Dewberry Consultants LLC
1000 N. Ashley Drive, Suite 801
Tampa, FL 33602-3718
813.225.1325
813.225.1385 fax
www.dewberry.com

South Carolina LiDAR Acquisition – Beaufort County

Report Produced for South Carolina Department of Natural Resources

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SUBMITTED BY:

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

SUBMITTED TO:
SC Dept of Natural Resources
1000 Assembly Street, Suite 125
Columbia, SC 29201
803.734.9494

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Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the South Carolina Department of Natural Resources (SCDNR) Beaufort County, SC Project Area.

The LiDAR data were processed to a bare-earth digital terrain model and a hydro-enforced digital terrain model. Detailed breaklines and bare-earth Digital Elevation Models (DEMs) were produced for the project area. Data was formatted according to tiles with each tile covering an area of 5,000 ft by 5,000 ft following the SCGS tiling and naming system (State provided). A total of 981 tiles were produced for the project encompassing an area of approximately 785 sq. miles.

THE PROJECT TEAM

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry was responsible for LAS classification, all LiDAR products, breakline production, Digital Elevation Model (DEM) production, and quality assurance.

Laser Mapping Specialist, Inc completed LiDAR data acquisition and data calibration for the project area.

SURVEY AREA

The project area addressed by this report falls within Beaufort County in South Carolina.

DATE OF SURVEY

The LiDAR aerial acquisition was conducted from March 6, 2013 (julian day 065) thru April 20, 2013 (julian day 079).

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) NSRS 2007
Vertical Datum: The Vertical datum for the project is North American Vertical Datum of 1988 (NAVD88)
Coordinate System: State Plane South Carolina FIPS 3900
Units: Horizontal units are in International Feet, Vertical units are in US Survey Feet.
Geiod Model: Geoid09

LIDAR VERTICAL ACCURACY

Dewberry did not conduct vertical accuracy testing of the LiDAR products. SCDNR will conduct additional, independent quality assurance/quality control and accuracy assessment studies of the elevation data produced by Dewberry.

PROJECT DELIVERABLES

The deliverables for the project are listed below.

1. Raw Point Cloud Data (Swaths)
2. Classified Point Cloud Data (Tiled)
3. Bare Earth Surface (Raster DEM – GRID format, 4 blocks)
4. Intensity Images (8-bit gray scale, tiled, GeoTIFF format)
5. Breakline Data (File GDB)
6. Bare Earth and Hydro-Enforced Terrains (File GDB)
7. Contours 1 ft (File GDB)
8. Edge of Roads (File GDB)
9. Metadata
10. Project Report (Acquisition, Processing, QC)
11. Project Extents, Including a shapefile derived from the LiDAR Deliverable

PROJECT TILING FOOTPRINT

Nine hundred and eighty-two (982) tiles intersect the project boundary. However, nine hundred and eighty-one (981) tiles were delivered for the project. A small portion of tile number 1113-03 intersects the project boundary; however, no LiDAR points are available for this tile due to it being completely covered by a water body. Therefore, it is excluded from this delivery. The extent of each tile is 5,000 feet by 5,000 feet (see Appendix A for a complete listing of delivered tiles).

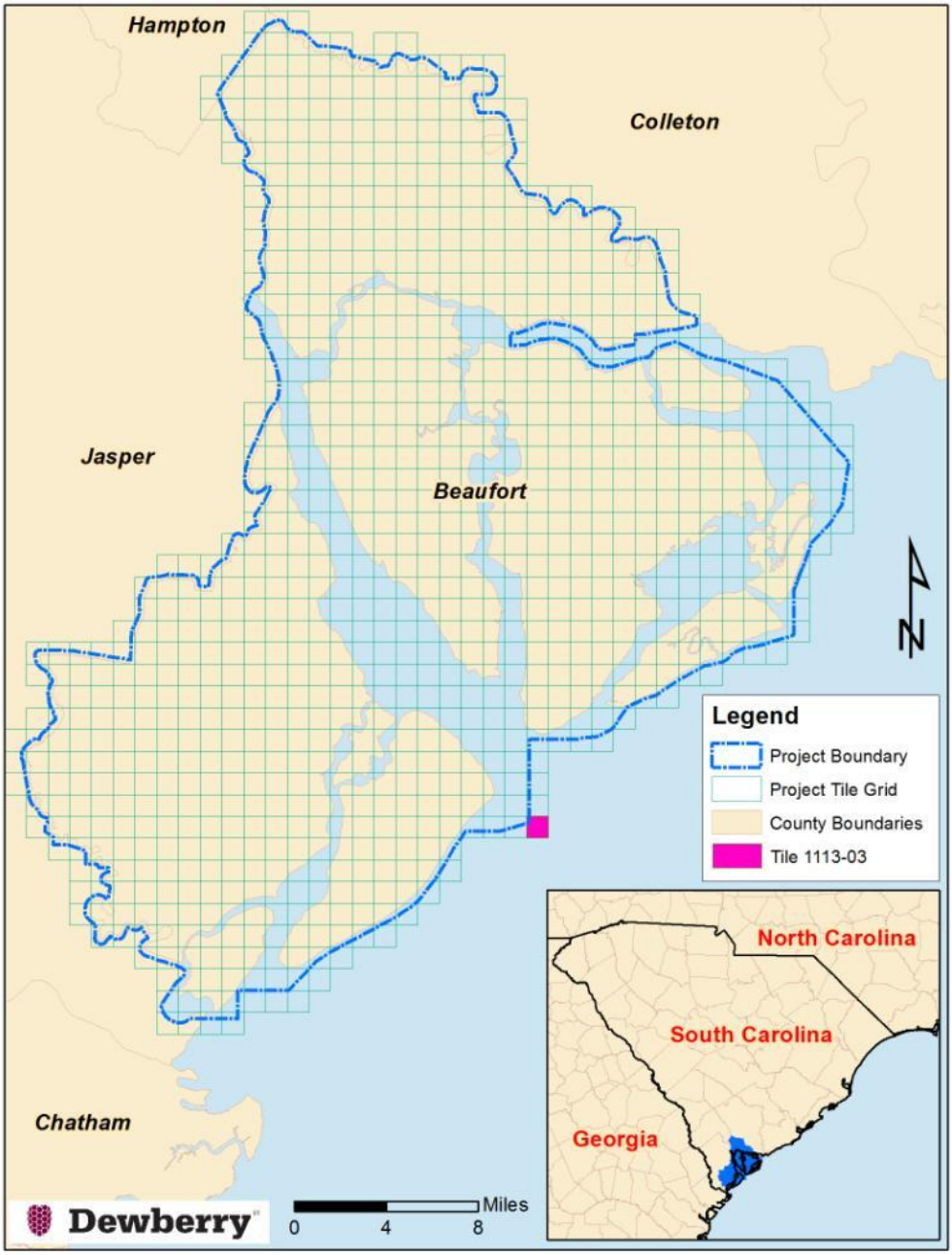


Figure 1 - Project Map

LiDAR Acquisition Report

LMSI provided high accuracy, calibrated multiple return LiDAR for roughly 785 square miles around the Beaufort County, SC area. Data was collected and delivered in compliance with the "U.S. Geological Survey National Geospatial Program Base LiDAR Specifications, Version 13 – ILMF 2010."

LIDAR ACQUISITION DETAILS

LIDAR acquisition began on March 6, 2012 (julian day 065) and was completed on April 20, 2013 (julian day 079). A total of 16 survey missions were flown to complete the project. LMSI utilized an Optech ALTM3100EA for the acquisition. The flight plan was flown as planned with no modifications. There were no unusual occurrences during the acquisition and the sensor performed within specifications. There were 203 flight lines required to complete the project.

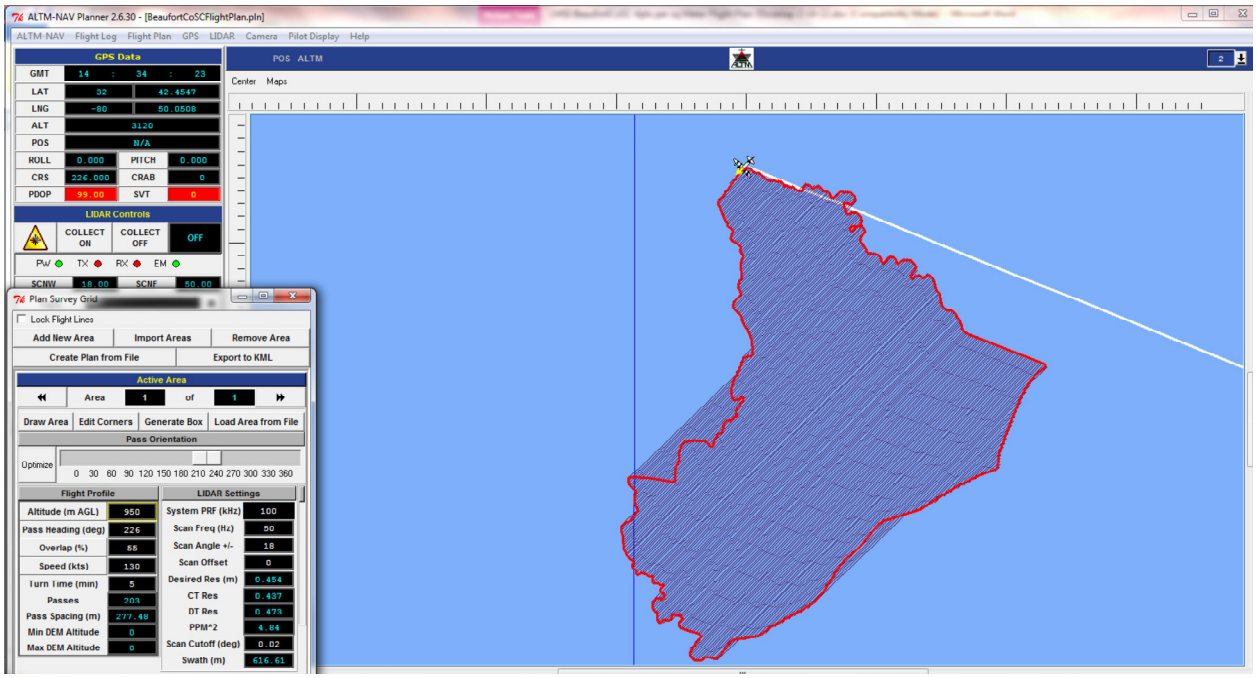


Figure 2 - Flight Layout

Laser Firing Rate: 100000
Altitude (mtr. AGL): 950
Swath Overlap (%): 55
Approx. Ground Speed (kts): 130
Scan Rate (Hz): 50
Scan Angle (°±): 18
Computed Along Track Spacing (mtr): 0.44
Computed Cross Track Spacing (mtr): 0.47
Average Raw Point Spacing (mtr): 4.8
Computed Swath Width (mtr): 616
Number of Lines Required: 203
Line Spacing (mtr): 277

LIDAR CONTROL

Two NGS monuments (G7_203 and GG) were used both for the base stations and as the tie points for radial ground control checkpoints. A third NGS monument (G7_228) was collected as a radial shot and used as a checkpoint for the network. The calculated coordinates for G7_228 were less than 1cm different than the published coordinates. LiDAR data was collected in horizontal UTM Zone 18 NAD 83 (2011) meters, vertical NAVD 88 Geoid 12a meters. The coordinates of all used base stations are provided in the table below.

Name	Easting (m)	Northing (m)	Ellipsoid Ht (m) NAD83 (2011)	Orthometric Ht (m)
G7_203 (Base 1)	523570.29	3598754.96	-24.91	6.82
GG (Base 2)	524329.39	3584650.06	-28.45	3.25

Table 1 – Base Stations used to control LiDAR acquisition

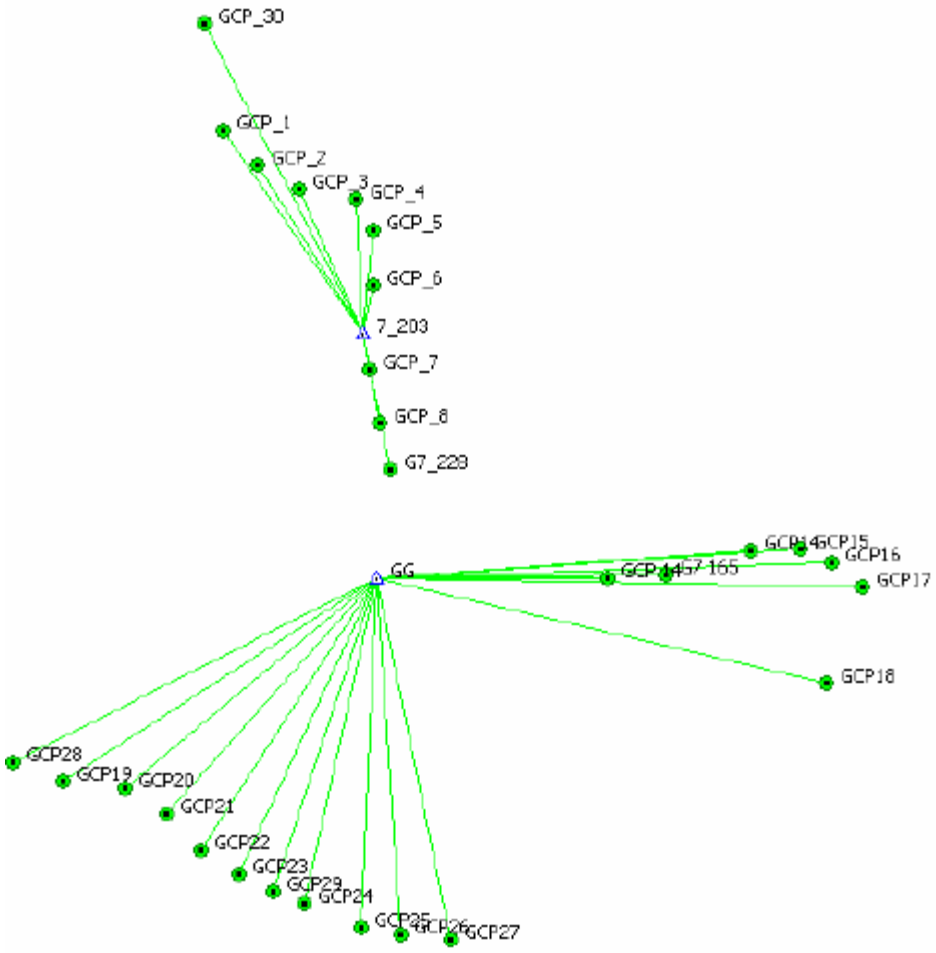


Figure 3 – Base Stations and radial ground control points

Name	dN (m)	dE (m)	dHt (m)	Horiz Precision (m)	Vert Precision (m)
7_203-G7_228	-7921.298	1553.822	-3.430	0.005	0.010
7_203-GCP_1	11683.423	-8116.072	-19.048	0.008	0.014
7_203-GCP_2	9728.459	-6115.974	-8.963	0.007	0.013
7_203-GCP_3	8381.569	-3750.091	-6.805	0.007	0.011
7_203-GCP_4	7731.136	-453.823	-8.307	0.004	0.010
7_203-GCP_5	5899.491	561.802	-2979	0.002	0.005
7_203-GCP_6	2784.166	551.130	-1.745	0.001	0.002
7_203-GCP_7	-2136.645	309.391	-4.383	0.001	0.002
7_203-GCP_8	-5230.059	975.363	0.866	0.002	0.004
7_203-GCP_30	17891.318	-9222.641	-31.549	0.007	0.013
G7 165-GG	-183.797	-16834.760	-24.984	0.007	0.015
GCP14-GG	-1563.553	-21805.130	-36.994	0.008	0.016
GCP15-GG	-1640.074	-24646.755	-45.759	0.010	0.016
GCP16-GG	-857.121	-26505.464	-54.445	0.018	0.016
GCP17-GG	534.755	-28301.189	-61.168	0.011	0.019
GCP18-GG	6174.535	-26131.100	-54.116	0.026	0.024
GCP19-GG	11848.575	18153.306	-39.651	0.009	0.018
GCP20-GG	12172.180	14622.069	-31.779	0.008	0.016
GCP21-GG	13642.321	1220.856	-30.571	0.008	0.016
GCP22-GG	15738.113	10225.602	-31.309	0.007	0.018
GCP23-GG	17208.628	7957.472	-30.716	0.007	0.016
GCP24-GG	18845.627	4181.425	-34570	0.008	0.017
GCP25-GG	20223.528	855.077	-31.957	0.010	0.017
GCP26-GG	20621.272	-1431.470	-35.525	0.010	0.016
GCP27-GG	20889.386	-4377.503	-37.473	0.010	0.017
GCP28-GG	10749.609	2113.385	-46.913	0.010	0.018
GCP29-GG	18125.687	6009.576	-28.869	0.008	0.016
GCP 14-GG	80.164	-13469.34	-13.194	0.007	0.013

Table 2 – GPS Observations

AIRBORNE GPS TRAJECTORIES

All airborne GPS trajectories were processed and checked on site. All trajectories were very high quality with forward/reverse separation between 2cm and 5 cm.

GPS processing reports for each mission are included in Appendix B.

LIDAR SURVEY COVERAGE CHECK

On a project level, a supplementary coverage check is carried out to ensure no data voids unreported by Field Operations are present. No data gaps are present except for water features.

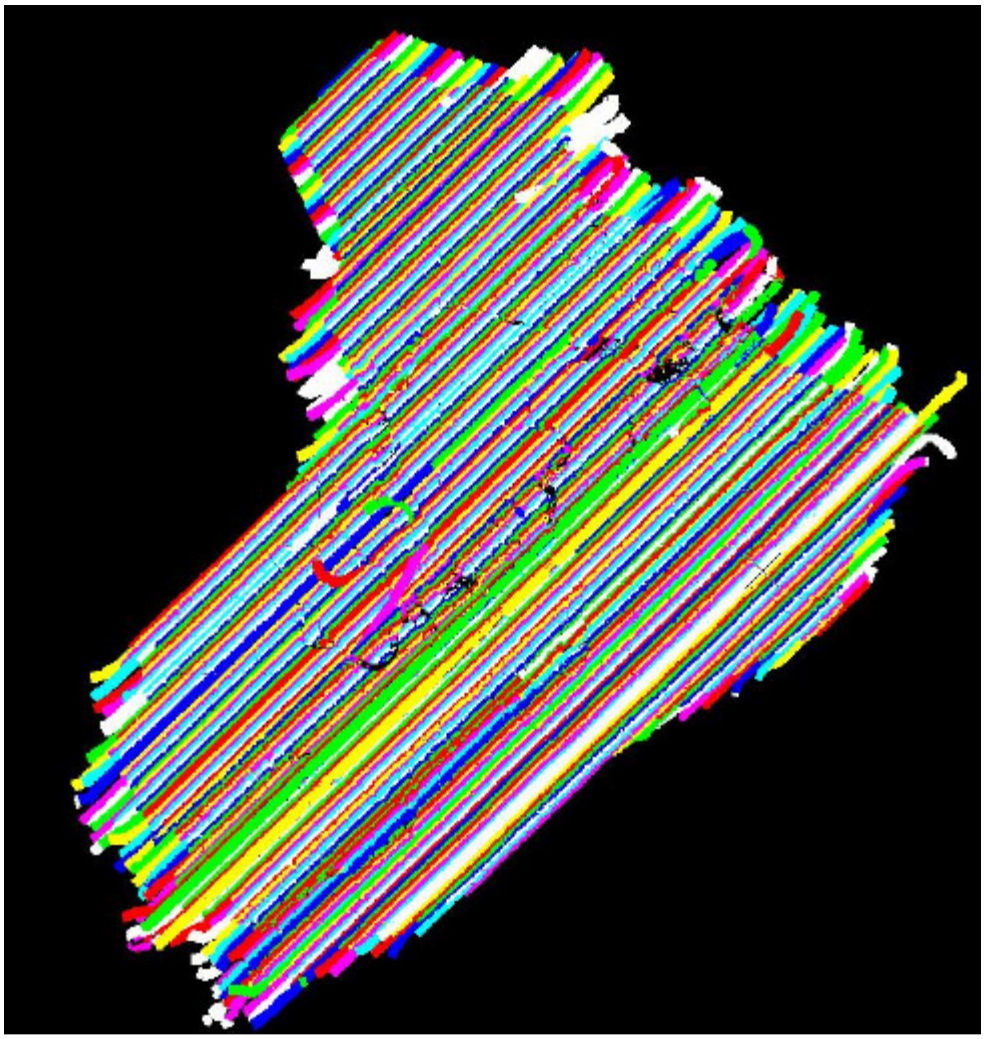


Figure 4 – LiDAR Swath output showing complete coverage.

LIDAR CONTROL REPORT

The radial points matched the LiDAR data to an average RMS of 0.01m.

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	DZ
1	523521.710	3564432.420	3.000	3.040	+0.040
2	546118.880	3586313.010	3.020	2.990	-0.030
3	509724.770	3572468.530	6.480	6.480	+0.000
4	523570.290	3598754.960	6.820	6.870	+0.050
5	524114.640	3601539.340	5.720	5.670	-0.050
6	518843.090	3566316.950	3.410	3.430	+0.020
7	516402.980	3567435.22	5.640	5.640	+0.000
8	524329.390	3584650.060	3.250	3.290	+0.040
9	512149.730	3570998.370	7.410	7.370	-0.040

10	550481.300	3578608.840	1.210	1.230	+0.020
11	552622.420	3584263.530	1.970	1.960	-0.010
12	514129.810	3568903.780	6.790	6.790	+0.000
13	515429.860	3610414.660	3.660	3.670	+0.010
14	514309.060	3616617.500	7.100	7.100	+0.000
15	517433.790	3608465.180	8.220	8.210	-0.010

Table 3 - Static GPS Validation

LiDAR Processing & Qualitative Assessment

DATA CLASSIFICATION AND EDITING

LiDAR mass points were produced to LAS 1.2 specifications, including the following LAS classification codes:

- Class 1 = Unclassified, used for all other features that do not fit into remaining classes
- Class 2 = Bare-Earth Ground
- Class 7 = Noise, low and high points
- Class 8 = Model Key Points (thinned bare-earth ground)
- Class 9 = Water, points located within collected breaklines
- Class 10 = Ignored Ground due to breakline proximity
- Class 11 = Withheld, Points with scan angles exceeding +/- 18 degrees
- Class 13 = Bridges and Culverts

Please note that the model key point class is a thinned ground dataset. To view the full ground dataset, classes 2 and 8 are both required.

The data was processed using GeoCue and TerraScan software. The initial step is the setup of the GeoCue project, which is done by importing a project defined tile boundary index encompassing the entire project area. The acquired 3D laser point clouds, in LAS binary format, were imported into the GeoCue project and tiled according to the project tile grid. Once tiled, the laser points were classified using a proprietary routine in TerraScan. This routine classifies any obvious outliers in the dataset to class 7 and points with scan angles exceeding +/- 18 degrees to class 11. After points that could negatively affect the ground are removed from class 1, the ground layer is extracted from this remaining point cloud. The ground extraction process encompassed in this routine takes place by building an iterative surface model.

This surface model is generated using three main parameters: building size, iteration angle and iteration distance. The initial model is based on low points being selected by a "roaming window" with the assumption that these are the ground points. The size of this roaming window is determined by the building size parameter. The low points are triangulated and the remaining points are evaluated and subsequently added to the model if they meet the iteration angle and distance constraints. This process is repeated until no additional points are added within iterations. A second critical parameter is the maximum terrain angle constraint, which determines the maximum terrain angle allowed within the classification model.

The following fields within the LAS files are populated to the following precision: GPS Time (0.000001 second precision), Easting (0.001 feet precision), Northing (0.001 feet precision), Elevation (0.001 feet precision), Intensity (integer value - 12 bit dynamic range), Number of Returns (integer - range of 1-4), Return number (integer range of 1-4), Scan Direction Flag (integer - range 0-1), Classification (integer), Scan Angle Rank (integer), Edge of flight line (integer, range 0-1), User bit field (integer - flight line information encoded). The LAS file also contains a Variable length record in the file header that defines the projection, datums, and units.

Once the initial ground routine has been performed on the data, Dewberry creates Delta Z (DZ) orthos to check the relative accuracy of the LiDAR data. These orthos compare the elevations of LiDAR points from overlapping flight lines on a 6 feet pixel cell size basis. If the elevations of points within each pixel are within 7 cm (0.230 ft) of each other, the pixel is colored green. If the elevations of points within each pixel are between 7 cm and 10.5 cm (0.344 ft) of each other, the pixel is colored yellow, and if the elevations of points within each pixel are greater than 10.5 cm (0.344 ft) in difference, the pixel is colored red. Pixels that do not contain points from overlapping flight lines are colored according to their intensity values. DZ orthos can be created using the full point cloud or ground only points and are used to review and verify the calibration of the data is acceptable. Some areas are expected to show sections or portions of red, including terrain variations, slope changes, and vegetated areas or buildings if the full point cloud is used. However, large or continuous sections of yellow or red pixels can indicate the data was not calibrated correctly or that there were issues during acquisition that could affect the usability of the data. The DZ orthos for Beaufort County showed that the data was calibrated correctly with no issues that would affect its usability. The figure below shows an example of the DZ orthos.

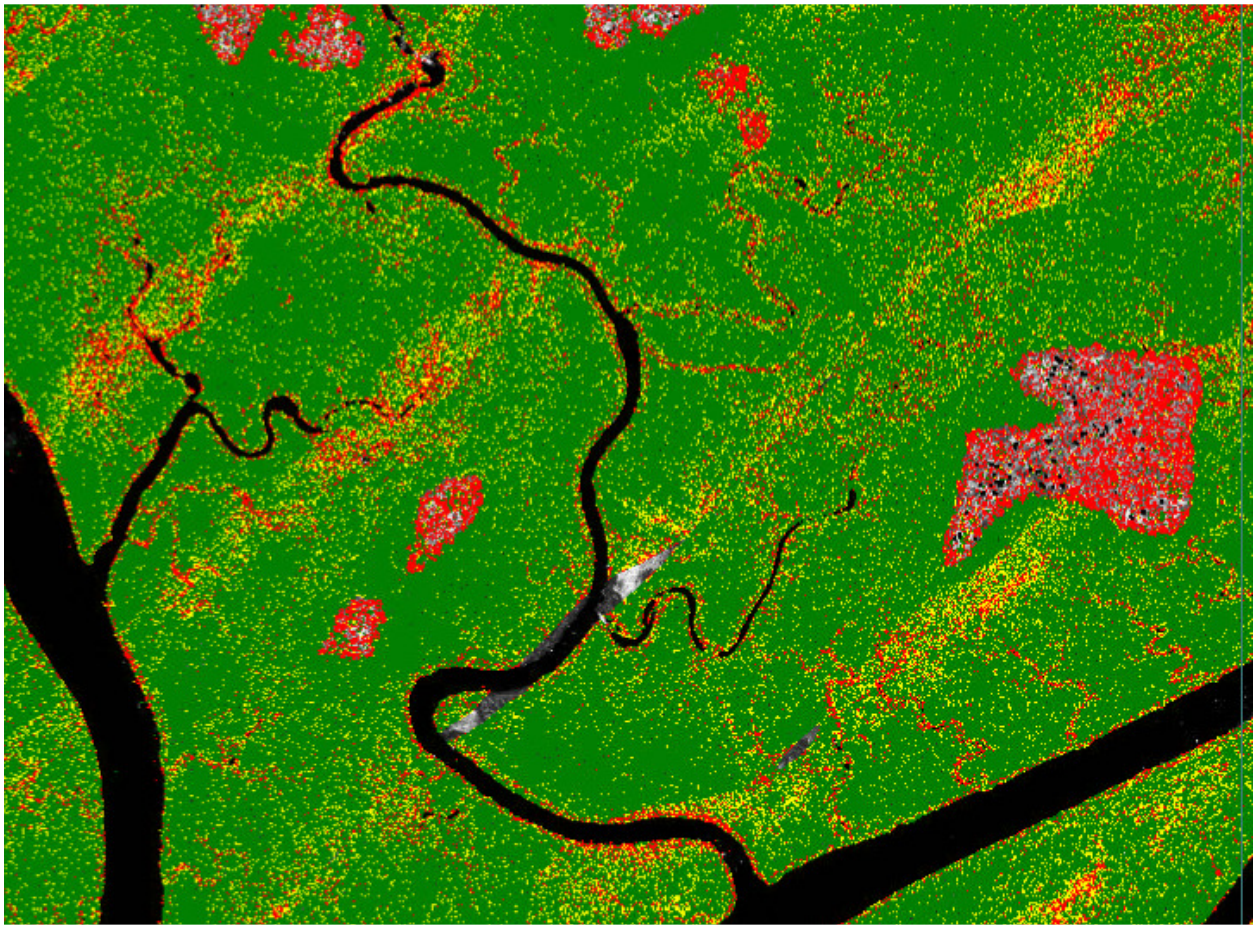


Figure 5 - DZ orthos created from the full point cloud. Some red pixels are visible along embankments, sloped terrain, and in vegetated land cover, as expected. Open, flat areas are green indicating the calibration and relative accuracy of the data is acceptable.

Once the calibration and relative accuracy of the data was confirmed, Dewberry utilized a variety of software suites for data processing. The LAS dataset was imported into GeoCue task management software for processing in Terrascan. Each tile was imported into Terrascan and a surface model was created to examine the ground classification. Dewberry analysts visually reviewed the ground surface model and corrected errors in the ground classification such as vegetation, buildings, and bridges that were present following the initial processing conducted by Dewberry. Bridge points and large culverts were classified as class 13 during this stage. Dewberry analysts employ 3D visualization techniques to view the point cloud at multiple angles and in profile to ensure that non-ground points are removed from the ground classification. After the ground classification corrections were completed, the dataset was processed through a water classification routine that utilizes breaklines compiled by Dewberry to automatically classify hydro features. The water classification routine selects ground points within the breakline polygons and automatically classifies them as class 9, water. The final classification routine applied to the dataset selects ground points within a specified distance of the water breaklines and classifies them as class 10, ignored ground due to breakline proximity. Lastly, a routine is used to classify select ground points from class 2 to class 8, model key points. Model key points are a thinned ground class. While less dense, model key points contain enough points at the necessary locations to create a somewhat generalized surface model, suitable for contours

and other processes. In order to view or use the full ground data, both classes 2 and 8 are required.

QUALITATIVE ASSESSMENT

For the Beaufort County LiDAR project, Dewberry is responsible for internal quality assurance/quality control for edgematching along flightlines, data voids, automated and manual feature extraction, generation of hillshades, and other visual and automated QA steps. SCDNR will conduct independent quality assurance/quality control and accuracy assessment studies of the elevation data produced by Dewberry, including survey checkpoints.

ANALYSIS

Dewberry utilizes GeoCue software as the primary geospatial process management system. GeoCue is a three tier, multi-user architecture that uses .NET technology from Microsoft. .NET technology provides the real-time notification system that updates users with real-time project status, regardless of who makes changes to project entities. GeoCue uses database technology for sorting project metadata. Dewberry uses Microsoft SQL Server as the database of choice. Specific analysis is conducted in Terrascan and QT Modeler environments.

Following the completion of LiDAR point classification, the Dewberry qualitative assessment process flow for the Beaufort County LiDAR project incorporated the following reviews:

1. *Format:* The LAS files are verified to meet project specifications. The LAS files for the Beaufort County LiDAR project conform to the specifications outlined below.

- Format, Echos, Intensity
    - LAS format 1.2
    - Point data record format 1
    - Multiple returns (echos) per pulse
    - Intensity values populated for each point
- ASPRS classification scheme
    - Class 1 – Unclassified
    - Class 2 – Bare-earth ground
    - Class 7 – Noise
    - Class 8 – Model Key Points (thinned bare-earth ground)
    - Class 9 – Water
    - Class 10 – Ignored Ground due to breakline proximity
    - Class 11 – Withheld due to scan angles exceeding +/- 18 degrees
    - Class 13 – Bridges and Culverts
- Projection
    - Datum – North American Datum 1983, NSRS 2007
    - Projected Coordinate System – State Plane South Carolina FIPS 3900
    - Linear Units – International Feet
    - Vertical Datum – North American Vertical Datum 1988, Geoid 09
    - Vertical Units – US Survey Feet
- LAS header information:
    - Class (Integer)

- Adjusted GPS Time (0.000001 seconds)
- Easting (0.001 feet)
- Northing (0.001 feet)
- Elevation (0.001 feet)
- Echo Number (Integer 1 to 4)
- Echo (Integer 1 to 4)
- Intensity (8 bit integer)
- Flight Line (Integer)
- Scan Angle (Integer degree)

2. *Data density, data voids:* The LAS files are used to produce Digital Elevation Models using the commercial software package "QT Modeler" which creates a 3-dimensional data model derived from Class 2 (ground points) in the LAS files. Grid spacing is based on the project density deliverable requirement for un-obscured areas. For the Beaufort Coutny LiDAR project it is stipulated that the minimum post spacing in un-obscured areas should be 1 point per 0.5 meters.

    a. Acceptable voids (areas with no LiDAR returns in the LAS files) that are present in the majority of LiDAR projects include voids caused by bodies of water. These are considered to be acceptable voids. No unacceptable voids are present in the Beaufort County LiDAR project.

3. *Bare earth quality:* Dewberry reviewed the cleanliness of the bare earth to ensure the ground has correct definition, meets the project requirements, there is correct classification of points, and there are less than 5% residual artifacts.

    a. *Artifacts:* Artifacts are caused by the misclassification of ground points and usually represent vegetation and/or man-made structures. The artifacts identified are usually low lying structures, such as porches or low vegetation used as landscaping in neighborhoods and other developed areas. These low lying features are extremely difficult for the automated algorithms to detect as non-ground and must be removed manually. The vast majority of these features have been removed but a small number of these features are still in the ground classification. The limited numbers of features remaining in the ground are usually 1 foot or less above the actual ground surface, and should not negatively impact the usability of the dataset.

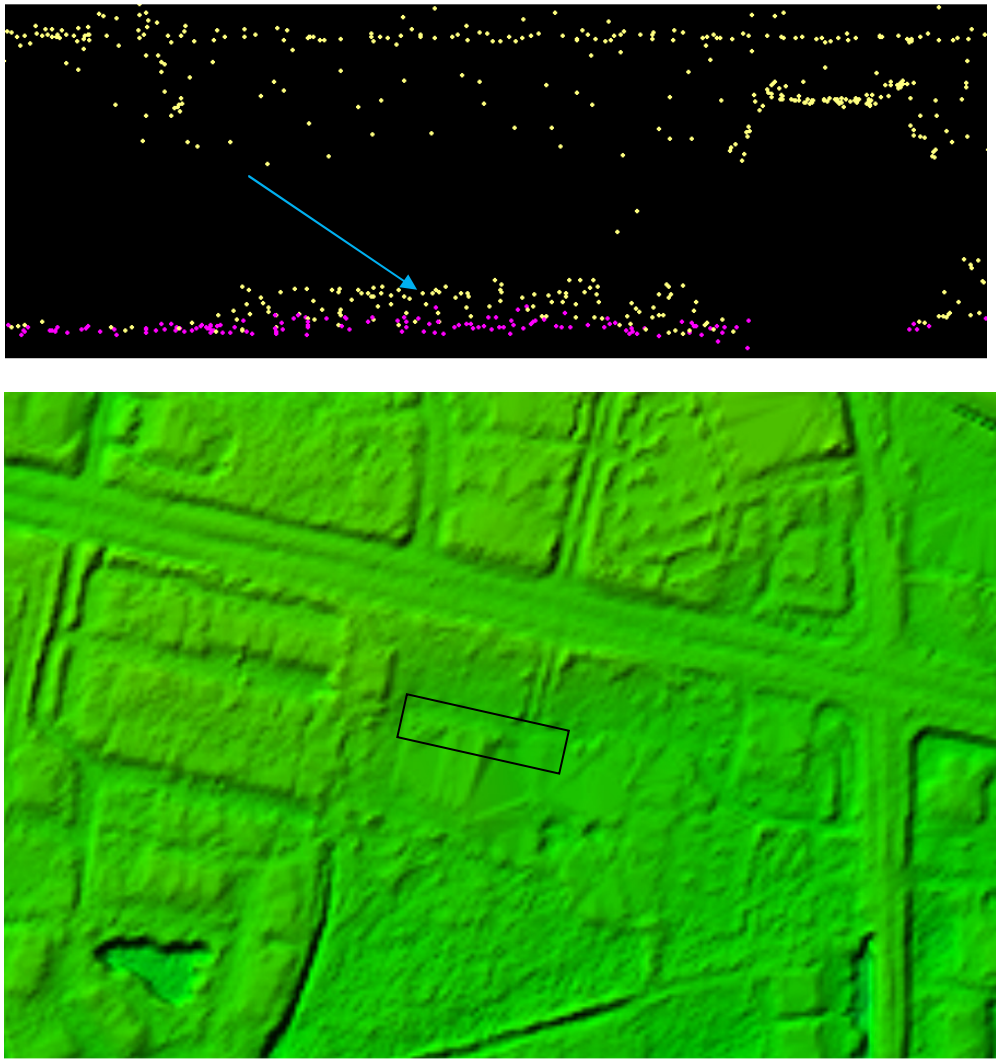


Figure 6 – Tile number 0193-01. Profile with points colored by class (class 1=yellow, class 2=pink) is shown in the top view and a TIN of the surface is shown in the bottom view. The arrow identifies low vegetation points. A limited number of these small features are still classified as ground but do not impact the usability of the dataset.

b. *Bridge Removal Artifacts:* The DEM surface models are created from TINs or Terrains. TIN and Terrain models create continuous surfaces from the inputs. Because a continuous surface is being created, the TIN or Terrain will use interpolation to triangulate across a bridge opening from legitimate ground points on either side of the actual bridge. This can cause visual artifacts or "saddles." These "artifacts" are only visual and do not exist in the LiDAR points or breaklines.

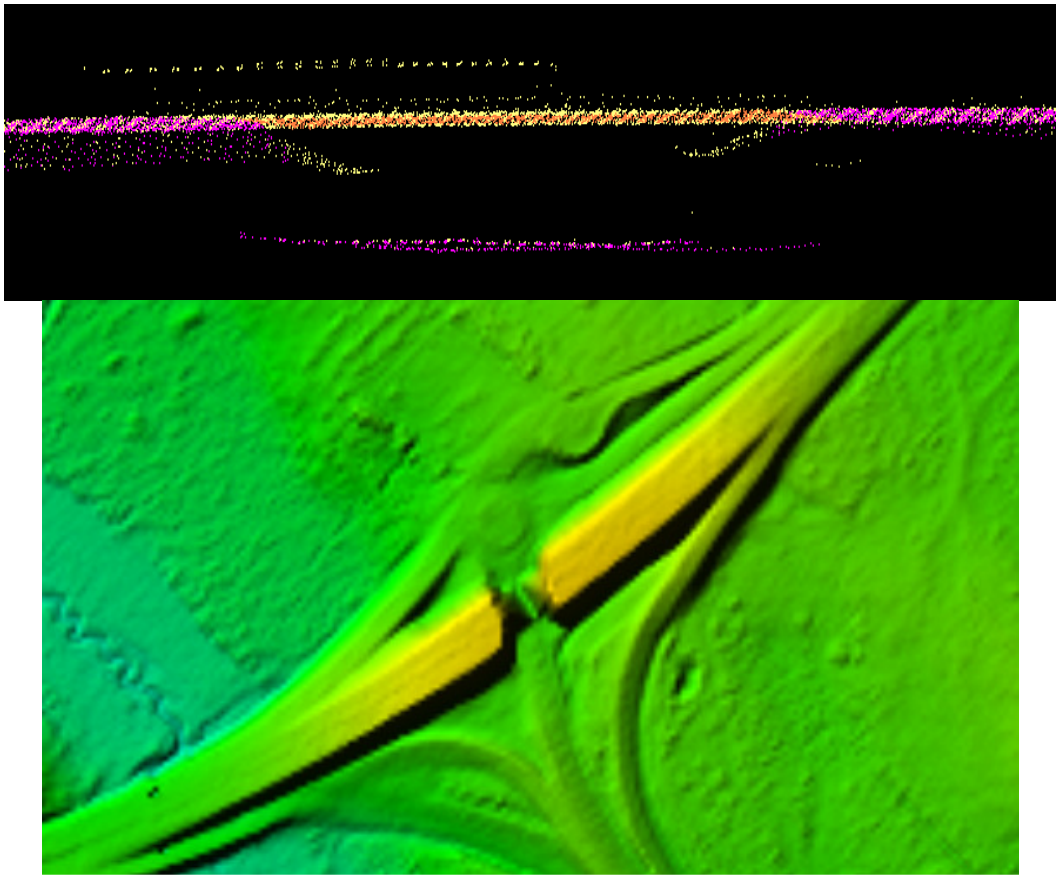


Figure 7 – The DEM in the bottom view shows a visual artifact because the surface model is interpolated from the ground points on the slope leading to the bridge to the lower ground points on either side of the bridge. The surface model must make a continuous model and in order to do so, points are connected through interpolation. This can cause visual artifacts when there are features with large elevation differences. The profile in the top view shows the LiDAR points of this particular feature colored by class. All bridge points have been removed from ground (pink) and are either unclassified (yellow) or bridge (orange). There are no ground points that can be modified to correct this visual artifact.

c. *Culverts and Bridges:* Bridges have been removed from the bare earth surface and have been reclassified to class 13. Large box culverts have also been classified to class 13. Smaller culverts that are mainly composed of legitimate ground points remain in the bare earth surface. Below are examples of culvert and bridges that have been reclassified or remain in the ground.

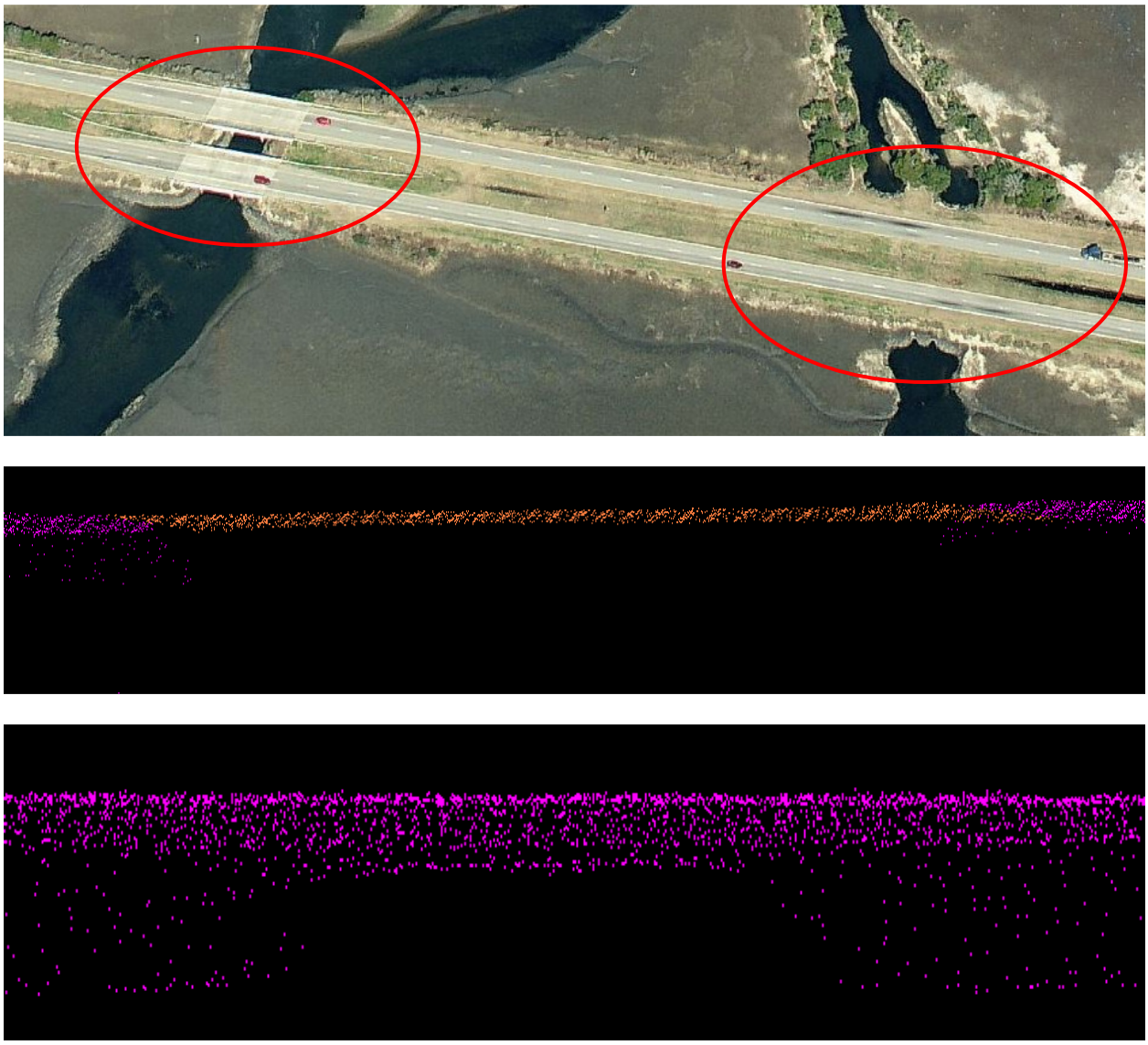


Figure 8 – Tile number 0267-02. Top: Area showing a bridge and culvert along a road. Middle: Profile with points colored by class (class 13=orange, class 2=pink) shows bridge moved to class 13. Bottom: Profile with points all in ground (pink). This small culvert remains in the bare earth surface.

d. *Tunnels:* Tunnels are generally included in the final ground model. Below shows an example of a tunnel that remains in the final bare earth terrain.

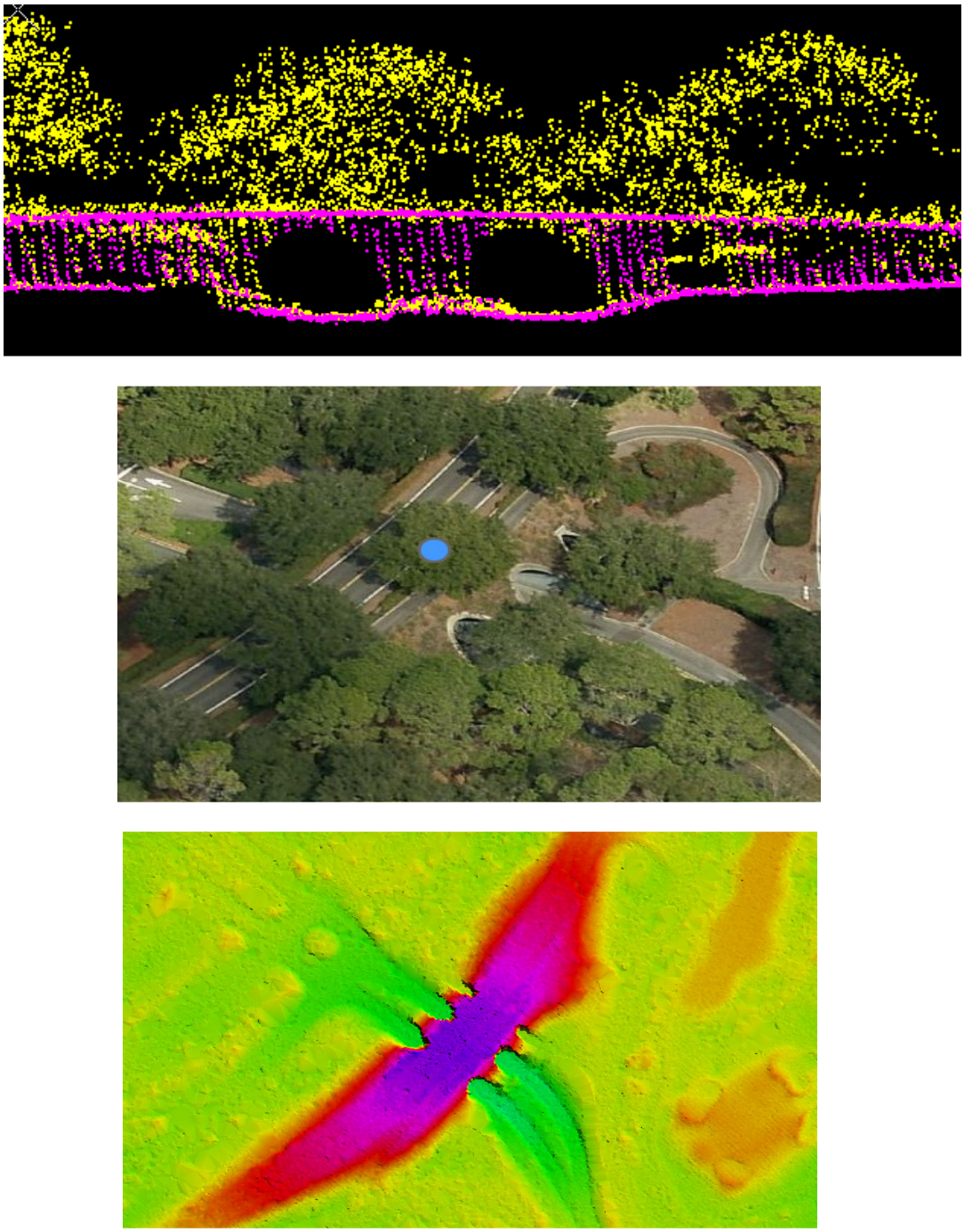


Figure 9 – Tile 0193-02. Profile with the points colored by class (class 1=yellow, class 2=pink) is shown in the top view. Middle: Aerial showing tunnel along roadway. Bottom: DEM of the surface showing this feature in the ground classification.

e. *Elevation Change within Breaklines:* Beaufort County contains a large number of tidal hydrographic features. These water features can have significant changes in elevation within a small distance. Hydrographic features have been reviewed to ensure that waterbodies are not floating above or excessively digging into the surrounding ground.

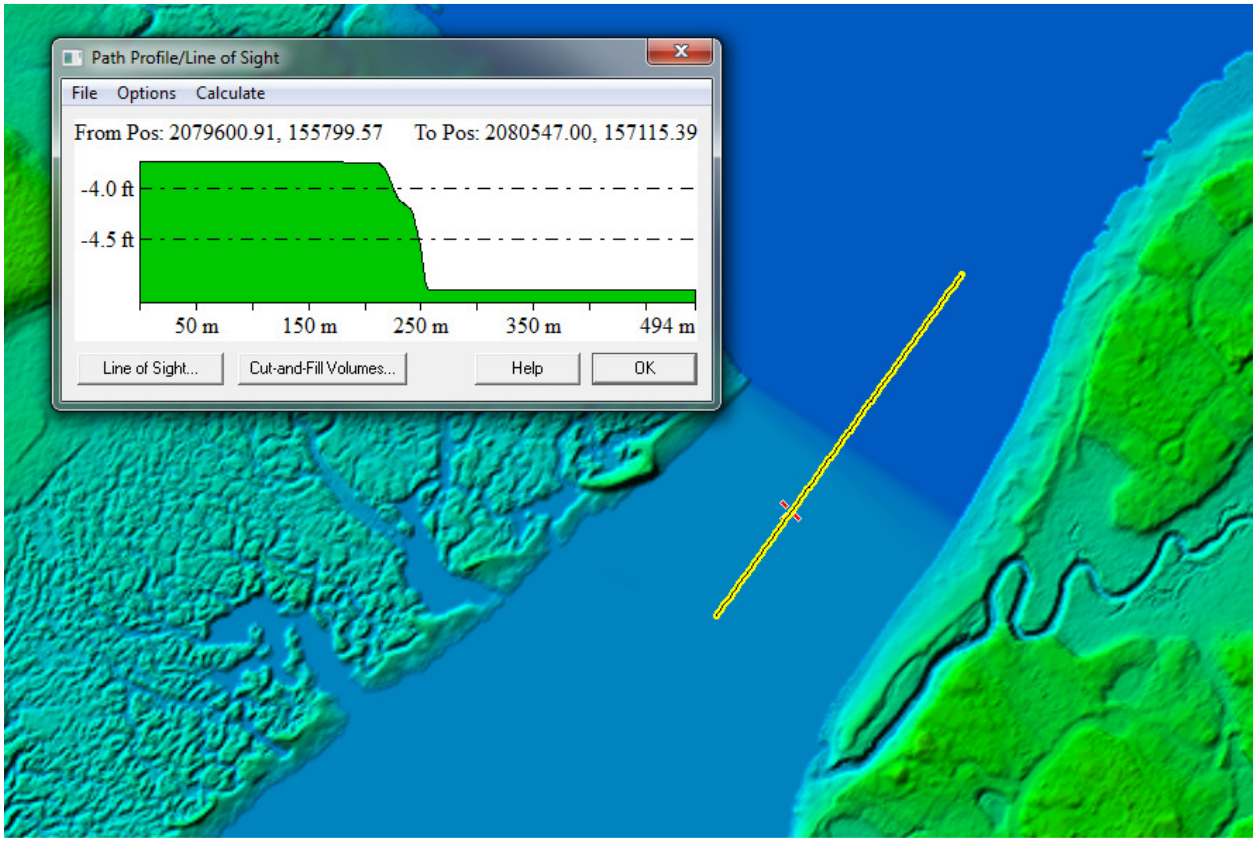


Figure 10 – Tiles 0175-02 and 0185-01. Elevation change in this tidal area changes from approximately -3.5 ft to -5 ft.

f. *Marsh Areas*: It is sometimes difficult to determine true ground in low wet areas; the lowest points available are used to represent ground. Marsh areas are present within the project area and were not collected with breaklines as they are not open bodies of water. As these areas are not included in the collected breaklines, marsh areas were not flattened in the final DEMs. While low points are used to determine ground in marsh areas, there is often greater variation within the low points due to wet soils that cause greater interpolation between points, and undulating or uneven ground. An example is shown below.

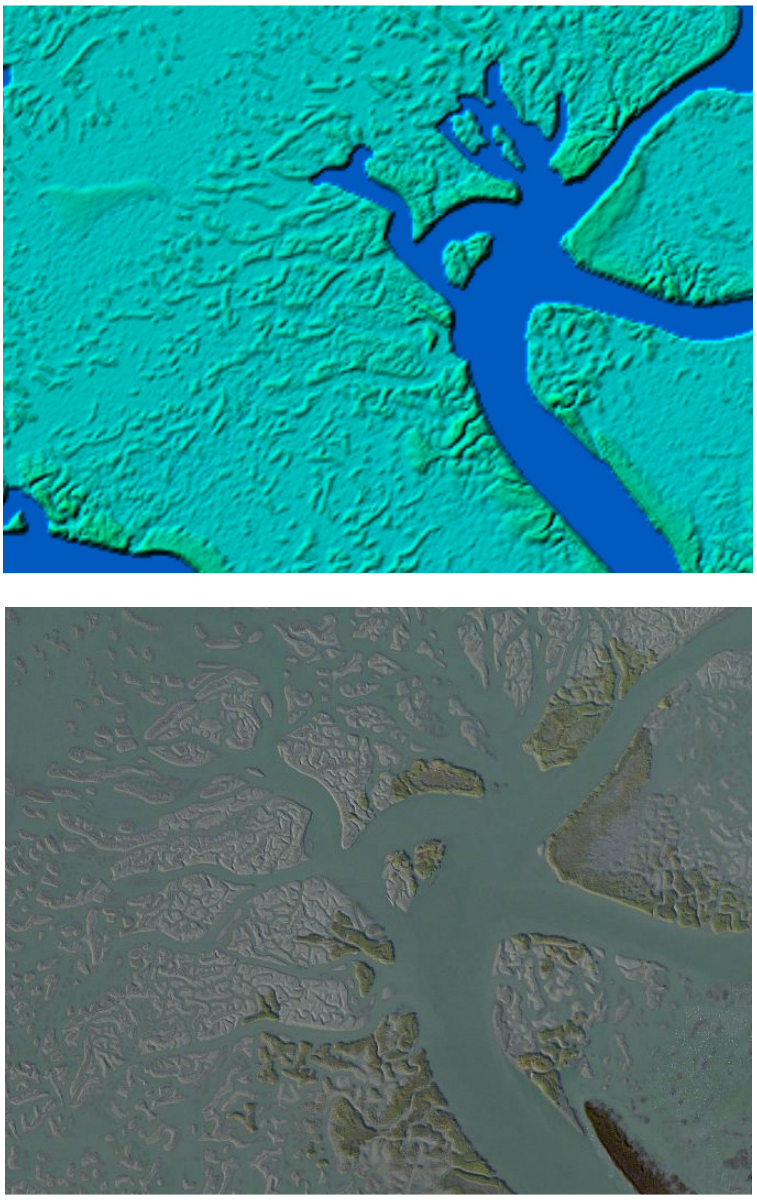


Figure 11 - Tile 1149-03. Top: DEM shows a marsh area that was not included in the collected breaklines. There is more variation in the low points representing ground. Bottom: Aerial image of same area showing marsh area.

DERIVATIVE LIDAR PRODUCTS

One Foot Contours

One-foot contours have been created for the full project area. The contour attributes include labeling as either Index or Intermediate and an elevation value. Some smoothing has been applied to the contours to enhance their aesthetic quality. All contours have been reviewed and edited for correct topology and correct behavior, including correct hydrographic crossings. The contours are all located within one file GDB.

LiDAR Vertical Accuracy

The vertical accuracy of the LiDAR was not tested by Dewberry. SCDNR will contract for an independent quality review and accuracy assessment study of the elevation data and products generated for this project.

Breakline Production & Qualitative Assessment Report

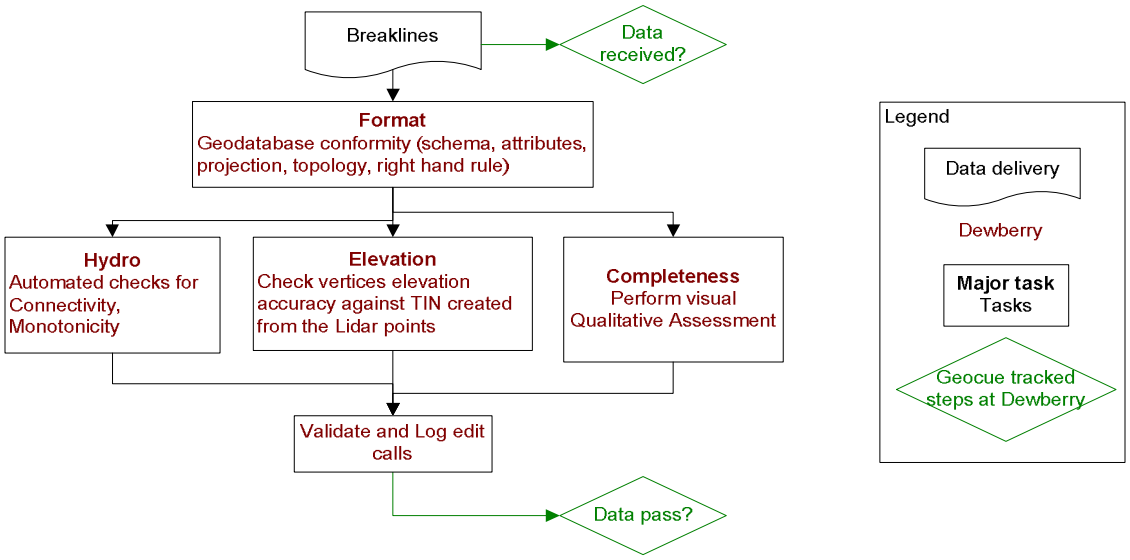
BREAKLINE PRODUCTION METHODOLOGY

Dewberry used GeoCue software to develop LiDAR stereo models of the Beaufort County LiDAR Project area so the LiDAR derived data could be viewed in 3-D stereo using Socet Set softcopy photogrammetric software. Using LiDARgrammetry procedures with LiDAR intensity imagery, Dewberry used the stereo models developed by Dewberry to stereo-compile the three types of hard breaklines in accordance with the project's Data Dictionary.

All drainage breaklines are monotonically enforced to show downhill flow. Exceptions may exist in tidally influenced areas. Water bodies are reviewed in stereo and the lowest elevation is applied to the entire waterbody.

BREAKLINE QUALITATIVE ASSESSMENT

Dewberry completed breakline qualitative assessments according to a defined workflow. The following workflow diagram represents the steps taken by Dewberry to provide a thorough qualitative assessment of the breakline data.



BREAKLINE TOPOLOGY RULES

Automated checks are applied on hydro features to validate the 3D connectivity of the feature and the monotonicity of the hydrographic breaklines. Dewberry's major concern was that the hydrographic breaklines have a continuous flow downhill and that breaklines do not undulate. Error points are generated at each vertex not complying with the tested rules and these potential edit calls are then visually validated during the visual evaluation of the data. This step also helped validate that breakline vertices did not have excessive minimum or maximum elevations and that elevations are consistent with adjacent vertex elevations.

The next step is to compare the elevation of the breakline vertices against the elevation extracted from the ESRI Terrain built from the LiDAR ground points, keeping in mind that a discrepancy is expected because of the hydro-enforcement applied to the breaklines and because of the interpolated imagery used to acquire the breaklines. A given tolerance is used to validate if the elevations differ too much from the LiDAR.

Dewberry's final check for the breaklines was to perform a full qualitative analysis. Dewberry compared the breaklines against LiDAR intensity images to ensure breaklines were captured in the required locations. The quality control steps taken by Dewberry are outlined in the QA Checklist below.

BREAKLINE QA/QC CHECKLIST

Project Number/Description: DNR Project #P24-N143-MJ
Beaufort County LiDAR

Date:_____08/20/2013_____

Overview
☒ All Feature Classes are present in GDB

☒ All features have been loaded into the geodatabase correctly. Ensure feature classes with subtypes are domained correctly.

☒ The breakline topology inside of the geodatabase has been validated. See Data Dictionary for specific rules

☒ Projection/coordinate system of GDB is accurate with project specifications

Perform Completeness check on breaklines using either intensity or ortho imagery

☒ Check entire dataset for missing features that were not captured, but should be to meet baseline specifications or for consistency (See Data Dictionary for specific collection rules). Features should be collected consistently across tile bounds within a dataset as well as be collected consistently between datasets.

☒ Check to make sure breaklines are compiled to correct tile grid boundary and there is full coverage without overlap

☒ Check to make sure breaklines are correctly edge-matched to adjoining datasets if applicable. Ensure breaklines from one dataset join breaklines from another dataset that are coded the same and all connecting vertices between the two datasets match in X,Y, and Z (elevation). There should be no breaklines abruptly ending at dataset boundaries and no discrepancies of Z-elevation in overlapping vertices between datasets.

Compare Breakline Z elevations to LiDAR elevations

☒ Using a terrain created from LiDAR ground points and water points, drape breaklines on terrain to compare Z values. Breakline elevations should be at or below the elevations of the immediately surrounding terrain. This should be performed before other breakline checks are completed.

Perform automated data checks using ESRI's Data Reviewer

The following data checks are performed utilizing ESRI's Data Reviewer extension. These checks allow automated validation of 100% of the data. Error records can either be written to a table for future correction, or browsed for immediate correction. Data Reviewer checks should always be performed on the full dataset.

☒ Perform "adjacent vertex elevation change check" on the Inland Ponds and Lakes feature class (Elevation Difference Tolerance=.001 feet). This check will return Waterbodies whose vertices are not all identical. This tool is found under "Z Value Checks."

☒ Perform "unnecessary polygon boundaries check" on Inland Ponds and Lakes and Tidal Waters feature classes. This tool is found under "Topology Checks."

☒ Perform "different Z-Value at intersection check" (Inland Streams and Rivers to Inland Streams and Rivers), (Ponds and Lakes to Ponds and Lakes), (Tidal Waters to Tidal Waters), (Streams and Rivers to Ponds and Lakes), (Streams and Rivers to Tidal Waters), (Ponds and Lakes to Tidal Waters), Elevation Difference Tolerance= .01 feet

Minimum, 600 feet Maximum, Touches. This tool is found under "Z Value Checks." Please note that polygon feature classes will need to be converted to lines for this check.

☒ Perform "duplicate geometry check" on (Inland Streams and Rivers to Inland Streams and Rivers), (Inland Ponds and Lakes to Inland Ponds and Lakes), (Tidal Waters to Tidal Waters), (Inland Streams and Rivers to Inland Ponds and Lakes), (Inland Streams and Rivers to Tidal Waters), and (Inland Ponds and Lakes to Tidal Waters). Attributes do not need to be checked during this tool. This tool is found under "Duplicate Geometry Checks."

☒ Perform "geometry on geometry check" (Inland Streams and Rivers to Inland Ponds and Lakes), (Inland Streams and Rivers to Tidal Waters), (Inland Ponds and Lakes to Tidal Waters), (Inland Streams and Rivers to Inland Streams and Rivers), (Inland Ponds and Lakes to Inland Ponds and Lakes), and (Tidal waters to Tidal waters). Spatial relationship is crosses, attributes do not need to be checked. This tool is found under "Feature on Feature Checks." Please note that "crosses" only works with line feature classes and not polygons. If the inputs are polygons, they will need to be converted to a line prior to running this tool.

☒ Perform "geometry on geometry check" (Inland Streams and Rivers to Inland Ponds and Lakes), (Inland Streams and Rivers to Tidal Waters), (Inland Ponds and Lakes to Tidal Waters), (Inland Streams and Rivers to Inland Streams and Rivers), (Inland Ponds and Lakes to Inland Ponds and Lakes), and (Tidal waters to Tidal waters). Spatial relationship is intersect, attributes do not need to be checked. This tool is found under "Feature on Feature Checks." Please note that false positives may be returned with this tool but that this tool may identify issues not found with "crosses."

