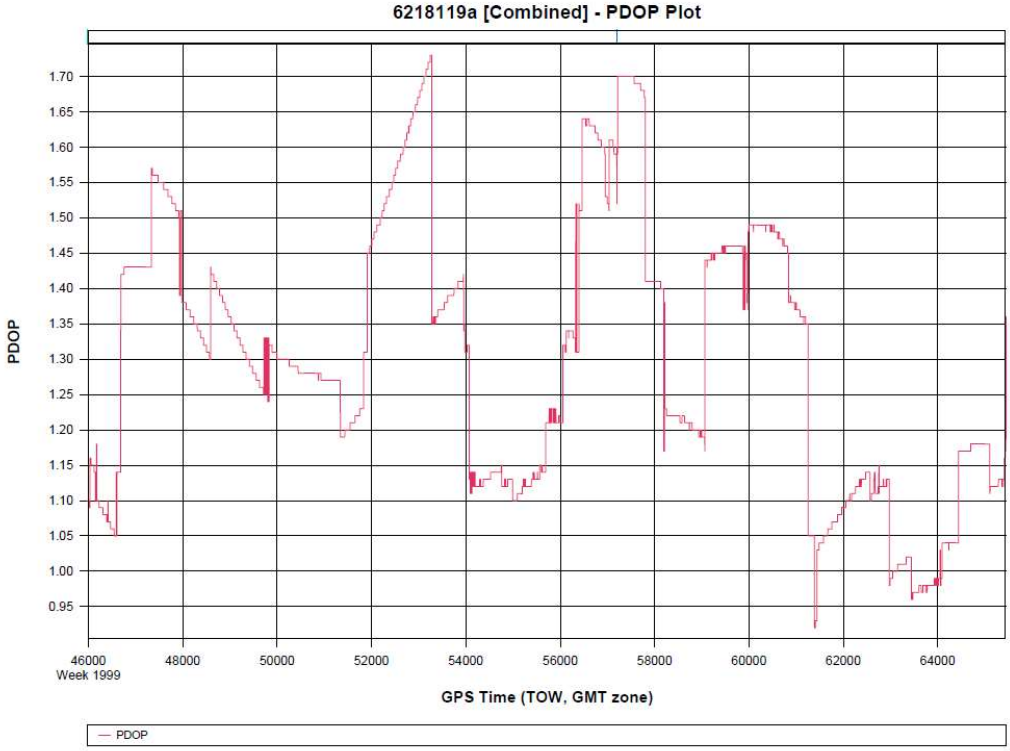

y gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
485,000
490,000
Time (sec)

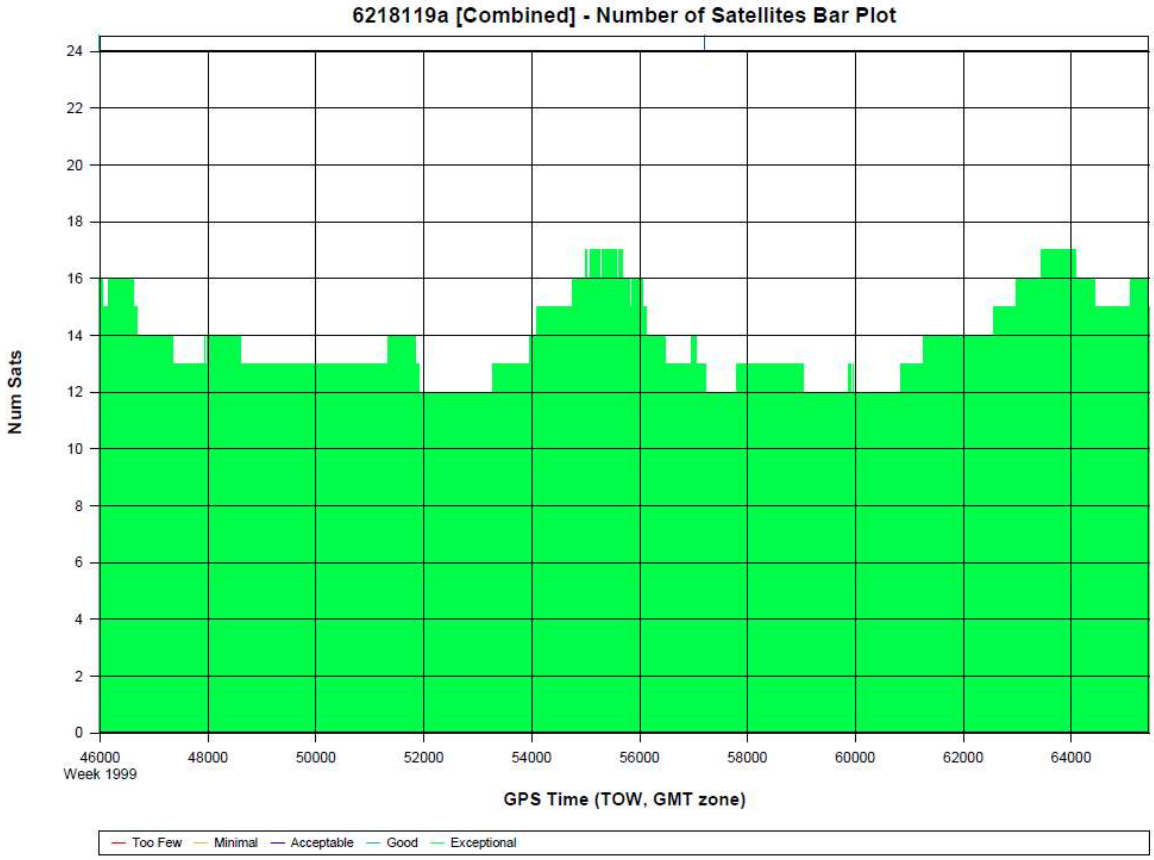

z gyro bias (deg/hr)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
485,000
490,000
Time (sec)

Mission 9 – 6218119a GNSS Processing



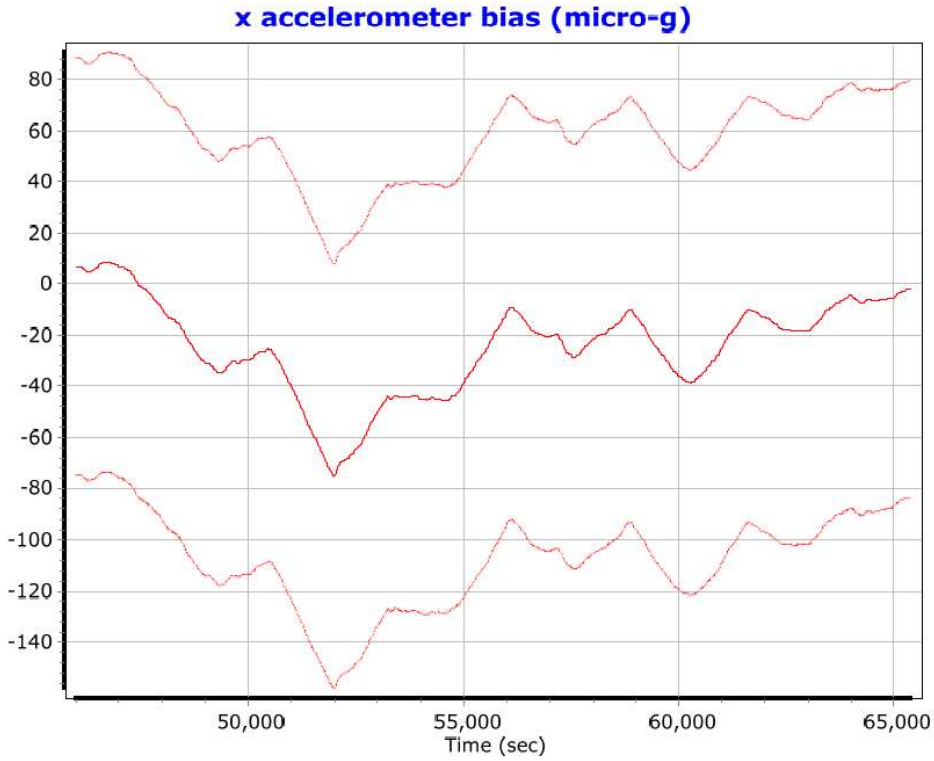

6218119a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
46000
Week 1999
48000
50000
52000
54000
56000
58000
60000
62000
64000
GPS Time (TOW, GMT zone)
East
North
Up

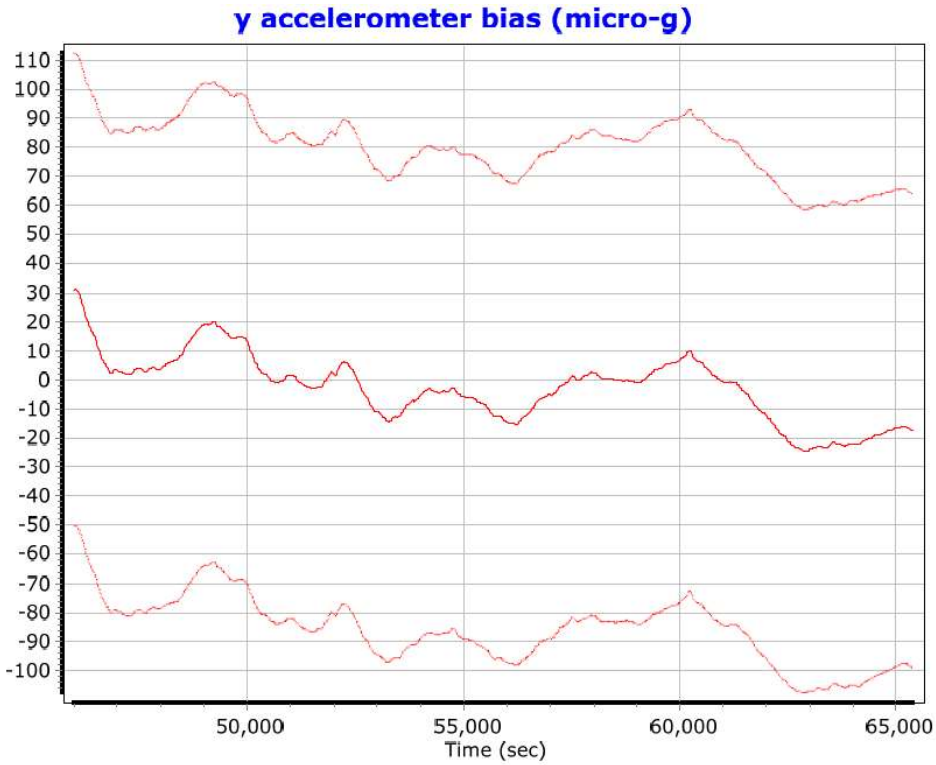

6218119a [Combined] - PDOP Plot
PDOP
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
46000
Week 1999
48000
50000
52000
54000
56000
58000
60000
62000
64000
GPS Time (TOW, GMT zone)
PDOP

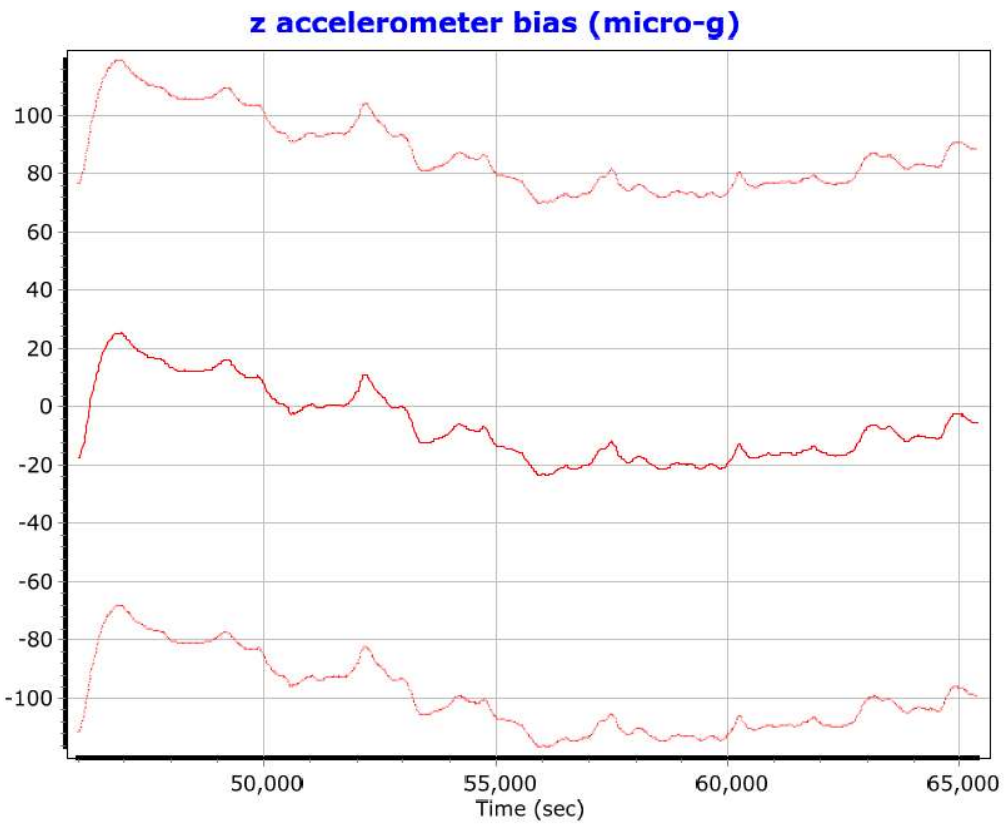

6218119a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
46000
Week 1999
48000
50000
52000
54000
56000
58000
60000
62000
64000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

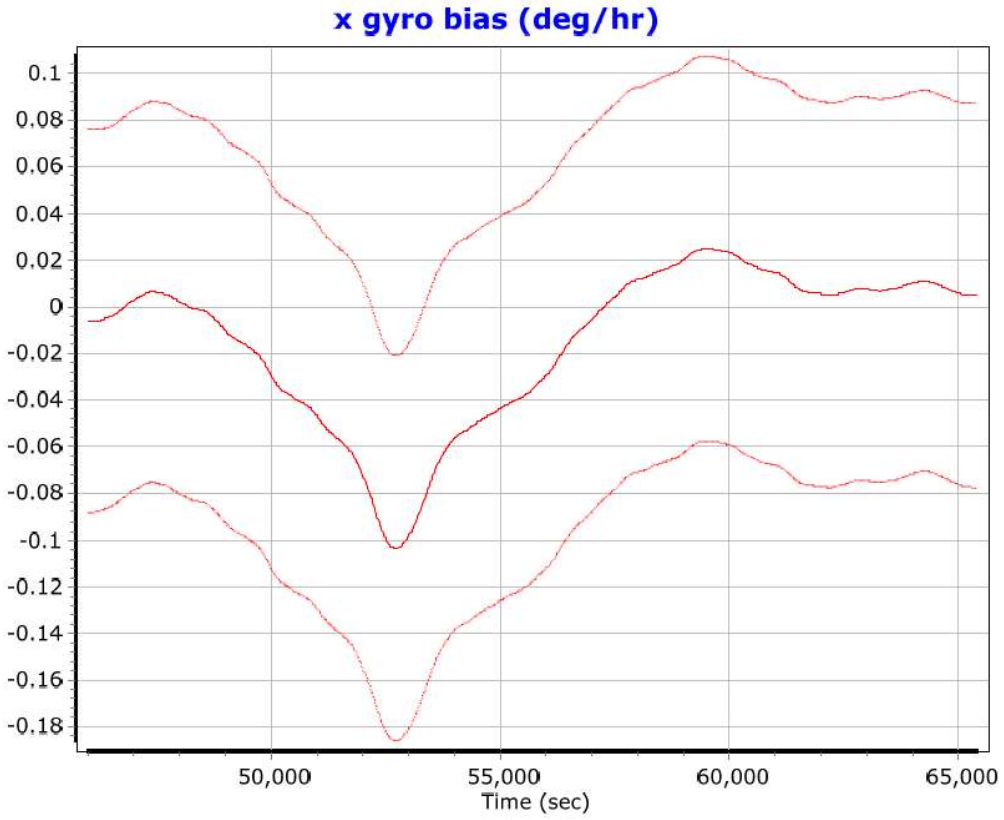
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218119a\05_INS-GPS_PROC\
01_POS\GNSS\6218119a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 22730
No processed position: 3258
Missing Fwd or Rev: 5
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0179 (m)
C/A Code: 0.76 (m)
L1 Doppler: 0.000 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.007 (m)
North: 0.006 (m)
Height: 0.028 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (19466 occurances):
East: 0.006 (m)
North: 0.006 (m)
Height: 0.028 (m)
Quality Number Percentages:
Q 1: 99.8 %
Q 2: 0.2 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 74.391 (km)
Minimum: 10.643 (km)
Average: 37.687 (km)
First Epoch: 35.141 (km)
Last Epoch: 32.656 (km)

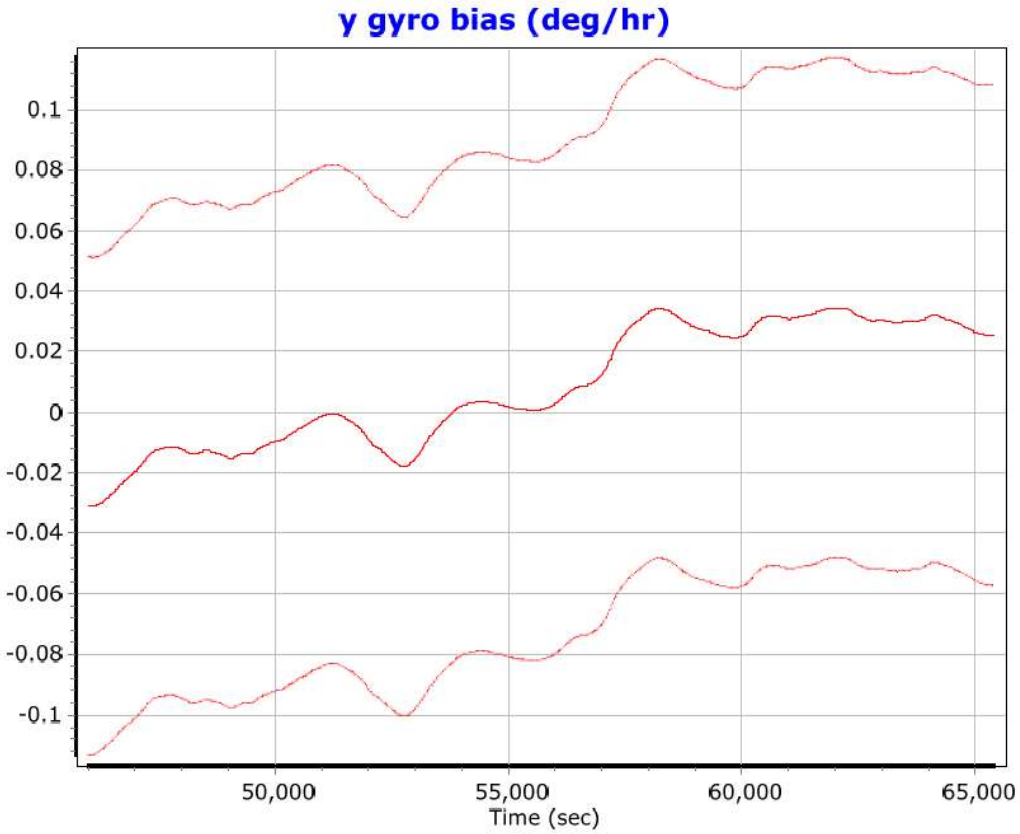
Mission 9 – 6218119a Sensor Errors





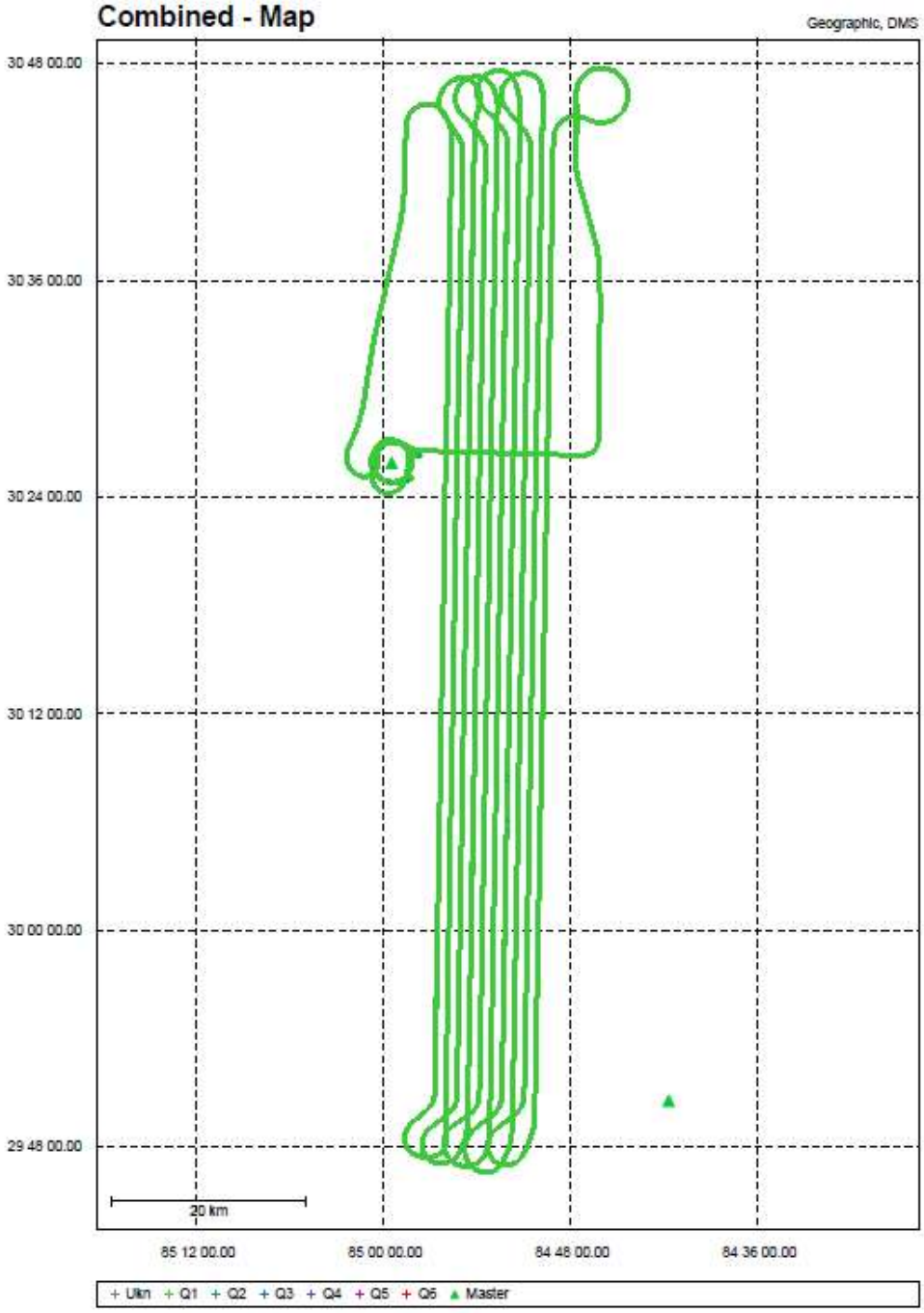

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
50,000
55,000
60,000
65,000
Time (sec)

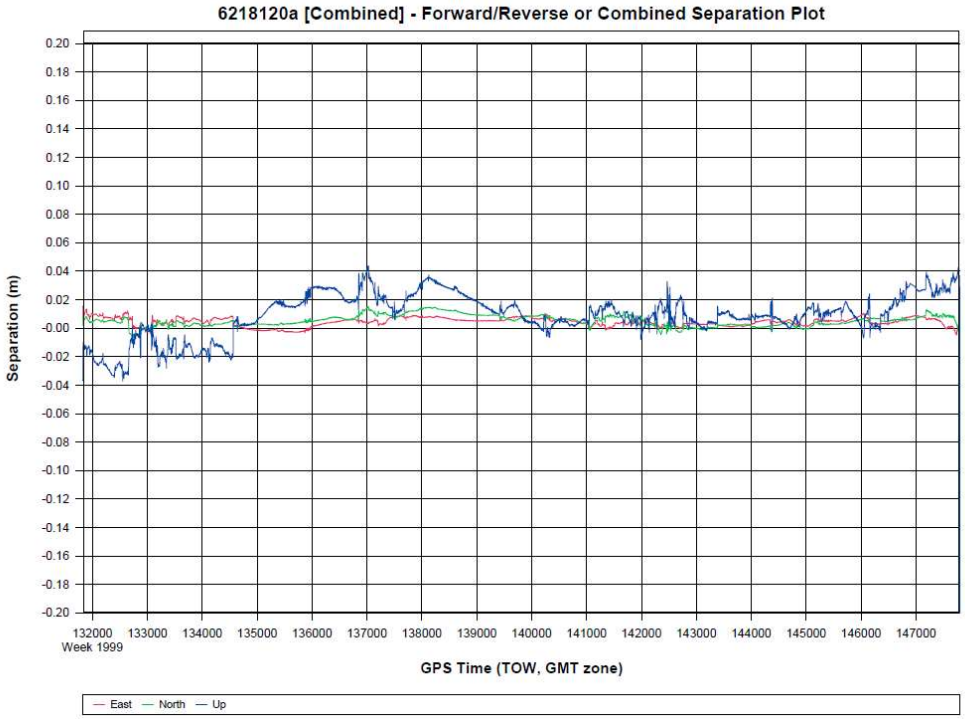

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
50,000
55,000
60,000
65,000
Time (sec)

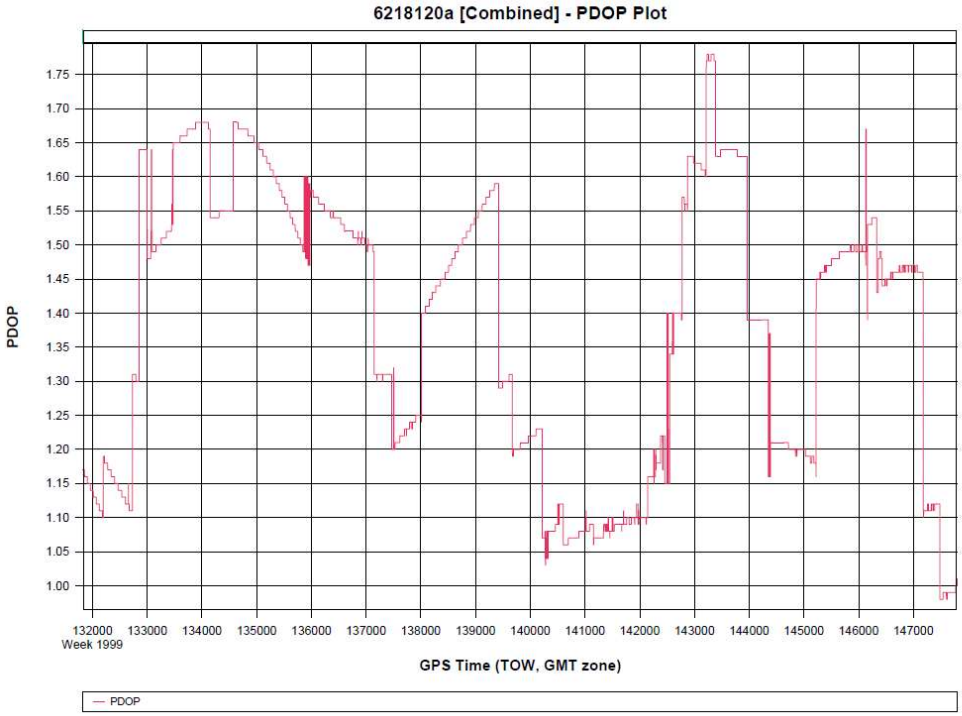

y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
50,000
55,000
60,000
65,000
Time (sec)

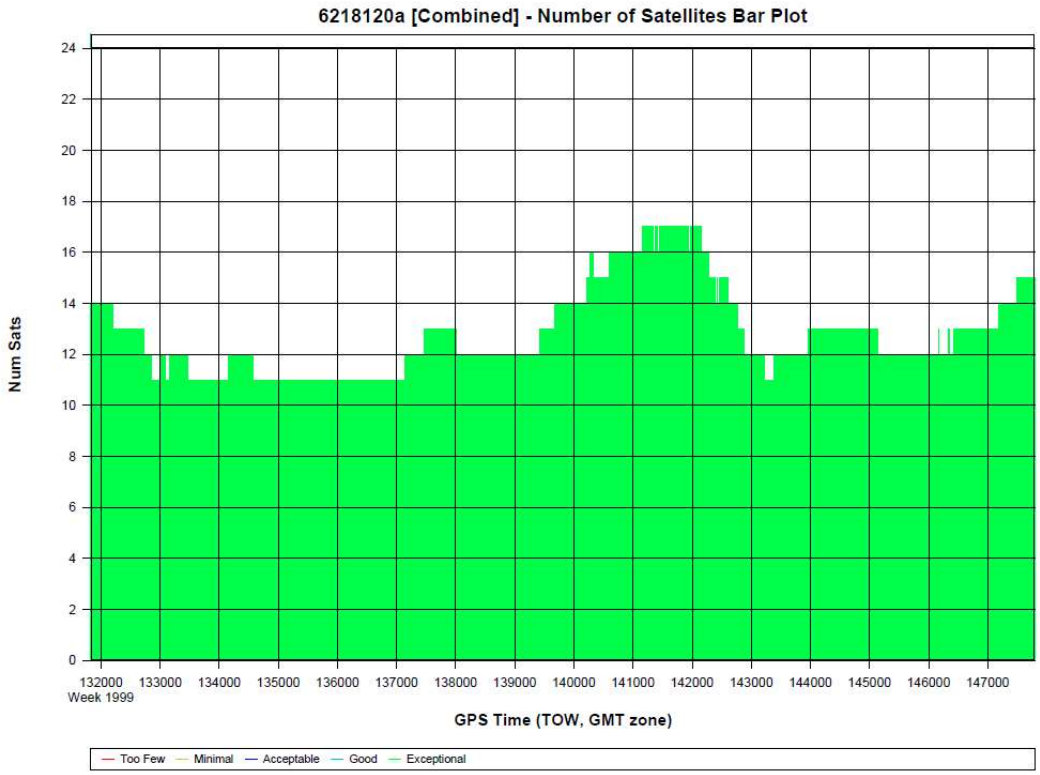

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
50,000
55,000
60,000
65,000
Time (sec)

Mission 10 – 6218120a GNSS Processing



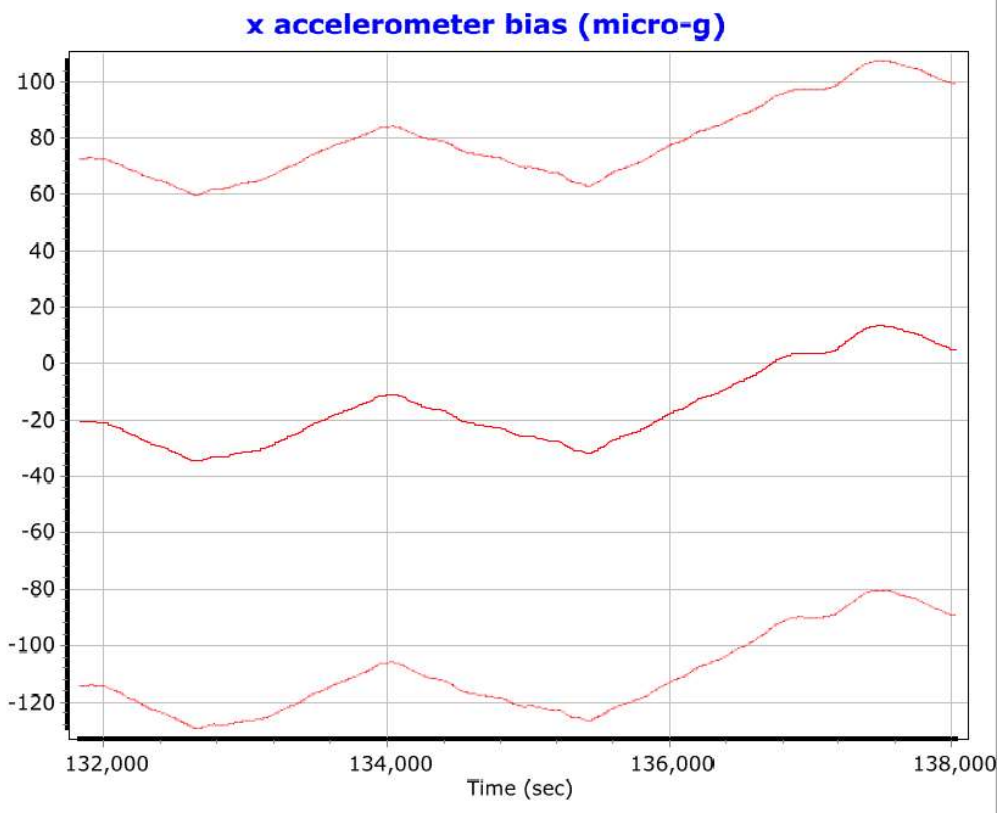

6218120a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
132000 133000 134000 135000 136000 137000 138000 139000 140000 141000 142000 143000 144000 145000 146000 147000
Week 1999
GPS Time (TOW, GMT zone)
East North Up

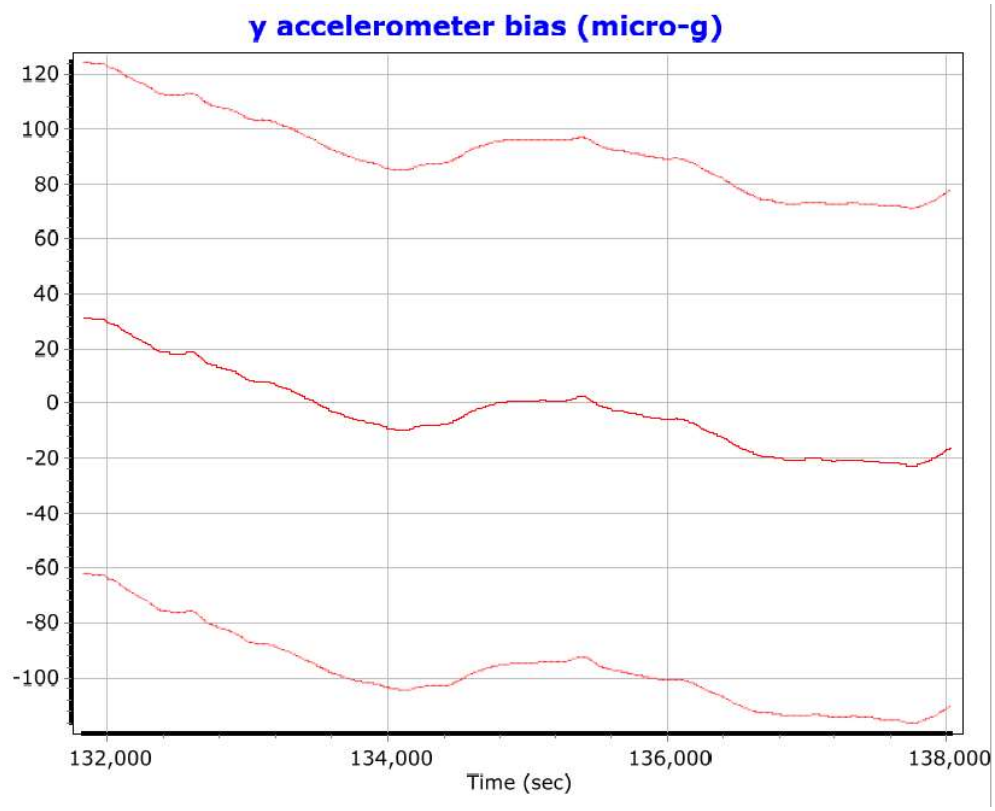

6218120a [Combined] - PDOP Plot
PDOP
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
132000 133000 134000 135000 136000 137000 138000 139000 140000 141000 142000 143000 144000 145000 146000 147000
Week 1999
GPS Time (TOW, GMT zone)
PDOP

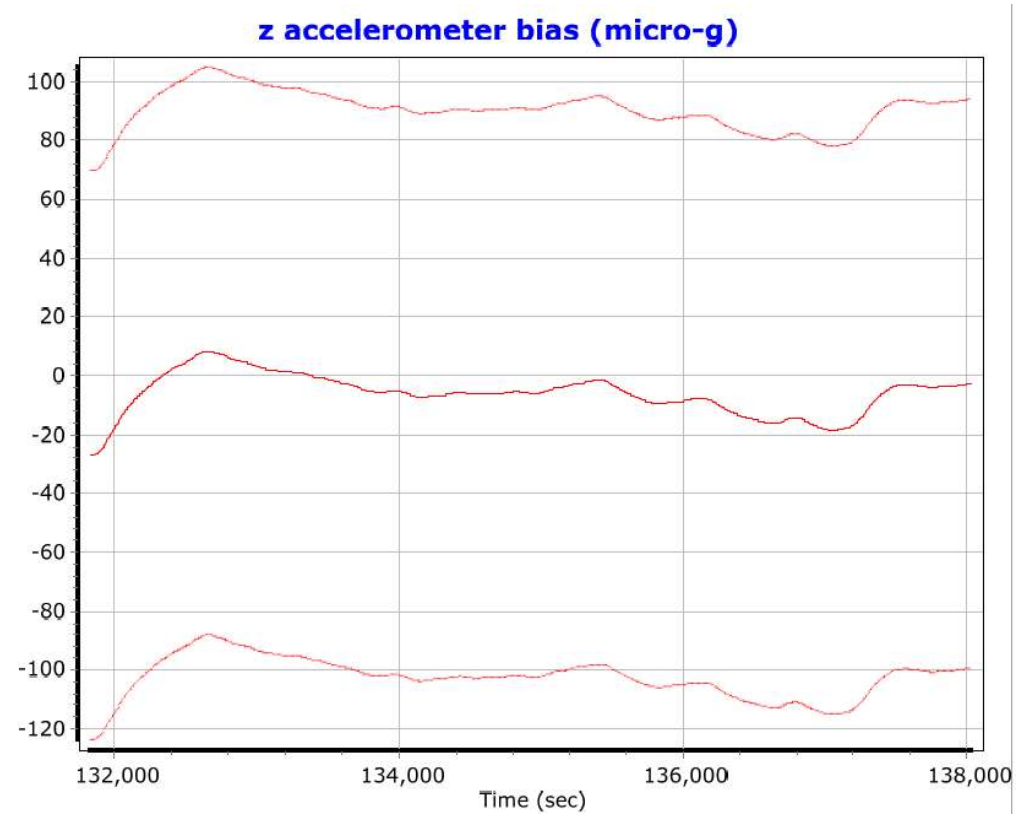

6218120a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
132000
133000
134000
135000
136000
137000
138000
139000
140000
141000
142000
143000
144000
145000
146000
147000
Week 1999
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

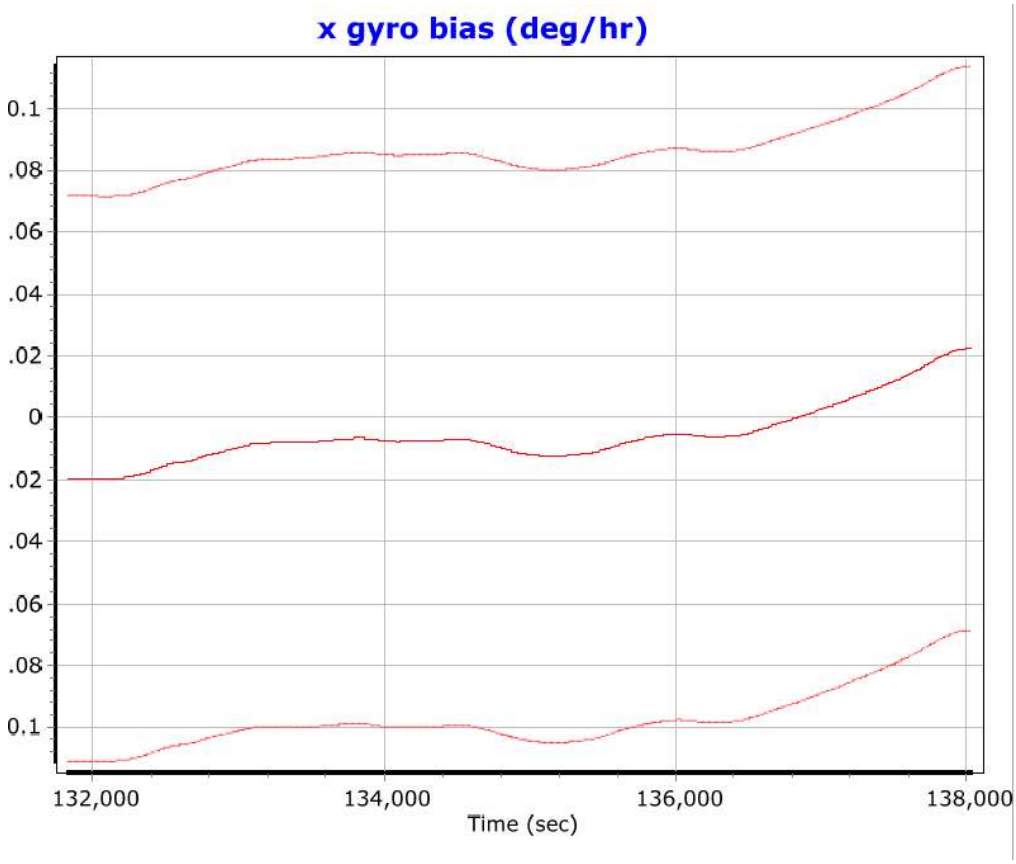
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218120a\05_INS-GPS_PROC\
01_POS\GNSS\6218120a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 19249
No processed position: 3273
Missing Fwd or Rev: 3
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0175 (m)
C/A Code: 0.77 (m)
L1 Doppler: 0.027 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.005 (m)
North: 0.006 (m)
Height: 0.020 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (15972 occurances):
East: 0.005 (m)
North: 0.006 (m)
Height: 0.018 (m)
Quality Number Percentages:
Q 1: 99.8 %
Q 2: 0.2 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 74.364 (km)
Minimum: 1.676 (km)
Average: 33.377 (km)
First Epoch: 35.008 (km)
Last Epoch: 33.313 (km)

