# FINAL REPORT OF SPECIFIC PURPOSE LIDAR SURVEY

## LiDAR, Breaklines and Contours for

## Gulf County, Florida

**State of Florida**
**Division of Emergency Management**
**Contract 07-HS-34-14-00-22-469**
**Task Order 20070525-492718a**
**PDS Task Order B**

**November 26, 2008**

**Prepared by:**


Dewberry
8401 Arlington Blvd.
Fairfax, VA 22031-4666
for
Program & Data Solutions (PDS)
1625 Summit Lake Drive, Suite 200
Tallahassee, FL 32317

**Final Report of Specific Purpose LiDAR Survey, including**

**LiDAR-Generated Breaklines and Contours for Gulf County, Florida**

**Contract 07-HS-34-14-00-22-469; T.O. No. 20070525-492718a, Task Order B**

For:
**State of Florida**
**Division of Emergency Management**
2555 Shumard Oak Blvd.
Tallahassee, FL 32399

By:
**Program & Data Solutions (PDS)**
1625 Summit Lake Drive, Suite 200
Tallahassee, FL 32317


Prepared by:
**David F. Maune, PhD, PSM, PS, GS, CP, CFM**
Florida Professional Surveyor and Mapper No. LS6659
Dewberry
8401 Arlington Blvd.
Fairfax, VA 22031

## Table of Contents

# Report of Specific Purpose LiDAR Survey, LiDAR-Generated Breaklines and Contours Gulf County, Florida

## Type of Survey: Specific Purpose Survey

This report pertains to a Specific Purpose LiDAR Survey of Gulf County, Florida, conducted in the summer of 2007, and breaklines and contours generated in 2007 and 2008, for the Florida Division of Emergency Management (FDEM).

The LiDAR dataset, breaklines and contours were prepared by the Program and Data Solutions (PDS) team under FDEM contract 07-HS-34-14-00-22-469, Task Order 20070525-492718a (PDS Task Order B). The LiDAR dataset of Gulf County was acquired by AeroMetric, Inc. in the summer of 2007 and processed to a bare-earth digital terrain model (DTM); it was produced to FDEM vertical accuracy specifications that differ from NOAA specifications previously used in Walton County, Santa Rosa County, Escambia County and northern Bay County. These differences are summarized in Table 1.

**Table 1. Comparison of FDEM and NOAA Vertical Accuracy Criteria**

| Vertical Accuracy Criteria | FDEM Specifications | NOAA Specifications |
|---|---|---|
| Fundamental Vertical Accuracy (FVA) at the 95% confidence level, in open terrain (non-vegetated) land cover only | **≤ 18.2-cm** (0.60-ft) (based on $RMSE_z$ of 9.25-cm x 1.9600) | **≤ 29.4-cm** (0.96-ft) (based on $RMSE_z$ of 15-cm x 1.9600) |
| Consolidated Vertical Accuracy (CVA) at the 95% confidence level, in all land cover categories combined | **≤ 36.3-cm** (1.19-ft) (based on 95$^{th}$ percentile) or $RMSE_z$ of 18.5-cm x 1.9600 | **≤ 36.3-cm** (1.19-ft) (based on 95$^{th}$ percentile) or $RMSE_z$ of 18.5-cm x 1.9600 |

Under Task Order B, this is one of 12 similar county reports prepared by the PDS team of coastal areas along the Florida Panhandle, from Escambia County through Levy County, considered by FDEM to be vulnerable to hurricane tidal surges. Of these 12 reports, those for coastal Escambia, Santa Rosa, Walton and northern Bay County are based on LiDAR data previously acquired in support of the Northwest Florida Water Management District (NWFWMD) and produced to different accuracy specifications as indicated in Table 1 and to different point densities.

The reports for coastal areas of Gulf County, as well as Okaloosa, Bay, Franklin, Wakulla, Jefferson, Taylor, Dixie, and Levy counties are based on LiDAR data acquired in 2007 by the PDS team under the referenced FDEM contract, produced to the more-rigorous FDEM specifications. Detailed breaklines and contours were produced by the PDS team for areas to be mapped/improved as identified by a tile index provided by FDEM to PDS. Each tile covers an area of 5000 ft by 5000 ft. The map at Appendix A displays the 725 tiles of Gulf County for which LiDAR DTMs and LiDAR-derived breaklines and contours were produced by the PDS team under Task Order B. To avoid double counting, tiles on the county border with Bay County and Franklin County were delivered only in one county dataset, as shown at Appendix A.

Rather than describe only the data provided of Gulf County in isolation, this report also explains the differences between LiDAR datasets acquired of Escambia, Santa Rosa, Walton and northern Bay counties and those of other counties in the Florida Panhandle produced to different specifications. In addition to the differences in vertical accuracy criteria, summarized in Table 1, there are also differences in the geodetic control used for the different contracts, and there are different point densities between the data acquired to NOAA specifications and data acquired to FDEM Baseline Specifications:

- For the nine new counties mapped by the PDS team for FDEM in the Florida Panhandle under Task Order B, a rigorous geodetic control network was established by the PDS team for all coastal counties between Okaloosa and Levy counties, but excluding Walton County which had been previously mapped by NOAA. Thus, the survey control used for Escambia, Santa Rosa, Walton and northern Bay counties may differ from the geodetic control network established for the nine other counties in the Panhandle. Primarily because a rigorous geodetic control network was surveyed by the PDS team for the nine new counties, it is expected that there will be differences in the elevations of topographic surfaces between counties, primarily around the boundaries of Escambia, Santa Rosa and Walton counties where the 2006 LiDAR datasets, controlled to older survey control, merge with the 2007 LiDAR datasets controlled to the new geodetic control network established by the PDS team. Furthermore, northern Bay County was flown to the less-demanding NOAA specifications whereas southern Bay County was flown to the more-demanding FDEM specifications.

- For the nine new counties, including Gulf County, the FDEM Baseline Specifications require a maximum post spacing of 4 feet, i.e., an average point density of less than 1 point per square meter. However, the PDS team required a much higher point density of its subcontractors in order to increase the probability of penetrating dense foliage during the mandated summer acquisition; with nominal post spacing of 0.7 meters per flight line and 50% sidelap between flight lines, the average point density is 4 points per square meter. The NOAA specifications for Escambia County, Santa Rosa County, Walton County, and northern Bay County, required a nominal post spacing of 2 meters, yielding an average point density of 0.25 points per square meter. The significance of this difference is that the nine new counties acquired for FDEM, including Gulf County, have LiDAR point densities approximately 16 times higher than the LiDAR point densities in Escambia County, Santa Rosa County, Walton County, and northern Bay County. With higher point density there is a greater probability of penetrating dense vegetation and minimizing areas defined as "low confidence areas."

## The PDS Team

PDS is a Joint Venture consisting of PBS&J, Dewberry, and URS Corp:

- PBS&J provided local client liaison in Tallahassee. PBS&J was also responsible for the overall ground survey effort including management of field survey subcontractors – Allen Nobles & Associates, Inc. (ANA) and Diversified Design & Drafting Services, Inc. (3DS) – which performed the geodetic control surveys and quality assurance/quality control (QA/QC) checkpoint surveys used for independent accuracy testing by Dewberry and URS. These surveyors executed a network adjustment of control points used throughout the Florida Panhandle. It was important to execute this network adjustment because of widely-held concerns that the survey control was deficient in the Florida Panhandle counties. Mr. Glenn Bryan, PSM, of PBS&J, and Mr. Brett Wood, PSM, of 3DS, were the technical leads for the control surveys and QA/QC surveys.

- Dewberry was responsible for the overall Work Plan and aerial survey effort for the nine new counties, including management of LiDAR subcontractors that performed the LiDAR data acquisition and post-processing and produced LAS classified data. A staff of QA/QC specialists at Dewberry's Fairfax (VA) office performed quality assessments of the breaklines and contours. Dewberry served as the single point of contact with FDEM. Dr. David Maune, PSM, was Dewberry's technical lead for the digital orthophoto and LiDAR surveys and derived products. Under separate contract with NOAA, Dr. Maune had previously served as Dewberry's Quality Manager for its independent QA/QC of LiDAR data produced by NOAA for the NWFWMD of Escambia, Santa Rosa, and Walton counties. Dewberry did not perform QA/QC of the existing LiDAR dataset of northern Bay County.

- URS Corp. was responsible for data management and information management. URS developed the GeoCue Distributed Production Management System (DPMS), managed and tracked the flow of data, performed independent accuracy testing and quality assessments of FDEM's new LiDAR data acquired in 2007, tracked and reported the status of individual tiles during production, and produced all final deliverables for FDEM. Mr. Robert Ryan, CP, of URS, was the technical lead for this effort.

## Name of Company in Responsible Charge

Dewberry
8401 Arlington Blvd.
Fairfax, VA 22031-4666

## Name of Responsible Surveyor

David F. Maune, PhD, PSM, PS, GS, CP, CFM
Florida Professional Surveyor and Mapper (PSM) No. LS6659

## Survey Area

The project area for this report encompasses approximately 650 square miles within Gulf County and small adjoining areas of Bay County, Calhoun County, Liberty County, and Franklin County.

## Map Reference

There are no hardcopy map sheets for this project. The map at Appendix A provides graphical reference to the 5000-ft x 5000-ft tiles covered by this report.

## Summary of FDEM Baseline Specifications

All new data produced for FDEM under the referenced contract are required to satisfy the Florida Baseline Specifications, included as appendices to PDS's Task Order B, dated May 23, 2007, from FDEM. To expedite production, the Florida Baseline Specifications were modified by FDEM to require new LiDAR data acquisition during the summer of 2007 (leaf-on) as opposed to the normal leaf-off.

Task Order B presented demanding technical challenges for the PDS team because the existing geodetic control monuments in the Florida Panhandle are believed to be the most inaccurate in Florida, with elevation discrepancies as much as several feet; and some areas in the Panhandle are subject to subsidence. LiDAR elevations produced relative to some survey control monuments are believed to differ by as much as several feet from LiDAR elevations produced relative to other control monuments in the Panhandle. This caused a new geodetic control network to be established by the PDS team for the counties to be newly surveyed, but without adjusting the geodetic control monuments used for Escambia

County, Santa Rosa County, Walton County, and northern Bay County for which existing LiDAR data was used "as is."