☒ Perform "polygon overlap/gap is sliver check" on (Tidal Waters to Tidal Waters), (Island to Island), (Island to Inland Ponds and Lakes) and (Inland Ponds and Lakes to Inland Ponds and Lakes), (Inland Ponds and Lakes to Tidal Waters). Maximum Polygon Area is not required. This tool is found under "Feature on Feature Checks."

Perform Dewberry Proprietary Tool Checks

☒ Perform monotonicity check on (Inland Streams and Rivers), (Tidal Waters to Tidal Waters if they are not a constant elevation), (Single Line Drains), and (Connectors) using "A3_checkMonotonicityStreamLines." This tool looks at line direction as well as elevation. Features in the output shapefile attributed with a "d" are correct monotonically, but were compiled from low elevation to high elevation. These features are ok and can be ignored. Features in the output shapefile attributed with an "m" are not correct monotonically and need elevations to be corrected. Input features for this tool need to be in a geodatabase and must be a line. If features are a polygon they will need to be converted to a line feature. Z tolerance is 0.01 feet.

☒ Perform connectivity check between (Inland Streams and Rivers to Inland Streams and Rivers), (Ponds and Lakes to Ponds and Lakes), (Tidal Waters to Tidal Waters), (Streams

and Rivers to Ponds and Lakes), (Streams and Rivers to Tidal Waters), (Single Line Drains to Connectors) and (Ponds and Lakes to Tidal Waters) using the tool "07_CheckConnectivityForHydro." The input for this tool needs to be in a geodatabase. The output is a shapefile showing the location of overlapping vertices from the polygon features and polyline features that are at different Z-elevation.

Metadata

☒ Each XML file (1 per feature class) is error free as determined by the USGS MP tool

☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc. Content should be consistent across all feature classes.

Completion Comments: Complete – Approved

Data Dictionary

HORIZONTAL AND VERTICAL DATUM

The horizontal datum shall be North American Datum of 1983 NSRS2007, units in International Feet. The vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD 88), units in US Survey Feet. Geoid09 shall be used to convert ellipsoidal heights to orthometric heights.

COORDINATE SYSTEM AND PROJECTION

All data shall be projected to horizontal State Plane South Carolina FIPS3900, NAD 83, NSRS 2007, International Feet, vertical NAVD 88 (Geoid 09), US Survey Feet.

DUAL LINE DRAINS (INLAND STREAMS AND RIVERS)

Feature Dataset: BREAKLINES
Feature Type: Polygon
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003
Feature Class: STREAMS_AND_RIVERS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict linear hydrographic features with a width greater than 20 feet.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Dual Line Drains (Streams and Rivers)	Linear hydrographic features such as streams, rivers, canals, etc. with an average width greater than 20 feet. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other natural or manmade embankments will not qualify for this project. Features will be collected while maintaining montonicity and connectivity between adjacent features. Features will be flat from bank to bank. Islands: The double line stream shall be captured around an island if the island is greater than 1/2 acre. In this case a segmented polygon shall be used around the island in order to allow for the island feature to remain as a “hole” in the feature.

SINGLE LINE DRAINS (INLAND STREAMS AND RIVERS)

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003
Feature Class: SINGLE LINE DRAINS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict linear hydrographic features with a width greater than 2.5 feet and less than 20 feet.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Single Line Drains (Streams and Rivers)	Linear hydrographic features such as streams, rivers, canals, etc. with an average width greater than 2.5 feet and less than 20 feet in width. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Features will be collected while maintaining montonicity and connectivity between adjacent features.

INLAND PONDS AND LAKES

Feature Dataset: BREAKLINES
Feature Type: Polygon
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003
Feature Class: PONDS_AND_LAKES
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict closed water body features that are at a constant elevation.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software

SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Ponds and Lakes	Land/Water boundaries of constant elevation water bodies such as lakes, reservoirs, ponds, etc. Features shall be defined as closed polygons and contain an elevation value that reflects the best estimate of the water elevation at the time of data capture. Water body features will be captured for features 1 acres in size or greater. "Donuts" will exist where there are islands within a closed water body feature. An Island within a Closed Water Body Feature that is 1/2 acre in size or greater will also have a "donut polygon" compiled. Water bodies shall be captured as closed polygons with the water feature to the right. The compiler shall take care to ensure that the z-value remains consistent for all vertices placed on the water body. Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually.

TIDAL WATERS

Feature Dataset: BREAKLINES
Feature Type: Polygon
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: TIDAL_WATERS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will outline the land / water interface at the time of LiDAR acquisition.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Tidal Waters	The coastal breakline will delineate the land water interface using LiDAR data as reference. In flight line boundary areas with tidal variation the coastal shoreline may require some feathering or edge matching to ensure a smooth transition.

STREAM CENTERLINES

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAM CENTERLINE
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polyline feature class approximates the center of water features to ensure connectivity of hydro network.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Stream Centerlines	Stream Centerlines will be collected at the approximate center of dual line drains and inland ponds and lakes as appropriate to maintain connectivity of the stream network

CONNECTORS

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAM CONNECTOR
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polyline feature class connects water bodies where culverts are present to maintain drainage network connectivity.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Stream Connectors	Stream Connectors will be collected in areas where culverts are present or as needed to maintain connectivity of the drainage network.

EDGE OF ROAD

Feature Dataset: Beaufort_Roads
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: BEAUFORT_ROADS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polyline feature class identifies existing paved road network based on LiDAR intensity imagery.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Edge of Roads	Edges of roads will be collected using the 6-inch LiDAR intensity imagery. A single line will be placed on each road edge and will be delineated at the edge of pavement. Paved shoulders will be included in the feature.

DEM Production & Qualitative Assessment

DEM PRODUCTION METHODOLOGY

Dewberry utilized ESRI software and Global Mapper for the DEM production and QC process. ArcGIS software is used to generate the products and the QC is performed in both ArcGIS and Global Mapper.

1. Classify Water Points: LAS point falling within hydrographic breaklines shall be classified to ASPRS class 9 using TerraScan. Breaklines must be prepared correctly prior to performing this task.
2. Classify Ignored Ground Points: Classify points in within 1 foot to the breaklines from Ground to class 10 (Ignored Ground).
3. Terrain Processing: A Terrain will be generated using the Breaklines and LAS data that has been imported into Arc as a Multipoint File.
4. Convert Terrain to Raster: Convert terrain to raster using Arc, using floating point for output cell values and natural neighbors interpolation.
5. Perform QAQC: During the QA process anomalies will be identified and corrective polygons will be created.
6. Split DEM: DEM will be split to reduce file size to max 1.5GB as per specifications.

DEM QUALITATIVE ASSESSMENT

Dewberry performed a comprehensive qualitative assessment of the bare earth DEM deliverables to ensure that all tiled DEM products were delivered with the proper extents, were free of processing artifacts, and contained the proper referencing information. This process was performed in ArcGIS software with the use of a tool set Dewberry has developed to verify that the raster extents match those of the tile grid and contain the correct projection information. The DEM data was reviewed at a scale of 1:5000 to review for artifacts caused by the DEM generation process and to review the hydro-enforced features. All corrections are completed using Dewberry's proprietary correction workflow. Upon completion of the corrections, the DEM data is loaded into Global Mapper for its second review and to verify corrections.

The images below show an example of a bare earth DEM.

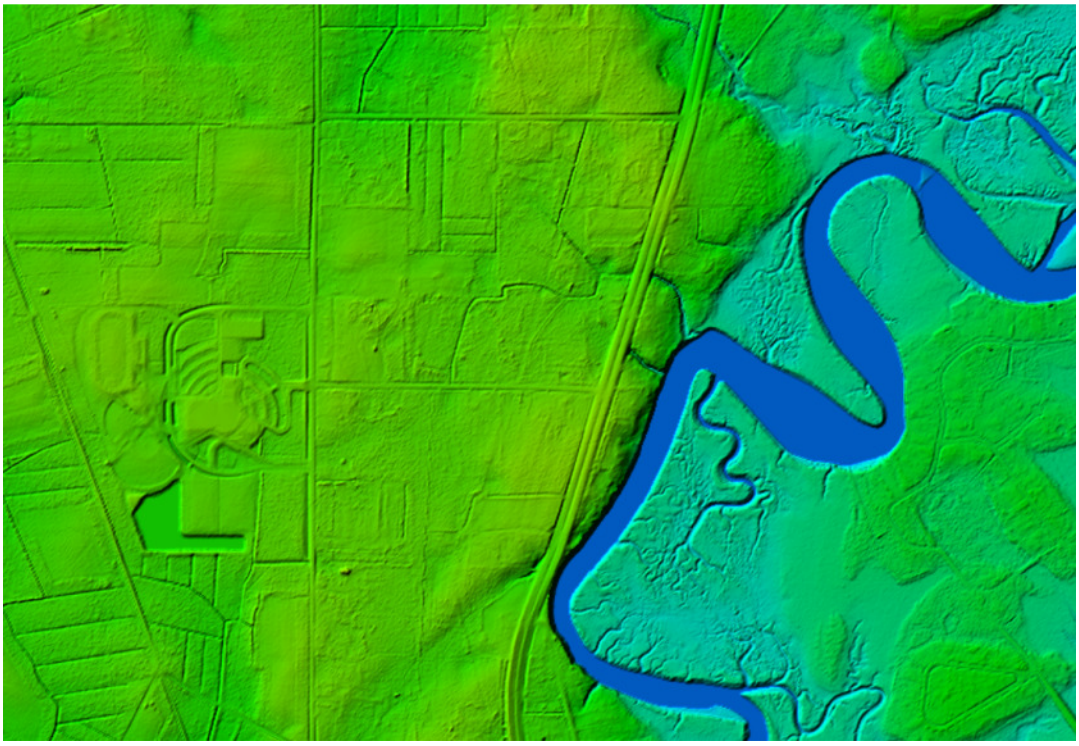
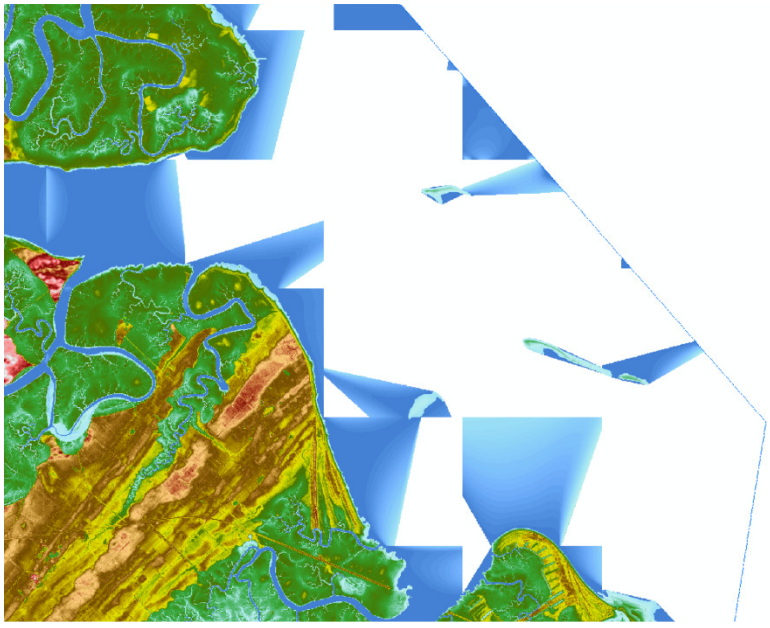


Figure 12 - Tile 0275-04. The bare earth DEM.

DEM Tidal Flattening

Because tidal breaklines were hydro-enforced and not hydro-flattened in the terrain, large tidal areas were not fully interpolated during the terrain to raster conversion. Tidal areas with consistent elevations from bank to bank were therefore patched into the final DEM to fill in unintentional void areas. Terrains remain hydro-enforced.



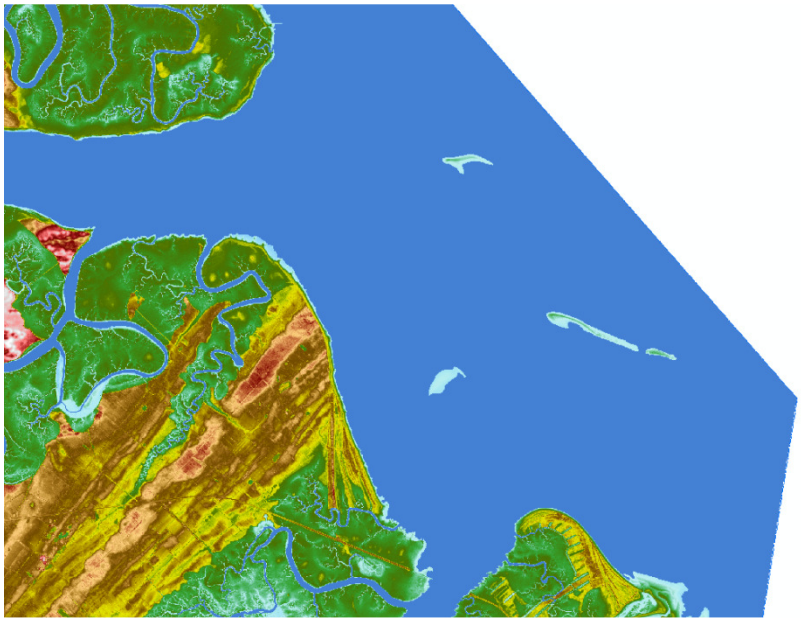


Figure 13 – Top: DEM after terrain to raster interpolation. Noticeable voids are present in the DEM where interpolation could not be completed. Bottom: DEM after patching tidal areas that contain uniform elevations.

DEM QA/QC CHECKLIST

Project Number/Description: Project#P24-N143-MJ Beaufort County LiDAR
Date:_____08/29/2013_____

Overview

☒ Correct number of files is delivered and all files are in ESRI GRID format
☒ Verify Raster Extents
☒ Verify Projection/Coordinate System

Review

☒ Manually review bare-earth DEMs in Arc with a hillshade to check for issues with the hydro-enforcement process or any general anomalies that may be present. Specifically, water should be flowing downhill, water features should NOT be floating above surrounding terrain and bridges should NOT be present in bare-earth DEM.
☒ DEM cell size is 5 feet
☒ Perform all necessary corrections in Arc using Dewberry's proprietary correction workflow.
☒ Review all corrections in Global Mapper

Metadata

☒ Project level DEM metadata XML file is error free as determined by the USGS MP tool
☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc.

Completion Comments: Complete – Approved

Appendix A: Complete List of Delivered Tiles

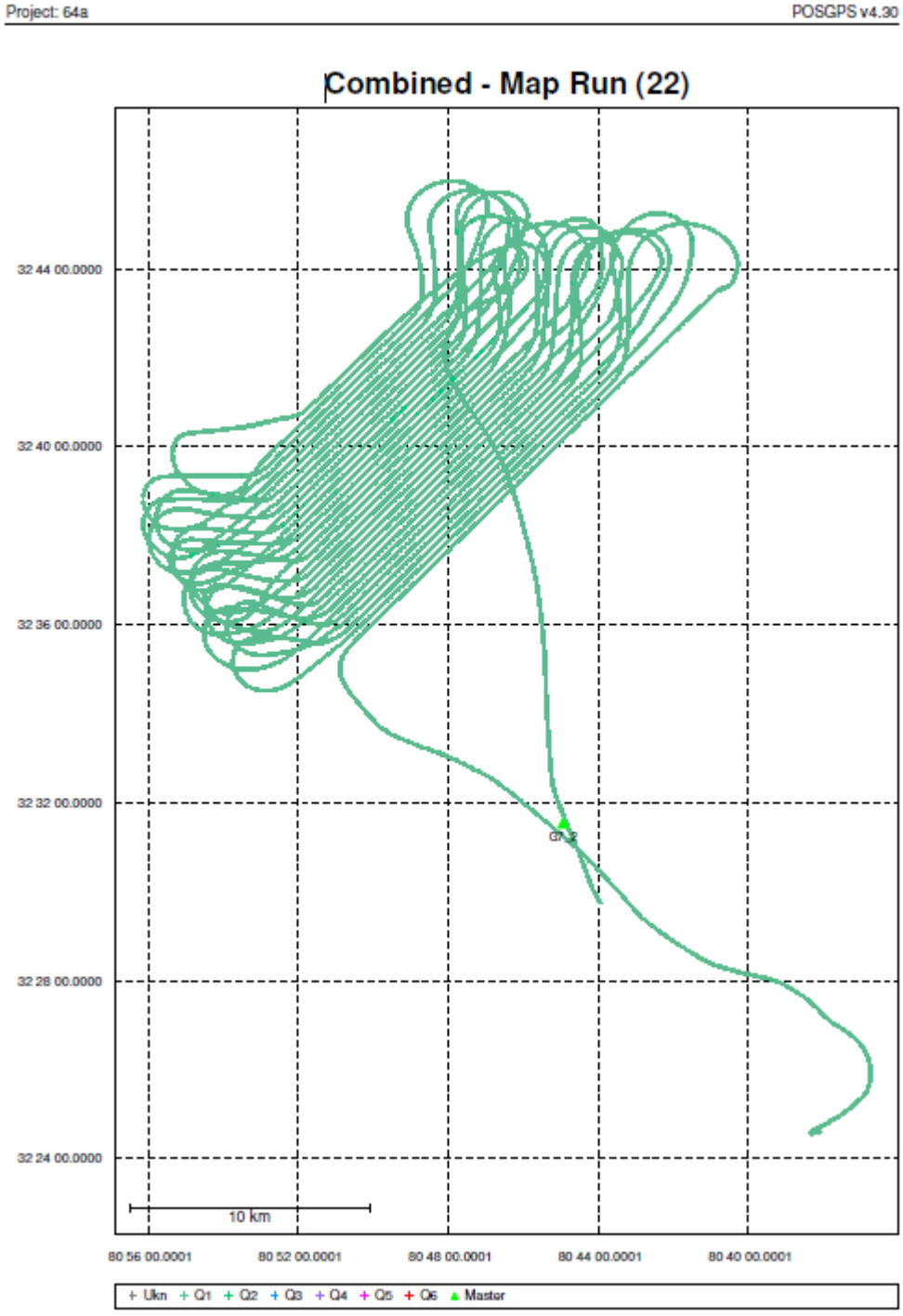
0028-02	0107-03	0122-02	0133-01	0143-03	0153-03
0029-02	0107-04	0122-03	0133-02	0143-04	0153-04
0029-04	0110-01	0122-04	0133-03	0144-01	0154-01
0038-01	0110-02	0123-01	0133-04	0144-02	0154-02
0038-02	0111-01	0123-02	0134-01	0144-03	0154-03
0039-01	0111-02	0123-03	0134-02	0144-04	0154-04
0039-02	0111-03	0123-04	0134-03	0145-01	0155-01
0039-03	0111-04	0124-01	0134-04	0145-02	0155-02
0039-04	0112-01	0124-02	0135-01	0145-03	0155-03
0048-01	0112-02	0124-03	0135-02	0145-04	0155-04
0049-01	0112-03	0124-04	0135-03	0146-01	0156-01
0049-02	0112-04	0125-01	0135-04	0146-02	0156-02
0049-03	0113-01	0125-02	0136-01	0146-03	0156-03
0049-04	0113-02	0125-03	0136-02	0146-04	0156-04
0059-01	0113-03	0125-04	0136-03	0147-01	0157-01
0059-02	0113-04	0126-01	0136-04	0147-02	0157-02
0059-03	0114-01	0126-02	0137-01	0147-03	0157-03
0059-04	0114-02	0126-03	0137-02	0147-04	0157-04
0069-01	0114-03	0126-04	0137-03	0148-01	0158-01
0101-02	0114-04	0127-01	0137-04	0148-02	0158-02
0101-04	0115-01	0127-02	0138-01	0148-03	0158-03
0102-01	0115-02	0127-03	0138-02	0148-04	0158-04
0102-02	0115-03	0127-04	0138-03	0149-01	0159-01
0102-04	0115-04	0128-01	0138-04	0149-02	0159-02
0103-01	0116-01	0128-02	0139-03	0149-03	0159-03
0103-02	0116-02	0128-03	0139-04	0149-04	0159-04
0103-03	0116-03	0128-04	0140-01	0150-01	0160-01
0103-04	0116-04	0129-04	0140-02	0150-02	0160-02
0104-01	0117-02	0130-01	0140-03	0150-03	0160-03
0104-02	0117-03	0130-02	0140-04	0150-04	0160-04
0104-03	0117-04	0130-03	0141-01	0151-01	0161-01
0104-04	0120-01	0130-04	0141-02	0151-02	0161-02
0105-01	0120-02	0131-01	0141-03	0151-03	0161-03
0105-02	0120-03	0131-02	0141-04	0151-04	0161-04
0105-03	0120-04	0131-03	0142-01	0152-01	0162-01
0105-04	0121-01	0131-04	0142-02	0152-02	0162-02
0106-01	0121-02	0132-01	0142-03	0152-03	0162-03
0106-02	0121-03	0132-02	0142-04	0152-04	0162-04
0106-03	0121-04	0132-03	0143-01	0153-01	0163-01
0106-04	0122-01	0132-04	0143-02	0153-02	0163-02

0163-03	0174-03	0186-02	0199-02	0254-02	0264-04
0163-04	0174-04	0186-03	0199-03	0254-03	0265-01
0164-01	0175-01	0186-04	0199-04	0254-04	0265-02
0164-02	0175-02	0187-01	0239-02	0255-01	0265-03
0164-03	0175-03	0187-02	0240-02	0255-02	0265-04
0164-04	0175-04	0187-03	0240-04	0255-03	0266-01
0165-01	0176-01	0187-04	0241-02	0255-04	0266-02
0165-02	0176-02	0188-01	0241-04	0256-01	0266-03
0165-03	0176-03	0188-02	0242-02	0256-02	0266-04
0165-04	0176-04	0188-03	0242-04	0256-03	0267-01
0166-01	0177-01	0188-04	0244-02	0256-04	0267-02
0166-02	0177-02	0189-01	0244-04	0257-01	0267-03
0166-03	0177-03	0189-02	0245-02	0257-02	0267-04
0166-04	0177-04	0189-03	0245-04	0257-03	0268-01
0167-01	0178-01	0189-04	0246-02	0257-04	0268-02
0167-02	0178-02	0192-01	0246-04	0258-01	0268-03
0167-03	0178-03	0192-03	0247-02	0258-02	0268-04
0167-04	0178-04	0193-01	0247-04	0258-03	0269-01
0168-01	0179-01	0193-02	0248-01	0258-04	0269-02
0168-02	0179-02	0193-03	0248-02	0259-01	0269-03
0168-03	0179-03	0193-04	0248-04	0259-02	0269-04
0168-04	0179-04	0194-01	0249-01	0259-03	0270-01
0169-01	0181-01	0194-02	0249-02	0259-04	0270-02
0169-02	0181-02	0194-03	0249-03	0260-01	0270-03
0169-03	0181-03	0194-04	0249-04	0260-02	0270-04
0169-04	0182-01	0195-01	0250-01	0260-03	0271-01
0170-01	0182-02	0195-02	0250-02	0260-04	0271-02
0170-02	0182-03	0195-03	0250-03	0261-01	0271-03
0171-01	0182-04	0195-04	0250-04	0261-02	0271-04
0171-02	0183-01	0196-01	0251-01	0261-03	0272-01
0171-03	0183-02	0196-02	0251-02	0261-04	0272-02
0171-04	0183-03	0196-03	0251-03	0262-01	0272-03
0172-01	0183-04	0196-04	0251-04	0262-02	0272-04
0172-02	0184-01	0197-01	0252-01	0262-03	0273-01
0172-03	0184-02	0197-02	0252-02	0262-04	0273-02
0172-04	0184-03	0197-03	0252-03	0263-01	0273-03
0173-01	0184-04	0197-04	0252-04	0263-02	0273-04
0173-02	0185-01	0198-01	0253-01	0263-03	0274-01
0173-03	0185-02	0198-02	0253-02	0263-04	0274-02
0173-04	0185-03	0198-03	0253-03	0264-01	0274-03
0174-01	0185-04	0198-04	0253-04	0264-02	0274-04
0174-02	0186-01	0199-01	0254-01	0264-03	0275-01

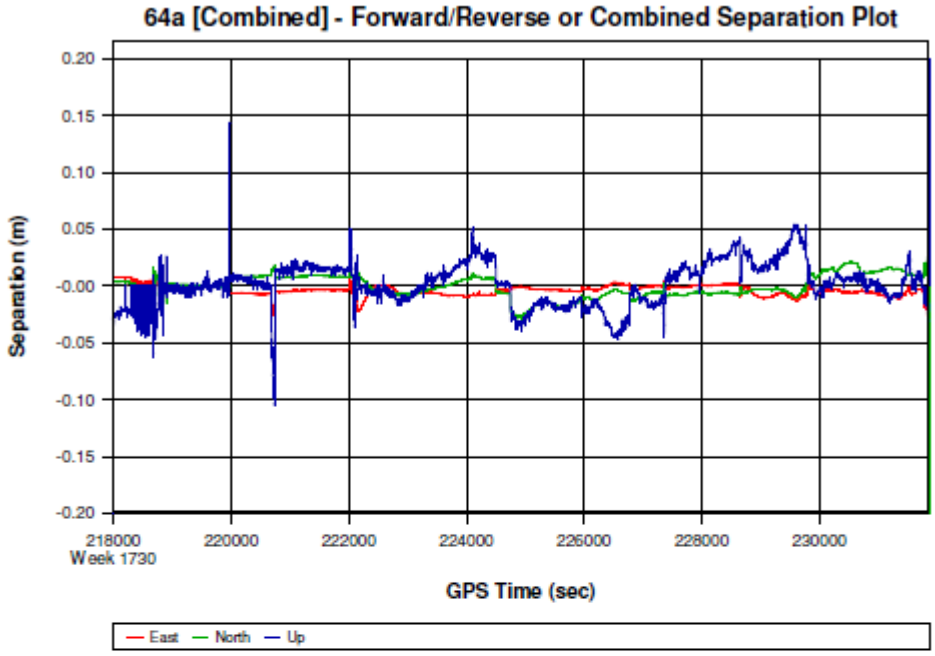
0275-02	0285-04	0296-02	0380-02	1115-04	1137-01
0275-03	0286-01	0296-03	0380-03	1116-01	1137-02
0275-04	0286-02	0296-04	0380-04	1116-02	1137-03
0276-01	0286-03	0297-01	0381-03	1116-03	1137-04
0276-02	0286-04	0297-02	0390-01	1116-04	1138-01
0276-03	0287-01	0297-03	0390-02	1117-01	1138-02
0276-04	0287-02	0297-04	0390-03	1117-02	1138-03
0277-01	0287-03	0298-01	0390-04	1117-03	1138-04
0277-02	0287-04	0298-02	1103-01	1117-04	1139-01
0277-03	0288-01	0298-03	1103-02	1118-01	1139-02
0277-04	0288-02	0298-04	1103-03	1118-02	1139-03
0278-01	0288-03	0299-01	1103-04	1118-03	1139-04
0278-02	0288-04	0299-02	1104-01	1118-04	1146-01
0278-03	0289-01	0299-03	1104-02	1119-01	1146-02
0278-04	0289-02	0299-04	1104-03	1119-02	1146-03
0279-01	0289-03	0330-04	1104-04	1119-03	1147-01
0279-02	0289-04	0340-01	1105-01	1119-04	1147-02
0279-03	0290-01	0340-02	1105-02	1125-01	1147-03
0279-04	0290-02	0340-03	1105-03	1125-02	1147-04
0280-01	0290-03	0340-04	1105-04	1125-03	1148-01
0280-02	0290-04	0341-02	1106-01	1125-04	1148-02
0280-03	0291-01	0341-04	1106-02	1126-01	1148-03
0280-04	0291-02	0350-01	1106-03	1126-02	1148-04
0281-01	0291-03	0350-02	1106-04	1126-03	1149-01
0281-02	0291-04	0350-03	1107-01	1126-04	1149-02
0281-03	0292-01	0350-04	1107-02	1127-01	1149-03
0281-04	0292-02	0351-01	1107-03	1127-02	1149-04
0282-01	0292-03	0351-02	1107-04	1127-03	1156-01
0282-02	0292-04	0351-03	1108-01	1127-04	1157-01
0282-03	0293-01	0351-04	1108-02	1128-01	1157-02
0282-04	0293-02	0360-01	1108-03	1128-02	1157-03
0283-01	0293-03	0360-02	1108-04	1128-03	1157-04
0283-02	0293-04	0360-03	1109-01	1128-04	1158-01
0283-03	0294-01	0360-04	1109-02	1129-01	1158-02
0283-04	0294-02	0361-03	1109-03	1129-02	1158-03
0284-01	0294-03	0361-04	1109-04	1129-03	1158-04
0284-02	0294-04	0370-01	1113-01	1129-04	1159-01
0284-03	0295-01	0370-02	1114-01	1135-01	1159-02
0284-04	0295-02	0370-03	1114-03	1136-01	1159-03
0285-01	0295-03	0370-04	1115-01	1136-02	1159-04
0285-02	0295-04	0371-04	1115-02	1136-03	1167-01
0285-03	0296-01	0380-01	1115-03	1136-04	1167-02

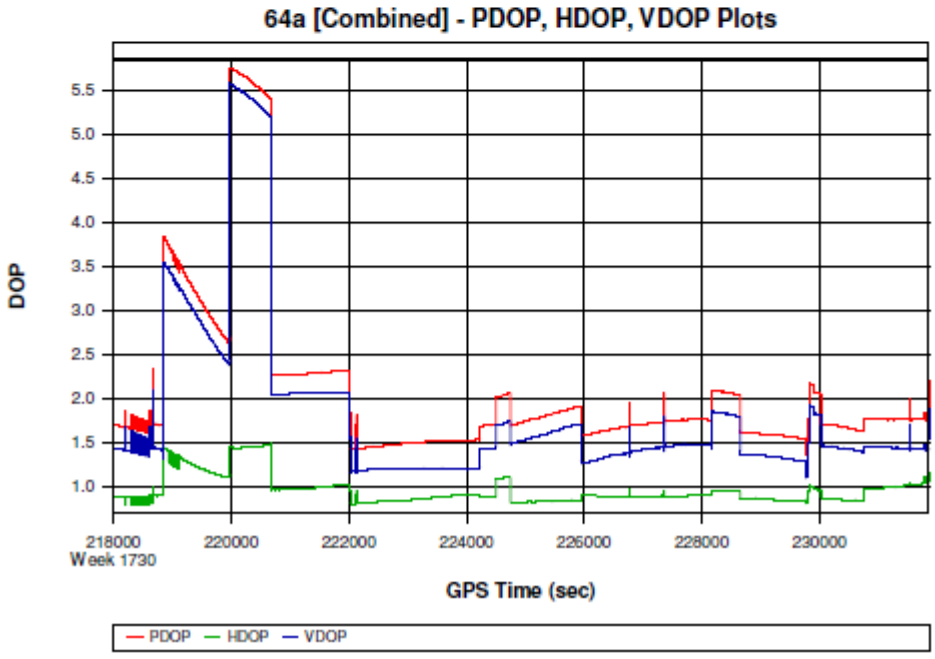
1167-03	1206-01	1216-01	1230-02	1243-01	1262-03
1167-04	1206-02	1216-02	1230-03	1243-02	1262-04
1168-01	1206-03	1216-03	1230-04	1243-03	1263-01
1168-02	1206-04	1216-04	1231-01	1243-04	1263-02
1168-03	1207-01	1217-01	1231-02	1244-01	1263-03
1168-04	1207-02	1217-02	1231-03	1244-02	1263-04
1169-01	1207-03	1217-03	1231-04	1244-03	1270-01
1169-02	1207-04	1217-04	1232-01	1244-04	1270-02
1169-03	1208-01	1220-01	1232-02	1245-01	1270-03
1169-04	1208-02	1220-02	1232-03	1245-03	1270-04
1177-01	1208-03	1220-03	1232-04	1245-04	1271-01
1178-01	1208-04	1220-04	1233-01	1246-01	1271-02
1178-03	1209-01	1221-01	1233-02	1246-03	1271-03
1179-01	1209-02	1221-02	1233-03	1250-01	1271-04
1179-02	1209-03	1221-03	1233-04	1250-02	1272-01
1179-03	1209-04	1221-04	1234-01	1250-03	1272-02
1200-01	1210-01	1222-01	1234-02	1250-04	1272-03
1200-02	1210-02	1222-02	1234-03	1251-01	1272-04
1200-03	1210-03	1222-03	1234-04	1251-02	1273-03
1200-04	1210-04	1222-04	1235-01	1251-03	1280-01
1201-01	1211-01	1223-01	1235-02	1251-04	1280-03
1201-02	1211-02	1223-02	1235-03	1252-01	1281-01
1201-03	1211-03	1223-03	1235-04	1252-02	1281-03
1201-04	1211-04	1223-04	1236-01	1252-03	1282-03
1202-01	1212-01	1224-01	1236-02	1252-04	1300-01
1202-02	1212-02	1224-02	1236-03	1253-01	1300-03
1202-03	1212-03	1224-03	1236-04	1253-02	9193-02
1202-04	1212-04	1224-04	1237-03	1253-03	9193-04
1203-01	1213-01	1225-01	1240-01	1253-04	9194-01
1203-02	1213-02	1225-02	1240-02	1254-03	9194-02
1203-03	1213-03	1225-03	1240-03	1260-01	9194-03
1203-04	1213-04	1225-04	1240-04	1260-02	9194-04
1204-01	1214-01	1226-01	1241-01	1260-03	9195-02
1204-02	1214-02	1226-02	1241-02	1260-04	9195-03
1204-03	1214-03	1226-03	1241-03	1261-01	9195-04
1204-04	1214-04	1226-04	1241-04	1261-02	9196-02
1205-01	1215-01	1227-01	1242-01	1261-03	9197-04
1205-02	1215-02	1227-03	1242-02	1261-04	
1205-03	1215-03	1227-04	1242-03	1262-01	
1205-04	1215-04	1230-01	1242-04	1262-02	

Appendix B: GPS Processing Reports for Each Mission

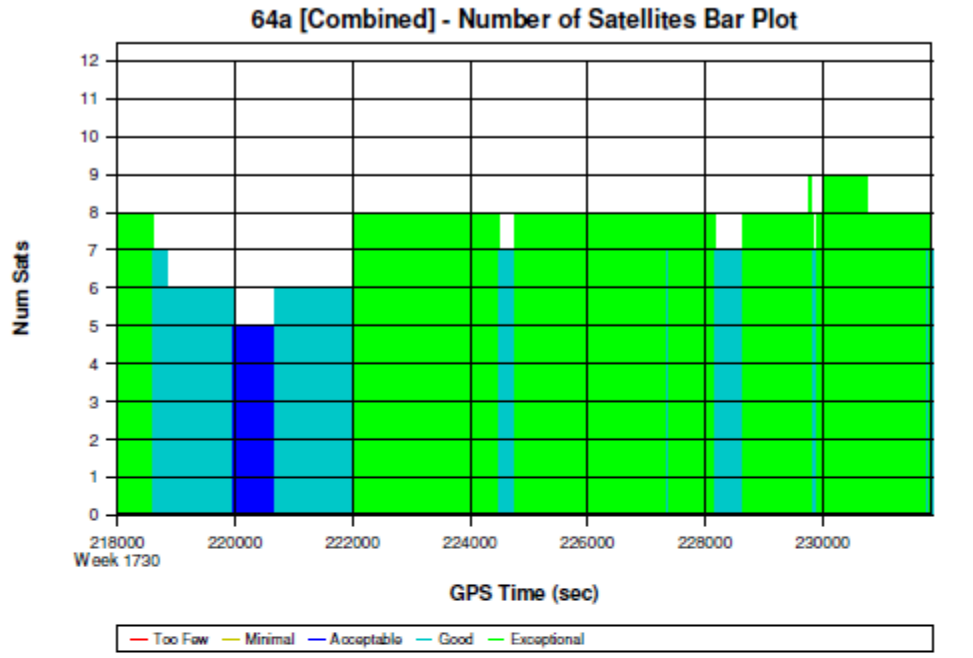


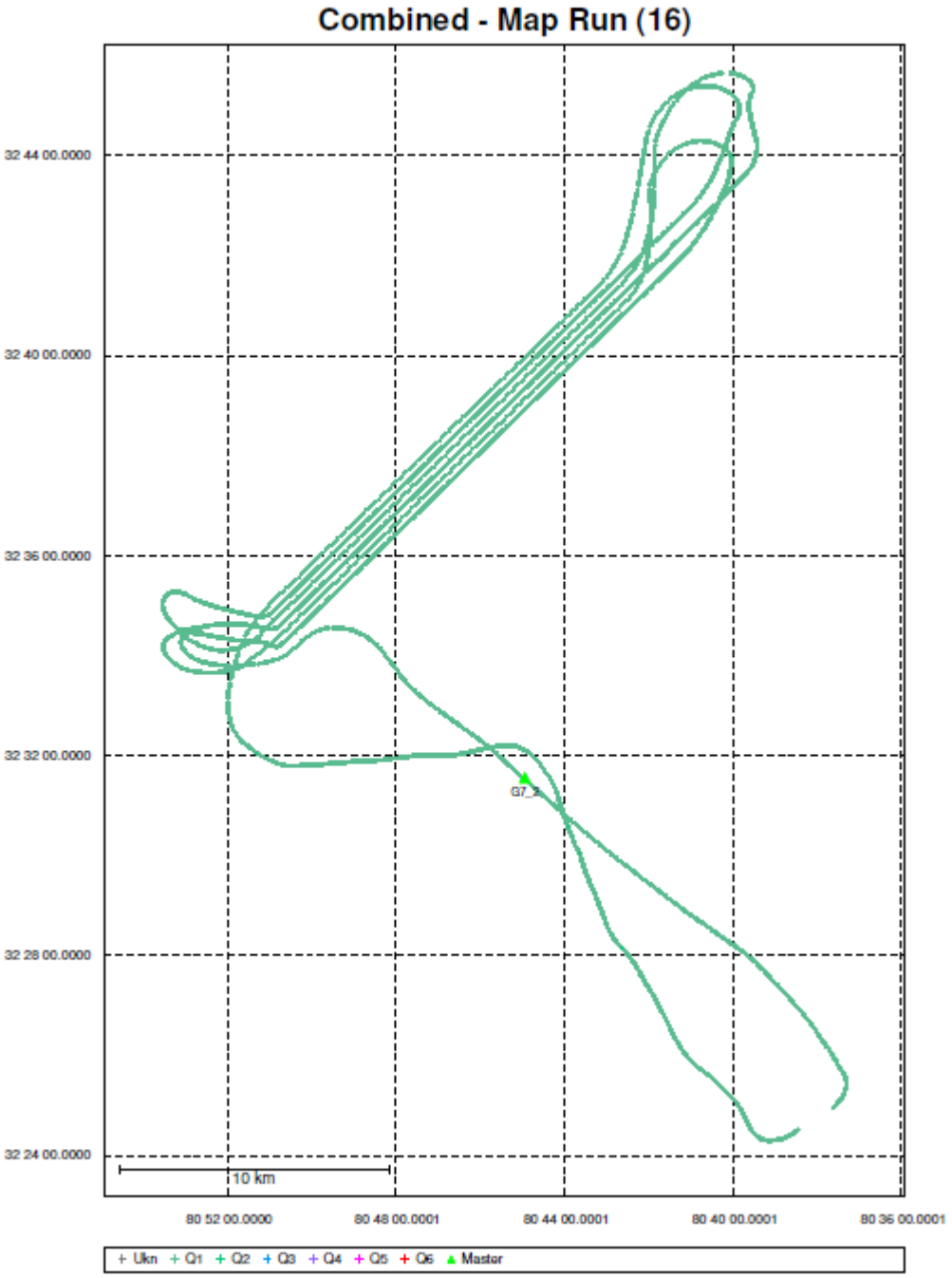
Project: 64a POSGPS v4.30

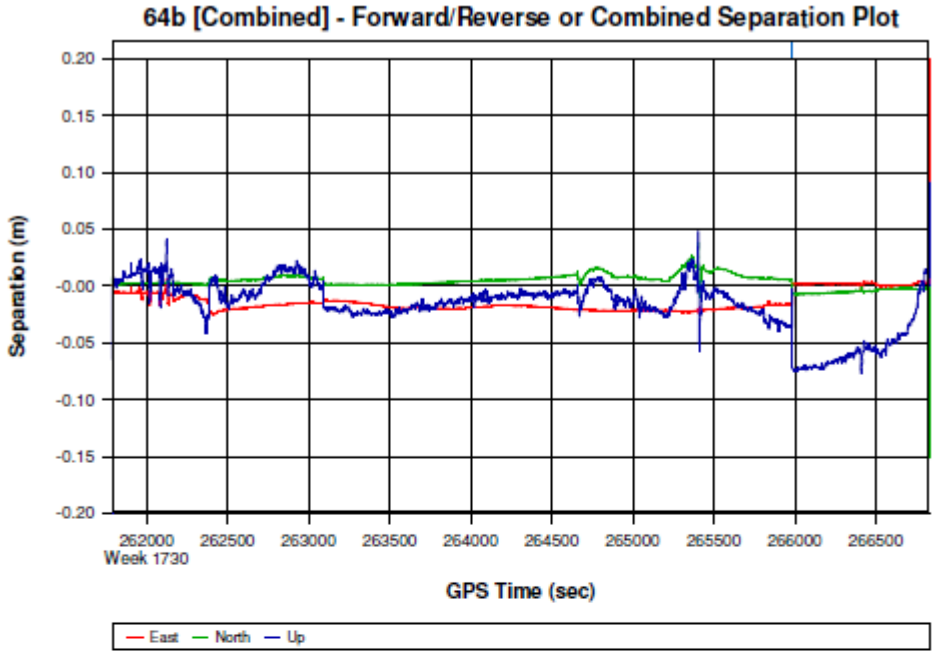


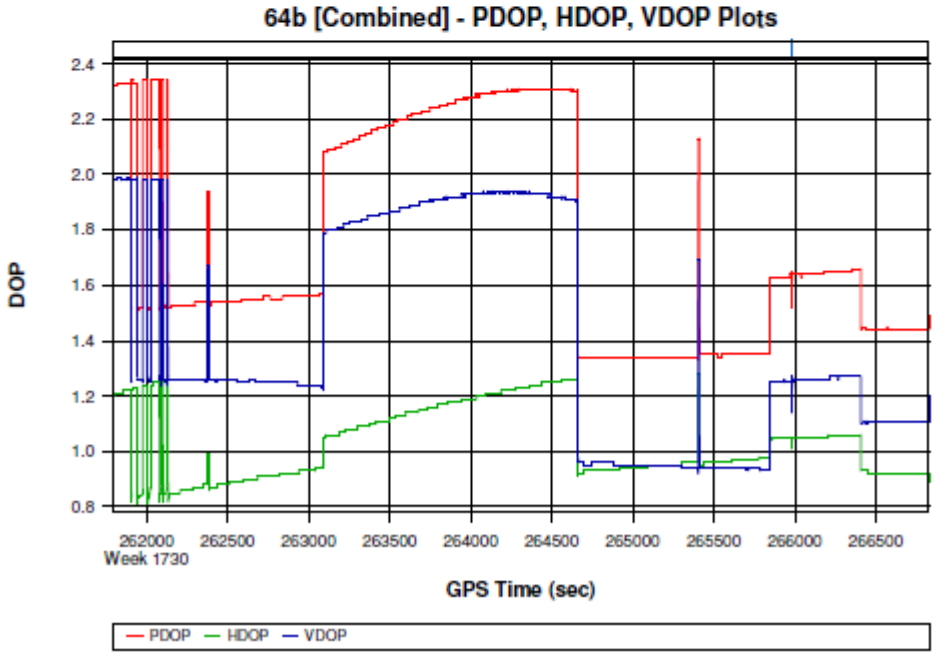


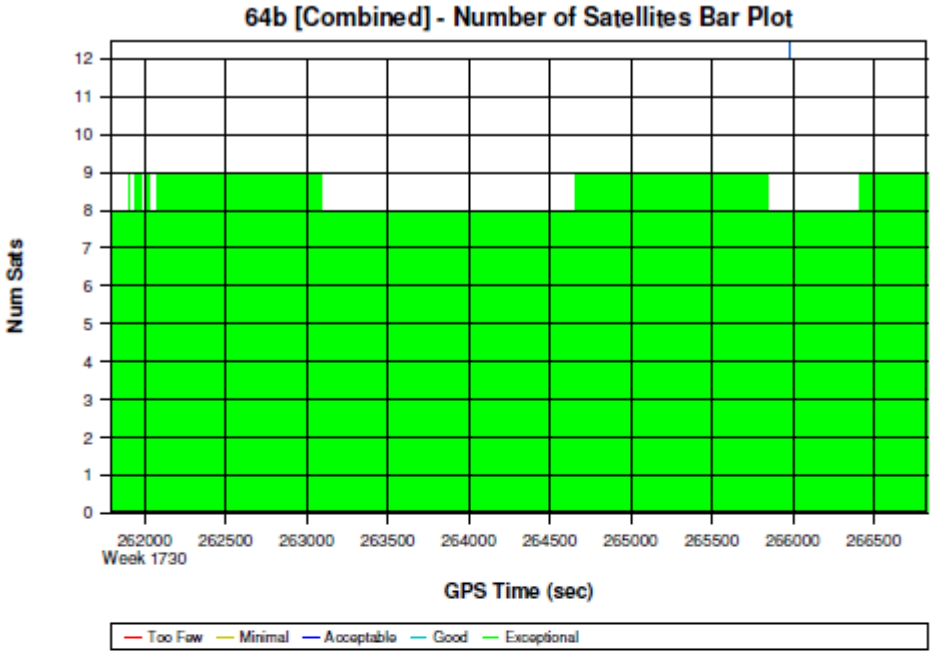
Project: 64a POSGPS v4.30

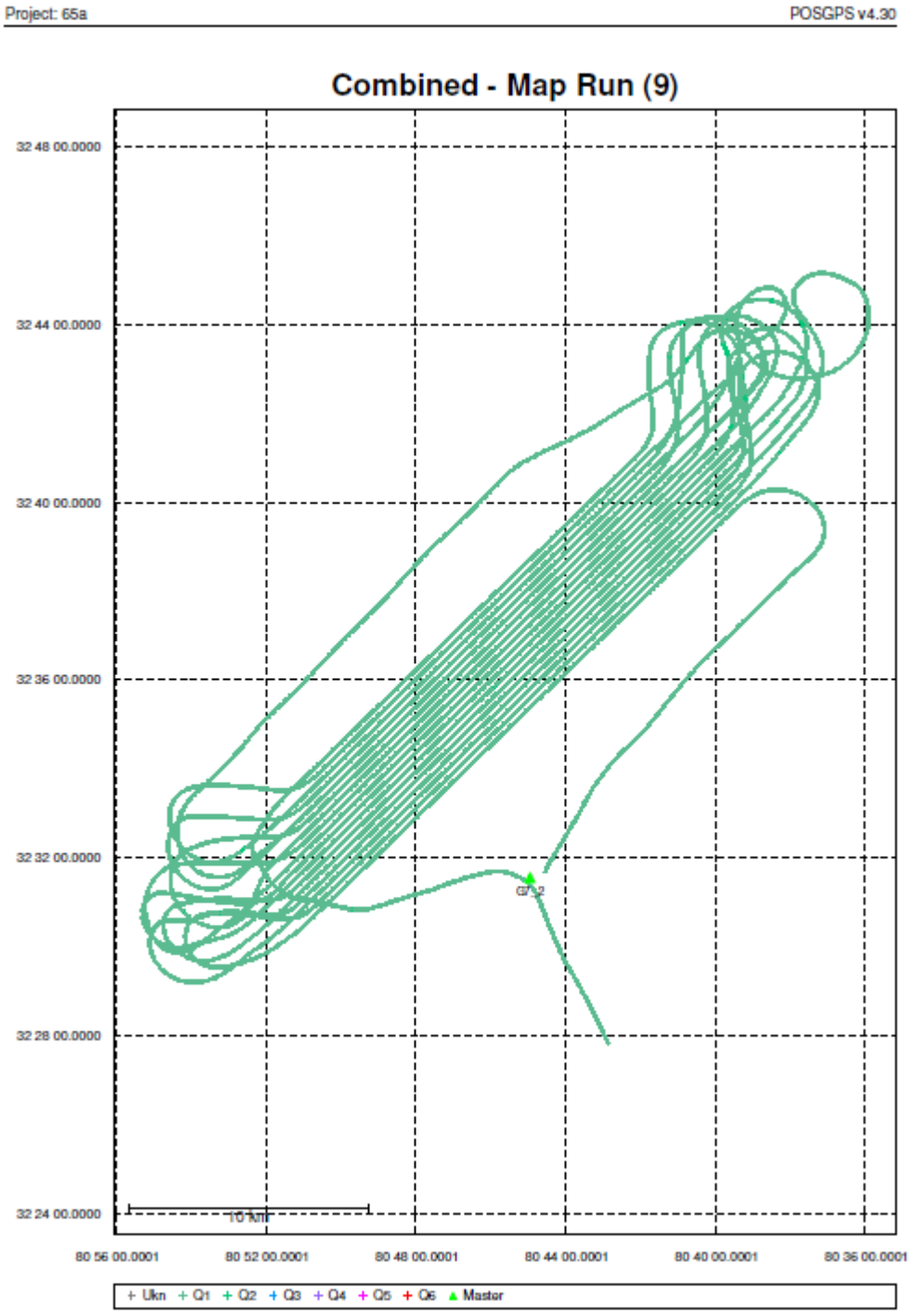



Combined - Map Run (16)
32 44 00.0000
32 40 00.0000
32 36 00.0000
32 32 00.0000
32 28 00.0000
32 24 00.0000
10 km
80 52 00.0000
80 48 00.0001
80 44 00.0001
80 40 00.0001
80 36 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

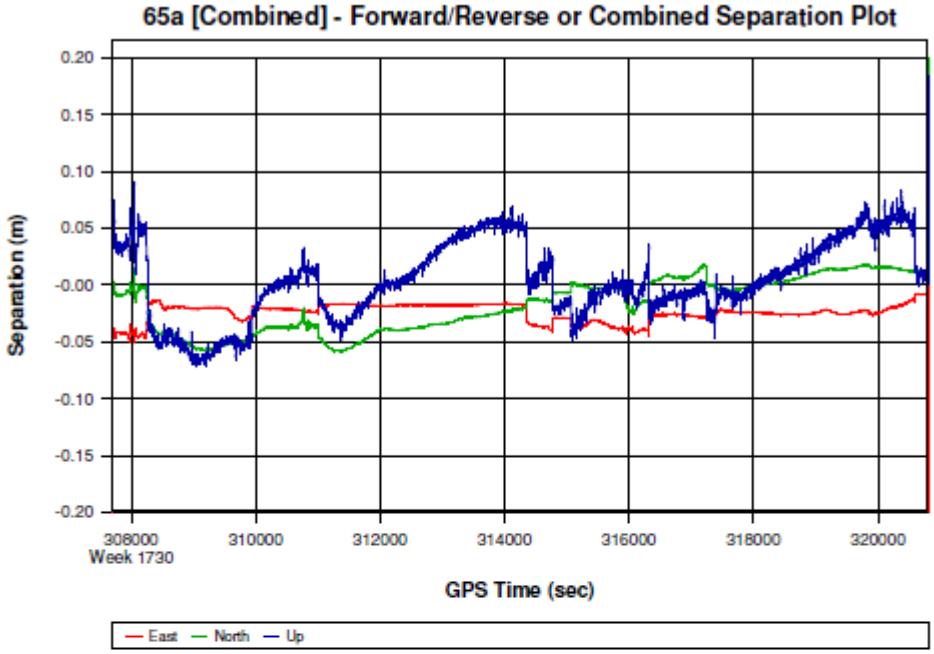

64b [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.15
0.10
0.05
-0.00
-0.05
-0.10
-0.15
-0.20
262000
Week 1730
262500
263000
263500
264000
264500
265000
265500
266000
266500
GPS Time (sec)
East
North
Up

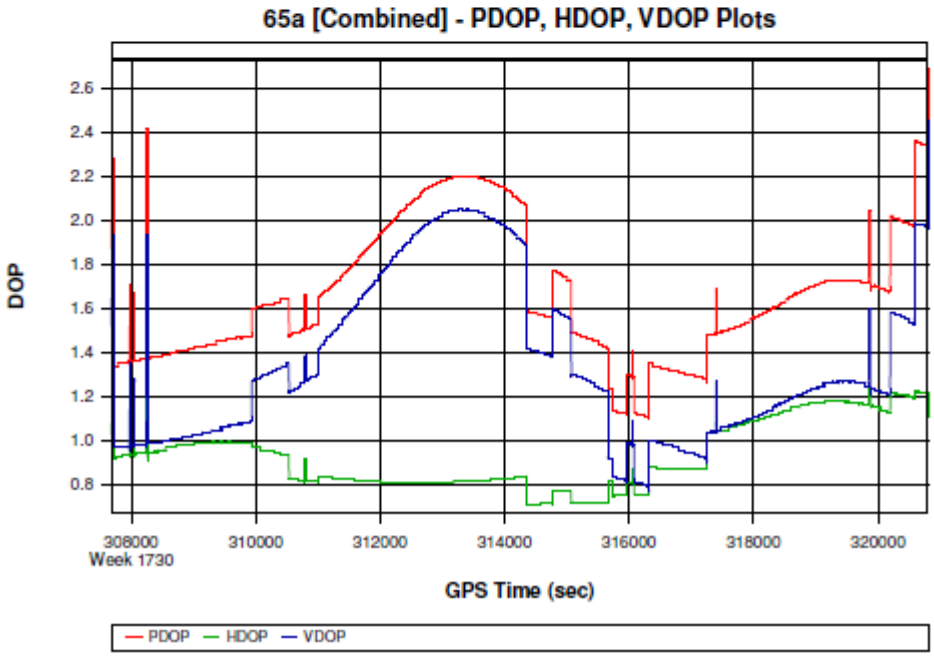

64b [Combined] - PDOP, HDOP, VDOP Plots
DOP
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
262000
Week 1730
262500
263000
263500
264000
264500
265000
265500
266000
266500
GPS Time (sec)
PDOP
HDOP
VDOP

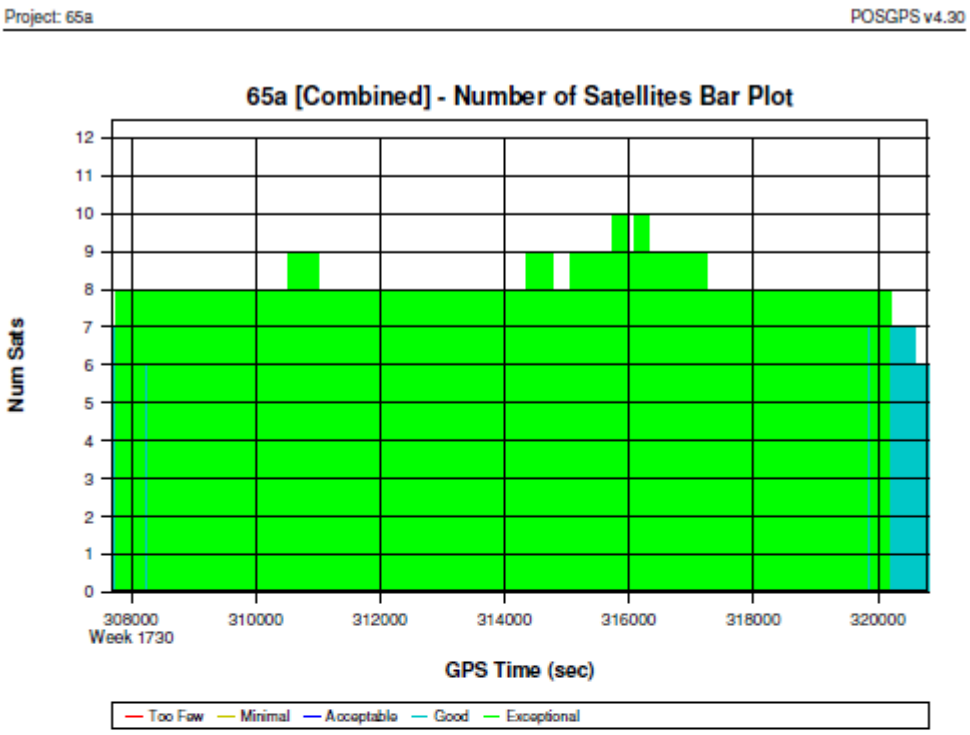

64b [Combined] - Number of Satellites Bar Plot
Num Sats
12
11
10
9
8
7
6
5
4
3
2
1
0
262000
Week 1730
262500
263000
263500
264000
264500
265000
265500
266000
266500
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional

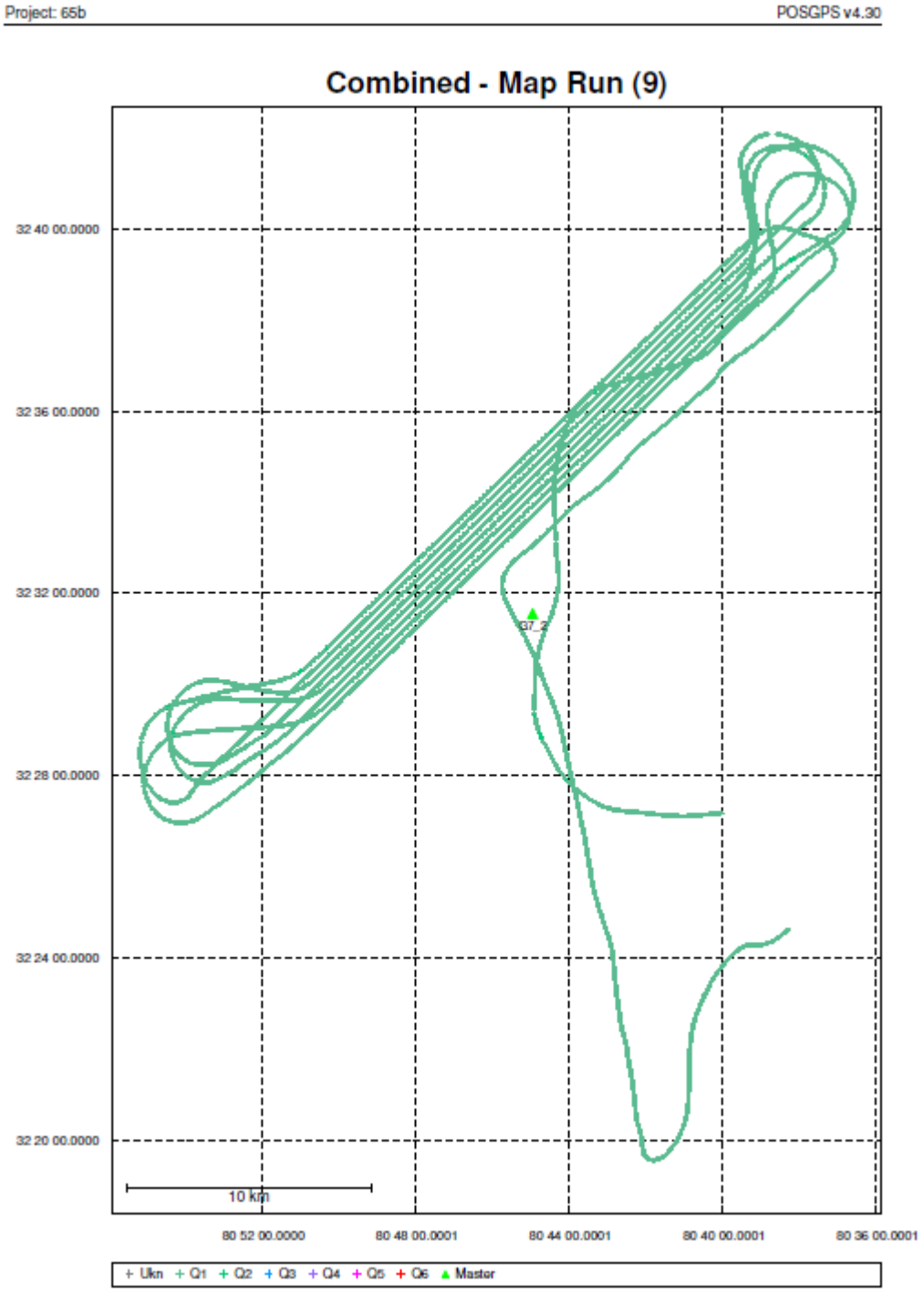

Project: 65a
POSGPS v4.30
Combined - Map Run (9)
32 48 00.0000
32 44 00.0000
32 40 00.0000
32 36 00.0000
32 32 00.0000
32 28 00.0000
32 24 00.0000
10 km
80 56 00.0001
80 52 00.0001
80 48 00.0001
80 44 00.0001
80 40 00.0001
80 36 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

Project: 65a POSGPS v4.30

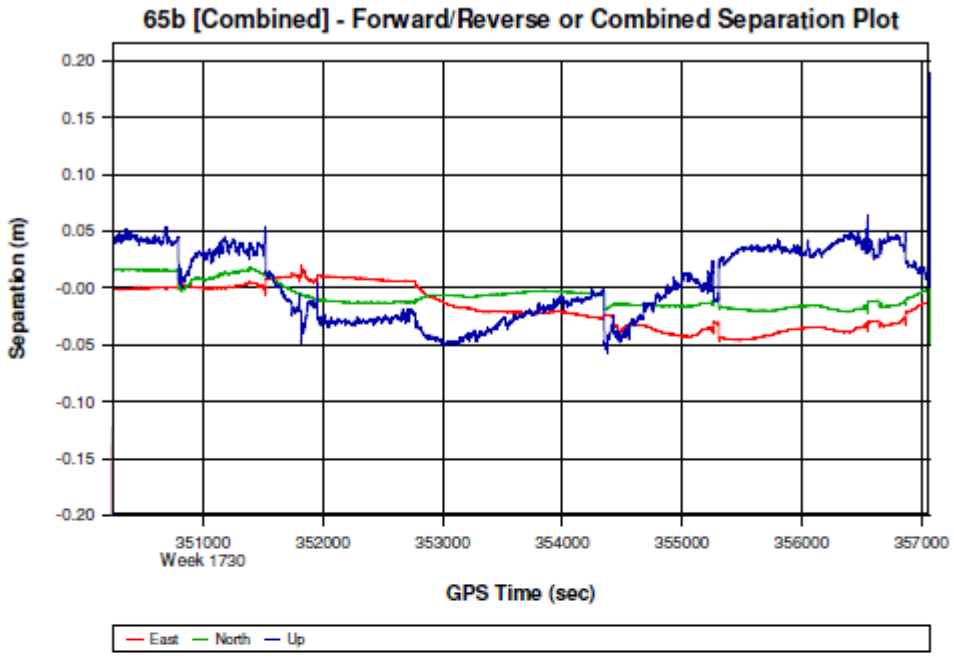


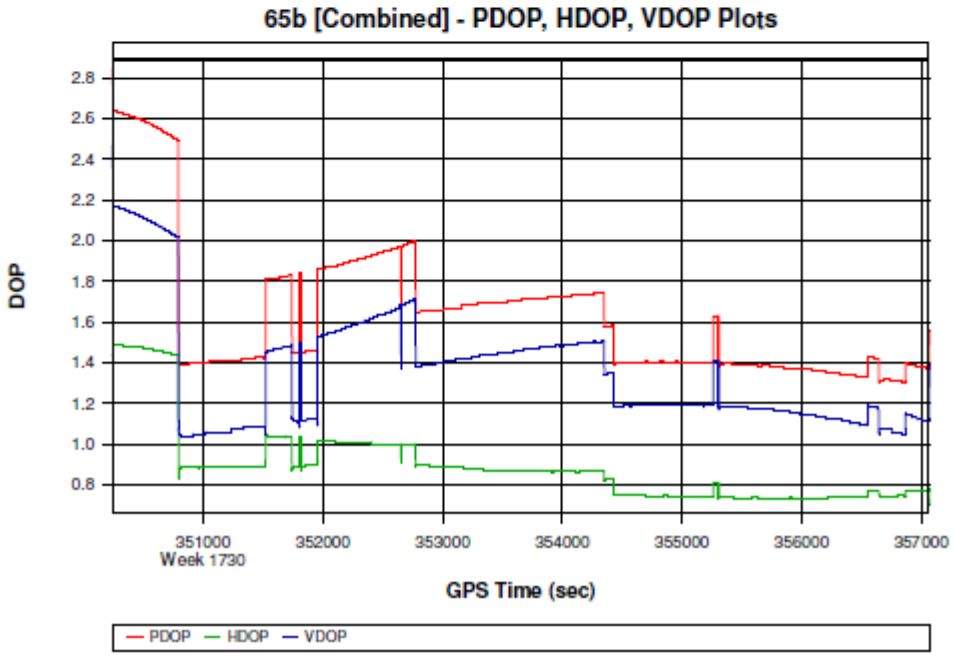



Project: 65a
POSGPS v4.30
65a [Combined] - Number of Satellites Bar Plot
Num Sats
12
11
10
9
8
7
6
5
4
3
2
1
0
308000
Week 1730
310000
312000
314000
316000
318000
320000
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional

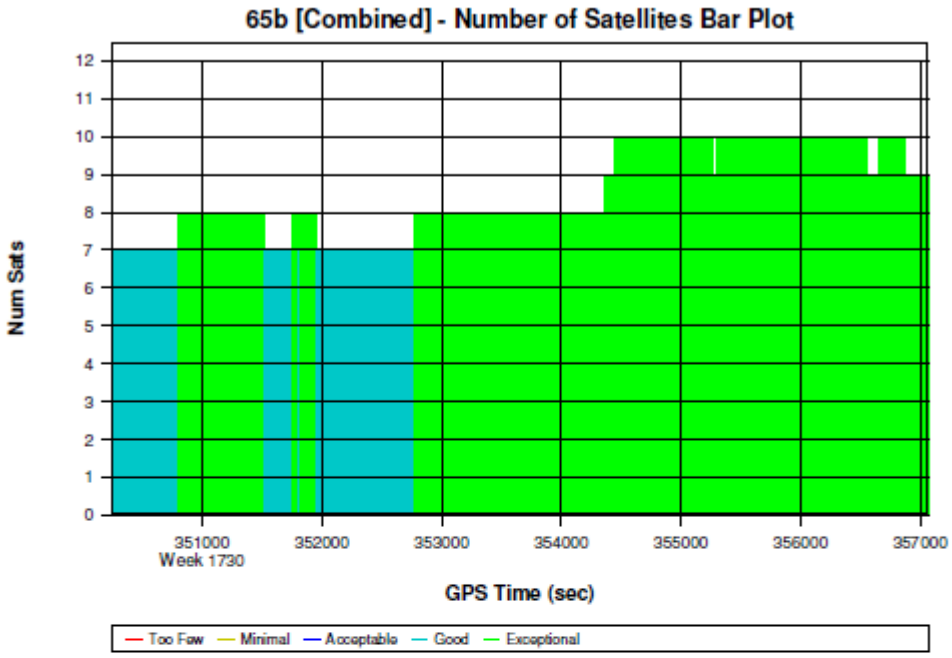

Project: 65b
POSGPS v4.30
Combined - Map Run (9)
32 40 00.0000
32 36 00.0000
32 32 00.0000
32 28 00.0000
32 24 00.0000
32 20 00.0000
10 km
80 52 00.0000
80 48 00.0001
80 44 00.0001
80 40 00.0001
80 36 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

Project: 65b POSGPS v4.30

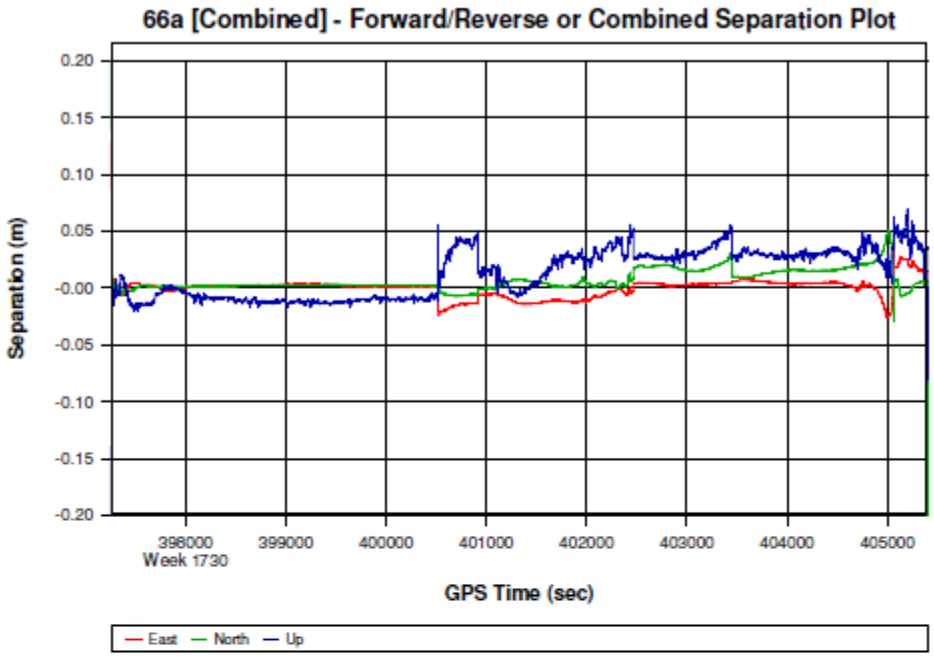


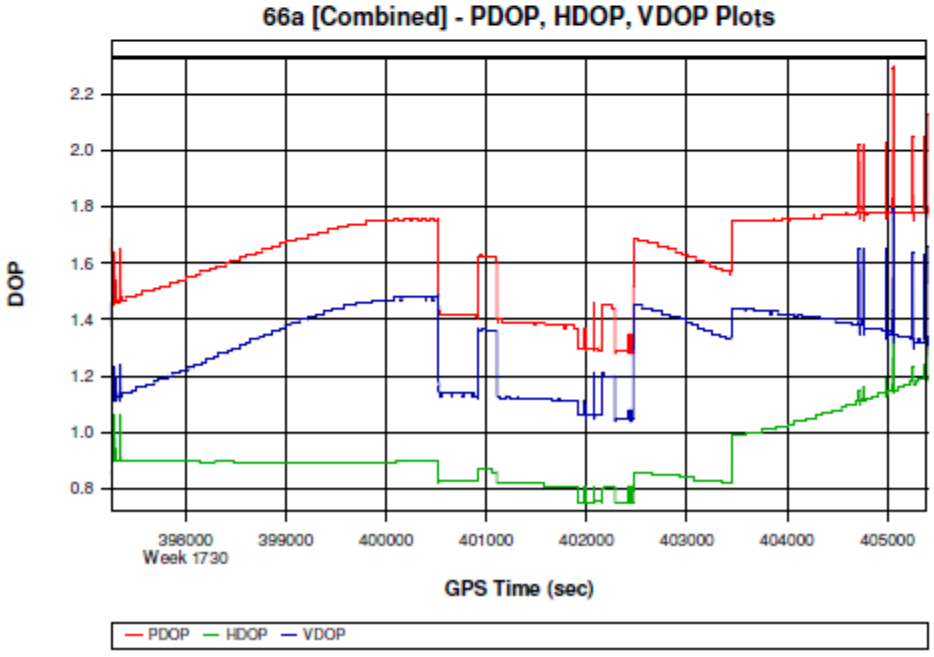


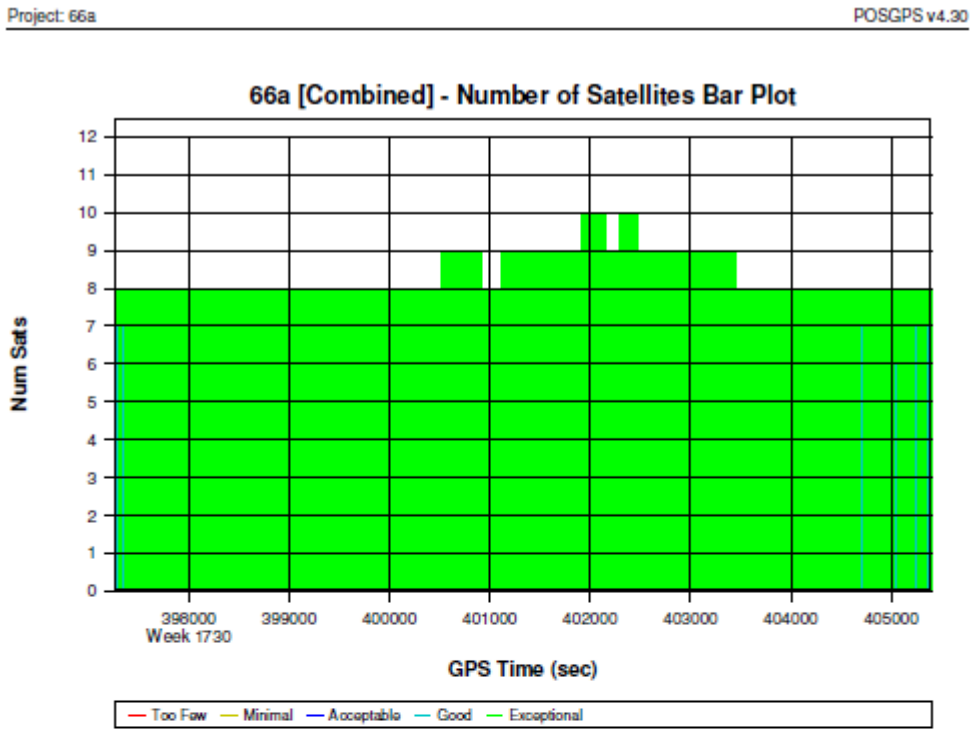
Project: 65b POSGPS v4.30

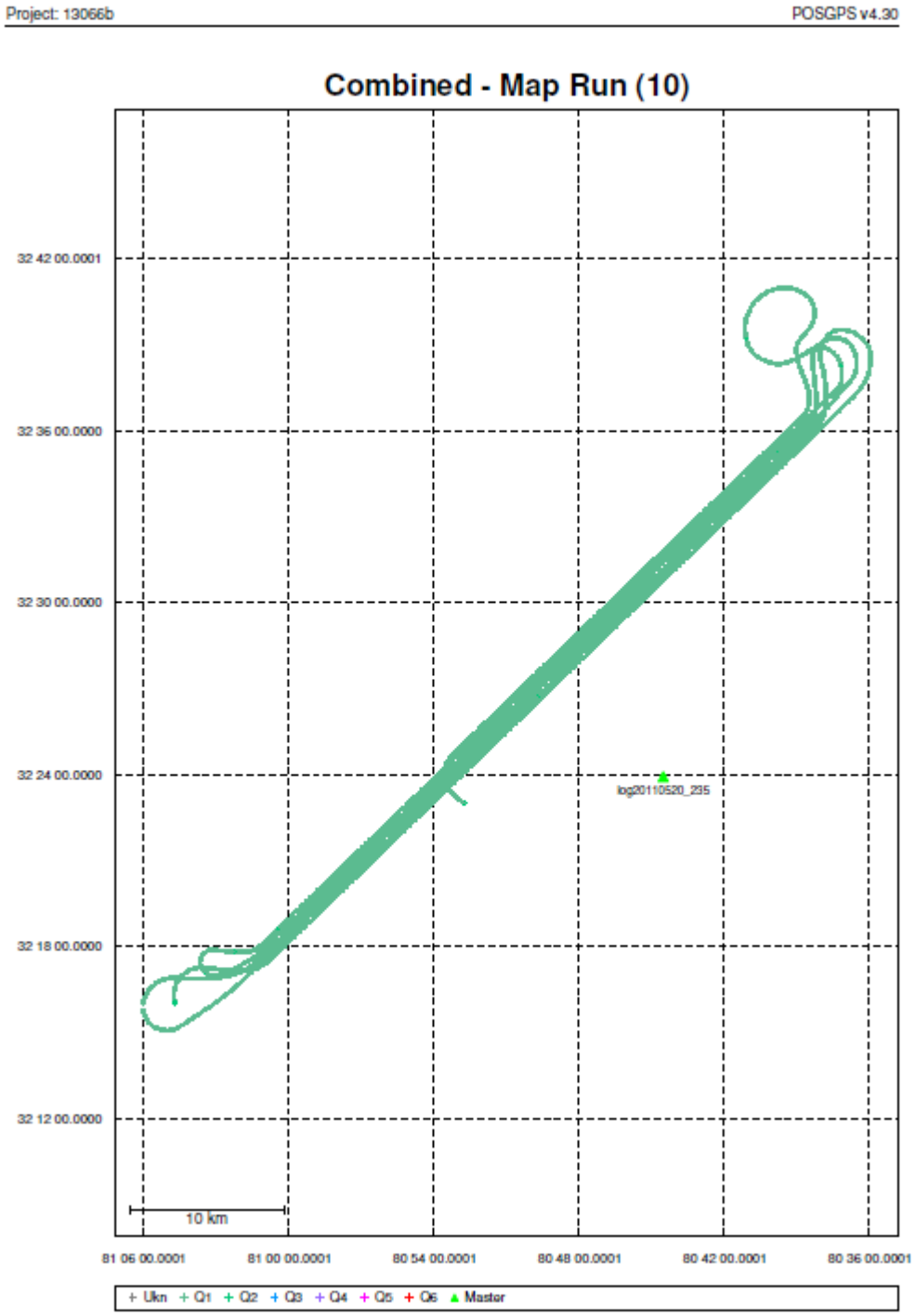


Project: 66a POSGPS v4.30

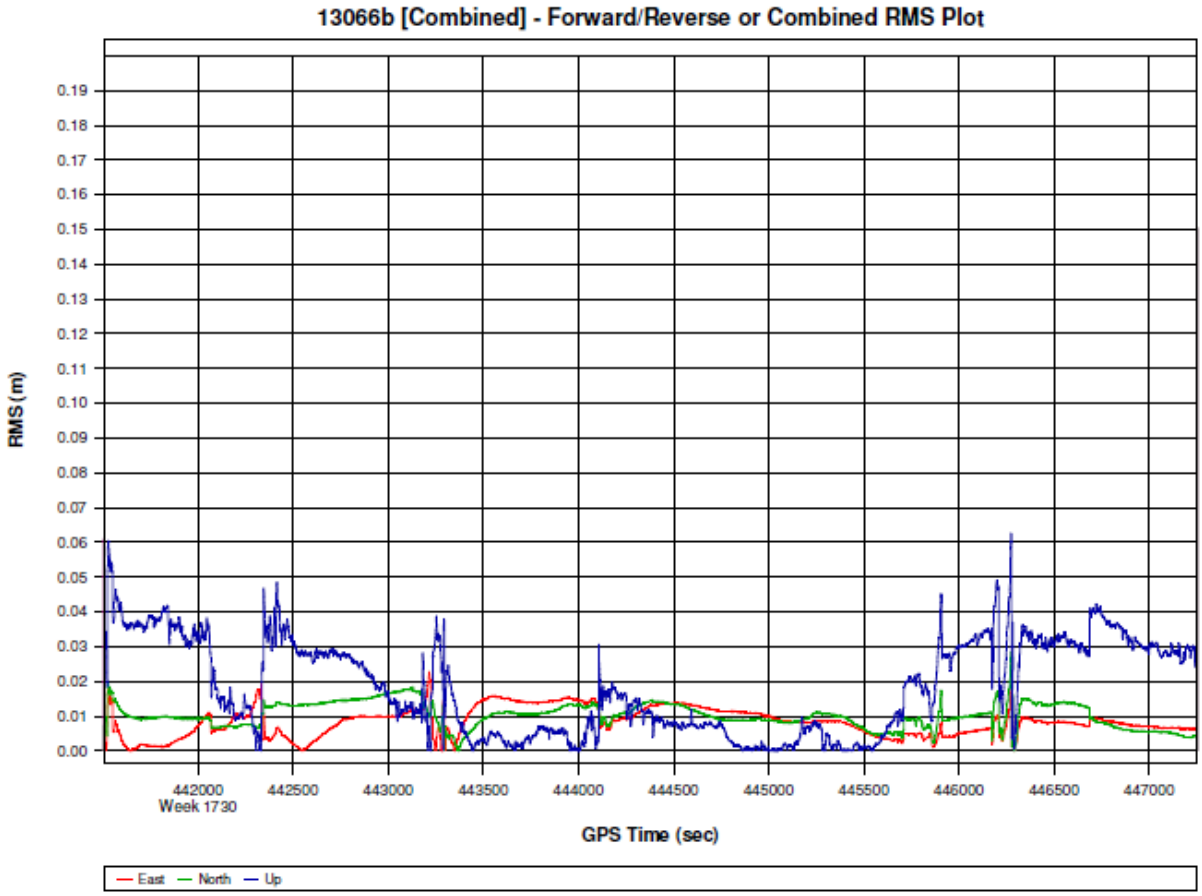




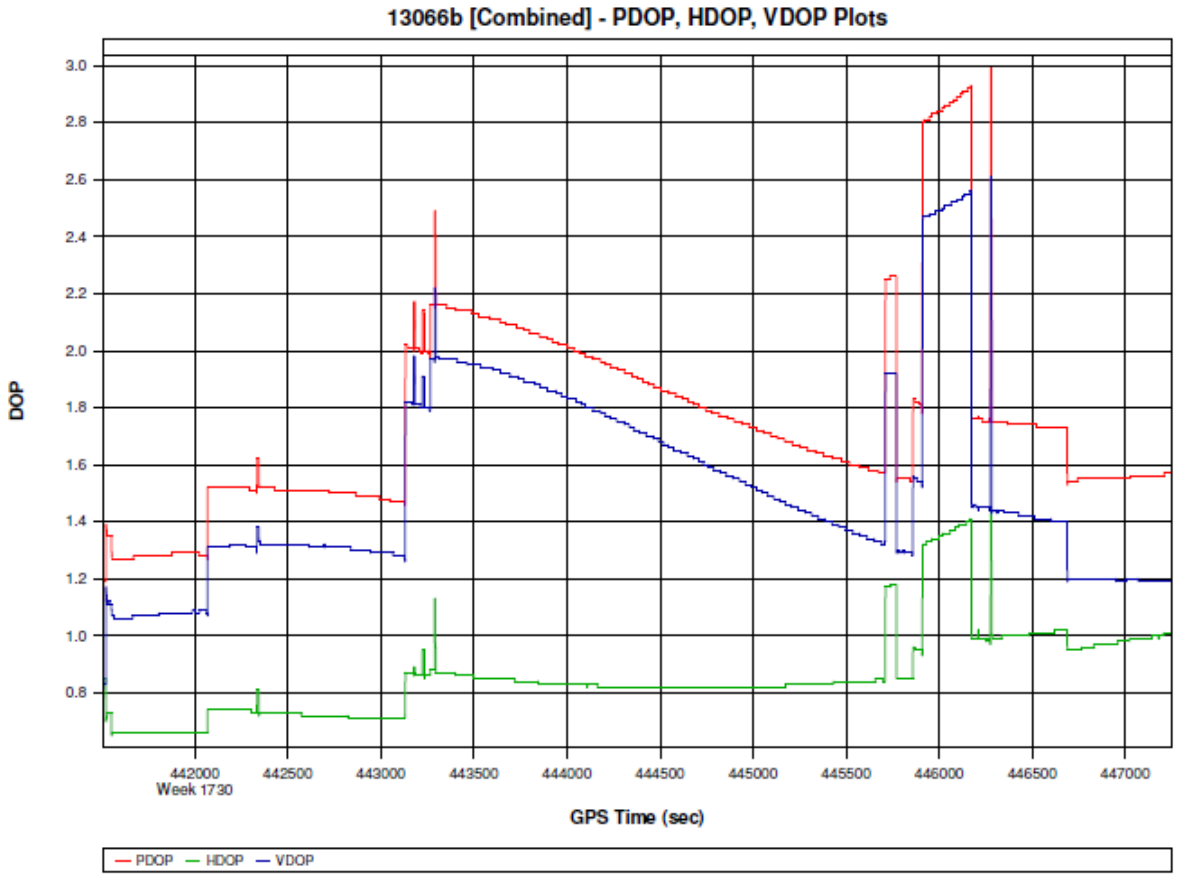

Project: 66a
POSGPS v4.30
66a [Combined] - Number of Satellites Bar Plot
Num Sats
12
11
10
9
8
7
6
5
4
3
2
1
0
398000
Week 1730
399000
400000
401000
402000
403000
404000
405000
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional


Project: 13066b
POSGPS v4.30
Combined - Map Run (10)
32 42 00.0001
32 36 00.0000
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
log20110520_235
10 km
81 06 00.0001
81 00 00.0001
80 54 00.0001
80 48 00.0001
80 42 00.0001
80 36 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

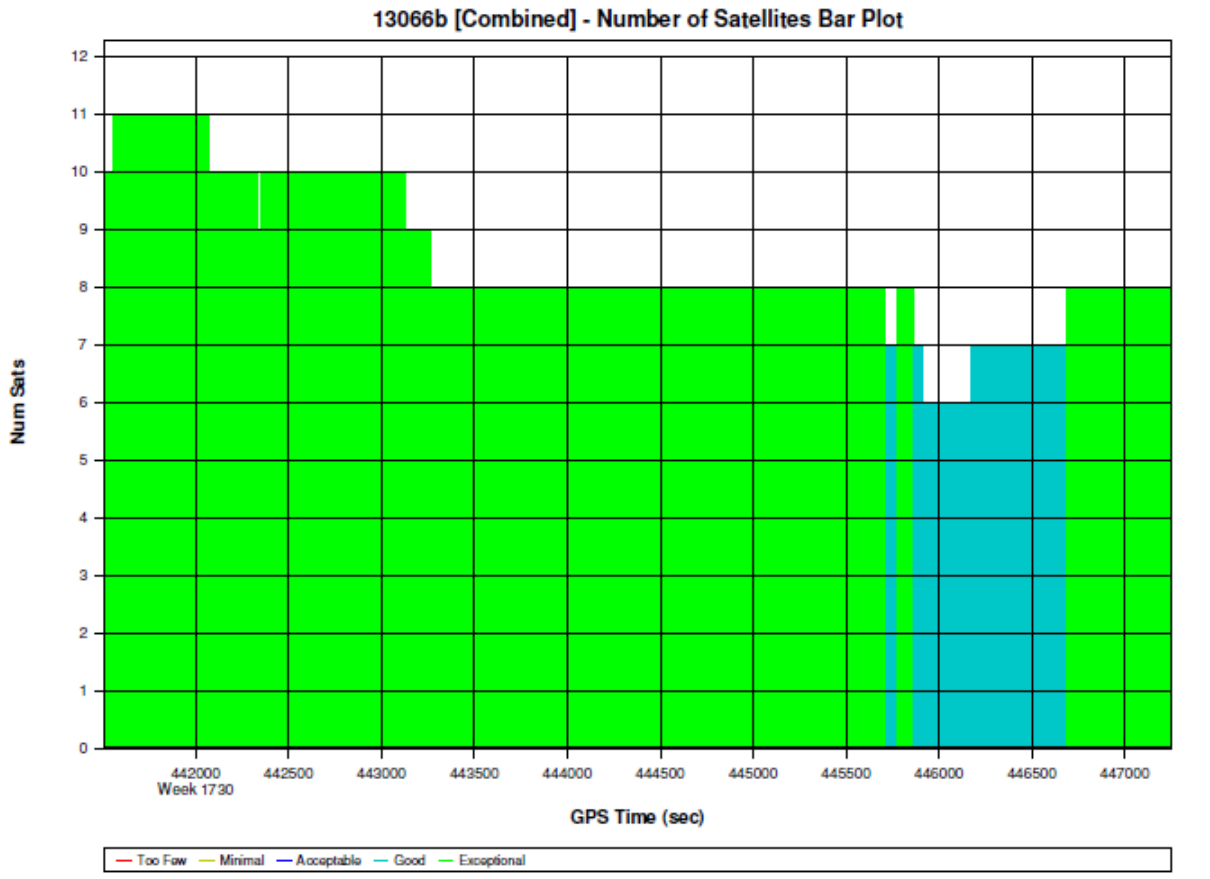
Project: 13066b POSGPS v4.30



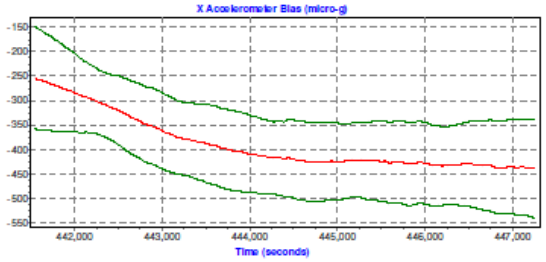
Project: 13066b POSGPS v4.30

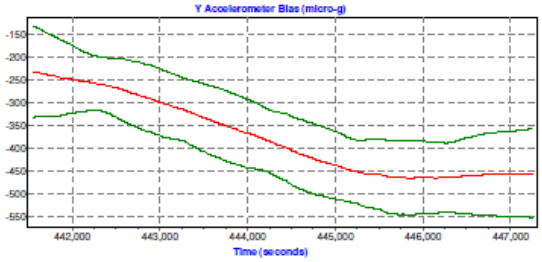


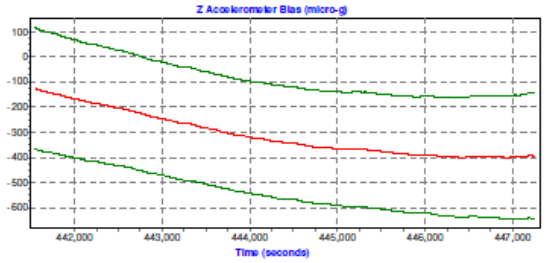
Project: 13066b POSGPS v4.30

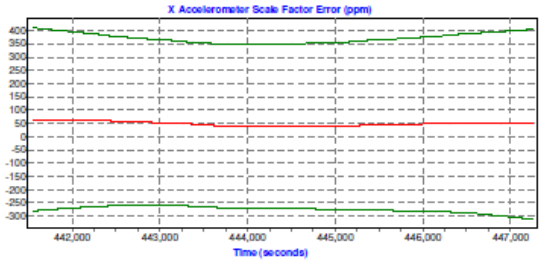


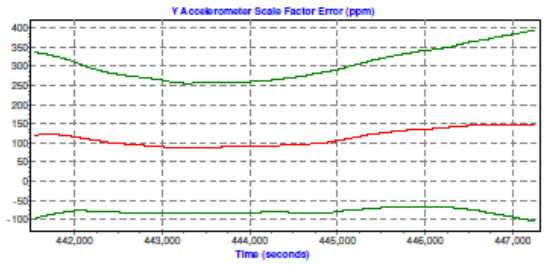
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13066b\pos\GPS\13066b.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      145376
      No processed position:  139627
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0234 (m)
      C/A Code:   0.89 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.019 (m)
      North:      0.017 (m)
      Height:     0.045 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (5729 occurances):
      East:       0.013 (m)
      North:      0.015 (m)
      Height:     0.032 (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:          37.018 (km)
      Minimum:          9.173 (km)
      Average:          19.848 (km)
      First Epoch:      13.010 (km)
      Last Epoch:       34.902 (km)
```

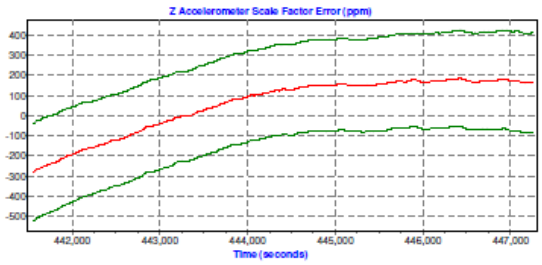

X Accelerometer Bias (micro-g)
Time (seconds)

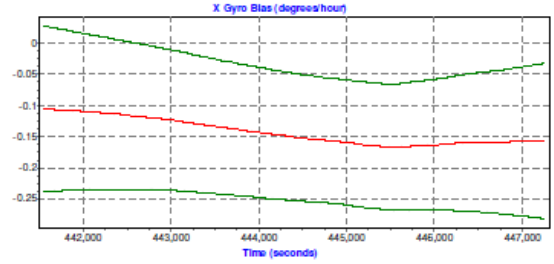

Y Accelerometer Bias (micro-g)
Time (seconds)

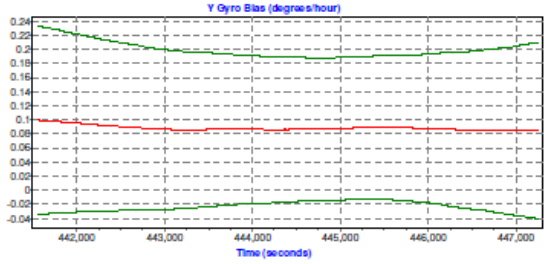

Z Accelerometer Bias (micro-g)
Time (seconds)

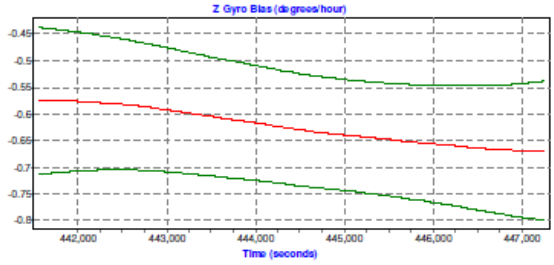

X Accelerometer Scale Factor Error (ppm)
Time (seconds)

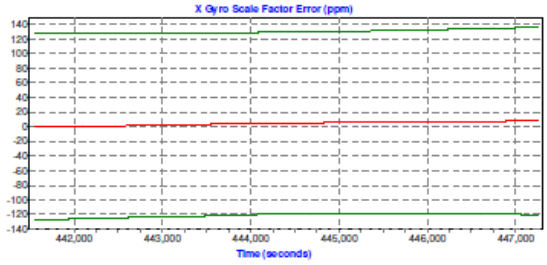

Y Accelerometer Scale Factor Error (ppm)
Time (seconds)

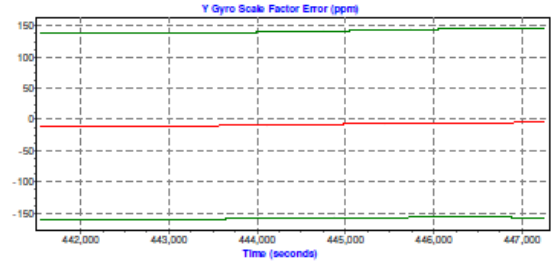

Z Accelerometer Scale Factor Error (ppm)
Time (seconds)

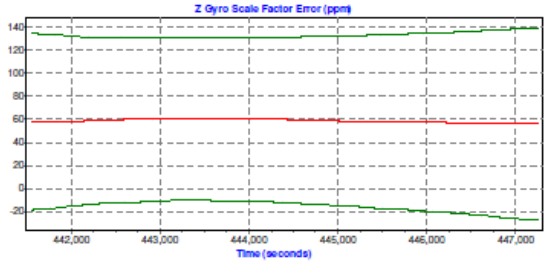

X Gyro Bias (degrees/hour)
Time (seconds)


Y Gyro Bias (degrees/hour)
Time (seconds)

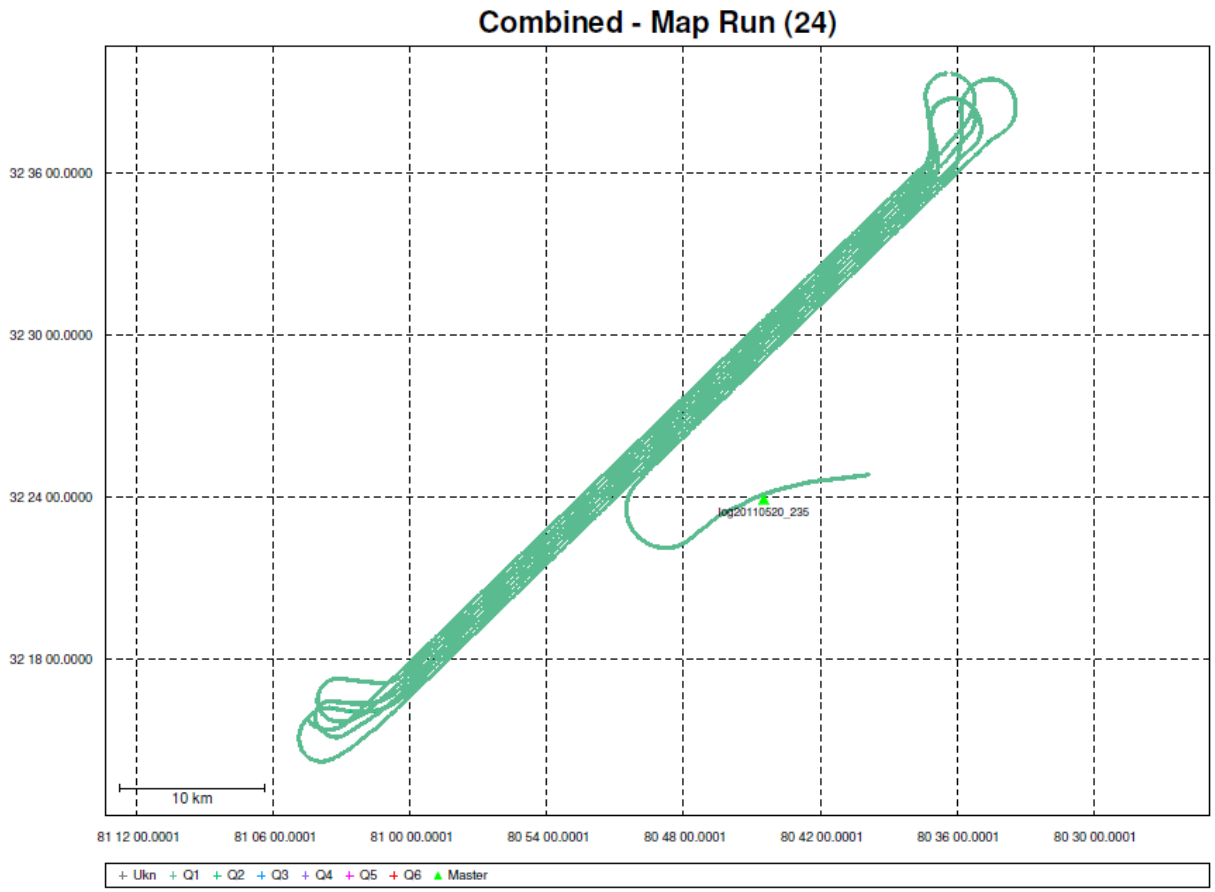

Z Gyro Bias (degrees/hour)
Time (seconds)


X Gyro Scale Factor Error (ppm)
Time (seconds)

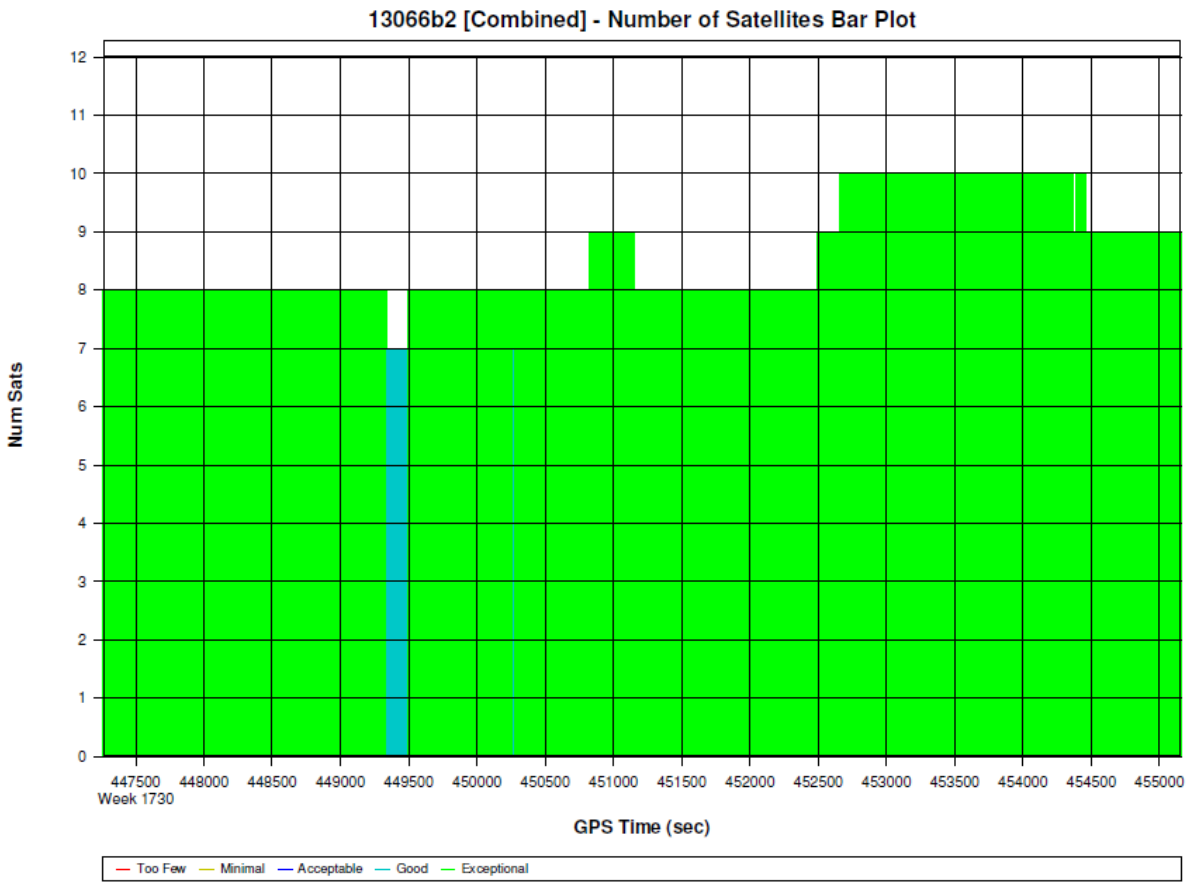

Y Gyro Scale Factor Error (ppm)
Time (seconds)


Z Gyro Scale Factor Error (ppm)
Time (seconds)

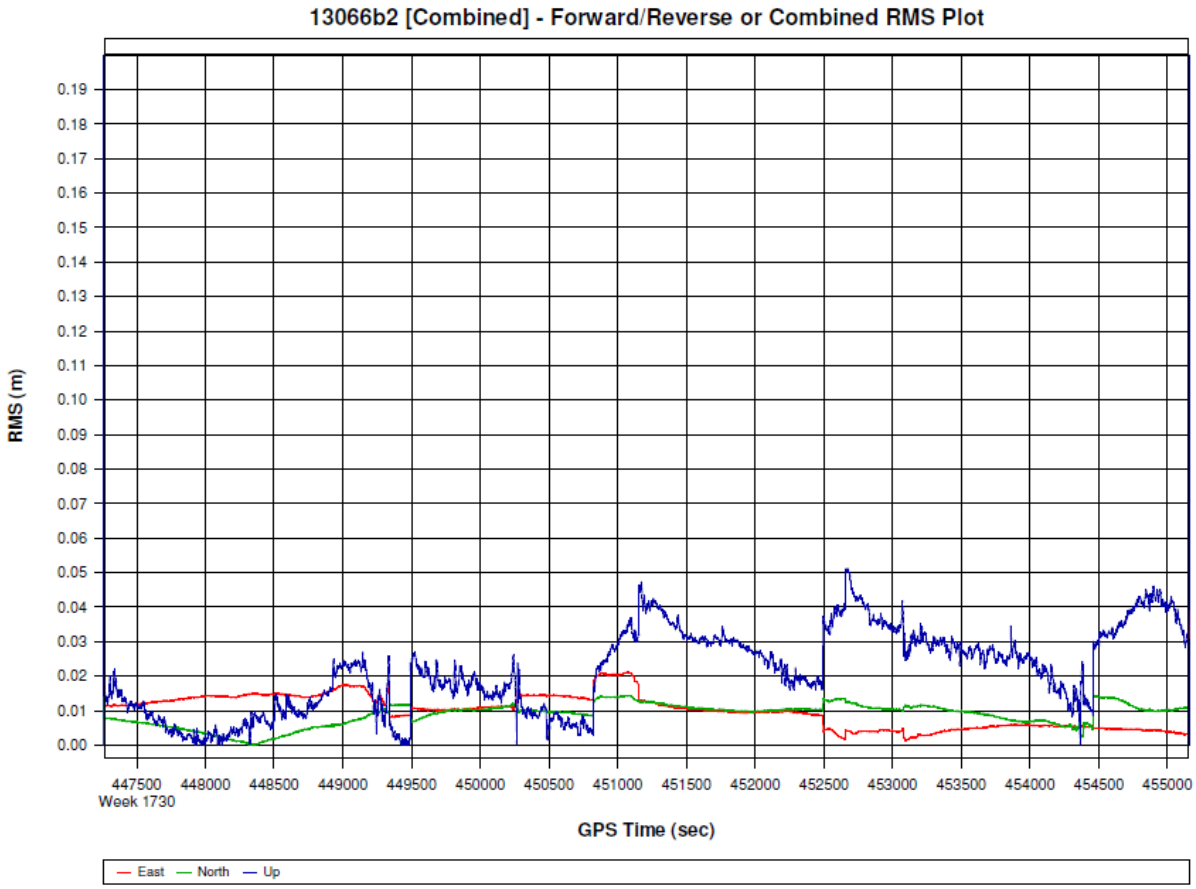
Project: 13066b2 POSGPS v4.30



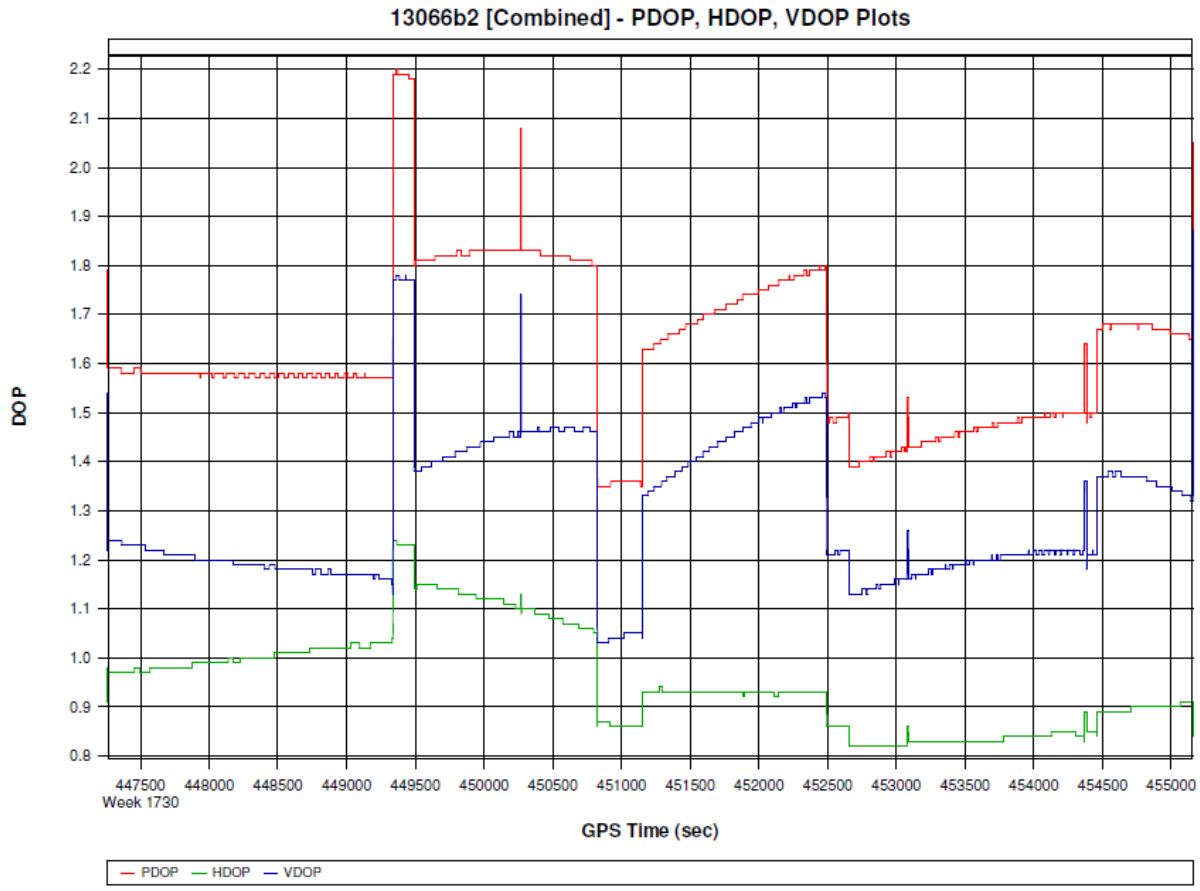
Project: 13066b2 POSGPS v4.30



Project: 13066b2 POSGPS v4.30

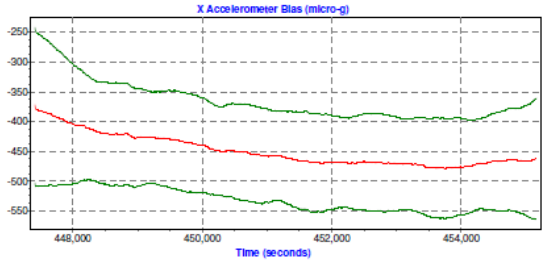


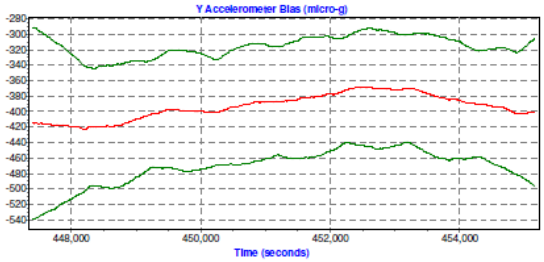
Project: 13066b2 POSGPS v4.30

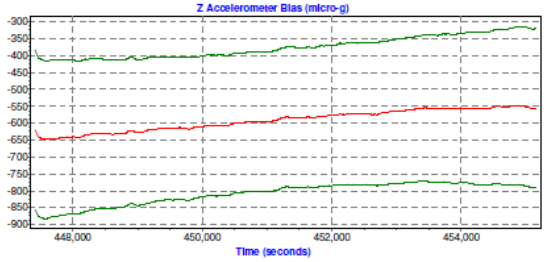


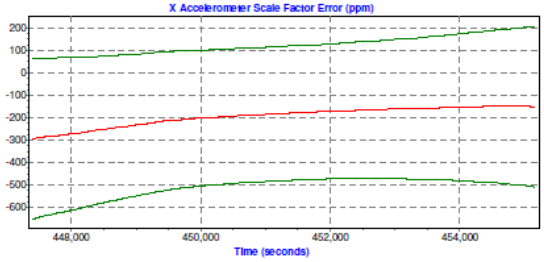
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13066b\pos2\GPS\13066b2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      145376
      No processed position:  137474
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0270 (m)
      C/A Code:   0.94 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.018 (m)
      North:      0.014 (m)
      Height:     0.038 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (7896 occurances):
      East:       0.016 (m)
      North:      0.013 (m)
      Height:     0.035 (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:          36.151 (km)
      Minimum:          1.052 (km)
      Average:          18.485 (km)
      First Epoch:      34.886 (km)
      Last Epoch:       7.449 (km)
```

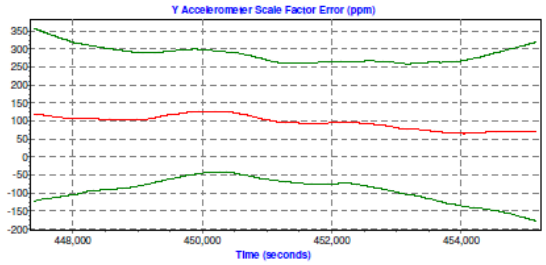
POSPac Version 4.3 - 1 - 5/17/2013 - 11:14:44 AM

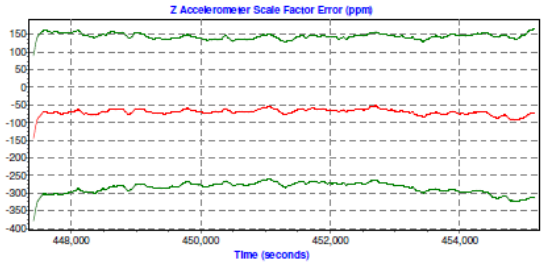


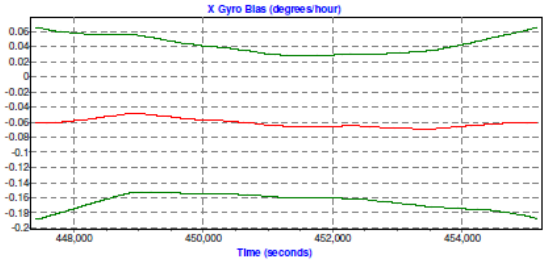


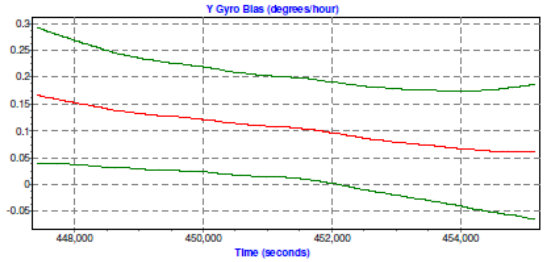


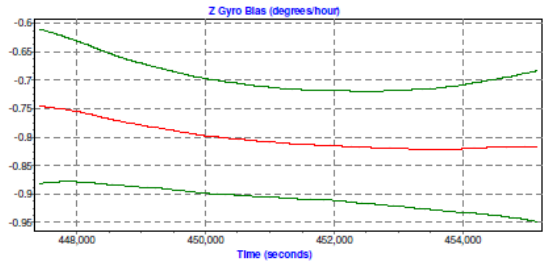


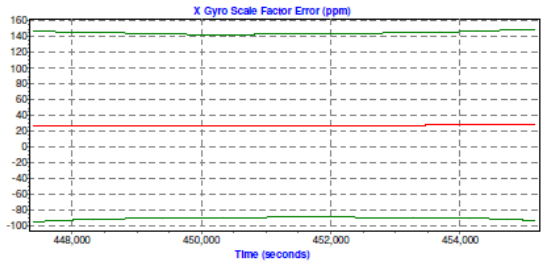


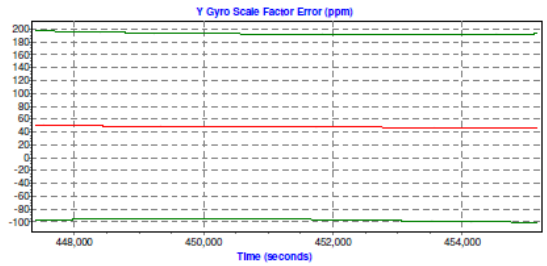


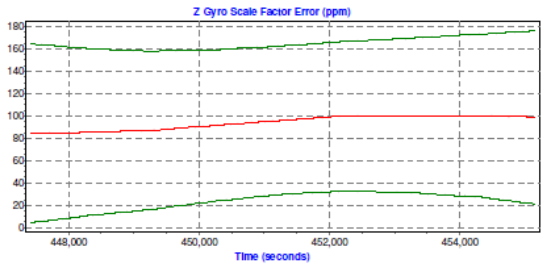

X Gyro Bias (degrees/hour)
Time (seconds)

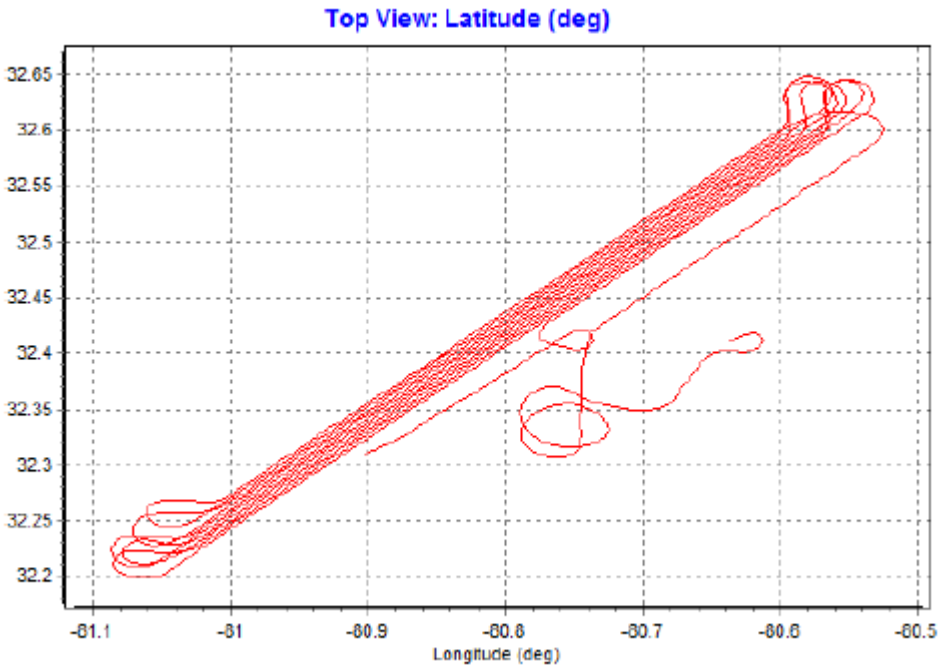

Y Gyro Bias (degrees/hour)
Time (seconds)

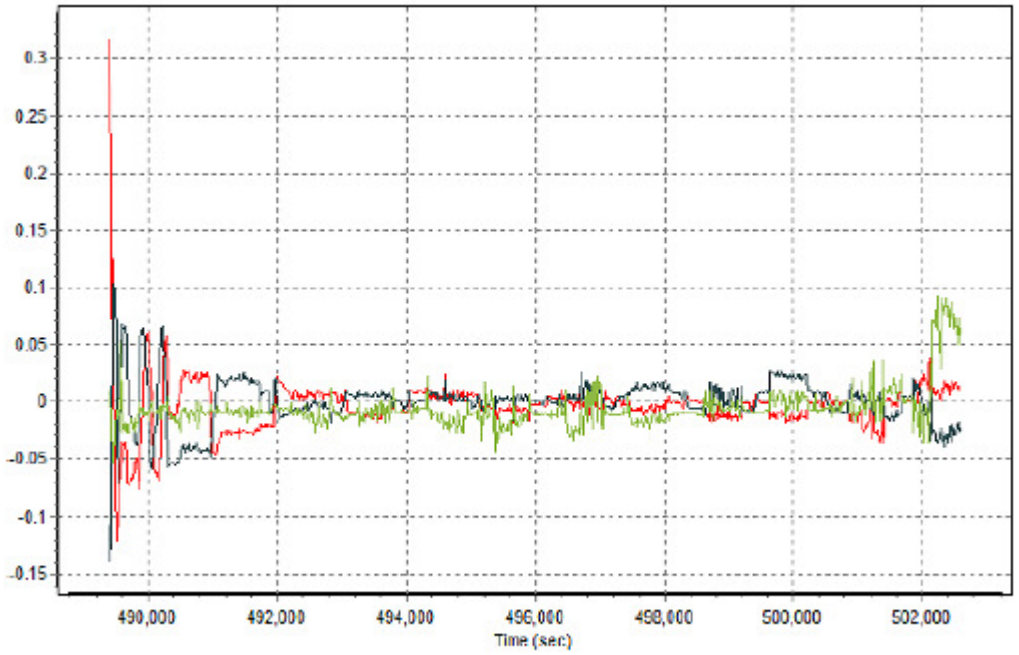

Z Gyro Bias (degrees/hour)
Time (seconds)

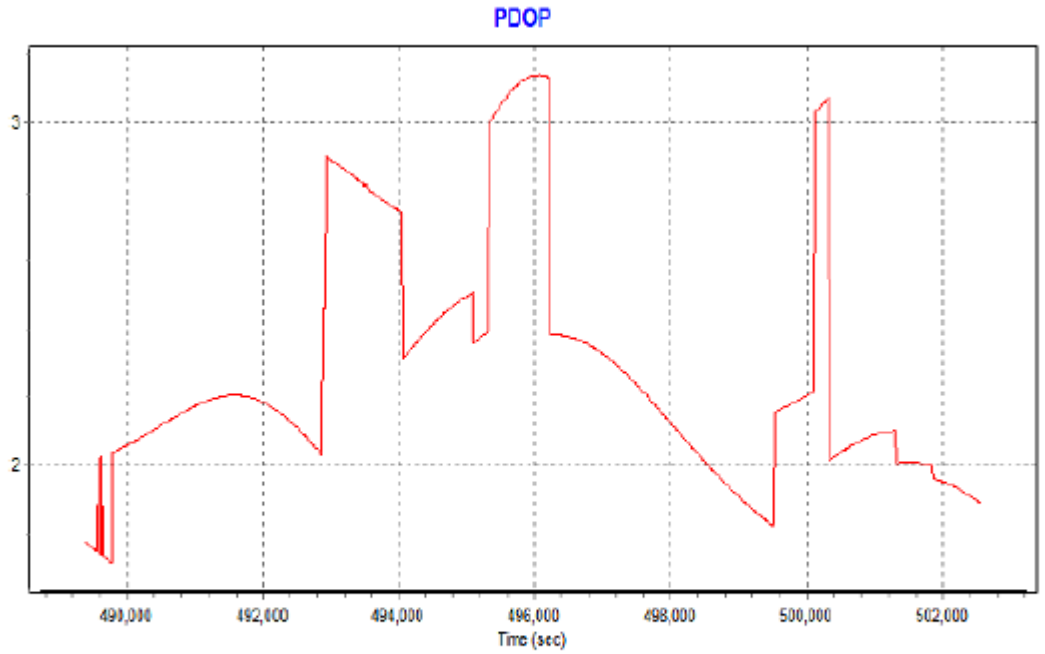

X Gyro Scale Factor Error (ppm)
Time (seconds)


Y Gyro Scale Factor Error (ppm)
Time (seconds)

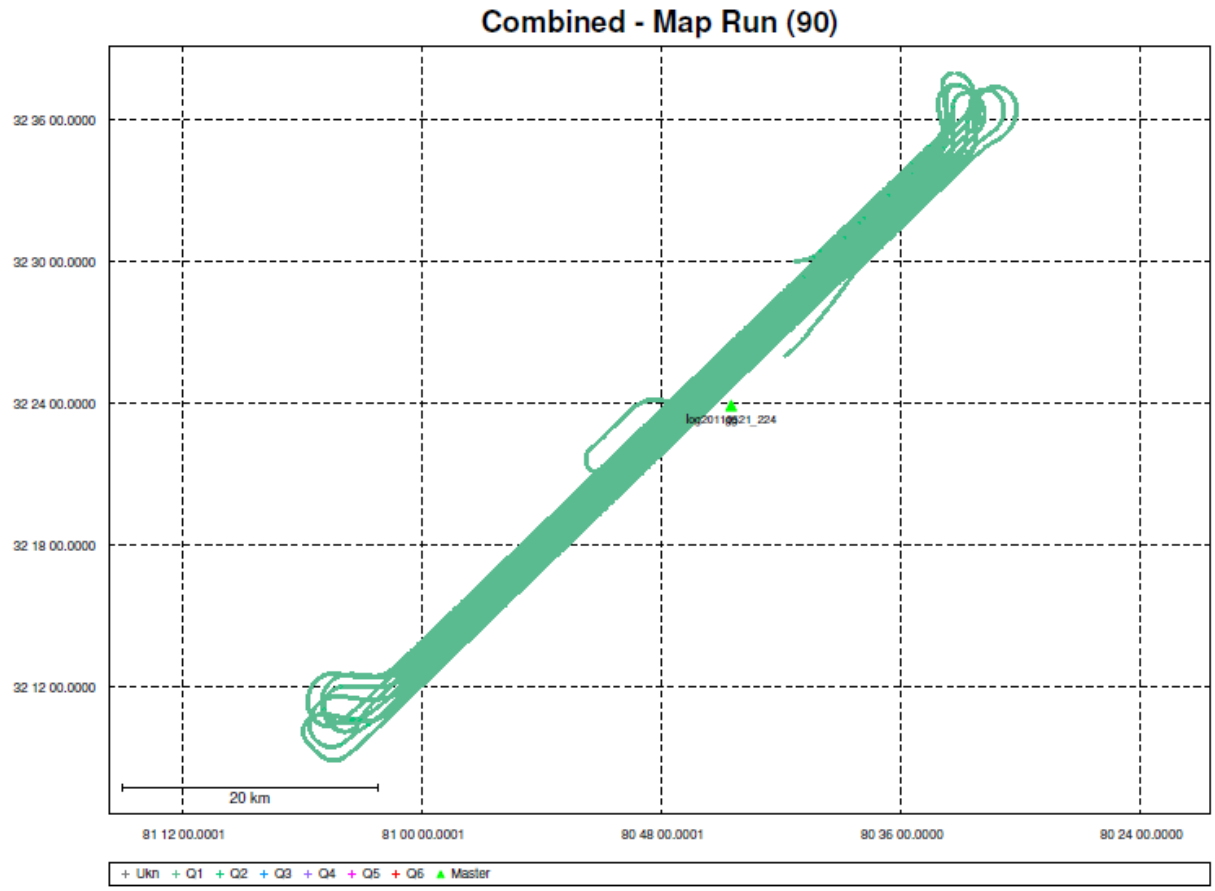

Z Gyro Scale Factor Error (ppm)
Time (seconds)


Top View: Latitude (deg)
32.65
32.6
32.55
32.5
32.45
32.4
32.35
32.3
32.25
32.2
-81.1
-81
-80.9
-80.8
-80.7
-80.6
-80.5
Longitude (deg)

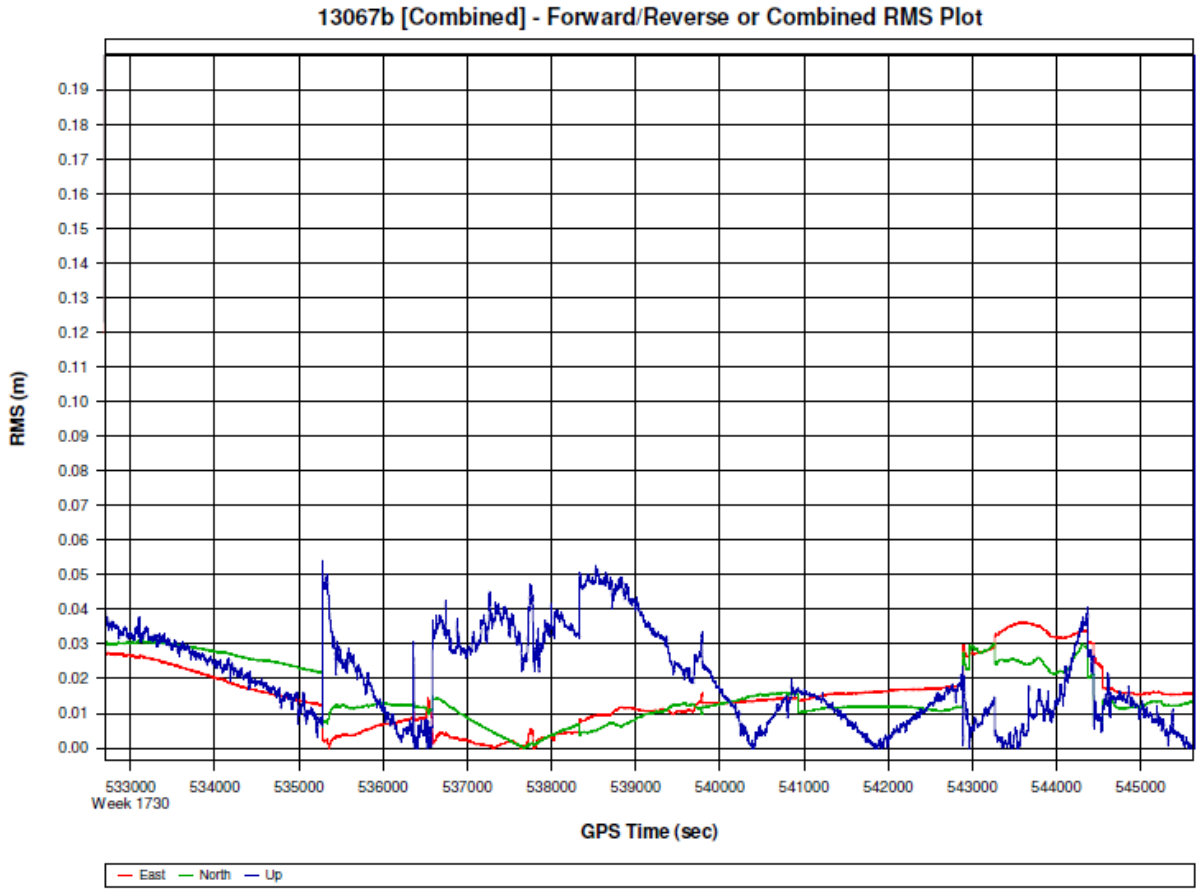

0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
490,000
492,000
494,000
496,000
498,000
500,000
502,000
Time (sec)


PDOP
3
2
490,000
492,000
494,000
496,000
498,000
500,000
502,000
Time (sec)