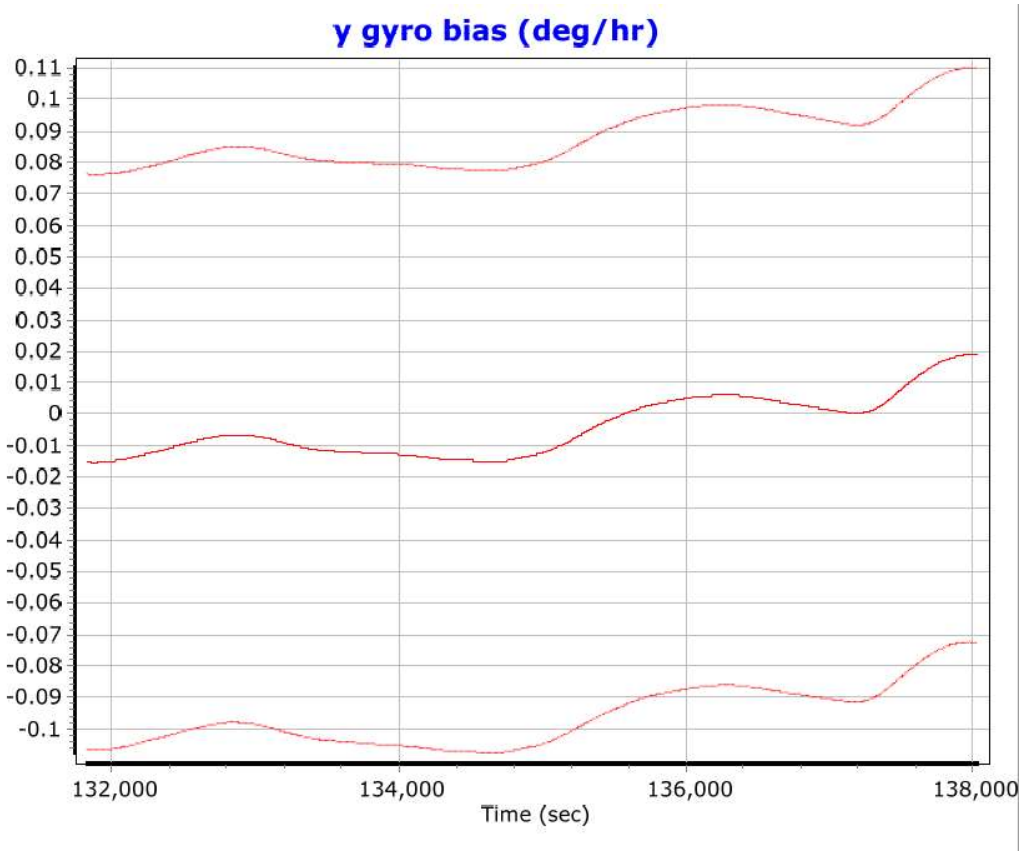
Mission 10 – 6218120a Sensor Errors





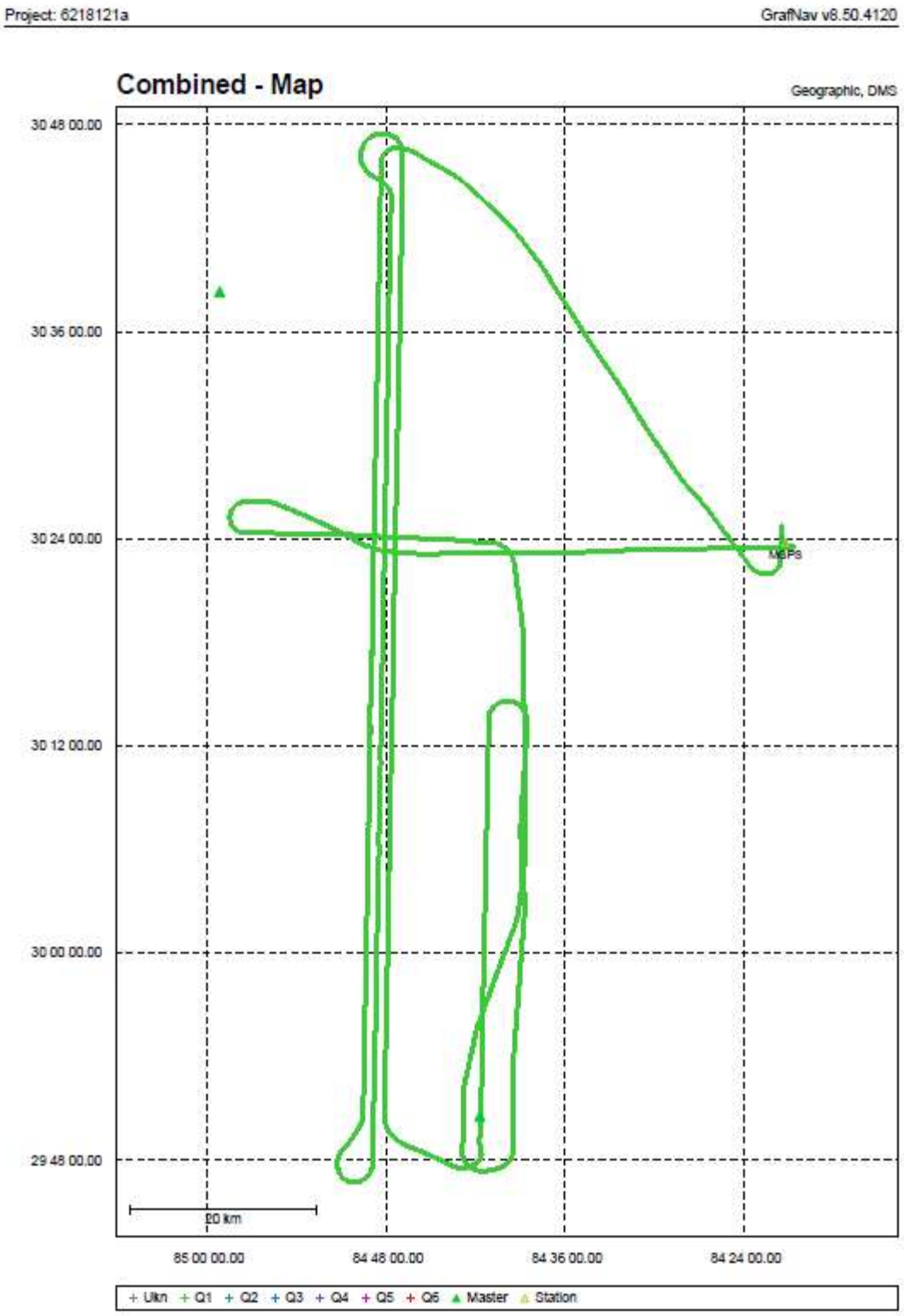

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
132,000
134,000
136,000
138,000
Time (sec)

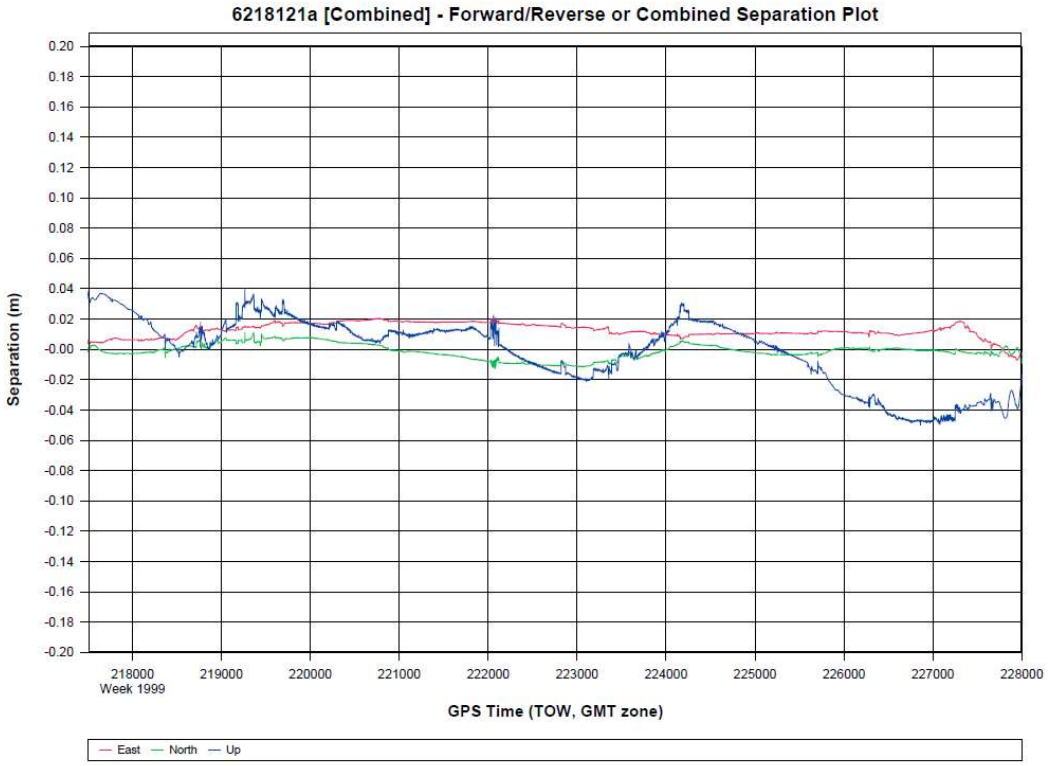

x gyro bias (deg/hr)
0.1
.08
.06
.04
.02
0
.02
.04
.06
.08
0.1
132,000
134,000
136,000
138,000
Time (sec)

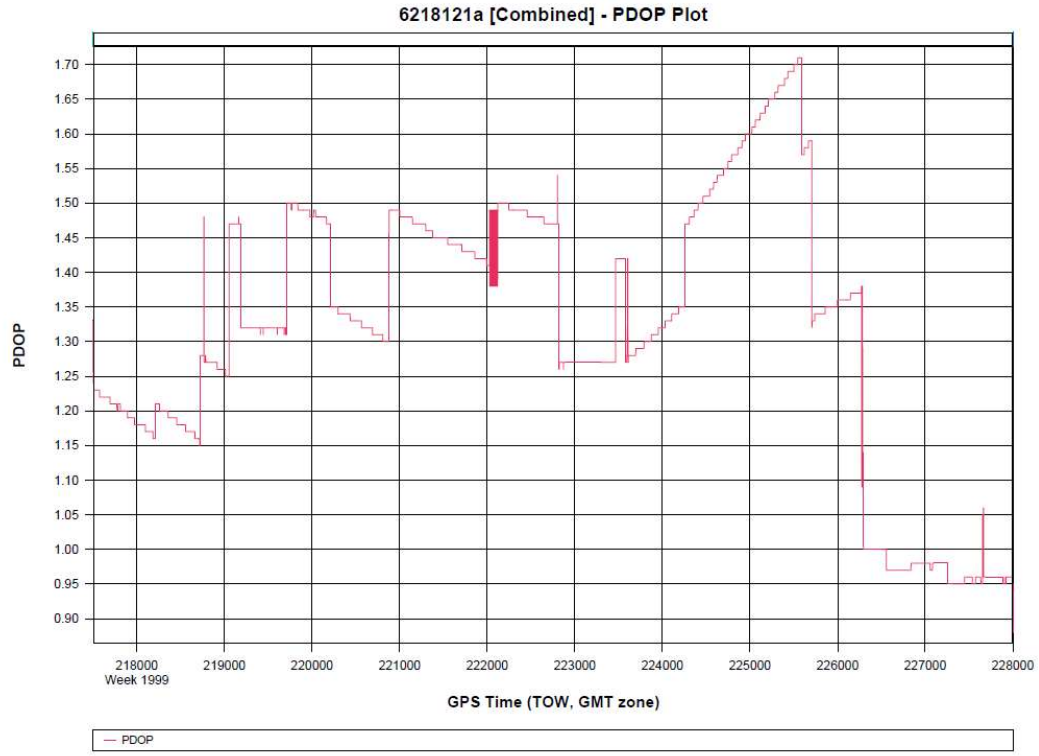

y gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
132,000
134,000
136,000
138,000
Time (sec)

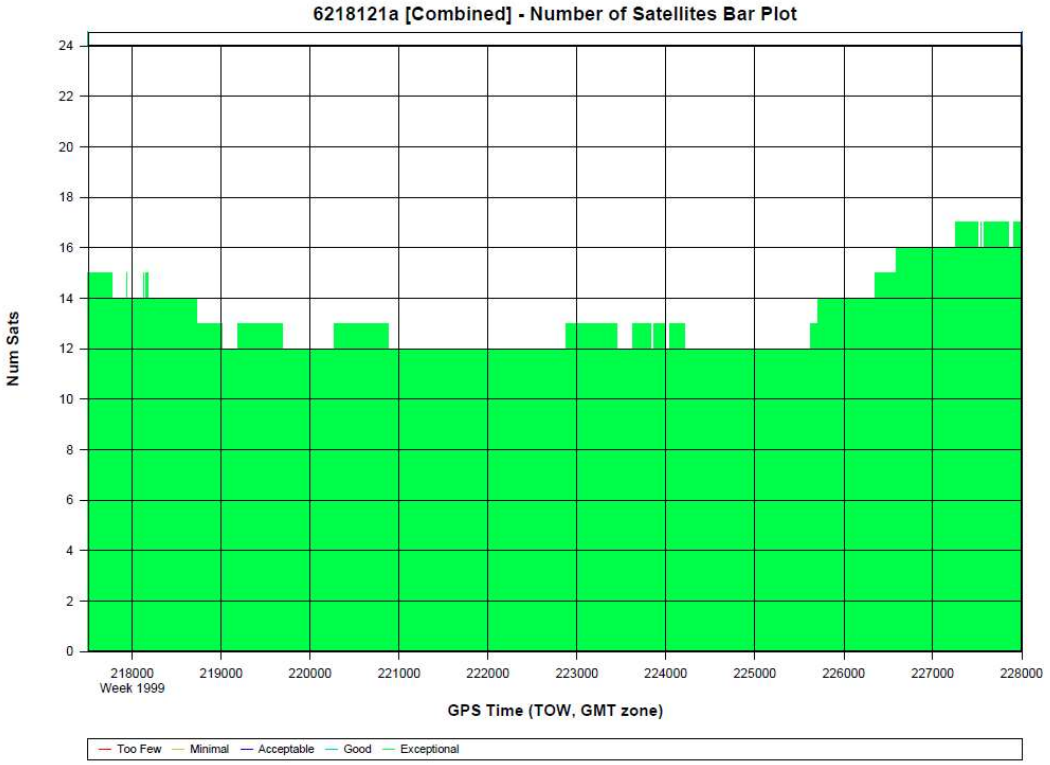

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
132,000
134,000
136,000
138,000
Time (sec)

Mission 11 – 6218121a GNSS Processing



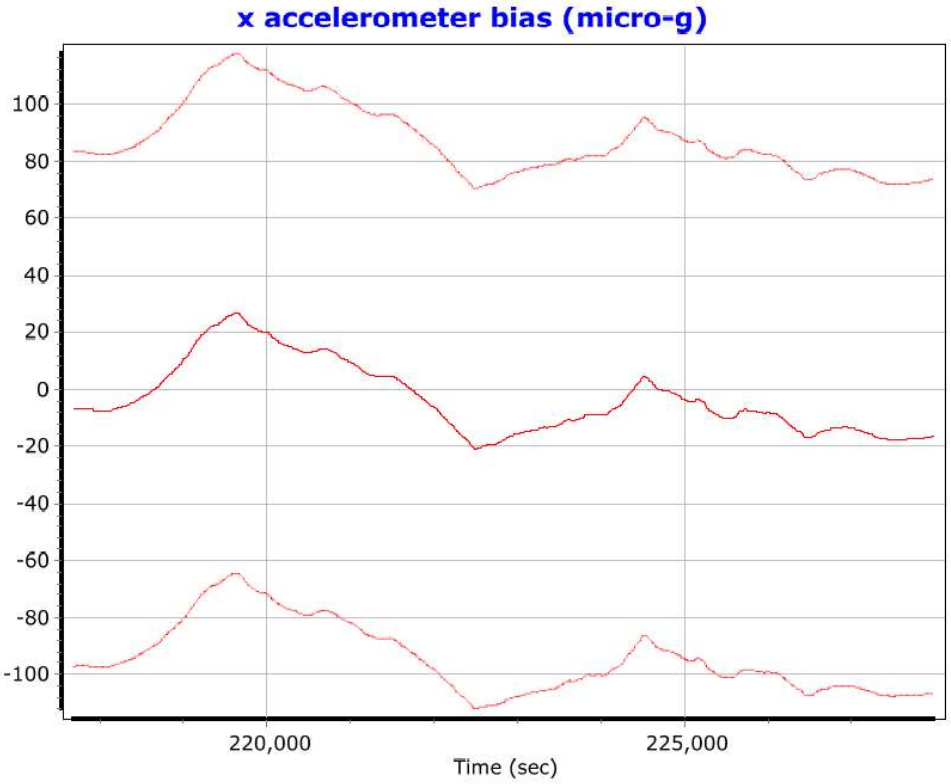

6218121a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
218000
Week 1999
219000
220000
221000
222000
223000
224000
225000
226000
227000
228000
GPS Time (TOW, GMT zone)
East
North
Up

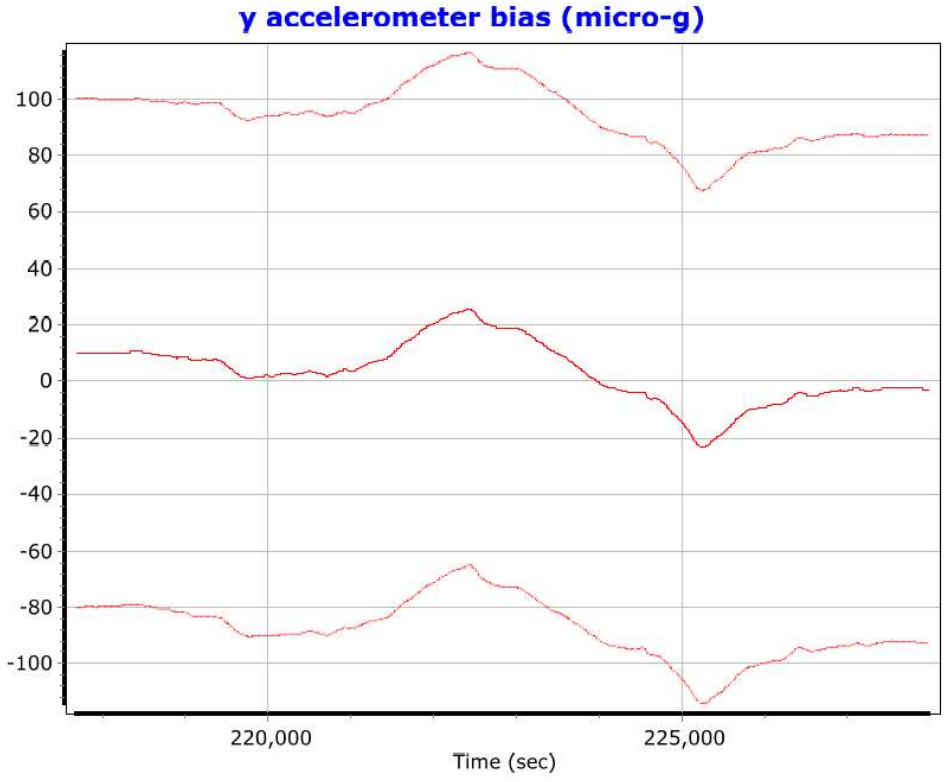

6218121a [Combined] - PDOP Plot
PDOP
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
218000
Week 1999
219000
220000
221000
222000
223000
224000
225000
226000
227000
228000
GPS Time (TOW, GMT zone)
PDOP

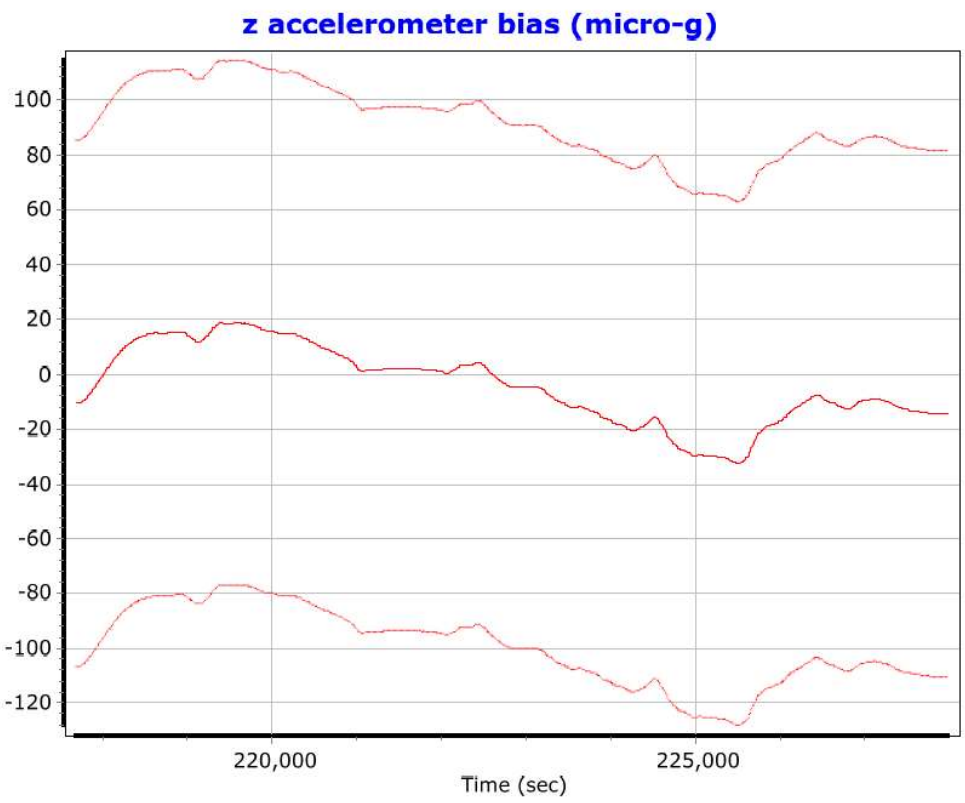

6218121a [Combined] - Number of Satellites Bar Plot
Num Sats
0
2
4
6
8
10
12
14
16
18
20
22
24
218000
Week 1999
219000
220000
221000
222000
223000
224000
225000
226000
227000
228000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

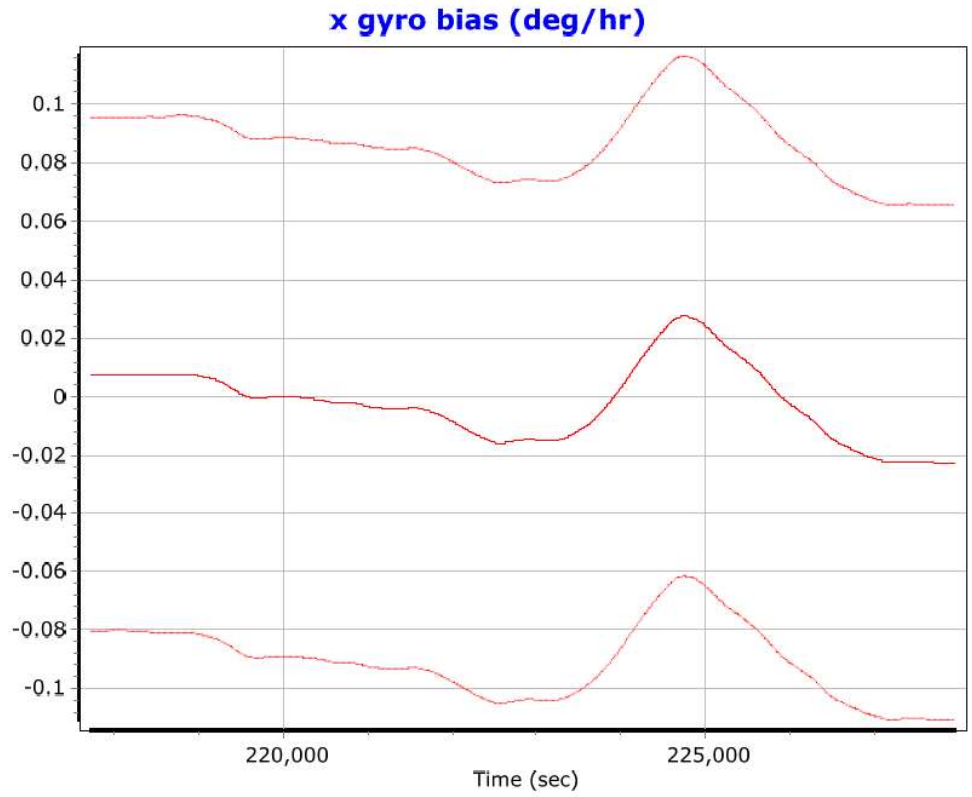
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218121a\05_INS-GPS_PROC\
01_POS\GNSS\6218121a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 10508
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0179 (m)
C/A Code: 0.62 (m)
L1 Doppler: 0.023 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.013 (m)
North: 0.005 (m)
Height: 0.023 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (10502 occurances):
East: 0.013 (m)
North: 0.005 (m)
Height: 0.023 (m)
Quality Number Percentages:
Q 1: 99.5 %
Q 2: 0.5 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 58.818 (km)
Minimum: 3.518 (km)
Average: 30.484 (km)
First Epoch: 32.799 (km)
Last Epoch: 33.031 (km)

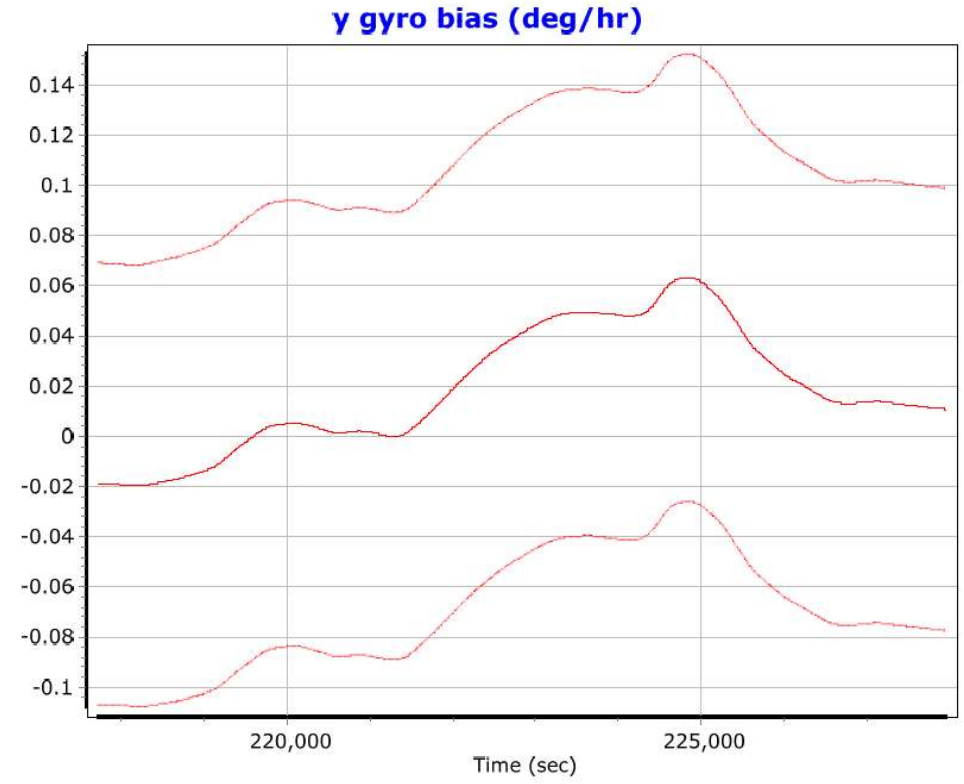
Mission 11 – 6218121a Sensor Errors

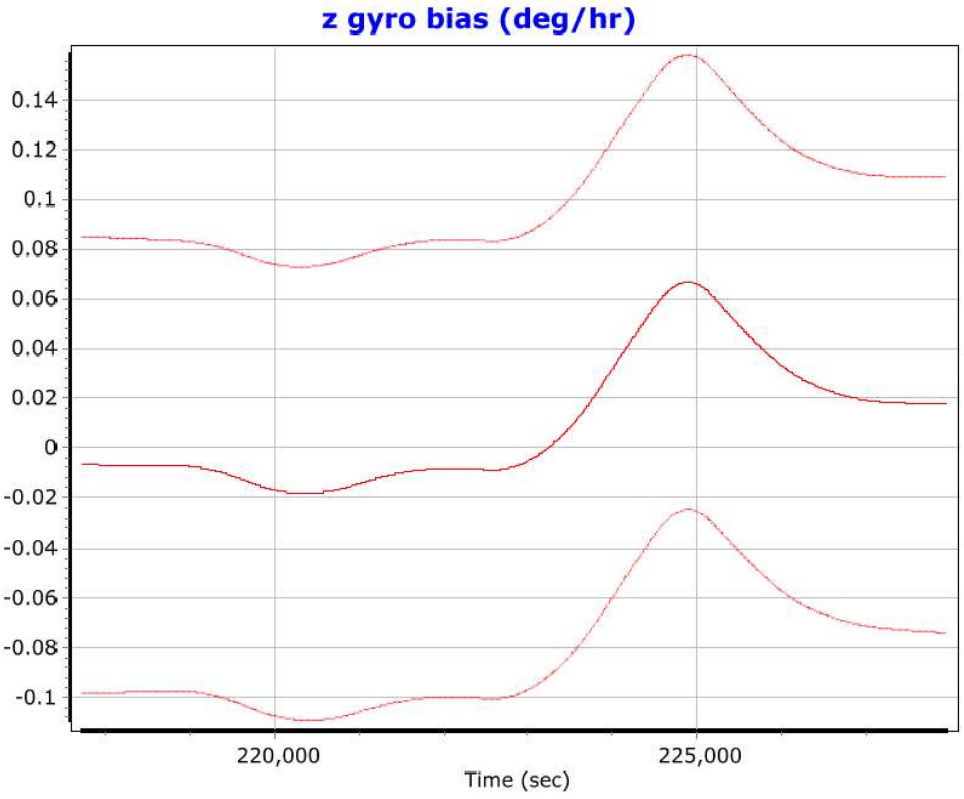




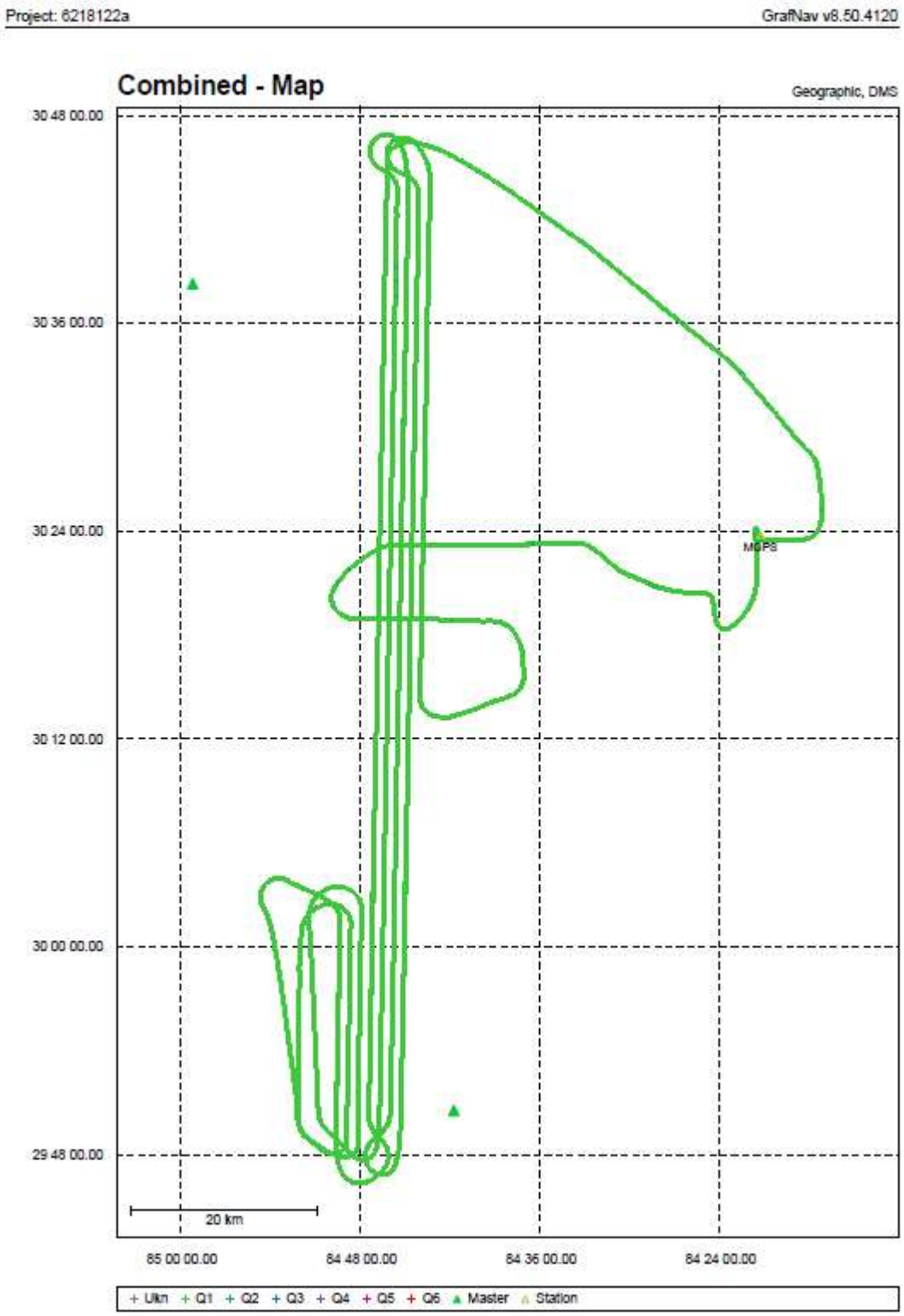

z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
220,000
225,000
Time (sec)

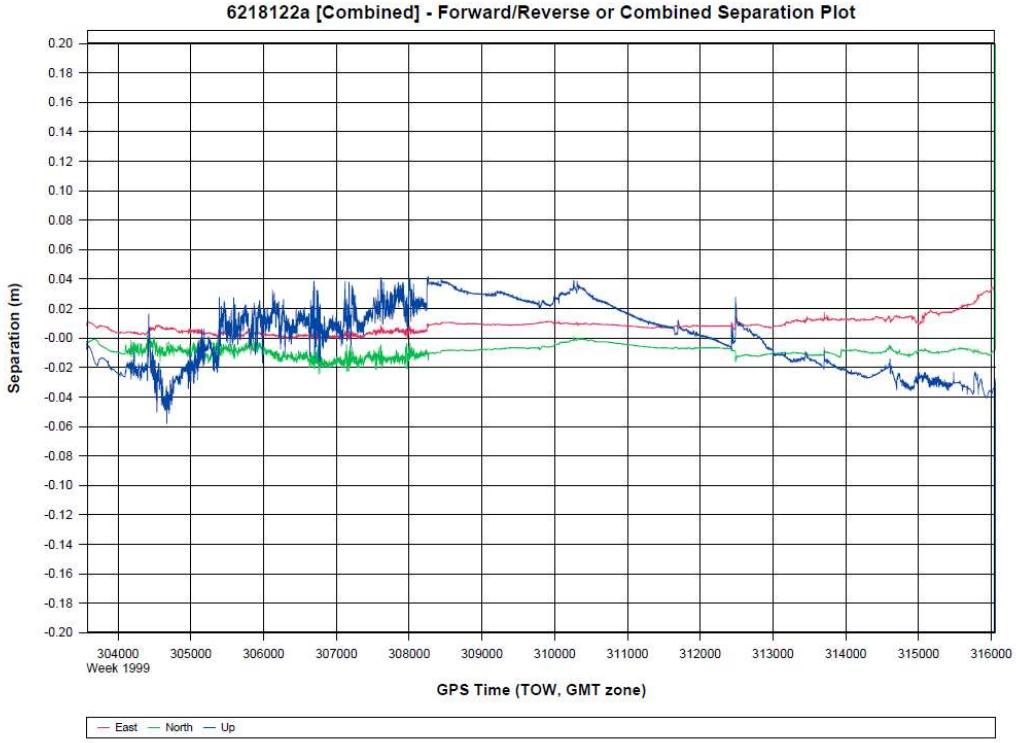

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
220,000
225,000
Time (sec)

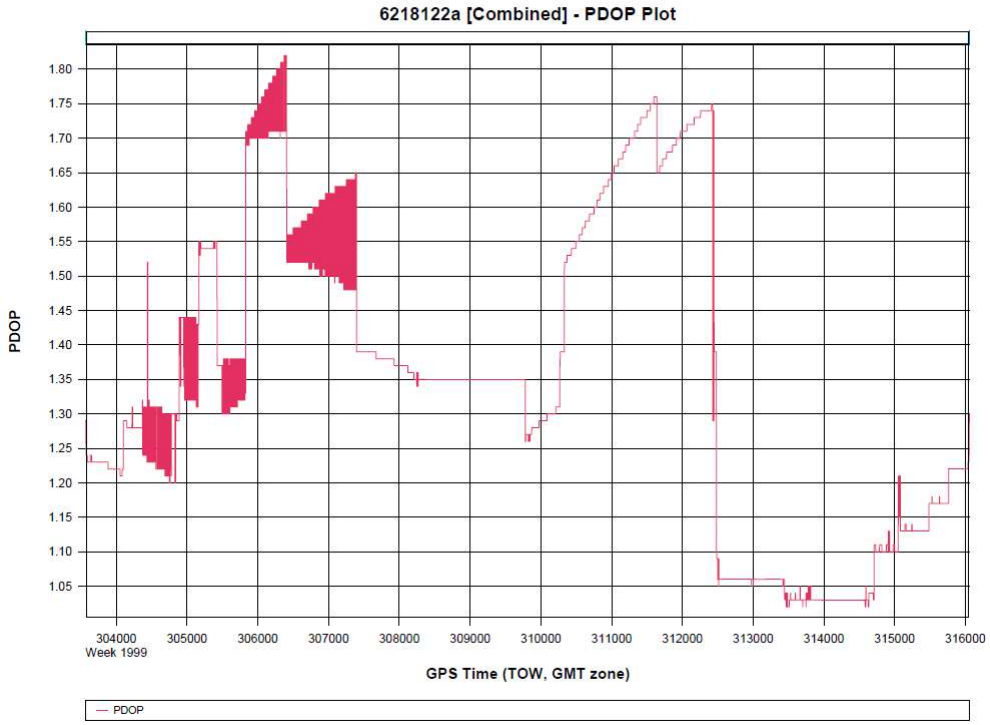

y gyro bias (deg/hr)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
220,000
225,000
Time (sec)

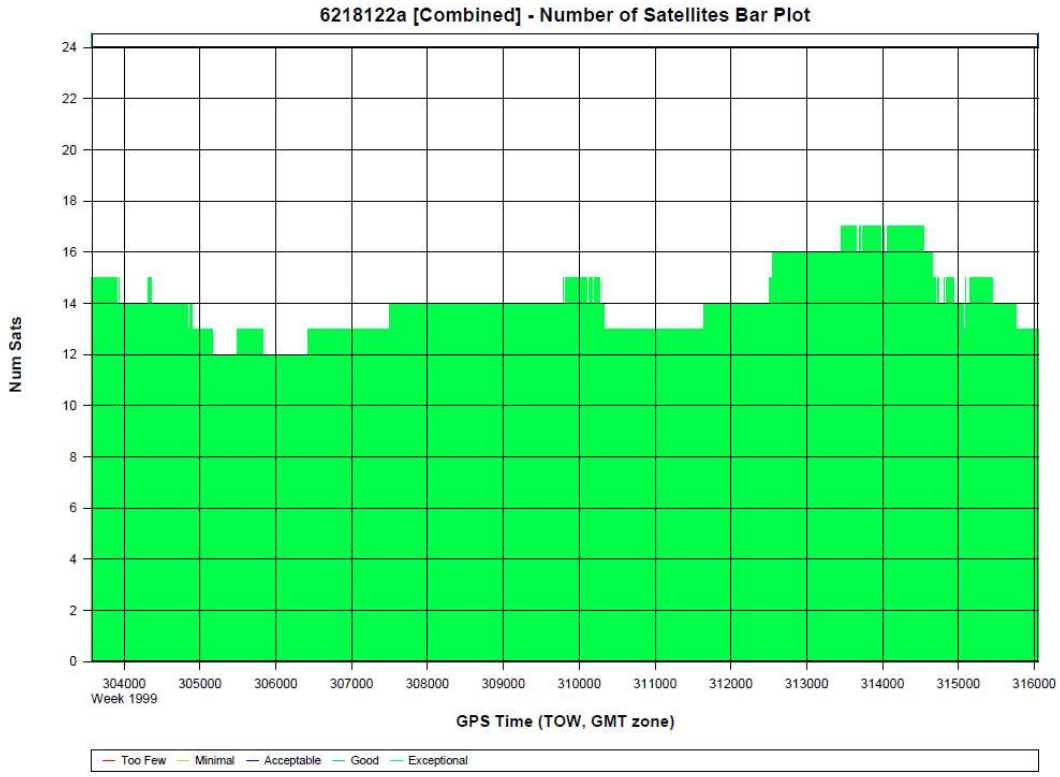

z gyro bias (deg/hr)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
220,000
225,000
Time (sec)

Mission 12 – 6218122a GNSS Processing



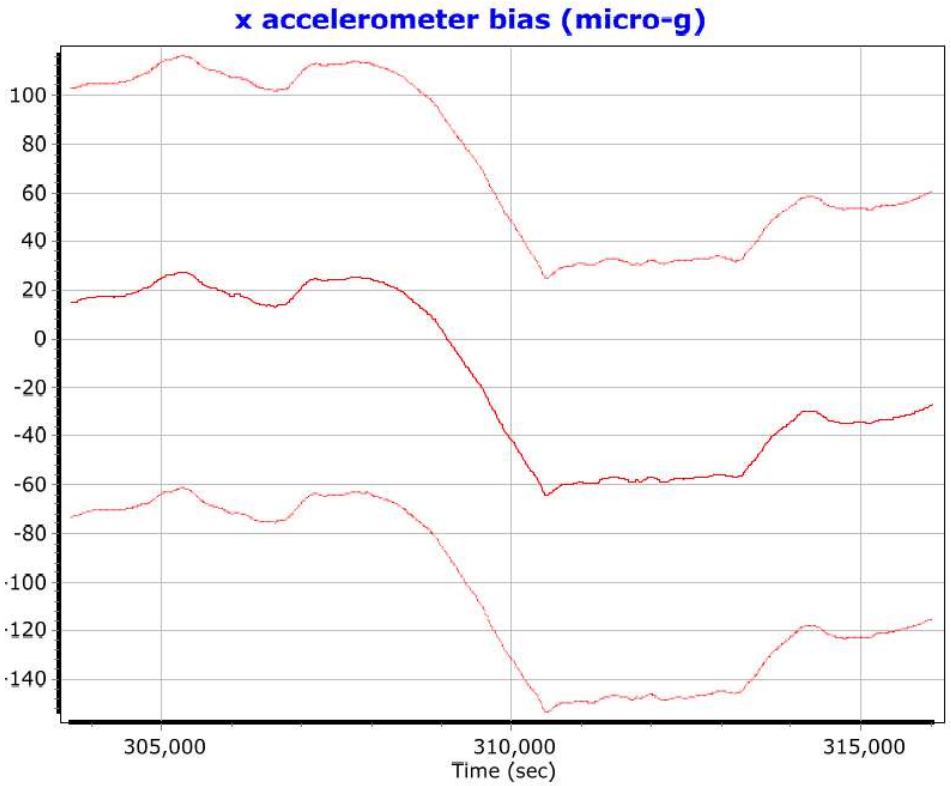

6218122a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
304000
Week 1999
305000
306000
307000
308000
309000
310000
311000
312000
313000
314000
315000
316000
GPS Time (TOW, GMT zone)
East
North
Up