The official State Plane Coordinate System tiling scheme was provided by FDEM to the PDS team on July 10, 2007 for Florida's North Zone and West Zone. The Gulf County tiling footprint graphic is shown at Appendix A.

The Florida Baseline Specifications required the LiDAR data to be collected using an approved sensor with a maximum field of view (FOV) of 20˚ on either side of nadir, with GPS baseline distances limited to 20 miles, with maximum post spacing of 4 feet in unobscured areas for random point data, and with vertical root mean square error ($RMSE_z$) ≤ 0.30 ft and Fundamental Vertical Accuracy (FVA) ≤ 0.60 ft at the 95% confidence level in open terrain (bare-earth and low grass); this accuracy is equivalent to 1 ft contours in open terrain when tested in accordance with the National Map Accuracy Standard (NMAS). In other land cover categories (brush lands and low trees, forested areas fully covered by trees, and urban areas), the Florida Baseline Specifications required the LiDAR data's $RMSE_z$ to be ≤ 0.61 ft with Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA) ≤ 1.19 ft at the 95% confidence level; this accuracy is equivalent to 2 ft contours when tested in accordance with the NMAS. *Low confidence areas*, originally called *obscured vegetated areas*, are defined for areas where the vertical data may not meet the data accuracy requirements due to heavy vegetation.

The Florida Baseline Specifications also required the horizontal accuracy to meet or exceed 3.8 feet at the 95% confidence level, using $RMSE_r$ x 1.7308. This means that the horizontal (radial) RMSE ($RMSE_r$) must meet or exceed 2.20 ft. This is the horizontal accuracy required of maps compiled at a scale of 1:1,200 (1" = 100') in accordance with the traditional National Map Accuracy Standard.

To meet and exceed these specifications for the nine new county LiDAR datasets, the PDS team established the following more-rigorous specifications for its LiDAR subcontractors:

- Instead of a 20˚ FOV on either side of nadir, the PDS team limited the FOV to 18˚
- Instead of GPS baselines ≤ 20 miles, the PDS team limited baseline lengths to ≤ 20 km, except in one small isolated area where the baseline length was approximately 23 km (14 miles).
- Instead of 4 foot post spacing which yields an average of 0.67 points per $m^2$, the PDS team chose 0.7 m point spacing and 50% sidelap that yields an average of 4 points per $m^2$. Thus, the PDS team's average point density is nearly 6 times higher than required by FDEM, greatly increasing the probability of LiDAR points penetrating through dense vegetation so as to minimize areas defined as *low confidence areas*. The PDS team defines *low confidence areas* as vegetated areas of ½ acre or larger that are considered obscured to the extent that adequate vertical data cannot be clearly determined to accurately define the DTM. Such areas indicate where the vertical data may not meet the data accuracy requirements due to heavy vegetation.

The first deliverable is LiDAR mass points, delivered to LAS 1.1 specifications, including the following LAS classification codes:

- Class 1 = Unclassified, and used for all other features that do not fit into the Classes 2, 7, 9, or 12, including vegetation, buildings, etc.
- Class 2 = Ground, includes accurate LiDAR points in overlapping flight lines
- Class 7 = Noise, includes LiDAR points in overlapping flight lines
- Class 9 = Water, includes LiDAR points in overlapping flight lines

- Class 12 = Overlap, including areas of overlapping flight lines which have been deliberately removed from Class 1 because of their reduced accuracy.

Table 2 compares the LiDAR LAS classes specified by the FDEM and NOAA specifications.

**Table 2. Comparison of FDEM and NOAA LAS Classes**

| FDEM LAS Classes | NOAA LAS Classes |
|---|---|
| Class 1 – Unclassified, including vegetation, buildings, bridges, piers<br>Class 2 – Ground points (used for contours)<br>Class 7 – Noise<br>Class 9 – Water<br>Class 12 – Overlap points deliberately removed | Class 1 – Unclassified<br>Class 2 – Ground points (used for contours)<br>Class 9 – Water |

For each 500 square mile area within the nine new county datasets, a total of 120 "blind" QA/QC checkpoints were surveyed, totally unknown to (i.e., "blind" from) the LiDAR subcontractors. Each set of 120 QA/QC checkpoints had the goal to include 30 checkpoints in each of the following four land cover categories:

- Category 1 = bare-earth and low grass
- Category 2 = brush lands and low trees
- Category 3 = forested areas fully covered by trees
- Category 4 = urban areas

In a few cases, there were insufficient dispersed areas to acquire 30 QA/QC checkpoints for one or more land cover categories; when this occurred, Dewberry advised the surveyors to select additional QA/QC checkpoints for land cover categories that were predominant in the area and therefore more representative of the area being tested.

The following vertical accuracy guidelines were specified by the Florida Baseline Specifications:

- In category 1, the $RMSE_z$ must be ≤ 0.30 ft ($Accuracy_z$ ≤ 0.60 ft at the 95% confidence level); $Accuracy_z$ in Category 1 refers to Fundamental Vertical Accuracy (FVA) which defines how accurate the elevation data are when not complicated by asphalt or vegetation that may cause elevations to be either lower or higher than the bare earth terrain. This is equivalent to the accuracy expected of 1 ft contours in non-vegetated terrain.
- In category 2, the $RMSE_z$ must be ≤ 0.61 ft ($Accuracy_z$ ≤ 1.19 ft at the 95% confidence level); $Accuracy_z$ in Category 2 refers to Supplemental Vertical Accuracy (SVA) in brush lands and low trees and defines how accurate the elevation data are when complicated by such vegetation that frequently causes elevations to higher than the bare earth terrain. This is equivalent to the accuracy expected of 2 ft contours in such terrain.
- In category 3, the $RMSE_z$ must be ≤ 0.61 ft ($Accuracy_z$ ≤ 1.19 ft at the 95% confidence level); $Accuracy_z$ in Category 3 refers to Supplemental Vertical Accuracy (SVA) in forested areas fully covered by trees and defines how accurate the elevation data are when complicated by such

vegetation that frequently causes elevations to be higher than the bare earth terrain. This is equivalent to the accuracy expected of 2 ft contours in such terrain.

- In category 4, the $RMSE_z$ must be ≤ 0.61 ft ($Accuracy_z$ ≤ 1.19 ft at the 95% confidence level); $Accuracy_z$ in Category 4 refers to Supplemental Vertical Accuracy (SVA) in urban areas typically paved with asphalt and defines how accurate the elevation data are when complicated by asphalt that frequently causes elevations to be lower than the bare earth terrain. This is equivalent to the accuracy expected of 2 ft contours in such terrain.
- In all land cover categories combined, the $RMSE_z$ must be ≤ 0.61 ft ($Accuracy_z$ ≤ 1.19 ft at the 95% confidence level); $Accuracy_z$ in all categories combined refers to Consolidated Vertical Accuracy (CVA).
- The terms FVA, SVA and CVA are explained in Chapter 3, *Accuracy Standards & Guidelines*, of "Digital Elevation Model Technologies and Applications: The DEM Users Manual," published by the American Society for Photogrammetry and Remote Sensing (ASPRS), January, 2007.

A second major deliverable consists of nine types of breaklines, produced in accordance with the PDS team's Data Dictionary at Appendix C:

1. Coastal shoreline features
2. Single-line hydrographic features
3. Dual-line hydrographic features
4. Closed water body features
5. Road edge-of-pavement features
6. Bridge and overpass features
7. Soft breakline features
8. Island features
9. Low confidence areas

Another major deliverable includes both one-foot and two-foot contours, produced from the mass points and breaklines, certified to meet or exceed NSSDA standards for one-foot contours. Two-foot contours within obscured vegetated areas are not required to meet NSSDA standards. These contours were also produced in accordance with the PDS team's Data Dictionary at Appendix C.

Table 3 is included below for ease in understanding the accuracy requirements when comparing the traditional National Map Accuracy Standard (NMAS) and the newer National Standard for Spatial Data Accuracy (NSSDA). This table is extracted from Table 13.2 of "Digital Elevation Model Technologies and Applications: The DEM Users Manual," published in January, 2007 by ASPRS. The traditional NMAS uses Vertical Map Accuracy Standard (VMAS) to define vertical accuracy at the 90% confidence level, whereas the NSSDA uses $Accuracy_z$ to define vertical accuracy at the 95% confidence level. Both the VMAS and $Accuracy_z$ are computed with different multipliers for the very same $RMSE_z$ value which represents vertical accuracy at the 68% confidence level for each equivalent contour interval specified. The term $Accuracy_z$ (vertical accuracy at the 95% confidence level) is comparable to the terms described below as Fundamental Vertical Accuracy (FVA), Consolidated Vertical Accuracy (CVA) and Supplemental Vertical Accuracy (SVA) which also define vertical accuracy at the 95% confidence level. In open (non-vegetated) terrain, $Accuracy_z$ is exactly the same as FVA (both computed as $RMSE_z$ x 1.9600) because there is no logical justification for elevation errors to depart from a normal error distribution. In vegetated areas, vertical accuracy at the 95% confidence level ($Accuracy_z$) can also be computed as $RMSE_z$ x 1.9600; however, because vertical errors do not always have a normal error distribution in vegetated terrain, alternative guidelines from the National Digital Elevation Program (NDEP) and American Society for Photogrammetry and Remote Sensing (ASPRS) allow the 95$^{th}$ percentile method to be used (as with the CVA and SVA) to report the vertical accuracy at the 95% confidence level in land cover categories other than open terrain.

**Table 3. Comparison of NMAS/NSSDA Vertical Accuracy**

| **NMAS** Equivalent Contour Interval | **NMAS** VMAS (90 percent confidence level) | **NSSDA** $RMSE_z$ (68 percent confidence level) | **NSSDA** $Accuracy_z$, (95 percent confidence level) |
|---|---|---|---|
| 1 ft | 0.5 ft | 0.30 ft or 9.25 cm | 0.60 ft or 18.2 cm |
| 2 ft | 1.0 ft | 0.61 ft or 18.5 cm | 1.19 ft or 36.3 cm |

The next major deliverable includes metadata compliant with the Federal Geographic Data Committee's (FGDC) Content Standard for Spatial Metadata in an ArcCatalog-compatible XML format. Copies of all survey reports, including this Report of Specific Purpose LiDAR Survey, must be delivered in PDF format as attachments to the metadata.