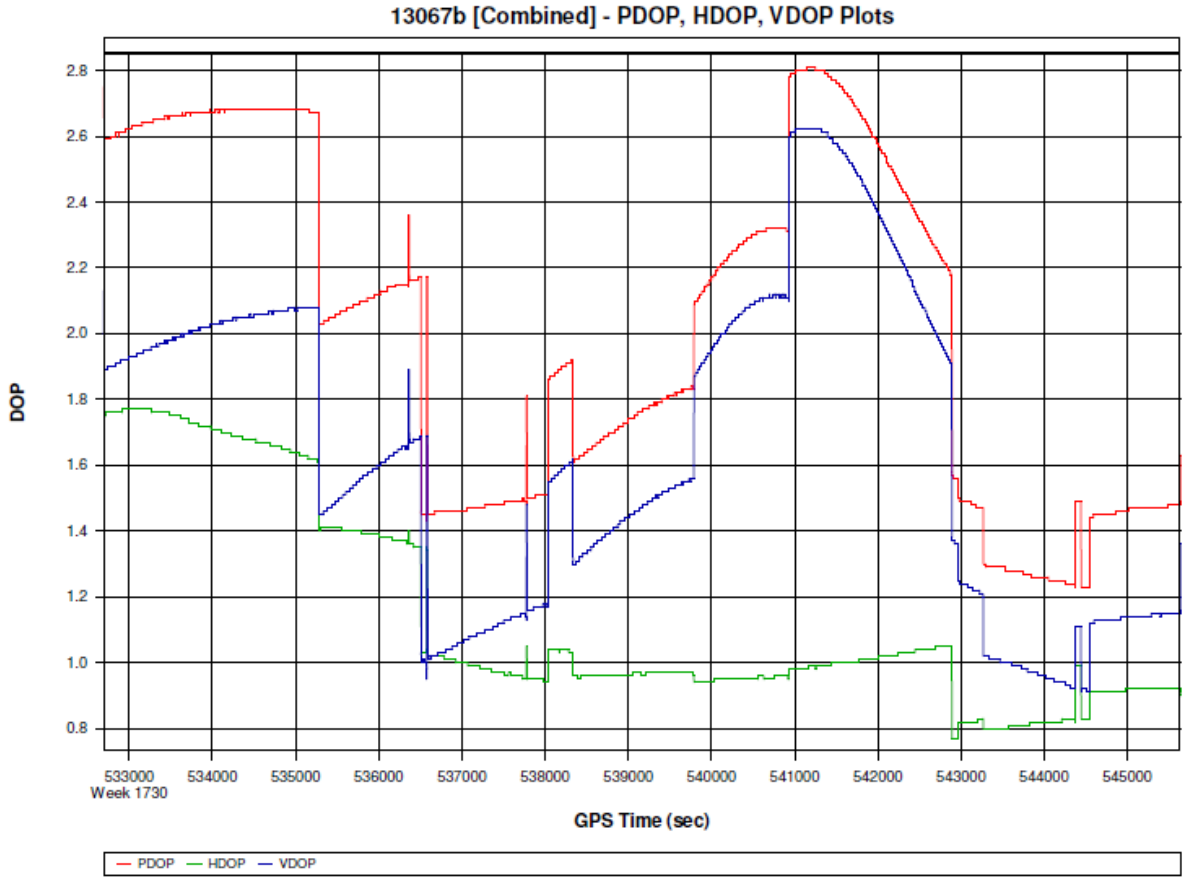
Project: 13067b POSGPS v4.30



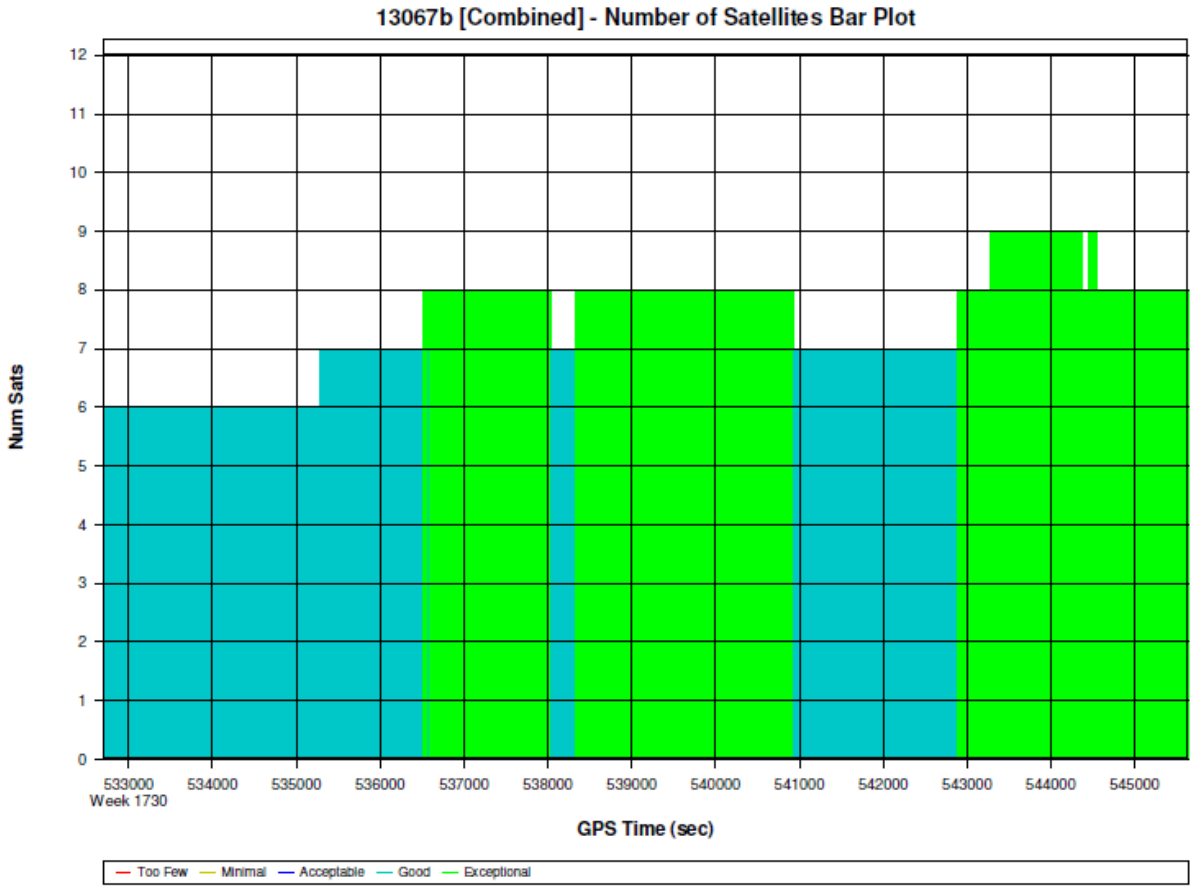
Project: 13067b POSGPS v4.30



Project: 13067b POSGPS v4.30



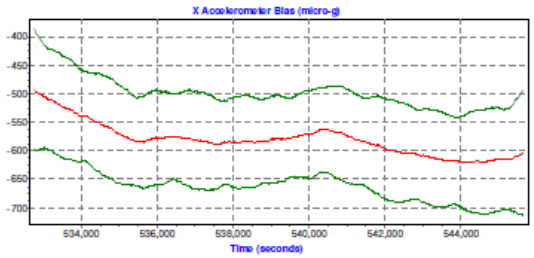
Project: 13067b POSGPS v4.30

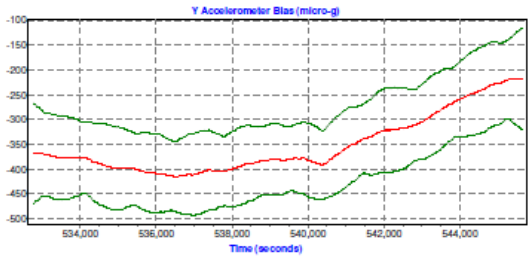


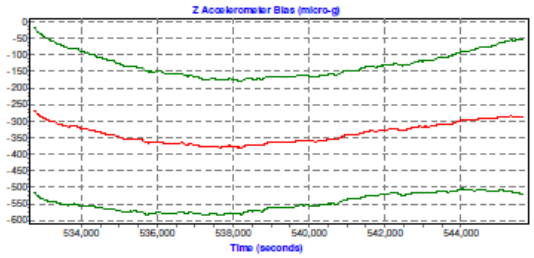
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13067b\pos\GPS\13067b.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      164809
      No processed position:  151859
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0289 (m)
      C/A Code:   1.11 (m)
      L1 Doppler: 0.019 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.026 (m)
      North:      0.025 (m)
      Height:     0.040 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (12944 occurances):
      East:       0.025 (m)
      North:      0.025 (m)
      Height:     0.034 (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:          42.509 (km)
      Minimum:          1.416 (km)
      Average:          19.332 (km)
      First Epoch:      12.433 (km)
      Last Epoch:       5.851 (km)
```

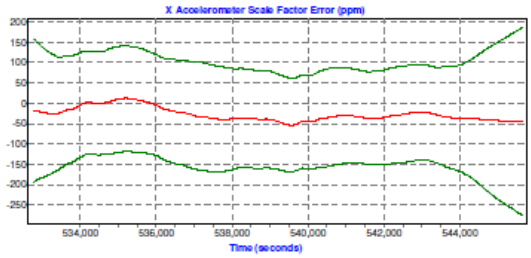
Sensor Errors

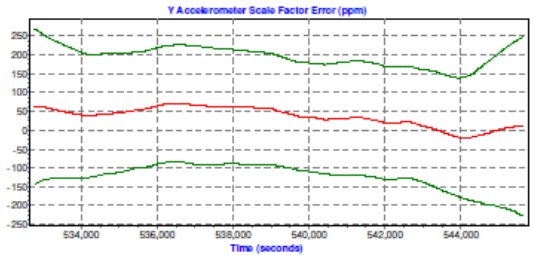
POSPac Version 4.3 - 1 - 4/15/2013 - 9:25:53 AM

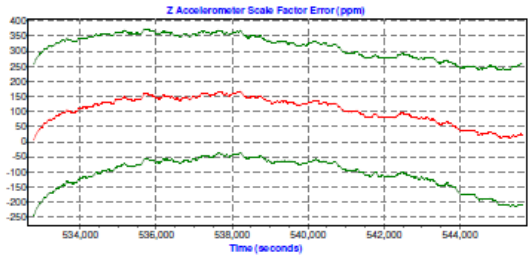






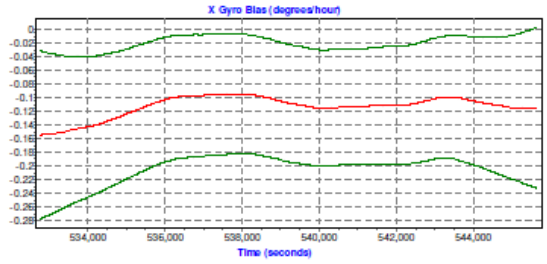


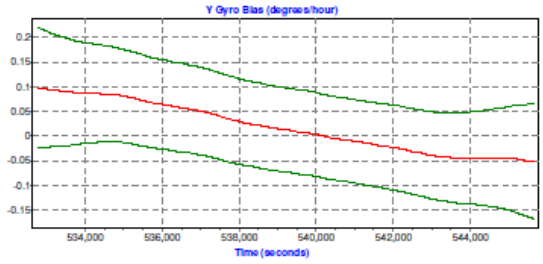


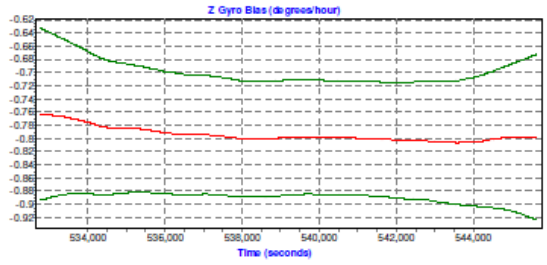


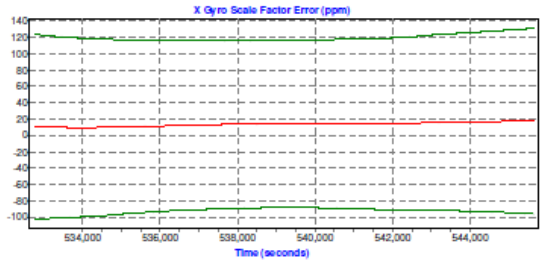
Sensor Errors

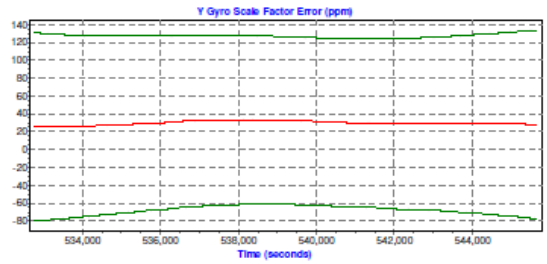
POSPac Version 4.3 - 2 - 4/15/2013 - 9:25:53 AM



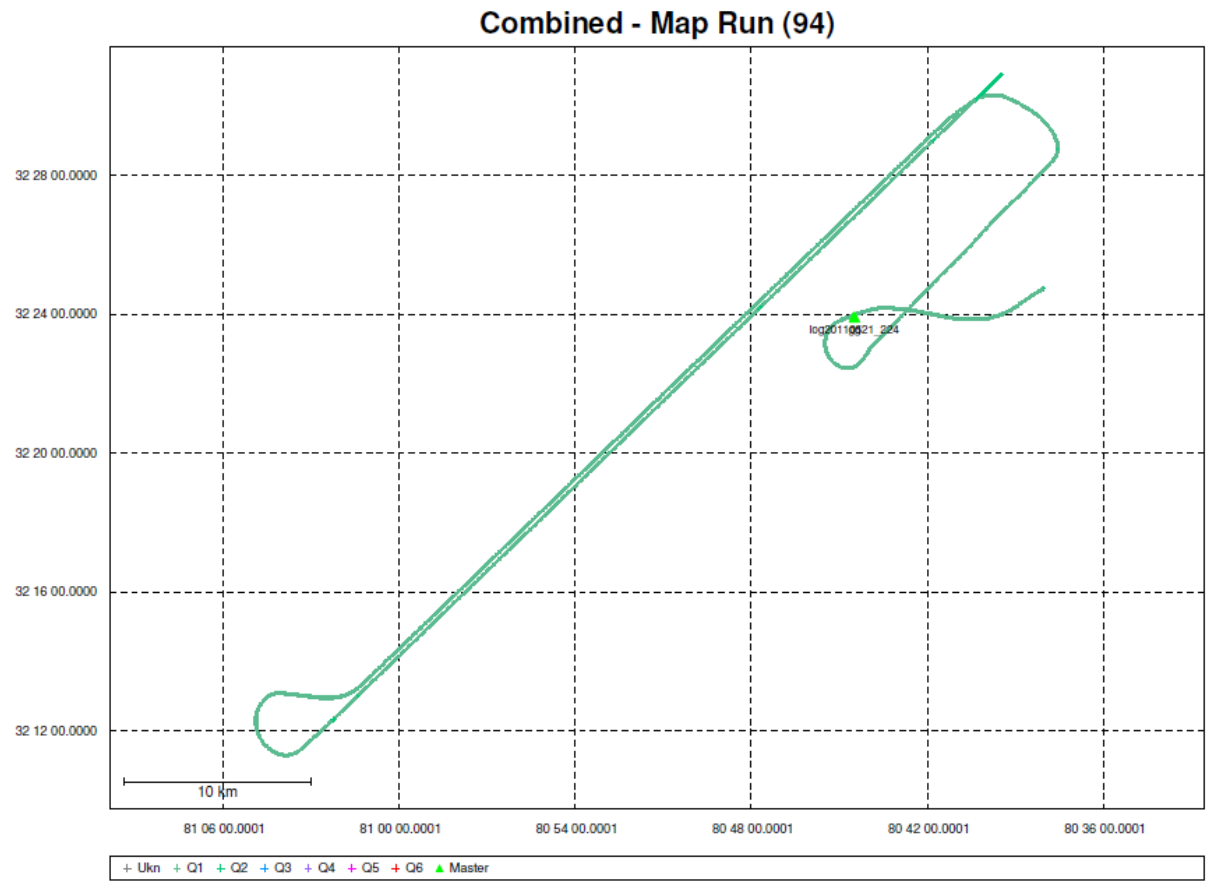




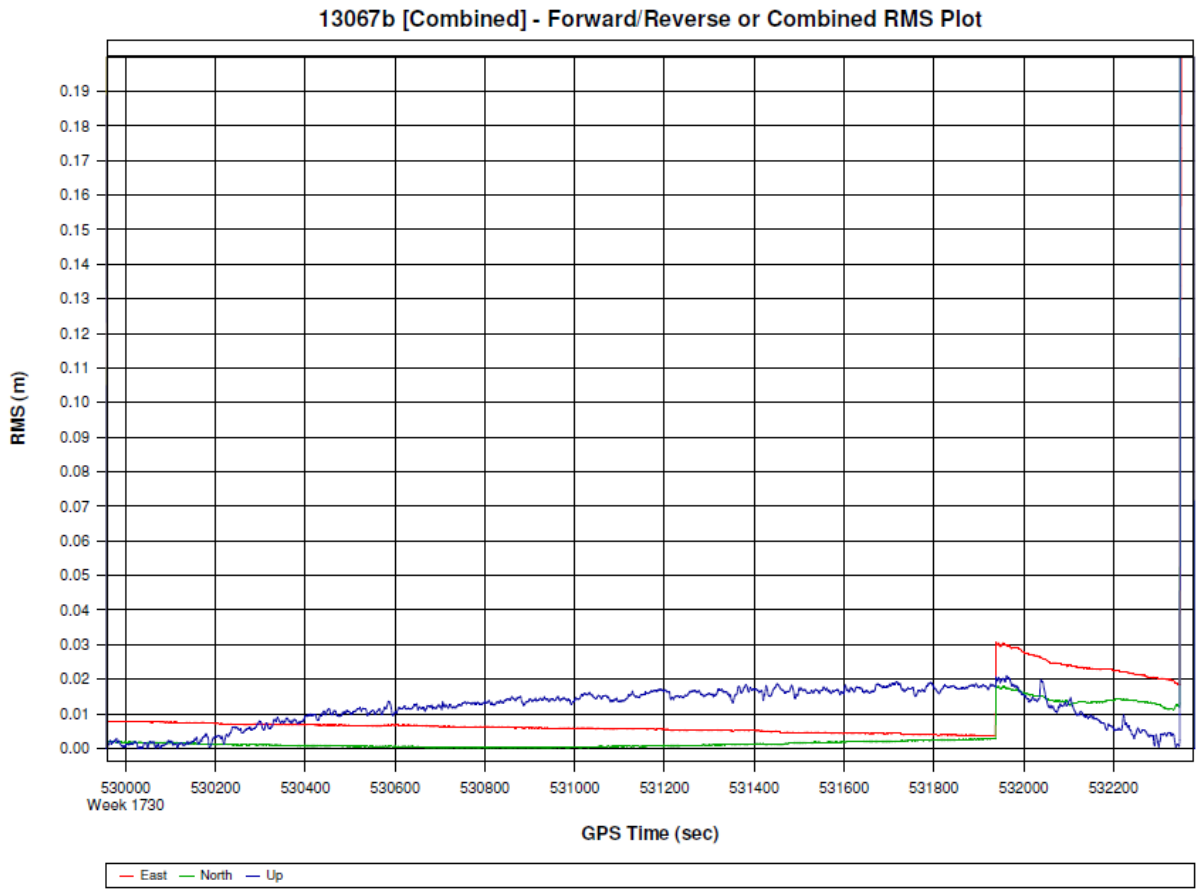




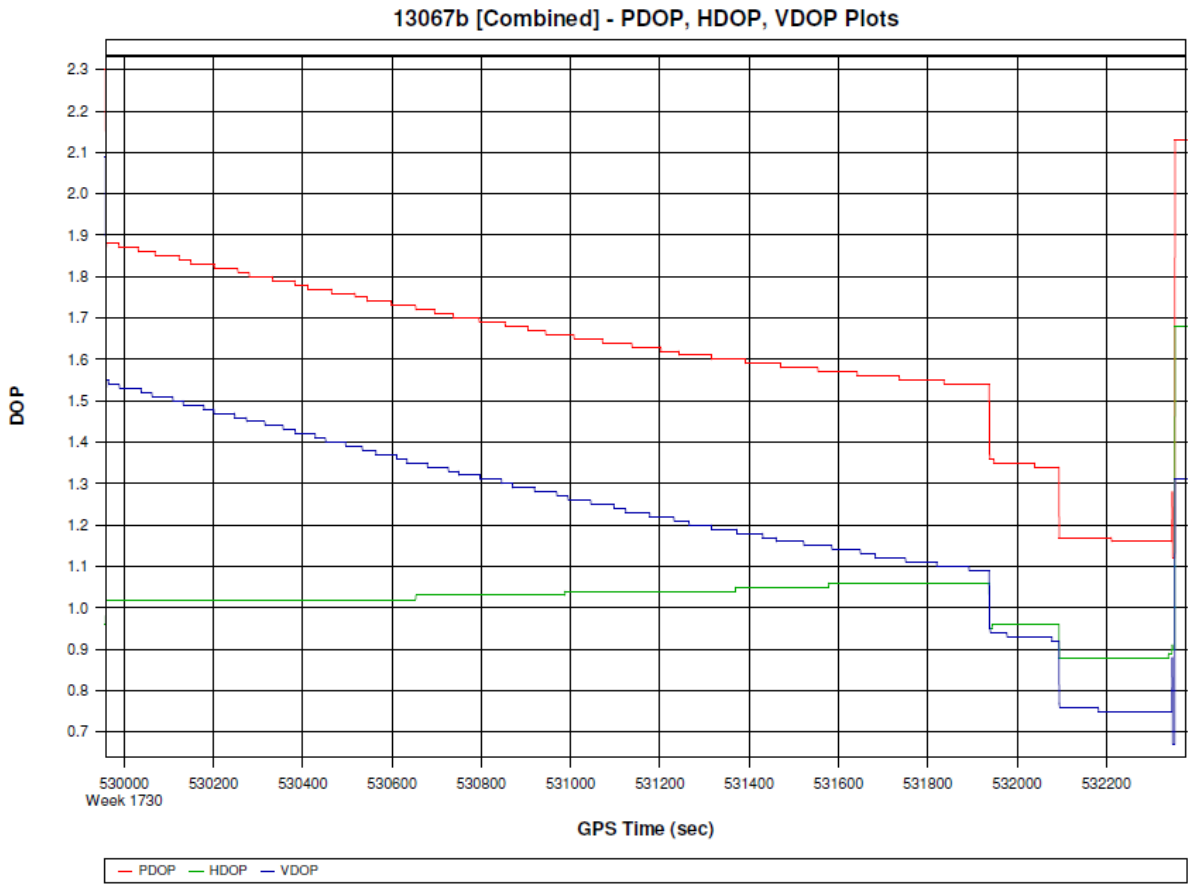
Project: 13067b POSGPS v4.30



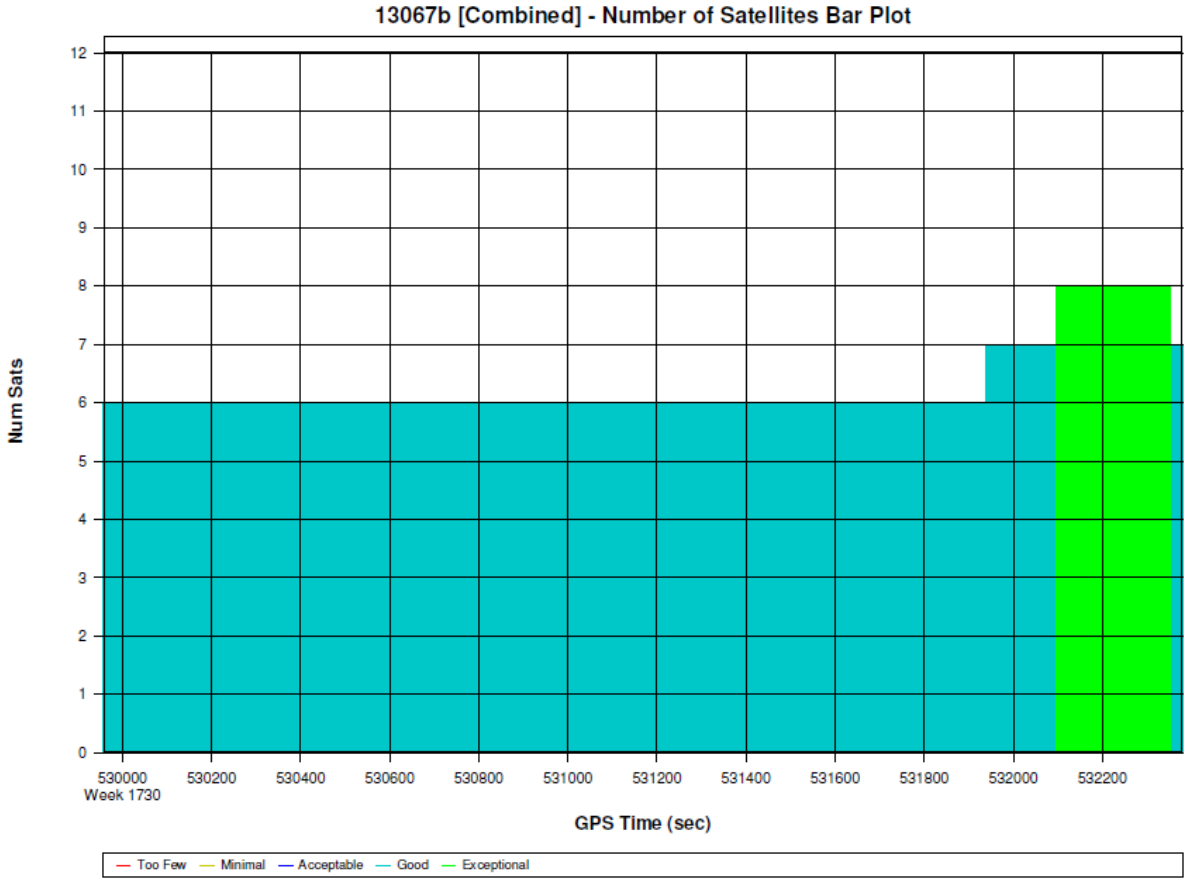
Project: 13067b POSGPS v4.30



Project: 13067b POSGPS v4.30



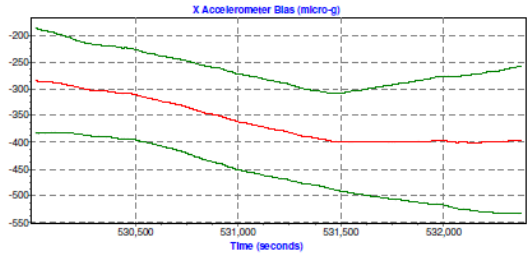
Project: 13067b POSGPS v4.30

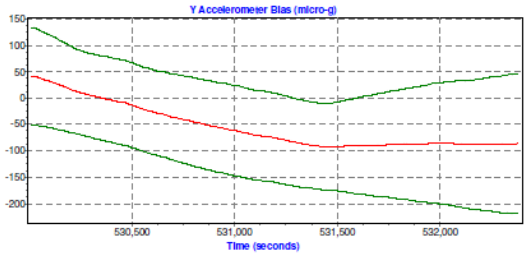


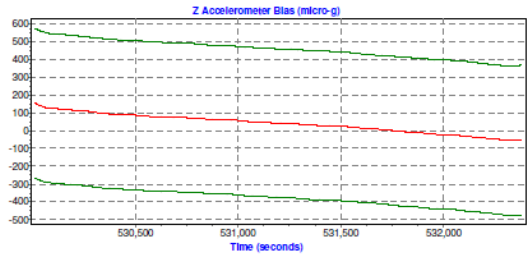
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13067b\pos\GPS\13067b.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      164809
      No processed position:  162384
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0390 (m)
      C/A Code:   1.10 (m)
      L1 Doppler: 0.020 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.138 (m)
      North:      0.178 (m)
      Height:     0.196 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (2389 occurances):
      East:       0.016 (m)
      North:      0.008 (m)
      Height:     0.018 (m)

Quality Number Percentages:
      Q 1:  97.9 %
      Q 2:   2.1 %
      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:          38.893 (km)
      Minimum:          0.656 (km)
      Average:          14.348 (km)
      First Epoch:      10.242 (km)
      Last Epoch:       15.172 (km)
```

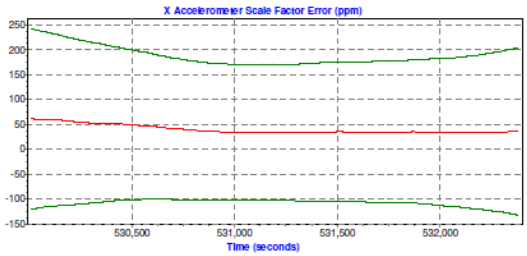
Sensor Errors

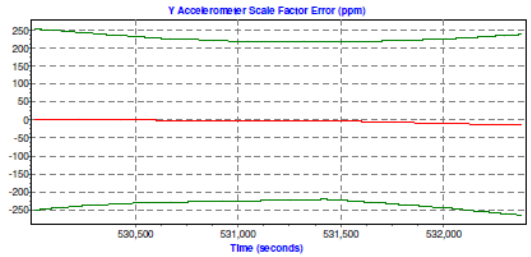
POSPac Version 4.3 - 1 - 5/17/2013 - 11:19:29 AM

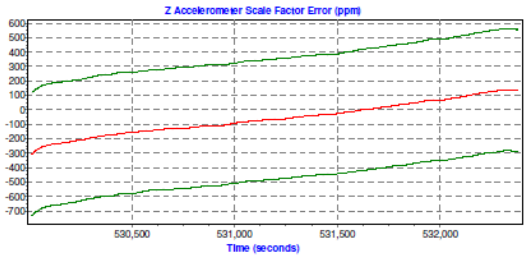






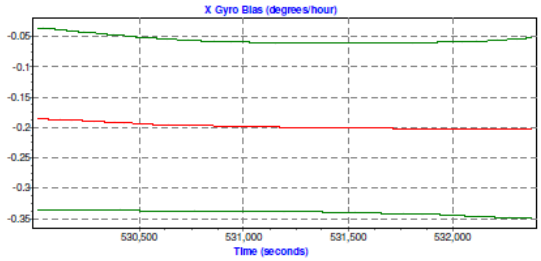


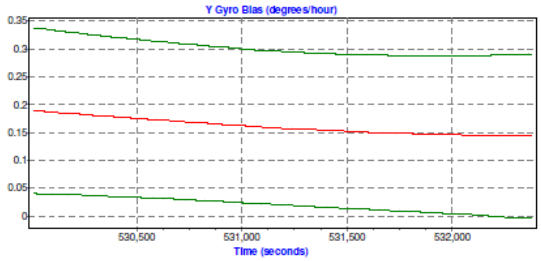


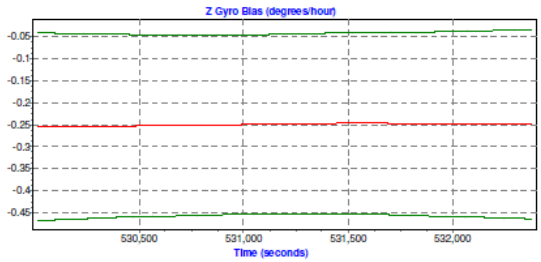


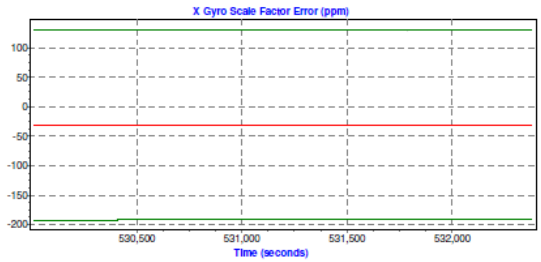
Sensor Errors

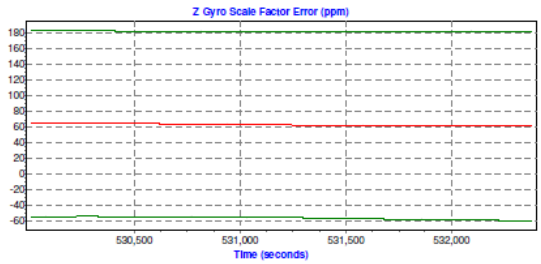
POSPac Version 4.3 - 2 - 5/17/2013 - 11:19:29 AM



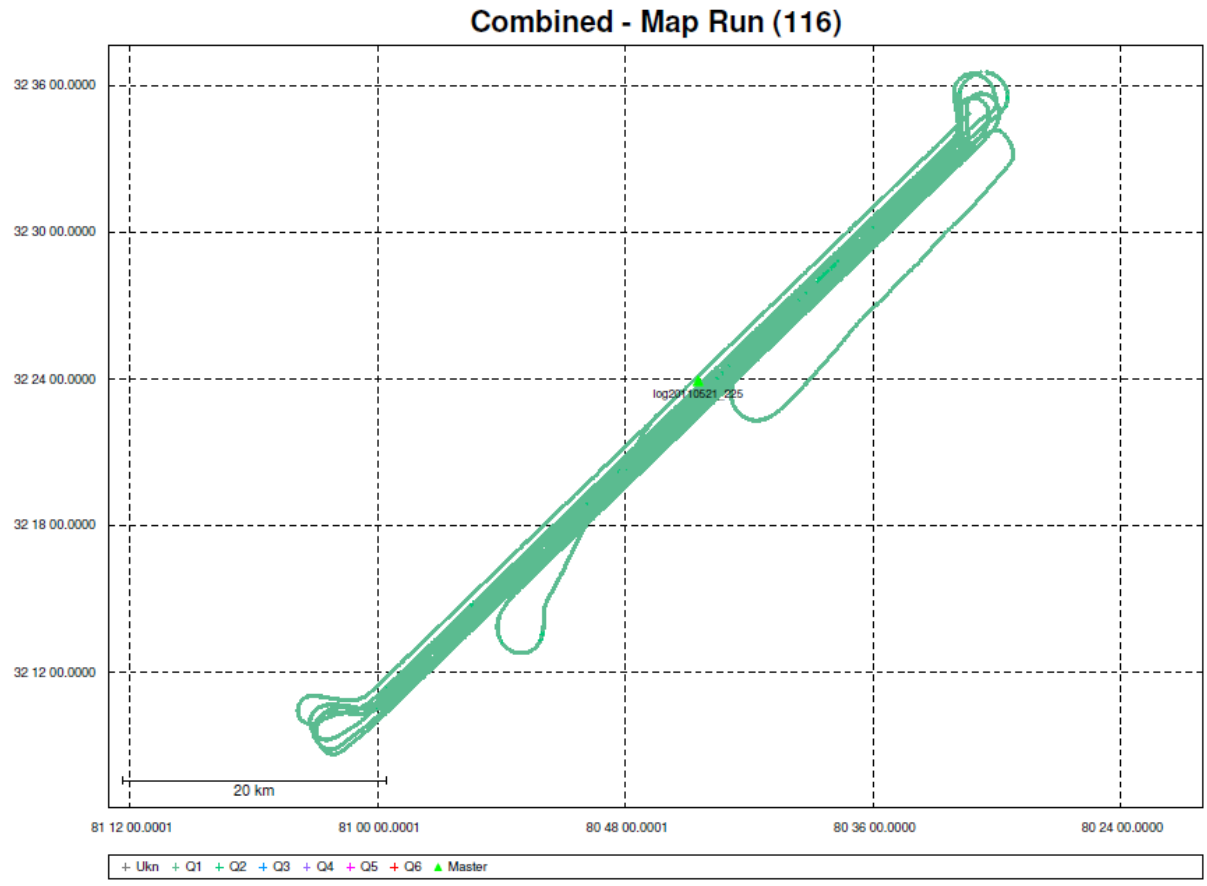




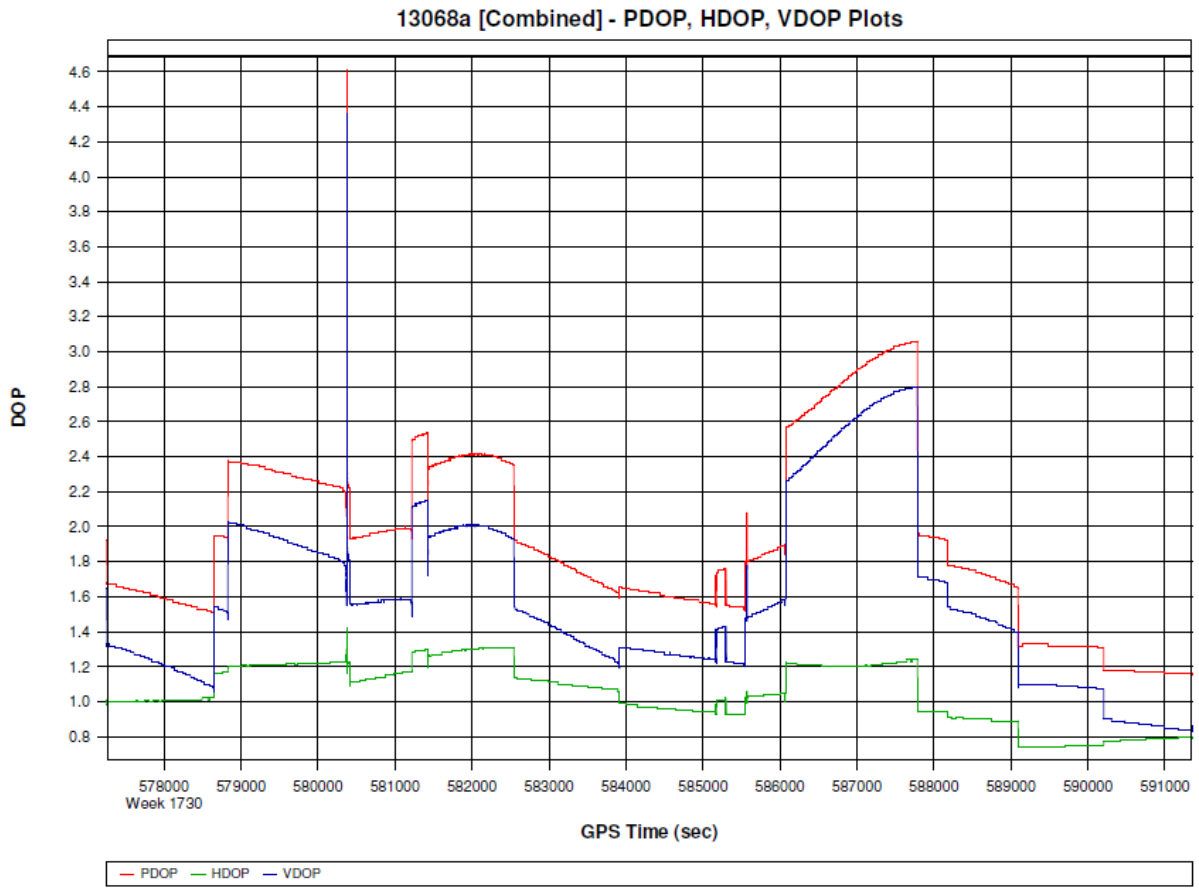




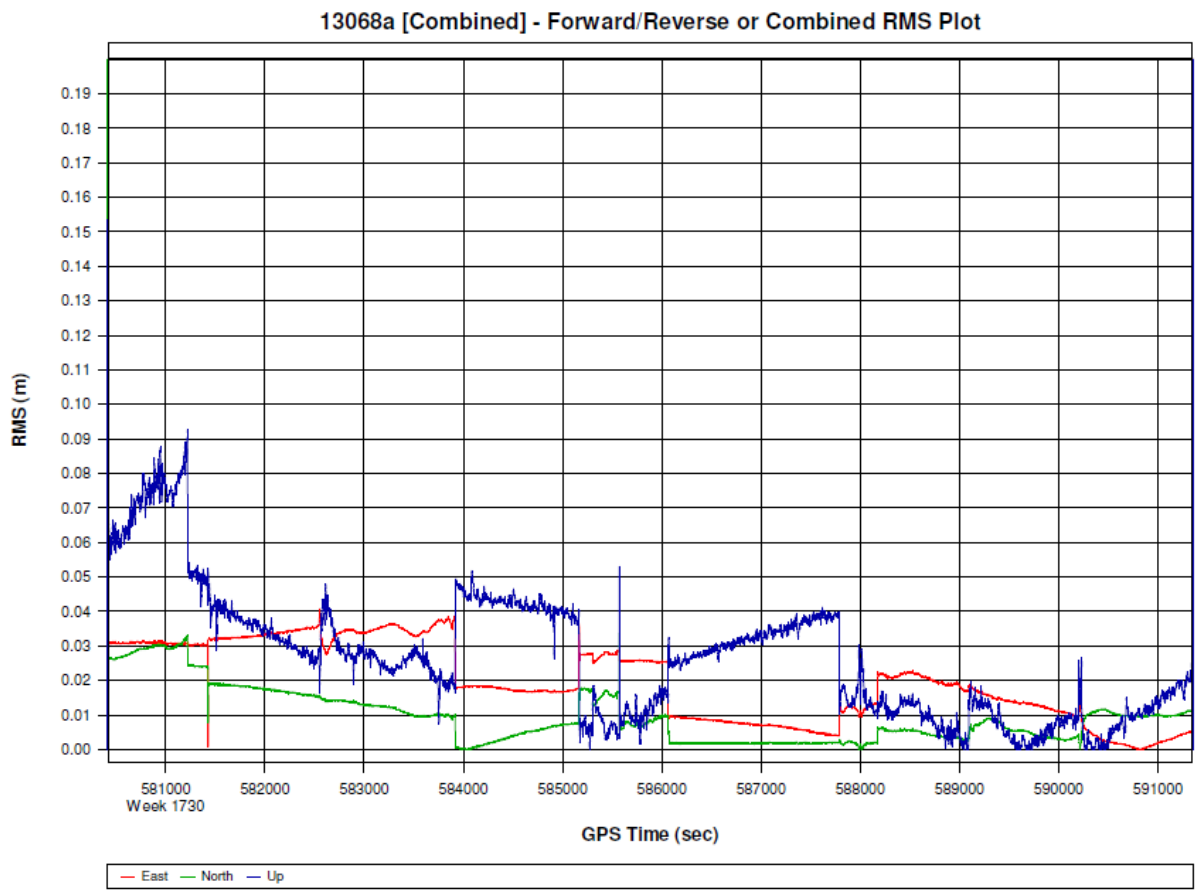
Project: 13068a POSGPS v4.30



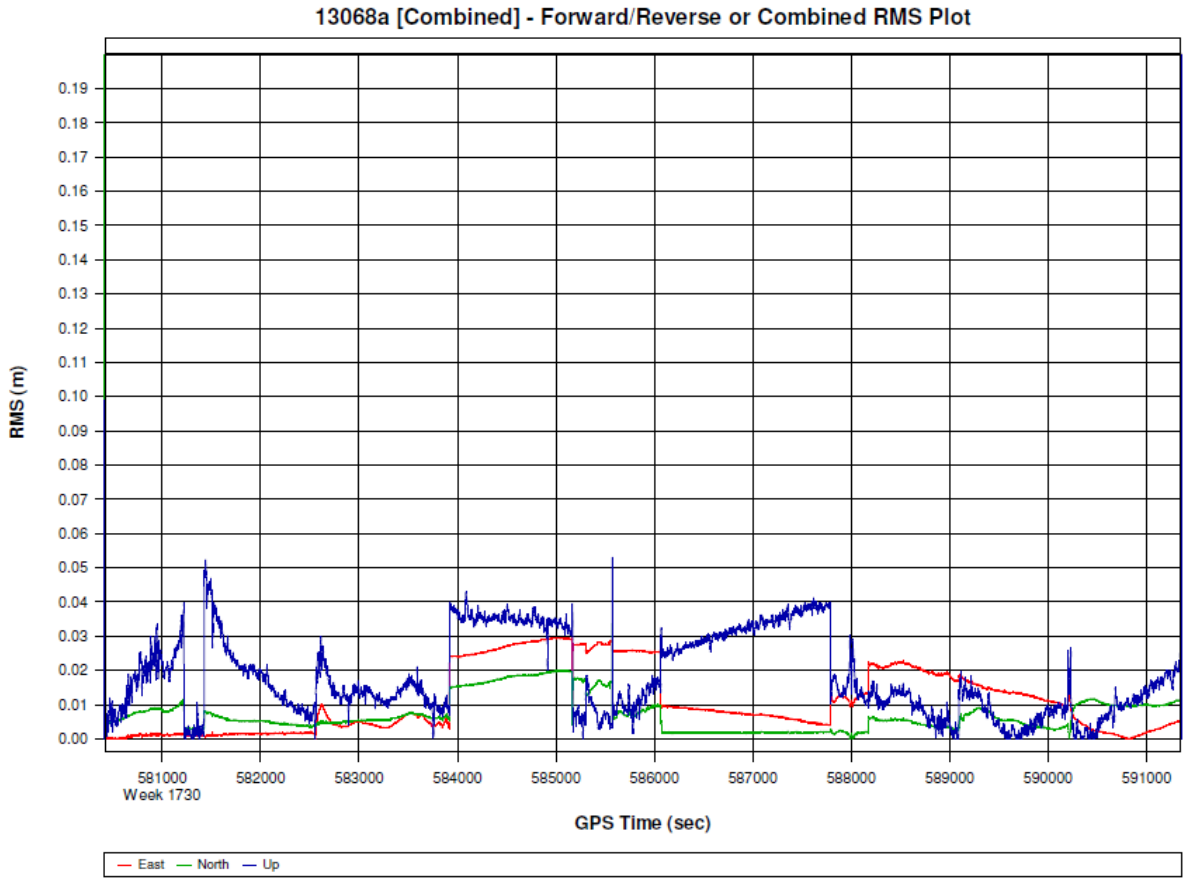
Project: 13068a POSGPS v4.30



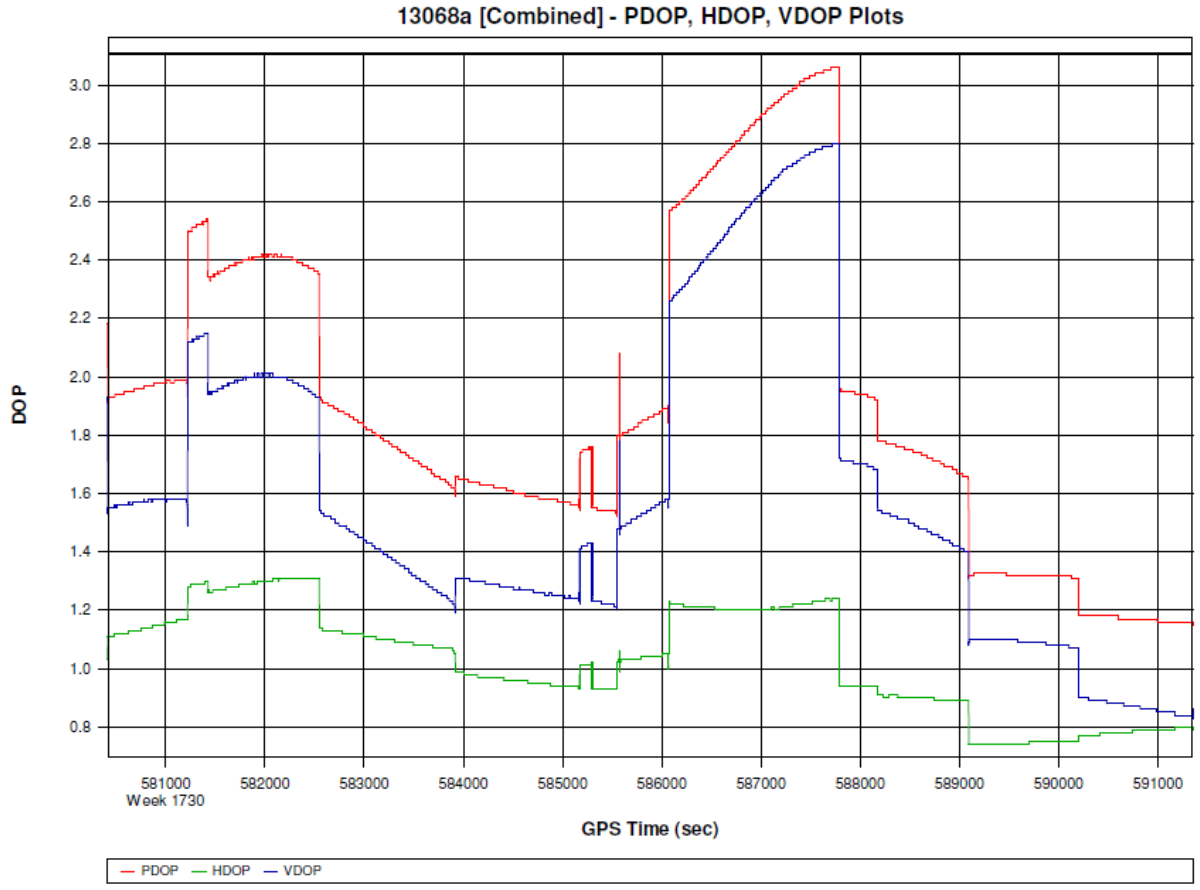
Project: 13068a POSGPS v4.30

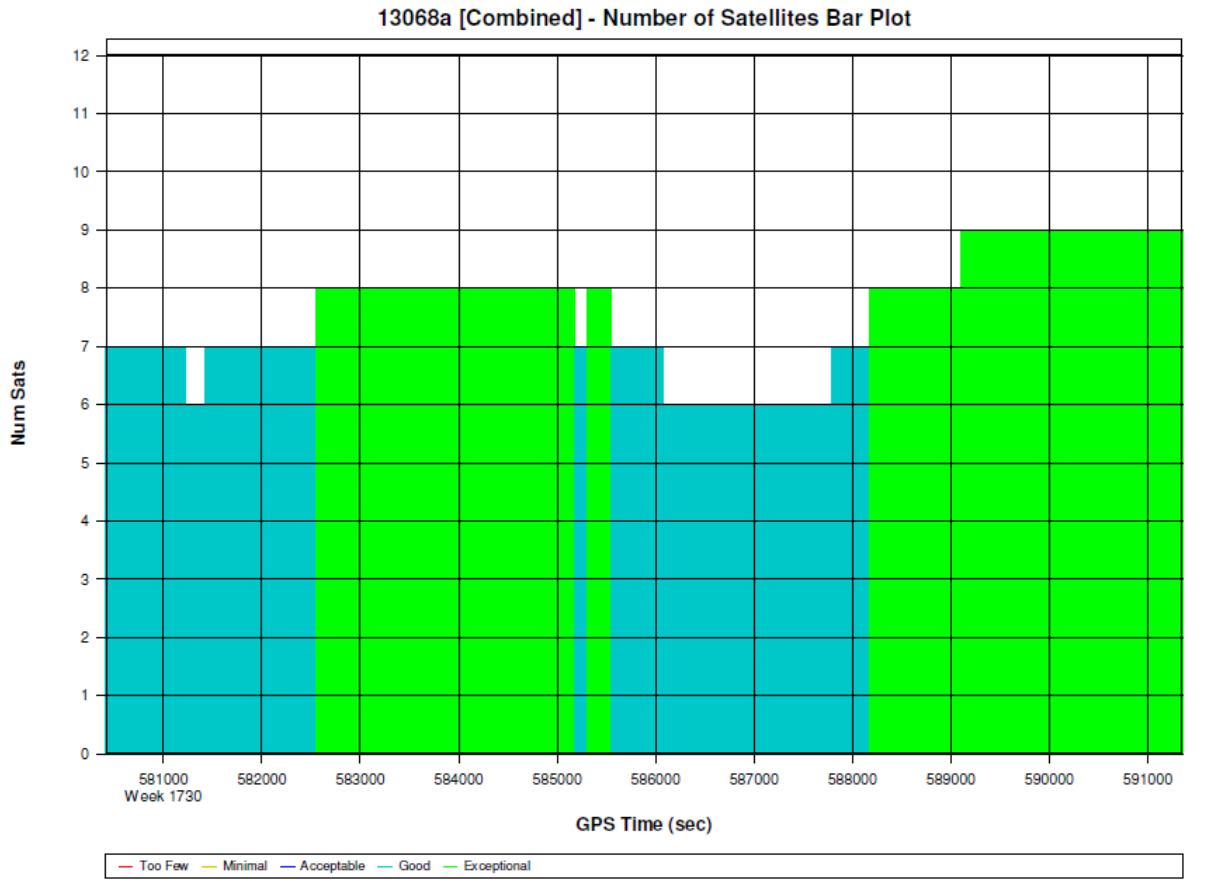


Project: 13068a POSGPS v4.30



Project: 13068a POSGPS v4.30

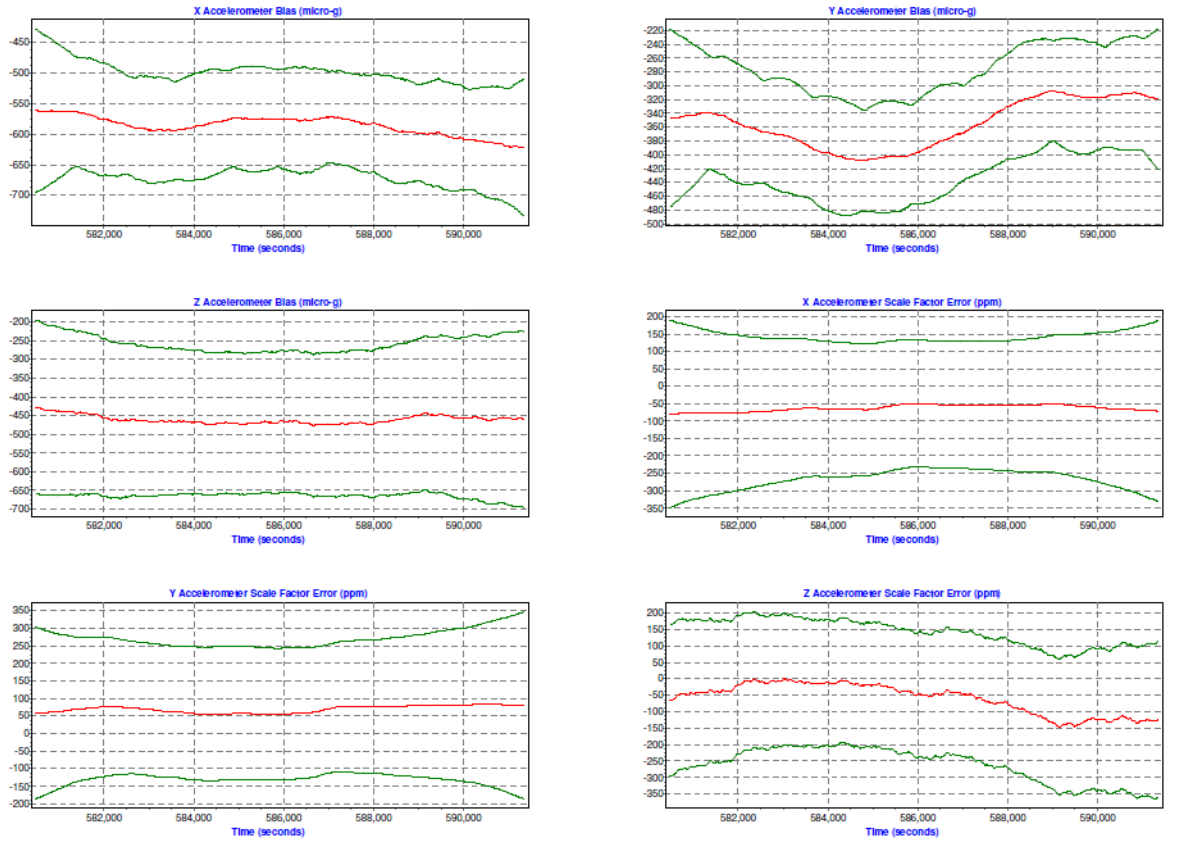



13068a [Combined] - Number of Satellites Bar Plot
Num Sats
0
1
2
3
4
5
6
7
8
9
10
11
12
581000
Week 1730
582000
583000
584000
585000
586000
587000
588000
589000
590000
591000
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional

```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13068a\pos\GPS\13068a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      146969
      No processed position:  136021
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0281 (m)
      C/A Code:   1.03 (m)
      L1 Doppler: 0.022 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.022 (m)
      North:      0.015 (m)
      Height:     0.031 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (10942 occurances):
      East:       0.021 (m)
      North:      0.012 (m)
      Height:     0.030 (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:          39.907 (km)
      Minimum:          0.987 (km)
      Average:          18.167 (km)
      First Epoch:      28.862 (km)
      Last Epoch:       4.163 (km)
```

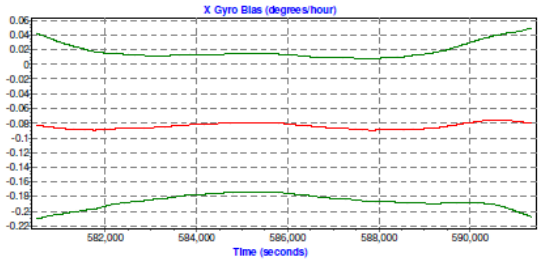
Sensor Errors

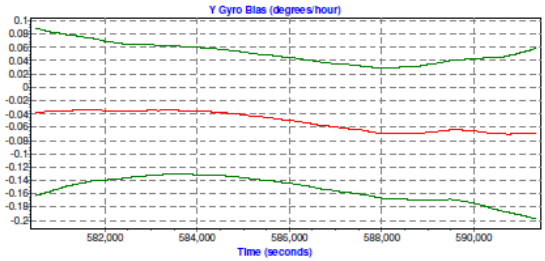
POSPac Version 4.3 - 1 - 5/17/2013 - 11:30:14 AM

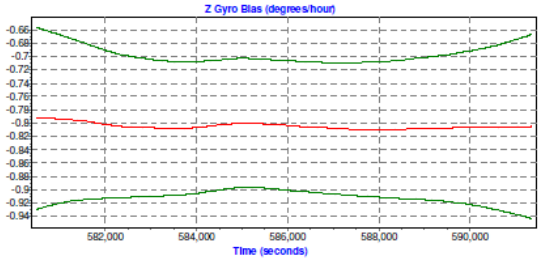


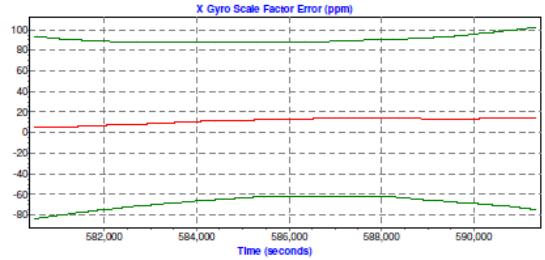
Sensor Errors

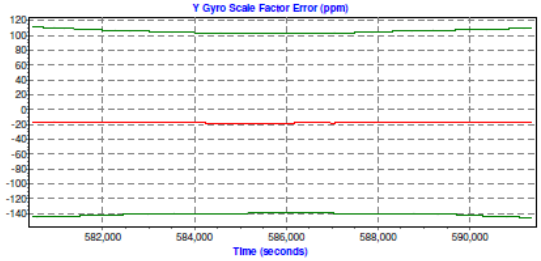
POSPac Version 4.3 - 2 - 5/17/2013 - 11:30:14 AM

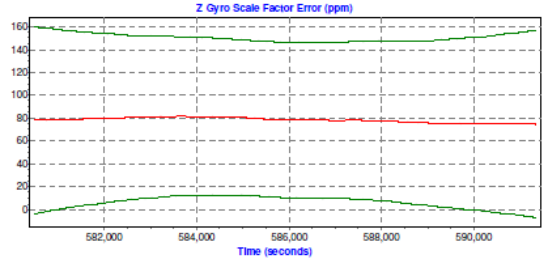


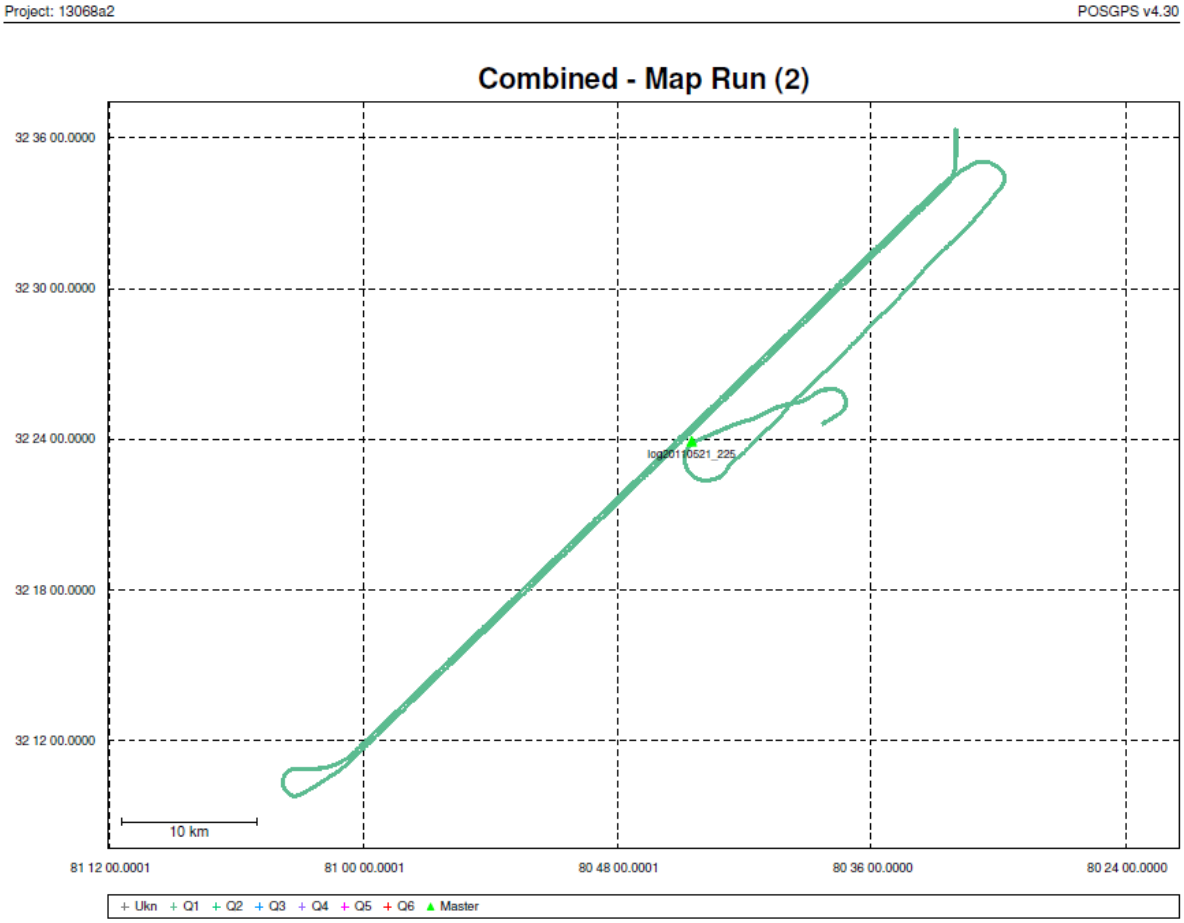




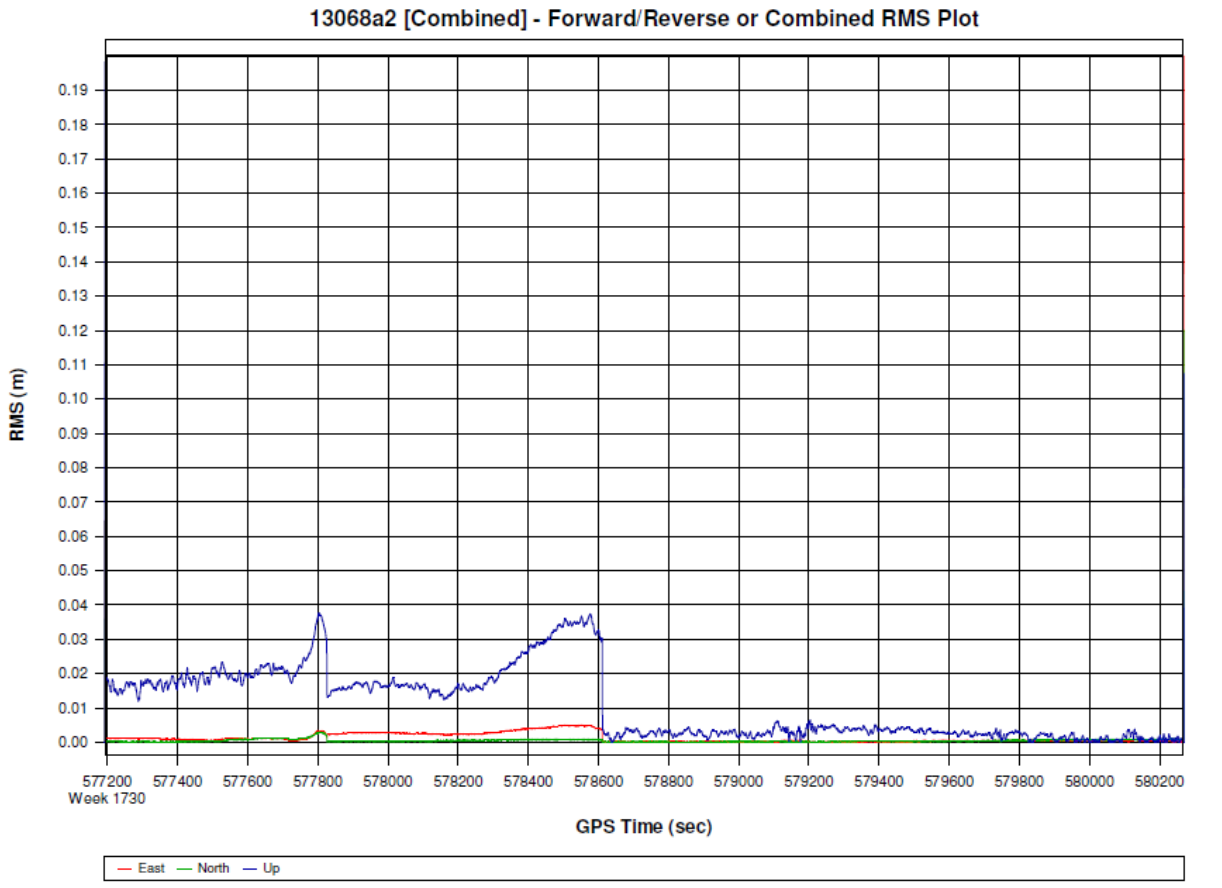




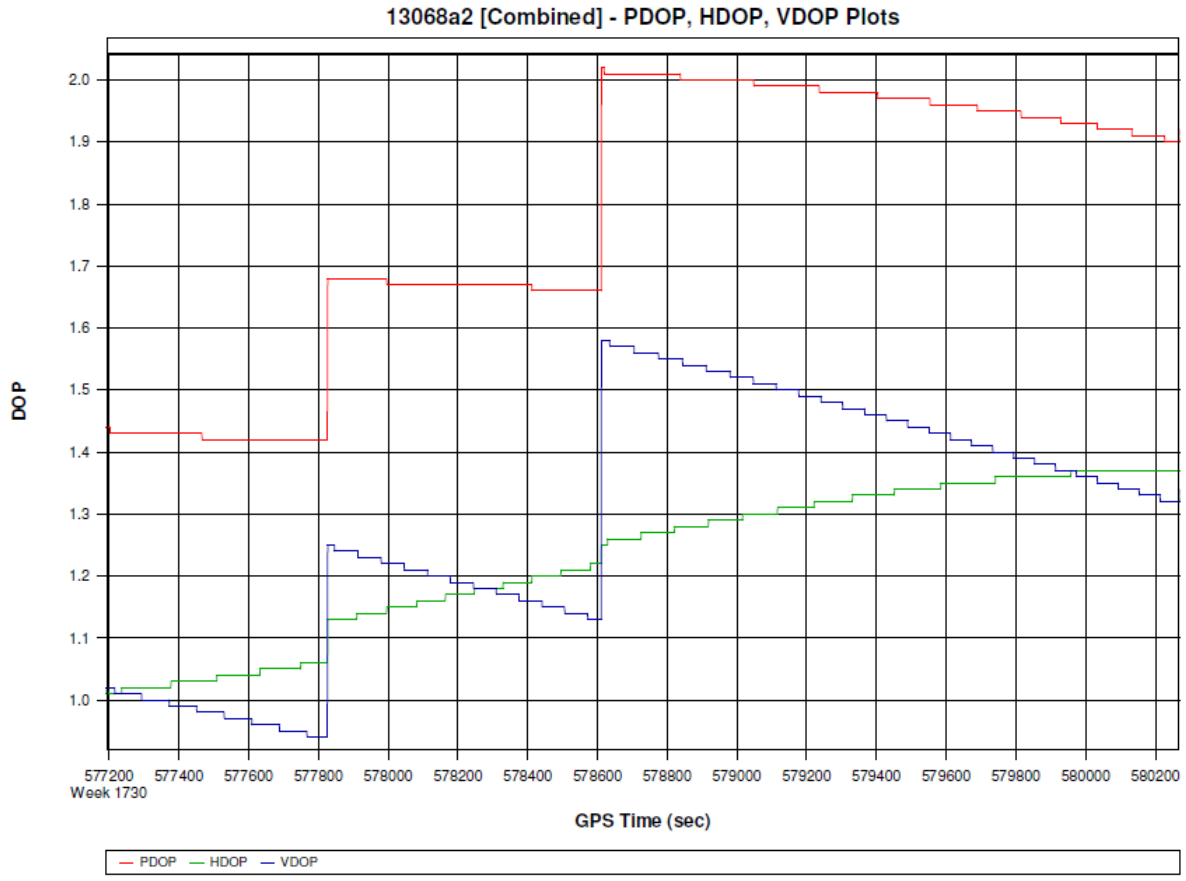


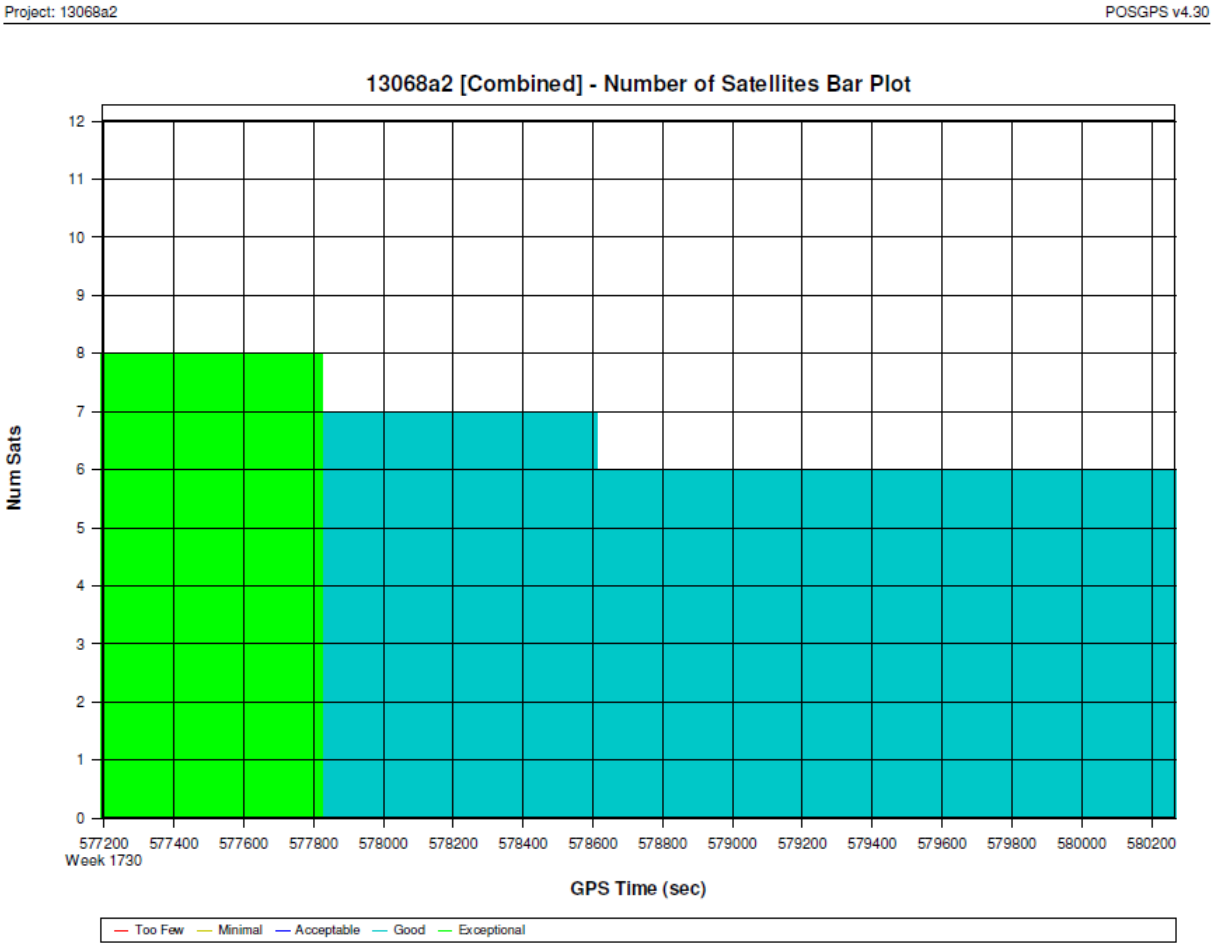

Project: 13068a2
POSGPS v4.30
Combined - Map Run (2)
32 36 00.0000
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
10 km
81 12 00.0001
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