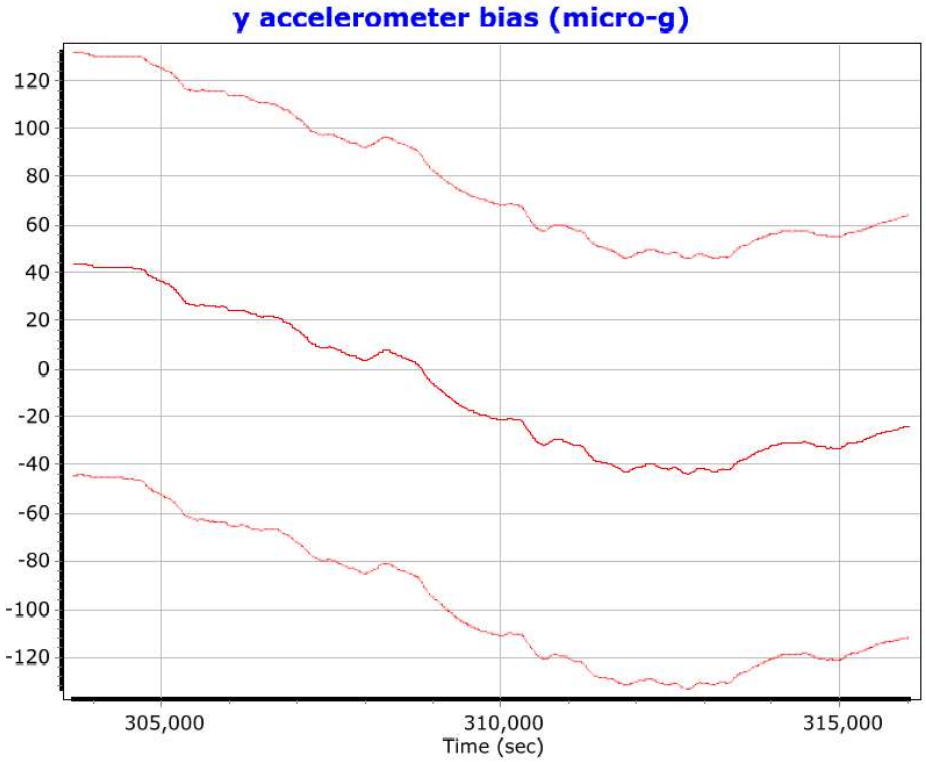

6218122a [Combined] - PDOP Plot
PDOP
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
304000
Week 1999
305000
306000
307000
308000
309000
310000
311000
312000
313000
314000
315000
316000
GPS Time (TOW, GMT zone)
PDOP

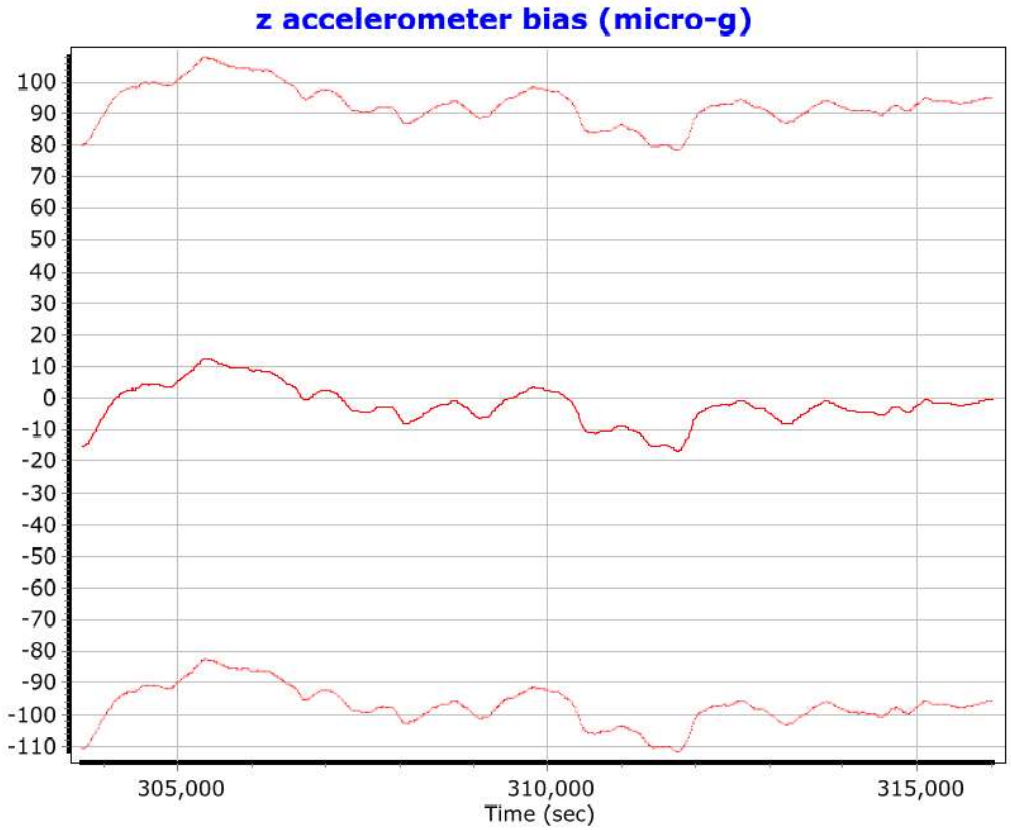

6218122a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
304000
Week 1999
305000
306000
307000
308000
309000
310000
311000
312000
313000
314000
315000
316000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

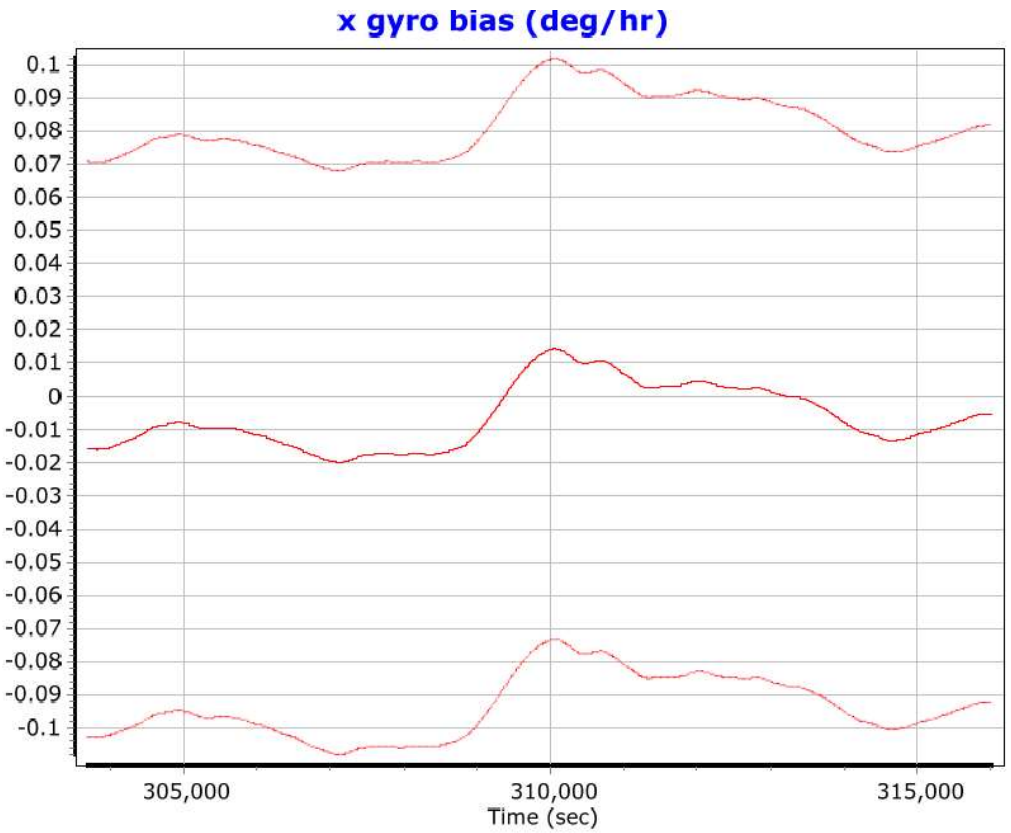
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218122a\05_INS-GPS_PROC\
01_POS\GNSS\6218122a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 12492
No processed position: 0
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0175 (m)
C/A Code: 0.67 (m)
L1 Doppler: 0.023 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.010 (m)
North: 0.012 (m)
Height: 0.030 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (12487 occurances):
East: 0.010 (m)
North: 0.010 (m)
Height: 0.022 (m)
Quality Number Percentages:
Q 1: 99.2 %
Q 2: 0.8 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 58.725 (km)
Minimum: 2.249 (km)
Average: 31.943 (km)
First Epoch: 32.931 (km)
Last Epoch: 33.190 (km)

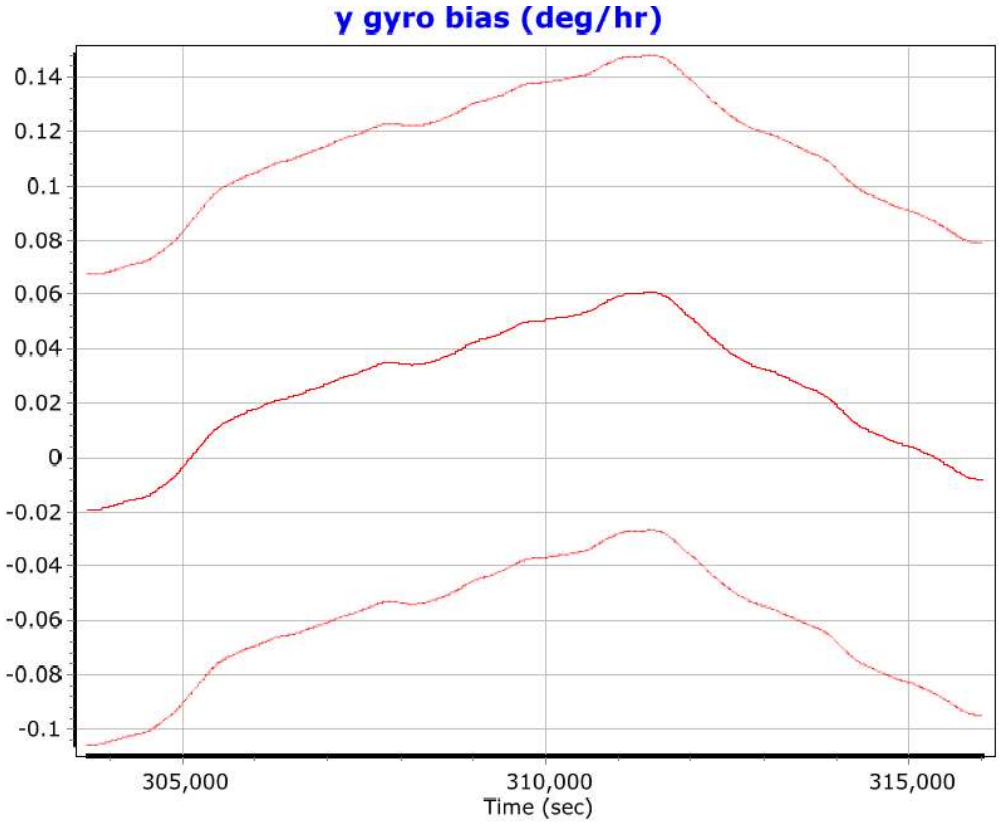
Mission 12 – 6218122a Sensor Errors

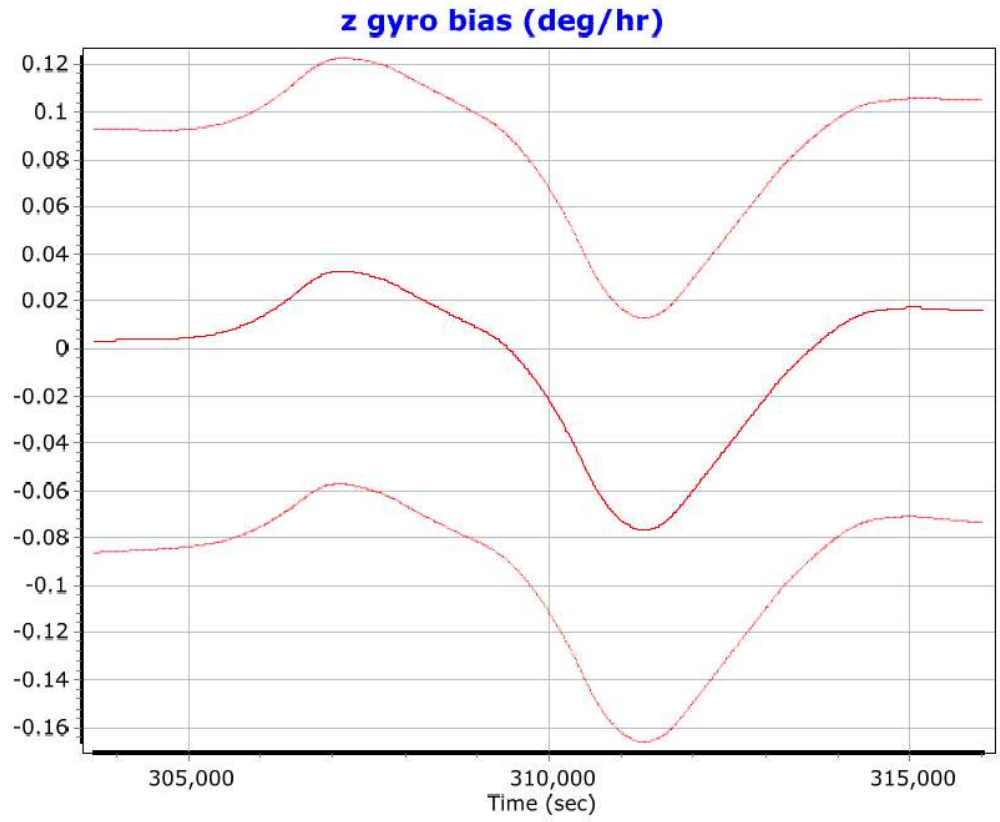





z accelerometer bias (micro-g)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
305,000
310,000
315,000
Time (sec)

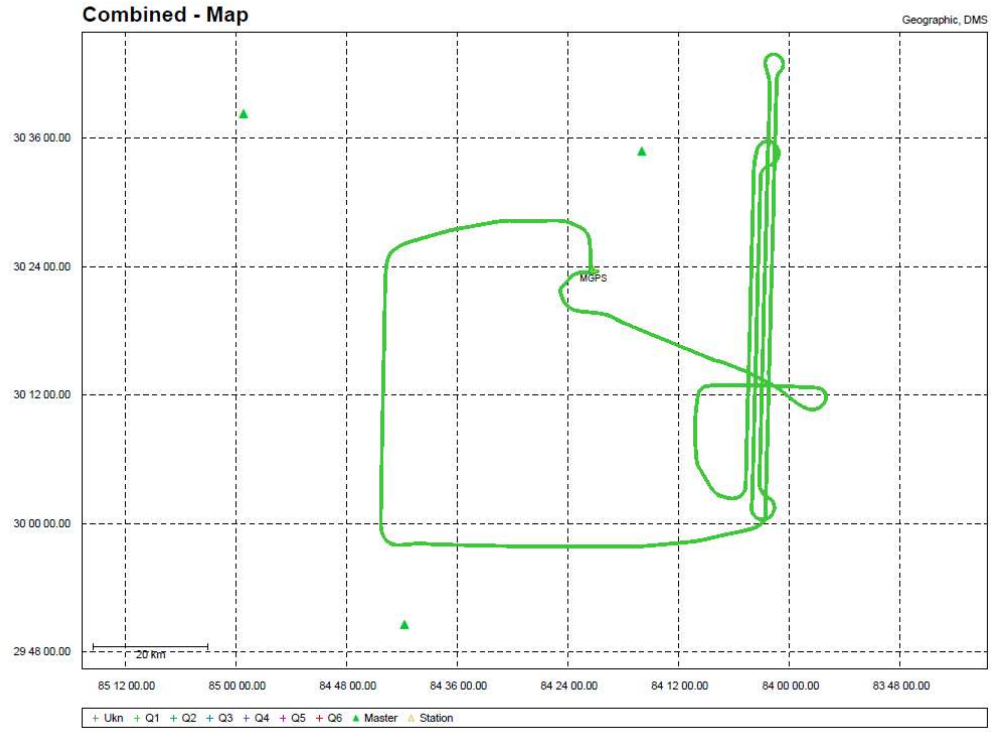

x gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
305,000
310,000
315,000
Time (sec)


y gyro bias (deg/hr)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
305,000
310,000
315,000
Time (sec)

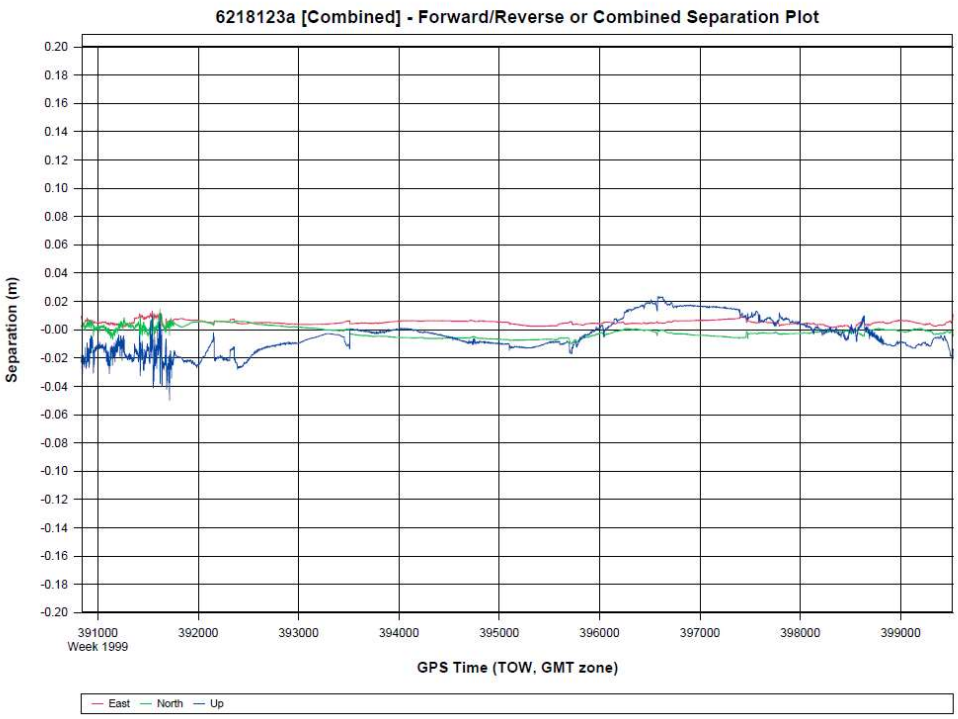

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
305,000
310,000
315,000
Time (sec)

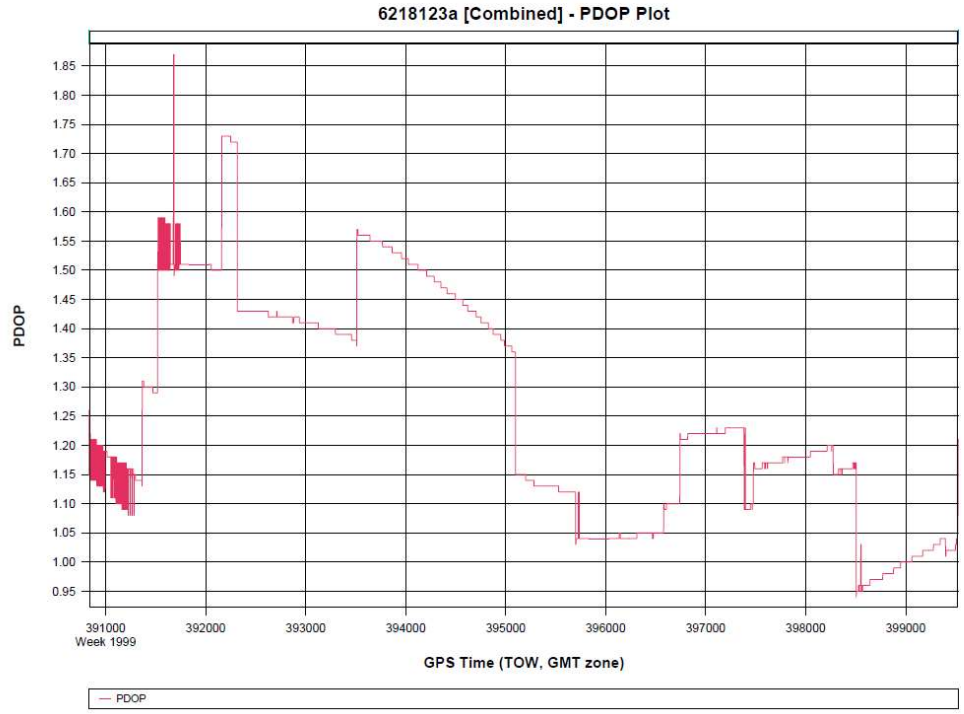
Mission 13 – 6218123a GNSS Processing

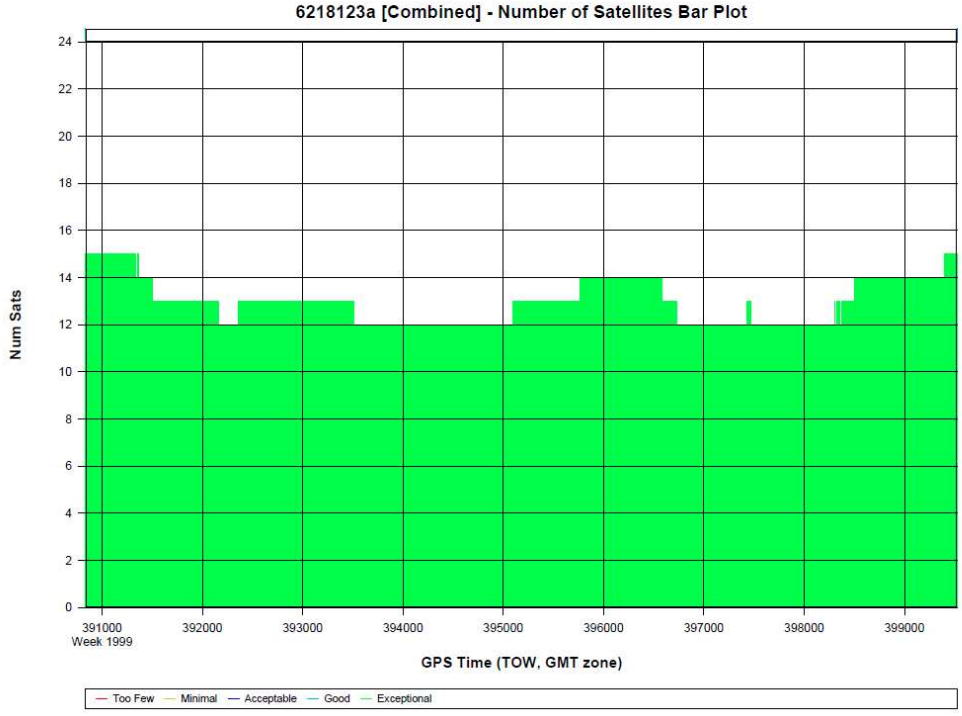
Project: 6218123a GrafNav v8.50.4120



Project: 6218123a GrafNav v8.50.4120

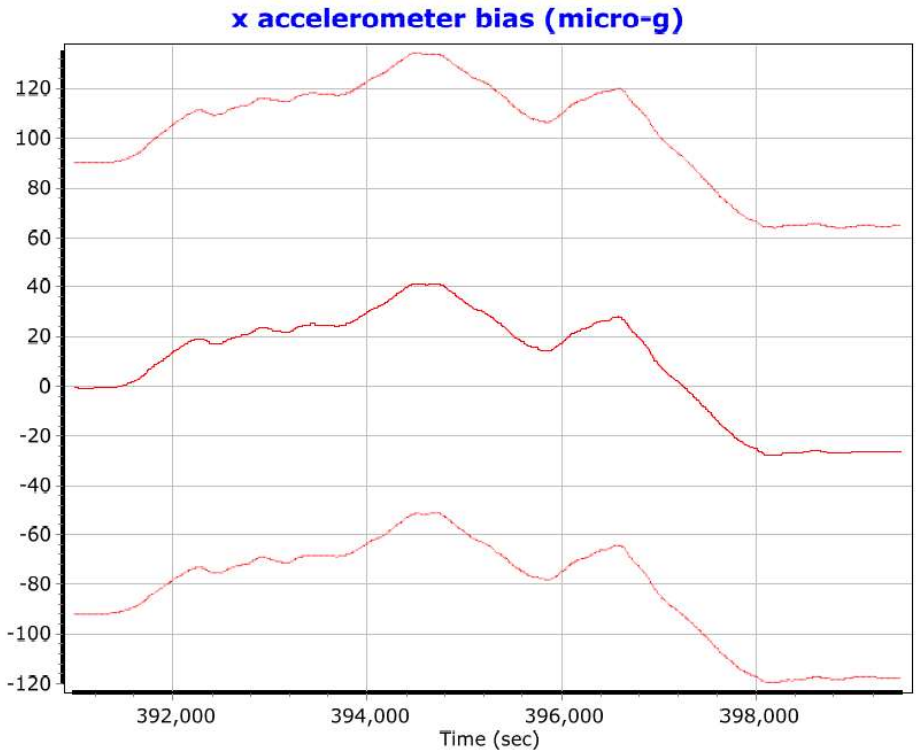


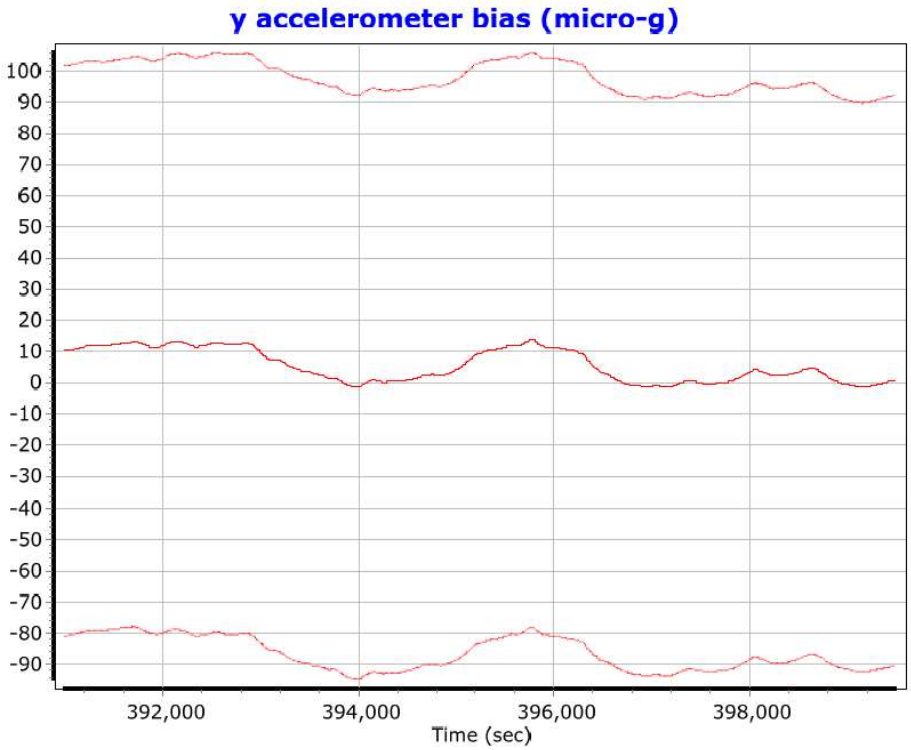

6218123a [Combined] - PDOP Plot
PDOP
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
391000
Week 1999
392000
393000
394000
395000
396000
397000
398000
399000
GPS Time (TOW, GMT zone)
PDOP

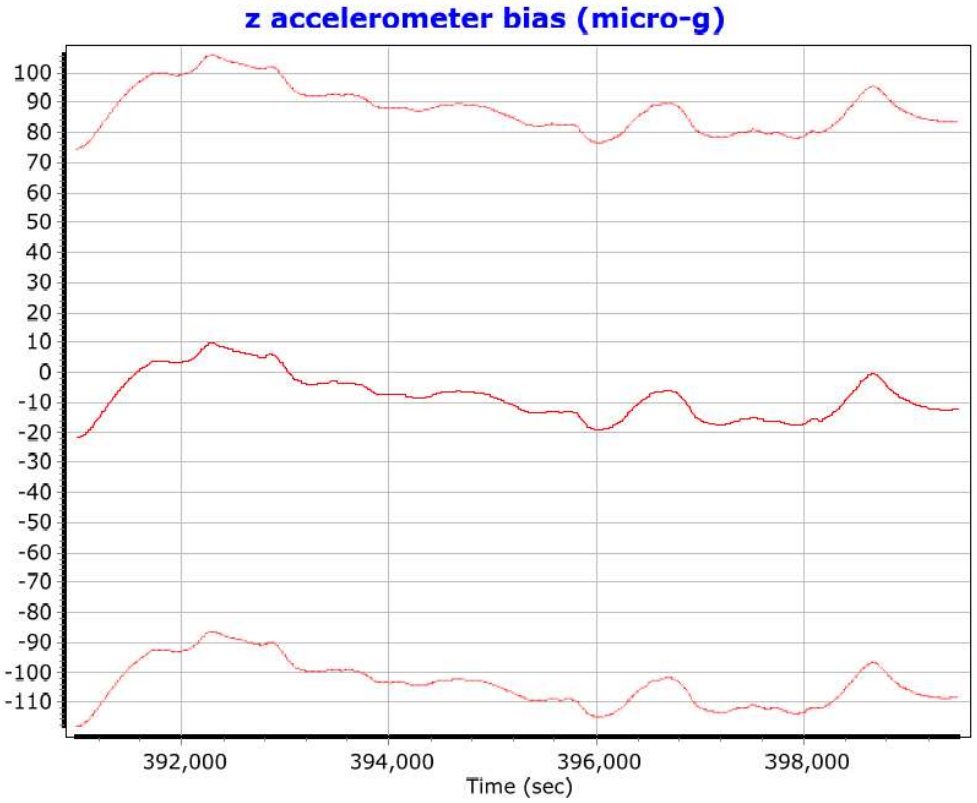

6218123a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
391000
Week 1999
392000
393000
394000
395000
396000
397000
398000
399000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

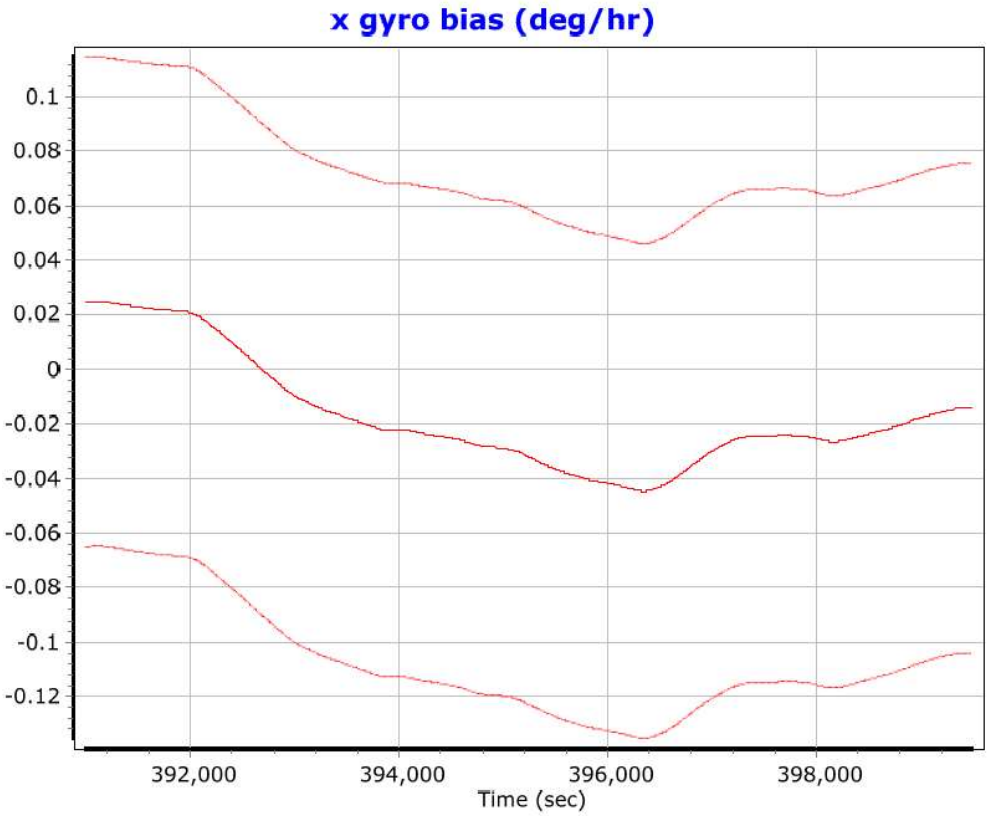
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218123a\05_INS-GPS_PROC\
01_POS\GNSS\6218123a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 8695
No processed position: 0
Missing Fwd or Rev: 5
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0154 (m)
C/A Code: 0.66 (m)
L1 Doppler: 0.021 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.005 (m)
North: 0.004 (m)
Height: 0.012 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (8690 occurances):
East: 0.005 (m)
North: 0.004 (m)
Height: 0.012 (m)
Quality Number Percentages:
Q 1: 99.6 %
Q 2: 0.4 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 66.774 (km)
Minimum: 7.893 (km)
Average: 41.486 (km)
First Epoch: 21.458 (km)
Last Epoch: 21.078 (km)

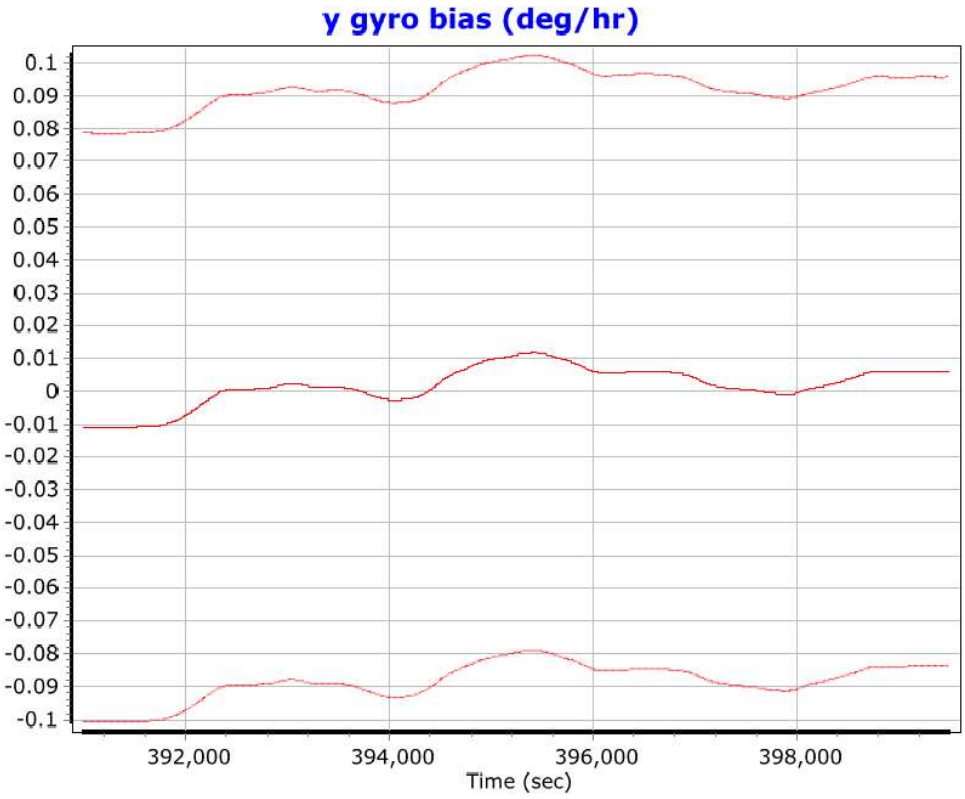
Mission 13 – 6218123a Sensor Errors

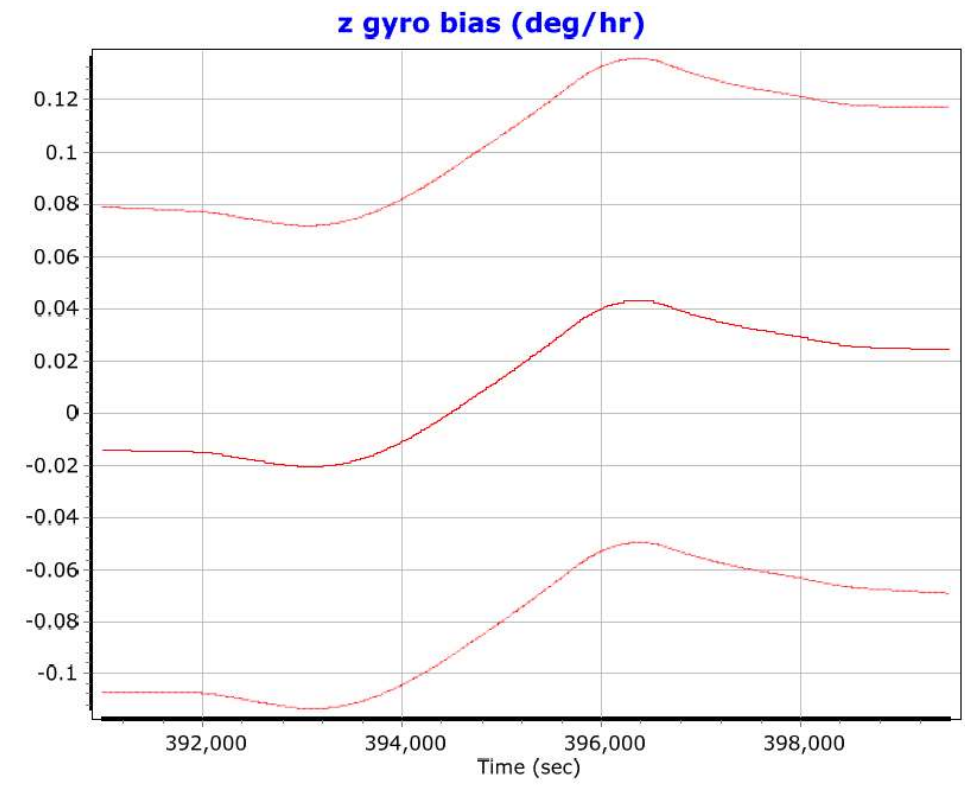




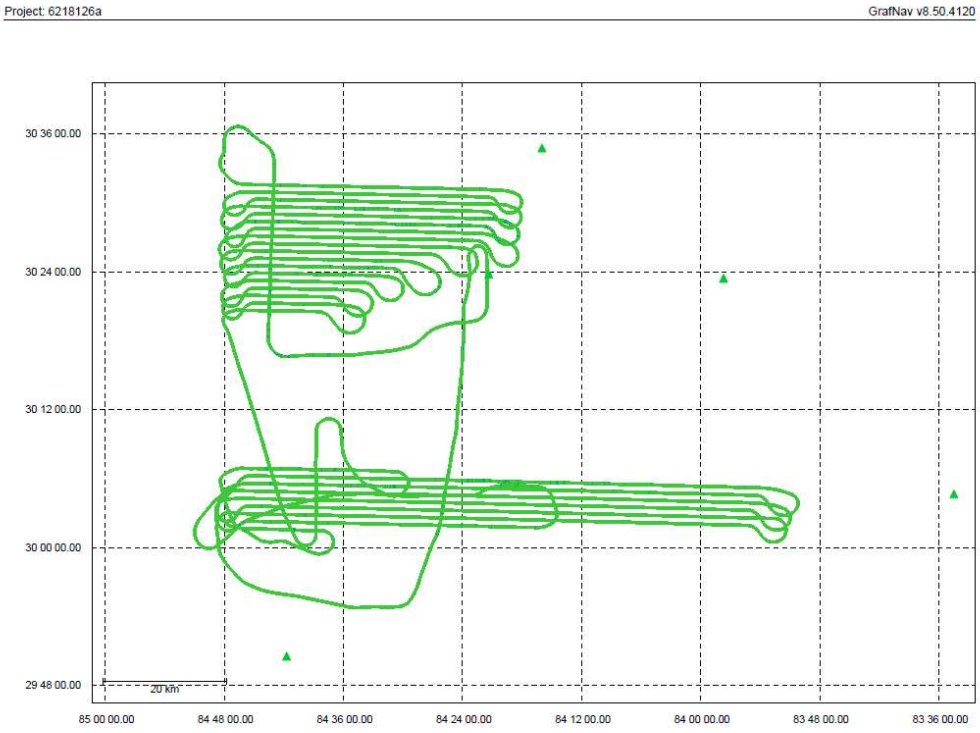

z accelerometer bias (micro-g)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
392,000
394,000
396,000
398,000
Time (sec)

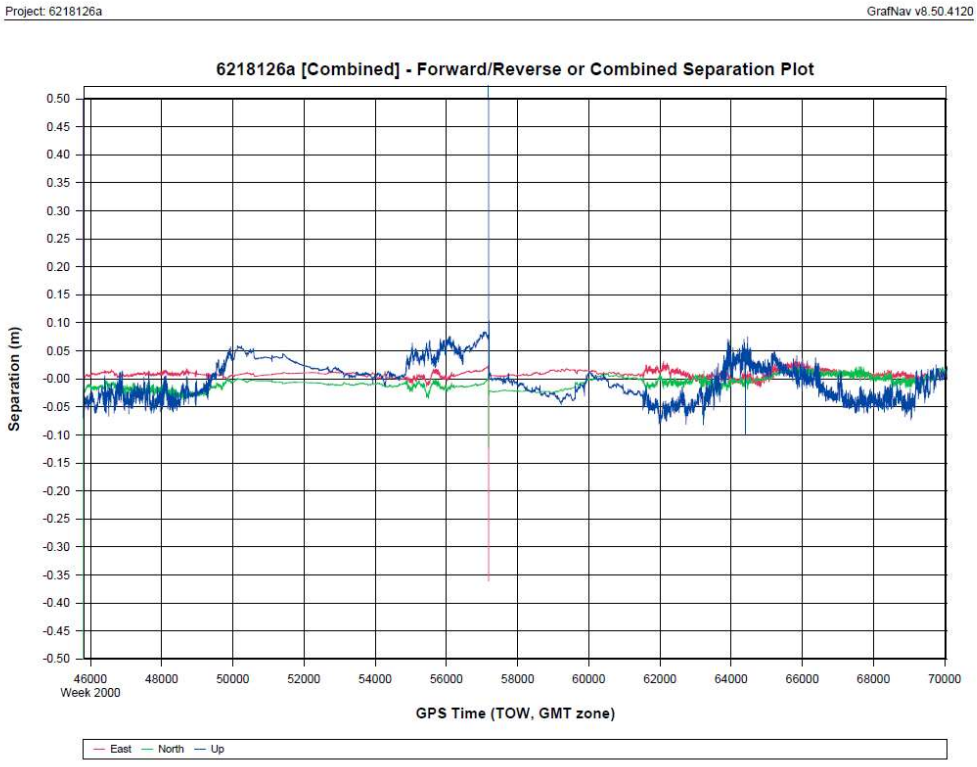

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
392,000
394,000
396,000
398,000
Time (sec)