The last major deliverable includes the Vertical Accuracy Report of Gulf County, based on independent comparison of the LiDAR data with the QA/QC checkpoints, surveyed and tested in accordance with guidelines of the National Standard for Spatial Data Accuracy (NSSDA), American Society for Photogrammetry and Remote Sensing (ASPRS), Federal Emergency Management Agency (FEMA), and National Digital Elevation Program (NDEP), and using the QA/QC checkpoints surveyed by PBS&J and listed at Appendix E.

Instead of delivering one vertical accuracy report, using 120 QA/QC checkpoints for each 500 square miles of the project area, separate reports are delivered for each county. Therefore, individual county vertical accuracy reports may be based on fewer than or more than 120 QA/QC checkpoints, depending on whether the area mapped in each county is smaller than or larger than 500 square miles. Regardless, the average density of QA/QC checkpoints remains the same on average for each countywide report.

Datums and Coordinates: North American Datum of 1983 (NAD 83)/HARN for horizontal coordinates and North American Vertical Datum of 1988 (NAVD 88) for vertical coordinates. All coordinates are Florida State Plane Coordinate System (SPCS) in U.S. Survey Feet. All counties listed are in the Florida SPCS North Zone, except for Levy County which is delivered in both Florida SPCS North and West Zones. Levy County is normally in the West Zone but the LiDAR data are also delivered in the North Zone for ease in merger with all Panhandle counties for SLOSH modeling of all counties from Escambia through Levy.

Appendix I to this report provides the Geodatabase structure for all digital vector deliverables in Gulf County.

## Acronyms and Definitions

3DS — Diversified Design & Drafting Services, Inc.
$Accuracy_r$ — Horizontal (radial) accuracy at the 95% confidence level, defined by the NSSDA

| | |
|---|---|
| $Accuracy_z$ | Vertical accuracy at the 95% confidence level, defined by the NSSDA |
| ANA | Allen Nobles & Associates, Inc. |
| ASFPM | Association of State Floodplain Managers |
| ASPRS | American Society for Photogrammetry and Remote Sensing |
| CFM | Certified Floodplain Manager (ASFPM) |
| CMAS | Circular Map Accuracy Standard, defined by the NMAS |
| CP | Certified Photogrammetrist (ASPRS) |
| CVA | Consolidated Vertical Accuracy, defined by the NDEP and ASPRS |
| DEM | Digital Elevation Model (gridded DTM) |
| DTM | Digital Terrain Model (mass points and breaklines to map the bare earth terrain) |
| DSM | Digital Surface Model (top reflective surface, includes treetops and rooftops) |
| FDEM | Florida Division of Emergency Management |
| FEMA | Federal Emergency Management Agency |
| FGDC | Federal Geographic Data Committee |
| FOV | Field of View |
| FVA | Fundamental Vertical Accuracy, defined by the NDEP and ASPRS |
| GS | Geodetic Surveyor |
| GIS | Geographic Information System Surveyor |
| LAS | LiDAR data format as defined by ASPRS |
| LiDAR | Light Detection and Ranging |
| LMSI | Laser Mapping Specialists Inc. |
| MHHW | Mean Higher High Water |
| MHW | Mean High Water, defines official shoreline in Florida |
| MLLW | Mean Lower Low Water |
| MLW | Mean Low Water |
| MSL | Mean Sea Level |
| NAD 83 | North American Datum of 1983 |
| NAVD 88 | North American Vertical Datum of 1988 |
| NDEP | National Digital Elevation Program |
| NMAS | National Map Accuracy Standard |
| NOAA | National Oceanic and Atmospheric Administration |
| NSSDA | National Standard for Spatial Data Accuracy |
| NSRS | National Spatial Reference System |
| NWFWMD | Northwest Florida Water Management District |
| PDS | Program & Data Solutions, joint venture between PBS&J, Dewberry and URS Corp |
| PS | Photogrammetric Surveyor |
| PSM | Professional Surveyor and Mapper (Florida) |
| QA/QC | Quality Assurance/Quality Control |
| $RMSE_h$ | Vertical Root Mean Square Error (RMSE) of ellipsoid heights |
| $RMSE_r$ | Horizontal (radial) Root Mean Square Error (RMSE) computed from $RMSE_x$ and $RMSE_y$ |
| $RMSE_z$ | Vertical Root Mean Square Error (RMSE) of orthometric heights |
| SLOSH | Sea, Lake, and Overland Surges from Hurricanes |
| SRWMD | Suwannee River Water Management District |
| SVA | Supplemental Vertical Accuracy, defined by the NDEP and ASPRS |
| TIN | Triangulated Irregular Network |
| VMAS | Vertical Map Accuracy Standard, defined by the NMAS |

## Ground Surveys and Dates

Past experience with control in the Florida Panhandle area indicated a need to improve the accuracy of the existing survey monuments. For the nine newly-mapped counties in the Florida Panhandle, including Gulf County, the PDS team established a geodetic control network to provide accurate and consistent horizontal and vertical control for LiDAR and photogrammetric mapping using GPS technology. The project consisted of a Primary and two Secondary control networks supporting the mapping of approximately 6,113 square miles located in Northwest Florida. PBS&J managed the overall ground survey effort including management of field survey subcontractors, Allen Nobles & Associates, Inc. (ANA) and Diversified Design & Drafting Services, Inc. (3DS), which performed control surveys and QA/QC checkpoint surveys used for independent accuracy testing, and executed a network adjustment of control points used throughout the Florida panhandle.

The Primary network stations (see Figure 1) were used as base stations supporting the airborne GPS data acquisition, and as a consistent control framework for the more densely spaced Secondary control networks, and all subsequent control surveying activity on the project. They were setup at 40 kilometer spacing per the 2 centimeter requirements for Primary Control stated in the NOS NGS-58. The Primary Control network consisted of 55 stations, including 10 Continuously Operating Reference Stations (CORS), 27 existing monuments from the National Spatial Reference System (NSRS) and 18 new monuments set so as to limit LiDAR GPS baseline lengths to 20 Km relative to GPS base stations on either side of stations spaced ≈40 Km apart. Third order differential leveling was used to establish elevations on 20 Primary network stations in specific areas where published vertical stations could not be occupied directly with GPS. A minimally constrained (free) Least Squares adjustment was run to verify the internal accuracy of the Primary network. After evaluating and removing any outliers, a final free adjustment was generated, consisting of 191 independent vectors. The input error estimates were scaled by a factor of 14.90 which resulted in a properly weighted adjustment with a variance factor of 1.0154, with no flagged residuals. A constrained (fixed) 3-D horizontal adjustment was run using the same input error estimates as were used in the free adjustment; the variance factor was 1.3712 and there were no flagged residuals. A constrained (fixed) 1-D vertical adjustment was run using the same input error estimates as were used in the free adjustment; Station BE3991 was fixed in latitude, longitude and orthometric height; the variance factor was 1.2866 and there were no flagged residuals.

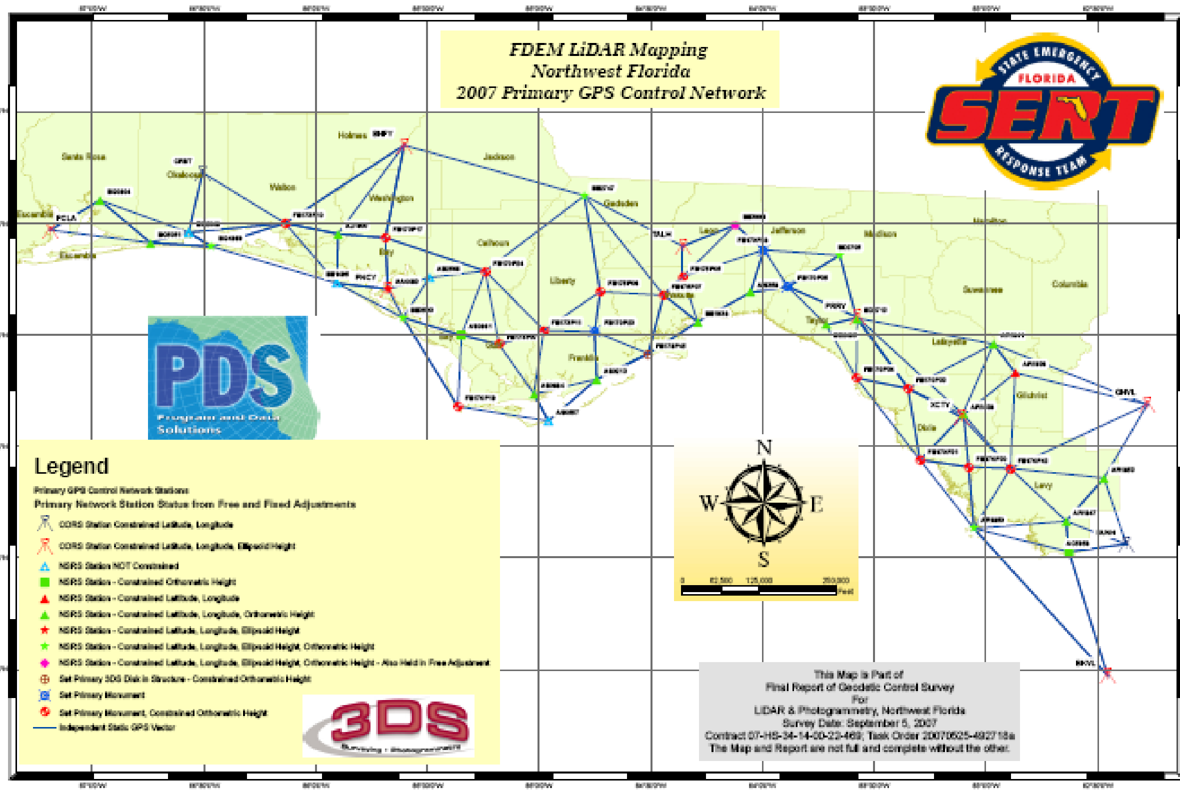



**Figure 1. Primary Control Network**

The Secondary network stations (see Figure 2) were used to support the measurement of both LiDAR and orthophoto QA/QC checkpoint sites. They were setup at 15 kilometer spacing per the 2 centimeter requirements for Secondary Control stated in NOS NGS-58.