Project: 13068a2 POSGPS v4.30



Project: 13068a2 POSGPS v4.30

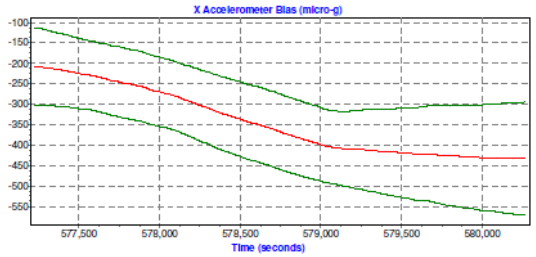


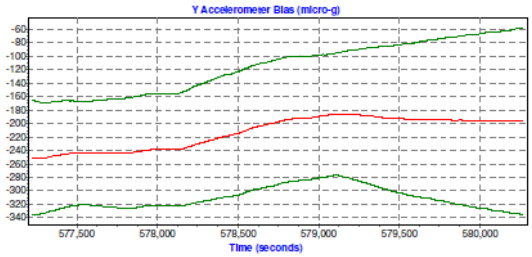

Project: 13068a2
POSGPS v4.30
13068a2 [Combined] - Number of Satellites Bar Plot
Num Sats
0
1
2
3
4
5
6
7
8
9
10
11
12
577200
Week 1730
577400
577600
577800
578000
578200
578400
578600
578800
579000
579200
579400
579600
579800
580000
580200
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional

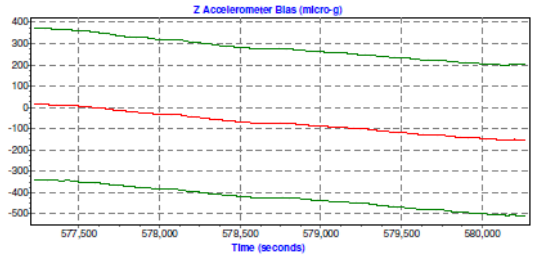
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13068a\pos2\GPS\13068a2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      146969
      No processed position:  143890
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0206 (m)
      C/A Code:   0.91 (m)
      L1 Doppler: 0.020 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.012 (m)
      North:      0.004 (m)
      Height:     0.022 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (3073 occurances):
      East:       0.003 (m)
      North:      0.001 (m)
      Height:     0.021 (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:          39.623 (km)
      Minimum:          0.777 (km)
      Average:          16.429 (km)
      First Epoch:      9.802 (km)
      Last Epoch:       30.236 (km)
```

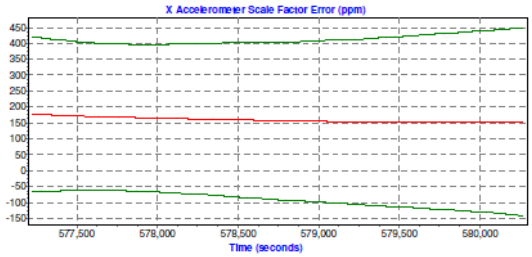
Sensor Errors

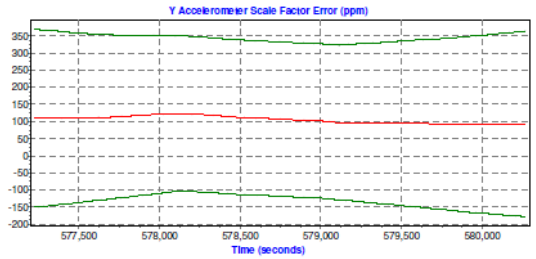
POSPac Version 4.3 - 1 - 4/15/2013 - 10:02:29 AM

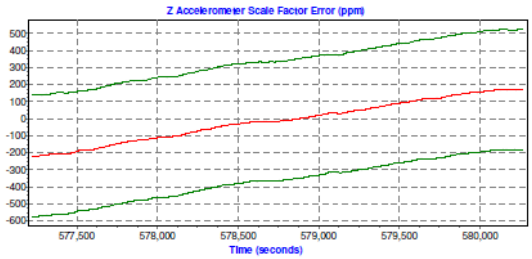






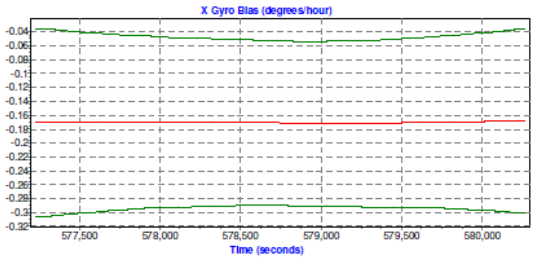


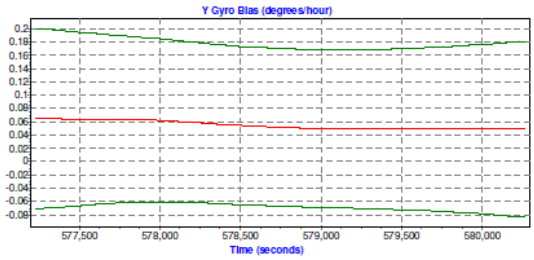


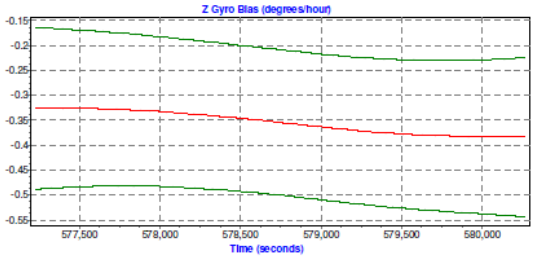


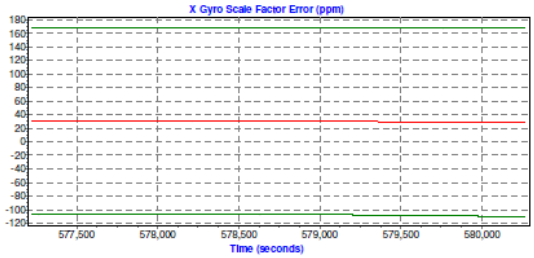
Sensor Errors

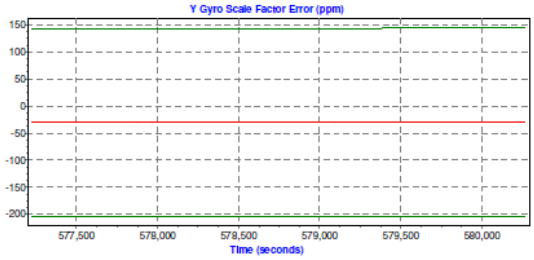
POSPac Version 4.3 - 2 - 4/15/2013 - 10:02:29 AM

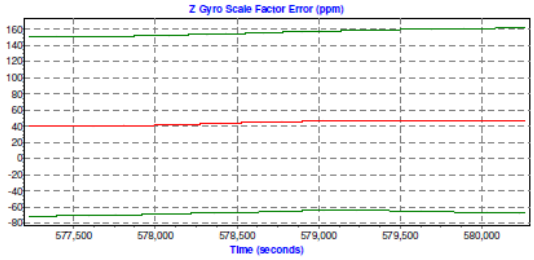


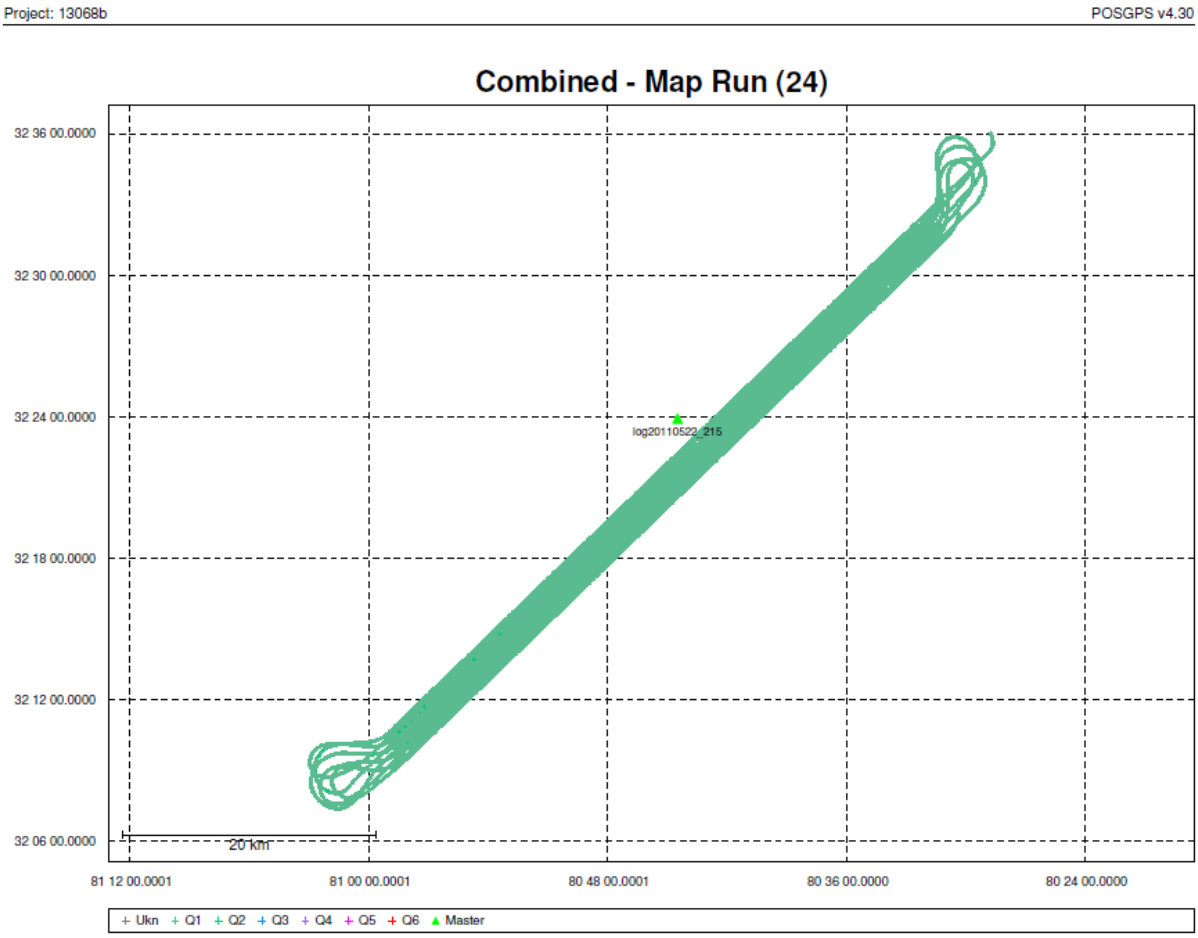




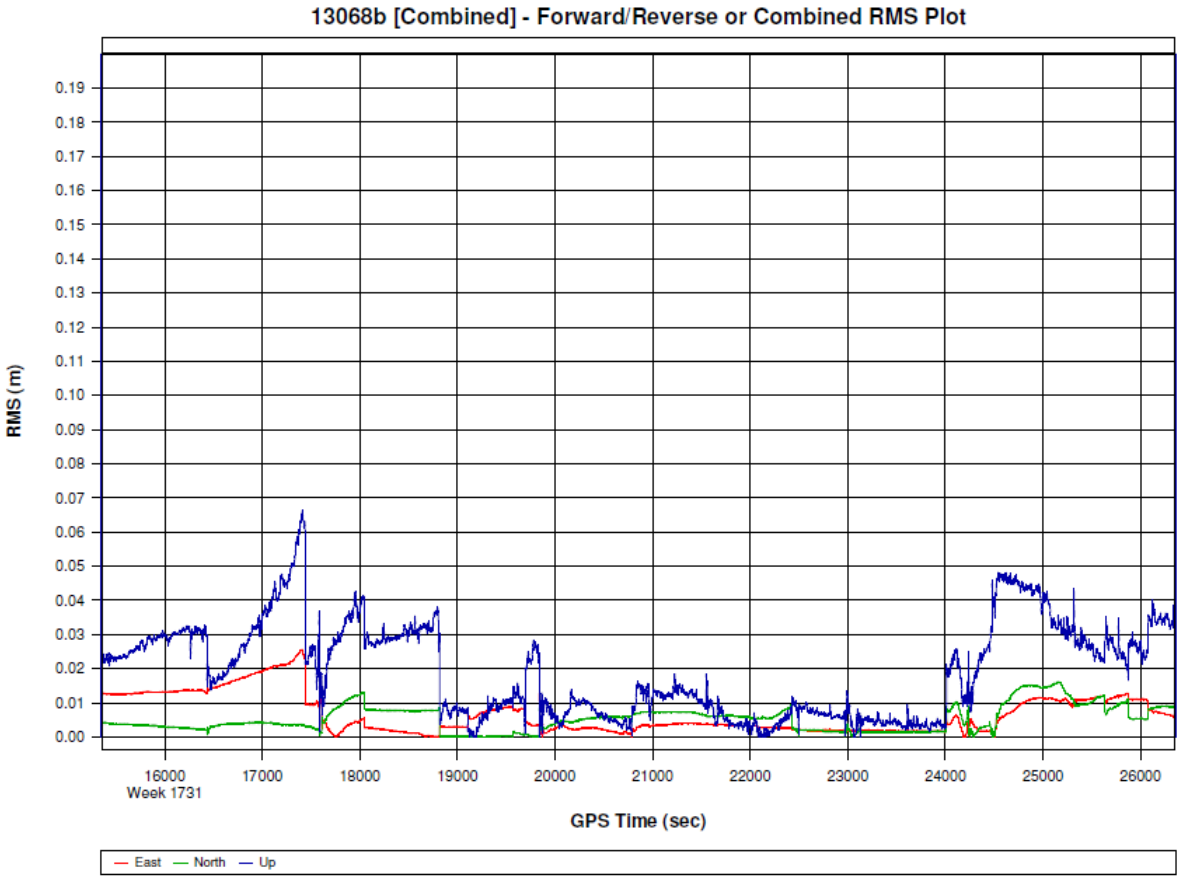




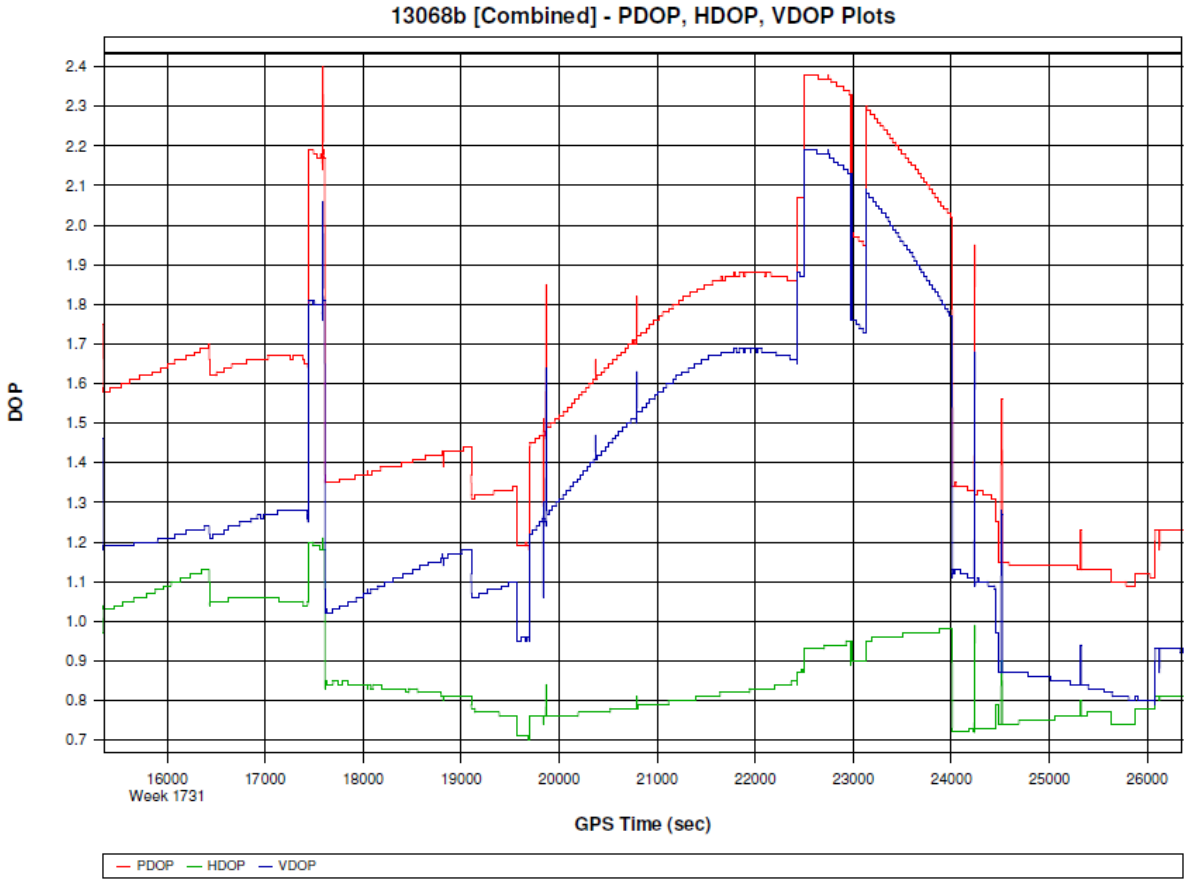



Project: 13068b
POSGPS v4.30
Combined - Map Run (24)
32 36 00.0000
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log20110522_215
20 km
81 12 00.0001
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

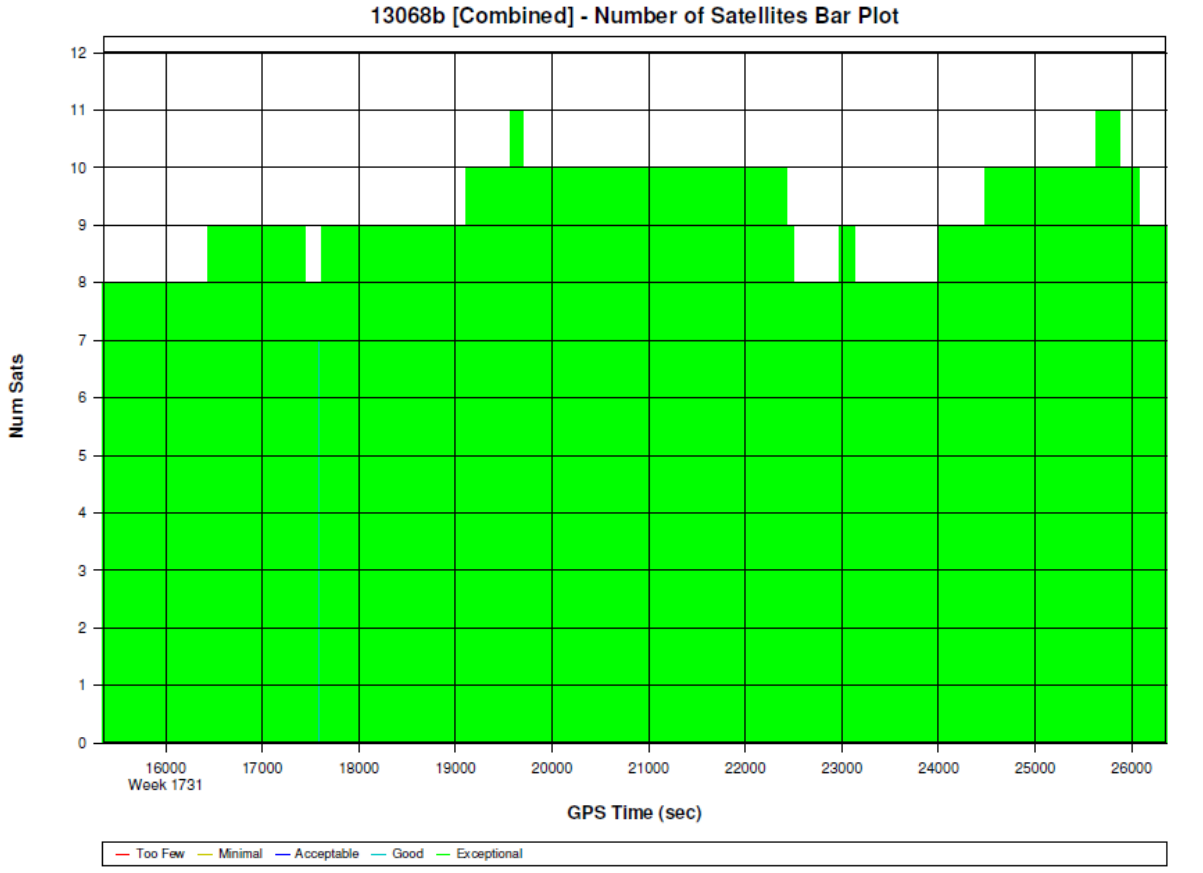
Project: 13068b POSGPS v4.30



Project: 13068b POSGPS v4.30



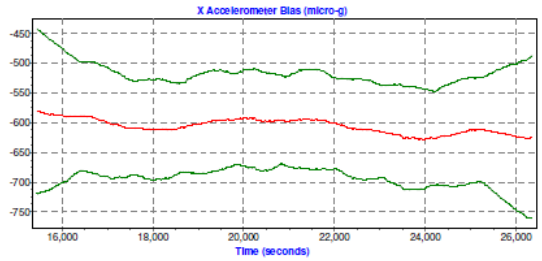
Project: 13068b POSGPS v4.30

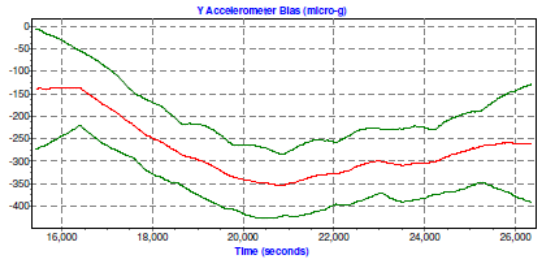


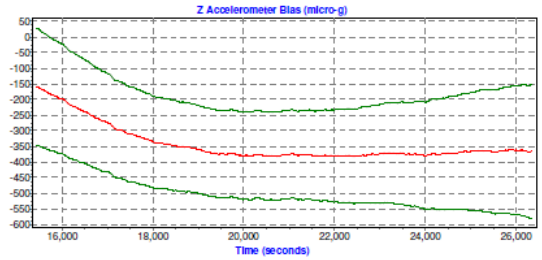
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13068b\pos\GPS\13068b.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      160832
      No processed position:  149817
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0284 (m)
      C/A Code:   0.97 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.013 (m)
      North:      0.010 (m)
      Height:     0.035 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11009 occurances):
      East:       0.012 (m)
      North:      0.009 (m)
      Height:     0.034 (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:          41.212 (km)
      Minimum:          2.196 (km)
      Average:          19.347 (km)
      First Epoch:      33.354 (km)
      Last Epoch:       27.432 (km)
```

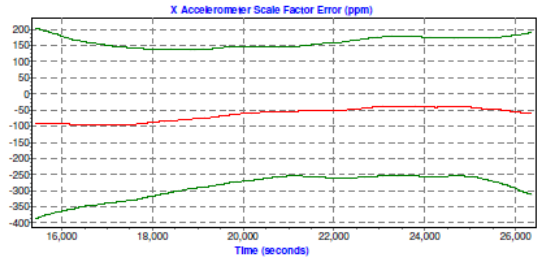
Sensor Errors

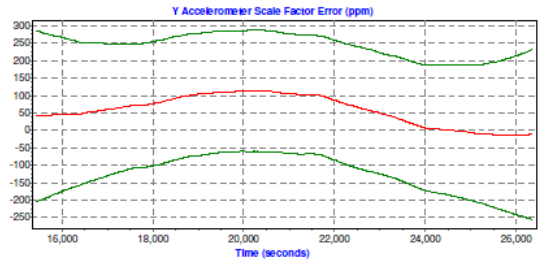
POSPac Version 4.3 - 1 - 4/15/2013 - 10:19:32 AM

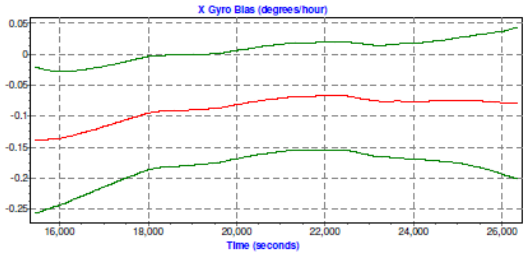


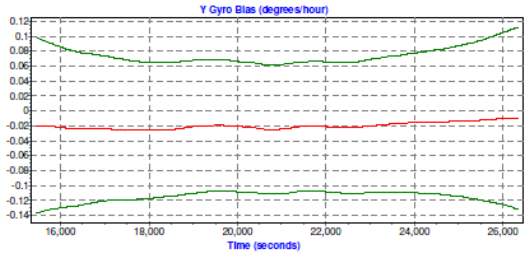


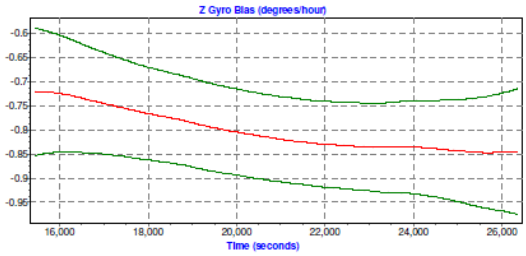


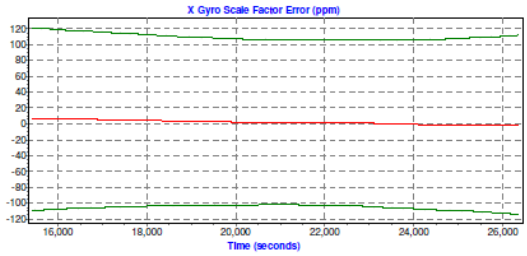




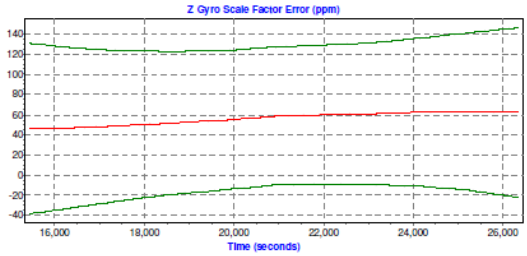

X Gyro Bias (degrees/hour)
Time (seconds)

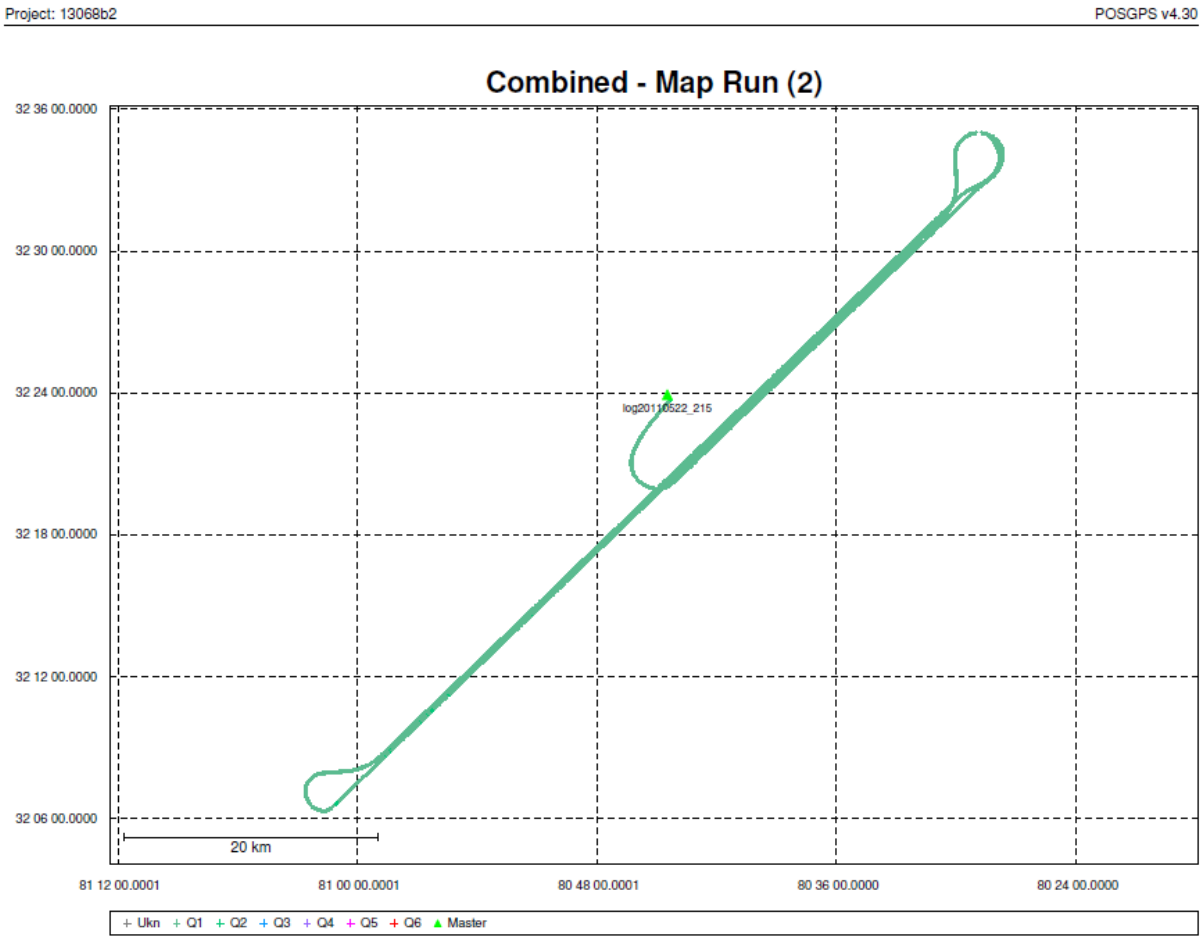

Y Gyro Bias (degrees/hour)
Time (seconds)


Z Gyro Bias (degrees/hour)
Time (seconds)

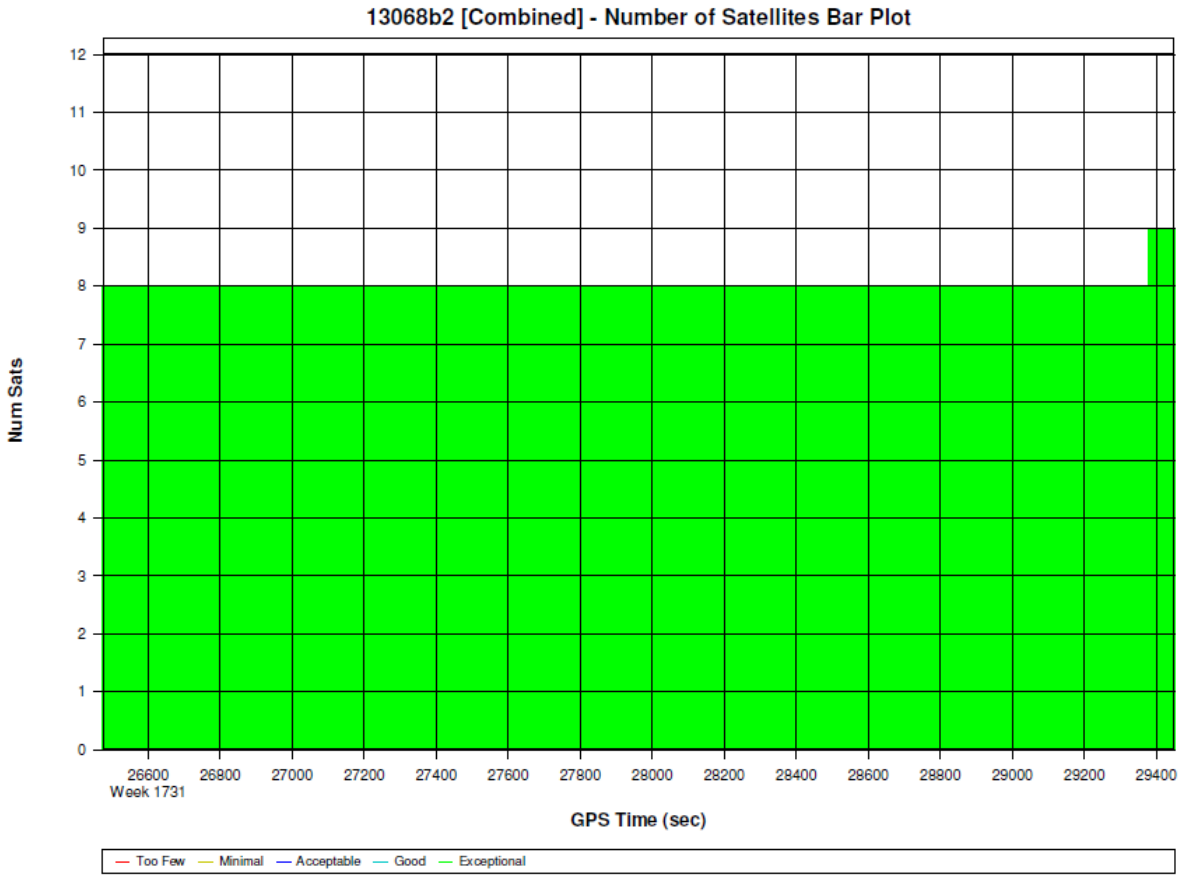

X Gyro Scale Factor Error (ppm)
Time (seconds)

Y Gyro Scale Factor Error (ppm)
Time (seconds)

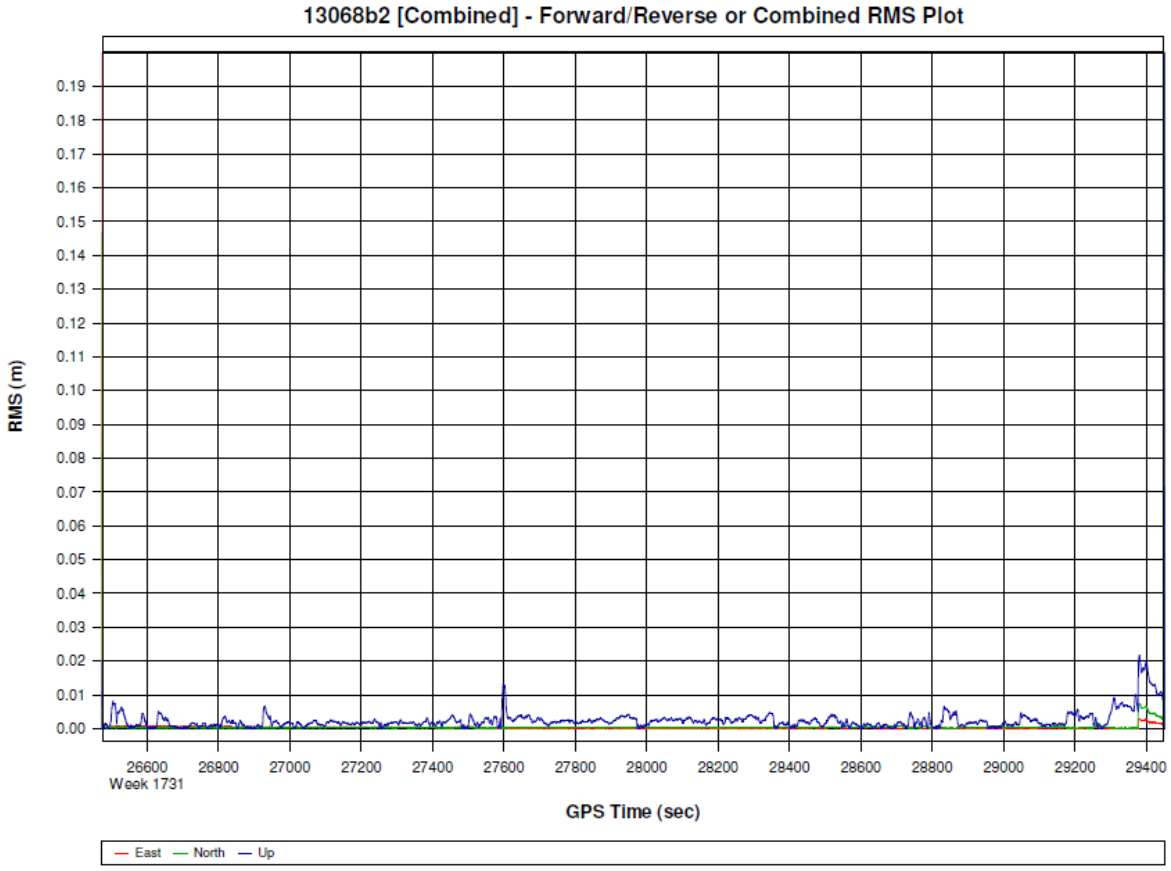

Z Gyro Scale Factor Error (ppm)
Time (seconds)


Project: 13068b2
POSGPS v4.30
Combined - Map Run (2)
32 36 00.0000
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log20110522_215
20 km
81 12 00.0001
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

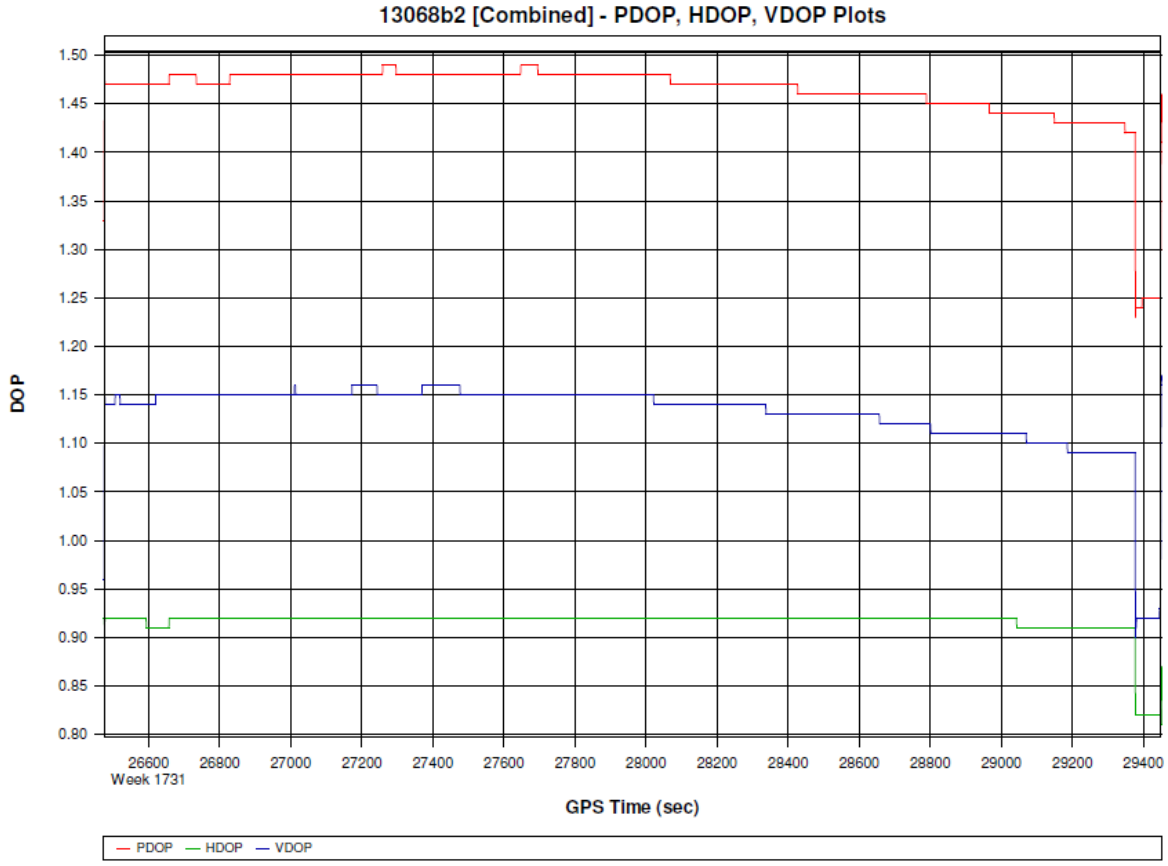
Project: 13068b2 POSGPS v4.30



Project: 13068b2 POSGPS v4.30



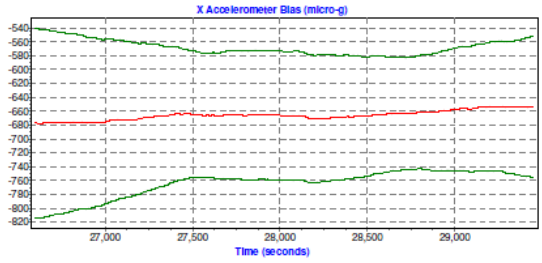
Project: 13068b2 POSGPS v4.30

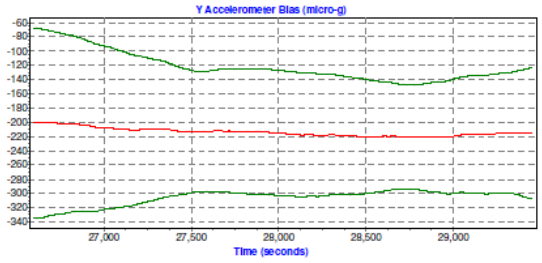


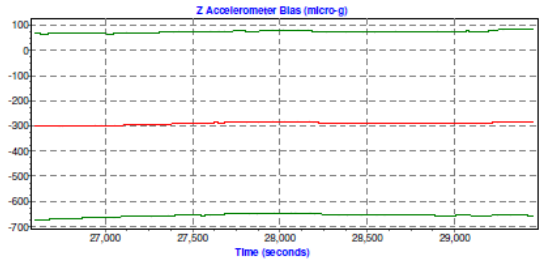
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13068b\pos2\GPS\13068b2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      160832
      No processed position:  157852
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0243 (m)
      C/A Code:   1.00 (m)
      L1 Doppler: 0.017 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.010 (m)
      North:      0.011 (m)
      Height:     0.014 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (2974 occurances):
      East:       0.001 (m)
      North:      0.001 (m)
      Height:     0.005 (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:          42.650 (km)
      Minimum:          0.798 (km)
      Average:          19.234 (km)
      First Epoch:      32.351 (km)
      Last Epoch:       0.798 (km)
```

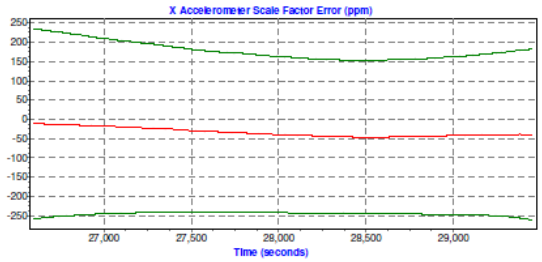
Sensor Errors

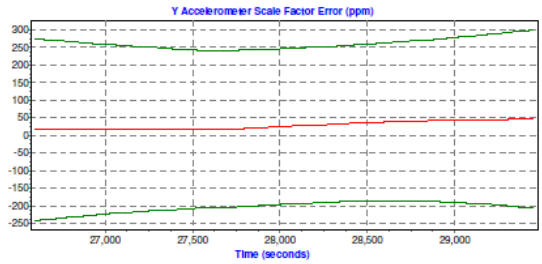
POSPac Version 4.3 - 1 - 4/15/2013 - 10:22:57 AM

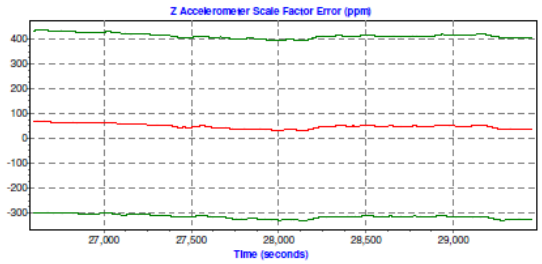






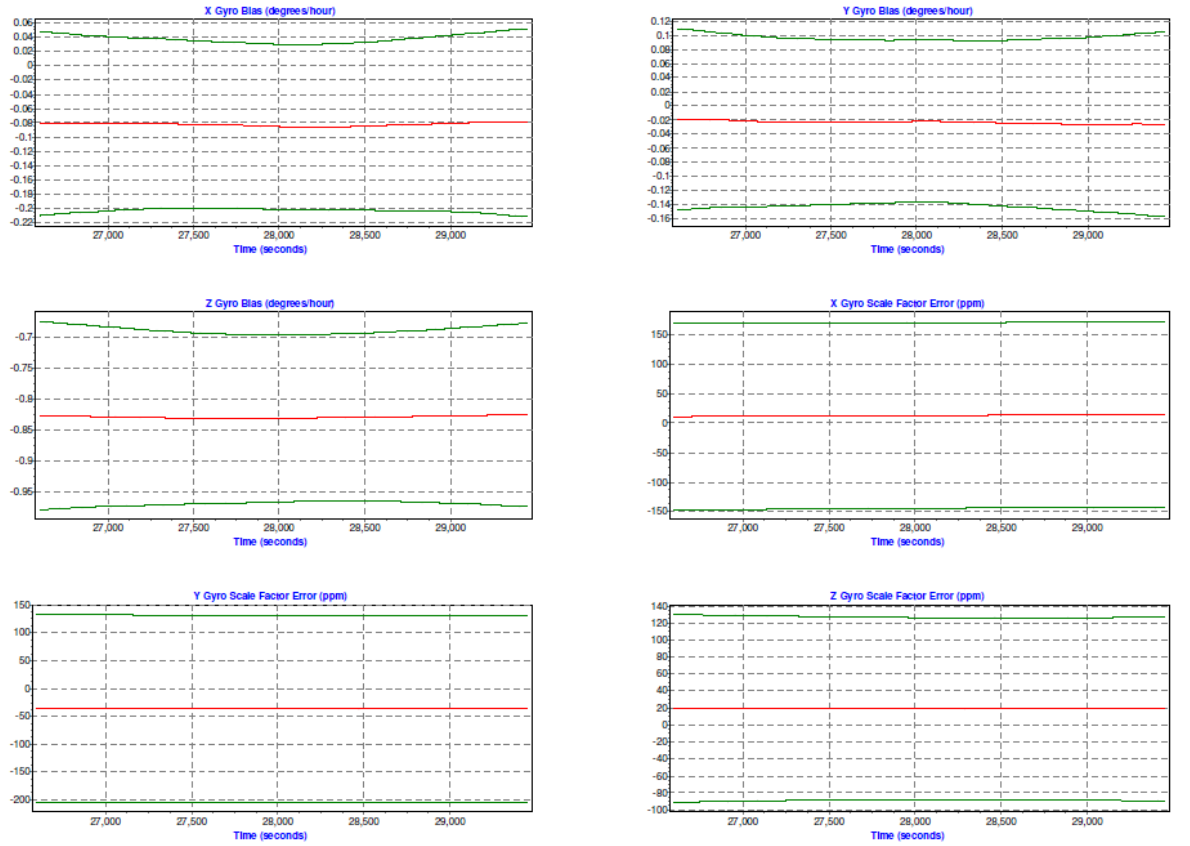


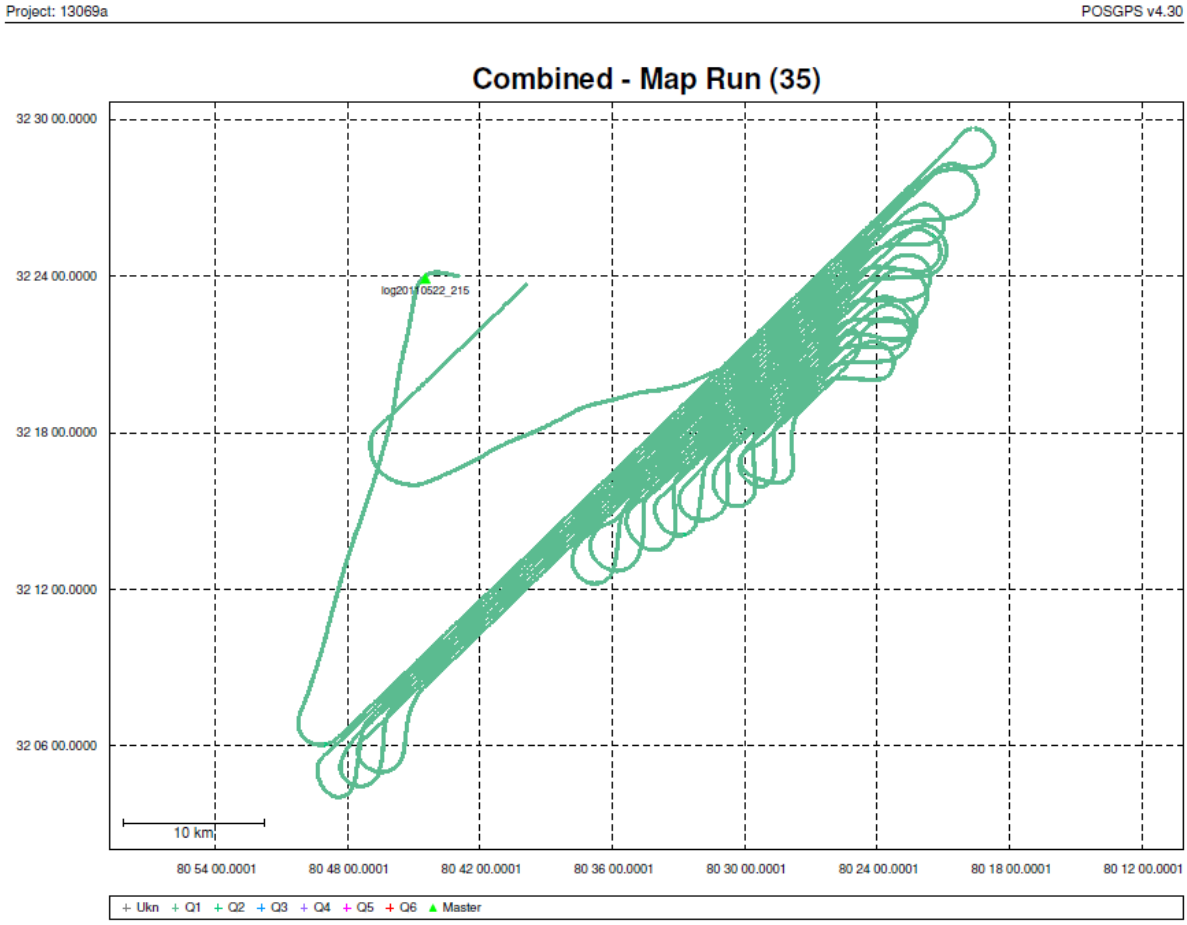




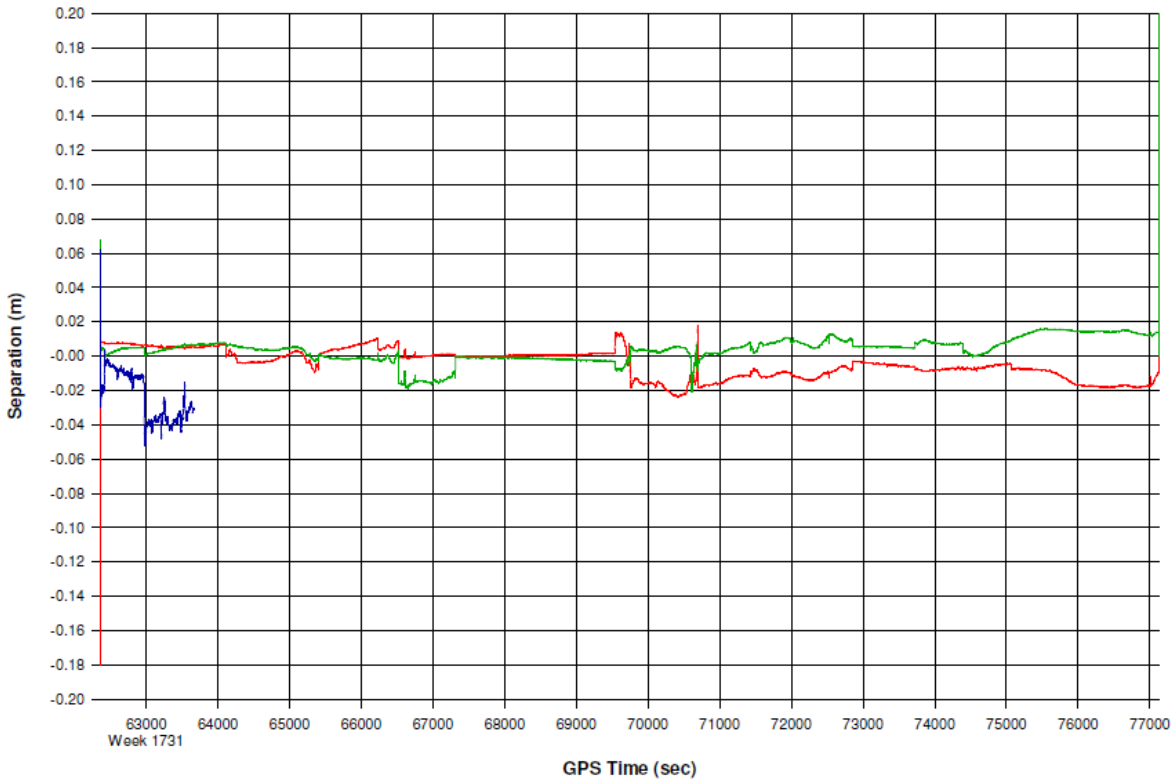
Sensor Errors

POSPac Version 4.3 - 2 - 4/15/2013 - 10:22:58 AM

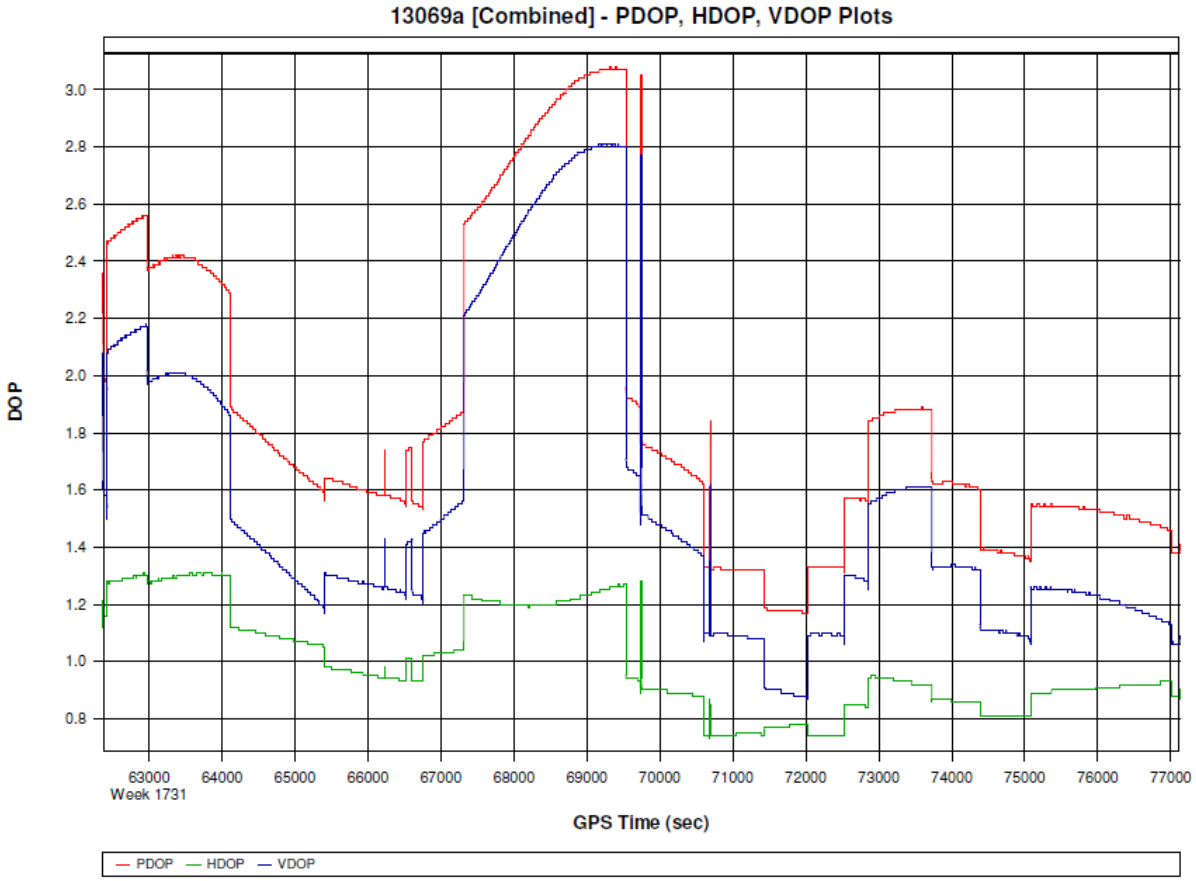



Project: 13069a
POSGPS v4.30
Combined - Map Run (35)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log2013 0522_215
10 km
80 54 00.0001
80 48 00.0001
80 42 00.0001
80 36 00.0001
80 30 00.0001
80 24 00.0001
80 18 00.0001
80 12 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

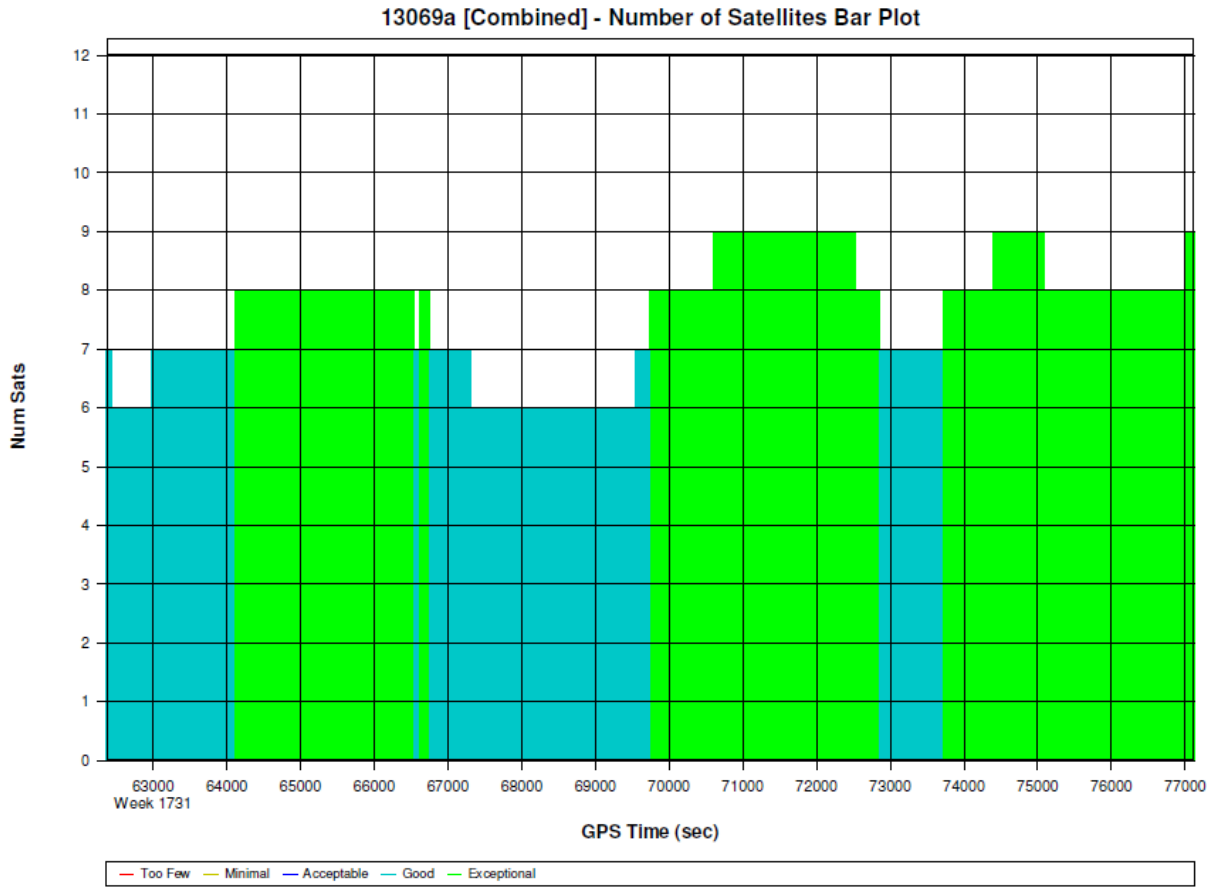
Project: 13069a POSGPS v4.30



Project: 13069a POSGPS v4.30



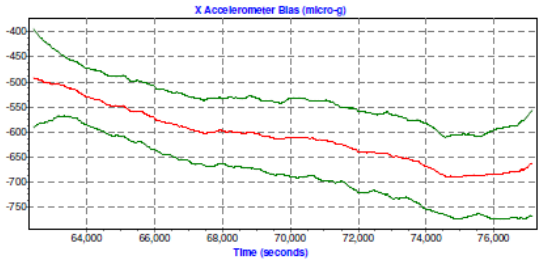
Project: 13069a POSGPS v4.30

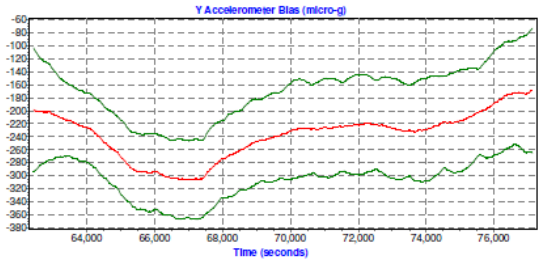


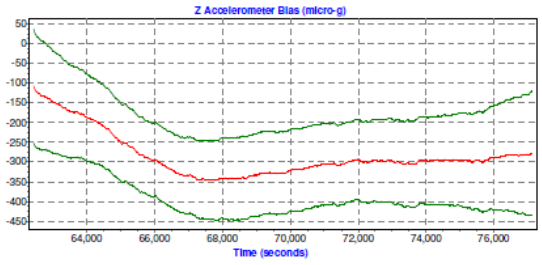
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13069a\pos\GPS\13069a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      160300
      No processed position:  145539
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0232 (m)
      C/A Code:   1.05 (m)
      L1 Doppler: 0.020 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.009 (m)
      North:      0.010 (m)
      Height:     0.026 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (14755 occurances):
      East:       0.009 (m)
      North:      0.008 (m)
      Height:     0.026 (m)

Quality Number Percentages:
      Q 1:  99.9 %
      Q 2:   0.1 %
      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:          41.474 (km)
      Minimum:          0.695 (km)
      Average:          26.045 (km)
      First Epoch:      7.248 (km)
      Last Epoch:       2.425 (km)
```