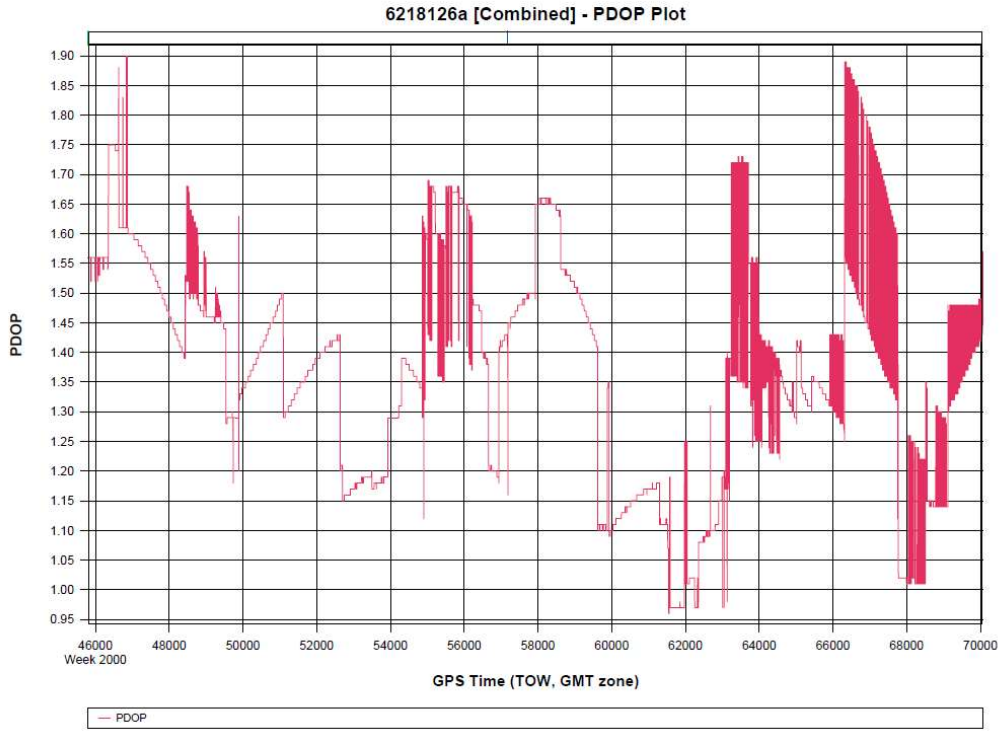

y gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
392,000
394,000
396,000
398,000
Time (sec)

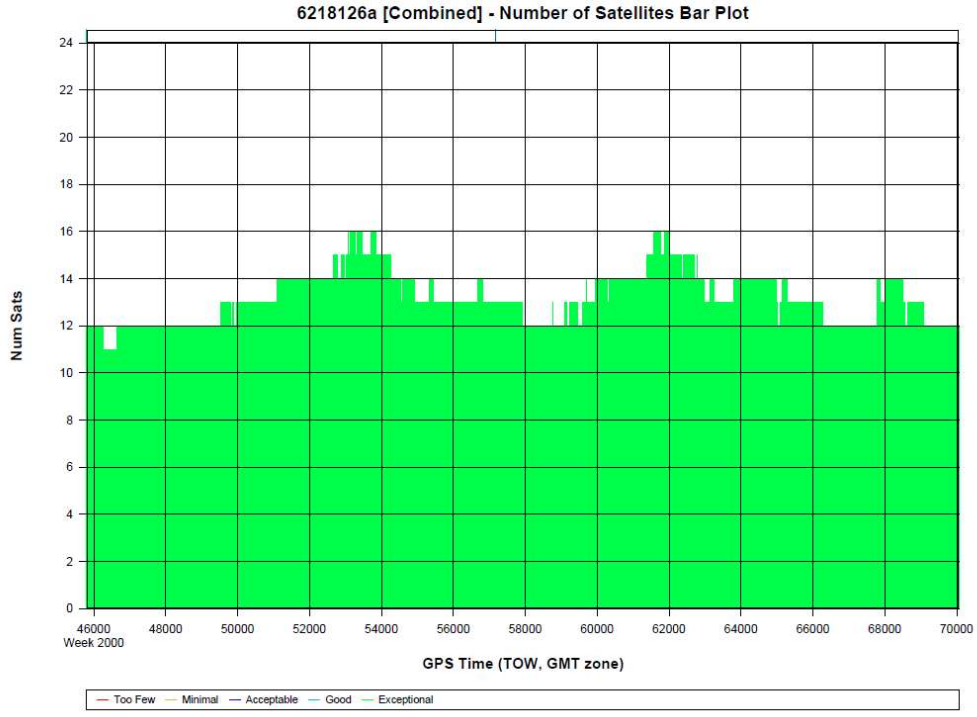

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
392,000
394,000
396,000
398,000
Time (sec)

Mission 14 – 6218126a GNSS Processing



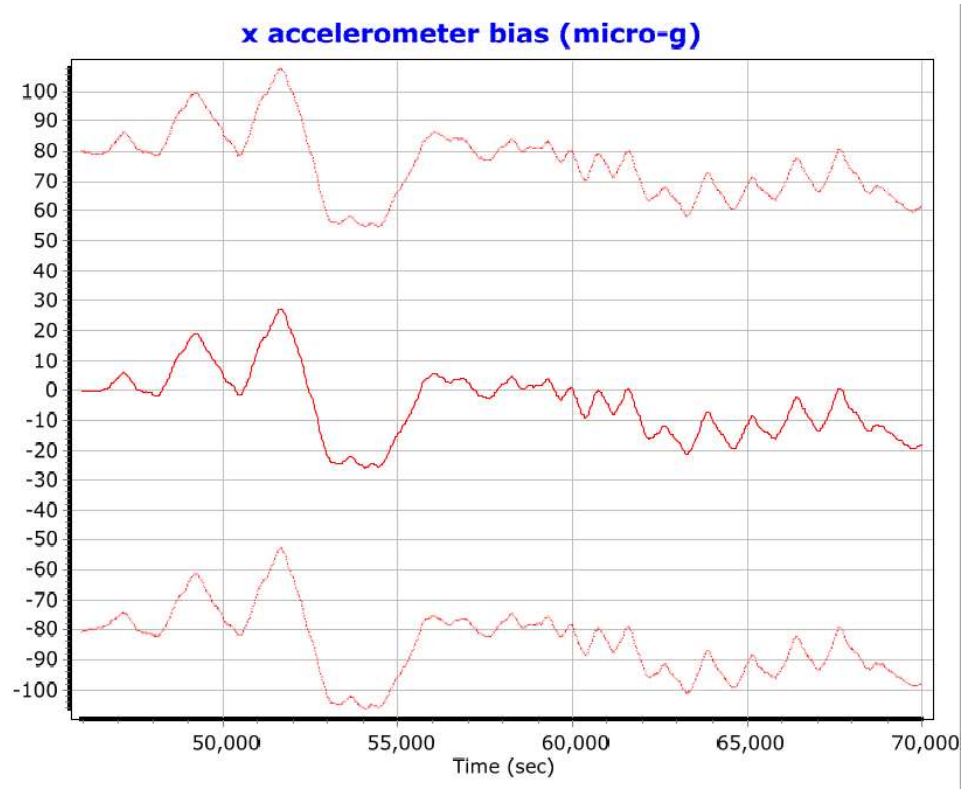


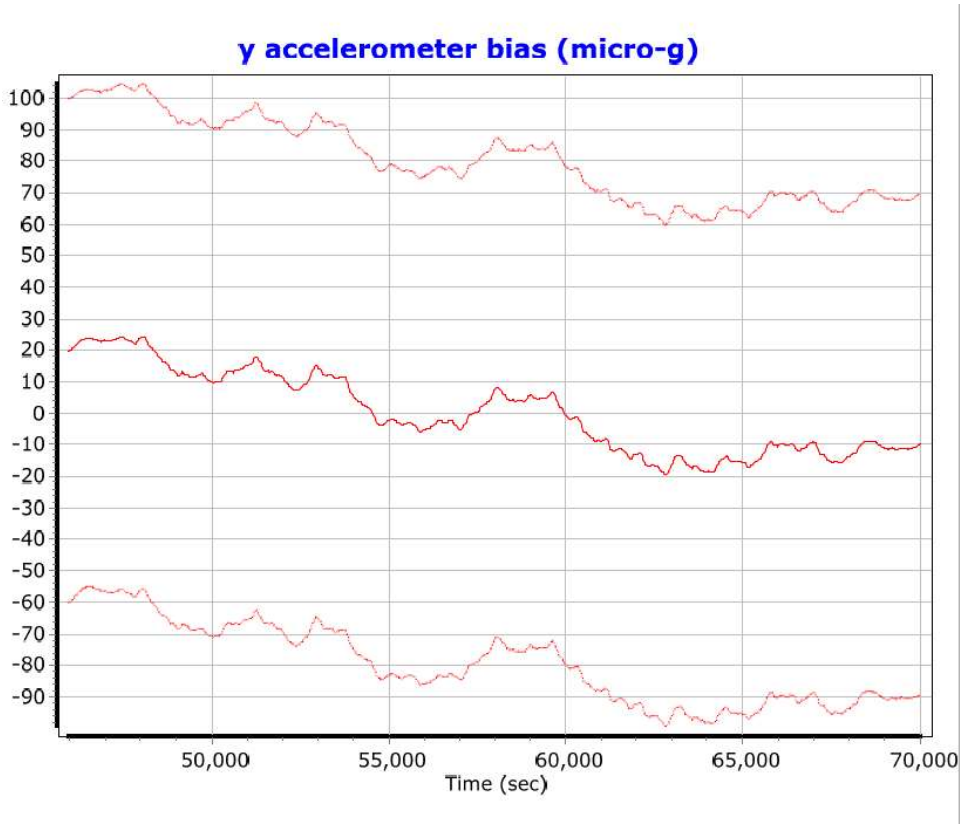

6218126a [Combined] - PDOP Plot
PDOP
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
46000
Week 2000
48000
50000
52000
54000
56000
58000
60000
62000
64000
66000
68000
70000
GPS Time (TOW, GMT zone)
PDOP

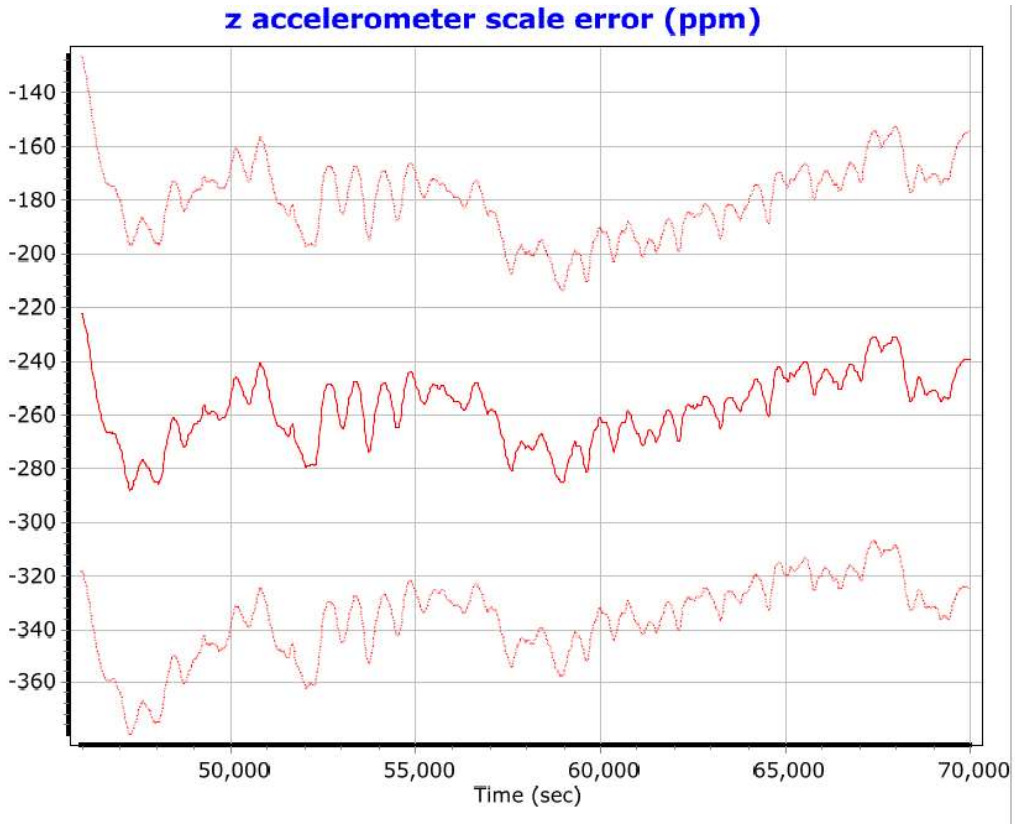

6218126a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
46000
Week 2000
48000
50000
52000
54000
56000
58000
60000
62000
64000
66000
68000
70000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218126a\05_INS-GPS_PROC\
01_POS\GNSS\6218126a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 24272
No processed position: 1
Missing Fwd or Rev: 5
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0245 (m)
C/A Code: 0.74 (m)
L1 Doppler: 0.022 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.012 (m)
North: 0.015 (m)
Height: 0.036 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (24264 occurances):
East: 0.010 (m)
North: 0.014 (m)
Height: 0.033 (m)
Quality Number Percentages:
Q 1: 97.7 %
Q 2: 2.3 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 61.059 (km)
Minimum: 0.613 (km)
Average: 31.680 (km)
First Epoch: 7.479 (km)
Last Epoch: 6.773 (km)

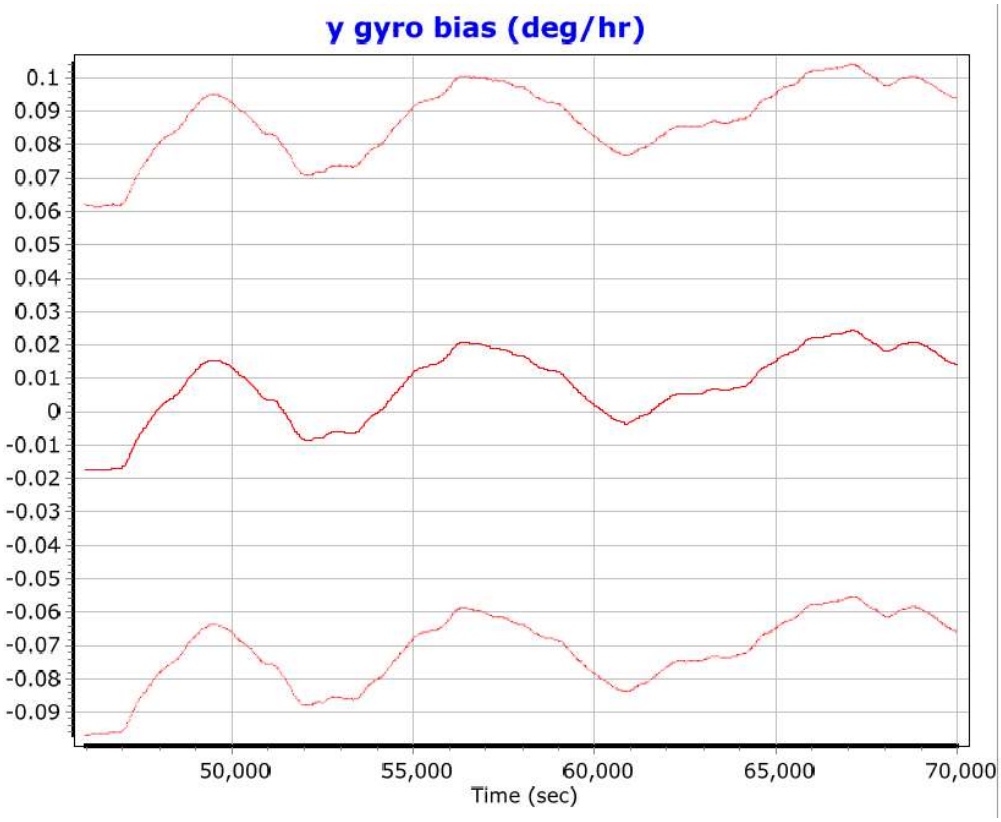
Mission 14 – 6218126a Sensor Errors

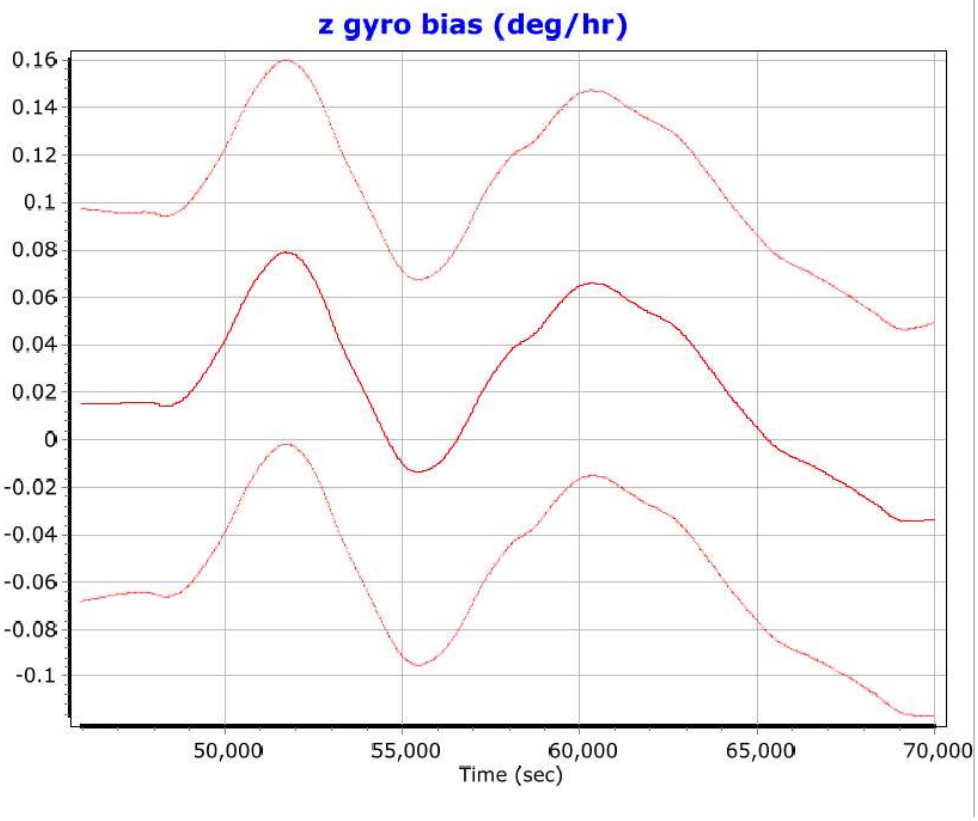




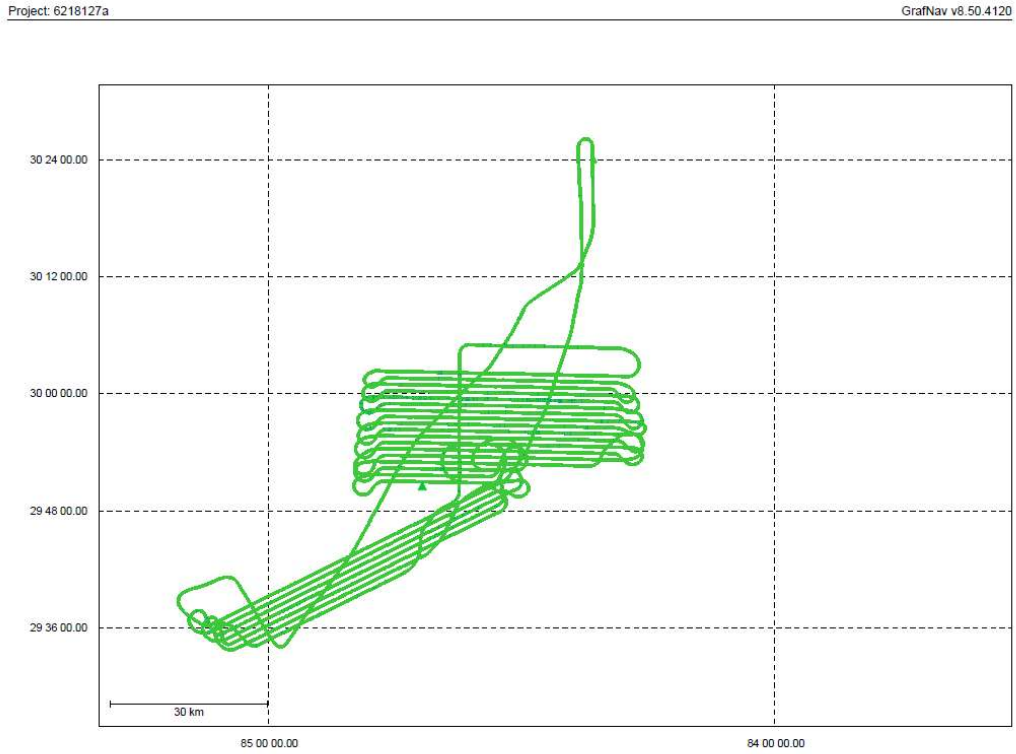

z accelerometer scale error (ppm)
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
50,000
55,000
60,000
65,000
70,000
Time (sec)

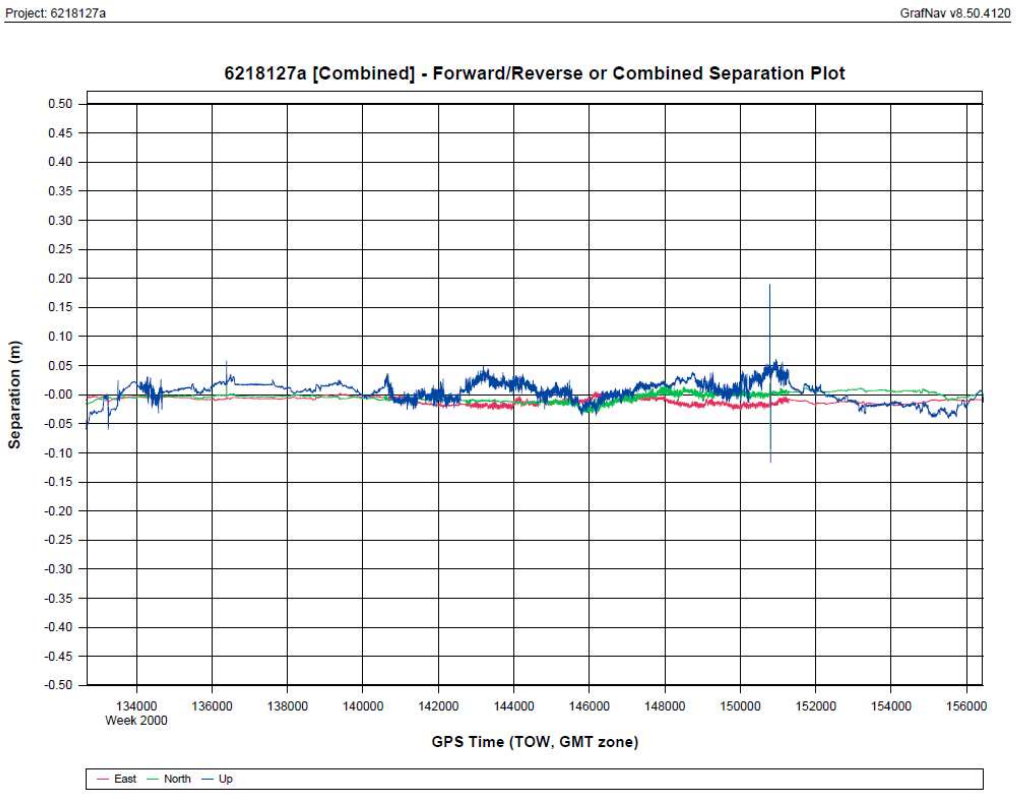

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
50,000
55,000
60,000
65,000
70,000
Time (sec)

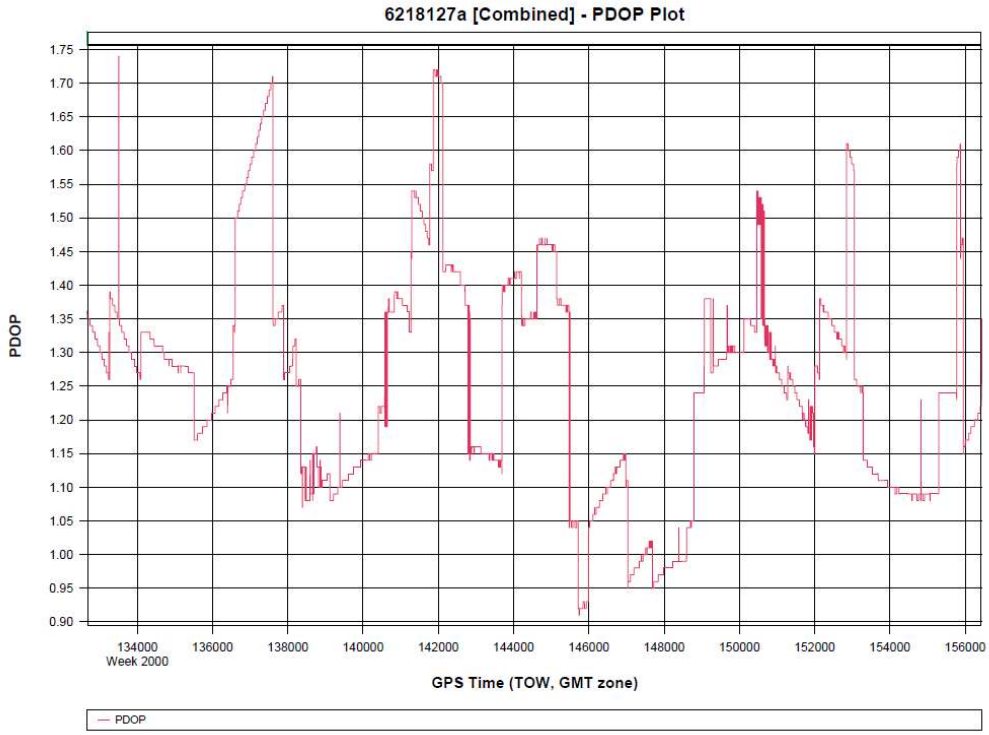

y gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
50,000
55,000
60,000
65,000
70,000
Time (sec)

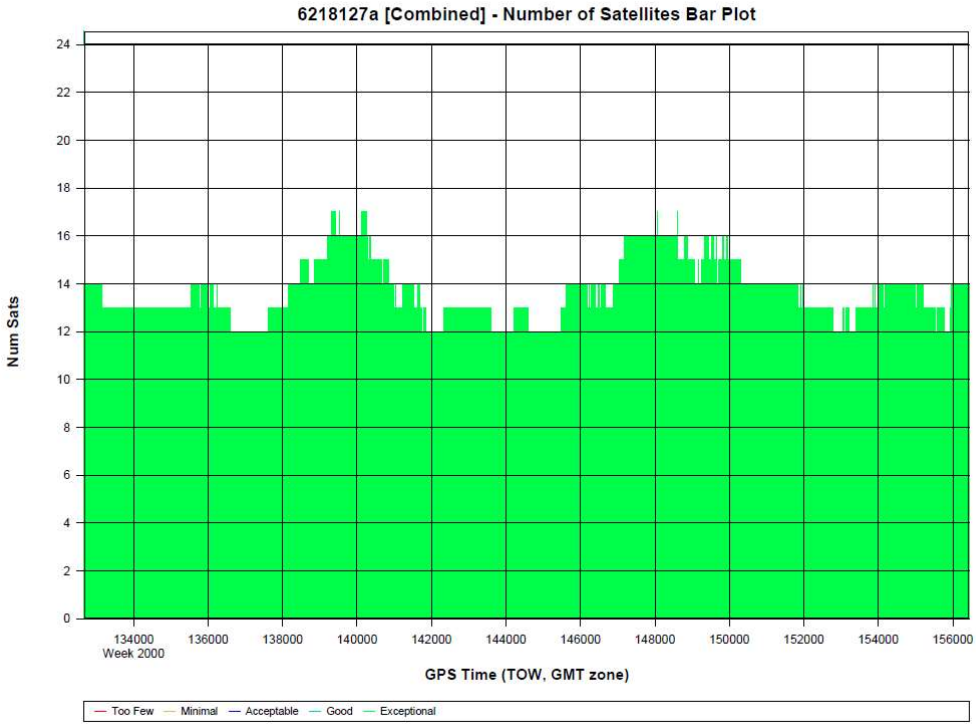

z gyro bias (deg/hr)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
50,000
55,000
60,000
65,000
70,000
Time (sec)

Mission 15 – 6218127a GNSS Processing



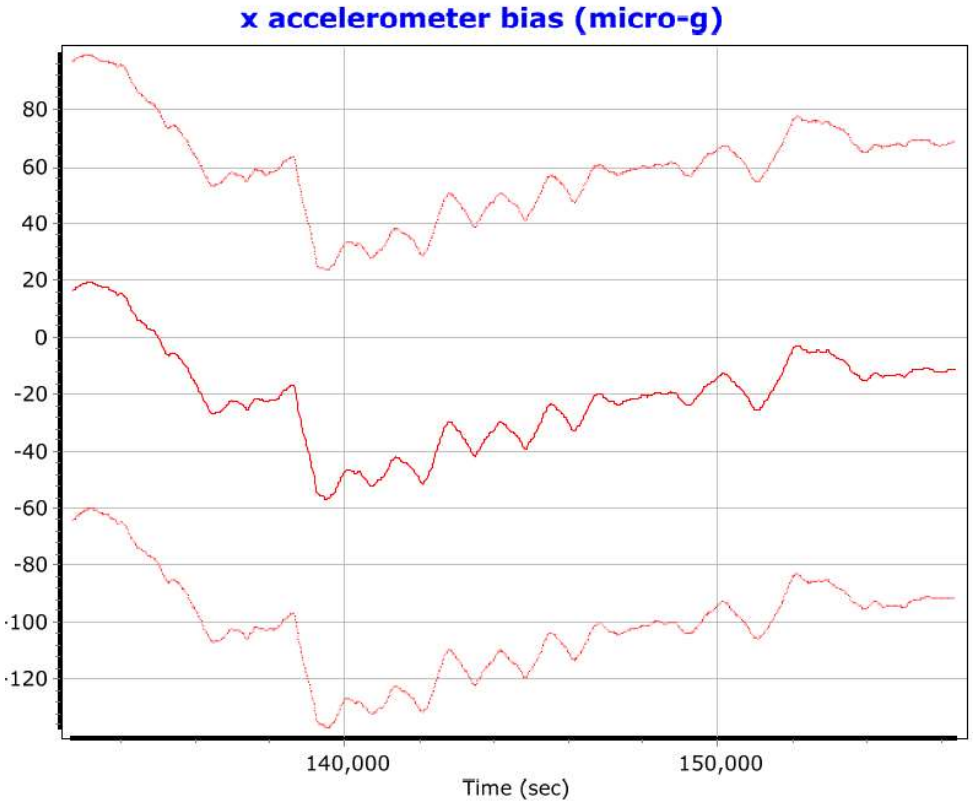


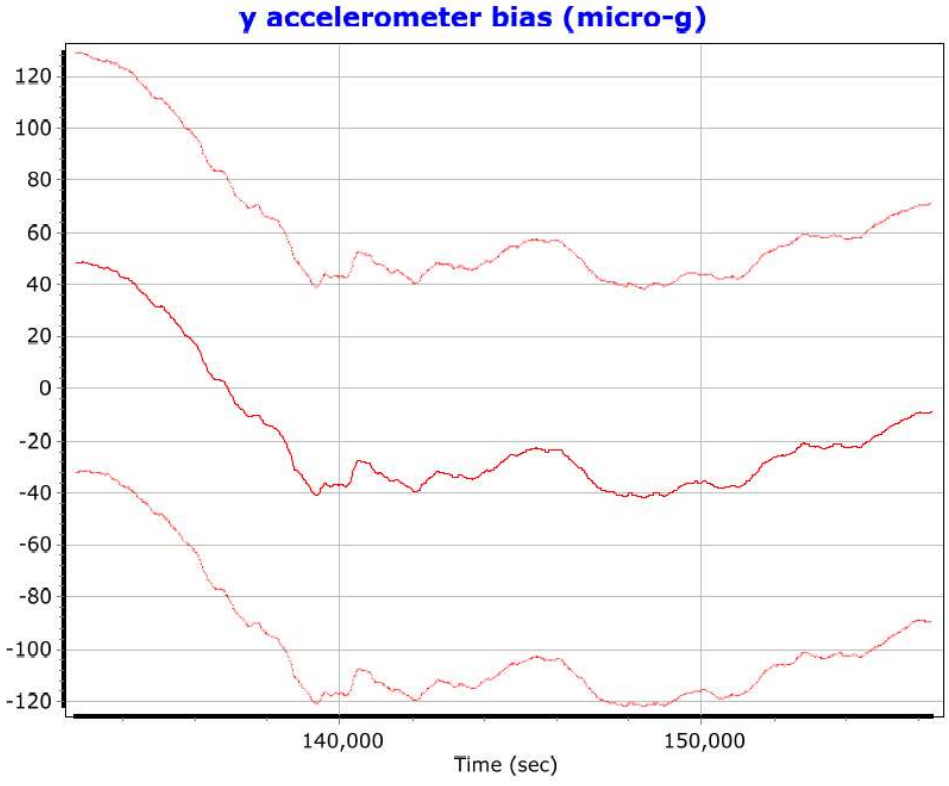

6218127a [Combined] - PDOP Plot
PDOP
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
134000
Week 2000
136000
138000
140000
142000
144000
146000
148000
150000
152000
154000
156000
GPS Time (TOW, GMT zone)
PDOP

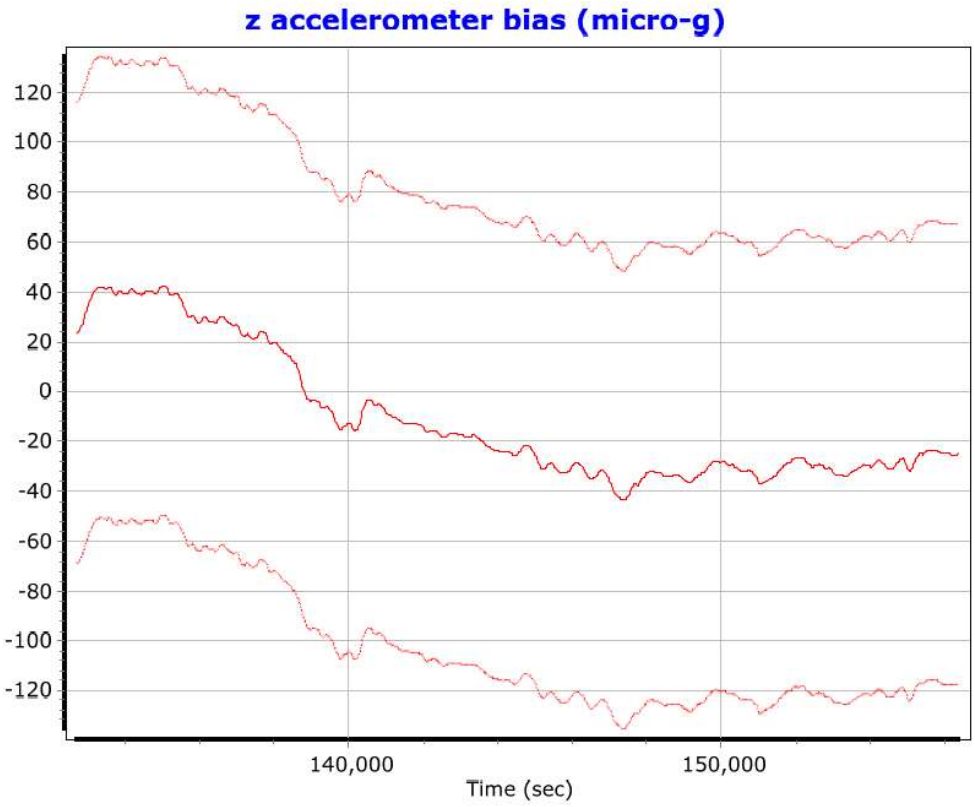

6218127a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
134000
Week 2000
136000
138000
140000
142000
144000
146000
148000
150000
152000
154000
156000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

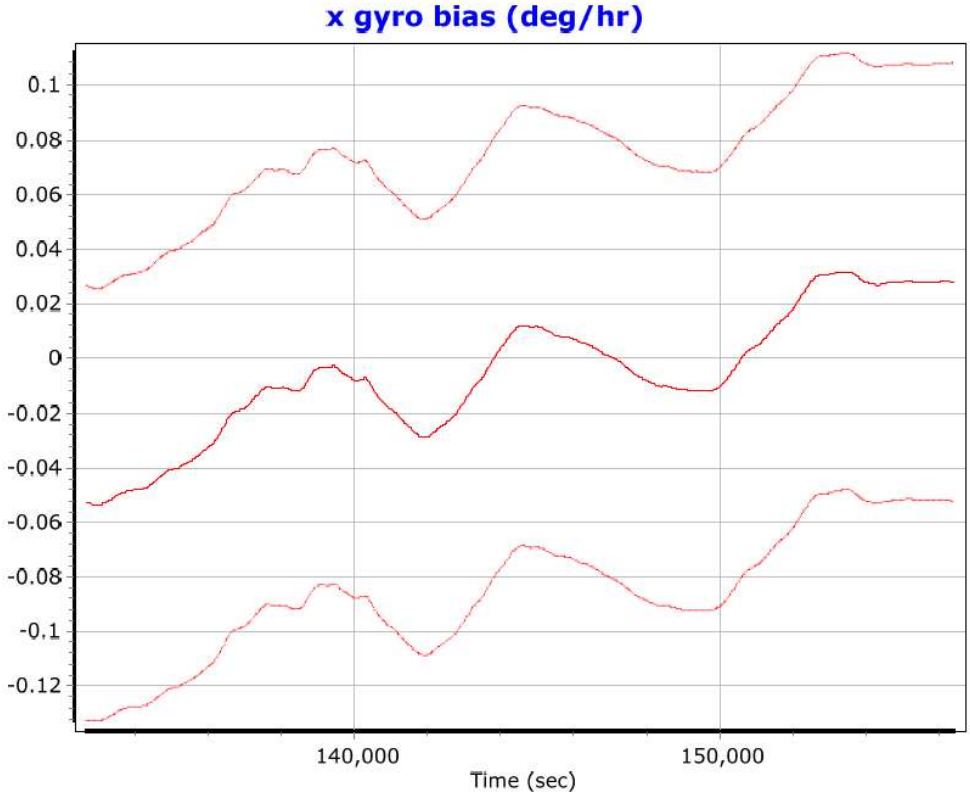
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218127a\05_INS-GPS_PROC\
01_POS\GNSS\6218127a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 23778
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0187 (m)
C/A Code: 0.61 (m)
L1 Doppler: 0.023 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.012 (m)
North: 0.008 (m)
Height: 0.018 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (23772 occurances):
East: 0.012 (m)
North: 0.008 (m)
Height: 0.018 (m)
Quality Number Percentages:
Q 1: 97.1 %
Q 2: 2.9 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 72.950 (km)
Minimum: 1.805 (km)
Average: 28.391 (km)
First Epoch: 45.143 (km)
Last Epoch: 44.092 (km)

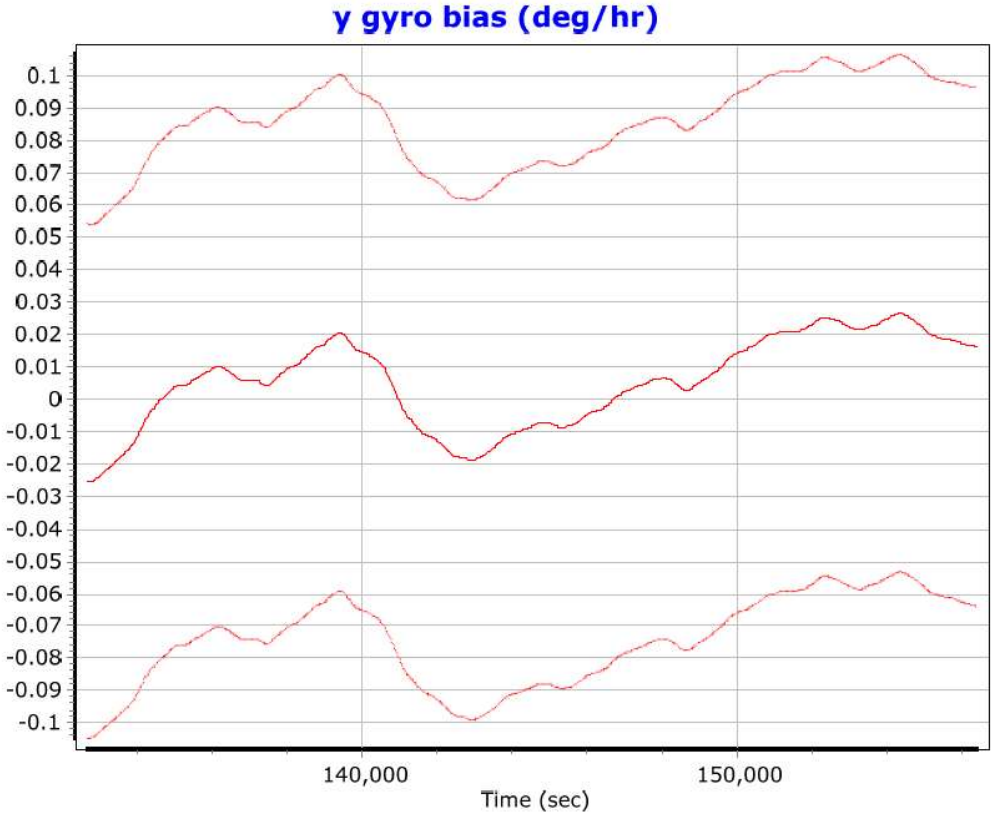
Mission 15 – 6218127a Sensor Errors






z accelerometer bias (micro-g)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
140,000
150,000
Time (sec)