The first Secondary Control network consisted of 4 stations in the Okaloosa County area. The second Secondary Control network consisted of all remaining mapping areas in the Florida Panhandle. The Secondary Control networks included a total of 80 control points, including 16 recovered NSRS monuments, 2 recovered DNR monuments, and 62 new monuments set for this network. A minimally constrained (free) Least Squares adjustment was run to verify the internal accuracy of the Secondary networks. After evaluating and removing any outliers, a final free adjustment was generated. This final free adjustment consisted of 254 independent vectors. The input error estimates were scaled by a factor of 6.234, which resulted in a properly weighted adjustment with a variance factor of 1.000; there were no flagged residuals. A constrained (fixed) 3-D horizontal adjustment was run using the same input error estimates as were used in the free adjustment; the variance factor was 1.6339 and there were six flagged residuals. A constrained (fixed) 1-D vertical adjustment was run using the same input error estimates as were used in the free adjustment; Station BE3991 was fixed in latitude, longitude and orthometric height; the variance factor was 1.2136 and there were no flagged residuals.

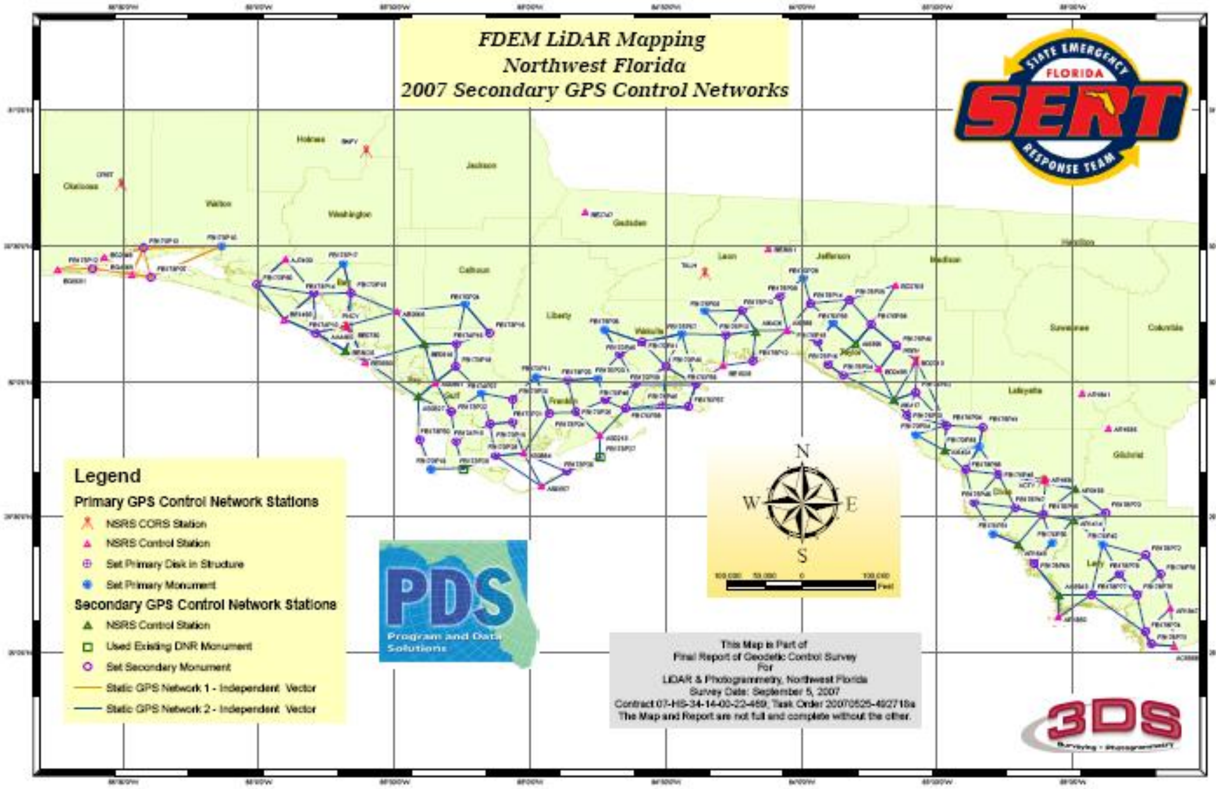



**Figure 2. Secondary Control Networks**

These GPS ground surveys were executed between May and September 2007. Full details are documented in 3DS's "Final Report of Geodetic Control Survey for LiDAR and Photogrammetry, Northwest Florida," dated March 13, 2008.

The QA/QC checkpoints used for this county are listed at Appendix E.

## LiDAR Aerial Survey Areas and Dates

AeroMetric, Inc. collected the LiDAR data for Gulf County during the summer of 2007.

## LiDAR Processing Methodology

A LiDAR processing report from AeroMetric, Inc. is included at Appendix D.

## LiDAR Vertical Accuracy Testing

URS performed the LiDAR vertical accuracy assessment for Gulf County in accordance with *ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data*, May 24, 2004, and Section 1.5 of the *Guidelines for Digital Elevation Data*, published by the National Digital Elevation Program (NDEP), May 10, 2004. These guidelines call for the mandatory determination of Fundamental Vertical Accuracy (FVA) and Consolidated Vertical Accuracy (CVA), and the optional determination of Supplemental Vertical Accuracy (SVA). NOAA's accuracy specifications are compared with FDEM's accuracy specifications at Table 1. NOAA's checkpoint requirements are compared with FDEM's checkpoint requirements at Table 4.

**Table 4. Comparison of FDEM and NOAA Checkpoint Requirements**

| | FDEM Specifications | NOAA Specifications |
|---|---|---|
| Land cover categories tested by QA/QC checkpoints | Four land cover categories tested:<br>1. Open terrain; bare-earth, low grass<br>2. Brush lands and low trees<br>3. Forested areas<br>4. Urban, built-up areas | Five land cover categories tested:<br>1. Open terrain; bare-earth, low grass<br>2. Weeds and crops<br>3. Scrub<br>4. Forested areas<br>5. Urban, built-up areas |
| Number of checkpoints per category | 20 checkpoints, per category, for each 500 square mile area | 20 checkpoints, per category, for each countywide dataset |

The LiDAR dataset of Gulf County, redelivered in August of 2008, passed the accuracy testing by URS as documented at Appendices E and F.

**Fundamental Vertical Accuracy (FVA)** is determined with QA/QC checkpoints located only in open terrain (grass, dirt, sand, and rocks) where there is a high probability that the LiDAR sensor detected the bare-earth ground surface, and where errors are expected to follow a normal error distribution. With a normal error distribution, the FVA at the 95 percent confidence level is computed as the vertical root mean square error ($RMSE_z$) of the checkpoints x 1.9600. The FVA is the same as $Accuracy_z$ at the 95% confidence level (for open terrain), as specified in Appendix 3-A of the *National Standard for Spatial Data Accuracy*, FGDC-STD-007.3-1998, see http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3. For FDEM, including Gulf County, the FVA standard is .60 feet, corresponding to an $RMSE_z$ of 0.30 feet or 9.25 cm, the accuracy expected from 1-foot contours. For Gulf County, the FVA standard is 0.96 feet, corresponding to an $RMSE_z$ of 15 cm, better than the $RMSE_z$ of 18.5 cm expected from 2-foot contours. ***In Gulf County, the $RMSE_z$ in open terrain equaled 0.21 ft compared with the 0.30 ft specification of FDEM; and the FVA computed using $RMSE_z$ x 1.9600 was equal to 0.41 ft, compared with the 0.60 ft specification of FDEM.***

**Consolidated Vertical Accuracy (CVA)** is determined with all checkpoints, representing open terrain and all other land cover categories combined. If errors follow a normal error distribution, the CVA can be computed by multiplying the consolidated $RMSE_z$ by 1.9600. However, because bare-earth elevation errors often vary based on the height and density of vegetation, a normal error distribution cannot be assumed, and $RMSE_z$ cannot necessarily be used to calculate the 95 percent confidence level. Instead, a nonparametric testing method, based on the 95$^{th}$ percentile, may be used to determine CVA at the 95 percent confidence level. NDEP guidelines state that errors larger than the 95$^{th}$ percentile should be documented in the quality control report and project metadata. For FDEM, the CVA specification for all classes combined should be less than or equal to 1.19 feet; this same CVA specification was used by NOAA. ***In Gulf County, the CVA computed using RMSE$_z$ x 1.9600 was equal to 0.63 ft, compared with the 1.19 ft specification of FDEM; and the CVA computed using the 95$^{th}$ percentile was equal to 0.66 ft. URS and Dewberry determined that the dataset passed the CVA standard.***

**Supplemental Vertical Accuracy (SVA)** is determined separately for each individual land cover category, recognizing that the LiDAR sensor and post-processing may not have mapped the bare-earth ground surface, and that errors may not follow a normal error distribution. SVA specifications are "target" values and not mandatory, recognizing that larger errors in some categories are offset by smaller errors in other land cover categories, so long as the overall mandatory CVA specification is satisfied. For each land cover category, the SVA at the 95 percent confidence level equals the 95$^{th}$ percentile error for all checkpoints in that particular land cover category. For FDEM's specification, the SVA target is 1.19 feet for each category; this same SVA target specification was used by NOAA**.** ***In Gulf County, the SVA tested as 0.39 ft in open terrain, bare earth and low grass; 0.48 ft in brush lands and low trees; 0.78 ft in forested areas; and 0.54 ft in urban, built-up areas, passing the FDEM SVA baseline target specifications in all land cover categories.***

The complete LiDAR Vertical Accuracy Report for Gulf County is at Appendix F.

## LiDAR Horizontal Accuracy Testing

The LiDAR data was compiled to meet 3.8 feet horizontal accuracy at the 95% confidence level.