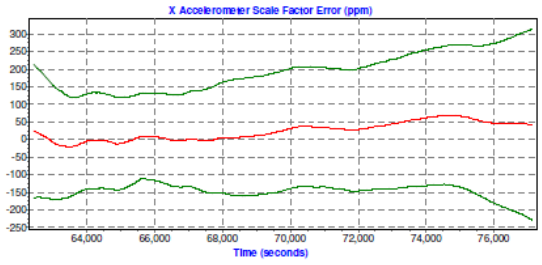
Sensor Errors

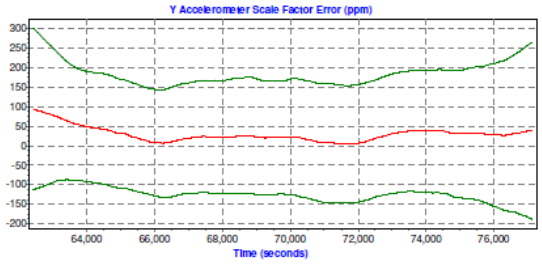
POSPac Version 4.3 - 1 - 4/15/2013 - 10:28:18 AM

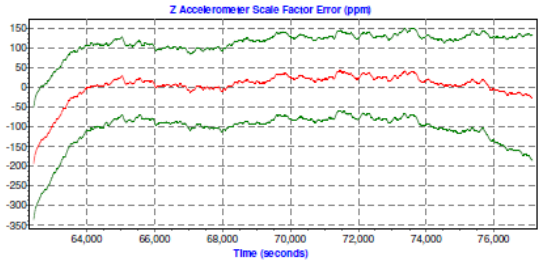






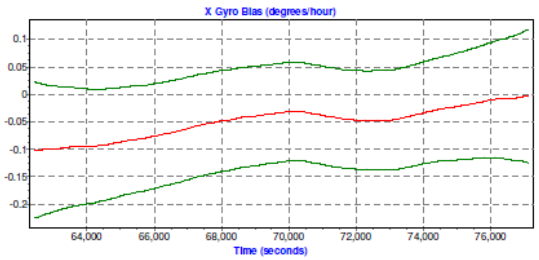


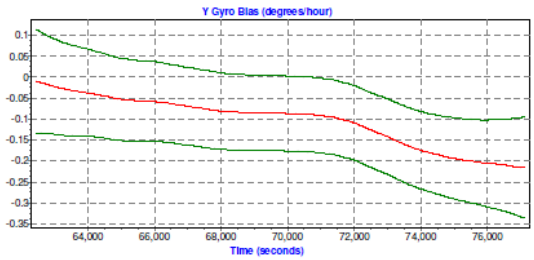


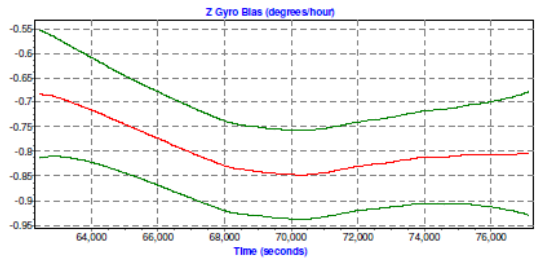


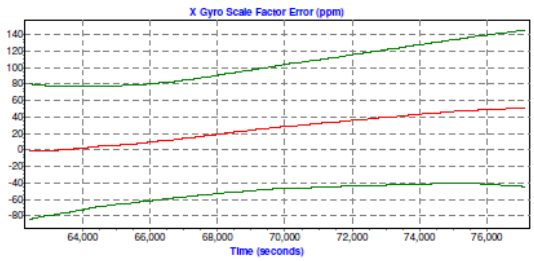
Sensor Errors

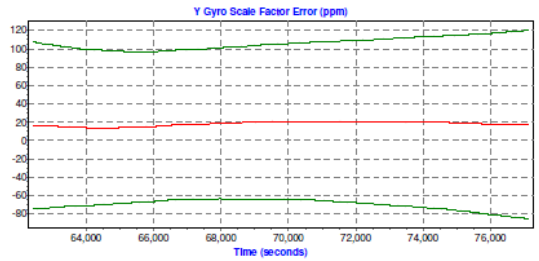
POSPac Version 4.3 - 2 - 4/15/2013 - 10:28:18 AM

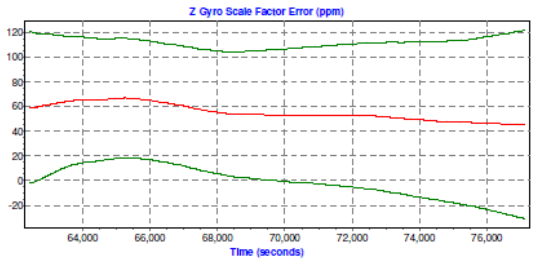


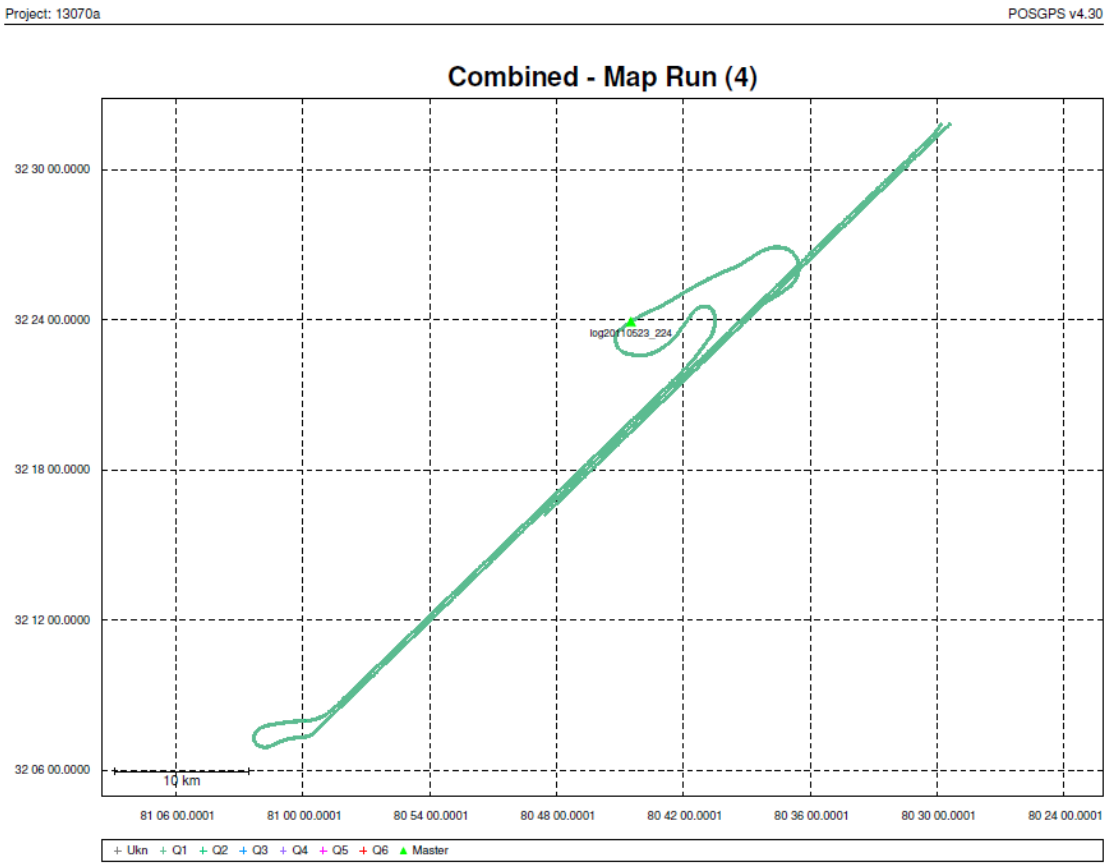




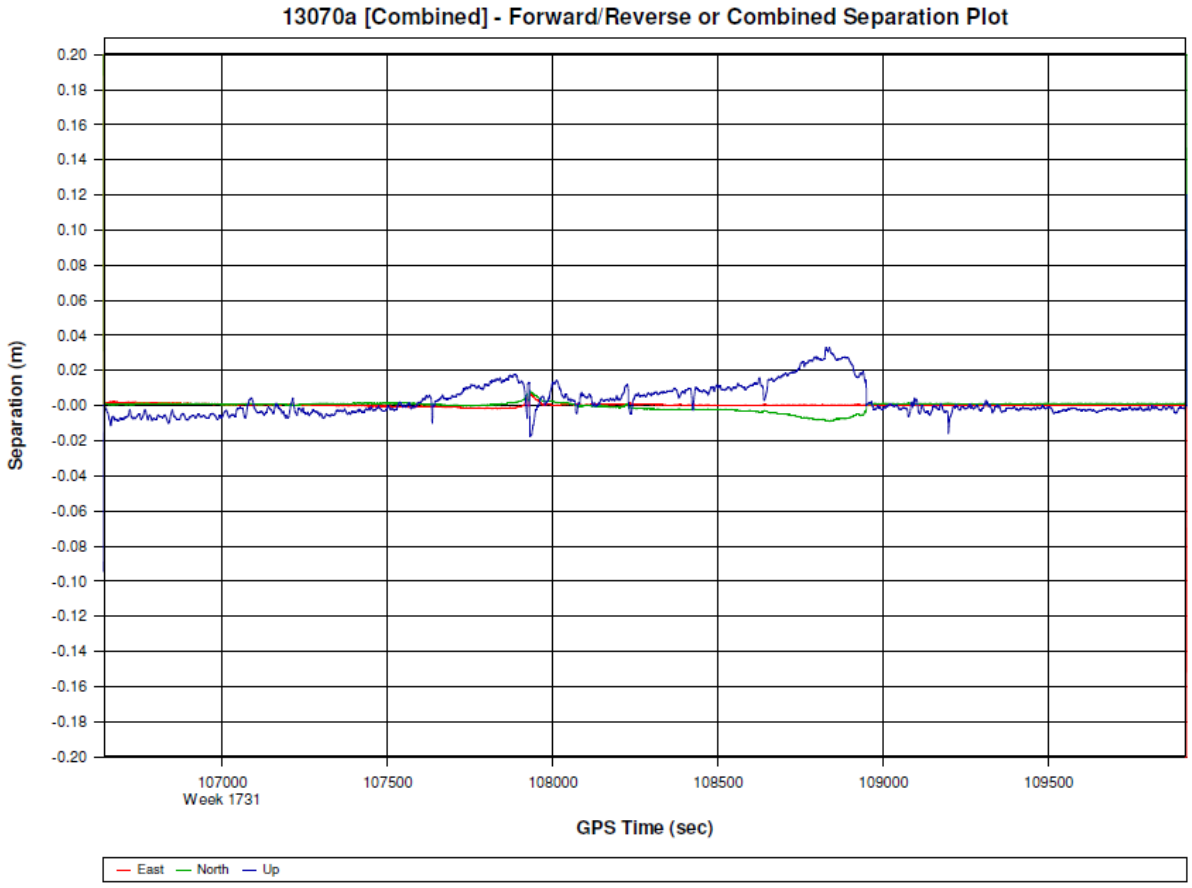




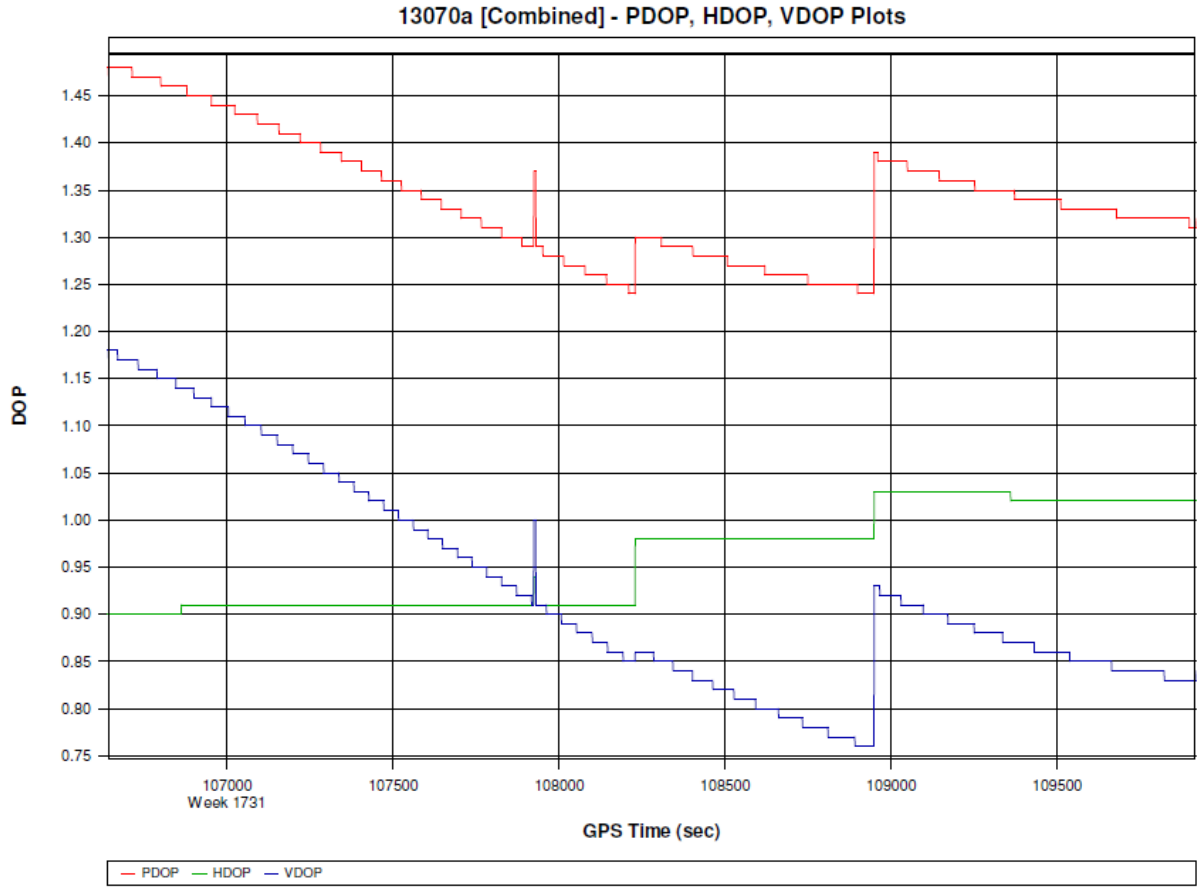



Project: 13070a
POSGPS v4.30
Combined - Map Run (4)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
10 km
81 06 00.0001
81 00 00.0001
80 54 00.0001
80 48 00.0001
80 42 00.0001
80 36 00.0001
80 30 00.0001
80 24 00.0001
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

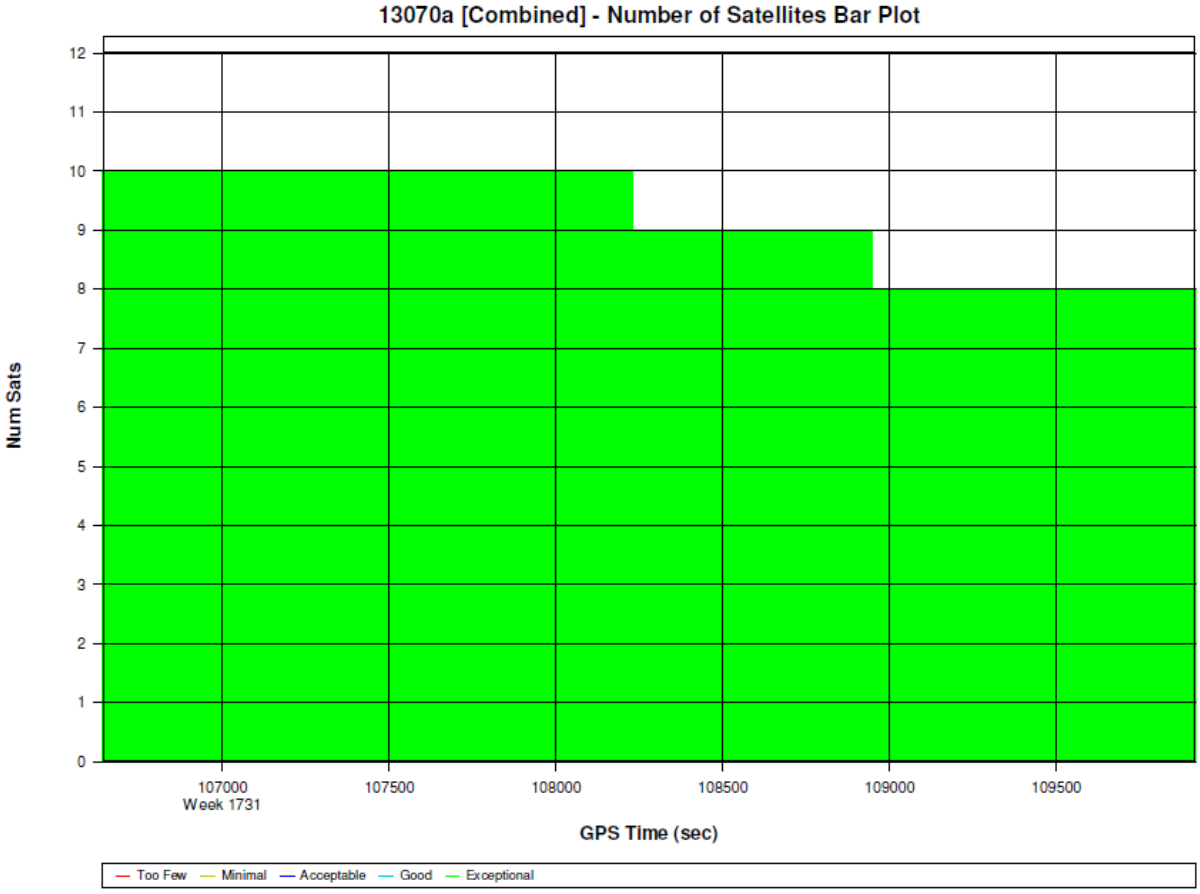
Project: 13070a POSGPS v4.30



Project: 13070a POSGPS v4.30



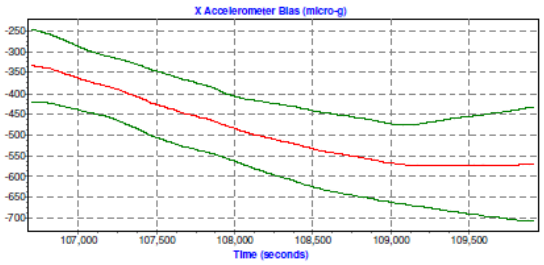
Project: 13070a POSGPS v4.30

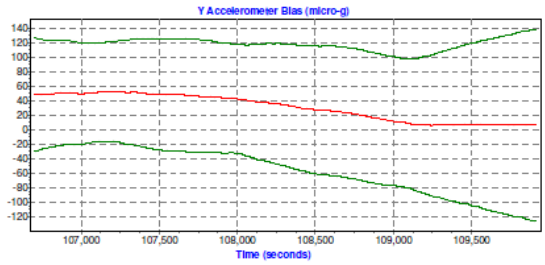


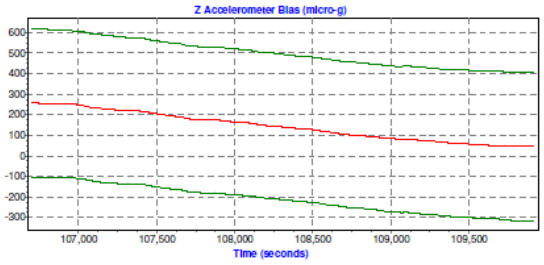
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13070a\pos\GPS\13070a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      154756
      No processed position:  151477
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0199 (m)
      C/A Code:   0.86 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.014 (m)
      North:      0.017 (m)
      Height:     0.009 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (3273 occurances):
      East:       0.001 (m)
      North:      0.002 (m)
      Height:     0.009 (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:          41.793 (km)
      Minimum:          0.843 (km)
      Average:          17.001 (km)
      First Epoch:      9.894 (km)
      Last Epoch:       15.663 (km)
```

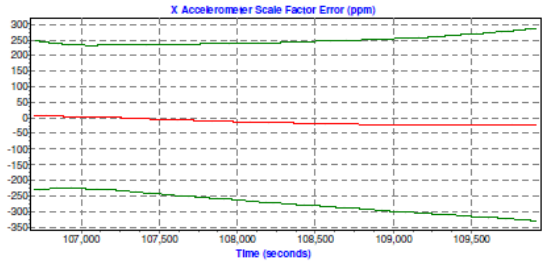
Sensor Errors

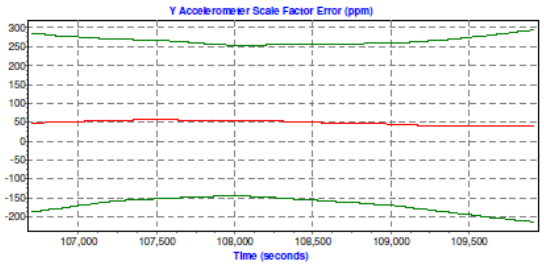
POSPac Version 4.3 - 1 - 5/20/2013 - 3:37:07 PM

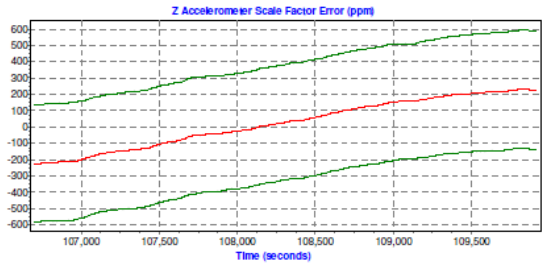


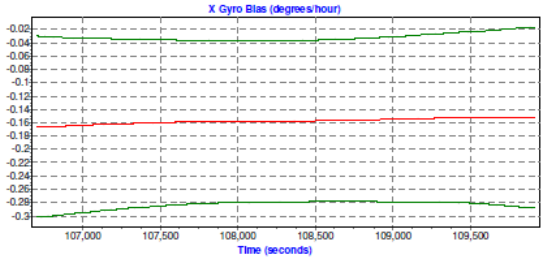


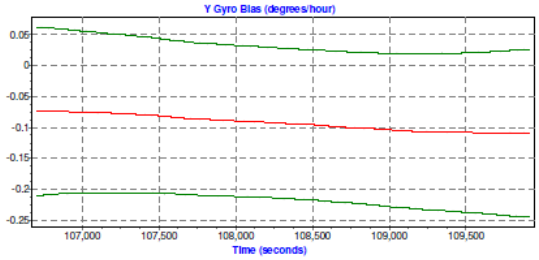


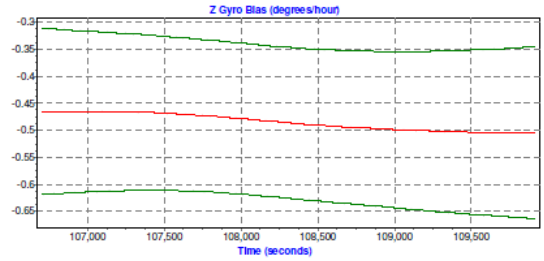


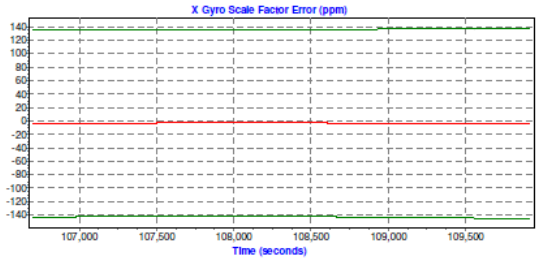




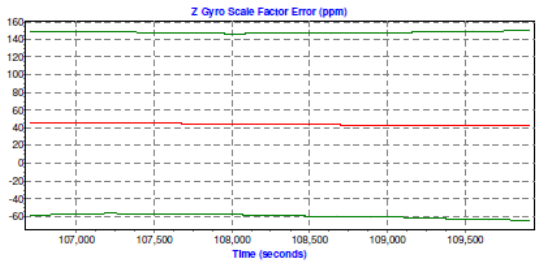

X Gyro Bias (degrees/hour)
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
-0.22
-0.24
-0.26
-0.28
-0.3
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)

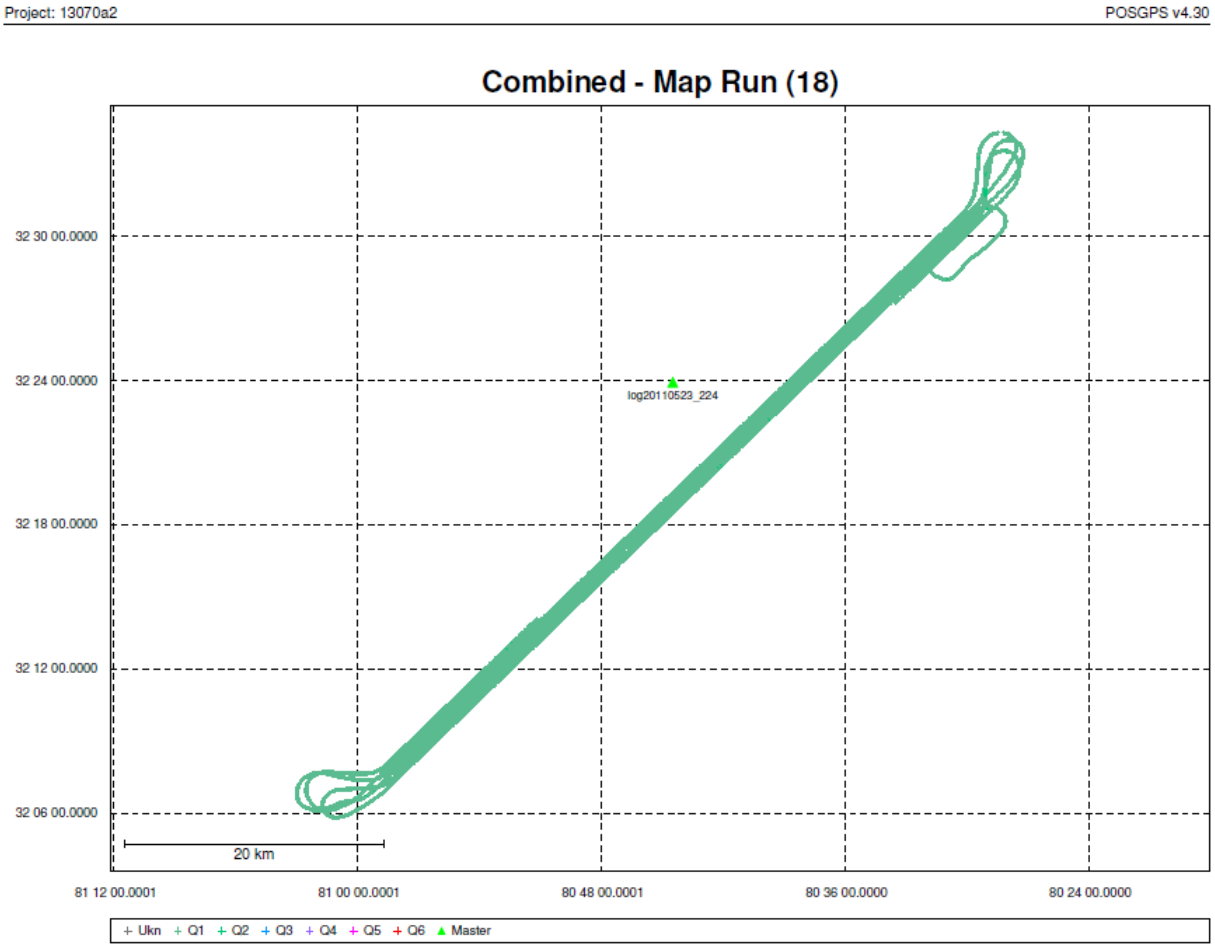

Y Gyro Bias (degrees/hour)
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)


Z Gyro Bias (degrees/hour)
-0.3
-0.35
-0.4
-0.45
-0.5
-0.55
-0.6
-0.65
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)

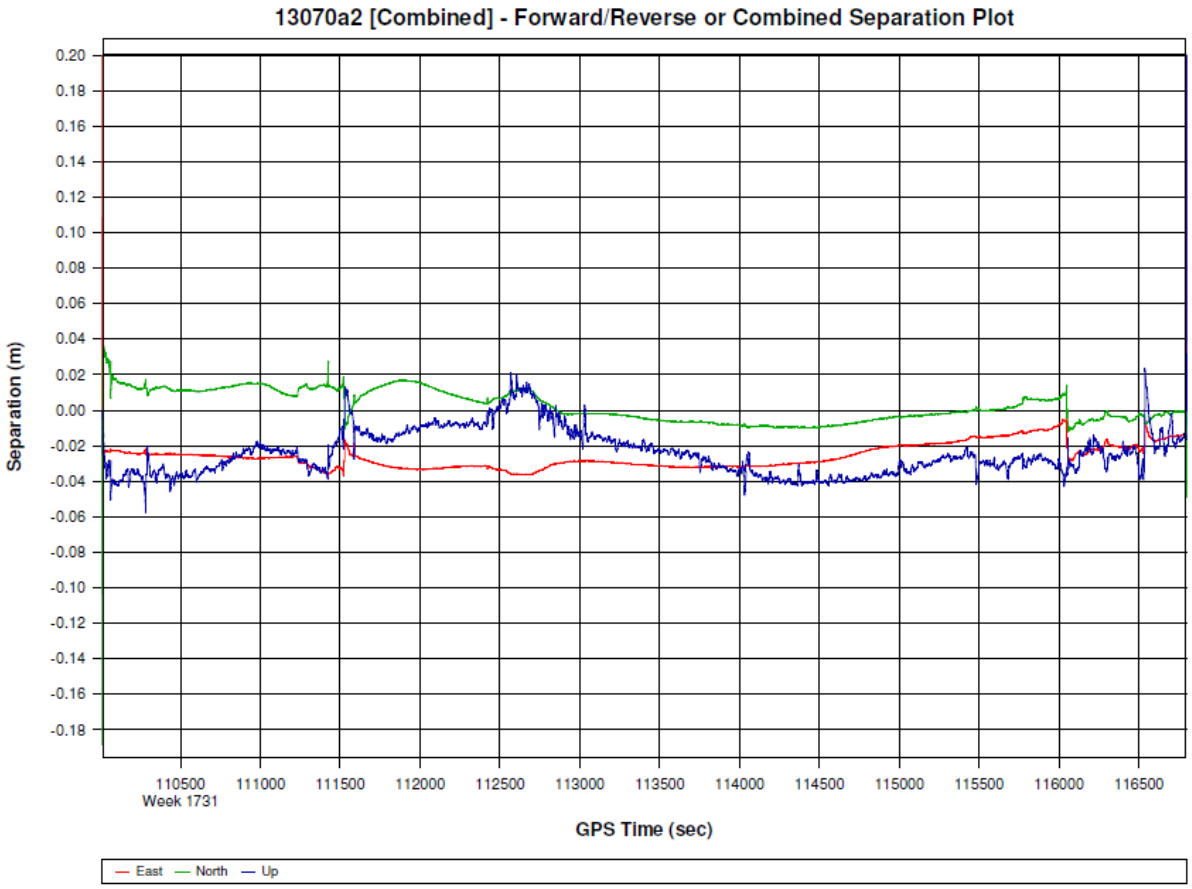

X Gyro Scale Factor Error (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)

Y Gyro Scale Factor Error (ppm)
150
100
50
0
-50
-100
-150
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)

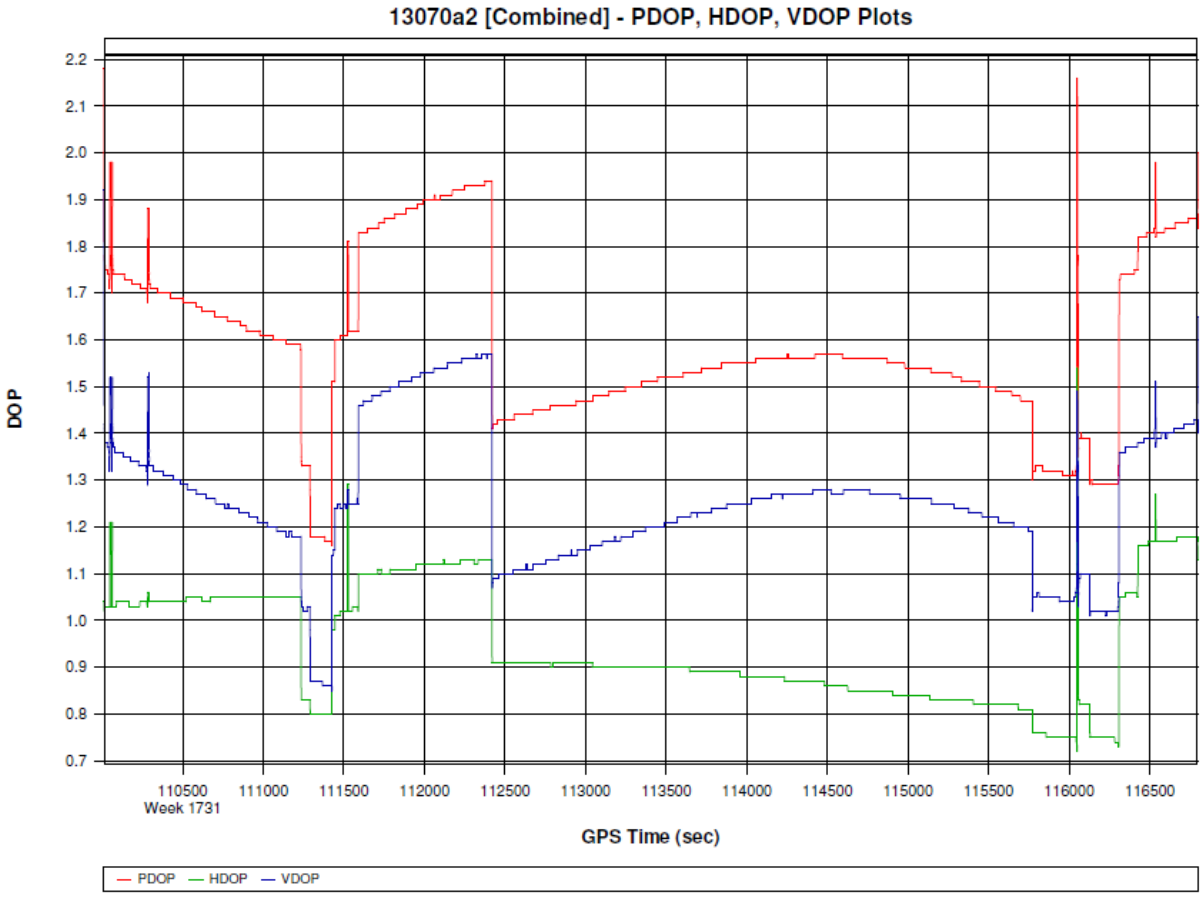

Z Gyro Scale Factor Error (ppm)
160
140
120
100
80
60
40
20
0
-20
-40
-60
107,000
107,500
108,000
108,500
109,000
109,500
Time (seconds)


Project: 13070a2
POSGPS v4.30
Combined - Map Run (18)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log20110523_224
20 km
81 12 00.0001
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

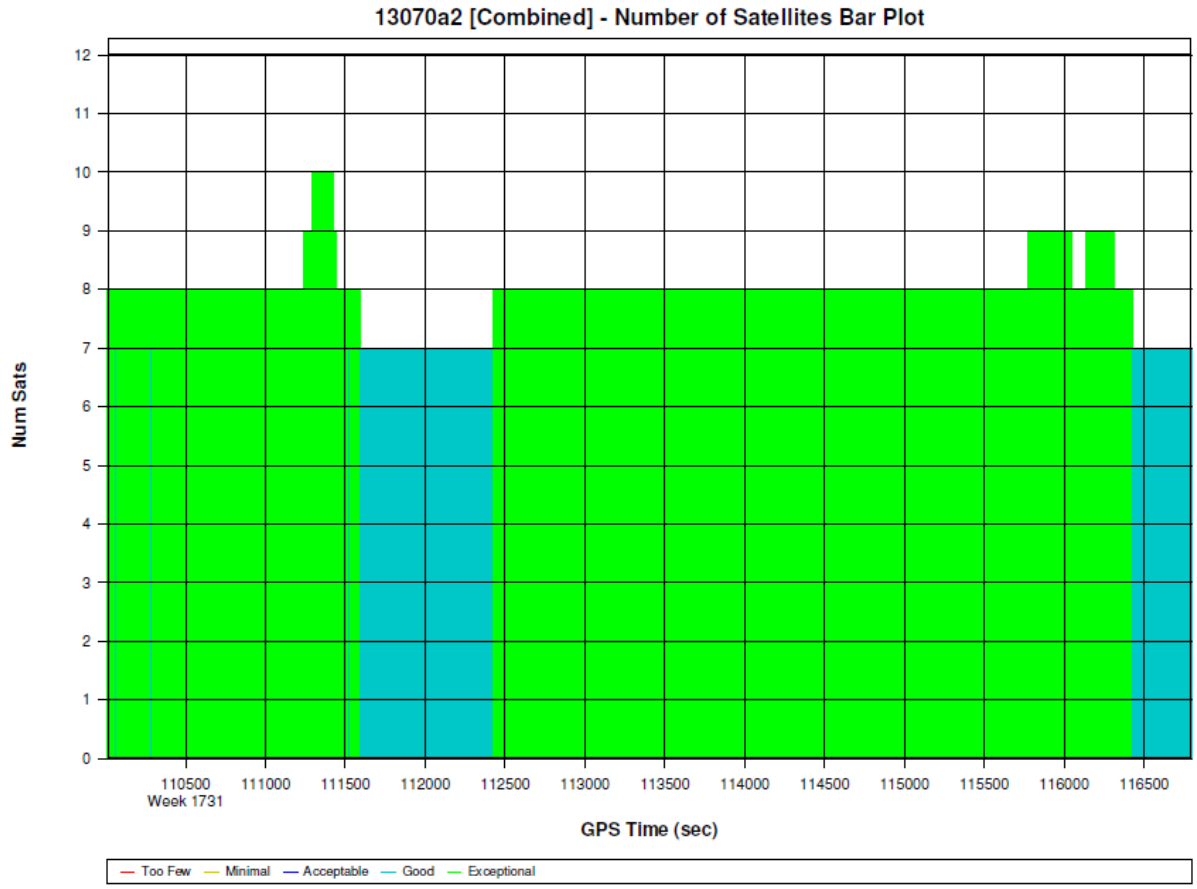
Project: 13070a2 POSGPS v4.30



Project: 13070a2 POSGPS v4.30



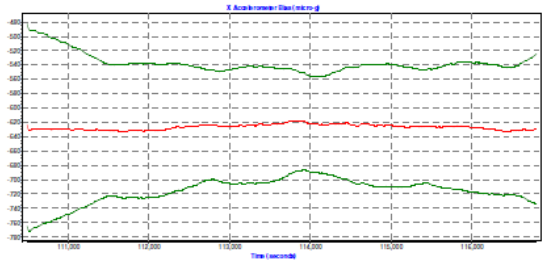
Project: 13070a2 POSGPS v4.30

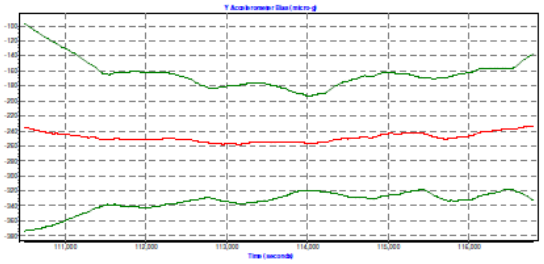


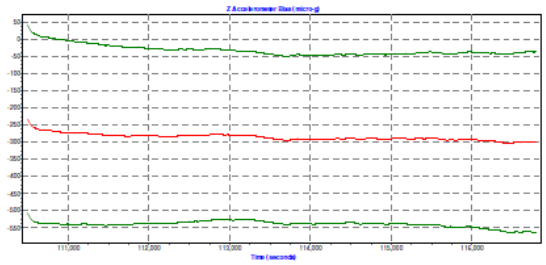
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13070a\pos2\GPS\13070a2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      154756
      No processed position:  147965
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0218 (m)
      C/A Code:   0.92 (m)
      L1 Doppler: 0.019 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.028 (m)
      North:      0.009 (m)
      Height:     0.029 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (6785 occurances):
      East:       0.027 (m)
      North:      0.009 (m)
      Height:     0.027 (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:          43.361 (km)
      Minimum:          6.207 (km)
      Average:          22.400 (km)
      First Epoch:      21.048 (km)
      Last Epoch:       18.289 (km)
```

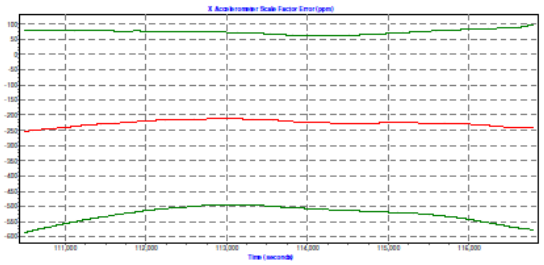
Sensor Errors

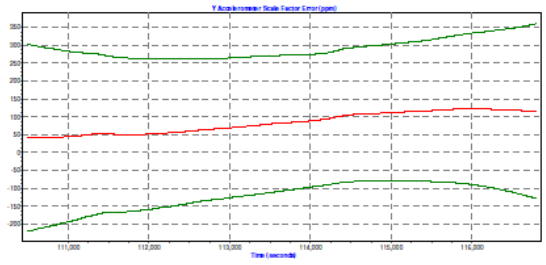
POSPac Version 4.3 - 1 - 5/20/2013 - 3:37:51 PM

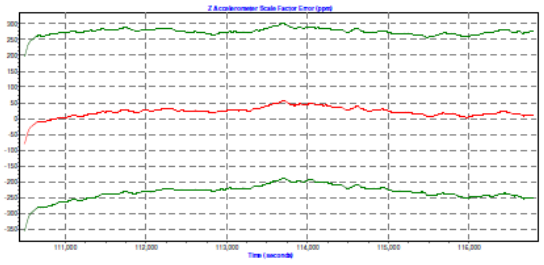






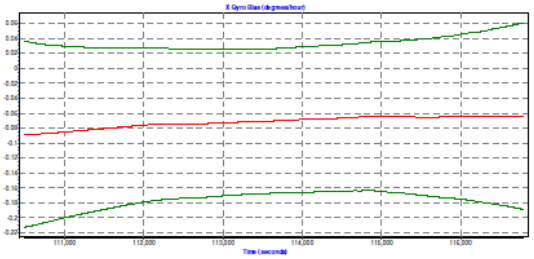


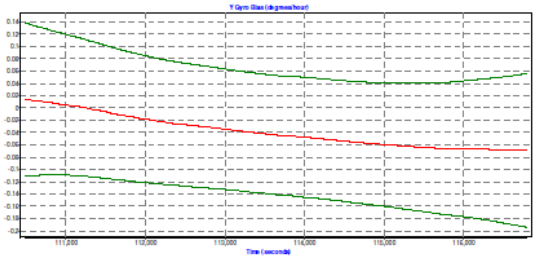


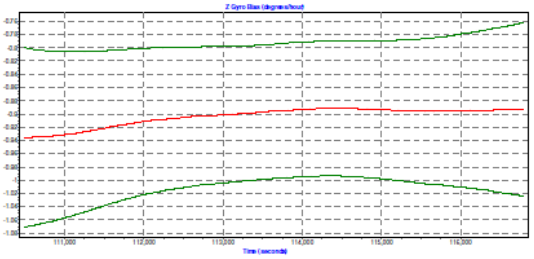


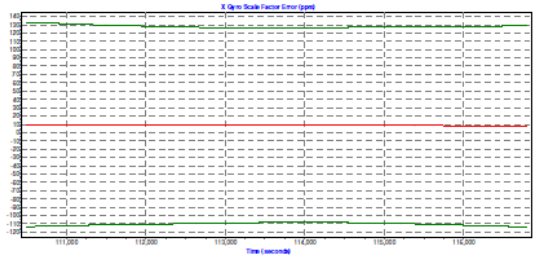
Sensor Errors

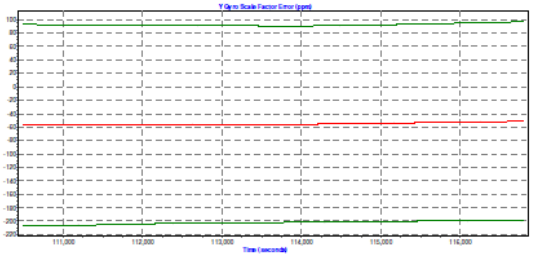
POSPac Version 4.3 - 2 - 5/20/2013 - 3:37:51 PM

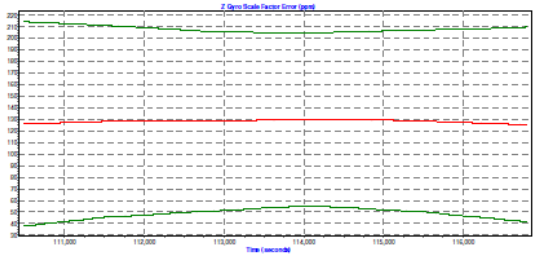


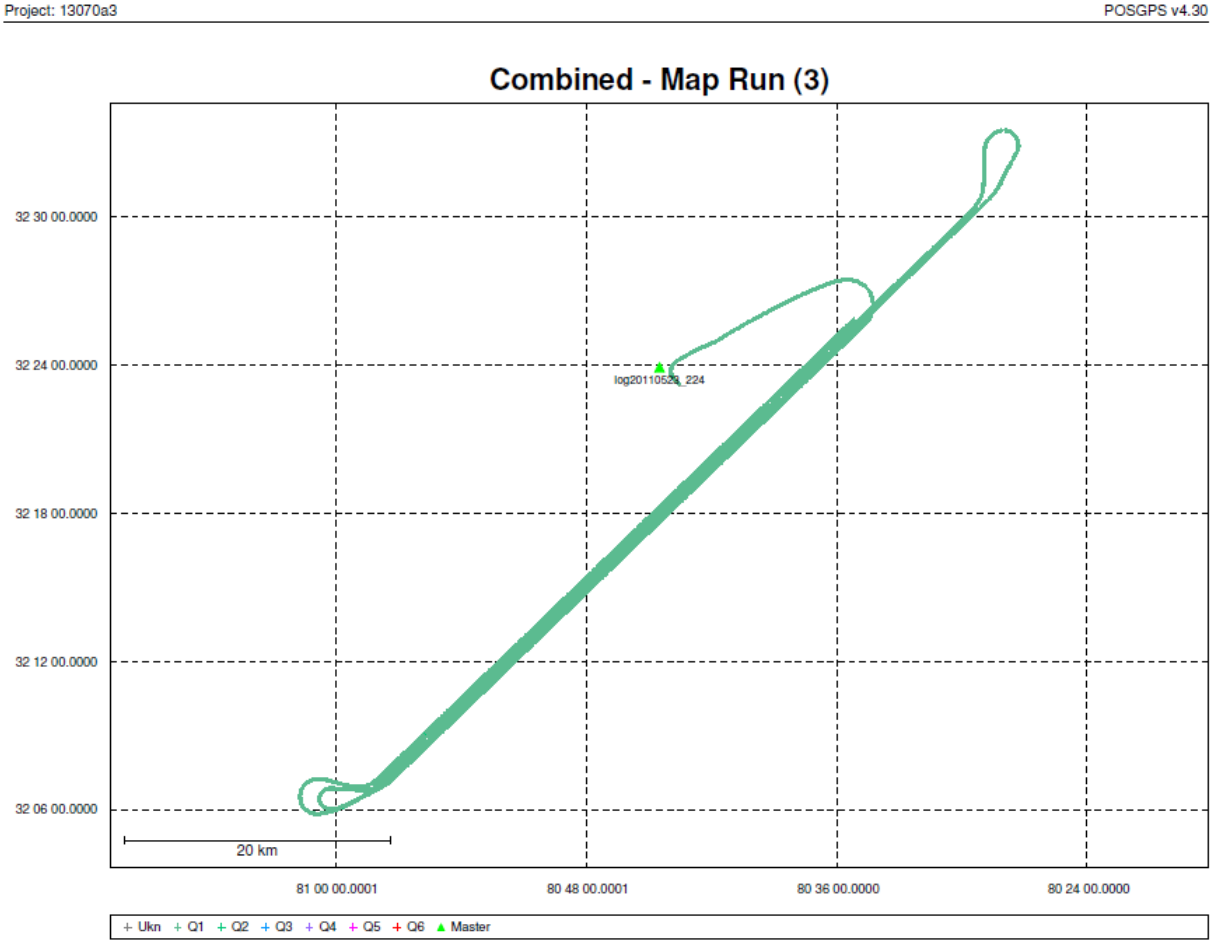




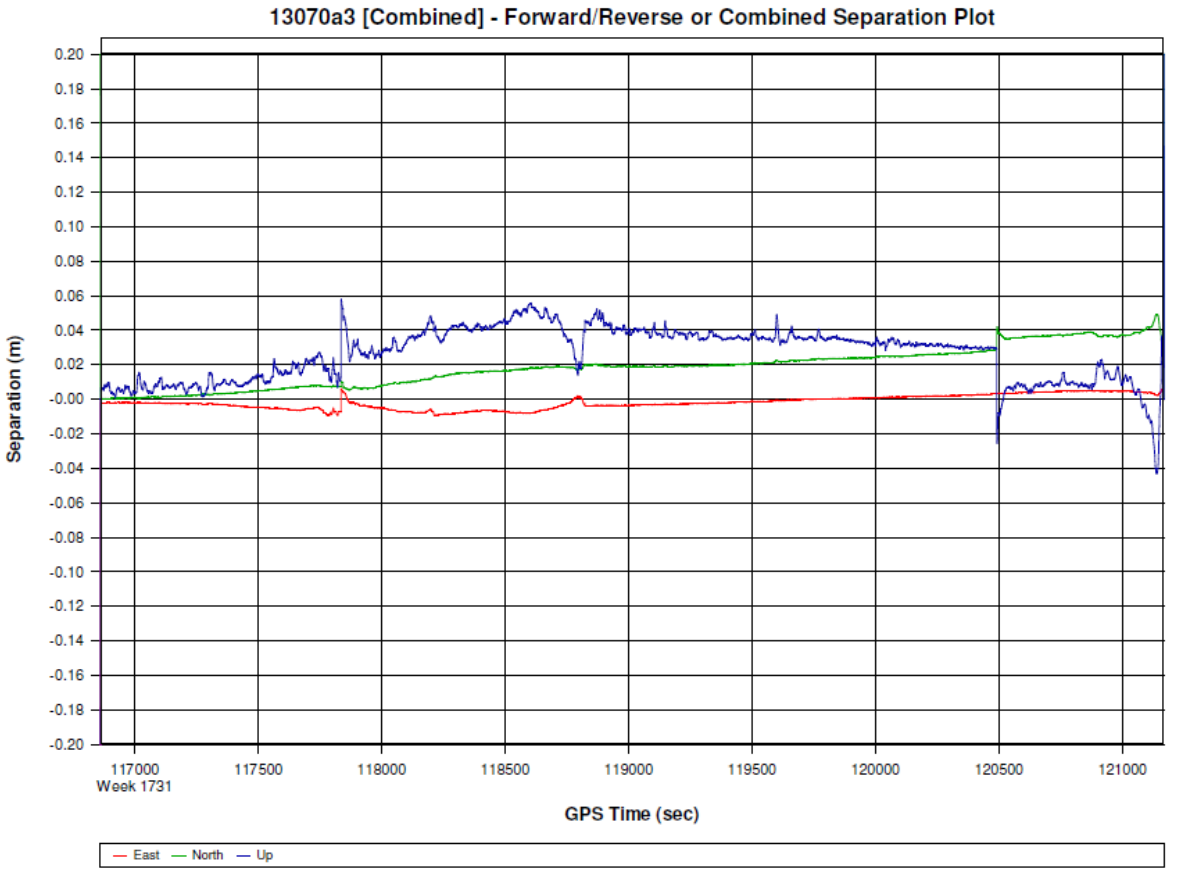




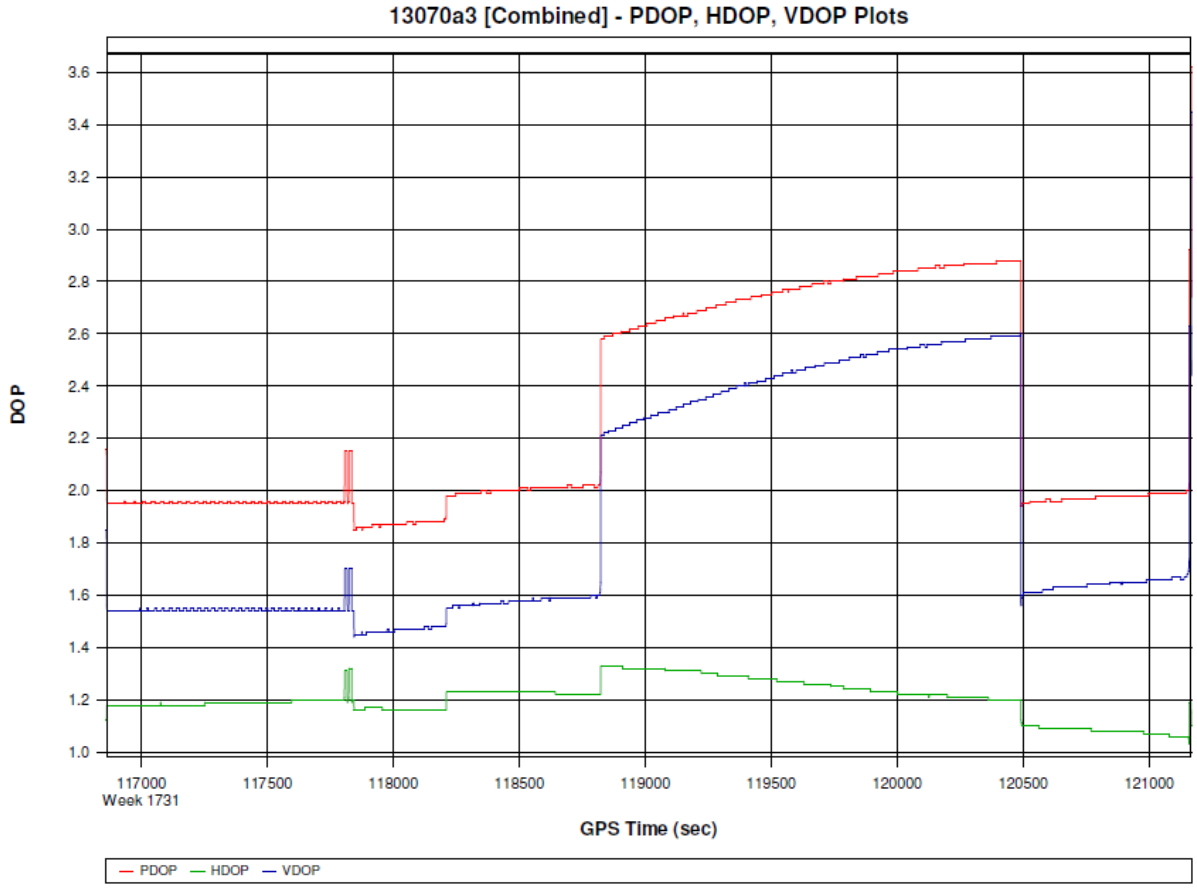



Project: 13070a3
POSGPS v4.30
Combined - Map Run (3)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
20 km
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

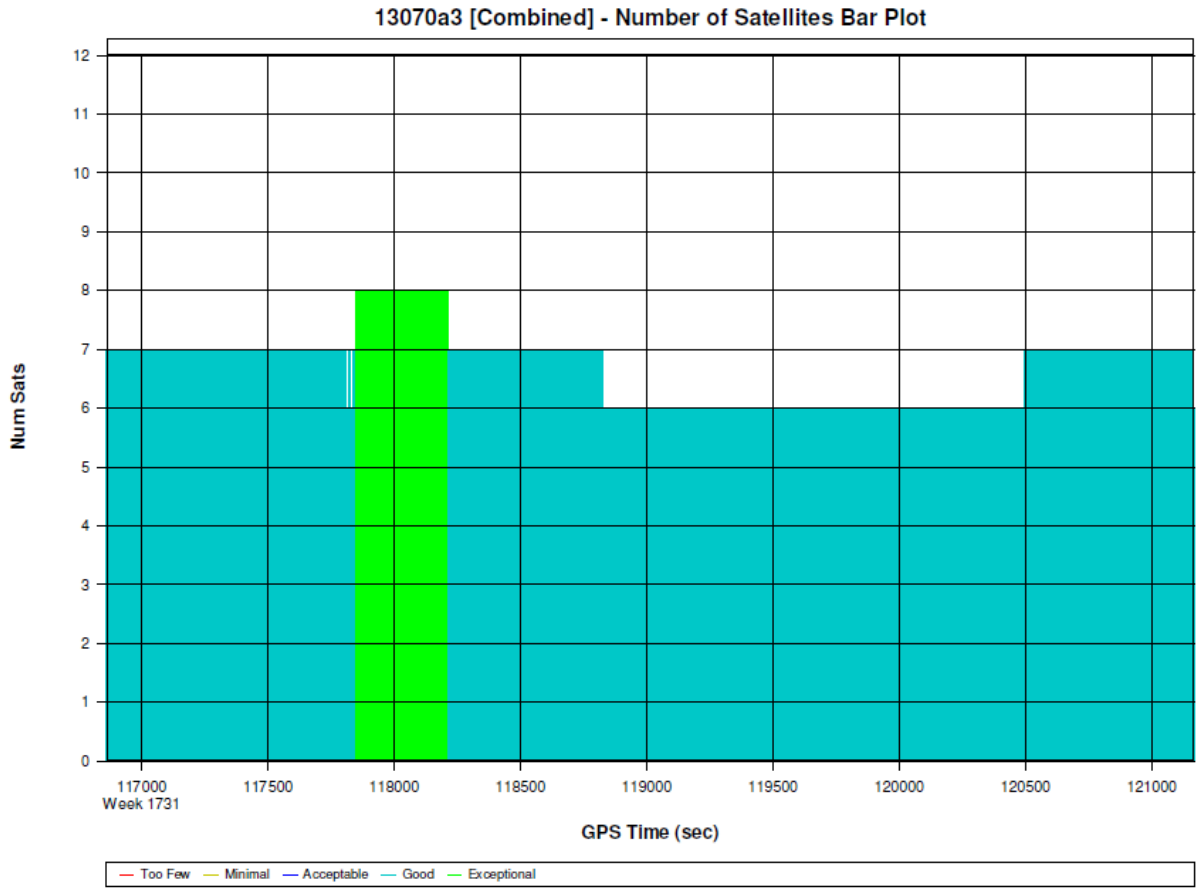
Project: 13070a3 POSGPS v4.30



Project: 13070a3 POSGPS v4.30



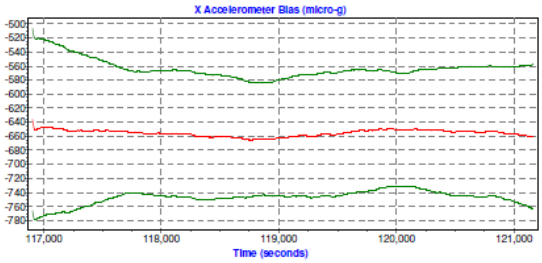
Project: 13070a3 POSGPS v4.30

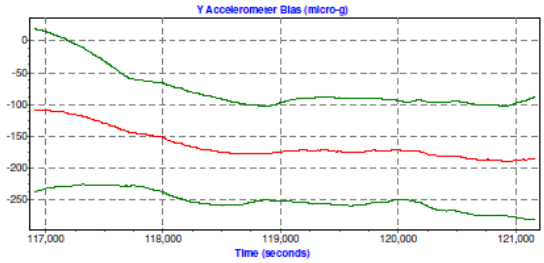


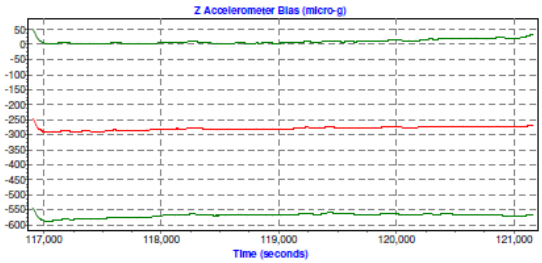
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13070a\pos3\GPS\13070a3.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      154756
      No processed position:  150445
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0246 (m)
      C/A Code:   1.12 (m)
      L1 Doppler: 0.020 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.006 (m)
      North:      0.024 (m)
      Height:     0.048 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (4305 occurances):
      East:       0.004 (m)
      North:      0.022 (m)
      Height:     0.030 (m)