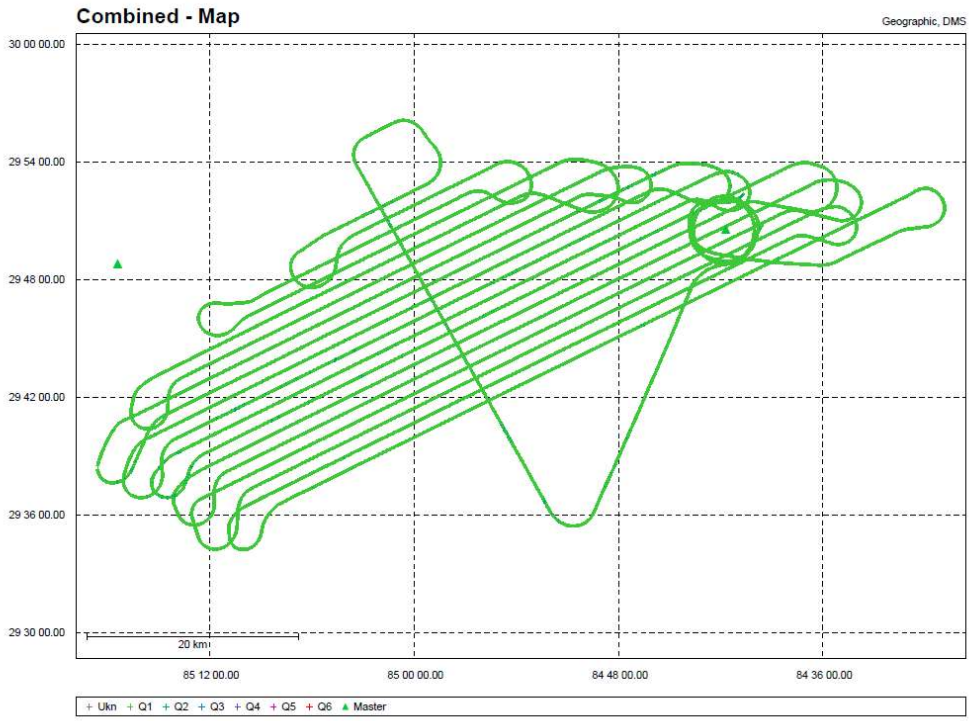

x gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
140,000
150,000
Time (sec)


y gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
140,000
150,000
Time (sec)

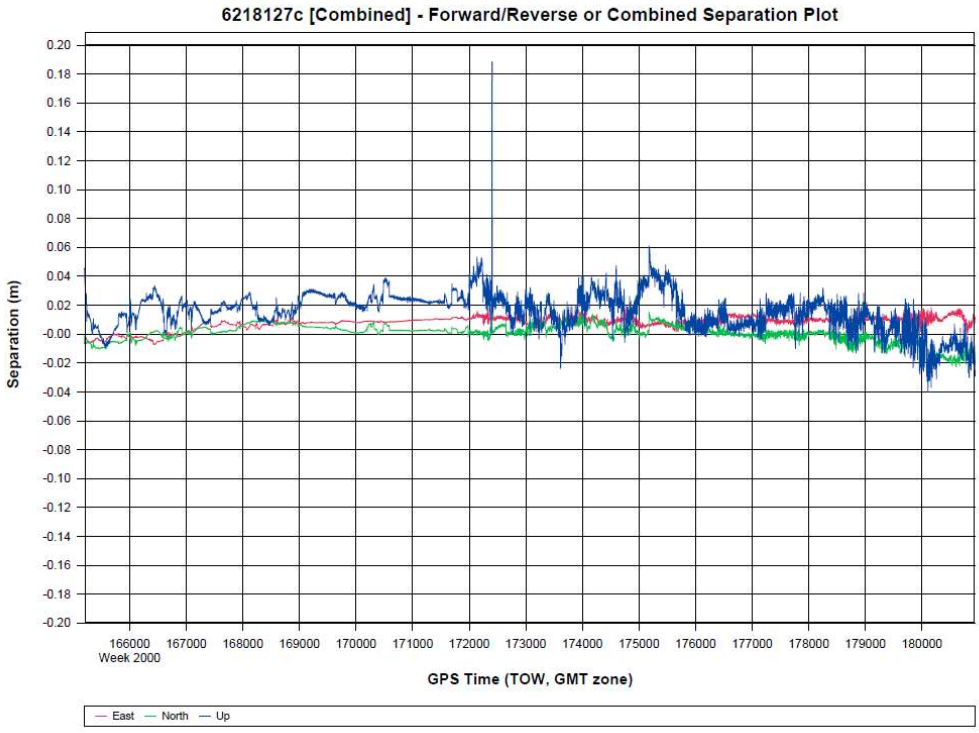

z gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
140,000
150,000
Time (sec)

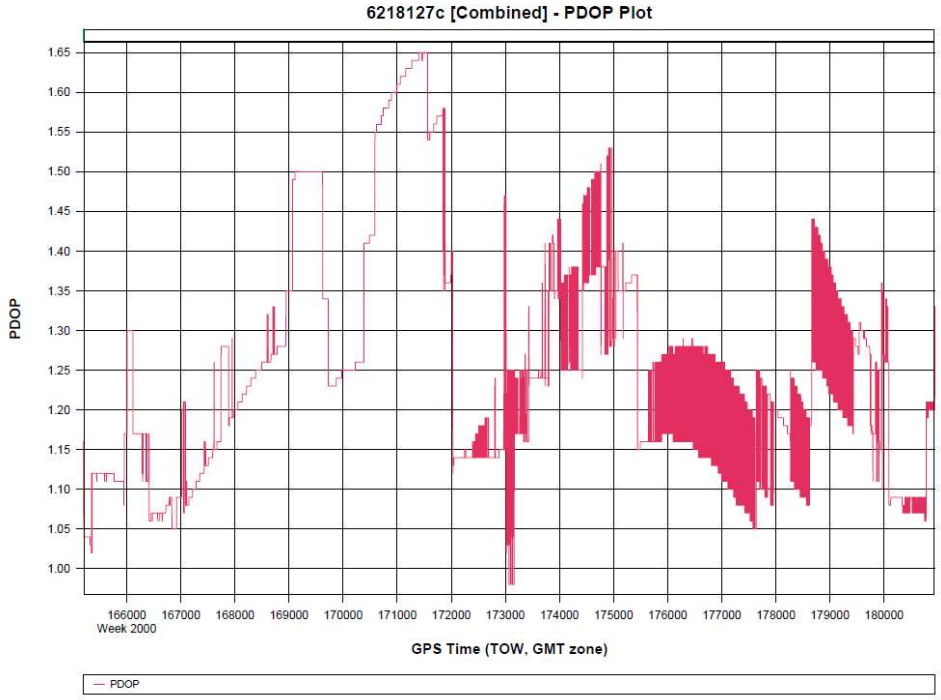
Mission 16 – 6218127c GNSS Processing

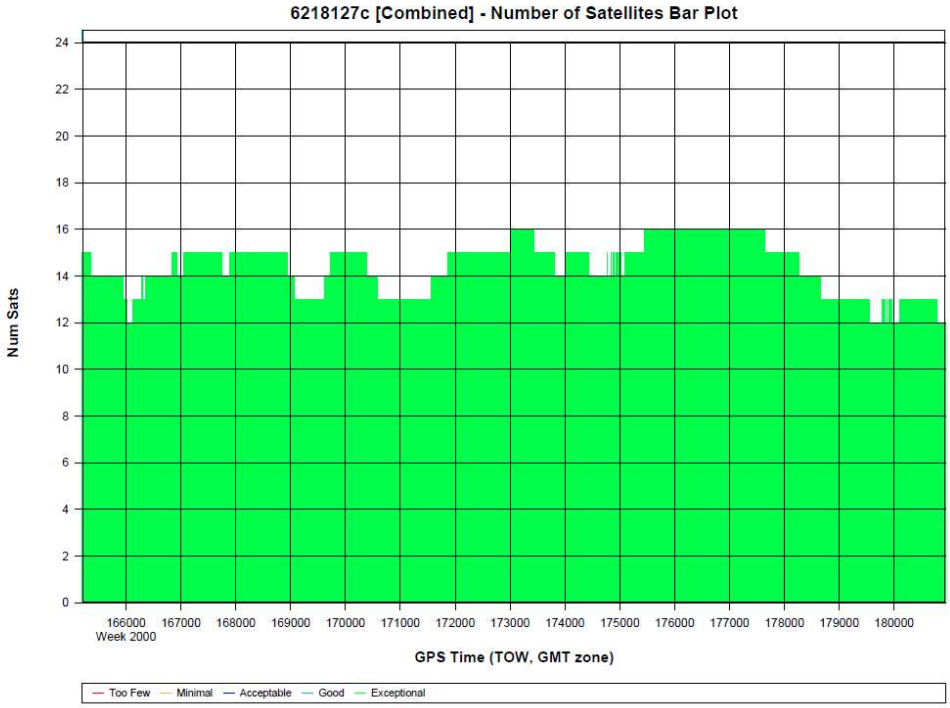
Project: 6218127c GrafNav v8.50.4120



Project: 6218127c GrafNav v8.50.4120

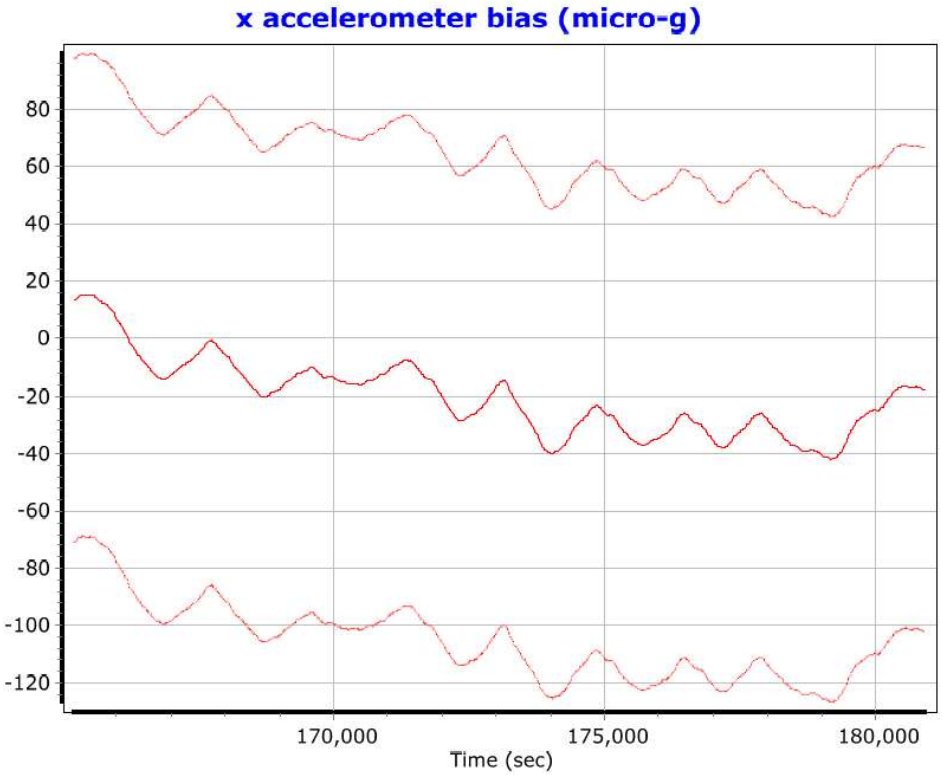


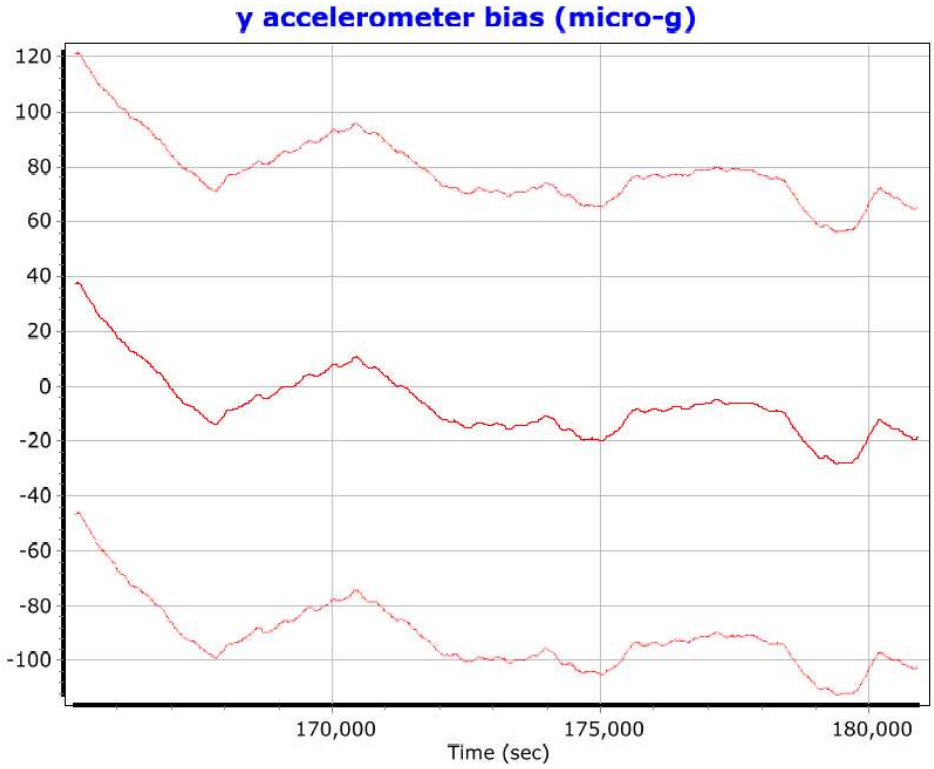

6218127c [Combined] - PDOP Plot
PDOP
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
166000
Week 2000
167000
168000
169000
170000
171000
172000
173000
174000
175000
176000
177000
178000
179000
180000
GPS Time (TOW, GMT zone)
PDOP

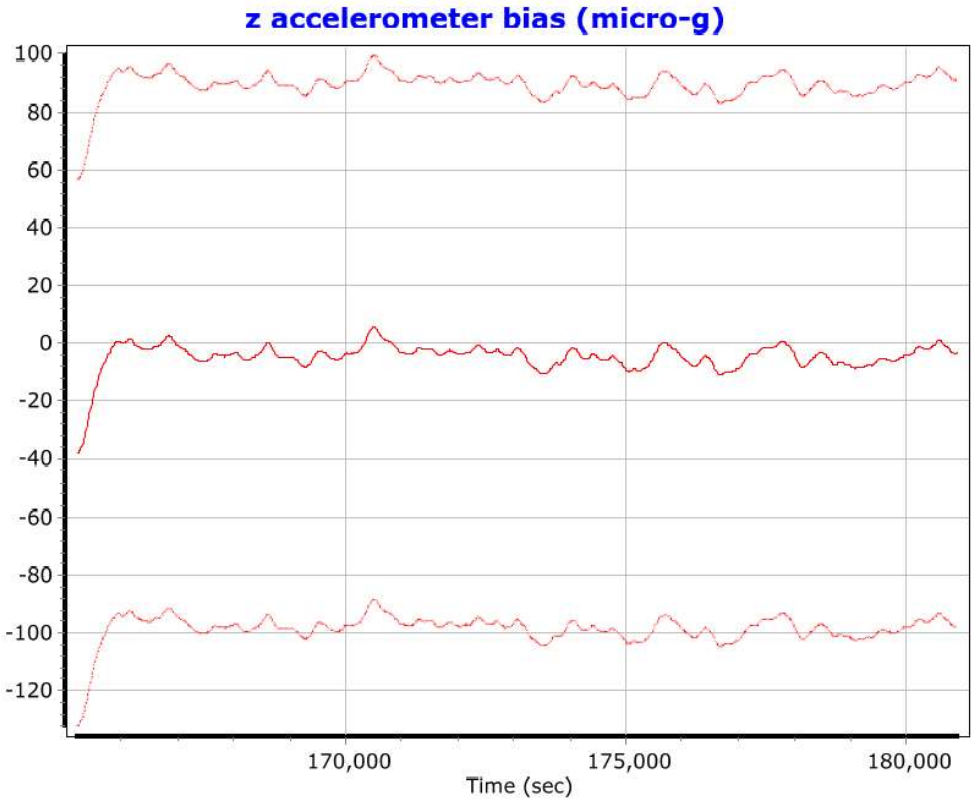

6218127c [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
166000
Week 2000
167000
168000
169000
170000
171000
172000
173000
174000
175000
176000
177000
178000
179000
180000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

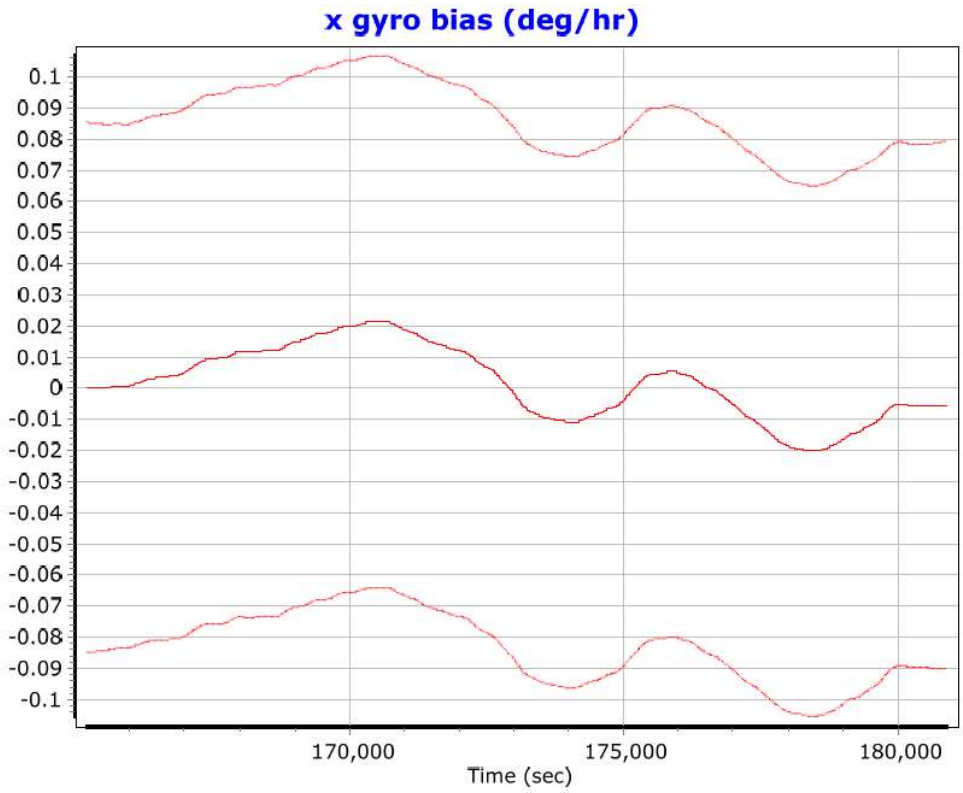
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218127c\05_INS-GPS_PROC\
01_POS\GNSS\6218127c.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 19822
No processed position: 4081
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0176 (m)
C/A Code: 0.64 (m)
L1 Doppler: 0.031 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.009 (m)
North: 0.006 (m)
Height: 0.020 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (15737 occurances):
East: 0.009 (m)
North: 0.006 (m)
Height: 0.020 (m)
Quality Number Percentages:
Q 1: 98.6 %
Q 2: 1.3 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 48.212 (km)
Minimum: 1.626 (km)
Average: 20.159 (km)
First Epoch: 30.679 (km)
Last Epoch: 32.152 (km)

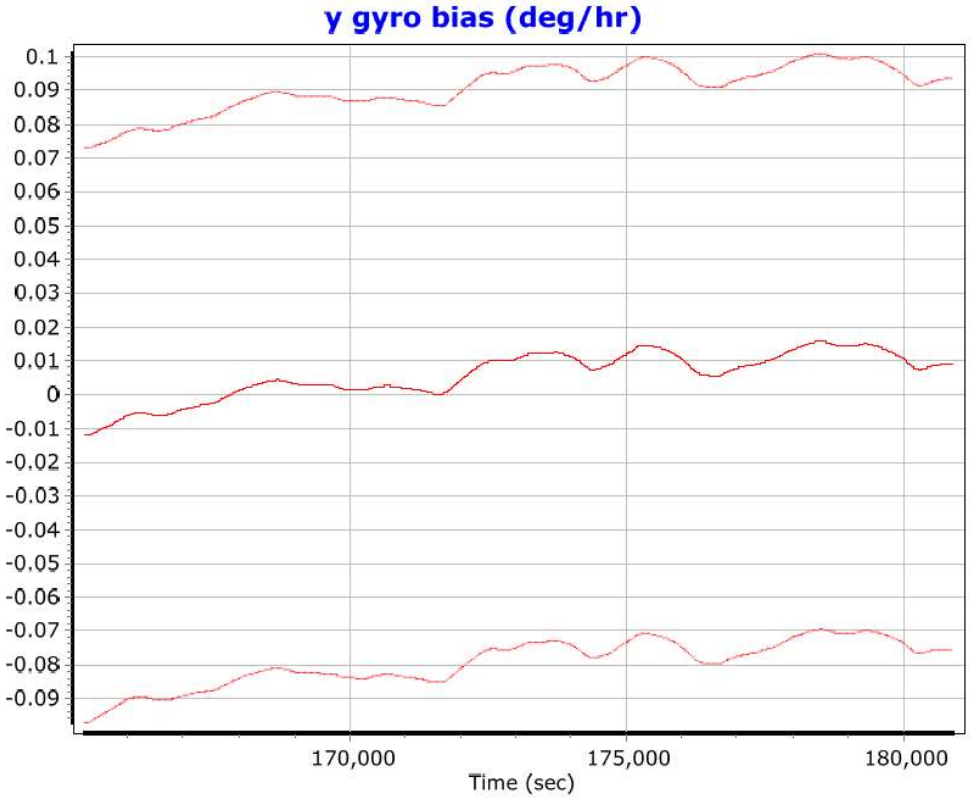
Mission 16 – 6218127c Sensor Errors

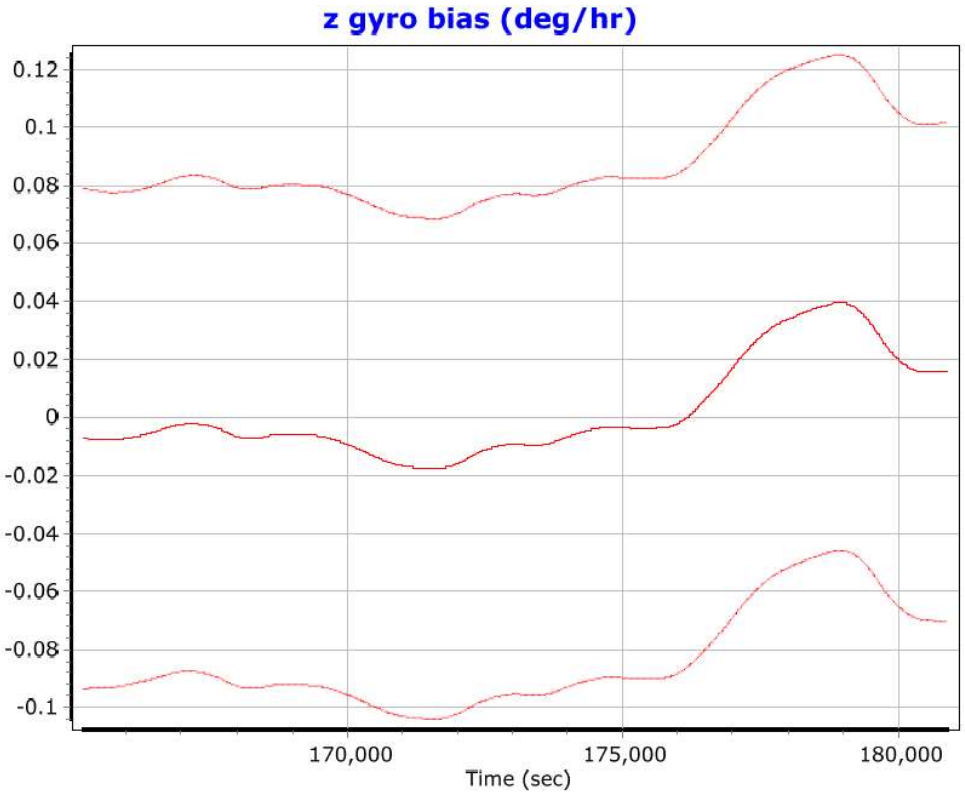





z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
170,000
175,000
180,000
Time (sec)

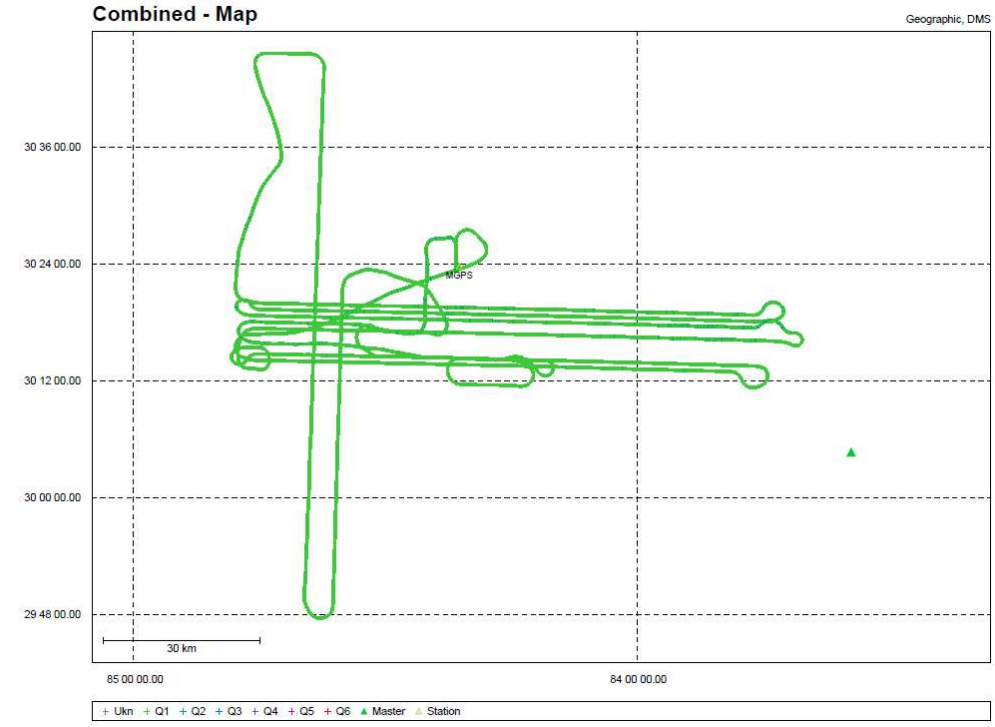

x gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
170,000
175,000
180,000
Time (sec)


y gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
170,000
175,000
180,000
Time (sec)

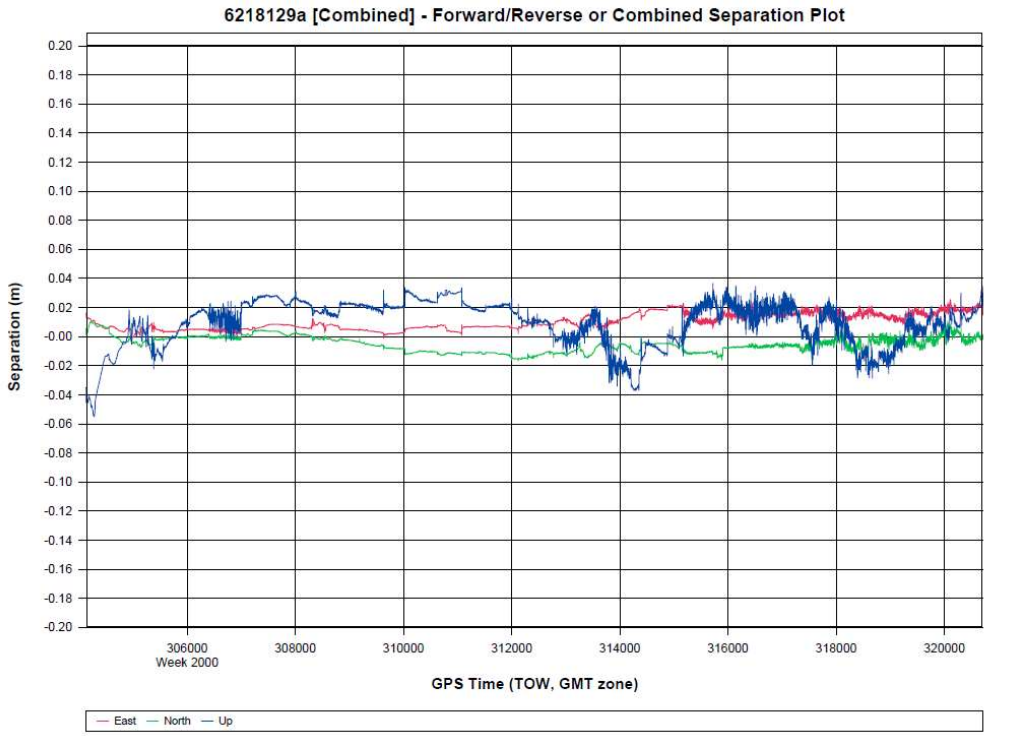

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
170,000
175,000
180,000
Time (sec)

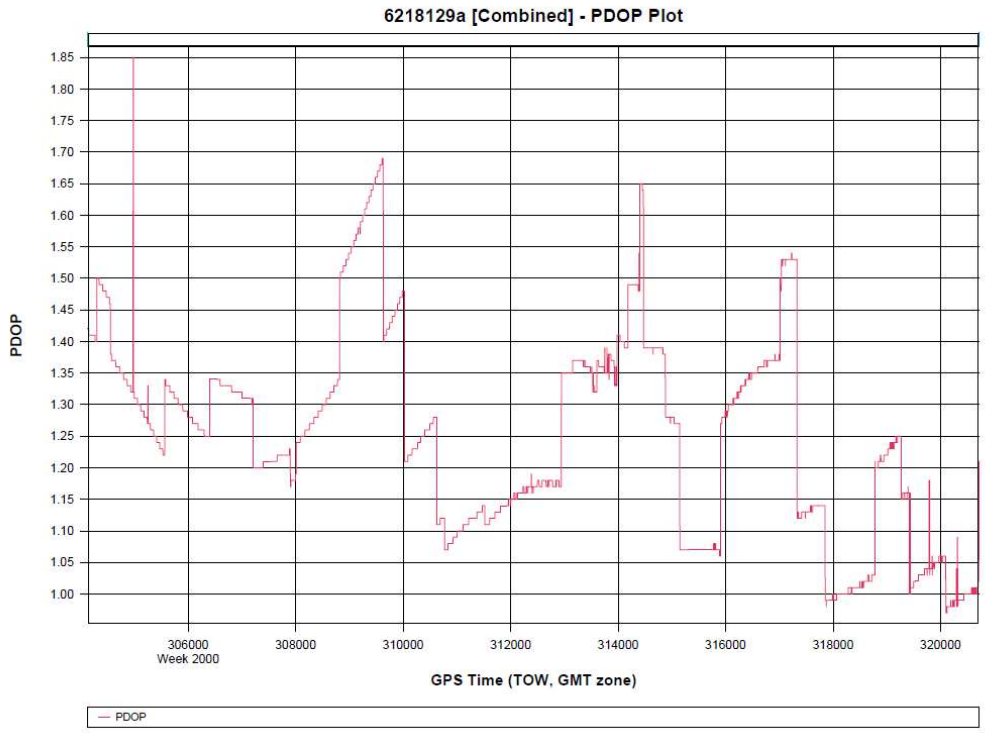
Mission 17 – 6218129a GNSS Processing

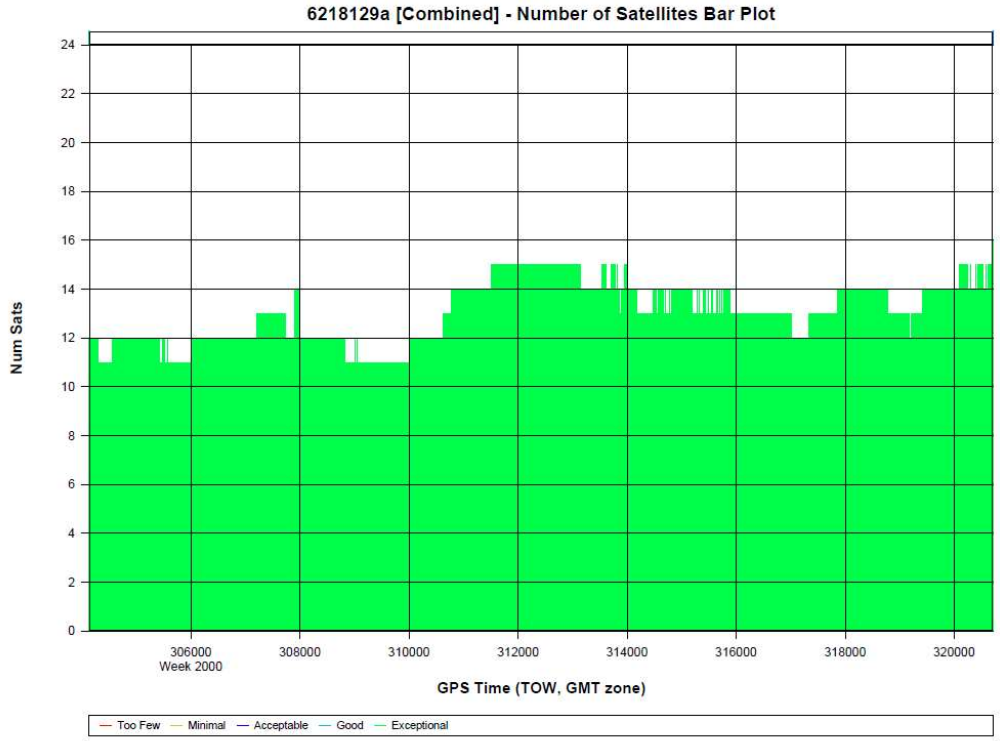
Project: 6218129a GrafNav v8.50.4120



Project: 6218129a GrafNav v8.50.4120

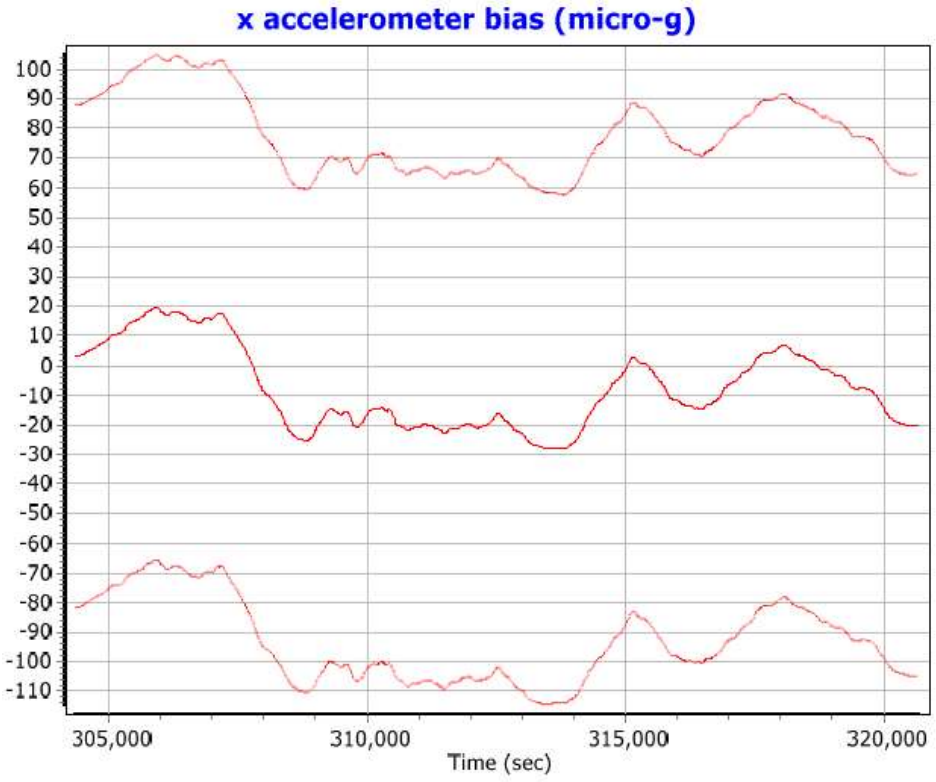


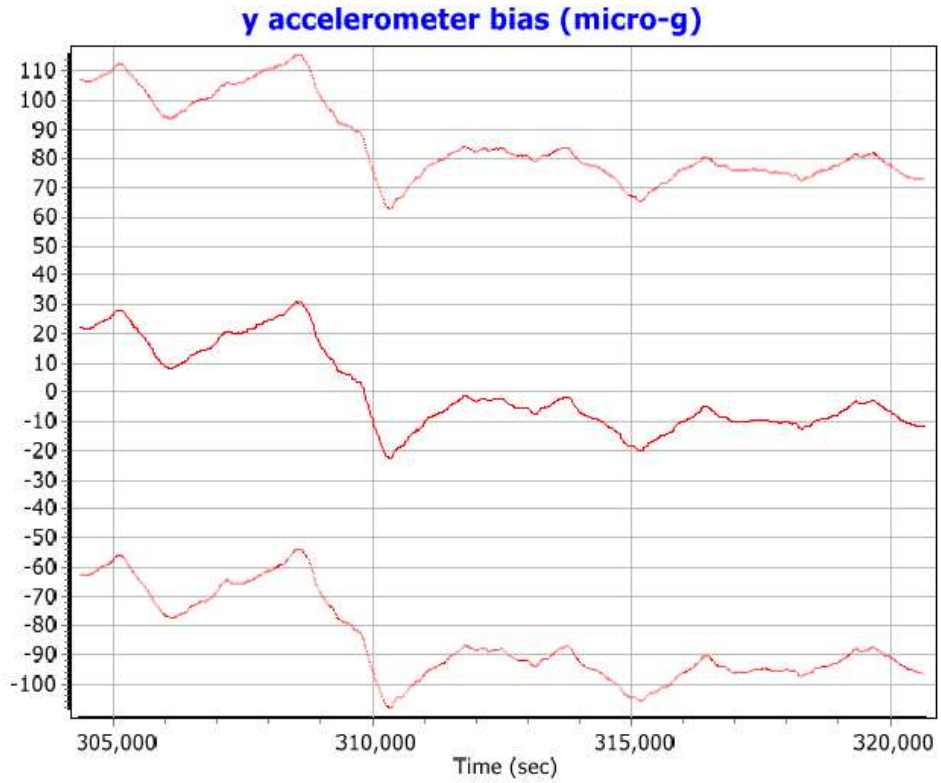

6218129a [Combined] - PDOP Plot
PDOP
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
306000
Week 2000
308000
310000
312000
314000
316000
318000
320000
GPS Time (TOW, GMT zone)
PDOP

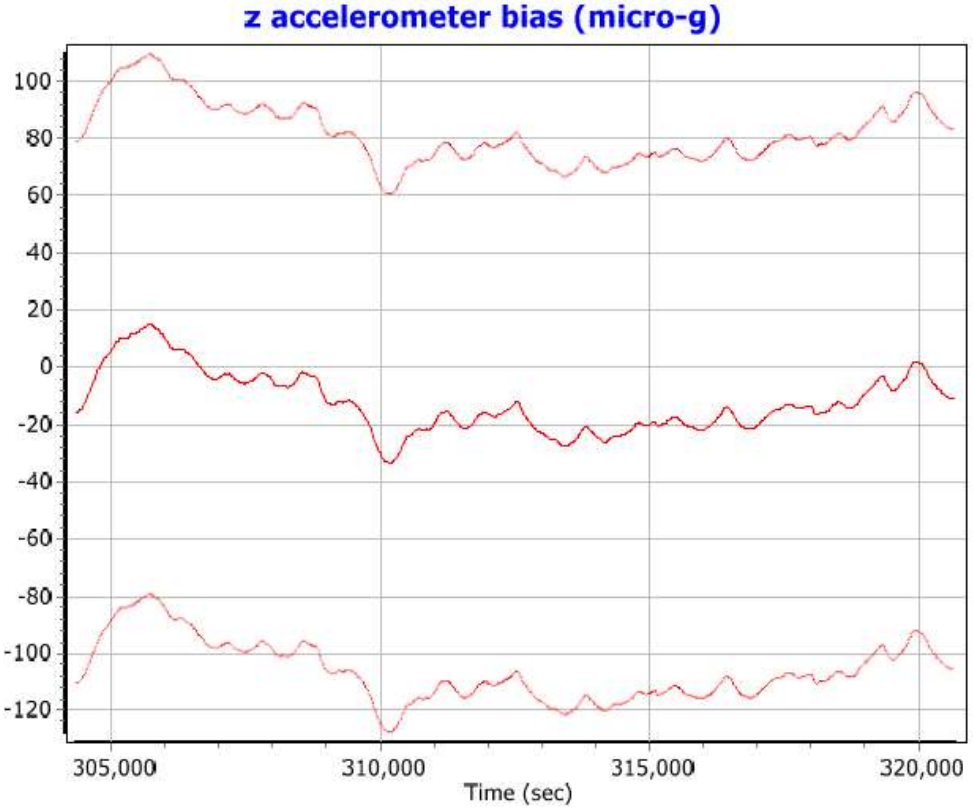

6218129a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
306000
Week 2000
308000
310000
312000
314000
316000
318000
320000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

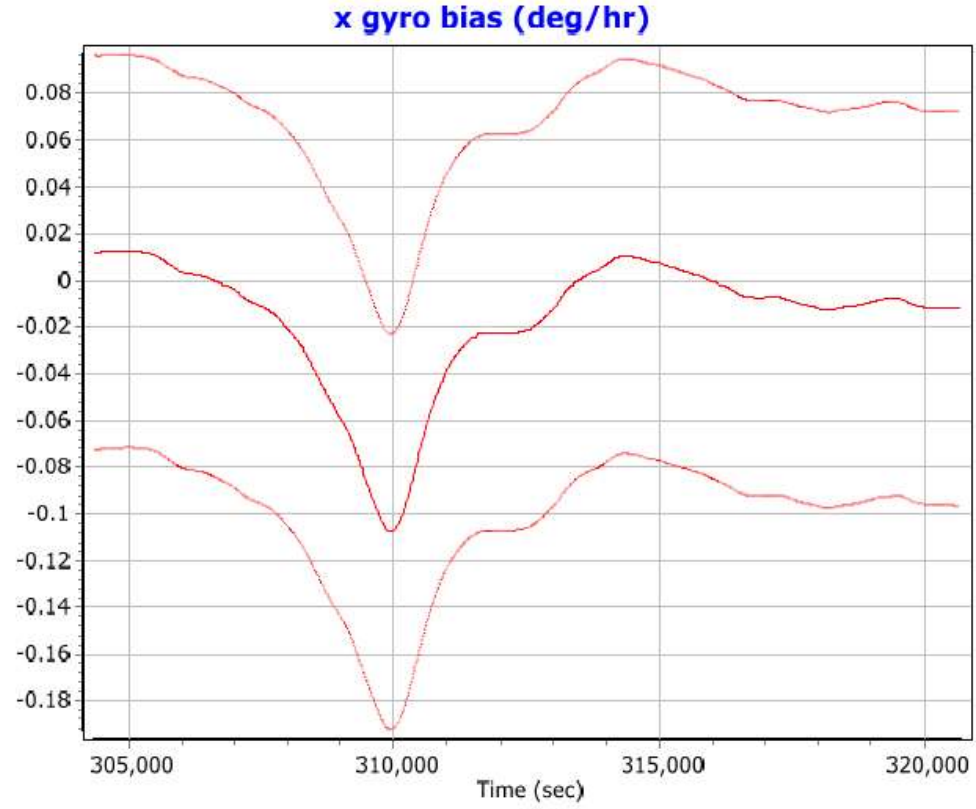
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218129a\05_INS-GPS_PROC\
01_POS\GNSS\6218129a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 16586
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0173 (m)
C/A Code: 0.66 (m)
L1 Doppler: 0.025 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.012 (m)
North: 0.007 (m)
Height: 0.018 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (16580 occurances):
East: 0.012 (m)
North: 0.007 (m)
Height: 0.018 (m)
Quality Number Percentages:
Q 1: 96.5 %
Q 2: 3.5 %
Q 3: 0.1 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 78.910 (km)
Minimum: 1.840 (km)
Average: 36.628 (km)
First Epoch: 30.928 (km)
Last Epoch: 25.275 (km)