Whereas FDEM baseline specifications call for horizontal accuracy testing, traditional horizontal accuracy testing of LiDAR data is not cost effective for the following reasons:

- Paragraphs 3.2.2 and 3.2.3 of the National Standard for Spatial Data Accuracy (NSSDA) states: "Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with coordinates of the same points from an independent source of higher accuracy … when a dataset, e.g., a gridded digital elevation dataset or elevation contour dataset does not contain well-defined points, label for vertical accuracy only." Similarly, in Appendix 3-C of the NSSDA, paragraph 1 explains well-defined points as follows: "A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points."
- Paragraph 1.5.3.4 of the *Guidelines for Digital Elevation Data*, published in 2004 by the National Digital Elevation Program (NDEP), states: "The NDEP does not require independent testing of horizontal accuracy for elevation products. When the lack of distinct surface features makes horizontal accuracy testing of mass points, TINs, or DEMs difficult or impossible, the data producer should specify horizontal accuracy using the following statement: *Compiled to meet __ (meters, feet) horizontal accuracy at 95 percent confidence level*."
- Paragraph 1.2, Horizontal Accuracy, of *ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data*, published by the American Society for Photogrammetry and Remote Sensing (ASPRS) in 2004, further explains why it is difficult and impractical to test the

horizontal accuracy of LiDAR data, and explains why ASPRS does not require horizontal accuracy testing of LiDAR-derived elevation products.

- ASPRS has been actively seeking to develop cost-effective techniques to use LiDAR intensity imagery to test the horizontal accuracy of LiDAR data. As recently as May 1, 2008, at the annual conference of ASPRS, the most relevant technique for doing so was in a paper entitled "New Horizontal Accuracy Assessment Tools and Techniques for Lidar Data," presented by the Ohio DOT. Whereas the technique had research value, it was neither practical nor affordable for use in horizontal accuracy testing of FDEM data.
- Appendix A of FDEM's Baseline Specifications require 20 horizontal test points for every 500 square mile area of digital orthophotos to be produced, and Appendix B of FDEM's Baseline Specifications requires 120 vertical test points for each 500 square mile area of LiDAR data to be produced. The PDS task orders included no funding for the more-expensive horizontal checkpoints that would be certain to appear on LiDAR intensity images as clearly-defined point features.
- In addition to LiDAR system factory calibration of horizontal and vertical accuracy, each of the PDS team's LiDAR subcontractors have different techniques for field calibration checks used to determine if bore-sighting is still accurate. AeroMetric's technique, used for Gulf and Franklin counties, is explained in the LiDAR Processing Report at Appendix D. AeroMetric's field calibration tests indicated the horizontal accuracy tested 2.6 feet at the 95 percent confidence level, well within FDEM's 3.8 foot specification.

## LiDAR Qualitative Assessments

In addition to vertical accuracy testing, URS also performed the LiDAR qualitative assessment.

An assessment of the vertical accuracy alone does not yield a complete picture with regard to the usability of LiDAR data for its intended purpose. It is very possible for a given set of LiDAR data to meet the accuracy requirements, yet still contain artifacts (non-ground points) in the bare-earth surface, or a lack of ground points in some areas that may render the data, in whole or in part, unsuitable for certain applications.

Based on the extremely large volume of elevation points generated, it is neither time efficient, cost effective, nor technically practical to produce a perfectly clean (artifact-free) bare-earth terrain surface. The purpose of the LiDAR Qualitative Assessment Report (see Appendix G) is to provide a qualitative analysis of the "cleanliness" of the bare-earth terrain surface for use in supporting riverine and coastal analysis, modeling, and mapping.

The main software programs used by URS in performing the bare-earth data cleanliness review include the following:

- *GeoCue*: a geospatial data/process management system especially suited to managing large LiDAR data sets
- *TerraModeler*: used for analysis and visualization
- *TerraScan*: runs inside of MicroStation; used for point classification and points file generation
- *GeoCue LAS EQC:* is also used for data analysis and edit

The following systematic approach was followed by URS in performing the cleanliness review and analysis:

- Uploaded data to the GeoCue data warehouse (enhanced data management)
    - LiDAR: cut the data into uniform tiles measuring 5,000 feet by 5,000 feet – using the State Plane tile index provided by FDEM
    - Imagery: Best available orthophotography was used to facilitate the data review. Additional LiDAR Orthos were created from the LiDAR intensity data and used for review purposes.
- Performed coverage/gap check to ensure proper coverage of the project area
    - Created a large post grid (~30 meters) from the bare-earth points, which was used to identify any holes or gaps in the data coverage.
- Performed tile-by-tile analyses
    - Using TerraScan and LAS EQC, checked for gross errors in profile mode (noise, high and low points)
    - Reviewed each tile for anomalies; identified problem areas with a polygon, annotated comment, and screenshot as needed for clarification and illustration. Used ortho imagery when necessary to aid in making final determinations with regards to:
        - Buildings left in the bare-earth points file
        - Vegetation left in the bare-earth points file
        - Water points left in the bare-earth points file
        - Proper definition of roads
        - Bridges and large box culverts removed from the bare-earth points file
        - Areas that may have been "shaved off" or "over-smoothed" during the auto-filtering process
- Prepared and sent the error reports to LiDAR firm for correction
- Reviewed revisions and comments from the LiDAR firm
- Prepared and submitted final reports to FDEM

## Breakline Production Methodology

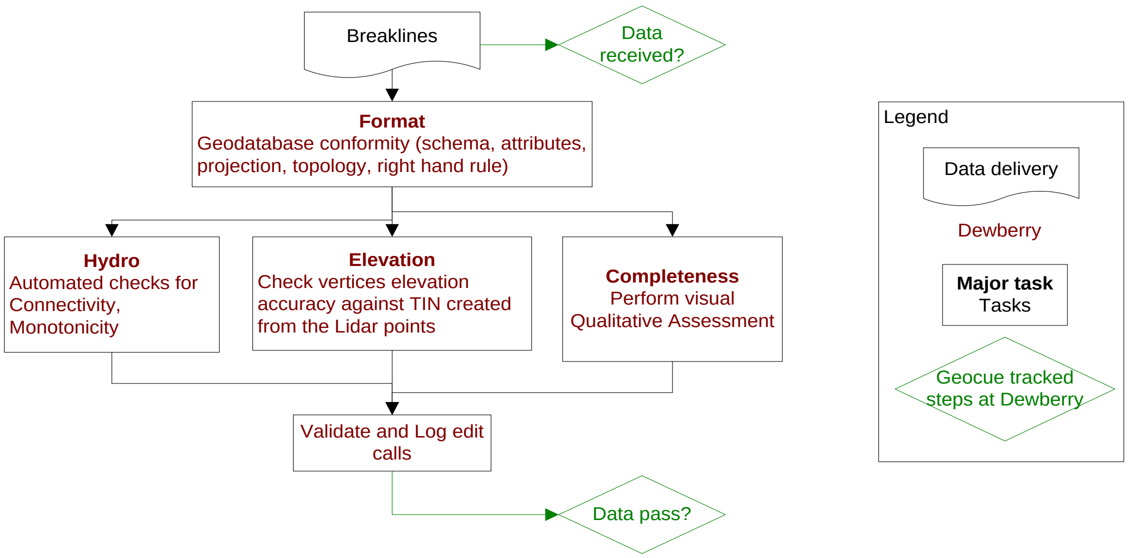
AeroMetric used GeoCue software to develop LiDAR stereo models of Gulf County so the LiDAR derived data could be viewed in 3-D stereo using DAT/EM System's Summit Evolution softcopy photogrammetric software. Using LiDARgrammetry procedures with LiDAR intensity imagery, AeroMetric stereo-compiled breaklines in accordance with the Data Dictionary at Appendix C. The LiDARgrammetry was performed under the direct supervision of an ASPRS Certified Photogrammetrist. The breaklines conform with data format requirements outlined by the FDEM Baseline Specifications.

## Contour Production Methodology

Using proprietary procedures developed by AeroMetric, the 2-foot and 1-foot contours were compiled from the breaklines and LiDAR data in accordance with the Data Dictionary at Appendix C. The contours conform with data format requirements outlined by the FDEM Baseline Specifications.

## Breakline Qualitative Assessments

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




In order to ensure a correct database format, Dewberry provided all subcontractors with geodatabase shells containing the required feature classes in the required format. Upon receipt of the data, Dewberry verified that the correct shell was used and validated the topology rules associated with it.

| Feature Class | Rule | Feature Class |
|---|---|---|
| SOFTFEATURE | Must Not Intersect | |
| OVERPASS | Must Not Intersect | |
| ROADBREAKLINE | Must Not Intersect | |
| HYDROGRAPHIC... | Must Not Intersect | |
| SOFTFEATURE | Must Not Overlap With | ROADBREAKLINE |
| SOFTFEATURE | Must Not Overlap With | HYDROGRAPHICF |
| ROADBREAKLINE | Must Not Overlap With | HYDROGRAPHICF |
| SOFTFEATURE | Must Not Self-Intersect | |
| OVERPASS | Must Not Self-Intersect | |
| ROADBREAKLINE | Must Not Self-Intersect | |
| HYDROGRAPHIC... | Must Not Self-Intersect | |

**Figure 3. Breaklines topology rules**

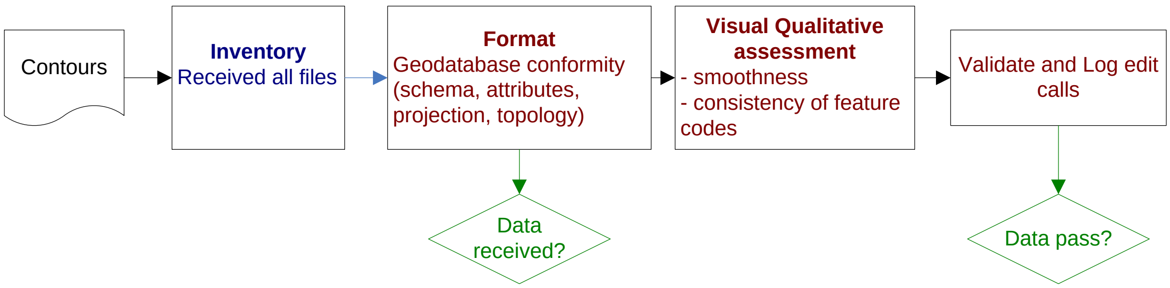
Then automated checks are applied on hydrofeatures to validate the 3D connectivity of the feature and the monotonicity of the hydrographic breaklines. Dewberry's major concern was that the hydrographic breaklines have a continuous flow downhill and that breaklines do not undulate. Error points are generated 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 TIN 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 do not differ too much from the LiDAR.