Quality Number Percentages:
      Q 1:  99.9 %
      Q 2:   0.1 %
      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:          42.481 (km)
      Minimum:          0.972 (km)
      Average:          20.306 (km)
      First Epoch:      15.058 (km)
      Last Epoch:       1.976 (km)
```

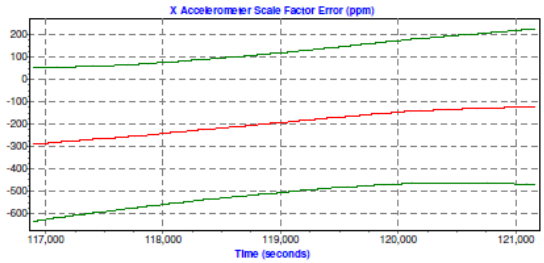
Sensor Errors

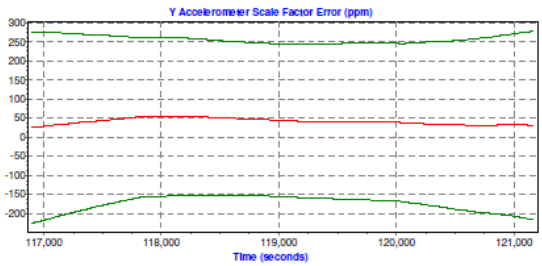
POSPac Version 4.3 - 1 - 5/20/2013 - 3:38:30 PM

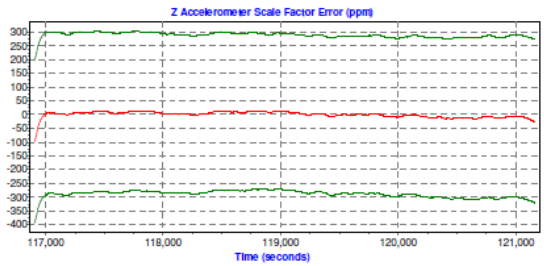


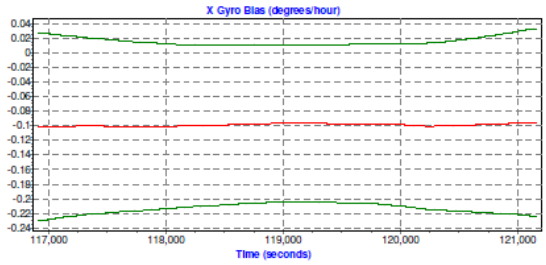


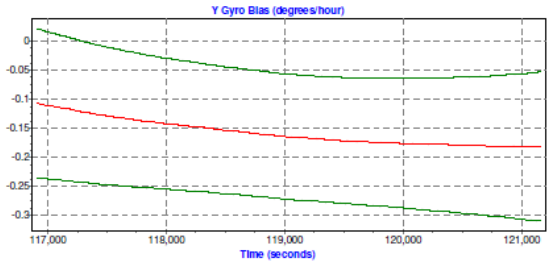


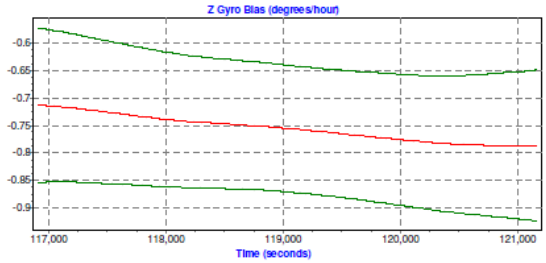


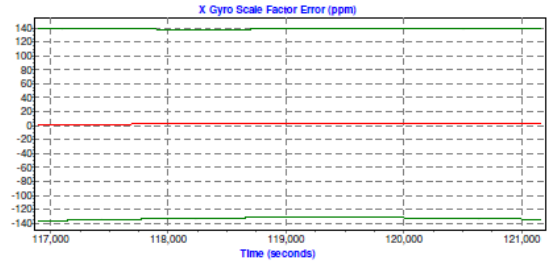


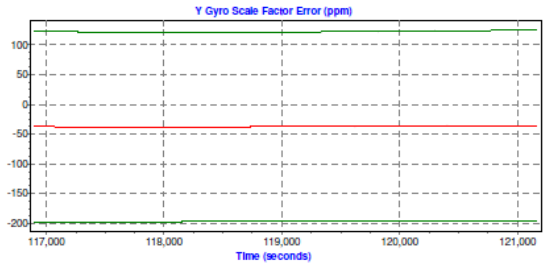


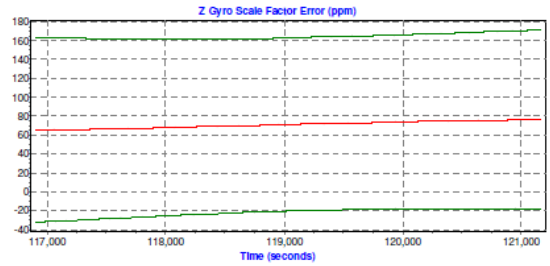

X Gyro Bias (degrees/hour)
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
-0.22
-0.24
117,000
118,000
119,000
120,000
121,000
Time (seconds)


Y Gyro Bias (degrees/hour)
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
117,000
118,000
119,000
120,000
121,000
Time (seconds)

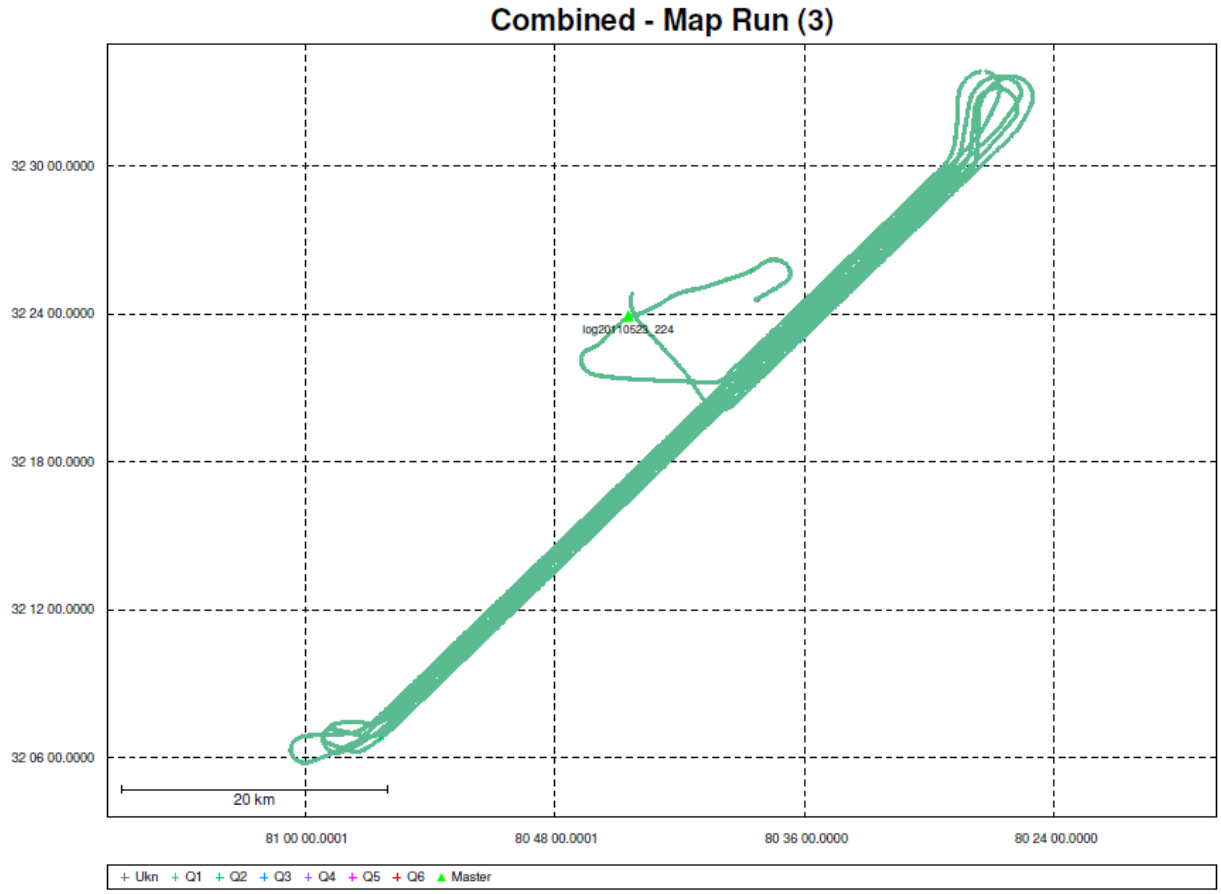

Z Gyro Bias (degrees/hour)
-0.6
-0.65
-0.7
-0.75
-0.8
-0.85
-0.9
117,000
118,000
119,000
120,000
121,000
Time (seconds)


X Gyro Scale Factor Error (ppm)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
117,000
118,000
119,000
120,000
121,000
Time (seconds)

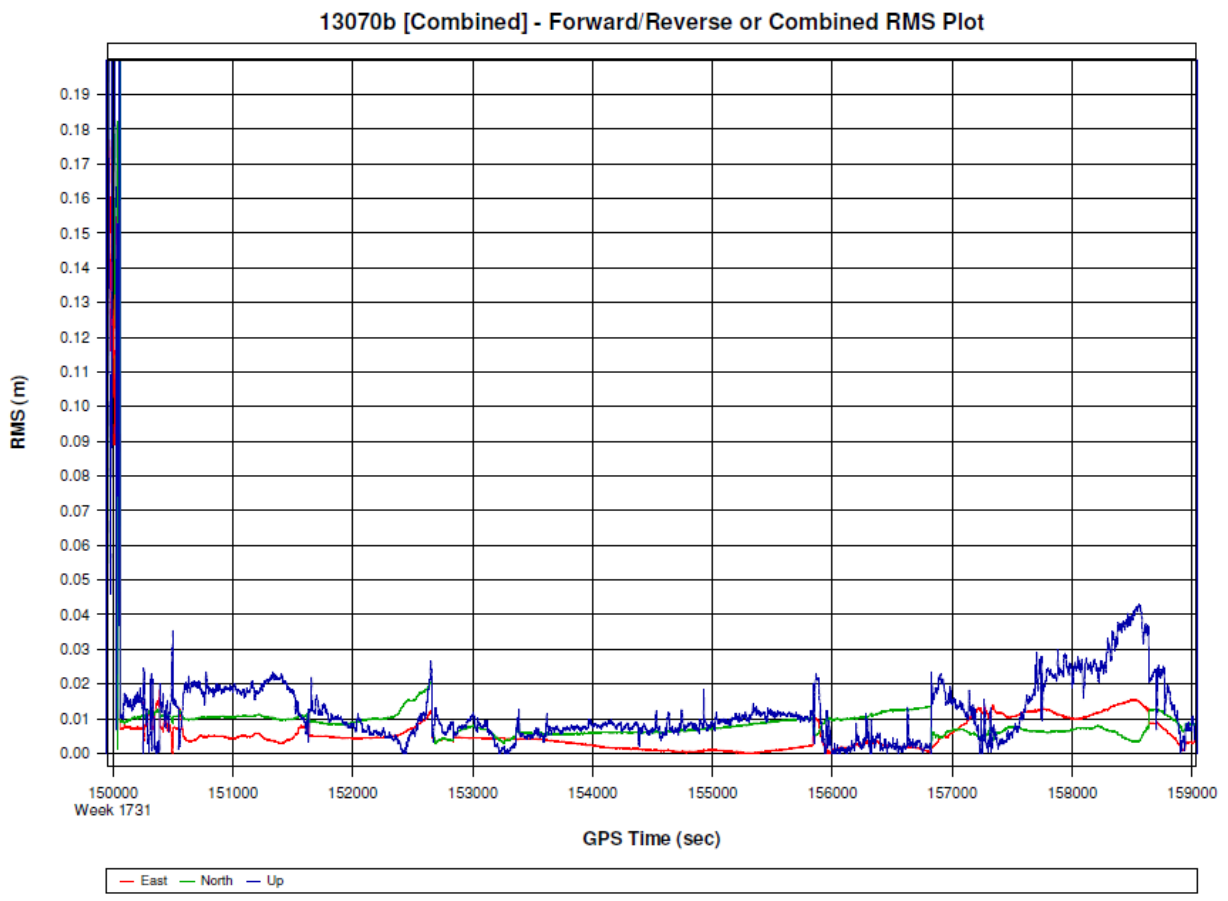

Y Gyro Scale Factor Error (ppm)
100
50
0
-50
-100
-150
-200
117,000
118,000
119,000
120,000
121,000
Time (seconds)


Z Gyro Scale Factor Error (ppm)
180
160
140
120
100
80
60
40
20
0
-20
-40
117,000
118,000
119,000
120,000
121,000
Time (seconds)

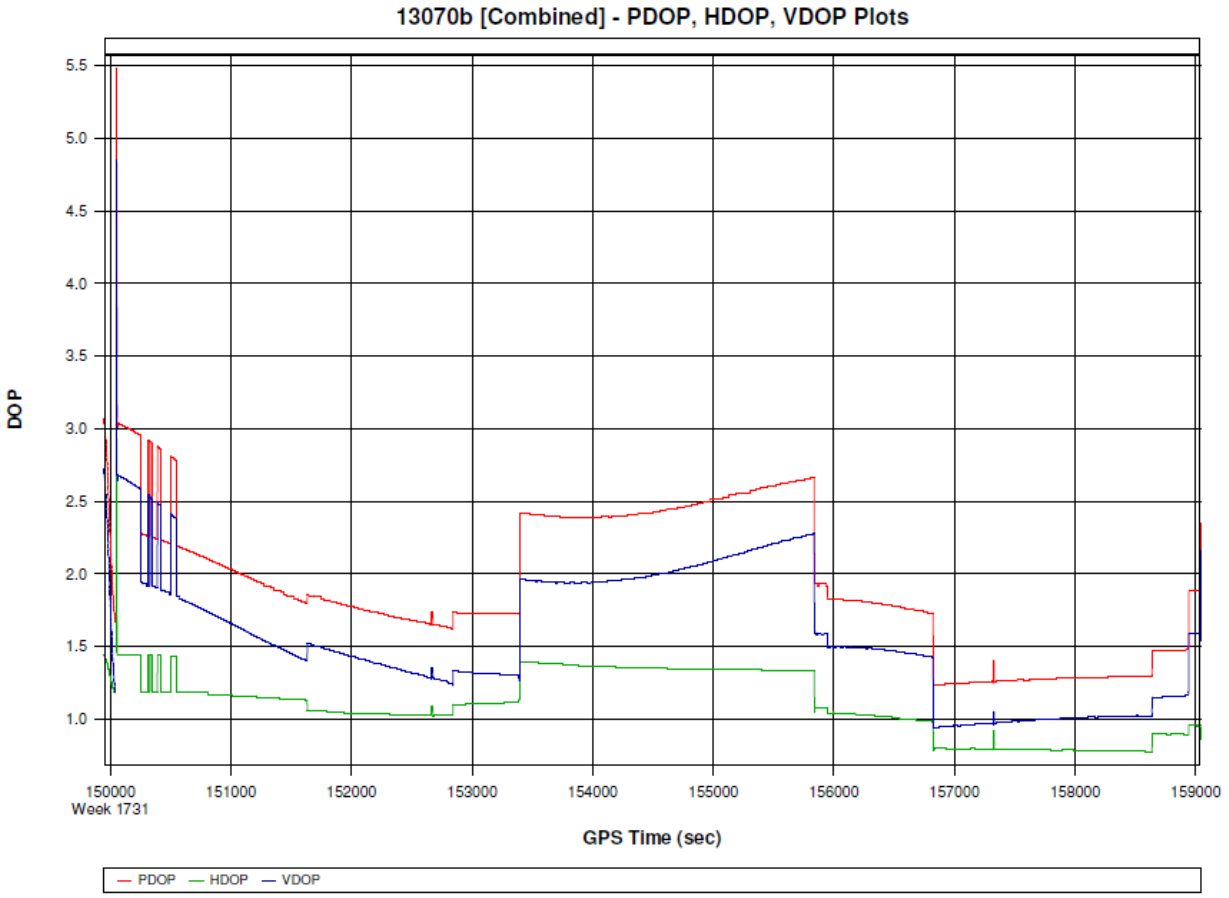
Project: 13070b POSGPS v4.30



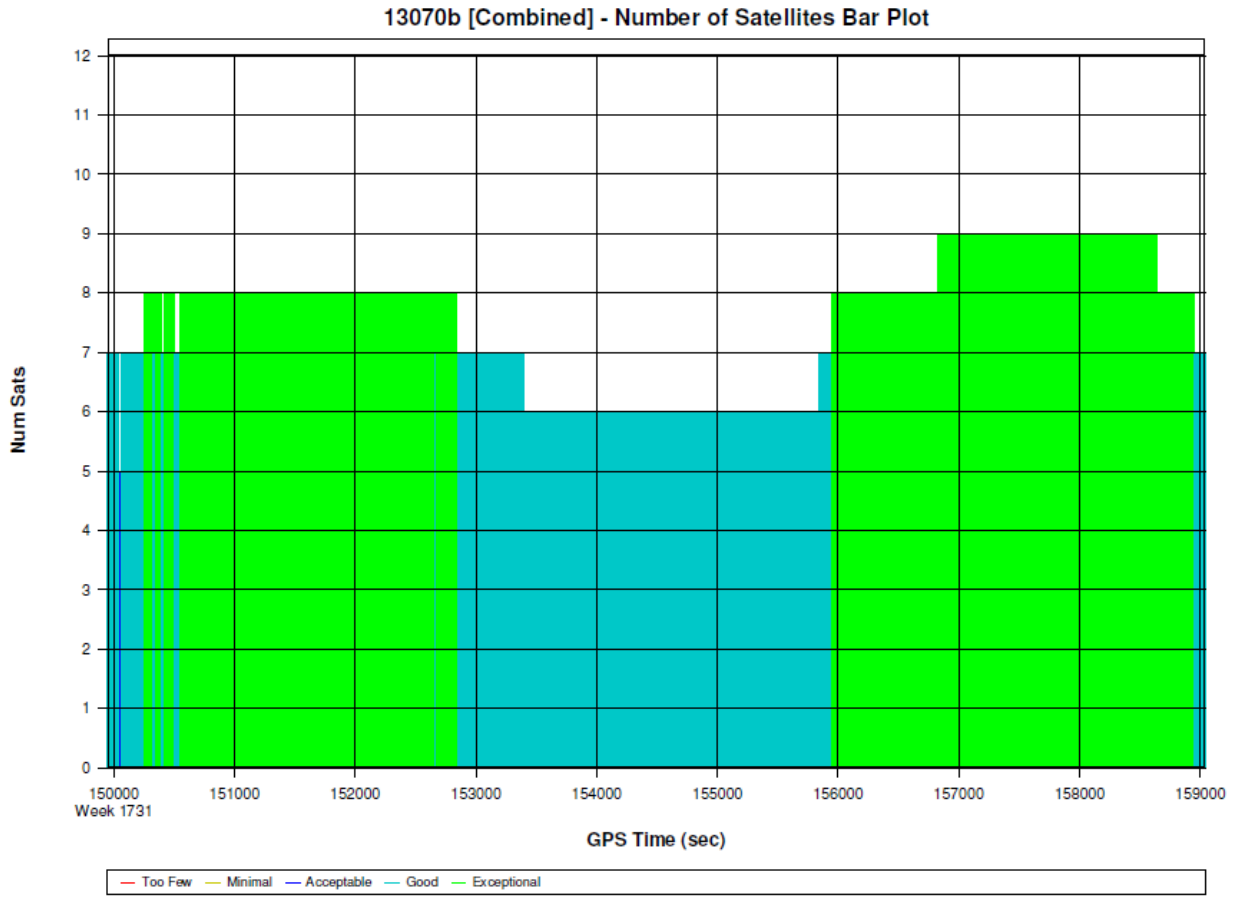
Project: 13070b POSGPS v4.30



Project: 13070b POSGPS v4.30



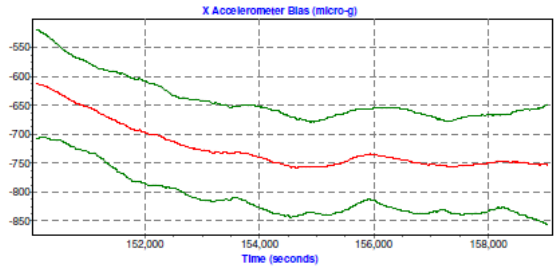
Project: 13070b POSGPS v4.30

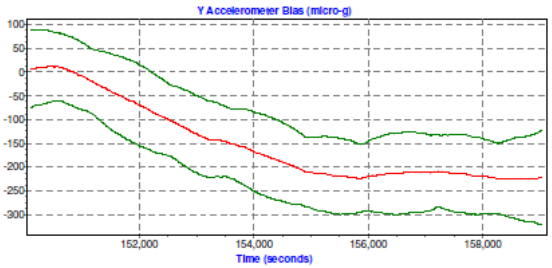


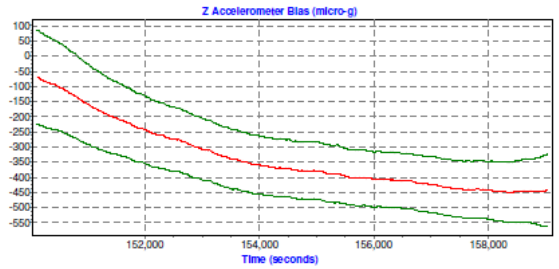
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13070b\pos\GPS\13070b.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      93810
      No processed position:  84720
      Missing Fwd or Rev:     3
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0219 (m)
      C/A Code:   1.02 (m)
      L1 Doppler: 0.020 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.026 (m)
      North:      0.044 (m)
      Height:     0.046 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (9017 occurances):
      East:       0.015 (m)
      North:      0.035 (m)
      Height:     0.033 (m)

Quality Number Percentages:
      Q 1:  98.7 %
      Q 2:   0.2 %
      Q 3:   0.0 %
      Q 4:   0.4 %
      Q 5:   0.6 %
      Q 6:   0.0 %

Position Standard Deviation Percentages:
      0.00 - 0.10 m:    98.9 %
      0.10 - 0.30 m:     0.0 %
      0.30 - 1.00 m:     0.5 %
      1.00 - 5.00 m:     0.6 %
      5.00 m + over:     0.0 %

Percentages of epochs with DD_DOP over 10.00:
      DOP over Tol:     0.0 %

Baseline Distances:
      Maximum:          41.677 (km)
      Minimum:          0.740 (km)
      Average:          20.102 (km)
      First Epoch:      9.867 (km)
      Last Epoch:       1.905 (km)
```

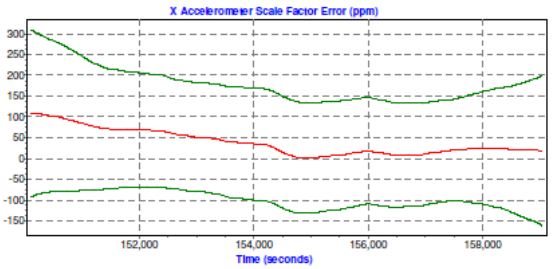
Sensor Errors

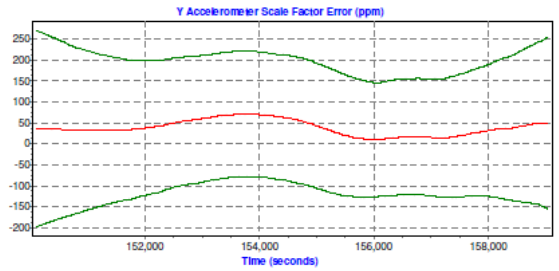
POSPac Version 4.3 - 1 - 4/15/2013 - 11:17:54 AM

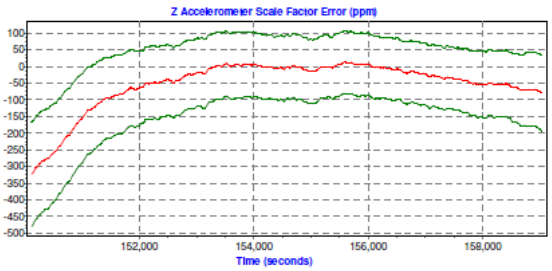






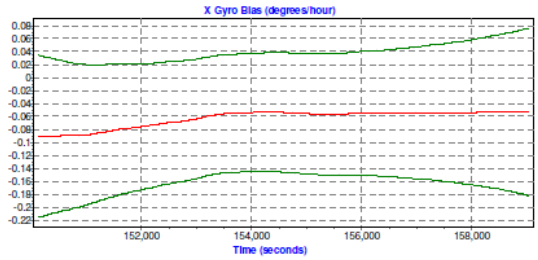


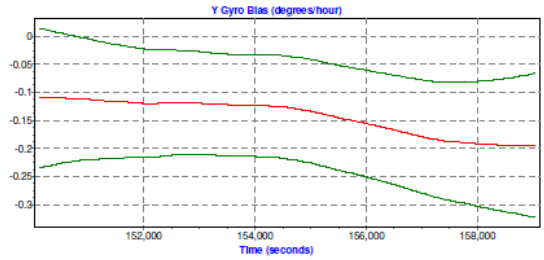


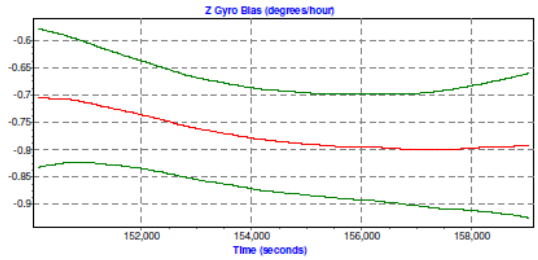


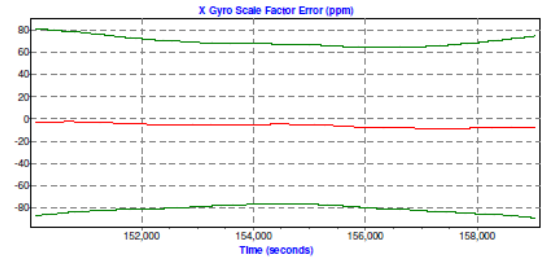
Sensor Errors

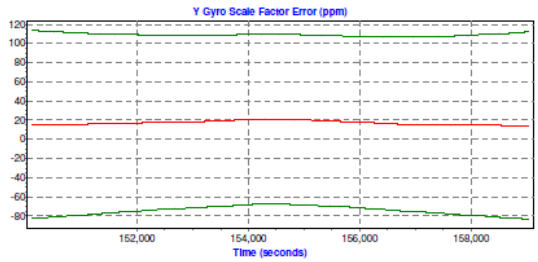
POSPac Version 4.3 - 2 - 4/15/2013 - 11:17:54 AM

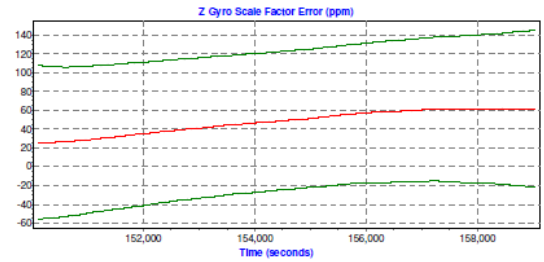


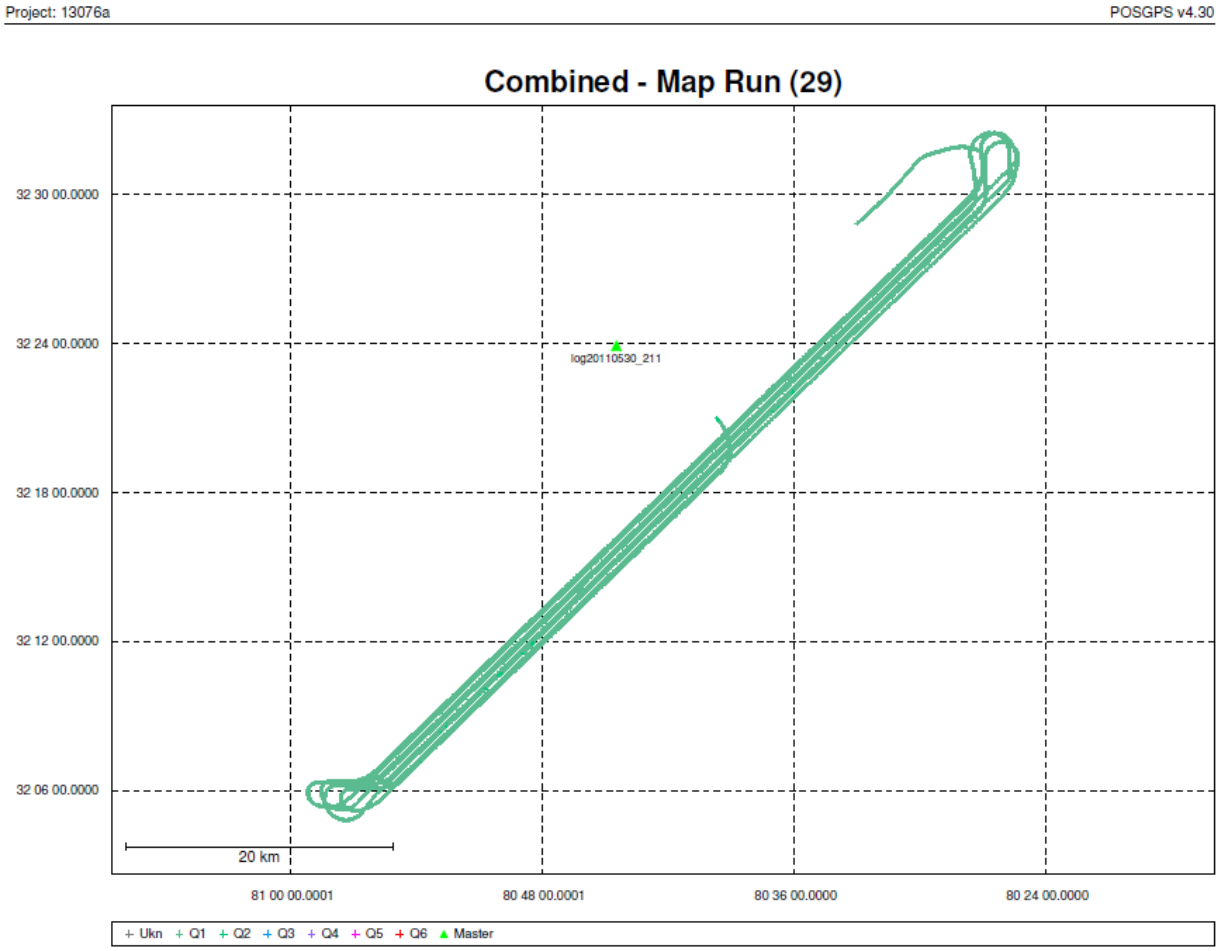




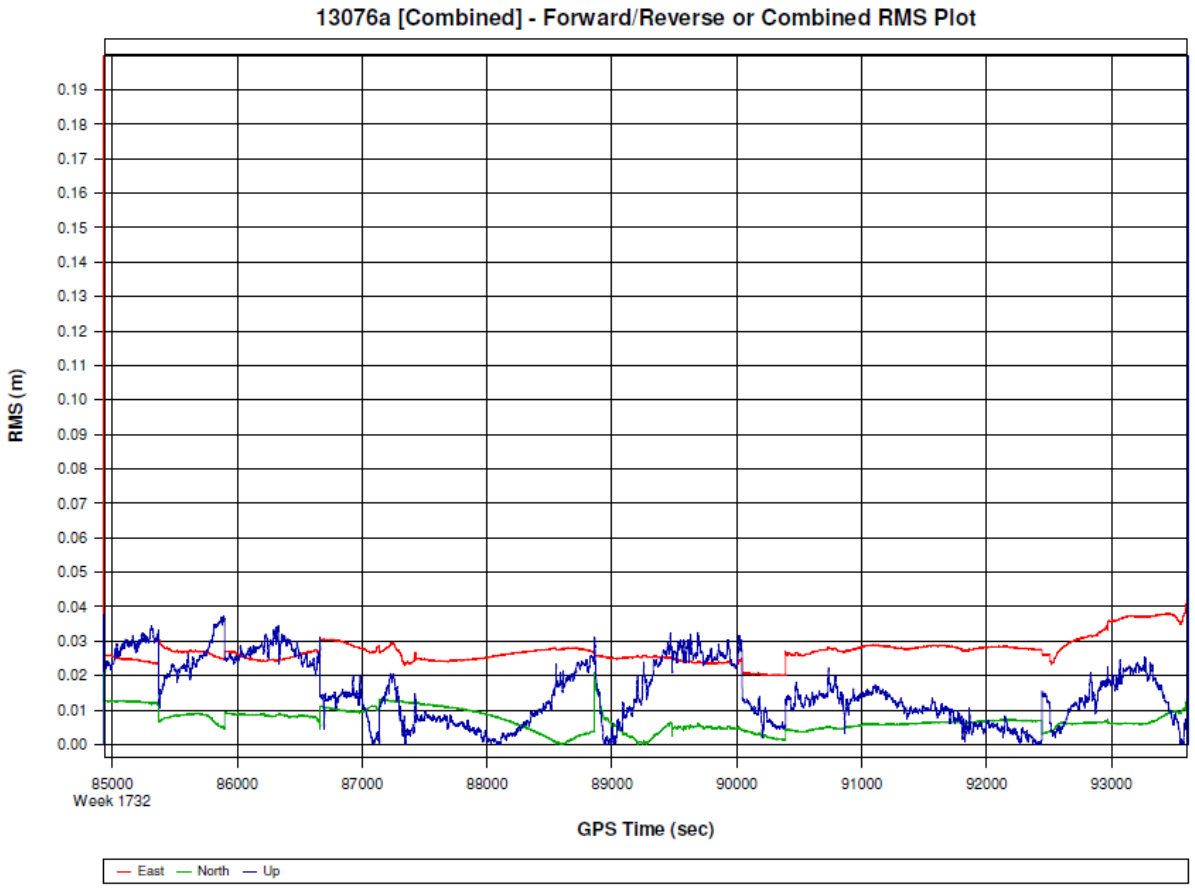




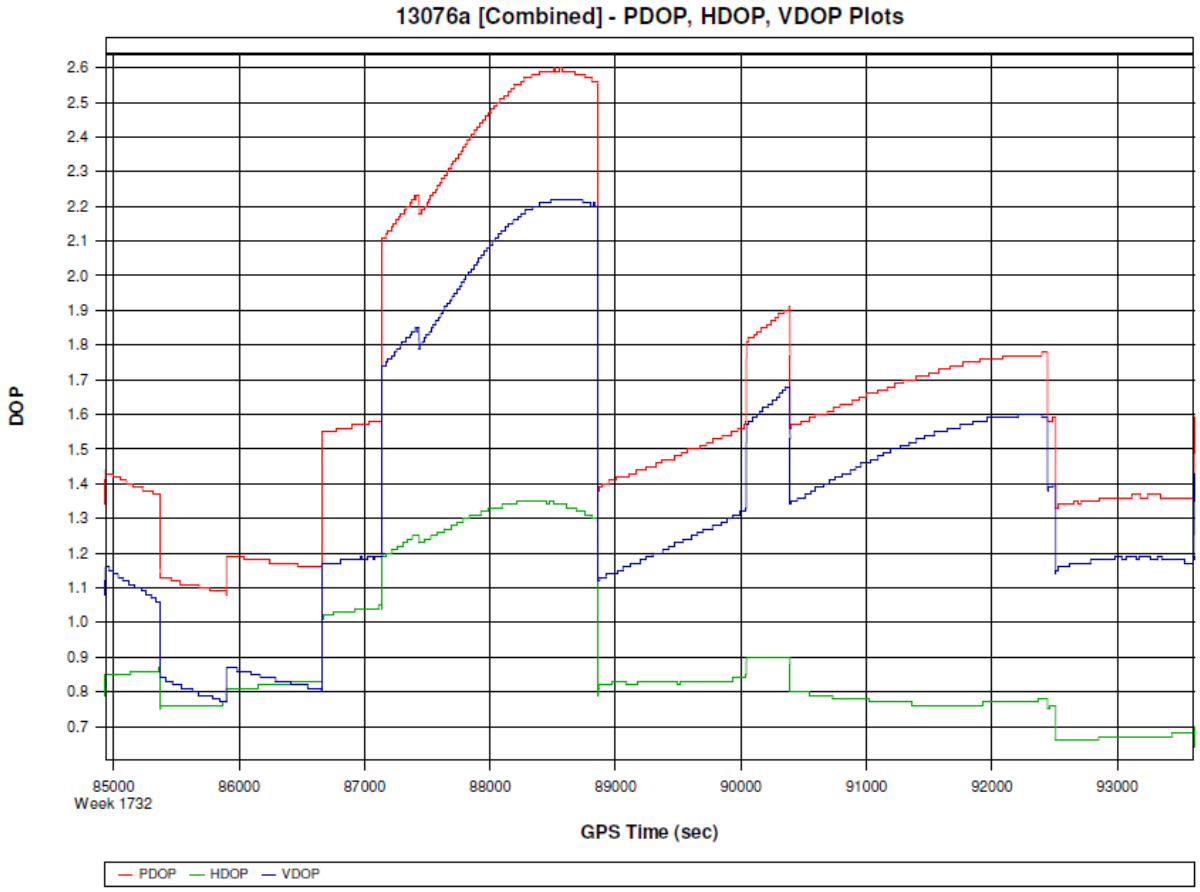


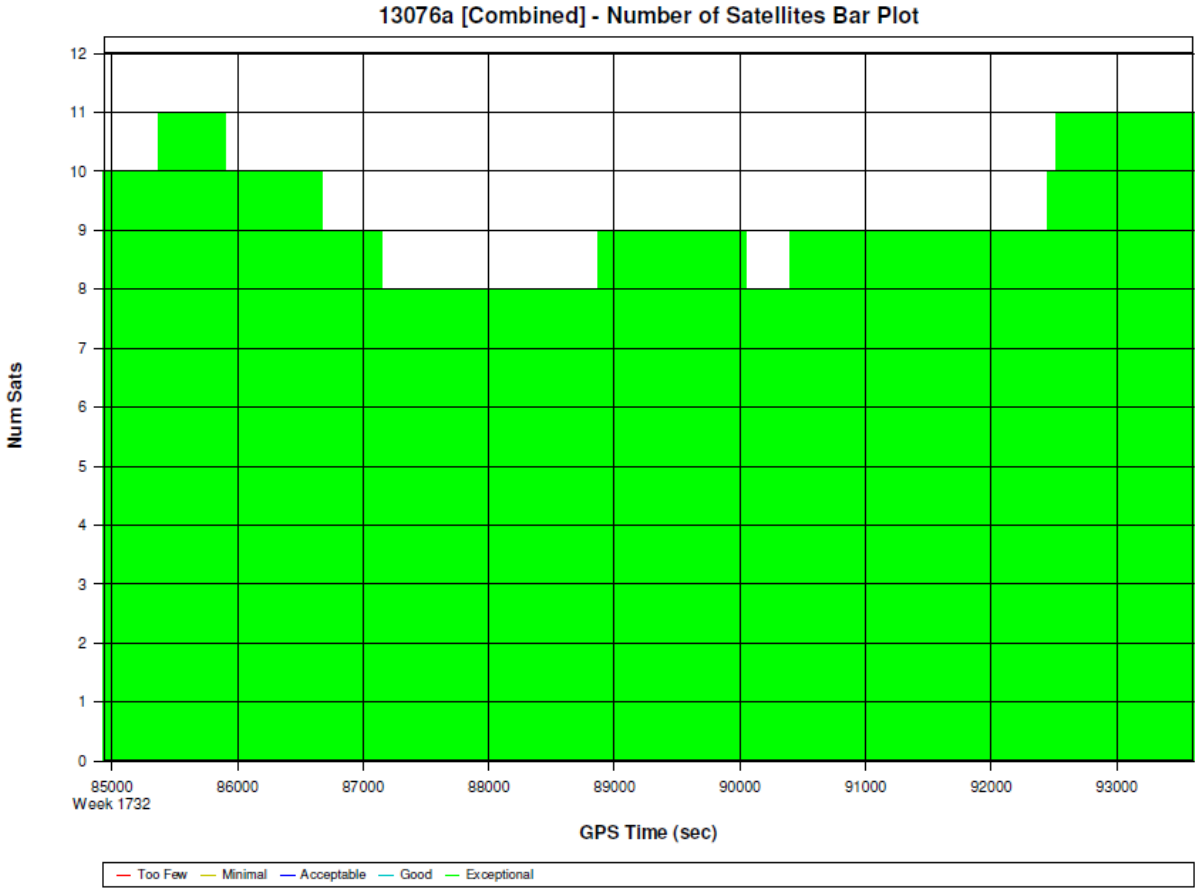

Project: 13076a
POSGPS v4.30
Combined - Map Run (29)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log20110530_211
20 km
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

Project: 13076a POSGPS v4.30



Project: 13076a POSGPS v4.30

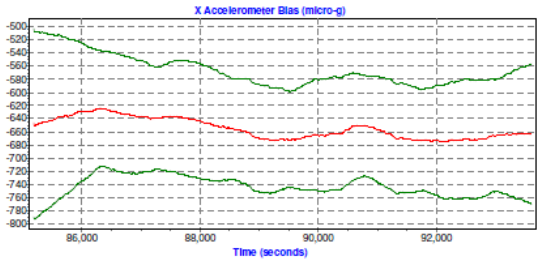


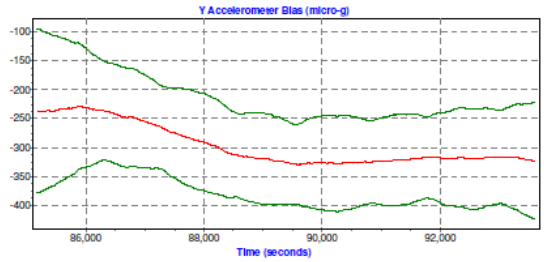

13076a [Combined] - Number of Satellites Bar Plot
Num Sats
0
1
2
3
4
5
6
7
8
9
10
11
12
85000
Week 1732
86000
87000
88000
89000
90000
91000
92000
93000
GPS Time (sec)
Too Few
Minimal
Acceptable
Good
Exceptional

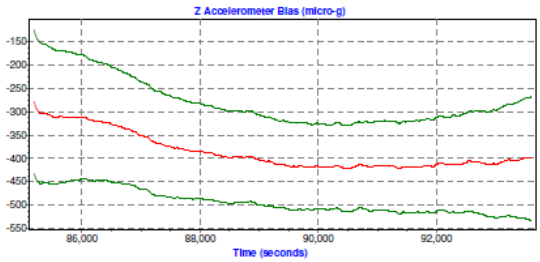
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13076a\pos\GPS\13076a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      105126
      No processed position:  96442
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0277 (m)
      C/A Code:   0.90 (m)
      L1 Doppler: 0.017 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.039 (m)
      North:      0.011 (m)
      Height:     0.026 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8678 occurances):
      East:       0.039 (m)
      North:      0.011 (m)
      Height:     0.025 (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:          40.956 (km)
      Minimum:          9.274 (km)
      Average:          22.726 (km)
      First Epoch:      20.152 (km)
      Last Epoch:       9.274 (km)
```

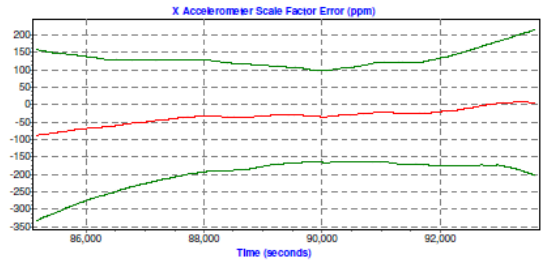
Sensor Errors

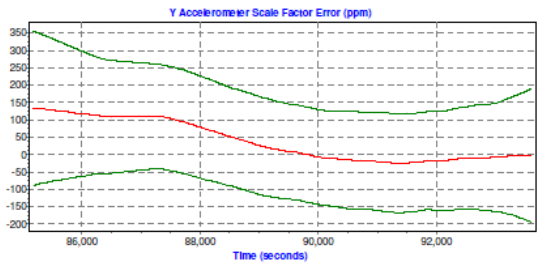
POSPac Version 4.3 - 1 - 4/15/2013 - 11:52:04 AM

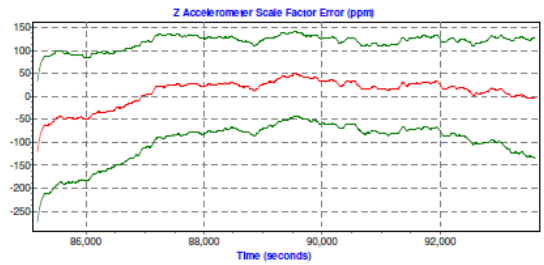






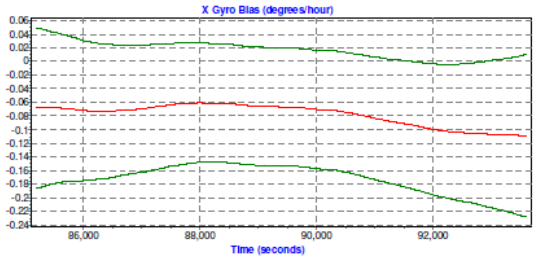


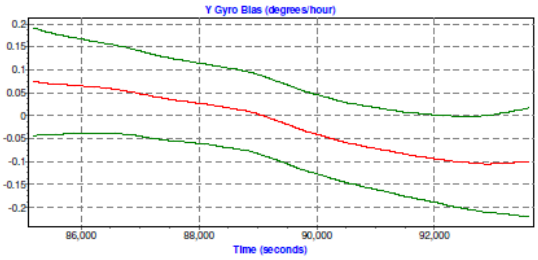


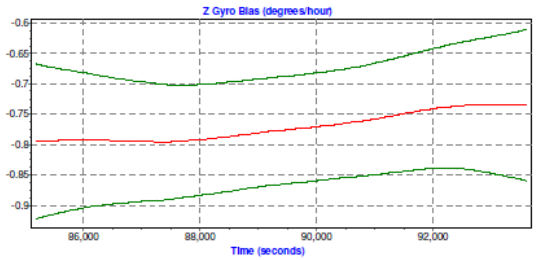


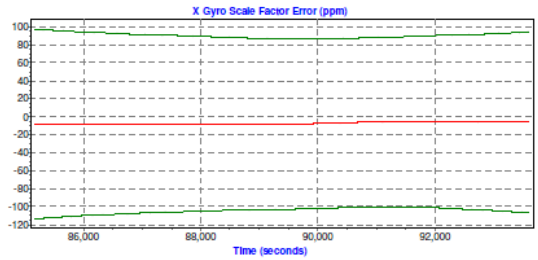
Sensor Errors

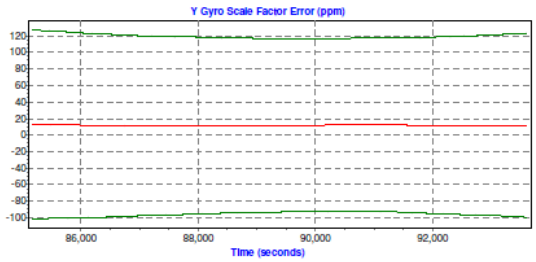
POSPac Version 4.3 - 2 - 4/15/2013 - 11:52:04 AM

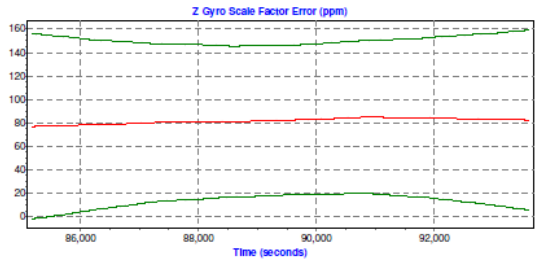




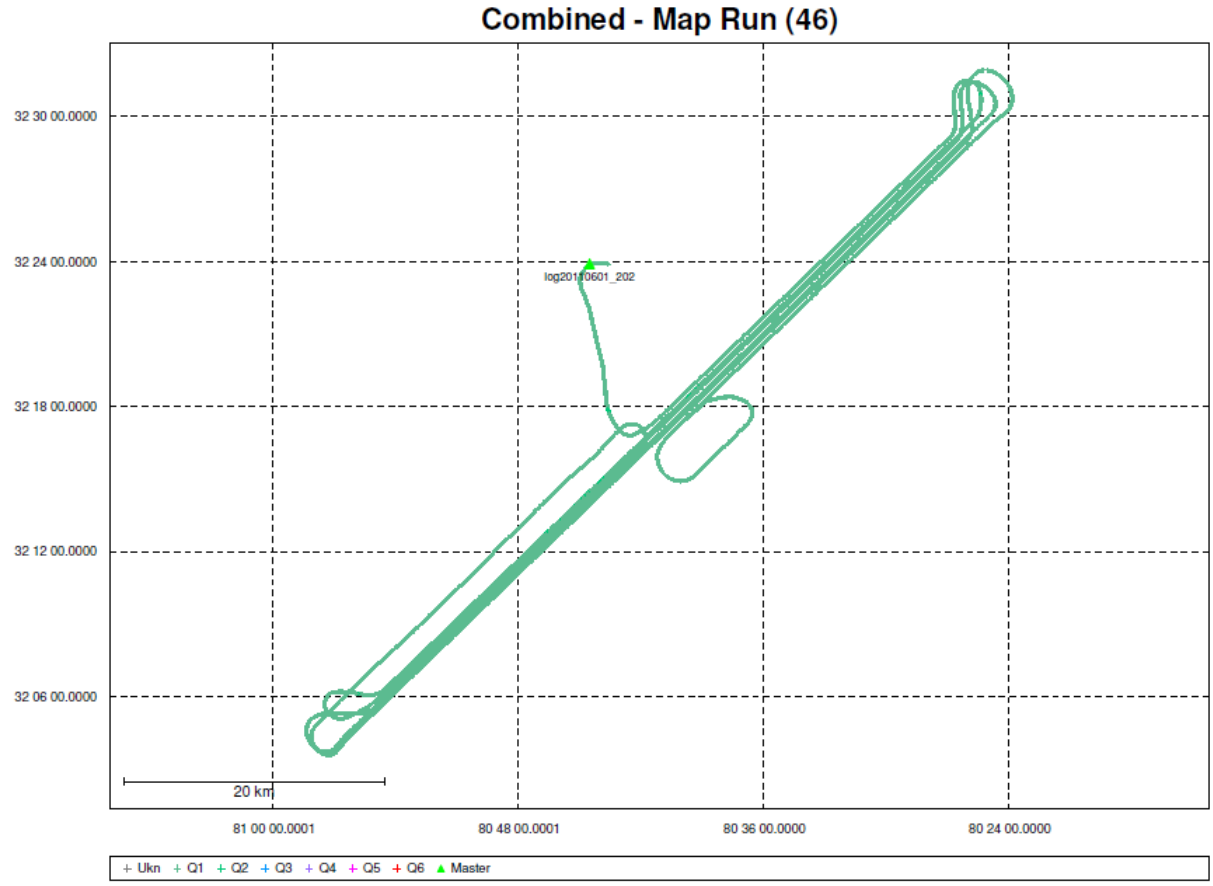




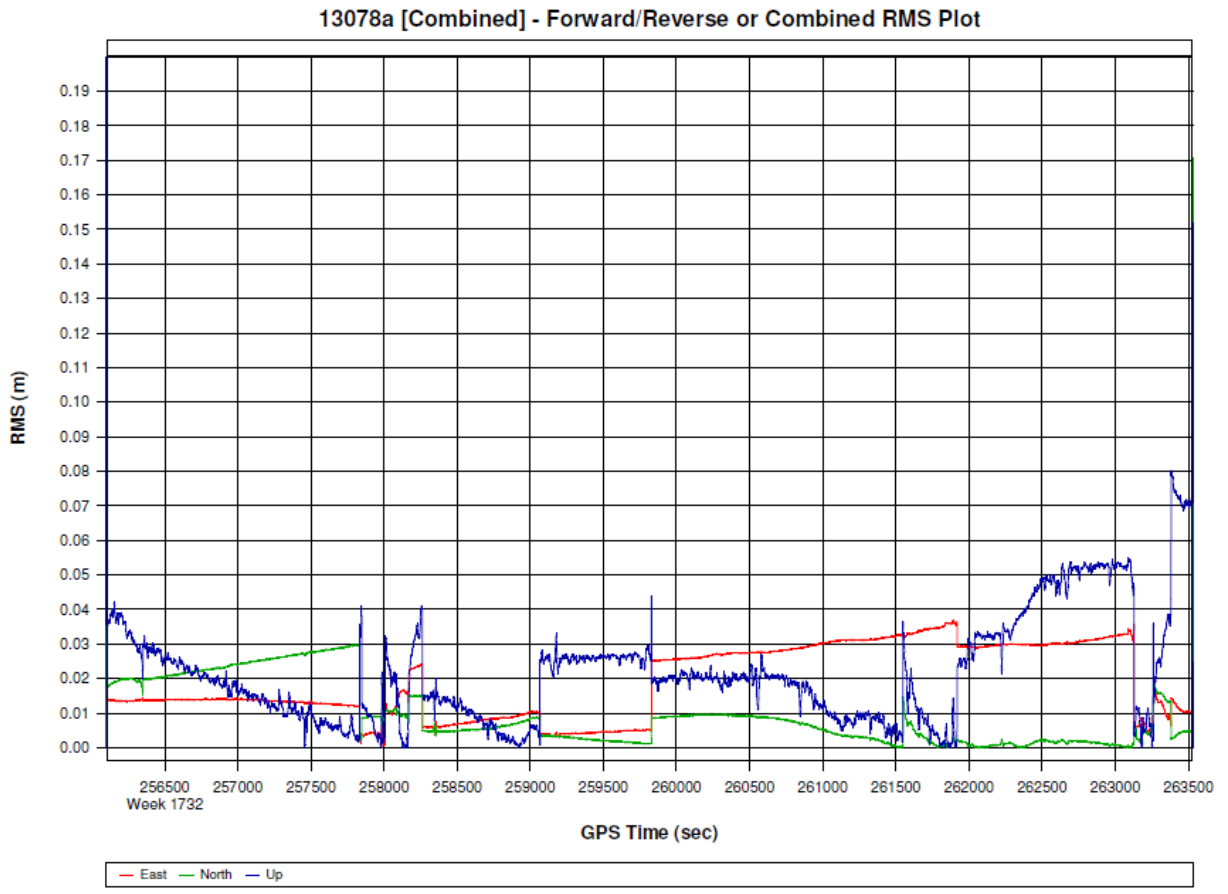




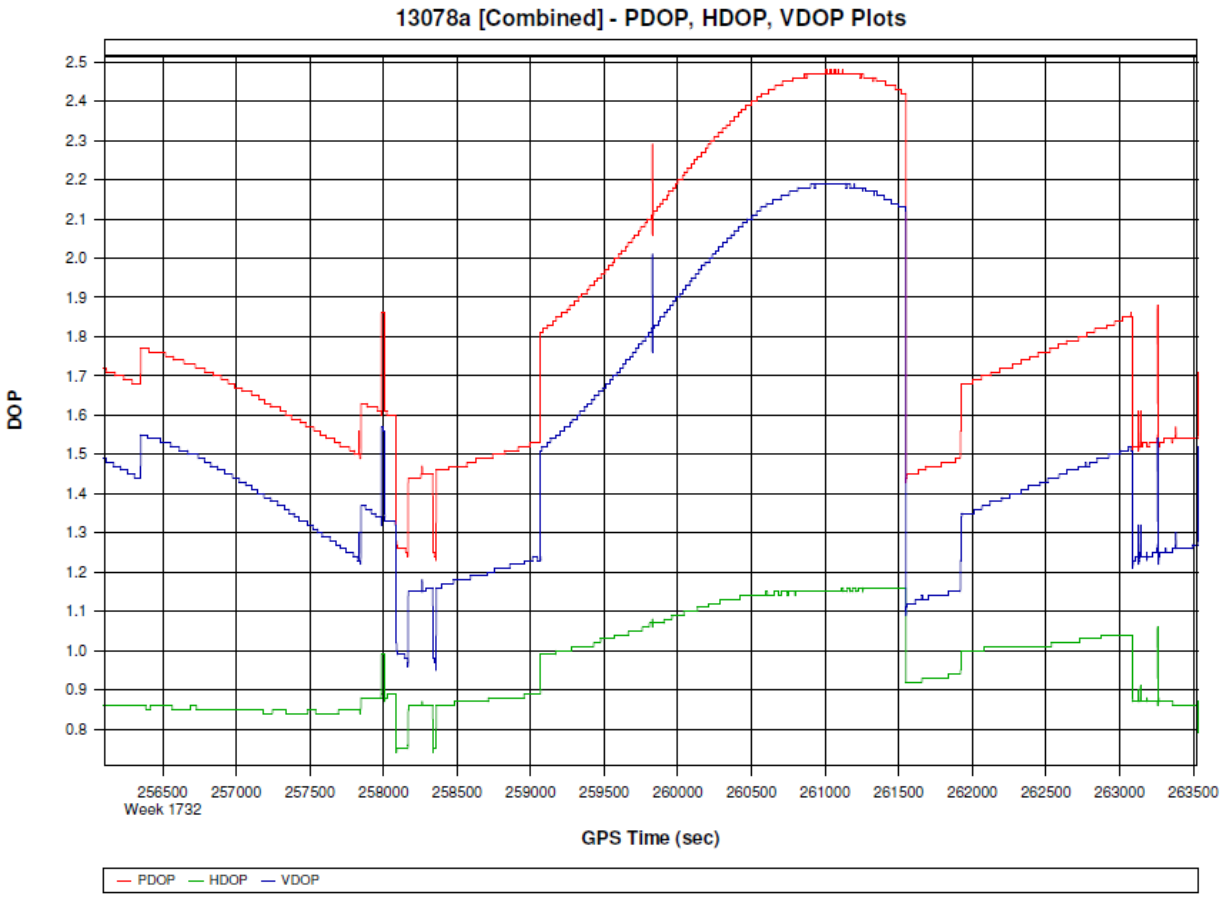
Project: 13078a POSGPS v4.30



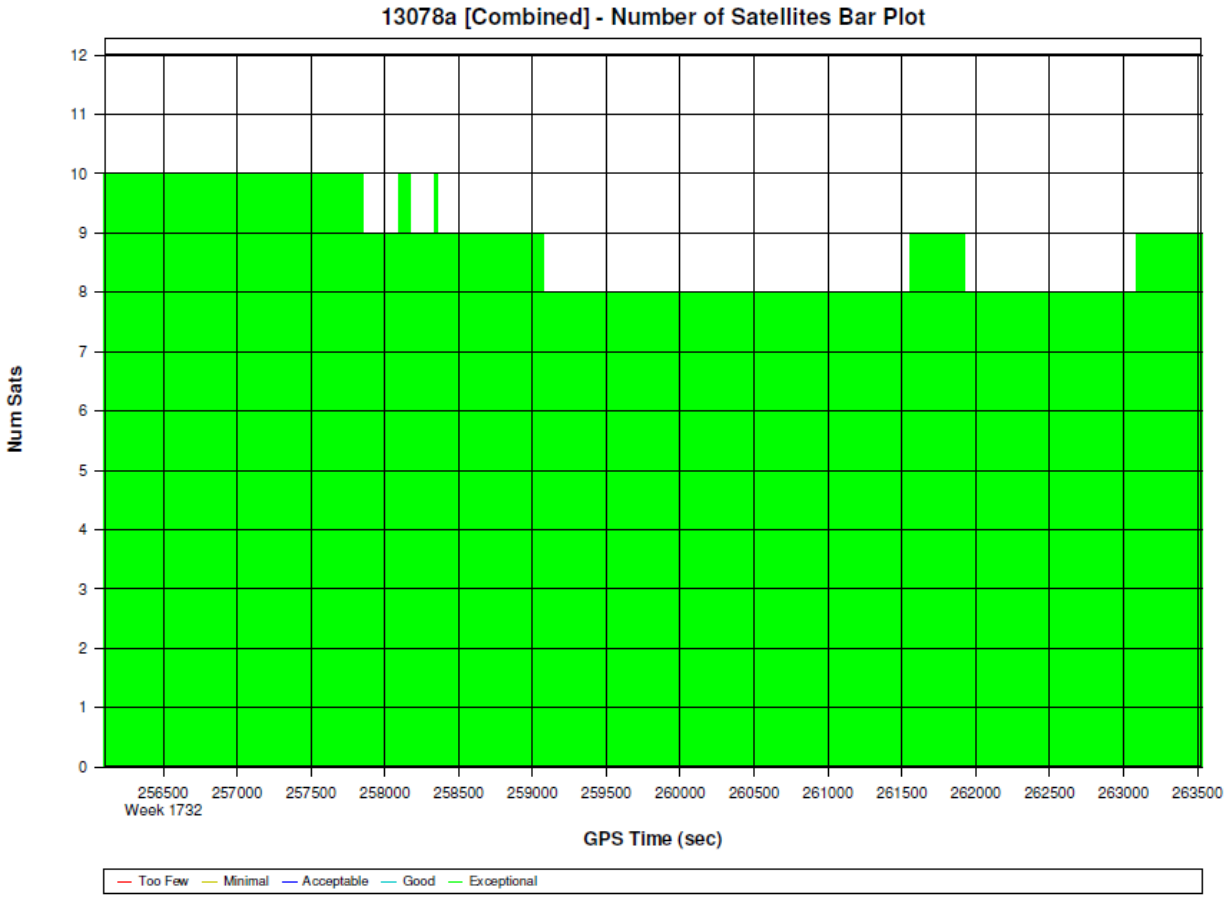
Project: 13078a POSGPS v4.30



Project: 13078a POSGPS v4.30



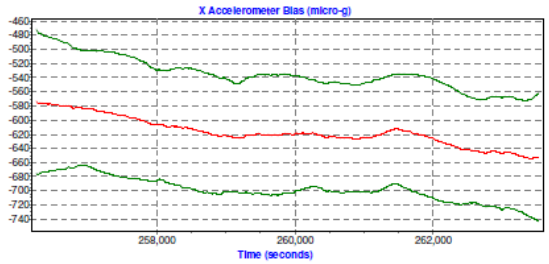
Project: 13078a POSGPS v4.30

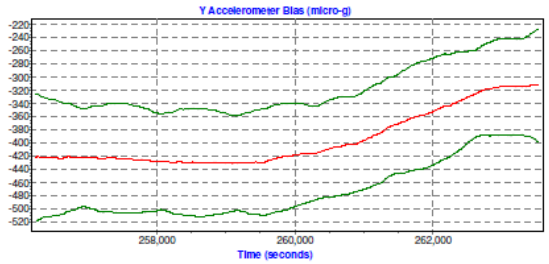


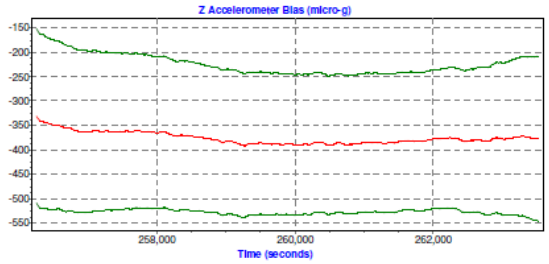
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13078a\pos\GPS\13078a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      163862
      No processed position:  156428
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0300 (m)
      C/A Code:   0.88 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.031 (m)
      North:      0.019 (m)
      Height:     0.040 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (7428 occurances):
      East:       0.031 (m)
      North:      0.018 (m)
      Height:     0.038 (m)

Quality Number Percentages:
      Q 1:  99.4 %
      Q 2:   0.6 %
      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:          42.729 (km)
      Minimum:          0.659 (km)
      Average:          22.799 (km)
      First Epoch:      1.551 (km)
      Last Epoch:       14.623 (km)
```

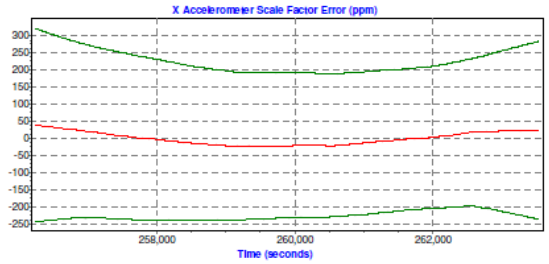
Sensor Errors

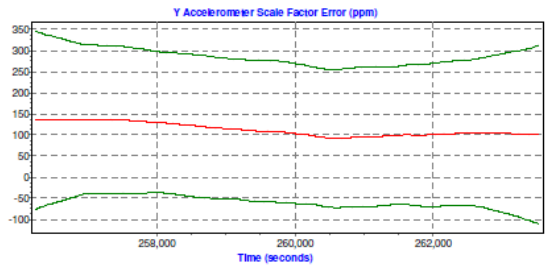
POSPac Version 4.3 - 1 - 4/15/2013 - 12:06:24 PM

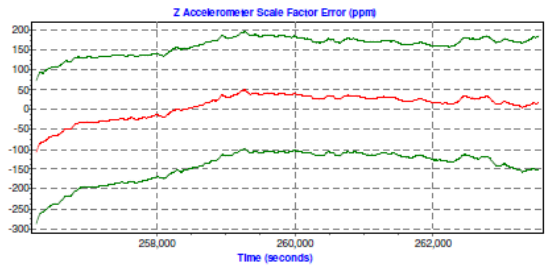






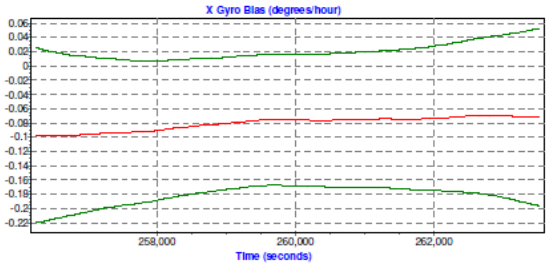


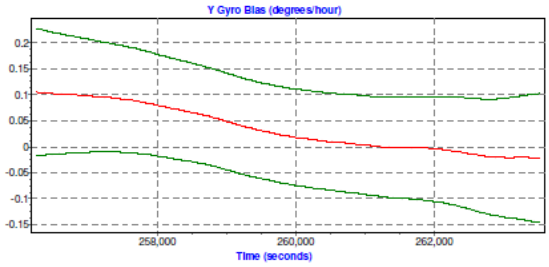


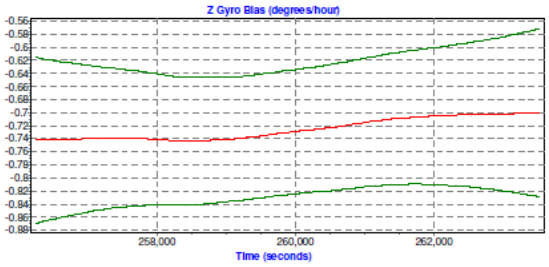


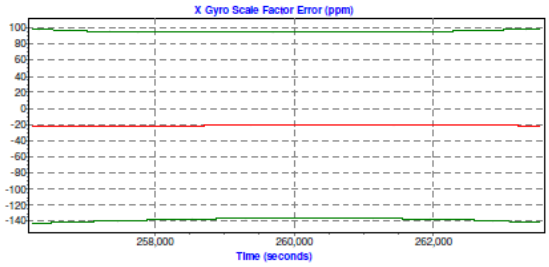
Sensor Errors

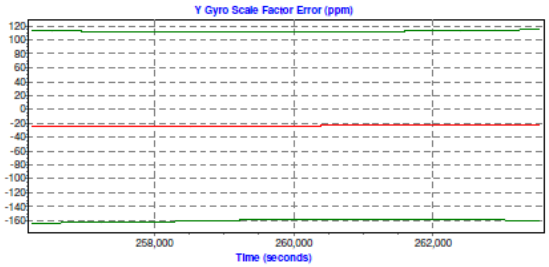
POSPac Version 4.3 - 2 - 4/15/2013 - 12:06:25 PM