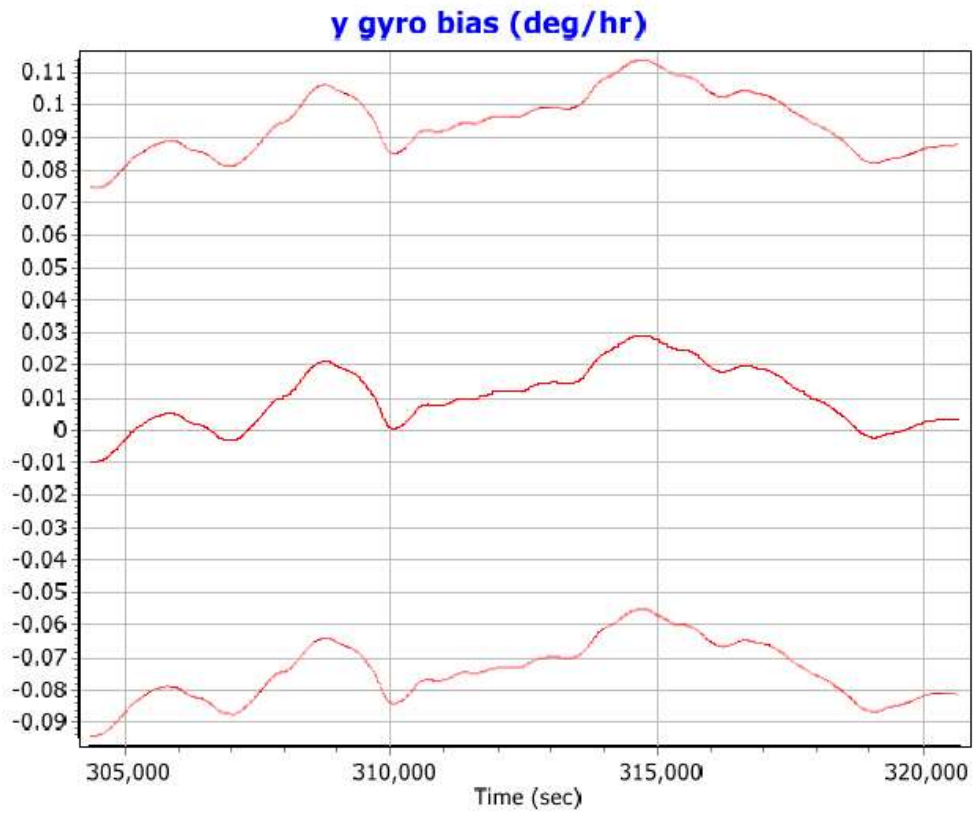
Mission 17 – 6218129a Sensor Errors






z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
305,000
310,000
315,000
320,000
Time (sec)

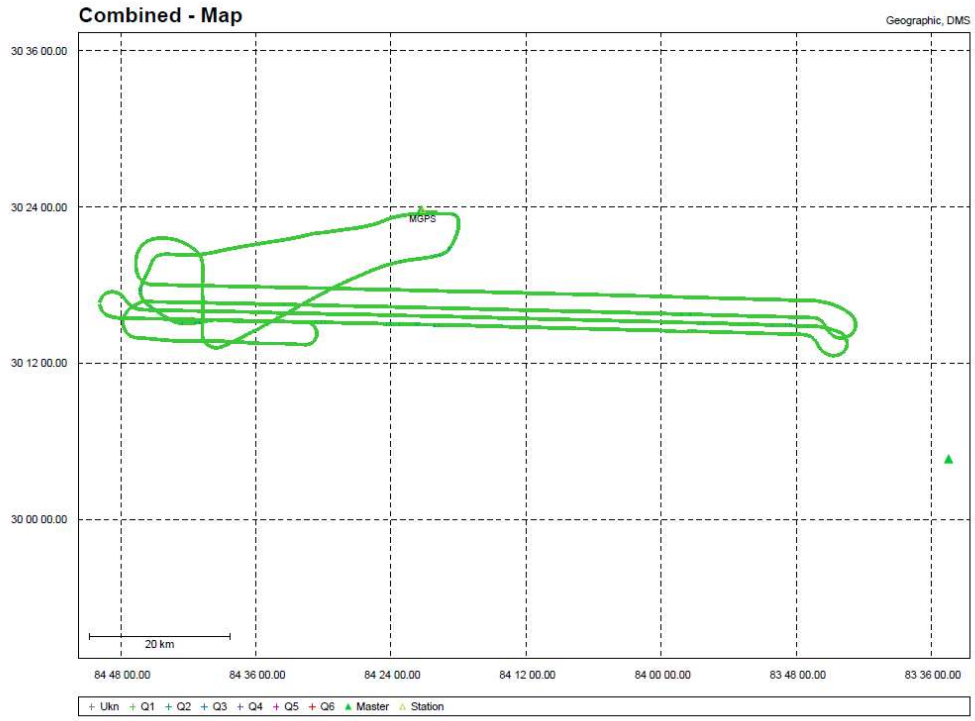

x gyro bias (deg/hr)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
305,000
310,000
315,000
320,000
Time (sec)


y gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
305,000
310,000
315,000
320,000
Time (sec)

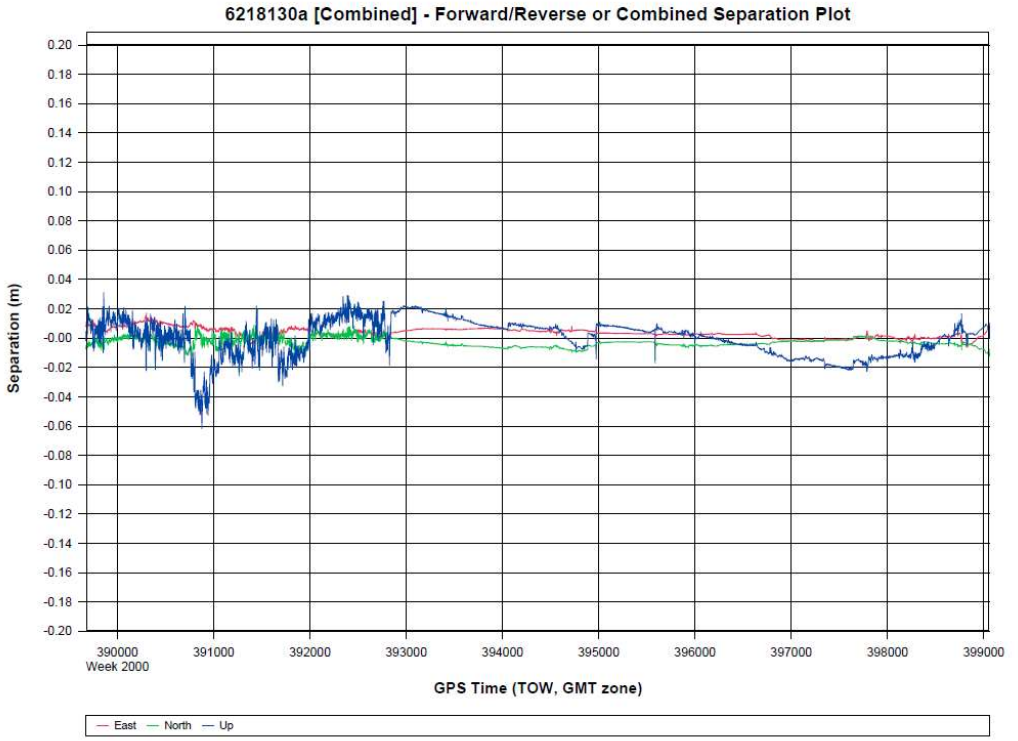

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
305,000
310,000
315,000
320,000
Time (sec)

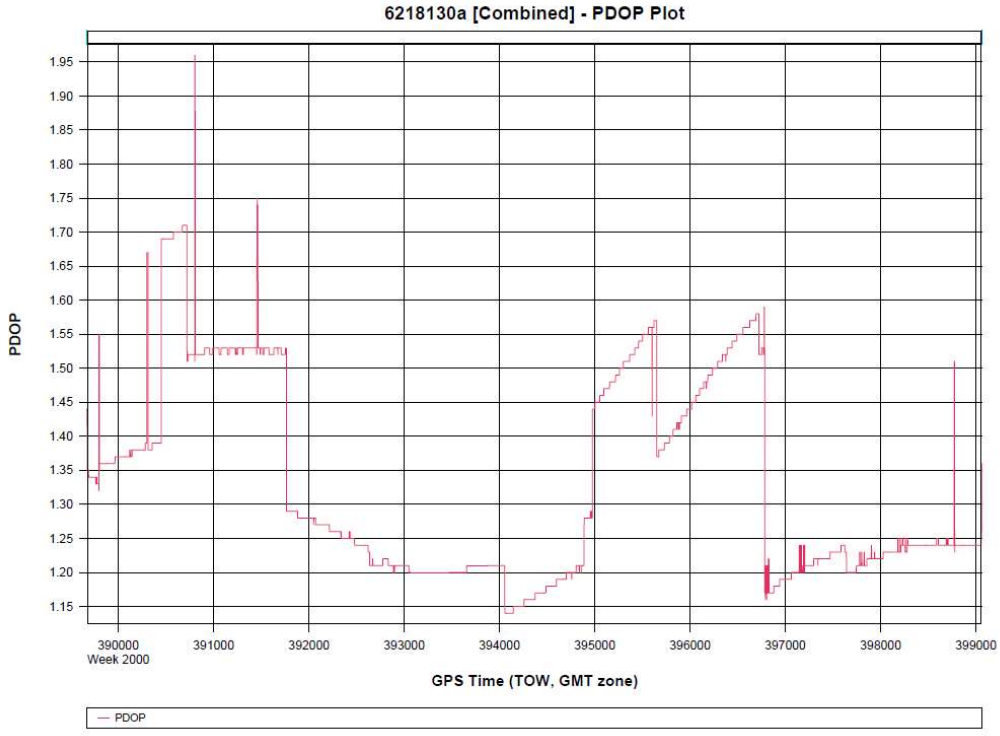
Mission 18 – 6218130a GNSS Processing

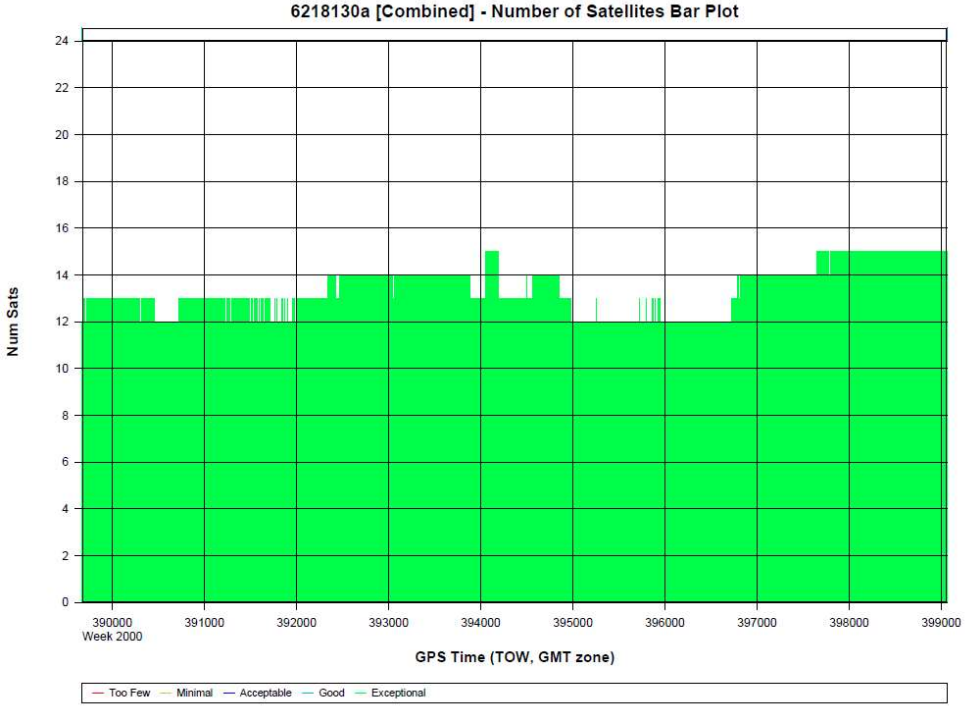
Project: 6218130a GrafNav v8.50.4120



Project: 6218130a GrafNav v8.50.4120

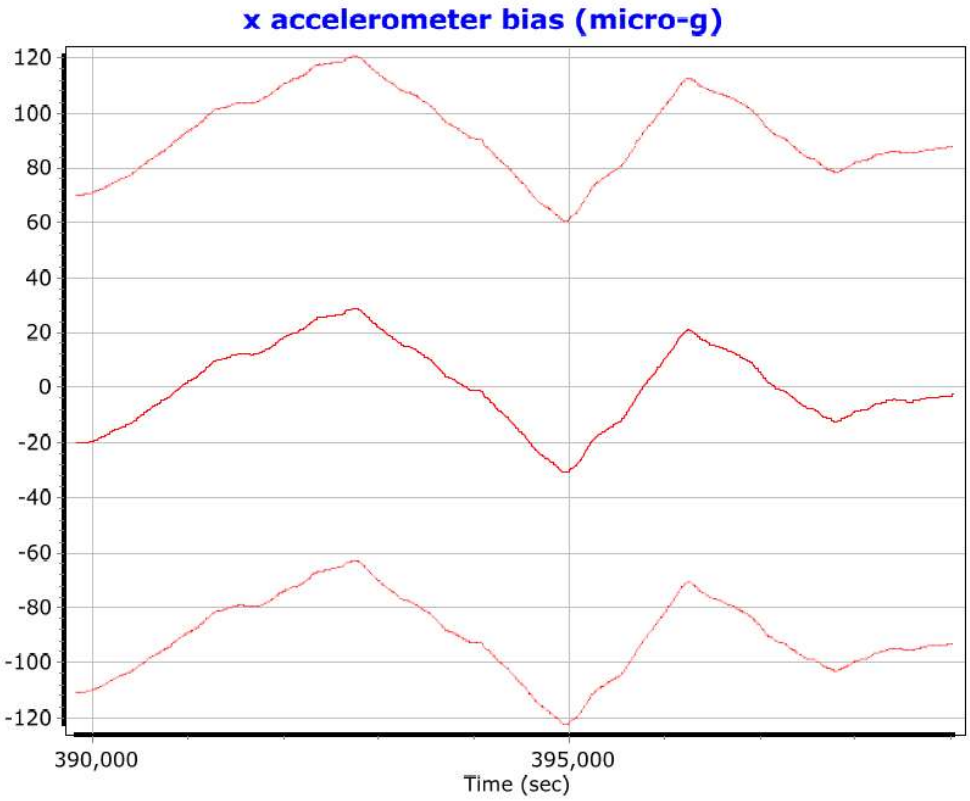


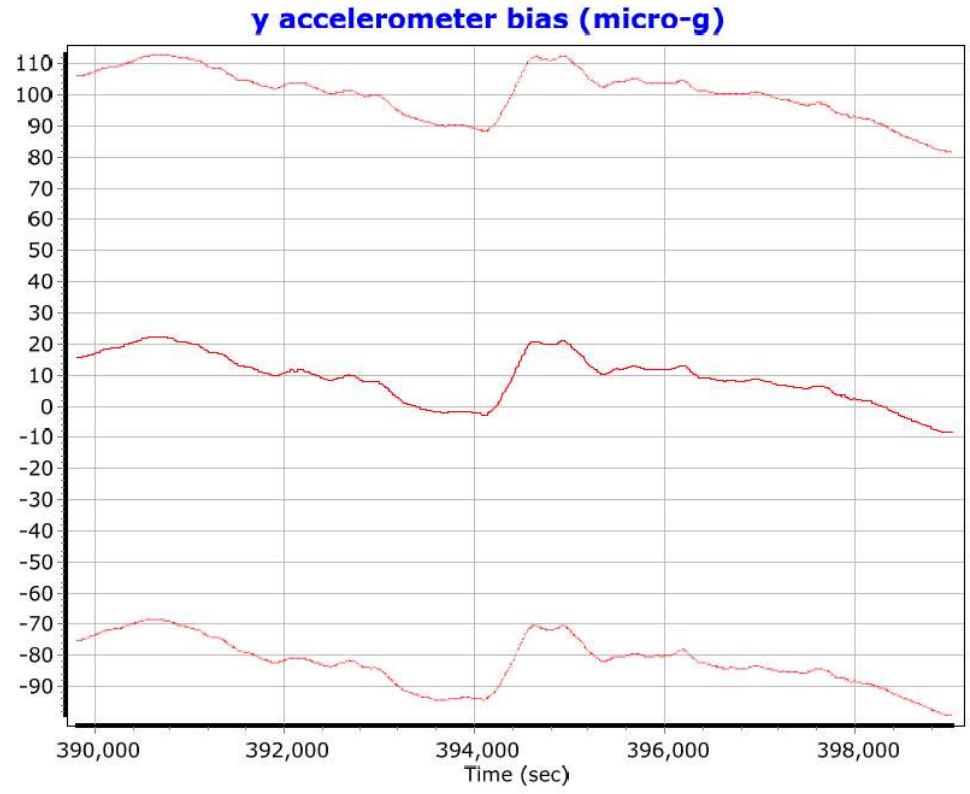

6218130a [Combined] - PDOP Plot
PDOP
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
390000
Week 2000
391000
392000
393000
394000
395000
396000
397000
398000
399000
GPS Time (TOW, GMT zone)
PDOP


6218130a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
390000
Week 2000
391000
392000
393000
394000
395000
396000
397000
398000
399000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

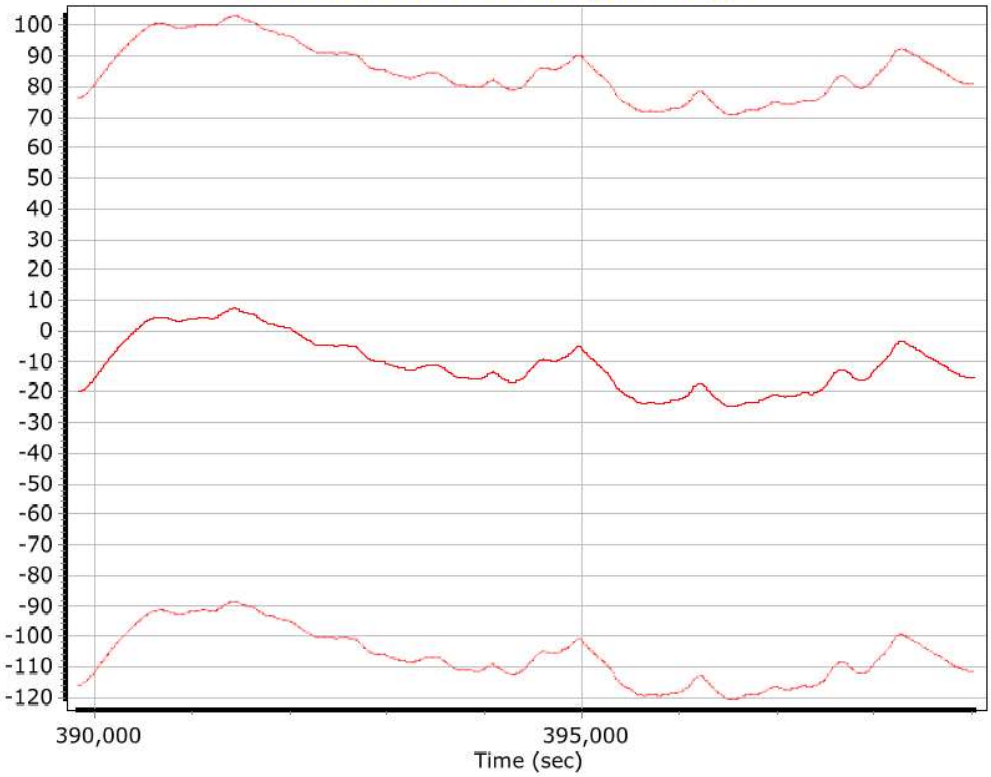
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\6218130a\05_INS-GPS_PROC\
01_POS\GNSS\6218130a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 9394
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0162 (m)
C/A Code: 0.67 (m)
L1 Doppler: 0.019 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.005 (m)
North: 0.004 (m)
Height: 0.012 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (9388 occurances):
East: 0.005 (m)
North: 0.004 (m)
Height: 0.012 (m)
Quality Number Percentages:
Q 1: 98.3 %
Q 2: 1.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 69.451 (km)
Minimum: 1.858 (km)
Average: 33.739 (km)
First Epoch: 27.764 (km)
Last Epoch: 27.939 (km)

Mission 18 – 6218130a Sensor Errors

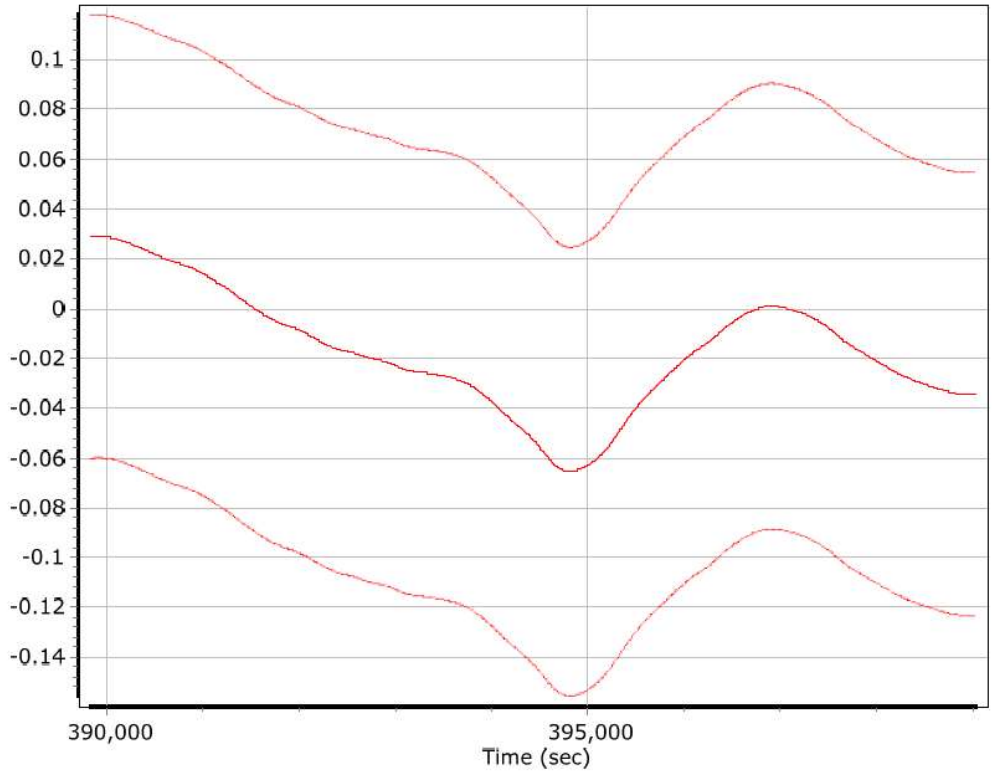


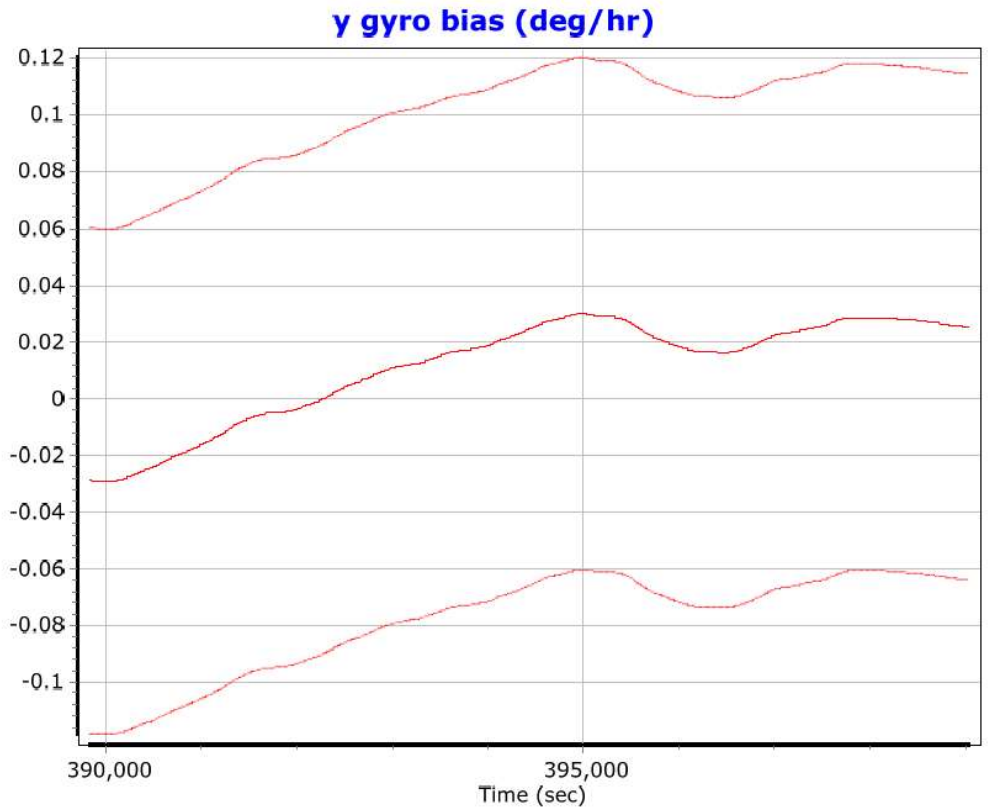


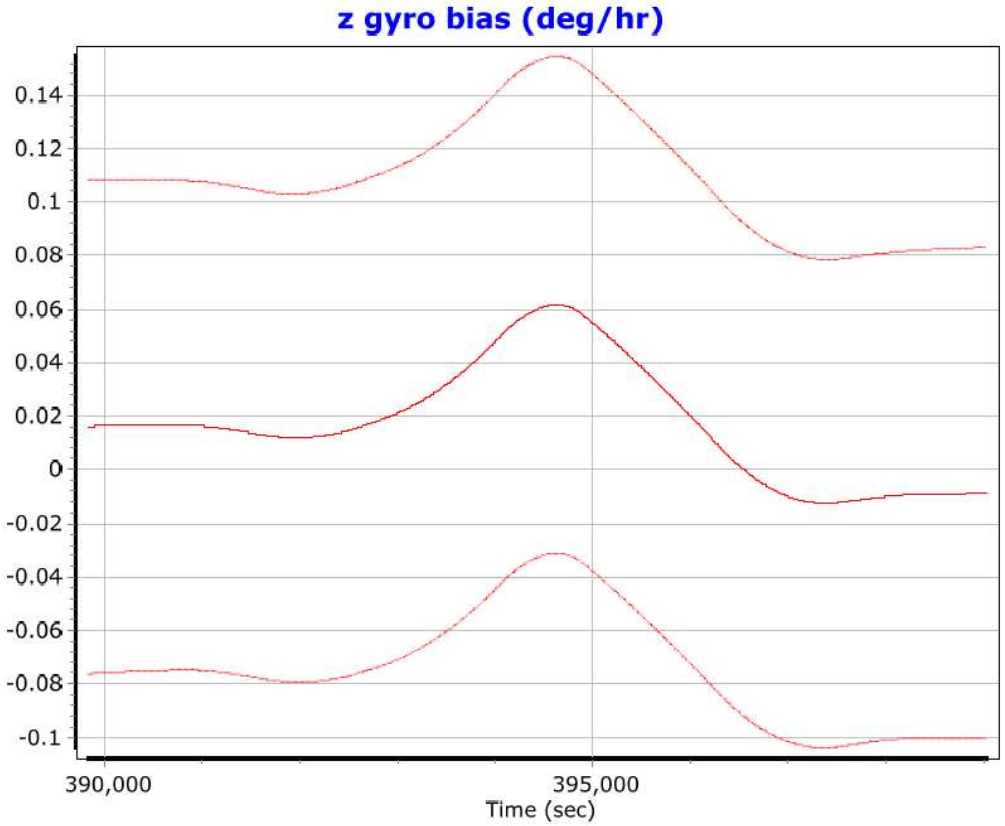
z accelerometer bias (micro-g)



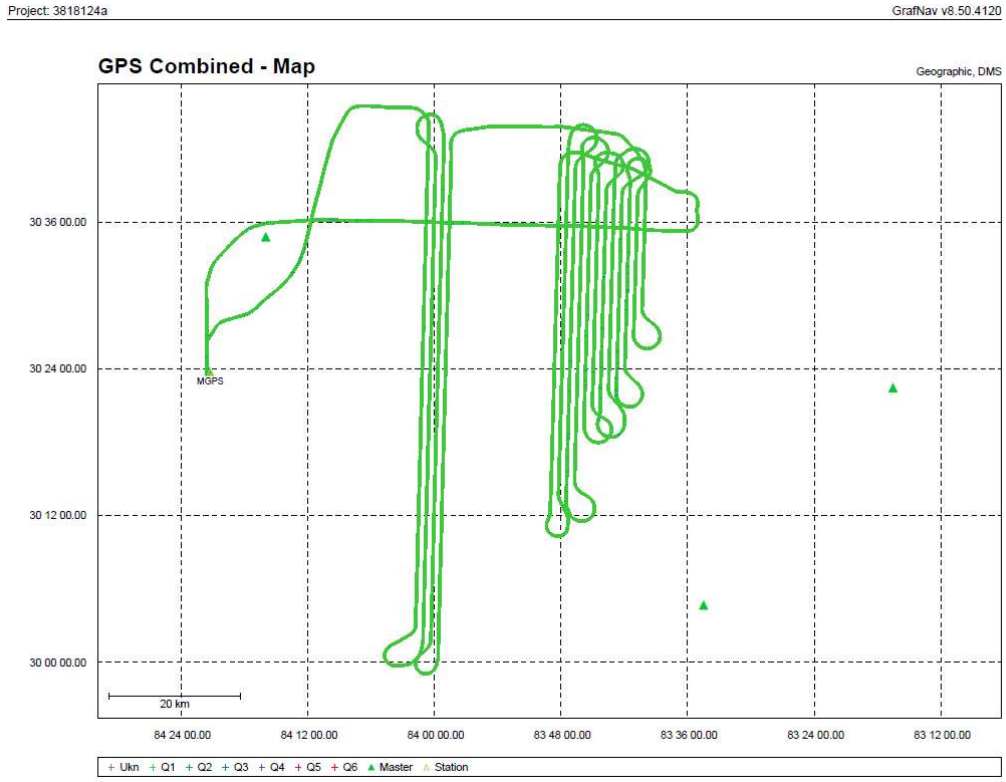
x gyro bias (deg/hr)

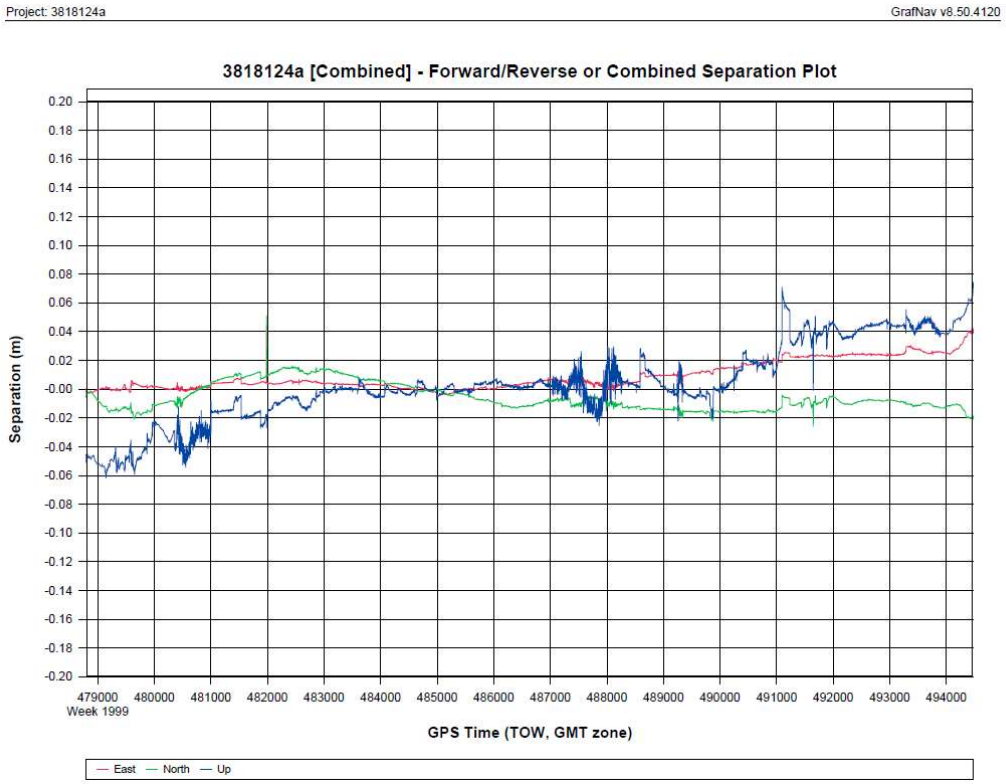


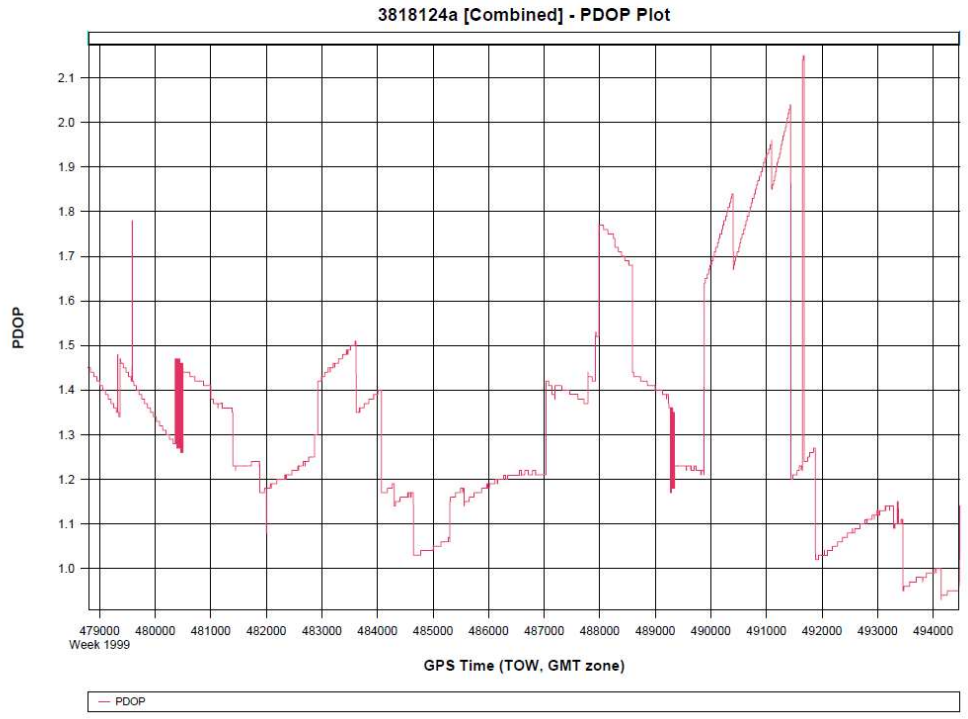

y gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
390,000
395,000
Time (sec)

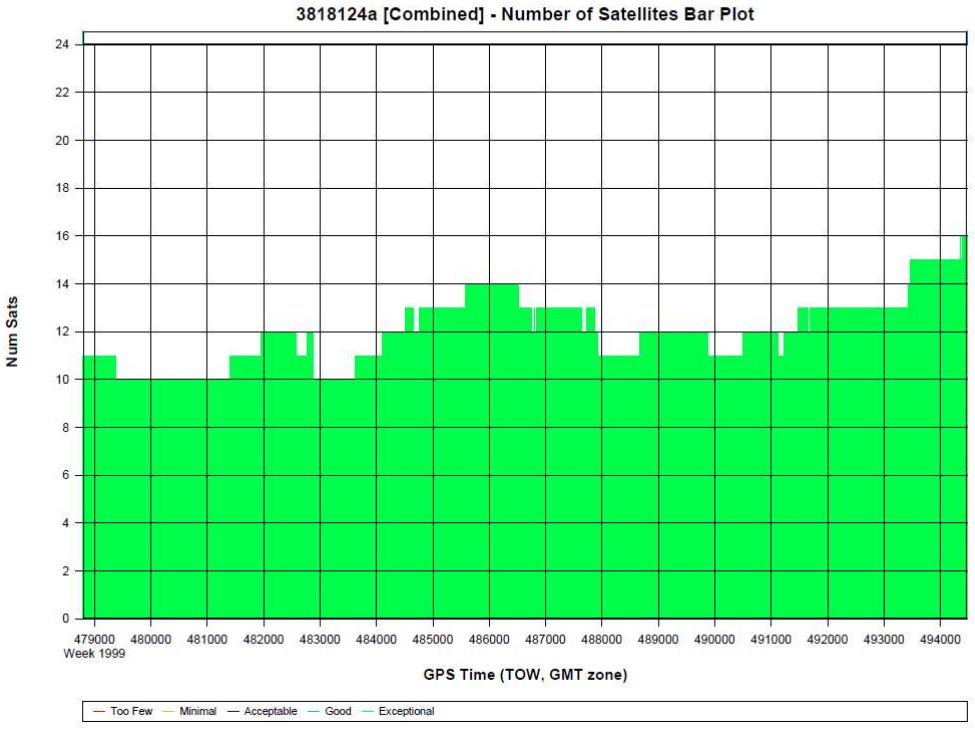

z gyro bias (deg/hr)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
390,000
395,000
Time (sec)

Mission 1 – 3818124a GNSS Processing



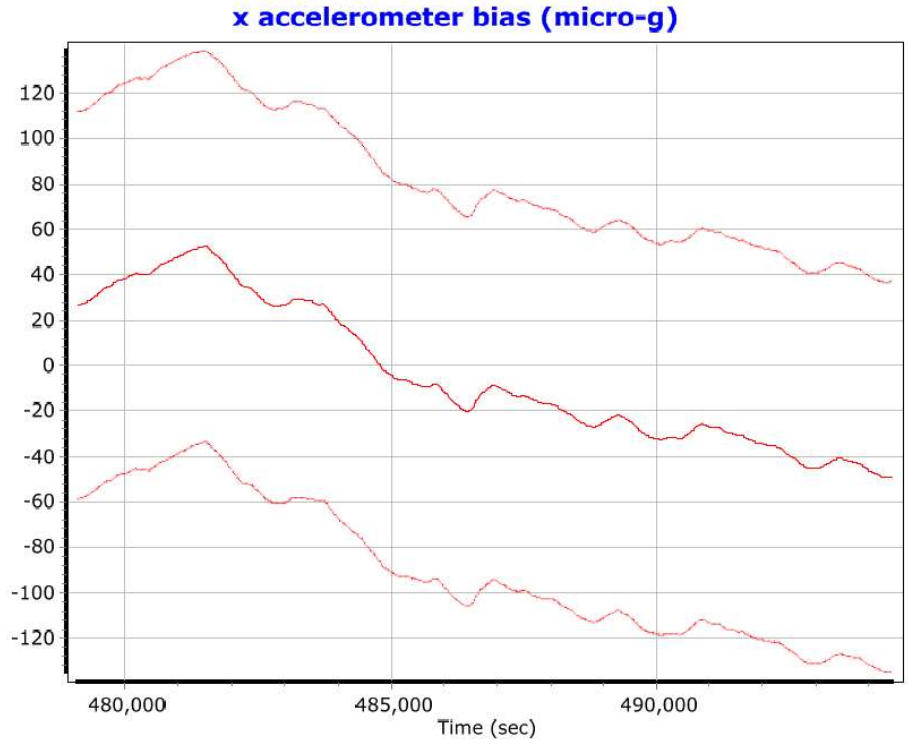


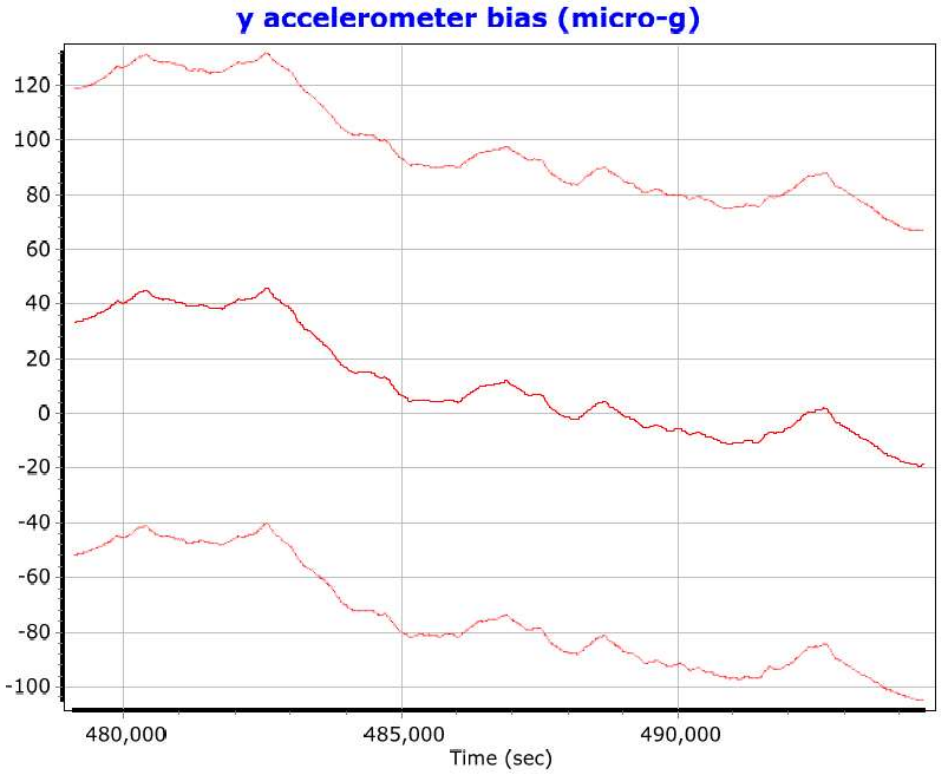

3818124a [Combined] - PDOP Plot
PDOP
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
479000 480000 481000 482000 483000 484000 485000 486000 487000 488000 489000 490000 491000 492000 493000 494000
Week 1999
GPS Time (TOW, GMT zone)
PDOP