Dewberry's final check for the breaklines was to perform a full qualitative analysis of the breaklines. Dewberry compared the breaklines against LiDAR intensity images to ensure breaklines were captured in the required locations.

## Contour Qualitative Assessments

Dewberry also performed the qualitative assessments of the contours using the following workflow.




Upon receipt of each delivery area, the first step performed by Dewberry was a series of data topology validations. Dewberry checked for the following instances in the data:

1. Contours must not overlap
2. Contours must not intersect
3. Contours must not have dangles (except at project boundary)
4. Contours must not self-overlap
5. Contours must not self-intersect

After the topology and geodatabase format validation was complete, Dewberry checked the elevation attribute of each contour to ensure NULL values are not included. Finally, Dewberry loaded the contour data plus the Lidar intensity images into ArcGIS and performed a full qualitative review of the contour data for smoothness and consistency of feature codes.

Appendix H summarizes Dewberry's qualitative assessments of the breaklines and contours, with graphic examples of what the breaklines and contours look like.

## Deliverables

Except for the Report of Geodetic Control Survey for LiDAR and Photogrammetry, Northwest Florida, dated March 13, 2008, which was delivered separately and pertains to all deliverables in the Florida Panhandle, the deliverables listed at Table 5 are included on the external hard drive that accompanies this report.

**Table 5. Summary of Deliverables**

| Copies | Deliverable Description | Format | Location |
|---|---|---|---|
| 2 | Report of Geodetic Control Survey for LiDAR and Photogrammetry, Northwest Florida, dated 3/13/2008 | Hardcopy and pdf | Submitted separately |
| 1 | Data Dictionary | pdf | Appendix C |
| 3 | LiDAR Processing Report | Hardcopy and pdf | Appendix D |
| 3 | LiDAR Vertical Accuracy Report | Hardcopy and pdf | Appendix F |
| 1 | LiDAR Qualitative Assessment Report | pdf | Appendix G |
| 1 | Breakline/Contour Qualitative Assessment Report | pdf | Appendix H |
| 1 | Breaklines, Contours, Network-Adjusted Control Points, Vertical accuracy checkpoints, Tiling Footprint, Lidar ground masspoints | Geodatabase | Submitted separately |

## References


ASPRS, 2007, *Digital Elevation Model Technologies and Applications: The DEM Users Manual*, 2nd edition, American Society for Photogrammetry and Remote Sensing, Bethesda, MD.

ASPRS, 2004, *ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data*, American Society for Photogrammetry and Remote Sensing, Bethesda, MD, May 24, 2004, http://www.asprs.org/society/committees/lidar/downloads/Vertical_Accuracy_Reporting_for_Lidar_Data.pdf.

Bureau of the Budget, 1947, *National Map Accuracy Standards*, Office of Management and Budget, Washington, D.C.

FDEM, 2006, Florida GIS, *Baseline Specifications for Orthophotography and LiDAR*, Appendix B, *Terrestrial LiDAR Specifications*, Florida Division of Emergency Management, Tallahassee, FL, October, 2006.

FEMA, 2004, Appendix A, *Guidance for Aerial Mapping and Surveying*, to "Guidelines and Specifications for Flood Hazard Mapping Partners," Federal Emergency Management Agency, Washington, D.C.

FGCC, 1984, *Standards and Specifications for Geodetic Control Networks*, Federal Geodetic Control Committee, Silver Spring, ,MD, reprinted August 1993.

FGCC, 1988, *Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques*, Federal Geodetic Control Committee, Silver Spring, MD, reprinted with corrections, August, 1989.

FGDC, 1998a, *Geospatial Positioning Accuracy Standards, Part I: Reporting Methodology*, Federal Geographic Data Committee, c/o USGS, Reston, VA, http://www.fgdc.gov/standards/standards_publications/.

FGDC, 1998b, *Geospatial Positioning Accuracy Standards, Part 2, Standards for Geodetic Networks*, Federal Geographic Data Committee, c/o USGS, Reston, VA, http://www.fgdc.gov/standards/standards_publications/

FGDC, 1998b, *Geospatial Positioning Accuracy Standards, Part 3, National Standard for Spatial Data Accuracy*, Federal Geographic Data Committee, c/o USGS, Reston, VA, http://www.fgdc.gov/standards/standards_publications/

FGDC, 1998d, Content Standard for Digital Geospatial Metadata (CSDGM), Federal Geographic Data Committee, c/o USGS, Reston, VA, www.fgdc.gov/metadata/contstan.html.

NDEP, 2004, *Guidelines for Digital Elevation Data*, Version 1.0, National Digital Elevation Program, May 10, 2004, http://www.ndep.gov/

NOAA, 1997, *Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 cm and 5 cm),* NOAA Technical Memorandum NOS NGS-58, November, 1997.

## General Notes

This report is incomplete without the external hard drives of the LiDAR masspoints, breaklines, contours, and control. See the Geodatabase structure at Appendix I.

This digital mapping data complies with the Federal Emergency Management Agency (FEMA) "Guidelines and Specifications for Flood Hazard Mapping Partners," Appendix A: *Guidance for Aerial Mapping and Surveying.*

The LiDAR vertical accuracy report at Appendix F conforms with the National Standard for Spatial Data Accuracy (NSSDA).

The digital mapping data is certified to conform to Appendix B, *Terrestrial LiDAR Specifications*, of the "Florida Baseline Specifications for Orthophotography and LiDAR." This report is certified to conform with Chapter 61G17-6, Minimum Technical Standards, of the Florida Administrative Code, as pertains to a Specific Purpose LiDAR Survey.

**THIS REPORT IS NOT VALID WITHOUT THE SIGNATURE AND RAISED SEAL OF A FLORIDA PROFESSIONAL SURVEYOR AND MAPPER IN RESPONSIBLE CHARGE**.

**Surveyor and Mapper in Responsible Charge:**
David F. Maune, PhD, PSM, PS, GS, CP, CFM
Professional Surveyor and Mapper
License #LS6659

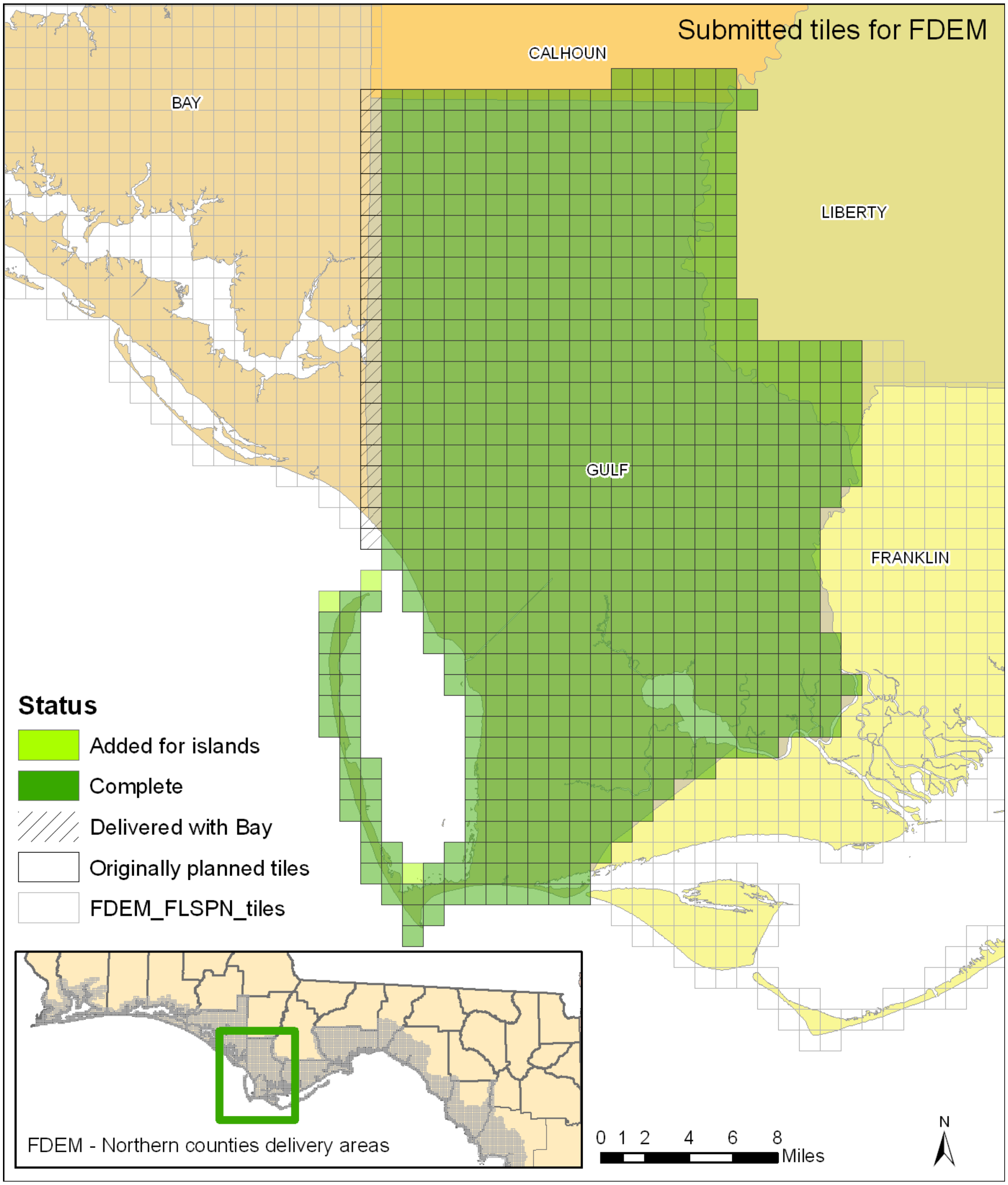
Signed: ______________________________ Date: _______________

DAVID F. MAUNE
LICENSE NUMBER
LS6659
STATE OF FLORIDA
PROFESSIONAL SURVEYOR & MAPPER

## List of Appendices

## Appendix A:  County Project Tiling Footprint: Gulf

725 tiles delivered (722 initially planned +3 added tiles because they contained island features) A row of tiles (22) at the boundary of Bay and Gulf was initially planned in Gulf delivery but will be delivered with Bay County.