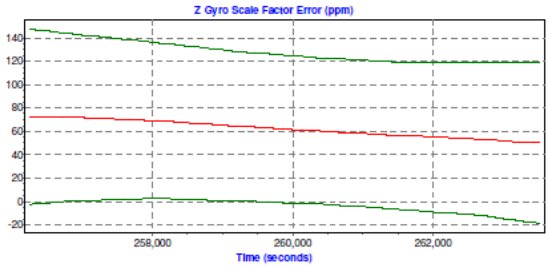


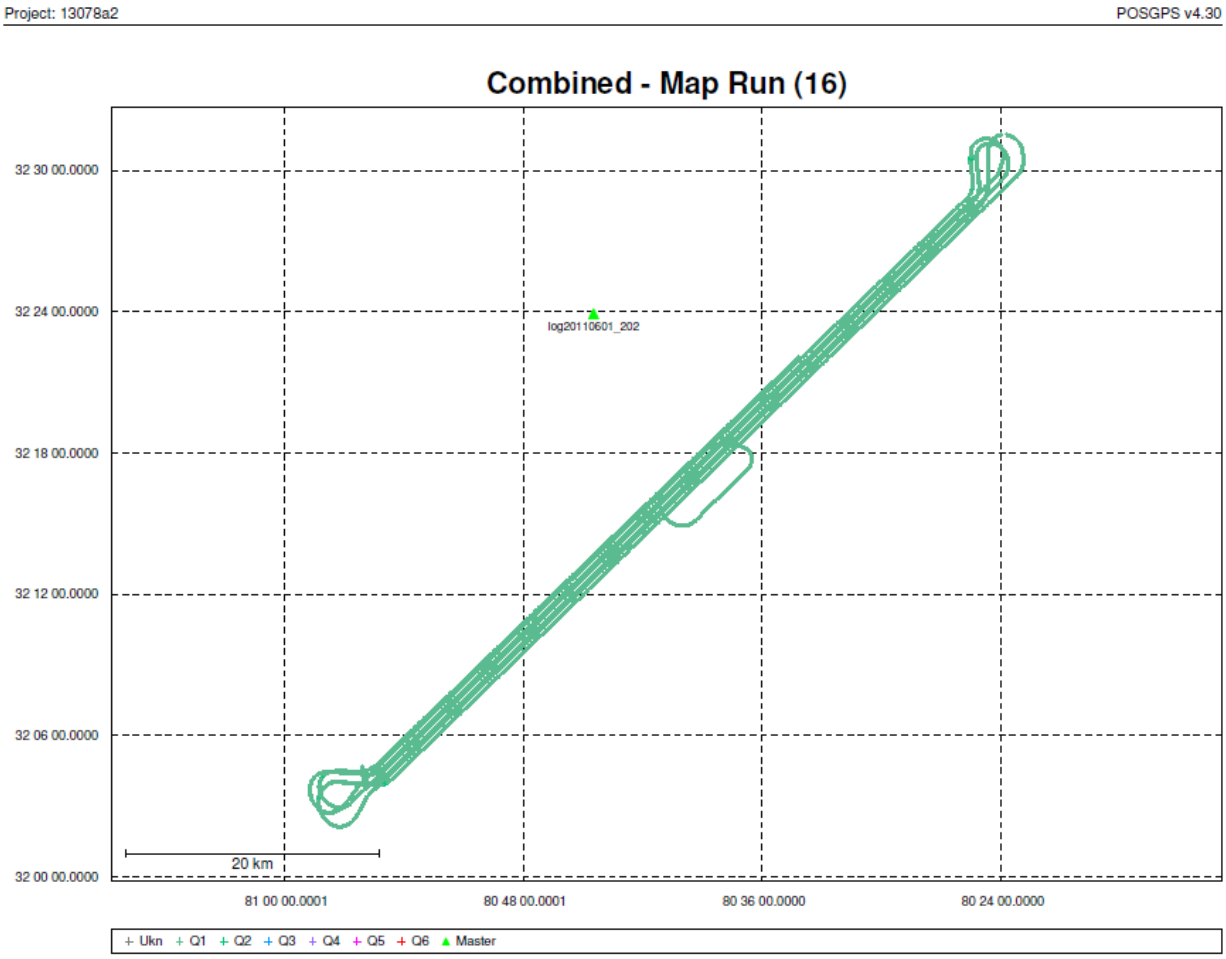




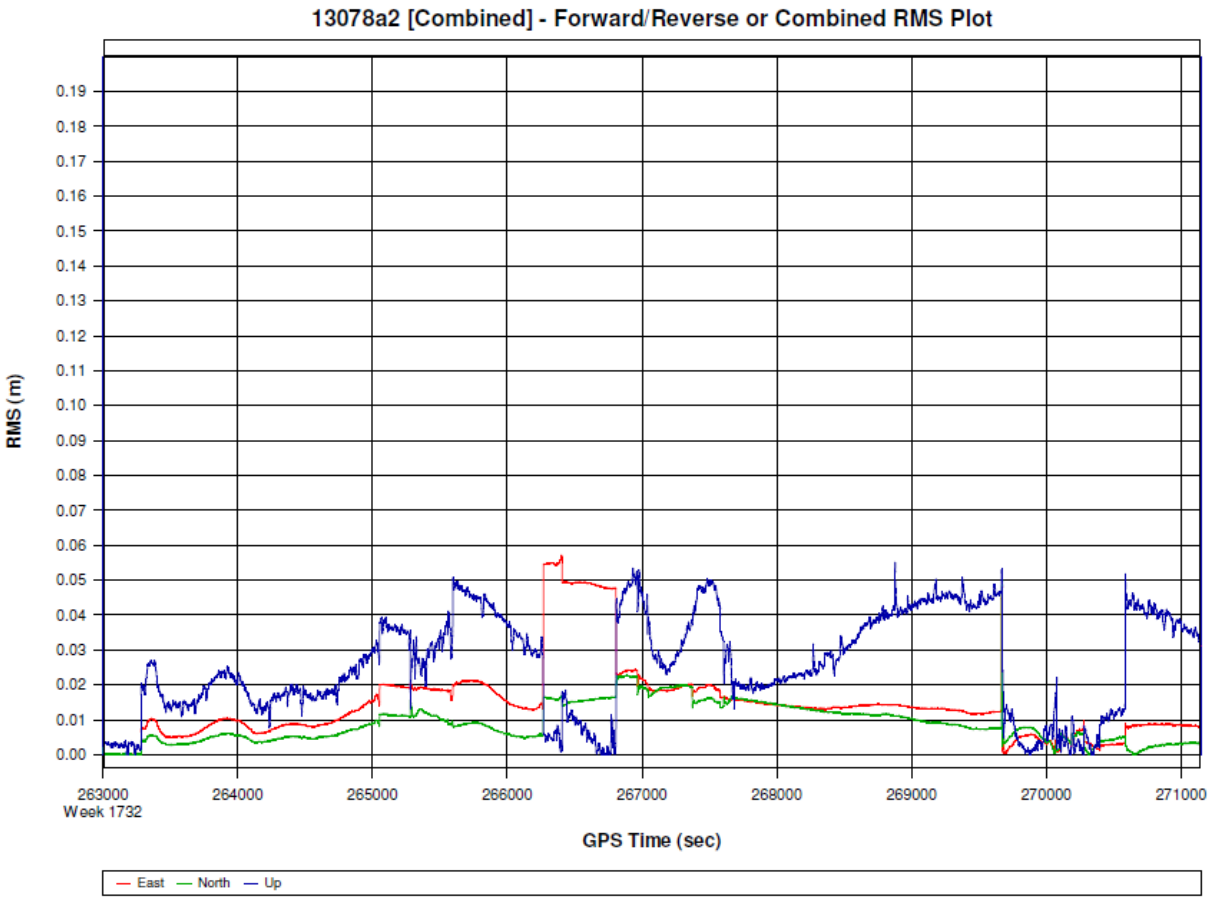




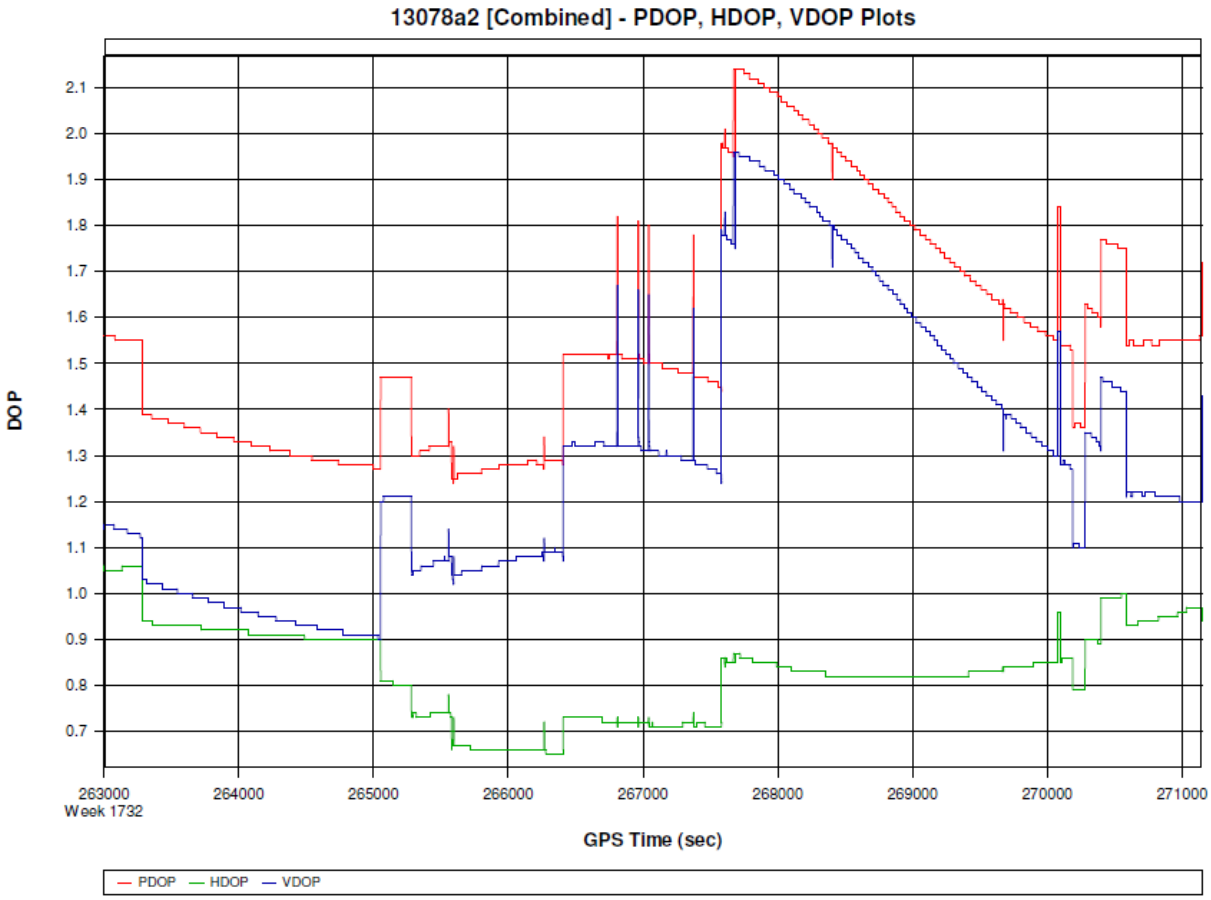



Project: 13078a2
POSGPS v4.30
Combined - Map Run (16)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
32 00 00.0000
log20110601_202
20 km
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master

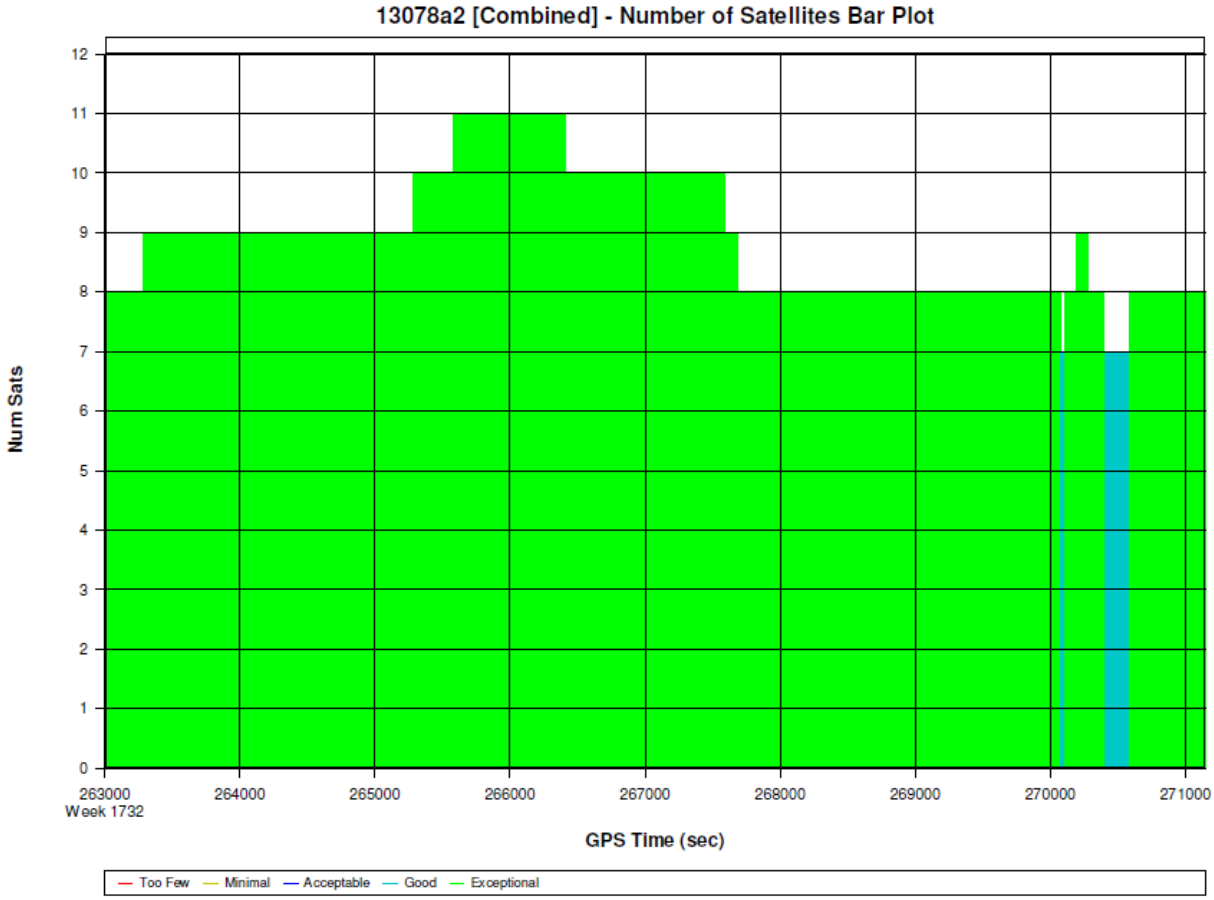
Project: 13078a2 POSGPS v4.30



Project: 13078a2 POSGPS v4.30



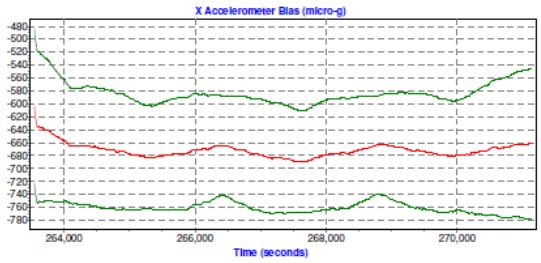
Project: 13078a2 POSGPS v4.30

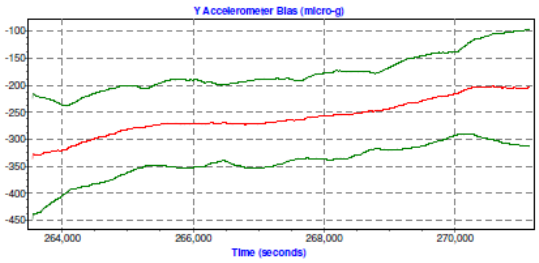


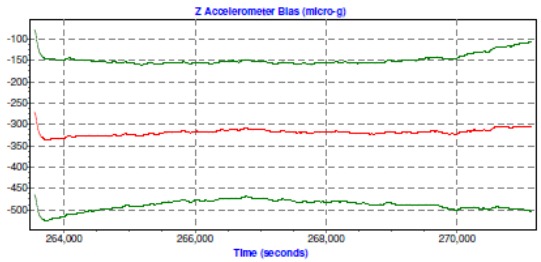
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13078a\pos2\GPS\13078a2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      163862
      No processed position:  155711
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0257 (m)
      C/A Code:   0.90 (m)
      L1 Doppler: 0.017 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.026 (m)
      North:      0.015 (m)
      Height:     0.044 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8145 occurances):
      East:       0.026 (m)
      North:      0.015 (m)
      Height:     0.042 (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:          45.123 (km)
      Minimum:          13.710 (km)
      Average:          25.133 (km)
      First Epoch:      16.563 (km)
      Last Epoch:       39.925 (km)
```

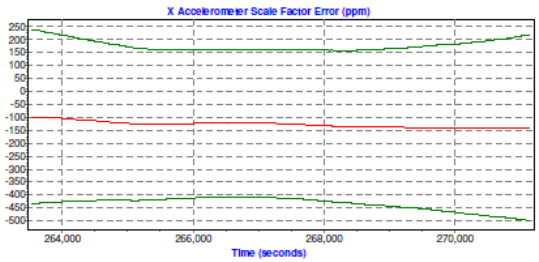
Sensor Errors

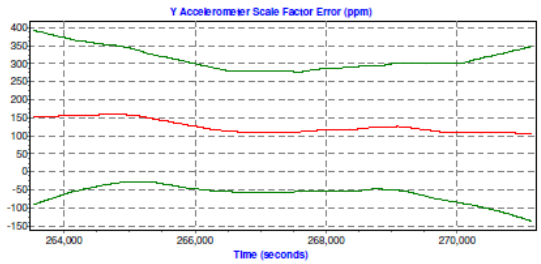
POSPac Version 4.3 - 1 - 4/15/2013 - 12:09:41 PM

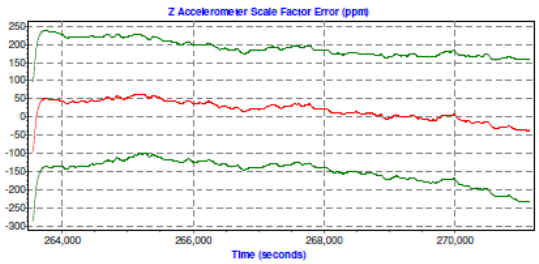


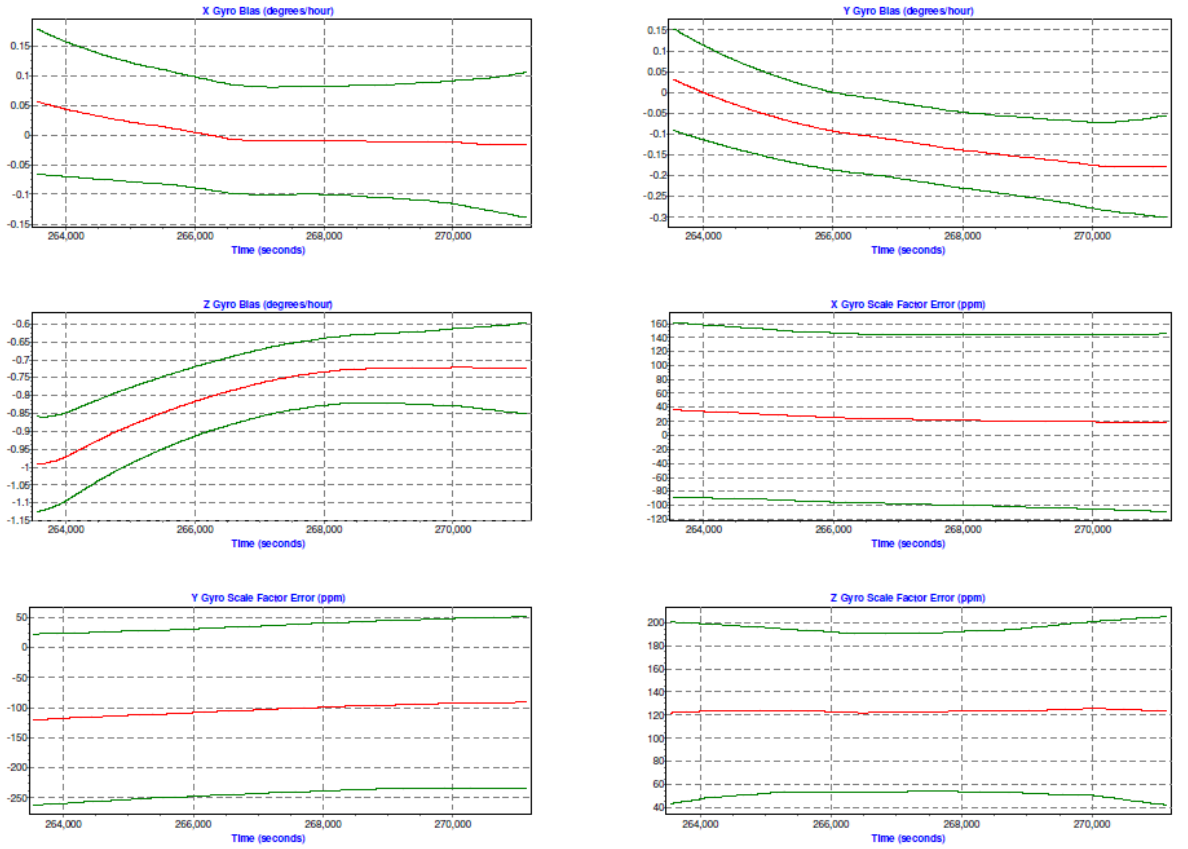




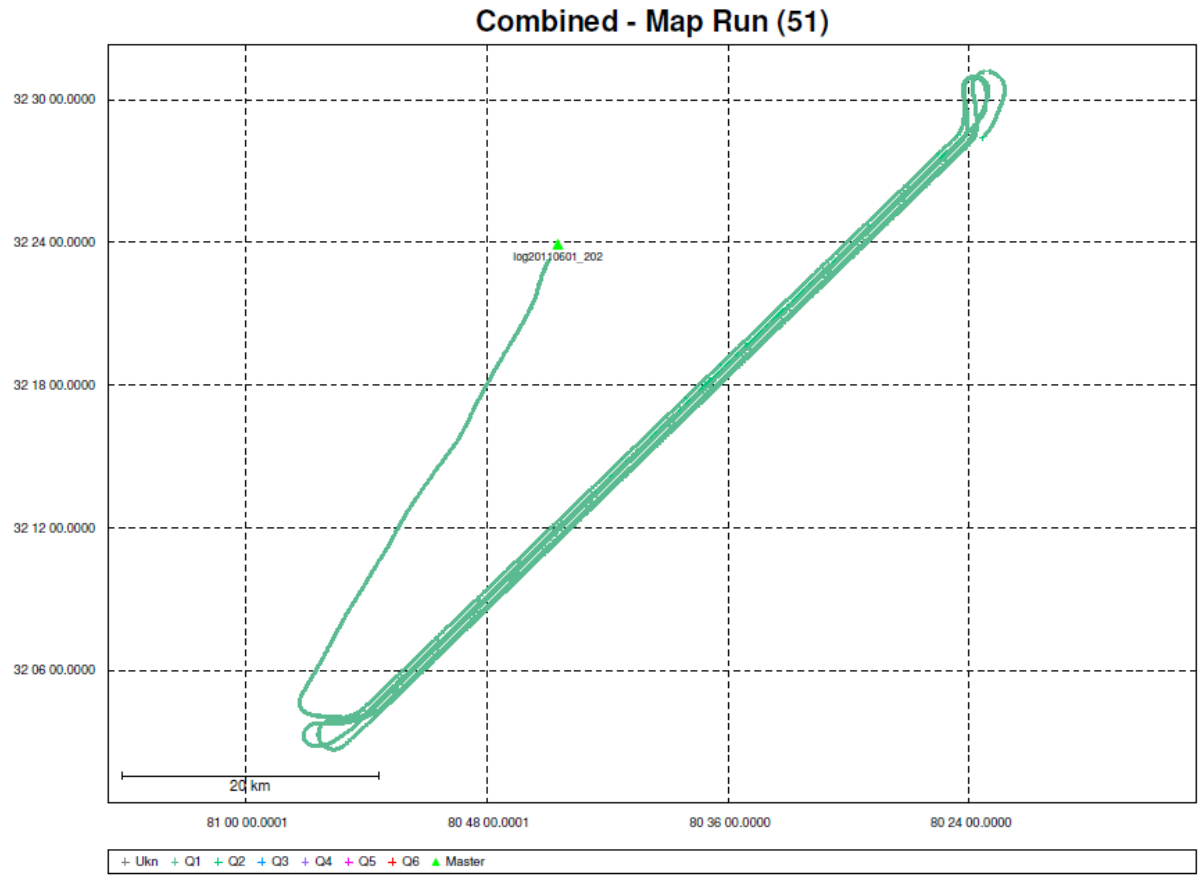




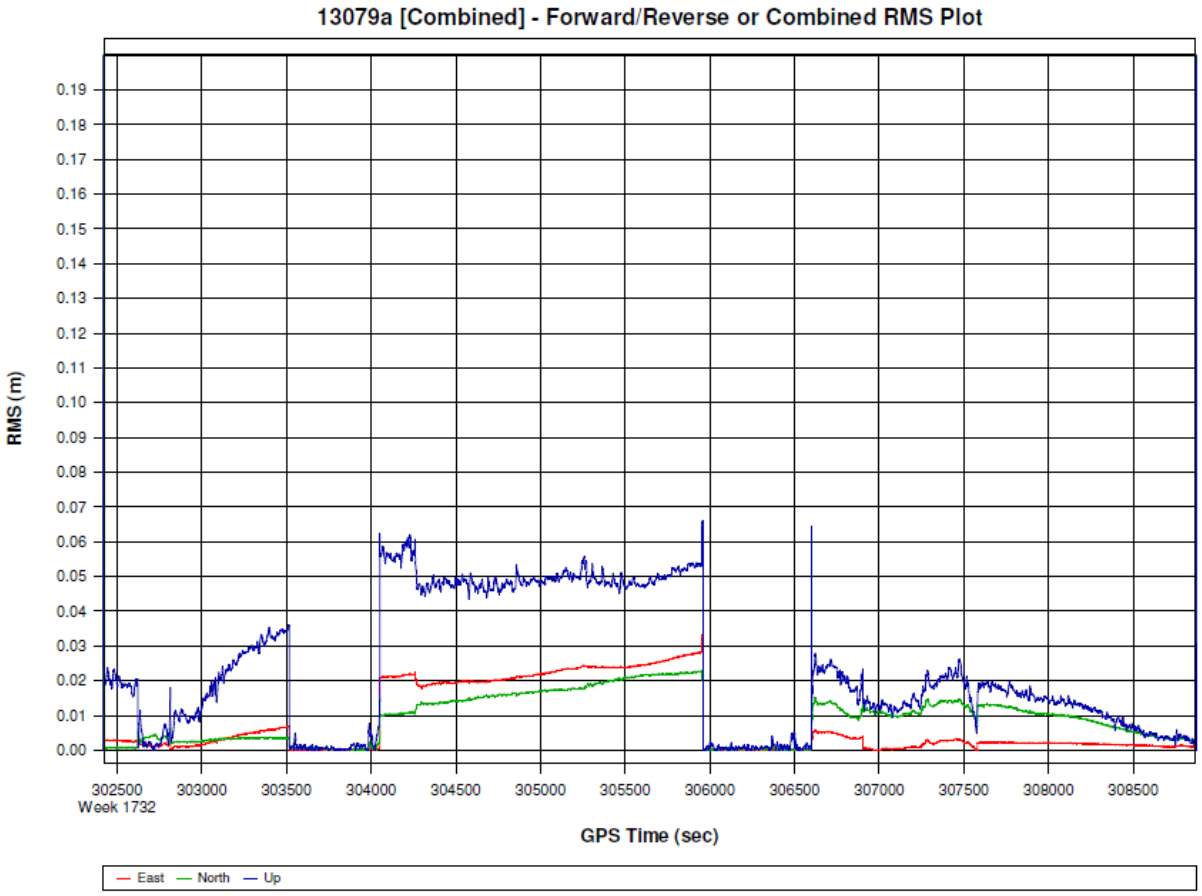



X Gyro Bias (degrees/hour)
Y Gyro Bias (degrees/hour)
Z Gyro Bias (degrees/hour)
X Gyro Scale Factor Error (ppm)
Y Gyro Scale Factor Error (ppm)
Z Gyro Scale Factor Error (ppm)
Time (seconds)
264,000
266,000
268,000
270,000

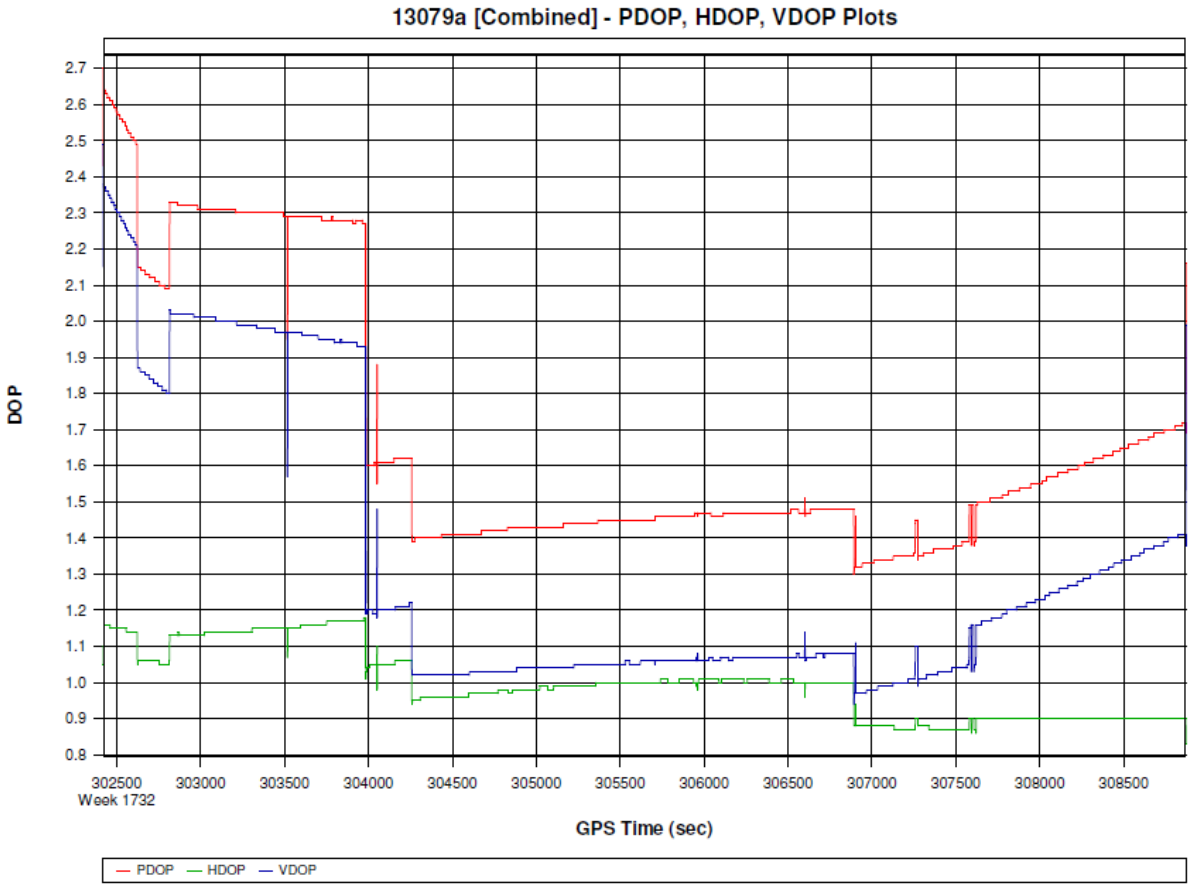
Project: 13079a POSGPS v4.30



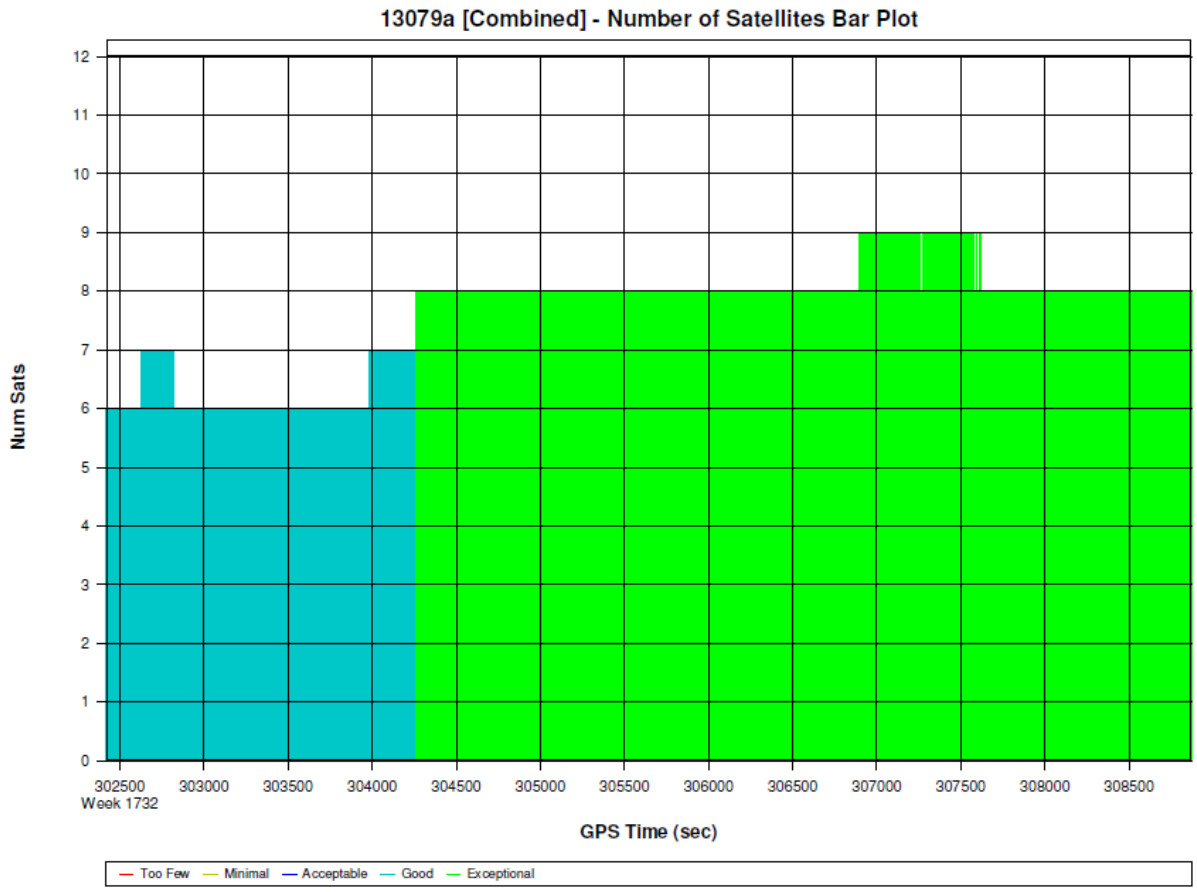
Project: 13079a POSGPS v4.30



Project: 13079a POSGPS v4.30



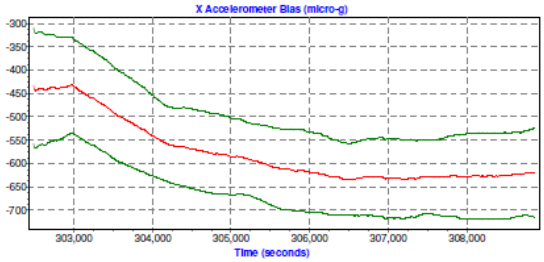
Project: 13079a POSGPS v4.30

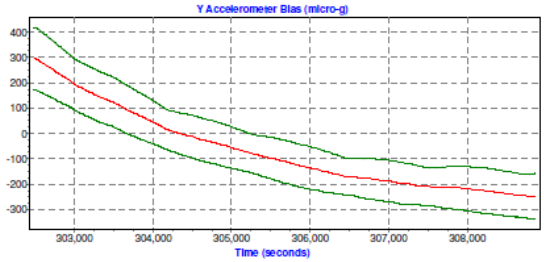


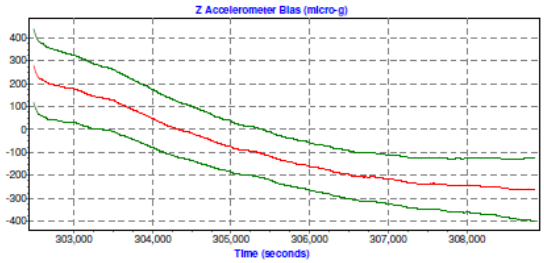
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13079a\pos\GPS\13079a.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      164231
      No processed position:  157775
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0331 (m)
      C/A Code:   1.05 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.019 (m)
      North:      0.018 (m)
      Height:     0.045 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (6450 occurances):
      East:       0.018 (m)
      North:      0.016 (m)
      Height:     0.042 (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:          43.474 (km)
      Minimum:          1.656 (km)
      Average:          25.949 (km)
      First Epoch:      1.656 (km)
      Last Epoch:       34.106 (km)
```

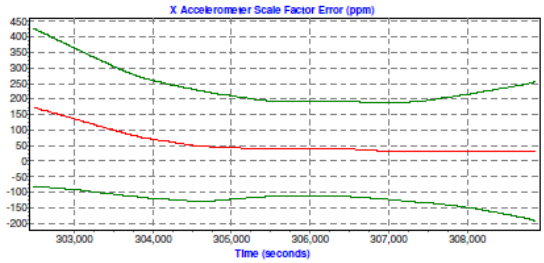
Sensor Errors

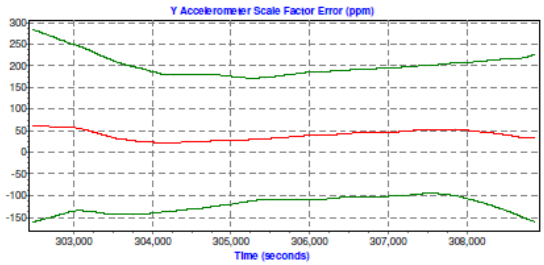
POSPac Version 4.3 - 1 - 4/15/2013 - 12:21:15 PM

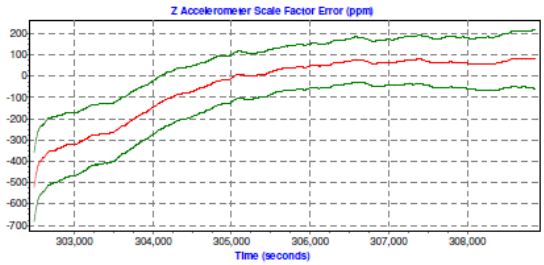


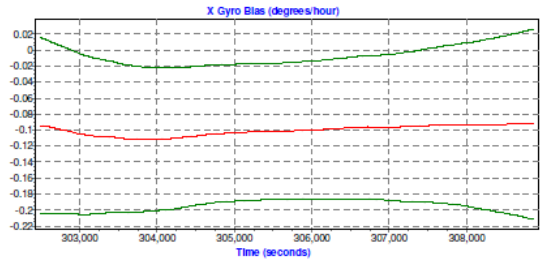


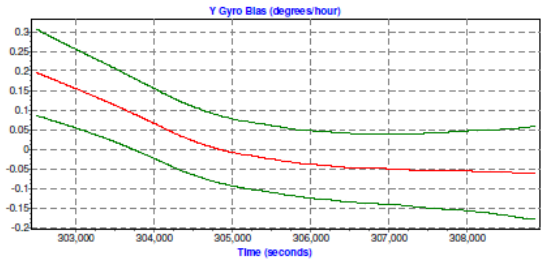


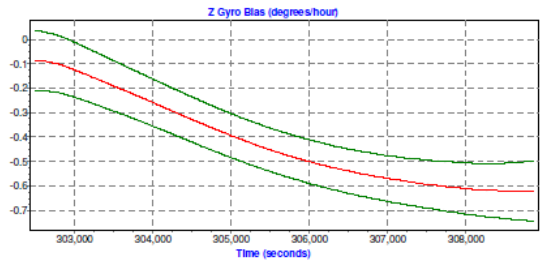


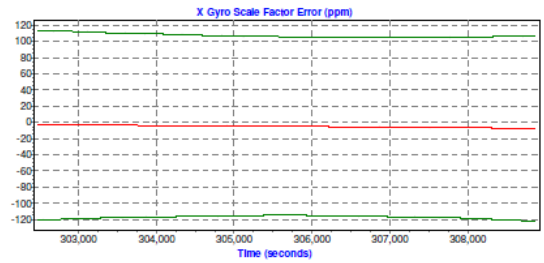


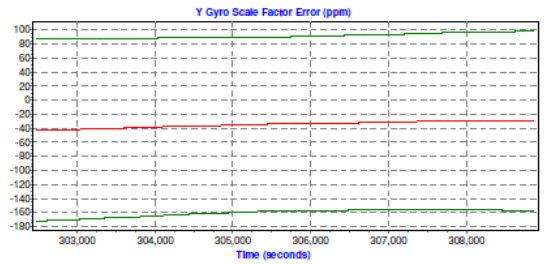


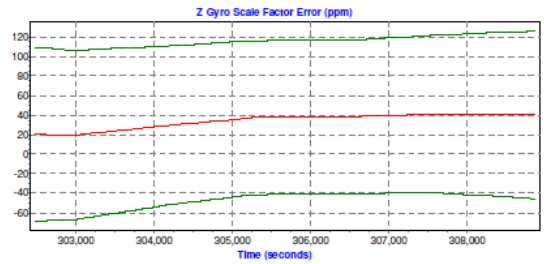

X Gyro Bias (degrees/hour)
Time (seconds)

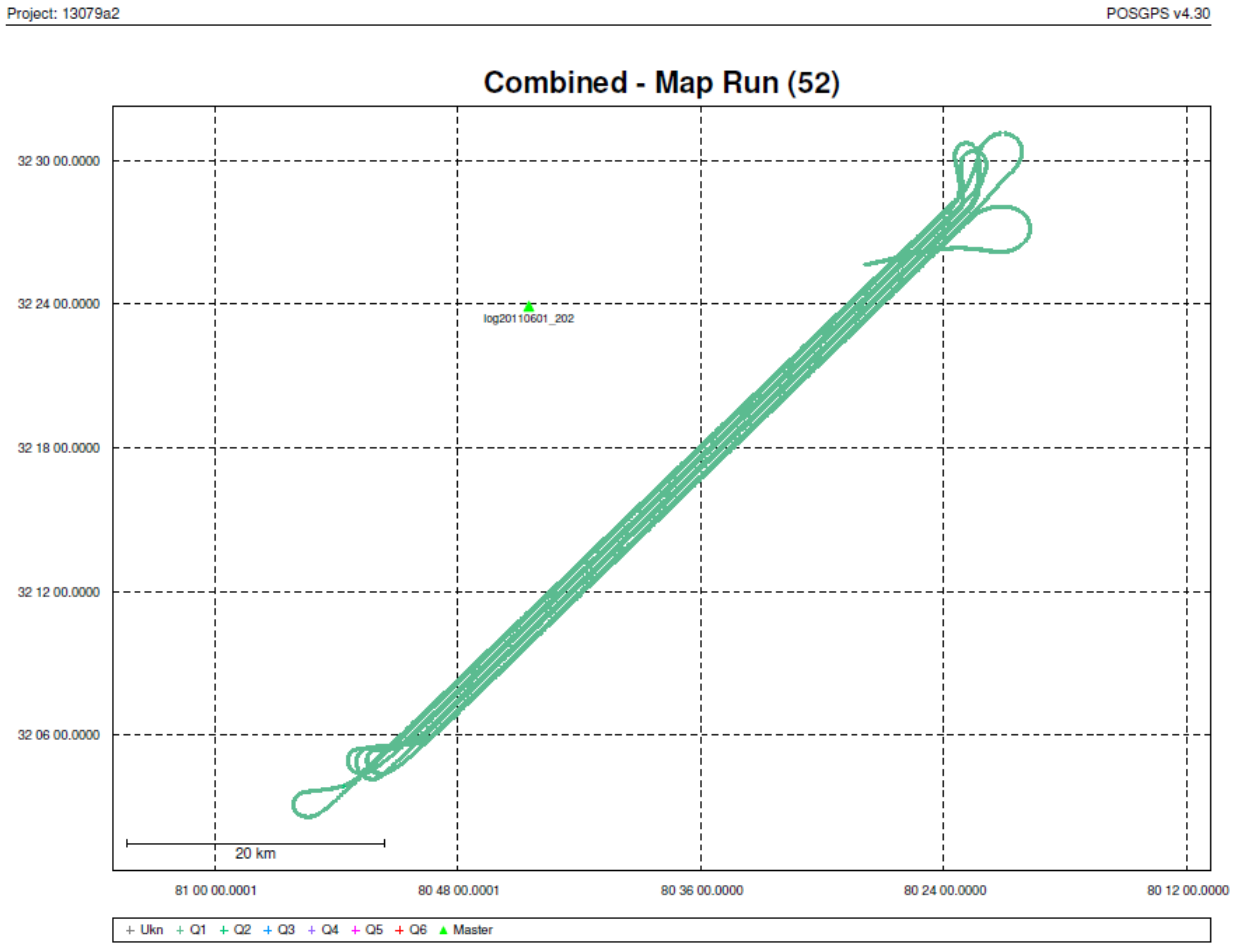

Y Gyro Bias (degrees/hour)
Time (seconds)


Z Gyro Bias (degrees/hour)
Time (seconds)

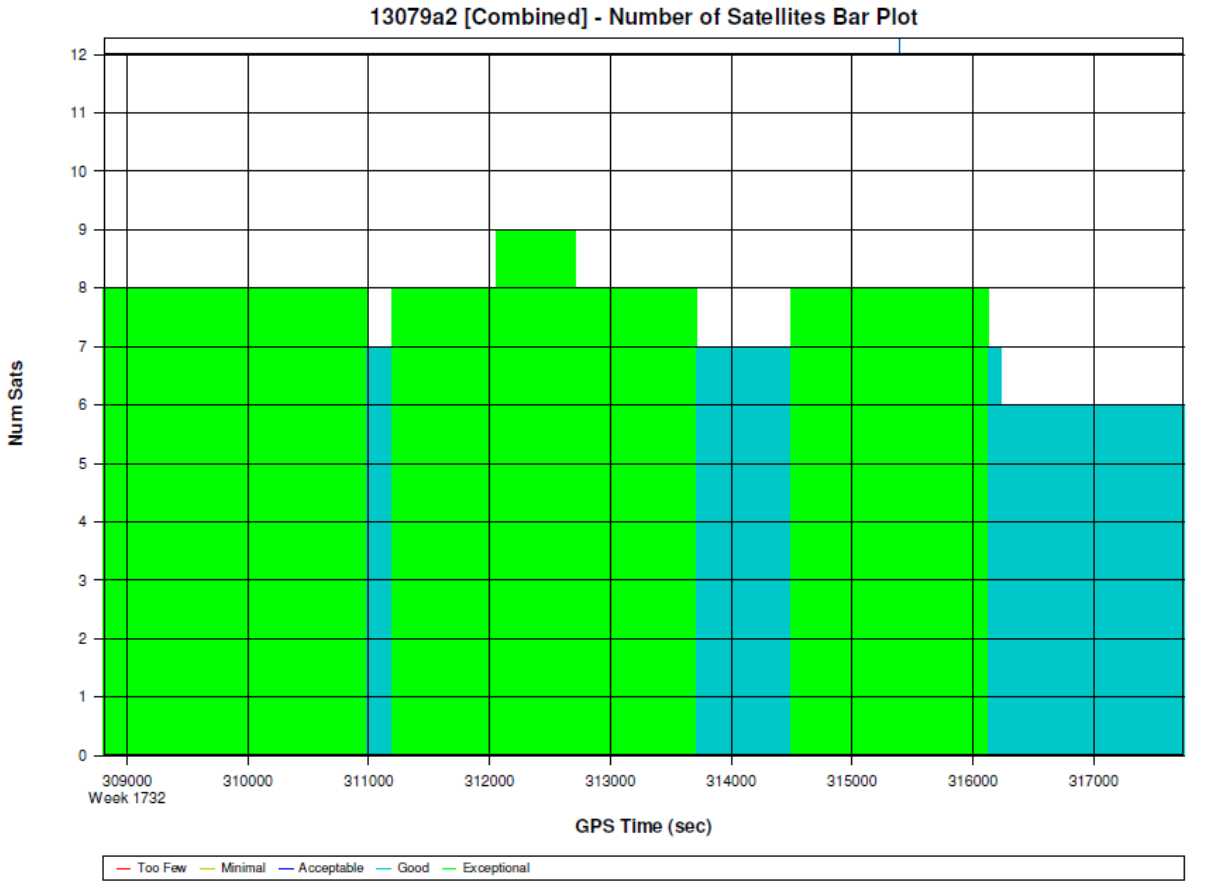

X Gyro Scale Factor Error (ppm)
Time (seconds)


Y Gyro Scale Factor Error (ppm)
Time (seconds)

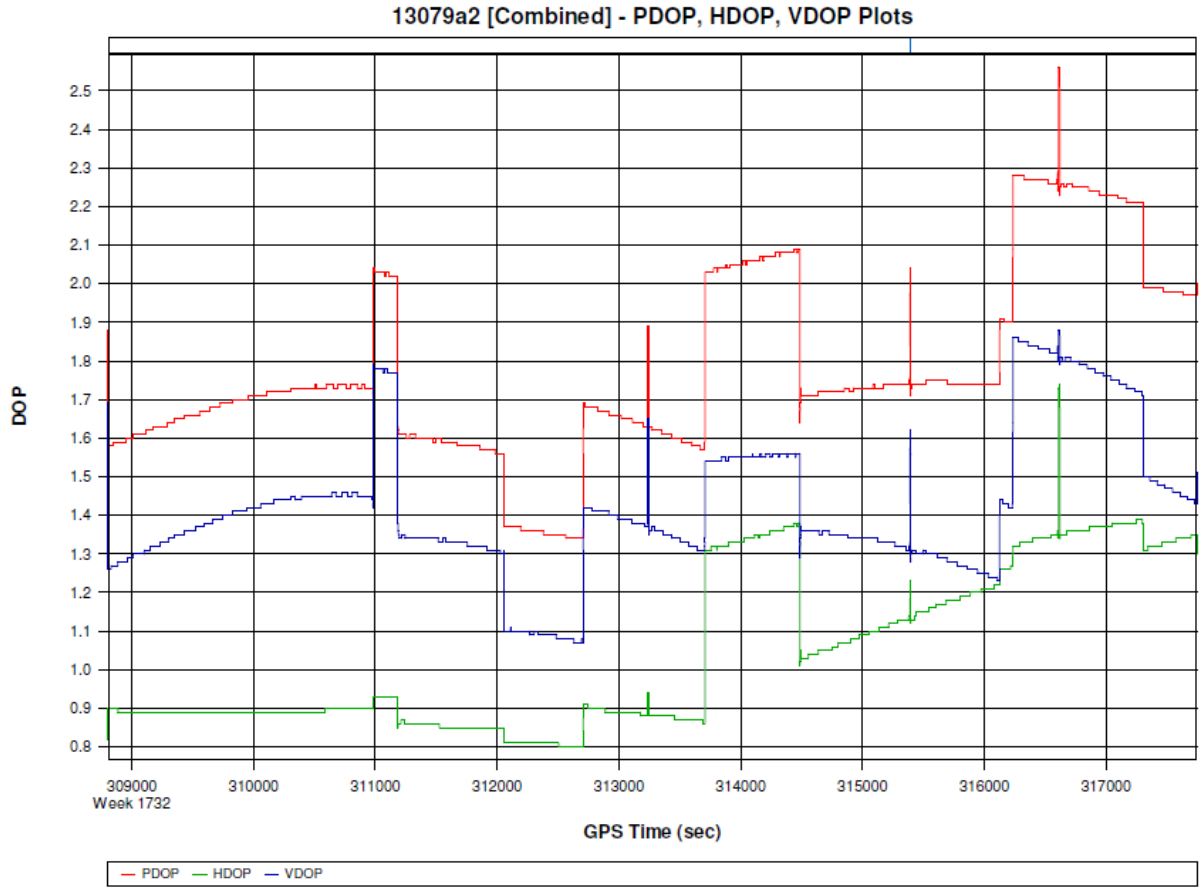

Z Gyro Scale Factor Error (ppm)
Time (seconds)


Project: 13079a2
POSGPS v4.30
Combined - Map Run (52)
32 30 00.0000
32 24 00.0000
32 18 00.0000
32 12 00.0000
32 06 00.0000
log20110601_202
20 km
81 00 00.0001
80 48 00.0001
80 36 00.0000
80 24 00.0000
80 12 00.0000
Ukn
Q1
Q2
Q3
Q4
Q5
Q6
Master

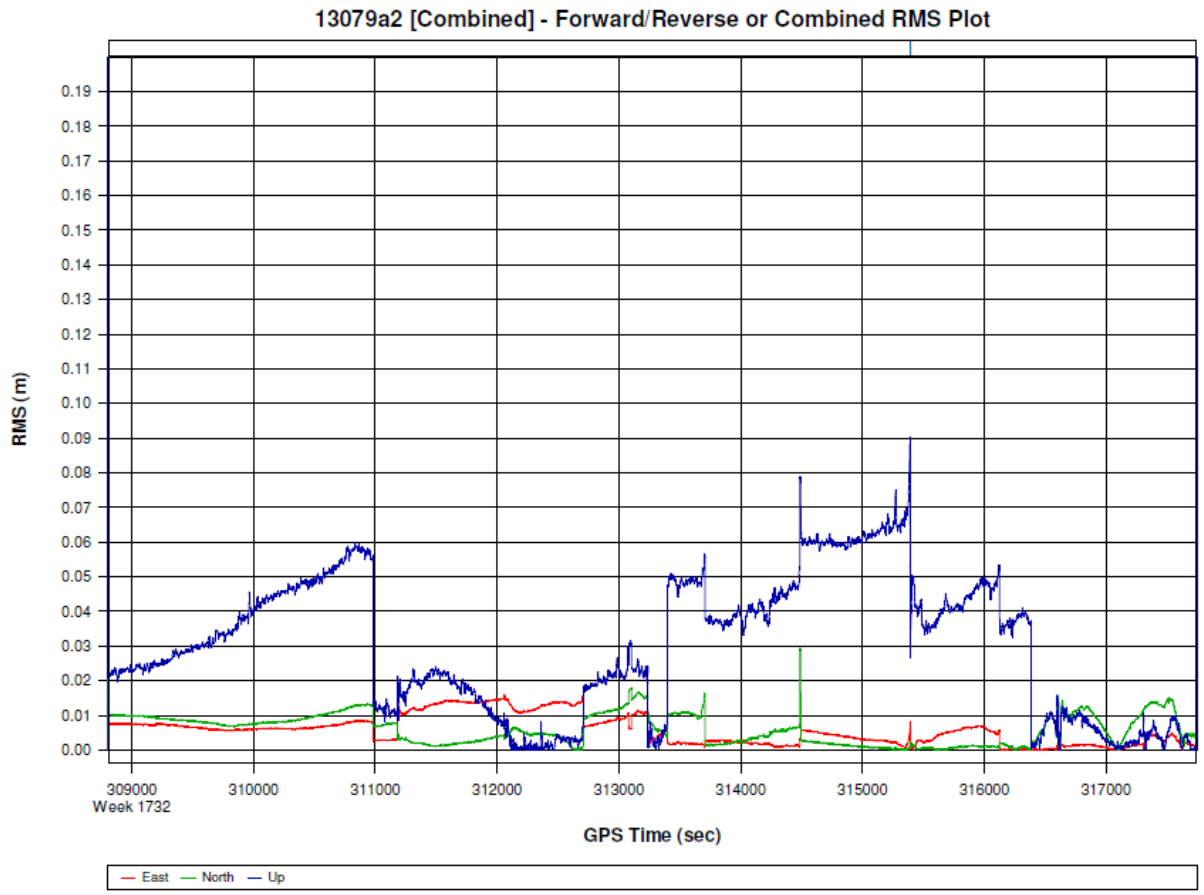
Project: 13079a2 POSGPS v4.30



Project: 13079a2 POSGPS v4.30



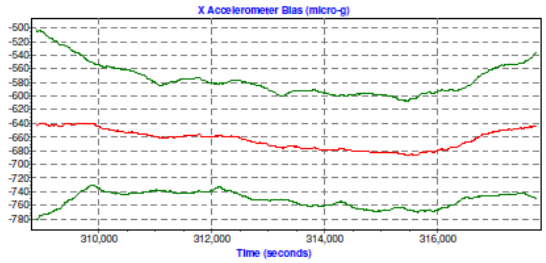
Project: 13079a2 POSGPS v4.30

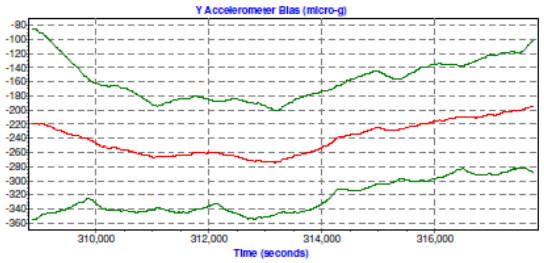


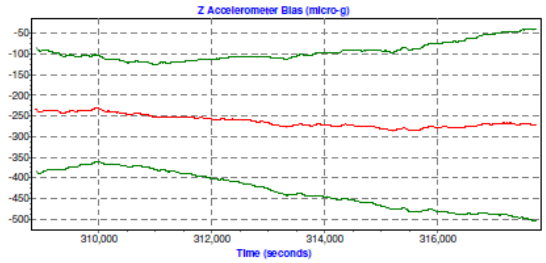
```
          Processing Summary Information

Program: POSGPS
Version: 4.30.3108
Project: C:\Projects\BeaufortSC\13079a\pos2\GPS\13079a2.gnv

Solution Type:    Combined Fwd/Rev

Number of Epochs:
      Total in GPB file:      164231
      No processed position:  155283
      Missing Fwd or Rev:     4
      With bad C/A code:      0
      With bad L1 Phase:      0

Measurement RMS Values:
      L1 Phase:   0.0260 (m)
      C/A Code:   0.97 (m)
      L1 Doppler: 0.018 (m/s)

Fwd/Rev Separation RMS Values:
      East:       0.013 (m)
      North:      0.015 (m)
      Height:     0.057 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8942 occurances):
      East:       0.010 (m)
      North:      0.010 (m)
      Height:     0.050 (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:    81.1 %
      0.10 - 0.30 m:    18.9 %
      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:          43.098 (km)
      Minimum:          17.022 (km)
      Average:          26.771 (km)
      First Epoch:      36.958 (km)
      Last Epoch:       26.234 (km)
```

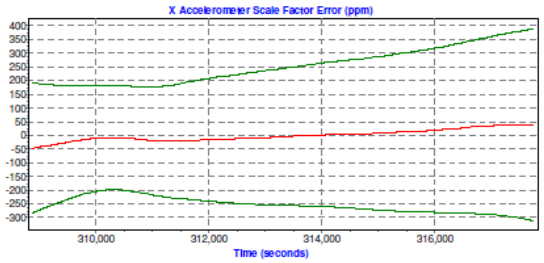
Sensor Errors

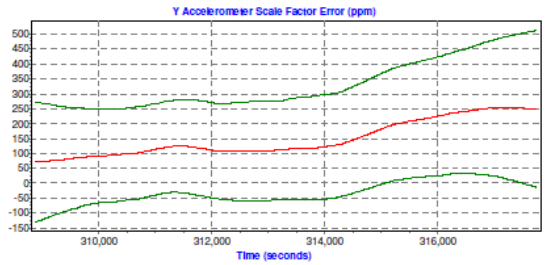
POSPac Version 4.3 - 1 - 4/15/2013 - 1:03:21 PM

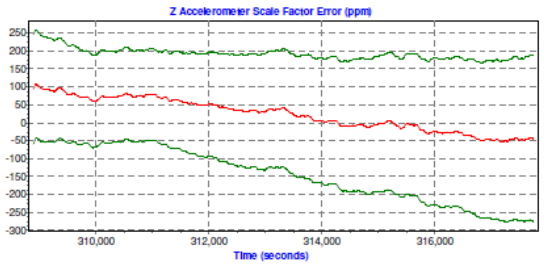


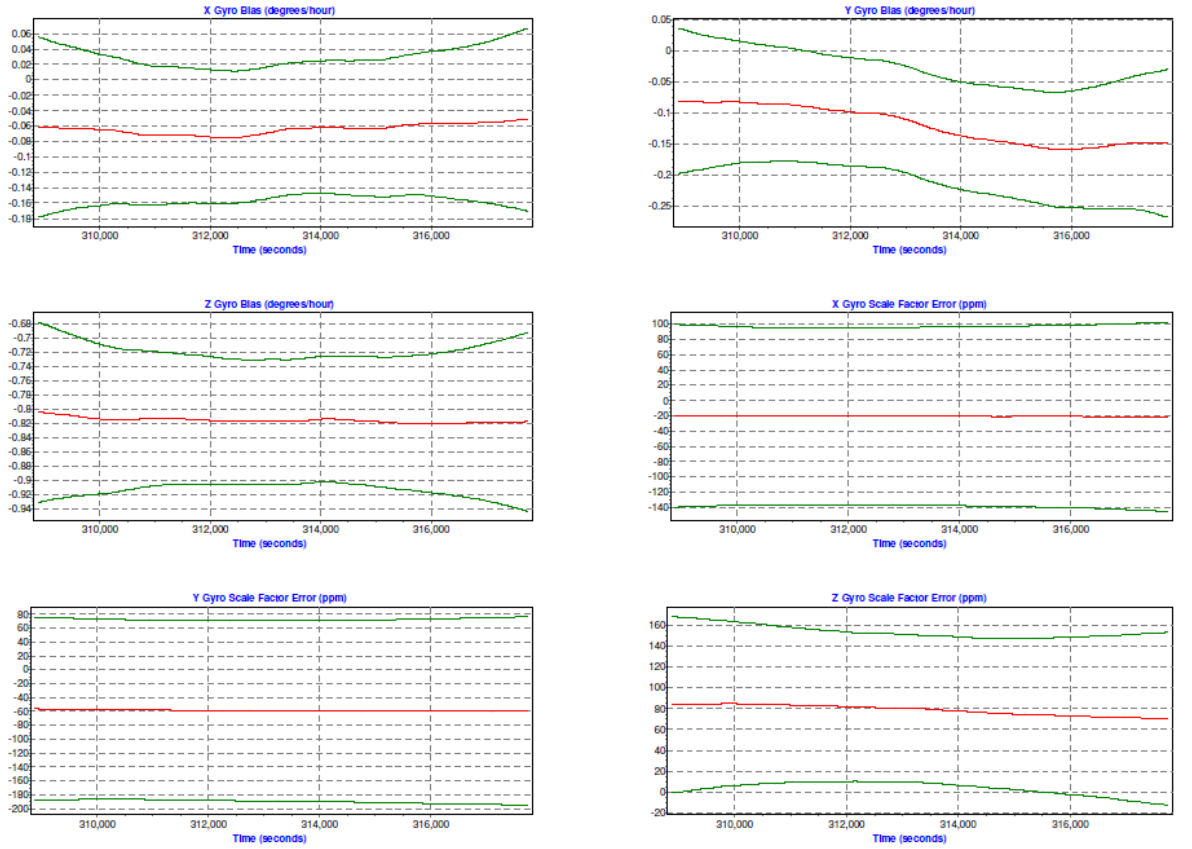










Sensor Errors

POSPac Version 4.3 - 2 - 4/15/2013 - 1:03:22 PM