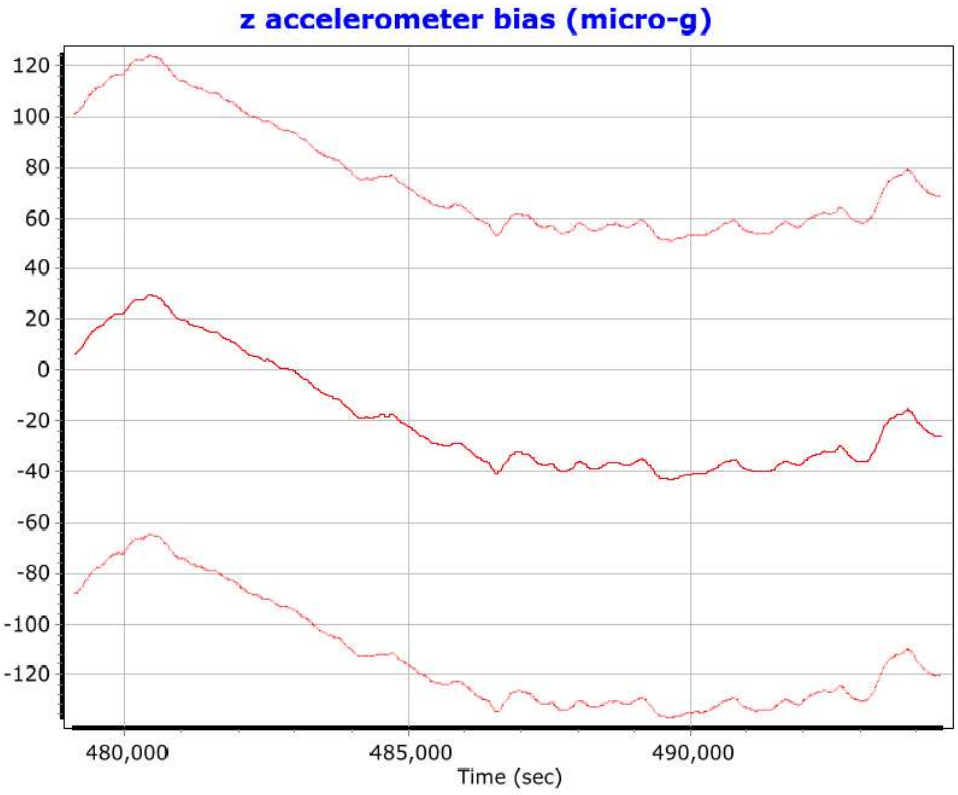

3818124a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
479000 480000 481000 482000 483000 484000 485000 486000 487000 488000 489000 490000 491000 492000 493000 494000
Week 1999
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

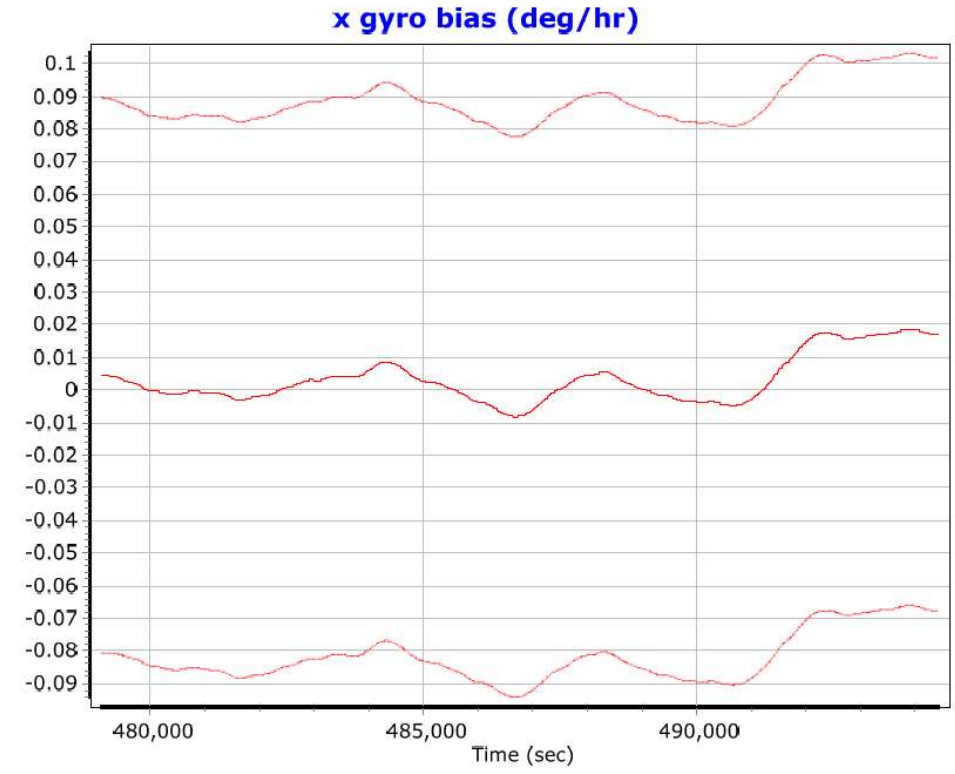
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\3818124a\05_INS-GPS_PROC\01_POS\GNSS\3818124a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 15685
No processed position: 1
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0191 (m)
C/A Code: 0.86 (m)
L1 Doppler: 0.025 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.013 (m)
North: 0.011 (m)
Height: 0.027 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (15678 occurances):
East: 0.013 (m)
North: 0.011 (m)
Height: 0.027 (m)
Quality Number Percentages:
Q 1: 98.3 %
Q 2: 1.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 50.679 (km)
Minimum: 1.711 (km)
Average: 27.099 (km)
First Epoch: 49.036 (km)
Last Epoch: 45.191 (km)

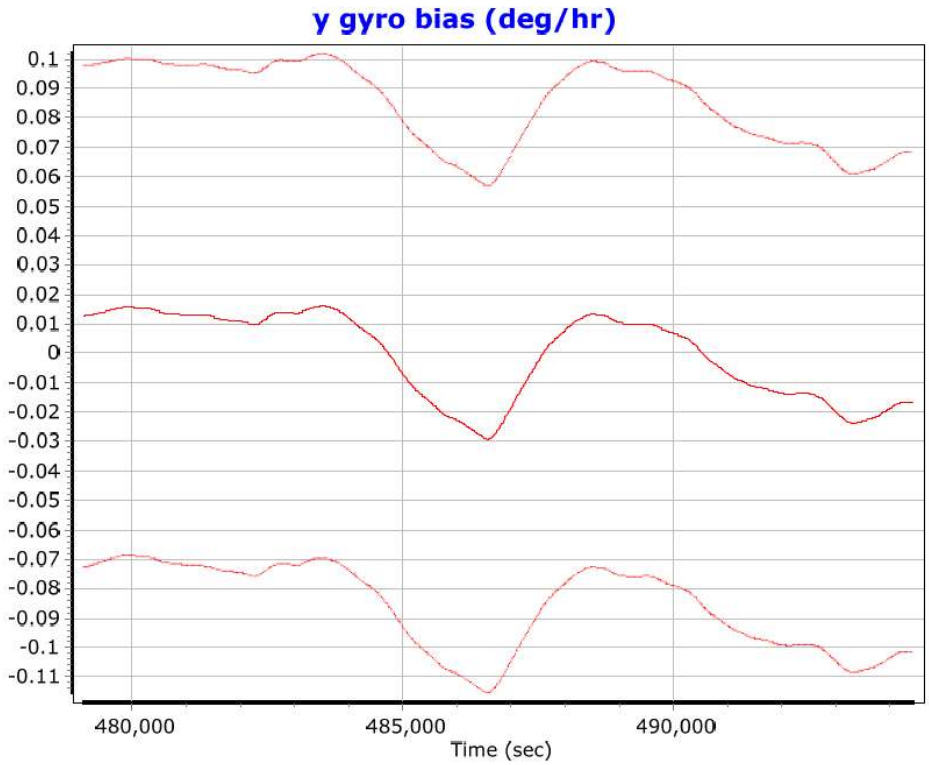
Mission 1 – 3818124a Sensor Errors

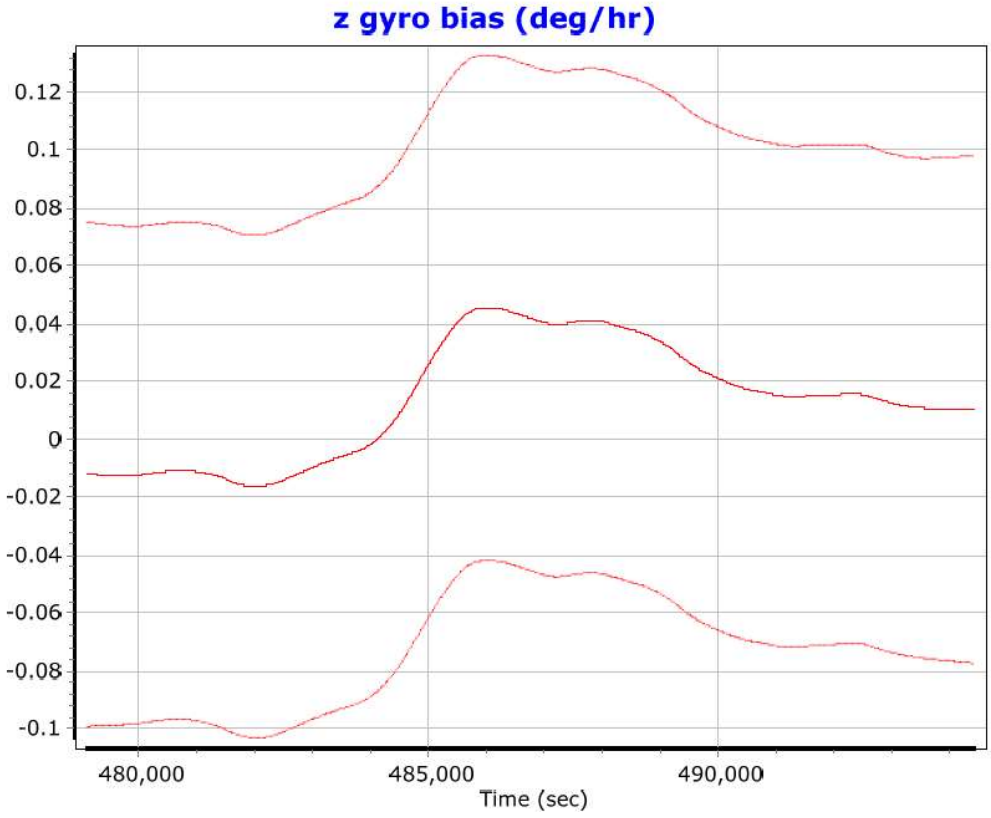




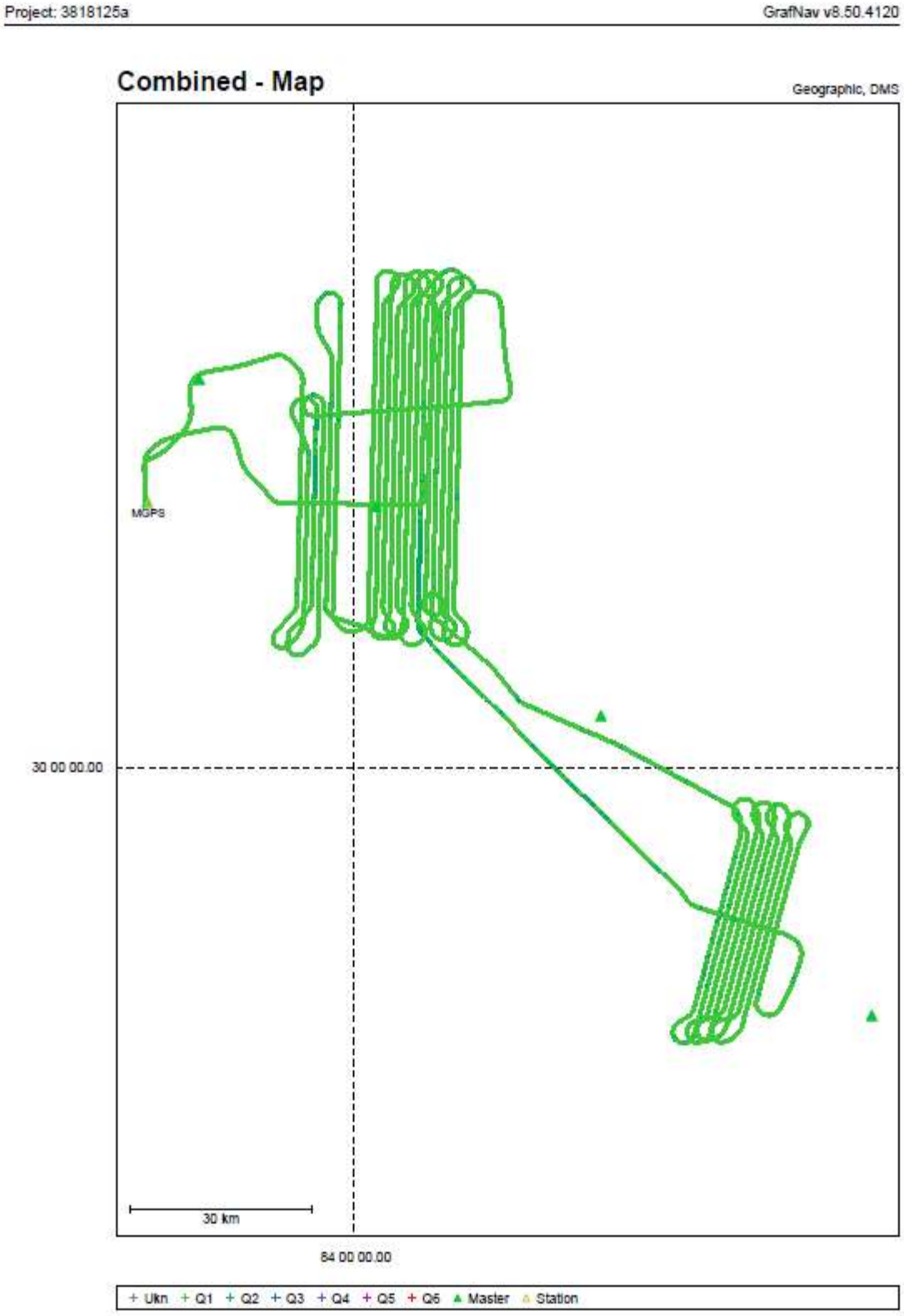

z accelerometer bias (micro-g)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
480,000
485,000
490,000
Time (sec)

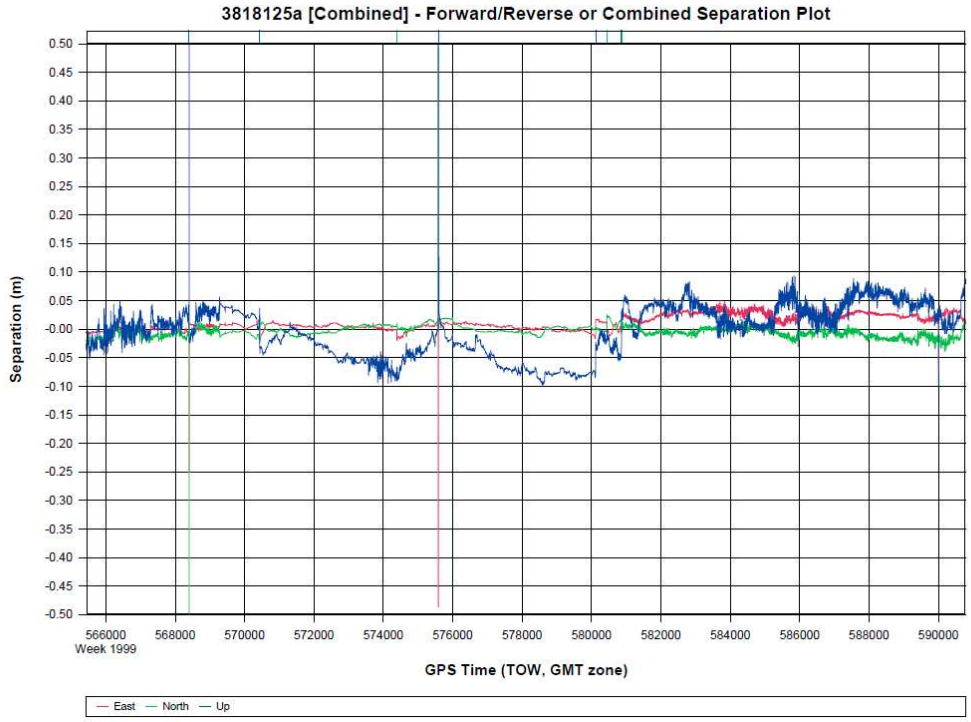

x gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
480,000
485,000
490,000
Time (sec)

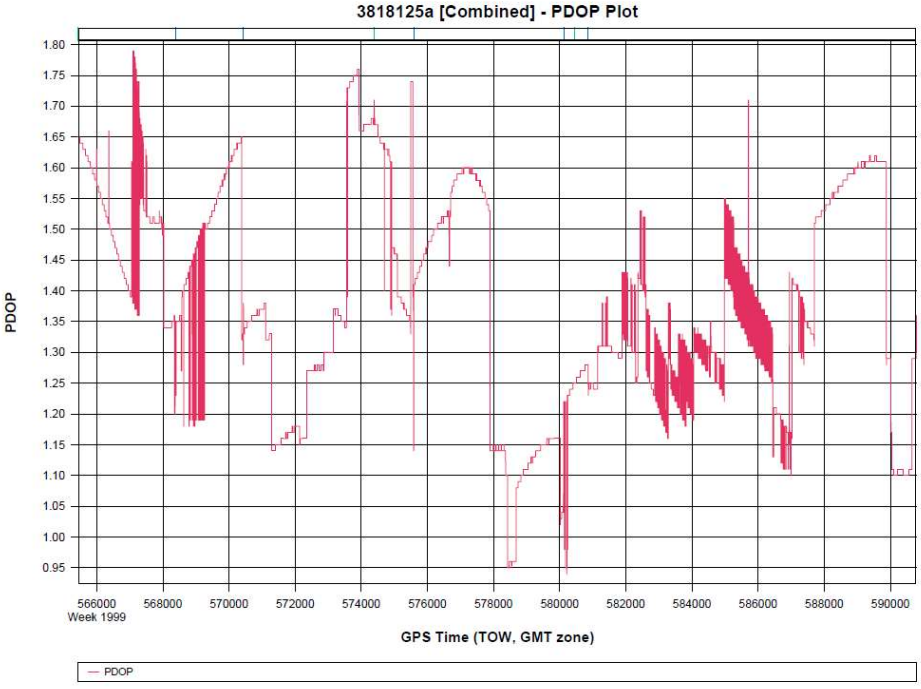

y gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
-0.11
480,000
485,000
490,000
Time (sec)

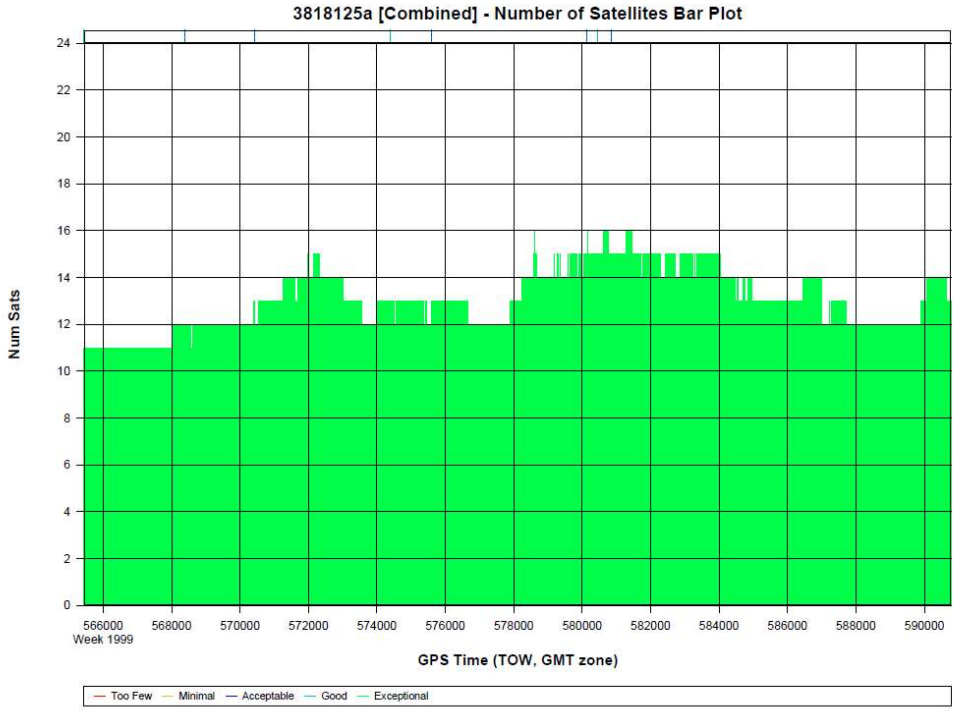

z gyro bias (deg/hr)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
480,000
485,000
490,000
Time (sec)

Mission 2 – 3818125a GNSS Processing



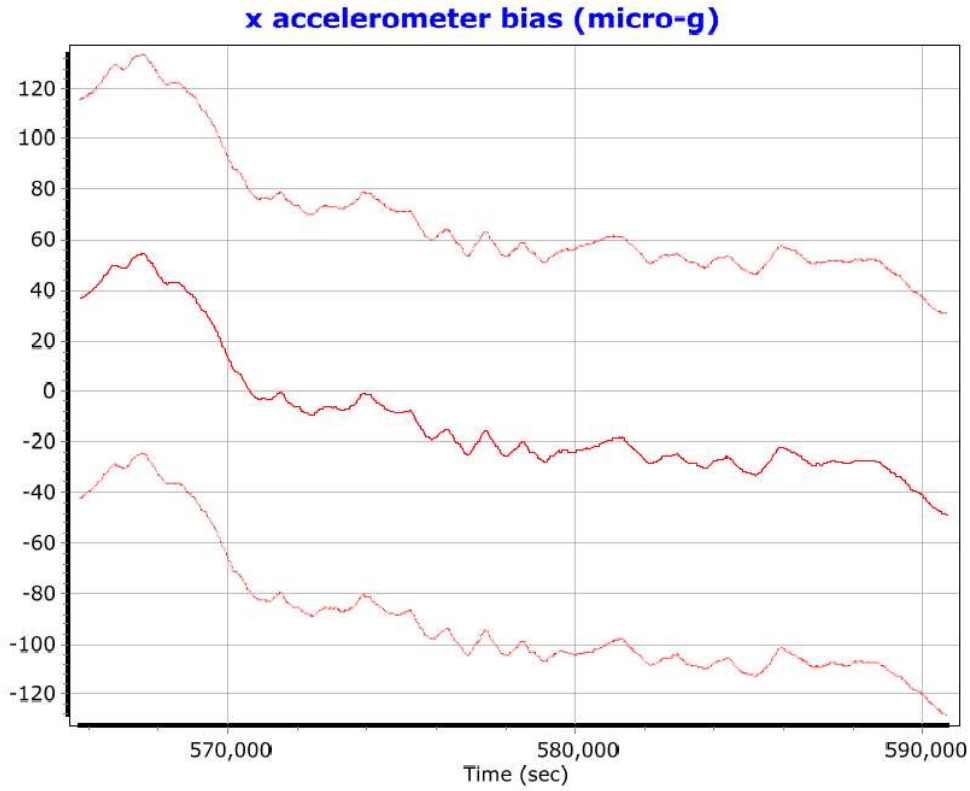

3818125a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
-0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
566000
Week 1999
568000
570000
572000
574000
576000
578000
580000
582000
584000
586000
588000
590000
GPS Time (TOW, GMT zone)
East
North
Up

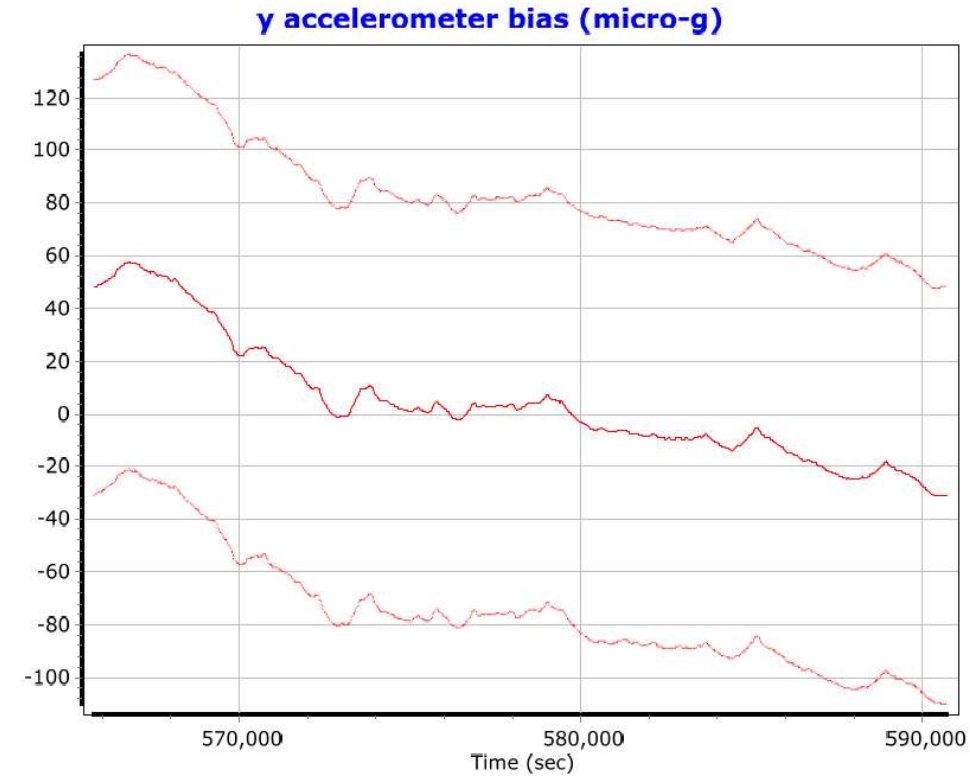

3818125a [Combined] - PDOP Plot
PDOP
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
566000
Week 1999
568000
570000
572000
574000
576000
578000
580000
582000
584000
586000
588000
590000
GPS Time (TOW, GMT zone)
PDOP

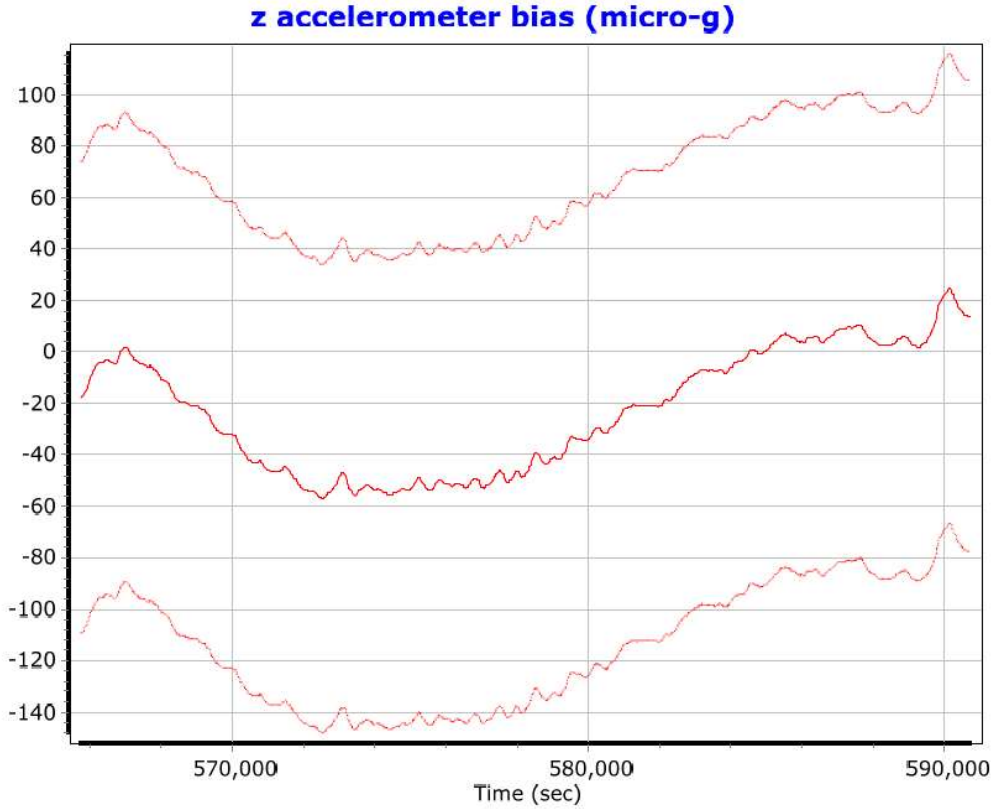

3818125a [Combined] - Number of Satellites Bar Plot
Num Sats
0
2
4
6
8
10
12
14
16
18
20
22
24
566000
Week 1999
568000
570000
572000
574000
576000
578000
580000
582000
584000
586000
588000
590000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

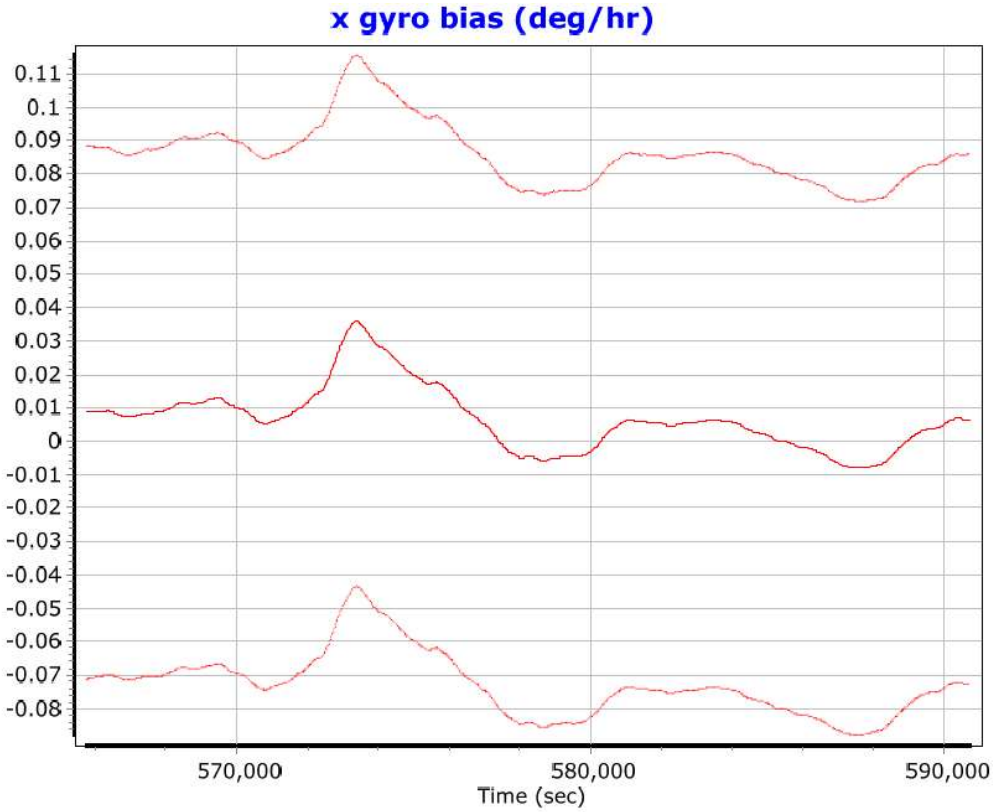
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\3818125a\05_INS-GPS_PROC\
01_POS\GNSS\3818125a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 25355
No processed position: 1
Missing Fwd or Rev: 7
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0199 (m)
C/A Code: 1.02 (m)
L1 Doppler: 0.024 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.017 (m)
North: 0.012 (m)
Height: 0.050 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (25345 occurances):
East: 0.017 (m)
North: 0.010 (m)
Height: 0.044 (m)
Quality Number Percentages:
Q 1: 95.4 %
Q 2: 4.6 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 87.666 (km)
Minimum: 1.899 (km)
Average: 39.644 (km)
First Epoch: 41.748 (km)
Last Epoch: 46.762 (km)

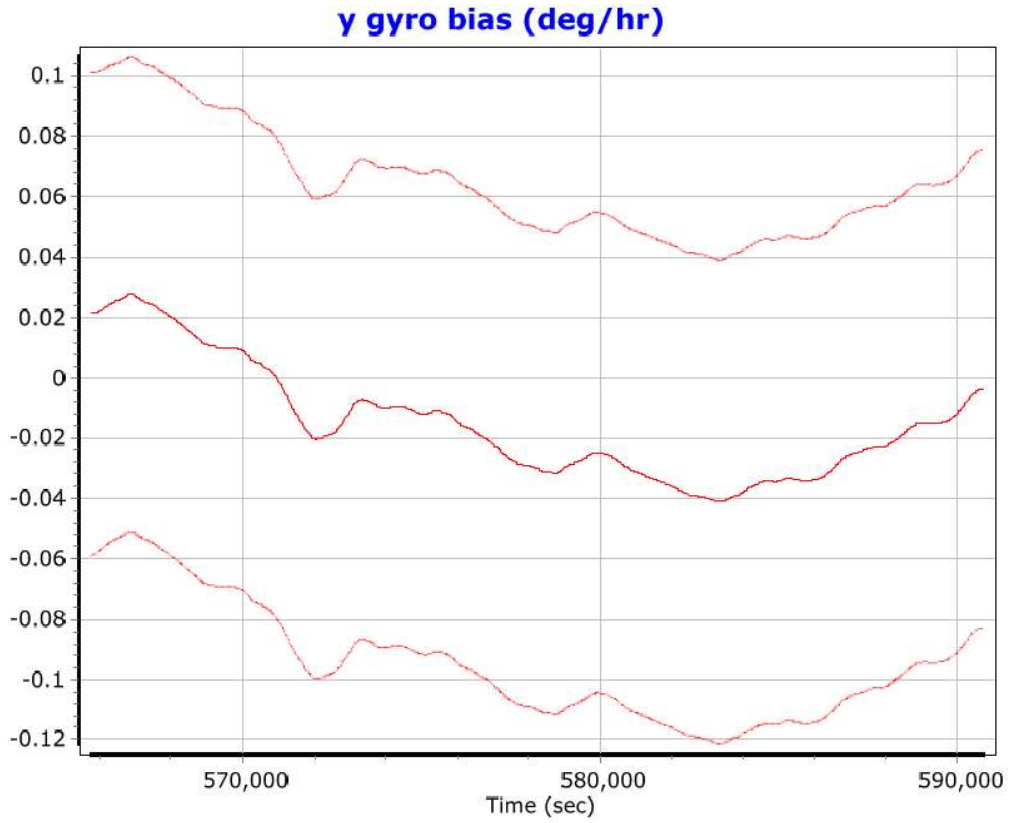
Mission 2 – 3818125a Sensor Errors

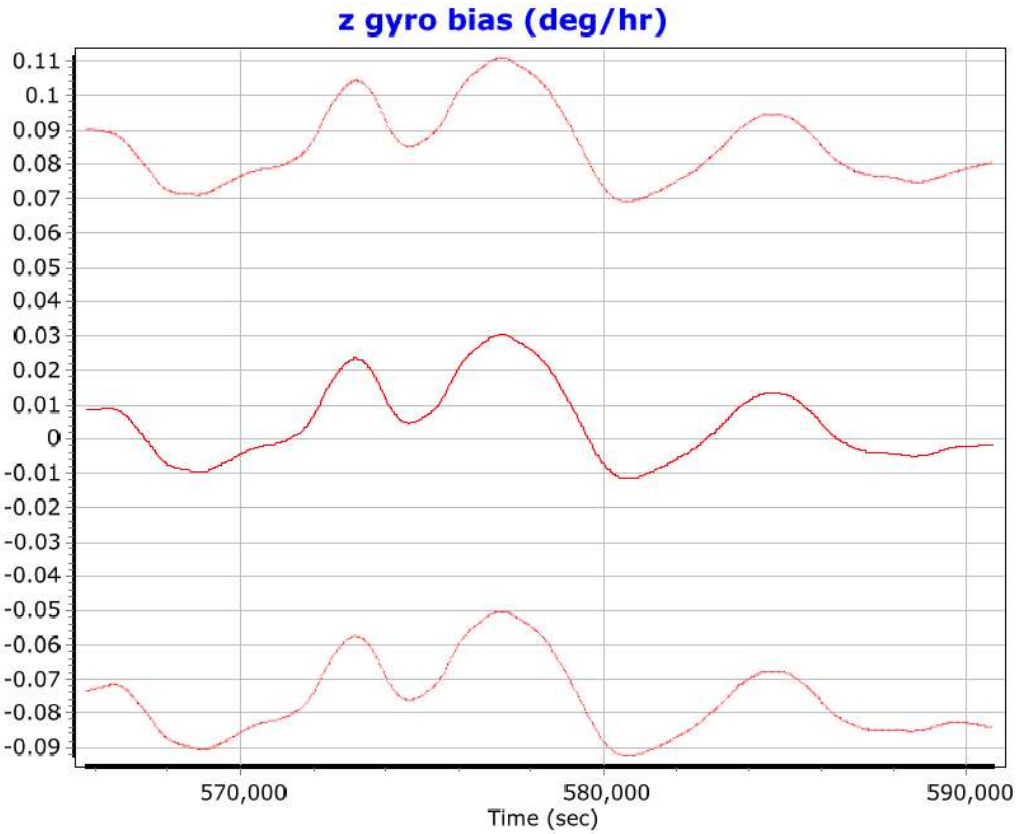





z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
570,000
580,000
590,000
Time (sec)

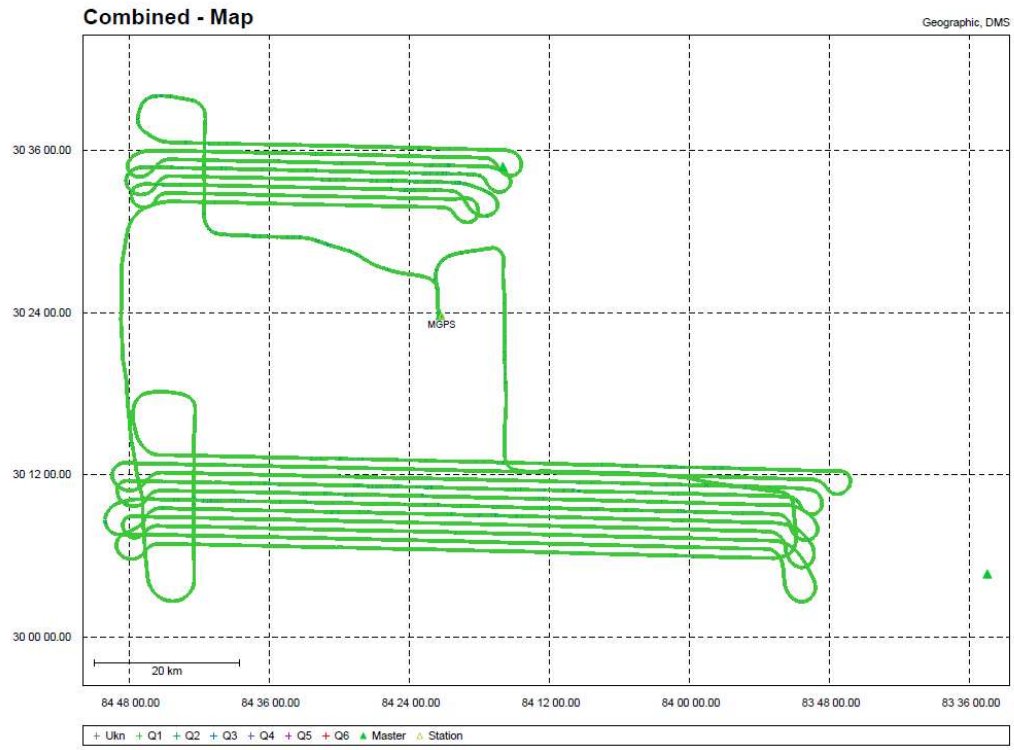

x gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
570,000
580,000
590,000
Time (sec)


y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
570,000
580,000
590,000
Time (sec)

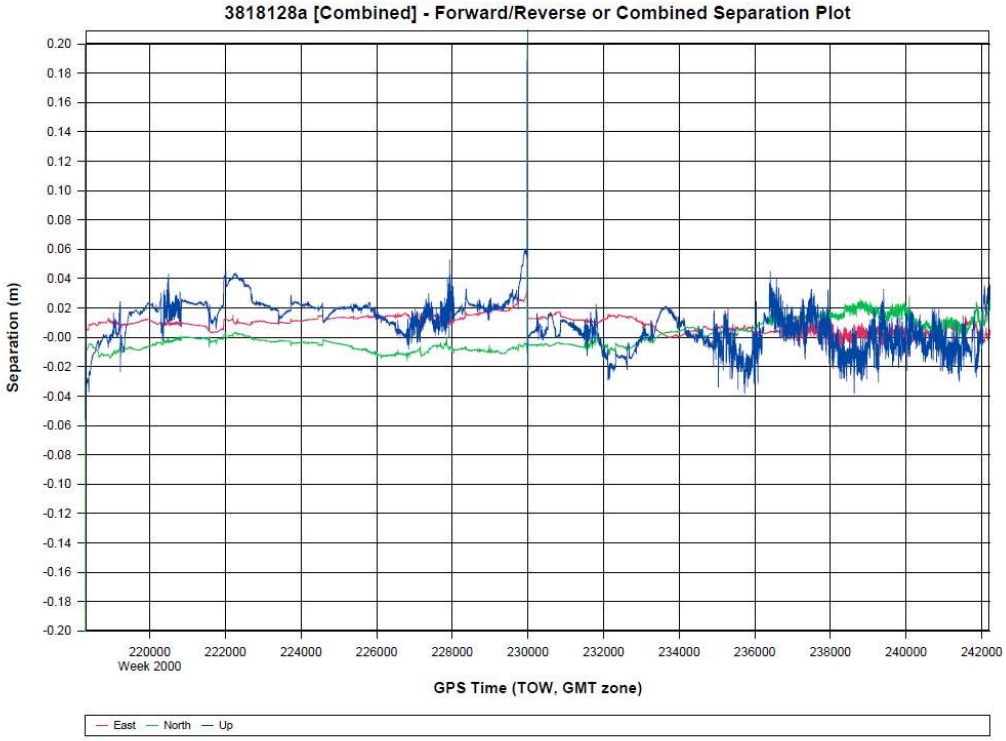

z gyro bias (deg/hr)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
570,000
580,000
590,000
Time (sec)