List of delivered complete tiles (722):

| | | | | | | |
|---|---|---|---|---|---|---|
| 062269_N | 059585_N | 064451_N | 064983_N | 068213_N | 058500_N | 063900_N |
| 062270_N | 061202_N | 066592_N | 064984_N | 068214_N | 058501_N | 063901_N |
| 062271_N | 061203_N | 066593_N | 064986_N | 068215_N | 058502_N | 063902_N |
| 062272_N | 061204_N | 066594_N | 064987_N | 068216_N | 058503_N | 063903_N |
| 062273_N | 061205_N | 066595_N | 064988_N | 068217_N | 058504_N | 063904_N |
| 062274_N | 066605_N | 066596_N | 064989_N | 068218_N | 058505_N | 063905_N |
| 062275_N | 066606_N | 066597_N | 064990_N | 068219_N | 067681_N | 063906_N |
| 062276_N | 066607_N | 059569_N | 064991_N | 068220_N | 067682_N | 063907_N |
| 062277_N | 066608_N | 064432_N | 068224_N | 068221_N | 067683_N | 063908_N |
| 062278_N | 059030_N | 064433_N | 068225_N | 068222_N | 058489_N | 063909_N |
| 062279_N | 059031_N | 064434_N | 068226_N | 068223_N | 058490_N | 063910_N |
| 062280_N | 059032_N | 064435_N | 068227_N | 061198_N | 058491_N | 063911_N |
| 062281_N | 059033_N | 059036_N | 068228_N | 061199_N | 058492_N | 067140_N |
| 062283_N | 059034_N | 059037_N | 068229_N | 061200_N | 058493_N | 057409_N |
| 062284_N | 059035_N | 059038_N | 062818_N | 061201_N | 058494_N | 057410_N |
| 062285_N | 062809_N | 059039_N | 062819_N | 061733_N | 058495_N | 057411_N |
| 062282_N | 062810_N | 059040_N | 062820_N | 061734_N | 058496_N | 057412_N |
| 059570_N | 062811_N | 059041_N | 062821_N | 061735_N | 063889_N | 057413_N |
| 068757_N | 062812_N | 059042_N | 062822_N | 061736_N | 063890_N | 057414_N |
| 068758_N | 062813_N | 068750_N | 061189_N | 061737_N | 063891_N | 057415_N |
| 068759_N | 062814_N | 068751_N | 061190_N | 061738_N | 063892_N | 067131_N |
| 068760_N | 062815_N | 068752_N | 061191_N | 067129_N | 061729_N | 067132_N |
| 068761_N | 062816_N | 059043_N | 061192_N | 067130_N | 061730_N | 067133_N |
| 068762_N | 062817_N | 059044_N | 061193_N | 063349_N | 061731_N | 067134_N |
| 068763_N | 068753_N | 059045_N | 061194_N | 056880_N | 061732_N | 067135_N |
| 068764_N | 068754_N | 066589_N | 061195_N | 056881_N | 067142_N | 067136_N |
| 068765_N | 068755_N | 066590_N | 061196_N | 056882_N | 067143_N | 067137_N |
| 068766_N | 068756_N | 066591_N | 061197_N | 064985_N | 067144_N | 067138_N |
| 068767_N | 064436_N | 067149_N | 068209_N | 056883_N | 067145_N | 057416_N |
| 068768_N | 064437_N | 067150_N | 068210_N | 066049_N | 067141_N | 057417_N |
| 068769_N | 064438_N | 067151_N | 062823_N | 066050_N | 067684_N | 057418_N |
| 066067_N | 064439_N | 056884_N | 062824_N | 066051_N | 067685_N | 067139_N |
| 066068_N | 064440_N | 056885_N | 062825_N | 066052_N | 067686_N | 063350_N |
| 066069_N | 066056_N | 066598_N | 062826_N | 066053_N | 067687_N | 063351_N |
| 066070_N | 066057_N | 066599_N | 057951_N | 066054_N | 067688_N | 063352_N |
| 066071_N | 066058_N | 066600_N | 057952_N | 066055_N | 067689_N | 063353_N |
| 059029_N | 066059_N | 066601_N | 057953_N | 068749_N | 067690_N | 063354_N |
| 059571_N | 066060_N | 066602_N | 057954_N | 061739_N | 067146_N | 063355_N |
| 059572_N | 066061_N | 066603_N | 057955_N | 061740_N | 067147_N | 063356_N |
| 059573_N | 066062_N | 066604_N | 057956_N | 061741_N | 067148_N | 063357_N |
| 059574_N | 066063_N | 064969_N | 057957_N | 061742_N | 063894_N | 076857_N |
| 059575_N | 066064_N | 064970_N | 057958_N | 061743_N | 063895_N | 076858_N |
| 059576_N | 066065_N | 064971_N | 057959_N | 061744_N | 063896_N | 076859_N |
| 059577_N | 066066_N | 064972_N | 057960_N | 061745_N | 063897_N | 065521_N |
| 059578_N | 064441_N | 064973_N | 057961_N | 063893_N | 063898_N | 065522_N |
| 066609_N | 064442_N | 064974_N | 057962_N | 067669_N | 063899_N | 065523_N |
| 066610_N | 064443_N | 064975_N | 057963_N | 067670_N | 057949_N | 065524_N |
| 066611_N | 064444_N | 064976_N | 057964_N | 067671_N | 057950_N | 065525_N |
| 059579_N | 064445_N | 064977_N | 057965_N | 067672_N | 067675_N | 065526_N |
| 059580_N | 064446_N | 064978_N | 064429_N | 067673_N | 067676_N | 065527_N |
| 059581_N | 064447_N | 064979_N | 064430_N | 067674_N | 067677_N | 065528_N |
| 059582_N | 064448_N | 064980_N | 064431_N | 058497_N | 067678_N | 077938_N |
| 059583_N | 064449_N | 064981_N | 068211_N | 058498_N | 067679_N | 063365_N |
| 059584_N | 064450_N | 064982_N | 068212_N | 058499_N | 067680_N | 063366_N |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 071998_N | 073082_N | 075780_N | 073620_N | 075236_N |
| 078470_N | 065518_N | 077395_N | 073083_N | 075781_N | 073621_N | 075237_N |
| 060657_N | 065519_N | 077396_N | 071999_N | 075768_N | 073622_N | 075238_N |
| 060658_N | 065520_N | 077397_N | 072000_N | 069845_N | 073623_N | 075239_N |
| 060659_N | 076317_N | 077398_N | 072001_N | 072548_N | 073624_N | 075240_N |
| 060660_N | 076318_N | 077394_N | 070919_N | 072549_N | 073625_N | 075241_N |
| 060661_N | 076319_N | 070367_N | 070920_N | 072550_N | 073626_N | 075242_N |
| 060662_N | 076320_N | 070368_N | 070921_N | 072551_N | 073627_N | 070911_N |
| 060663_N | 057419_N | 070370_N | 070922_N | 069289_N | 073628_N | 070912_N |
| 060664_N | 057420_N | 070371_N | 070923_N | 069290_N | 073629_N | 070913_N |
| 078471_N | 057421_N | 070372_N | 070924_N | 069291_N | 073630_N | 070914_N |
| 060665_N | 057422_N | 073066_N | 070925_N | 069292_N | 071461_N | 076308_N |
| 063358_N | 057423_N | 073067_N | 070926_N | 069293_N | 071462_N | 069839_N |
| 076848_N | 057424_N | 070373_N | 070927_N | 069294_N | 071463_N | 069840_N |
| 076849_N | 057425_N | 070374_N | 070928_N | 069295_N | 071464_N | 069841_N |
| 076852_N | 057426_N | 070375_N | 070929_N | 069830_N | 071465_N | 069842_N |
| 076853_N | 063359_N | 070376_N | 077389_N | 069831_N | 071466_N | 069843_N |
| 076854_N | 063360_N | 070377_N | 077391_N | 069832_N | 071467_N | 069844_N |
| 076855_N | 063361_N | 070378_N | 077392_N | 069833_N | 071468_N | 071446_N |
| 076856_N | 063362_N | 070379_N | 077393_N | 069834_N | 071469_N | 071447_N |
| 065529_N | 063363_N | 070380_N | 069296_N | 069835_N | 072532_N | 070915_N |
| 065530_N | 063364_N | 070381_N | 069297_N | 069836_N | 072533_N | 070916_N |
| 065531_N | 060109_N | 070382_N | 069298_N | 069837_N | 072537_N | 070917_N |
| 060649_N | 060110_N | 070383_N | 069299_N | 069838_N | 072538_N | 070918_N |
| 060650_N | 060111_N | 070384_N | 069300_N | 074147_N | 072539_N | 071451_N |
| 060651_N | 060112_N | 070385_N | 069301_N | 075773_N | 072540_N | 071452_N |
| 060652_N | 060113_N | 070386_N | 069302_N | 075774_N | 072541_N | 071453_N |
| 060653_N | 060114_N | 070387_N | 069303_N | 075775_N | 072542_N | 071454_N |
| 060654_N | 060115_N | 070388_N | 069304_N | 075776_N | 072543_N | 071455_N |
| 060655_N | 060116_N | 070389_N | 069305_N | 075777_N | 072544_N | 071456_N |
| 060656_N | 060117_N | 071986_N | 074165_N | 075778_N | 072545_N | 071457_N |
| 065509_N | 060118_N | 071987_N | 074166_N | 075779_N | 072546_N | 071458_N |
| 065510_N | 060119_N | 071992_N | 074167_N | 074153_N | 072547_N | 071459_N |
| 065511_N | 060120_N | 074160_N | 075767_N | 074154_N | 072534_N | 071460_N |
| 077929_N | 060121_N | 074161_N | 073084_N | 074155_N | 072535_N | 072526_N |
| 077930_N | 060122_N | 074162_N | 073085_N | 074156_N | 072536_N | 072527_N |
| 077931_N | 060123_N | 074163_N | 073086_N | 074157_N | 075227_N | 074687_N |
| 077932_N | 060124_N | 074164_N | 073087_N | 074158_N | 075228_N | 074688_N |
| 077933_N | 060125_N | 073073_N | 072002_N | 074159_N | 069846_N | 074693_N |
| 077934_N | 076313_N | 073074_N | 072003_N | 073613_N | 069847_N | 074694_N |
| 077935_N | 076314_N | 077388_N | 072004_N | 073614_N | 069848_N | 074695_N |
| 077936_N | 076315_N | 073606_N | 072005_N | 073615_N | 069849_N | 074698_N |
| 077937_N | 076316_N | 073607_N | 072006_N | 073616_N | 070906_N | 074699_N |
| 065512_N | 079010_N | 073075_N | 073088_N | 073617_N | 070907_N | 074700_N |
| 065513_N | 071993_N | 073076_N | 073089_N | 069306_N | 071470_N | 074701_N |
| 065514_N | 071994_N | 073077_N | 073090_N | 069307_N | 074696_N | 074702_N |
| 065515_N | 071995_N | 073078_N | 072007_N | 069308_N | 074697_N | 074703_N |
| 065516_N | 071996_N | 073079_N | 072008_N | 069309_N | 075233_N | 074704_N |
| 065517_N | 071997_N | 073080_N | 072009_N | 073618_N | 075234_N | |
| | | 073081_N | 072010_N | 073619_N | 075235_N | |