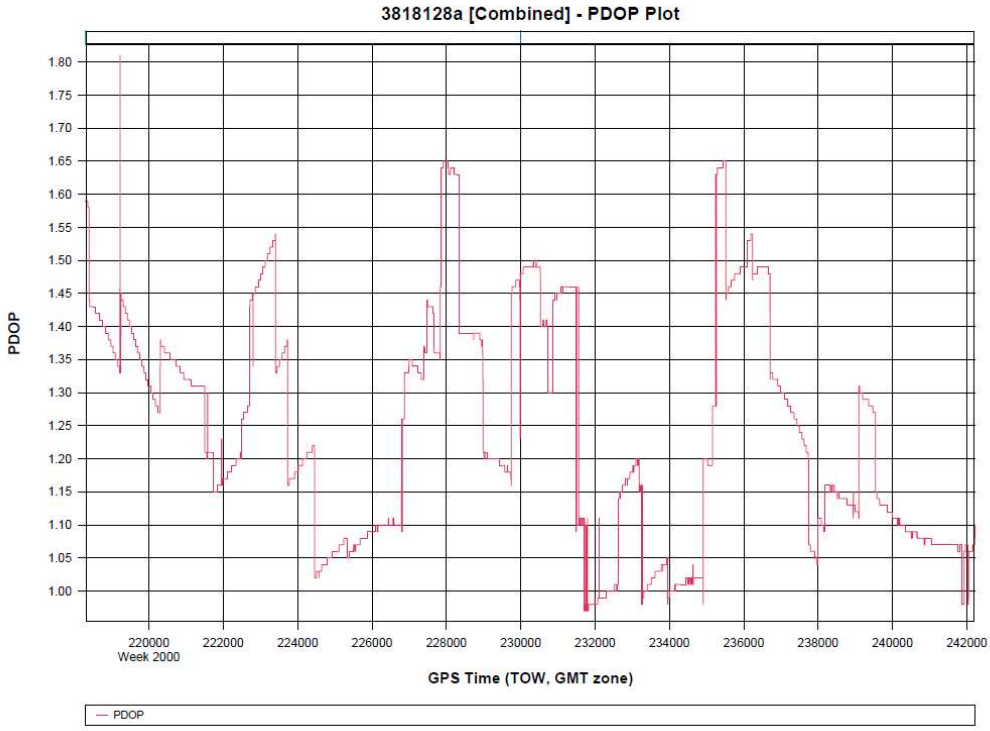
Mission 3 – 3818128a GNSS Processing

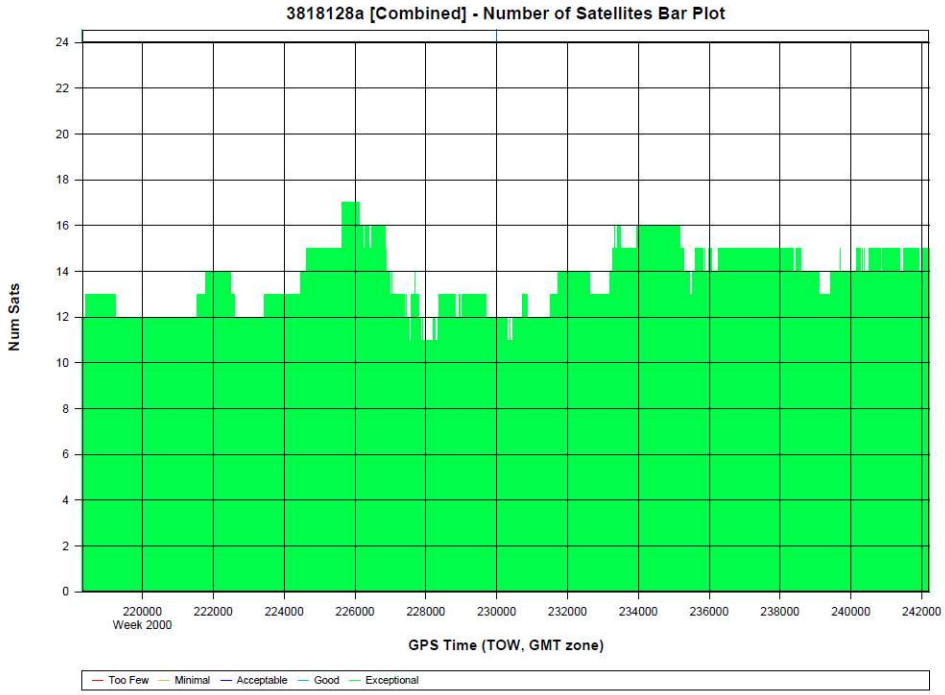
Project: 3818128a GrafNav v8.50.4120



Project: 3818128a GrafNav v8.50.4120

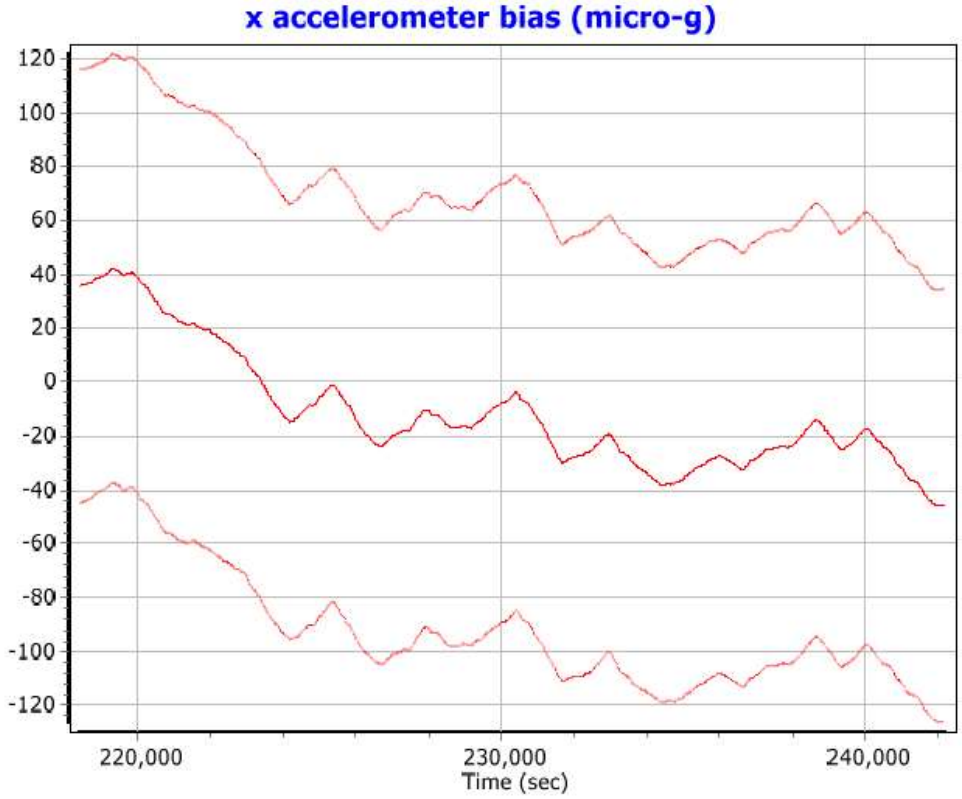


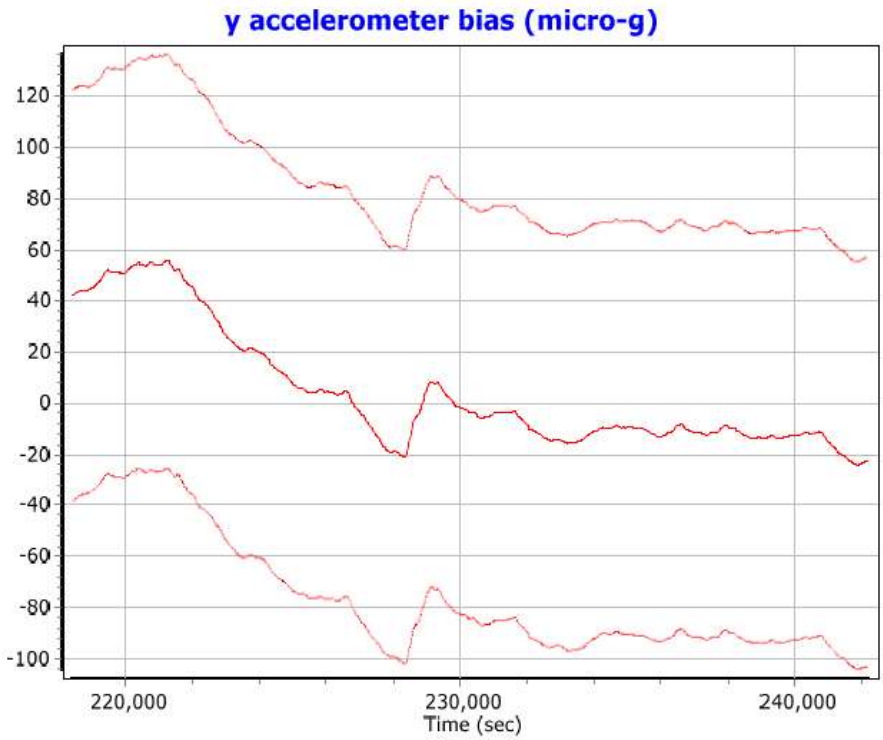

3818128a [Combined] - PDOP Plot
PDOP
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
220000
Week 2000
222000
224000
226000
228000
230000
232000
234000
236000
238000
240000
242000
GPS Time (TOW, GMT zone)
PDOP

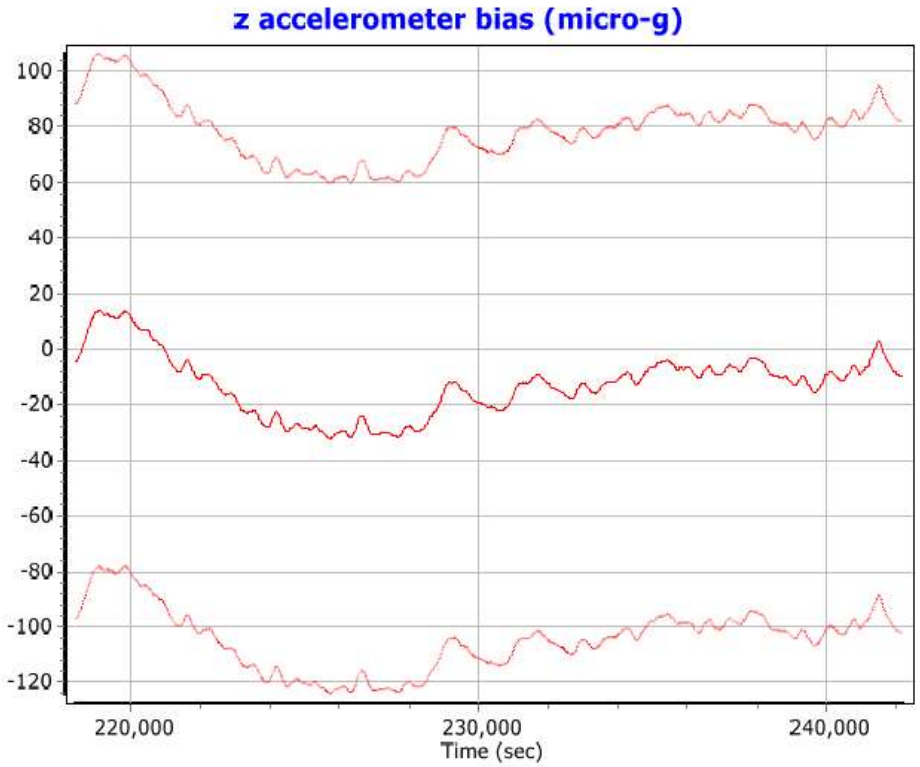

3818128a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
220000
Week 2000
222000
224000
226000
228000
230000
232000
234000
236000
238000
240000
242000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

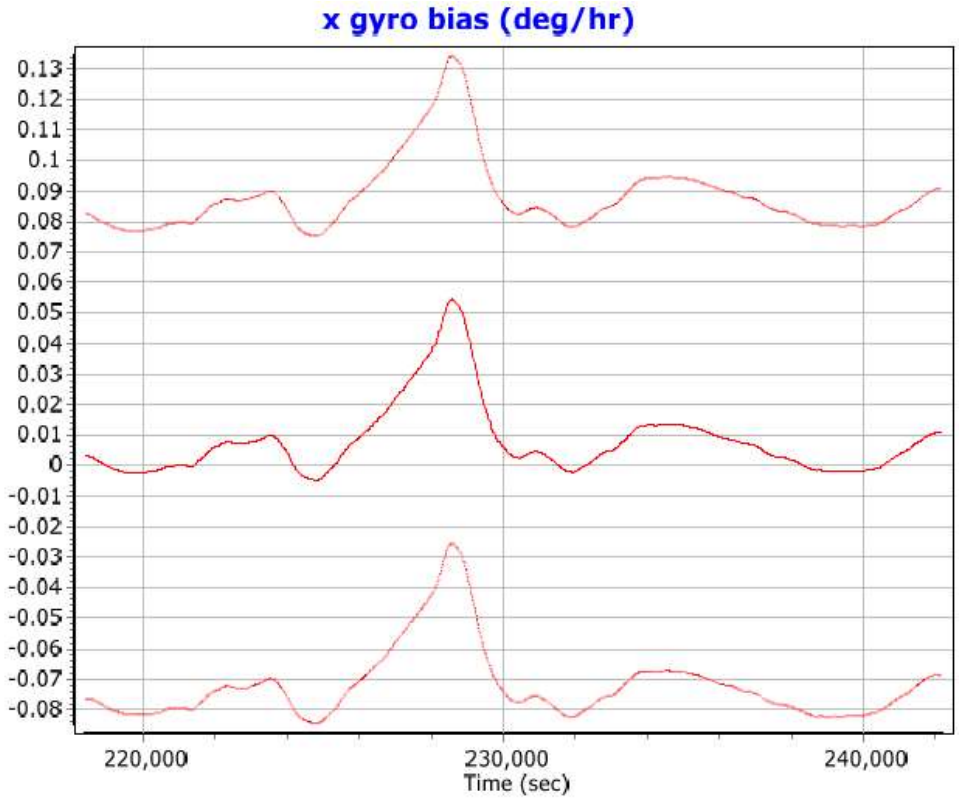
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\3818128a\05_INS-GPS_PROC\
01_POS\GNSS\3818128a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 23925
No processed position: 0
Missing Fwd or Rev: 6
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0189 (m)
C/A Code: 0.96 (m)
L1 Doppler: 0.024 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.011 (m)
North: 0.010 (m)
Height: 0.020 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (23917 occurances):
East: 0.011 (m)
North: 0.009 (m)
Height: 0.017 (m)
Quality Number Percentages:
Q 1: 97.3 %
Q 2: 2.7 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 70.087 (km)
Minimum: 6.405 (km)
Average: 40.102 (km)
First Epoch: 24.465 (km)
Last Epoch: 18.919 (km)

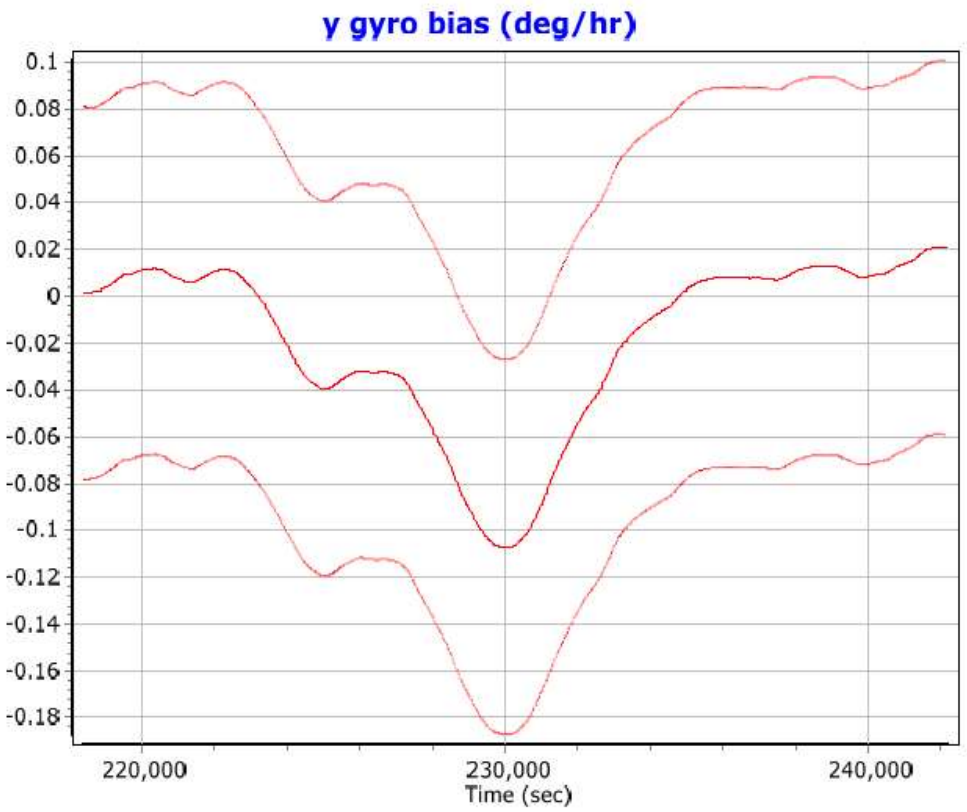
Mission 3 – 3818128a Sensor Errors

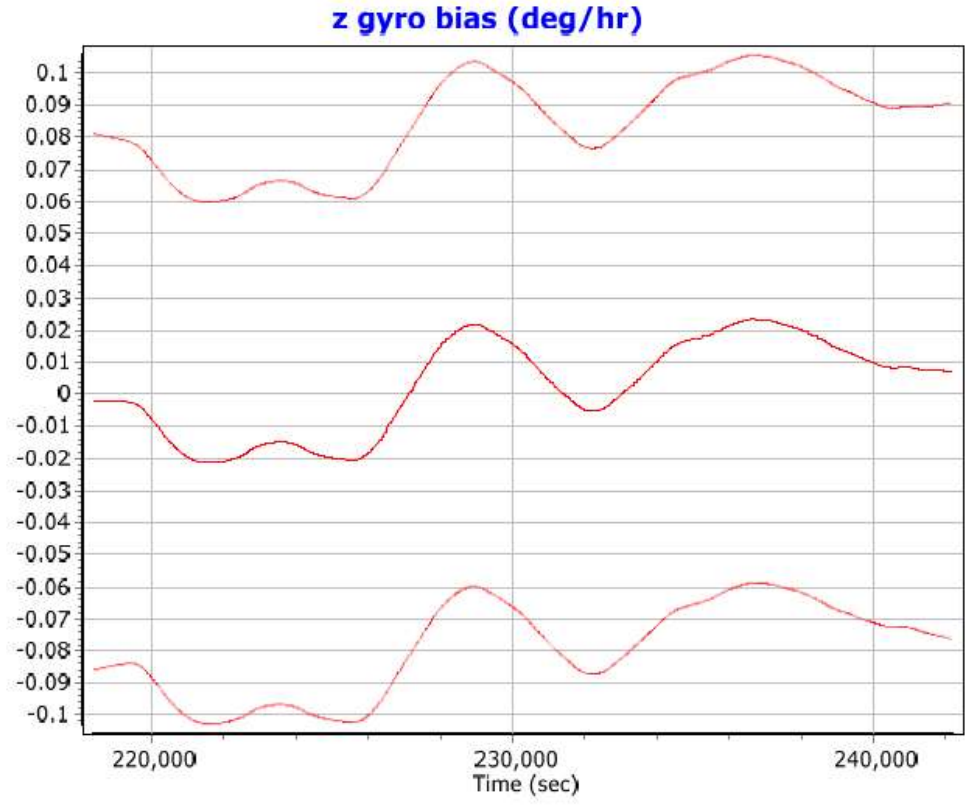





z accelerometer bias (micro-g)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
220,000
230,000
240,000
Time (sec)

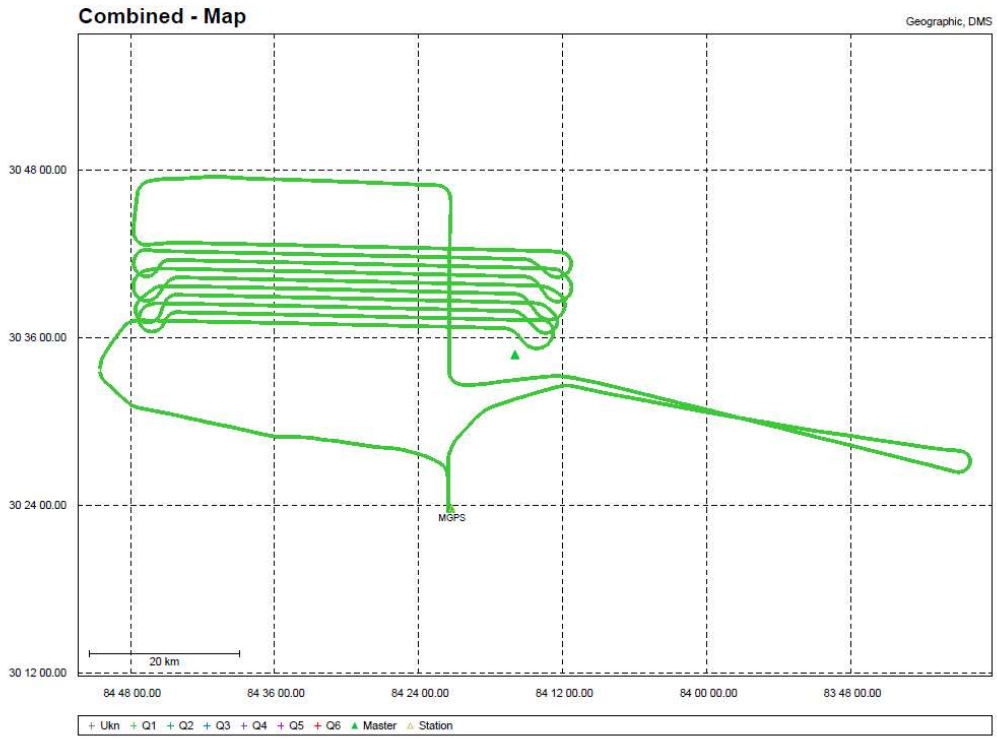

x gyro bias (deg/hr)
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
220,000
230,000
240,000
Time (sec)


y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
220,000
230,000
240,000
Time (sec)

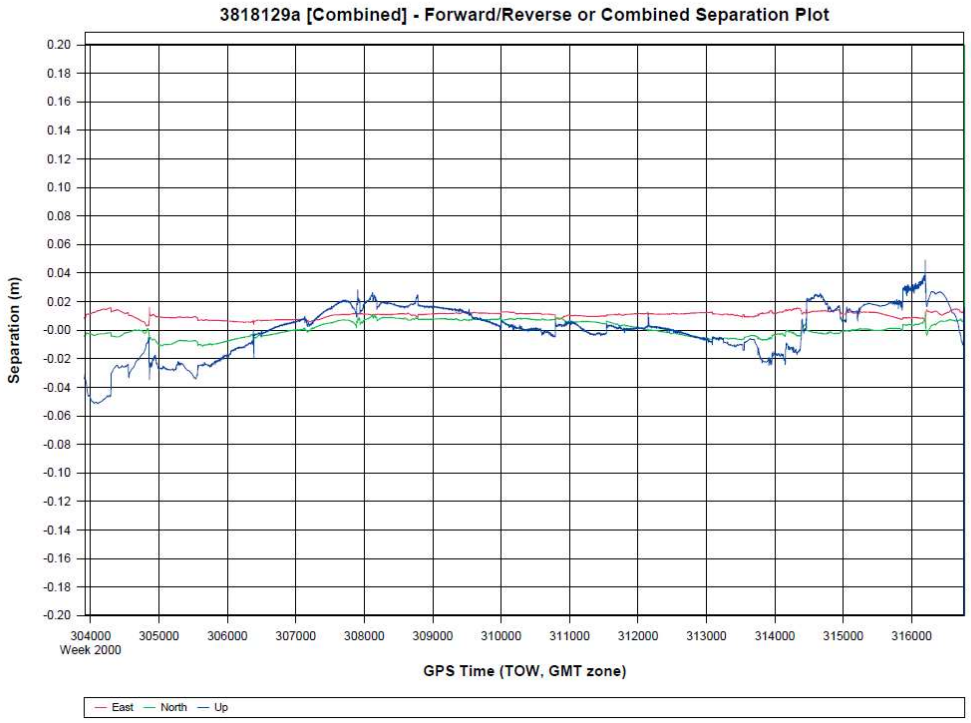

z gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
220,000
230,000
240,000
Time (sec)

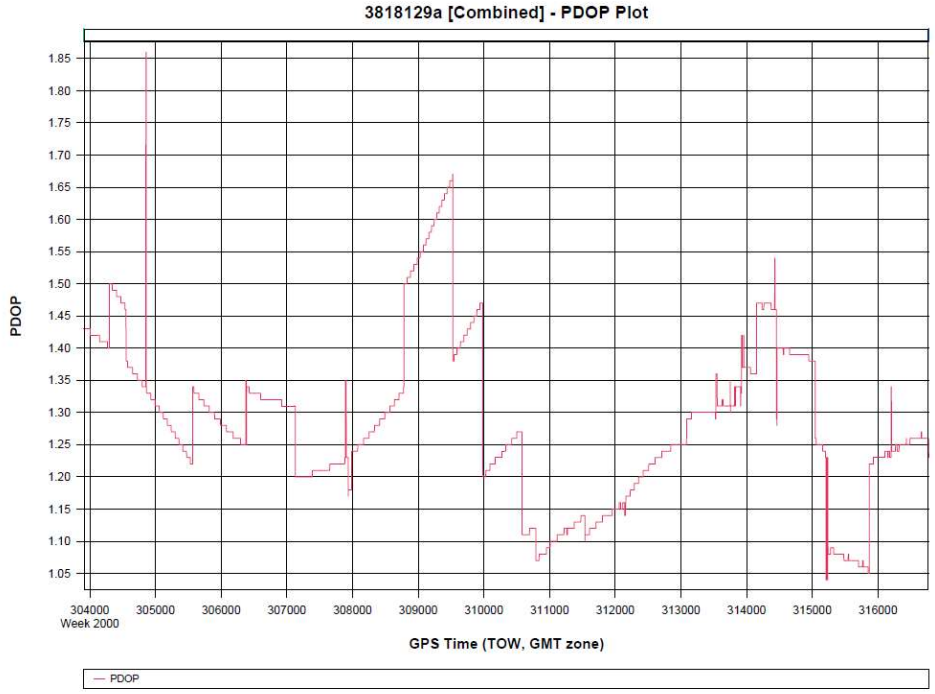
Mission 4 – 3818129a GNSS Processing

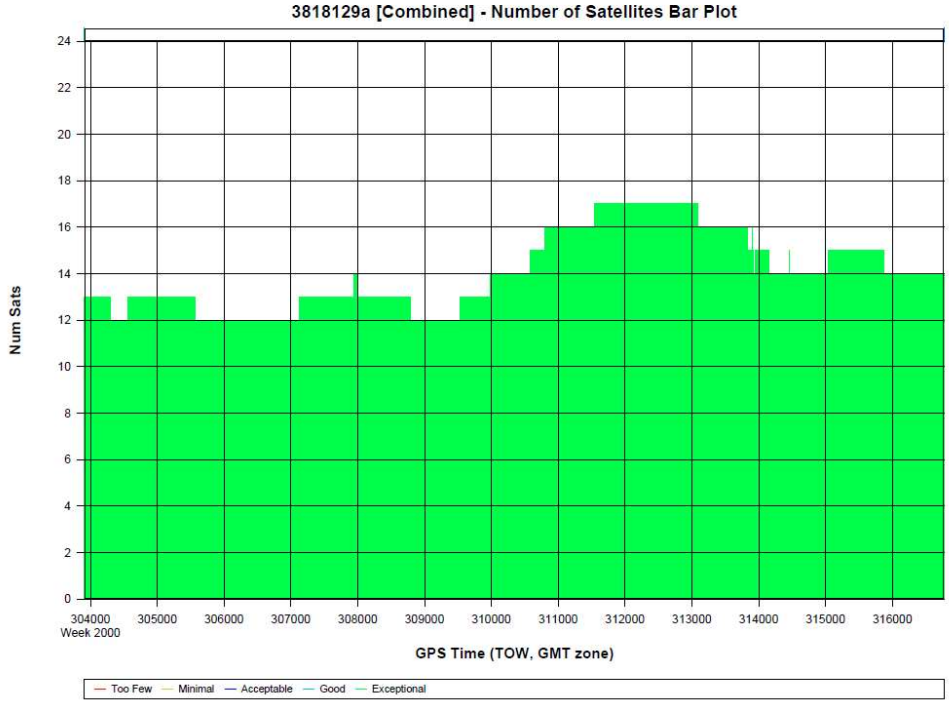
Project: 3818129a GrafNav v8.50.4120



Project: 3818129a GrafNav v8.50.4120

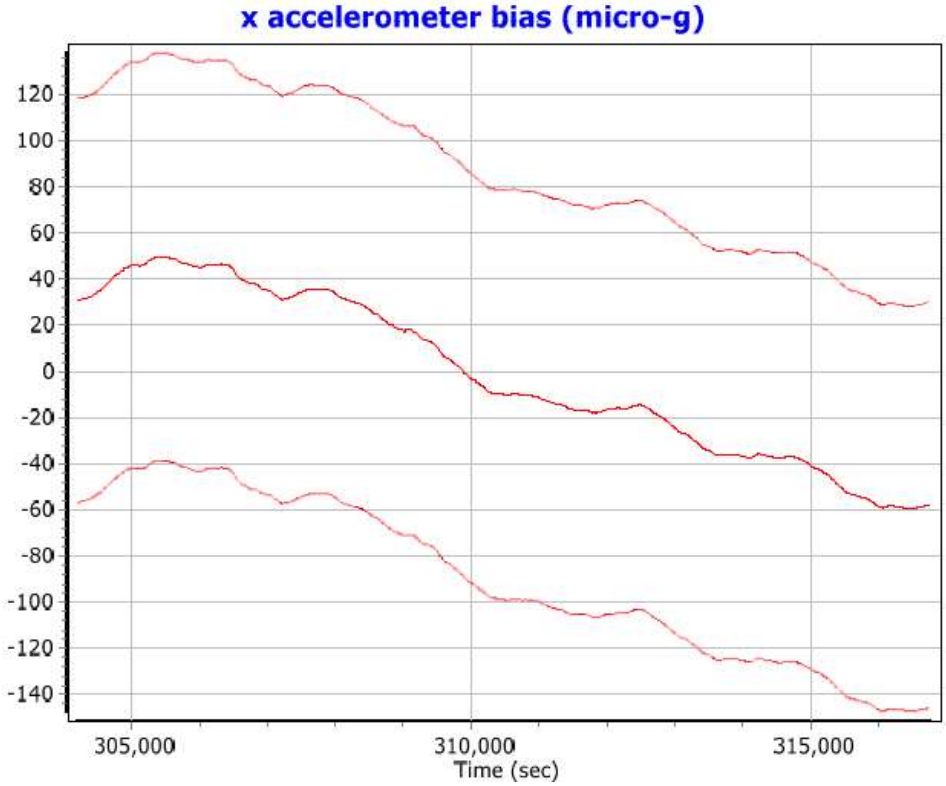


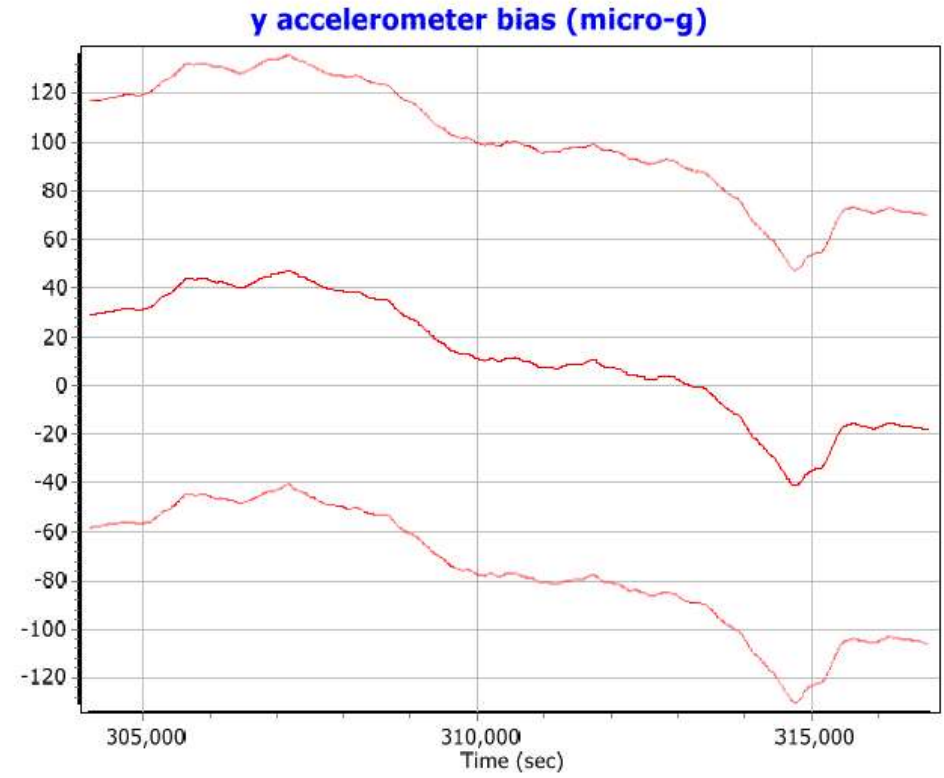

3818129a [Combined] - PDOP Plot
PDOP
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
304000
Week 2000
305000
306000
307000
308000
309000
310000
311000
312000
313000
314000
315000
316000
GPS Time (TOW, GMT zone)
PDOP

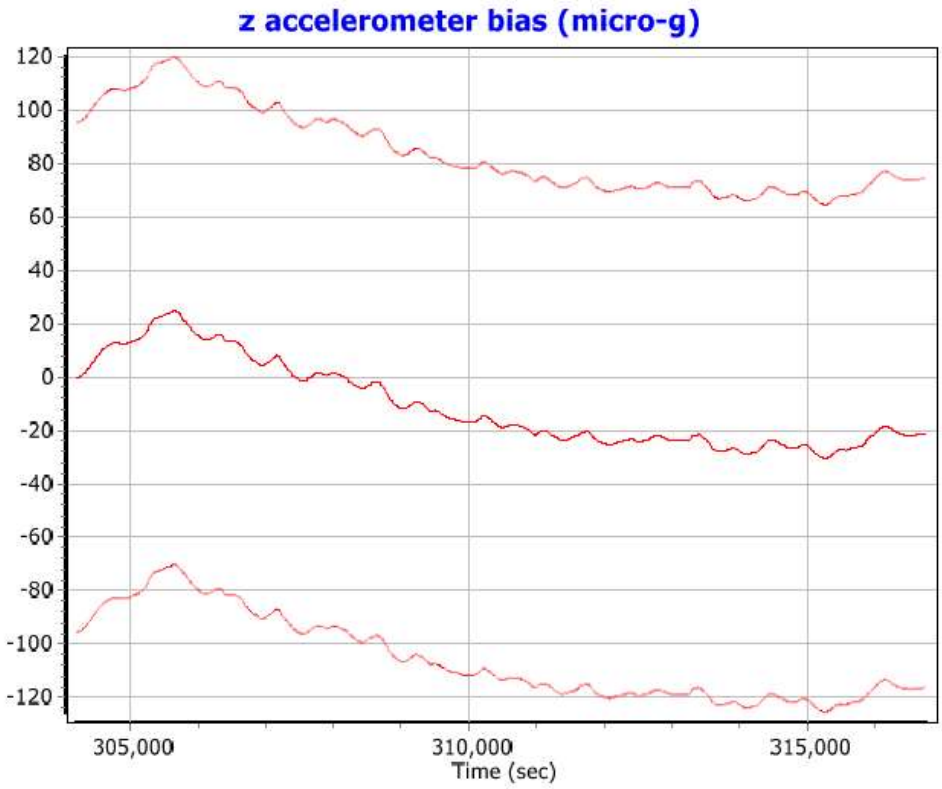

3818129a [Combined] - Number of Satellites Bar Plot
Num Sats
24
22
20
18
16
14
12
10
8
6
4
2
0
304000
Week 2000
305000
306000
307000
308000
309000
310000
311000
312000
313000
314000
315000
316000
GPS Time (TOW, GMT zone)
Too Few
Minimal
Acceptable
Good
Exceptional

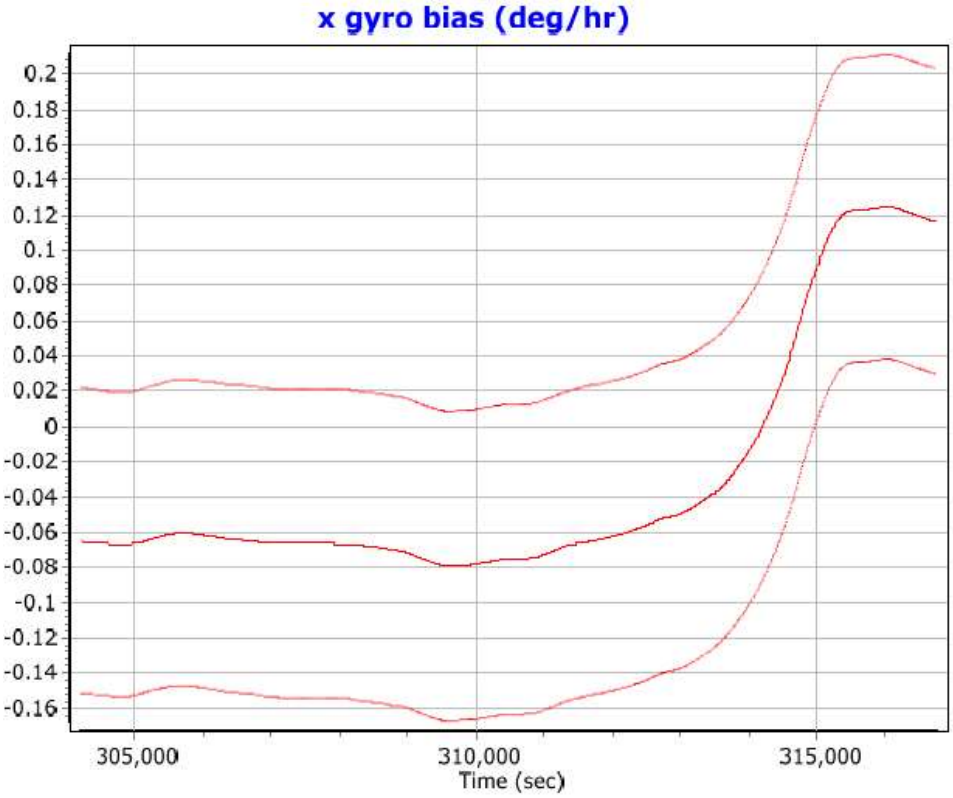
Processing Summary Information
Program: GrafNav
Version: 8.50.4120
Project: C:\projects\3143_Dewberry-NWFWMD_March-22-2018\LiDAR\3818129a\05_INS-GPS_PROC\
01_POS\GNSS\3818129a.gnv
Solution Type: Combined
Number of Epochs:
Total in GPB file: 12870
No processed position: 0
Missing Fwd or Rev: 4
With bad C/A code: 0
With bad L1 Phase: 0
Measurement RMS Values:
L1 Phase: 0.0167 (m)
C/A Code: 1.06 (m)
L1 Doppler: 0.023 (m/s)
Fwd/Rev Separation RMS Values:
East: 0.012 (m)
North: 0.009 (m)
Height: 0.020 (m)
Fwd/Rev Sep. RMS for dual FWD/REV fixes (12865 occurances):
East: 0.011 (m)
North: 0.006 (m)
Height: 0.017 (m)
Quality Number Percentages:
Q 1: 100.0 %
Q 2: 0.0 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %
Position Standard Deviation Percentages:
0.00 - 0.10 m: 100.0 %
0.10 - 0.30 m: 0.0 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %
Percentages of epochs with DD_DOP over 10.00:
DOP over Tol: 0.0 %
Baseline Distances:
Maximum: 65.094 (km)
Minimum: 1.980 (km)
Average: 27.772 (km)
First Epoch: 10.957 (km)
Last Epoch: 10.949 (km)

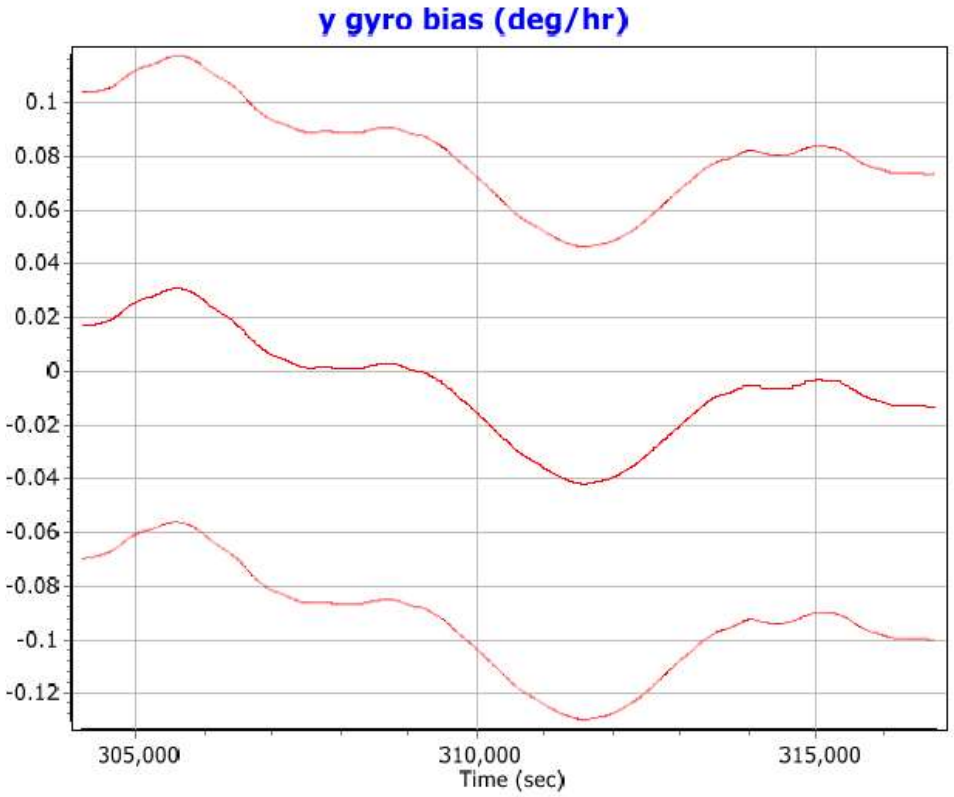
Mission 4 – 3818129a Sensor Errors






z accelerometer bias (micro-g)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
305,000
310,000
315,000
Time (sec)


x gyro bias (deg/hr)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
305,000
310,000
315,000
Time (sec)


y gyro bias (deg/hr)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
305,000
310,000
315,000
Time (sec)


z gyro bias (deg/hr)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
305,000
310,000
315,000
Time (sec)