List of delivered added tiles: (3 tiles were not counted in the FDEM project initially but added because they contained islands)

077390_N

069828_N

070366_N

# Appendix B:  Gulf County Geodetic Control Points

| Station | County | Longitude | Latitude | Height (meters) | Ellipsoid Height | Description |
|---|---|---|---|---|---|---|
| AS0861 | Gulf | 85 20 50.49564 | 29 59 51.55658 | 4.221 | -23.337 | RECOVERED NSRS STATION (SEE DATASHEET PID# AS0861) |
| BE0916 (N290) | Gulf | 85 23 20.68909 | 30 8 17.68802 | 14.095 | -13.652 | RECOVERED NSRS STATION (SEE DATASHEET PID# BE0916) |
| FB174P07 | Gulf | 85 10 41.12214 | 29 57 23.30006 | 6.023 | -21.474 | SET PRIMARY MONUMENT |
| FB173P16 | Gulf | 85 8 58.24520 | 30 10 44.42905 | 8.126 | -19.663 | SET SECONDARY MONUMENT |
| FB173P18 | Gulf | 85 16 29.79308 | 30 3 15.35602 | 8.503 | -19.125 | SET SECONDARY MONUMENT |
| FB173P19 | Gulf | 85 8 52.22663 | 29 50 35.84779 | 0.511 | -26.803 | SET SECONDARY MONUMENT |
| FB173P20 | Gulf | 85 3 49.99471 | 29 56 11.51293 | 1.369 | -26.066 | SET SECONDARY MONUMENT |
| FB173P21 | Gulf | 85 3 53.43131 | 29 51 3.34941 | 1.526 | -25.778 | SET SECONDARY MONUMENT |
| FB173P22 | Gulf | 85 17 24.70907 | 29 53 8.54080 | 4.893 | -22.488 | SET SECONDARY MONUMENT |
| FB173P29 | Gulf | 85 14 47.70443 | 29 40 47.77206 | 2.744 | -24.368 | **RECOVERED DNR MONUMENT (51-83 B 41) |
| FB173P30 | Gulf | 85 24 23.73323 | 29 47 20.43880 | 3.954 | -23.252 | SET SECONDARY MONUMENT |
| FB174P15 | Gulf | 85 16 25.20868 | 29 46 47.67238 | 6.079 | -21.14 | SET SECONDARY MONUMENT |
| FB174P16 | Gulf | 85 16 18.72712 | 30 8 25.92046 | 14.69 | -13.045 | SET SECONDARY MONUMENT |
| FB170P19 | Gulf | 85 21 52.83713 | 29 40 44.98303 | 0.493 | -26.591 | SET PRIMARY MONUMENT |

# Appendix C:  Data Dictionary

LiDARgrammetry Data Dictionary
& Stereo Compilation Rules

FINAL

FDEM (Florida Department of Emergency Management)
January 25, 2008

# Table of Contents

## Horizontal and Vertical Datum

Horizontal datum shall be referenced to the appropriate Florida State Plane Coordinate System. The horizontal datum shall be North American Datum of 1983/HARN adjustment in US Survey Feet. The vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD 88). Geoid03 shall be used to convert ellipsoidal heights to orthometric heights.

## Coordinate System and Projection

All data shall be projected to the appropriate Florida State Plane Coordinate System Zone, Units in US Survey Feet.

## Contour Topology Rules

The following contour topology rules have been incorporated into each geodatabase shell provided by PDS. The topology must be validated by each subcontractor prior to delivery to PDS. PDS shall further validate the topology before final submittal to FDEM.

| **Name: CONTOURS_Topology** | | | | Cluster Tolerance: 0.003<br>Maximum Generated Error Count: Undefined<br>State: Analyzed without errors |
|---|---|---|---|---|
| **Feature Class** | **Weight** | **XY Rank** | **Z Rank** | **Event Notification** |
| CONTOUR_1FT | 5 | 1 | 1 | No |
| CONTOUR_2FT | 5 | 1 | 1 | No |

**Topology Rules**

| Name | Rule Type | Trigger Event | Origin (*FeatureClass::Subtype*) | Destination (*FeatureClass::Subtype*) |
|---|---|---|---|---|
| Must not intersect | The rule is a line-no intersection rule | No | CONTOUR_1FT::All | CONTOUR_1FT::All |
| Must not intersect | The rule is a line-no intersection rule | No | CONTOUR_2FT::All | CONTOUR_2FT::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | CONTOUR_2FT::All | CONTOUR_2FT::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | CONTOUR_1FT::All | CONTOUR_1FT::All |

## *Breakline Topology Rules*

The following breakline topology rules have been incorporated into each geodatabase shell provided by PDS. The topology must be validated by each subcontractor prior to delivery to PDS. PDS shall further validate the topology before final submittal to FDEM.

| **Name: BREAKLINES_Topology** | | | Cluster Tolerance: 0.003<br>Maximum Generated Error Count: Undefined<br>State: Analyzed without errors | |
|---|---|---|---|---|
| **Feature Class** | **Weight** | **XY Rank** | **Z Rank** | **Event Notification** |
| COASTALSHORELINE | 5 | 1 | 1 | No |
| HYDROGRAPHICFEATURE | 5 | 1 | 1 | No |
| OVERPASS | 5 | 1 | 1 | No |
| ROADBREAKLINE | 5 | 1 | 1 | No |
| SOFTFEATURE | 5 | 1 | 1 | No |

### Topology Rules

| **Name** | **Rule Type** | **Trigger Event** | **Origin** (*FeatureClass::Subtype*) | **Destination** (*FeatureClass::Subtype*) |
|---|---|---|---|---|
| Must not intersect | The rule is a line-no intersection rule | No | SOFTFEATURE::All | SOFTFEATURE::All |
| Must not intersect | The rule is a line-no intersection rule | No | OVERPASS::All | OVERPASS::All |
| Must not intersect | The rule is a line-no intersection rule | No | ROADBREAKLINE::All | ROADBREAKLINE::All |
| Must not intersect | The rule is a line-no intersection rule | No | HYDROGRAPHICFEATURE::All | HYDROGRAPHICFEATURE::All |
| Must not intersect | The rule is a line-no intersection rule | No | COASTALSHORELINE::All | COASTALSHORELINE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | SOFTFEATURE::All | ROADBREAKLINE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | SOFTFEATURE::All | HYDROGRAPHICFEATURE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | SOFTFEATURE::All | COASTALSHORELINE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | ROADBREAKLINE::All | HYDROGRAPHICFEATURE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | ROADBREAKLINE::All | COASTALSHORELINE::All |
| Must not overlap | The rule is a line-no overlap line rule | No | HYDROGRAPHICFEATURE::All | COASTALSHORELINE::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | SOFTFEATURE::All | SOFTFEATURE::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | OVERPASS::All | OVERPASS::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | ROADBREAKLINE::All | ROADBREAKLINE::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | HYDROGRAPHICFEATURE::All | HYDROGRAPHICFEATURE::All |
| Must not self-intersect | The rule is a line-no self intersect rule | No | COASTALSHORELINE::All | COASTALSHORELINE::All |

# Coastal Shoreline

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** COASTALSHORELINE
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polygon
**Annotation Subclass:** None

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| SHAPE_AREA | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Coast | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Coastal Shoreline | 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. Orthophotography will not be use to delineate this shoreline. | The feature shall be extracted at the apparent land/water interface, as determined by the LiDAR intensity data, to the extent of the tile boundaries. For the polygon closure vertices and segments, null values or a value of 0 are acceptable since this is not an actual shoreline. The digital orthophotography is not a suitable source for capturing this feature. Efforts should be taken to gradually feather the difference between tidal conditions of neighboring flights. Stair-stepping of the breakline feature will not be allowed.<br><br>If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water |

where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.

Breaklines shall snap and merge seamlessly with linear hydrographic features.

## *Linear Hydrographic Features*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** HYDROGRAPHICFEATURE
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polyline
**Annotation Subclass:** None

### Description

This polyline feature class will depict linear hydrographic features with a length of 0.5 miles or longer as breaklines.

### 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | HydroL | 0 | 0 | | Assigned by PDS |

### Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Single Line Feature | Linear hydrographic features such as streams, shorelines, canals, swales, embankments, etc. with an average width less than or equal to 8 feet. . In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other embankments fall into the soft breakline feature class | Capture linear hydro features as single breaklines. Average width shall be 8 feet or less to show as single line. Each vertex placed should maintain vertical integrity. |
| 2 | Dual Line Feature | Linear hydrographic features such as streams, shorelines, canals, swales, etc. with an average width greater than 8 feet. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other embankments fall into the soft breakline feature class. | Capture features showing dual line (one on each side of the feature). Average width shall be great than 8 feet to show as a double line. Each vertex placed should maintain vertical integrity and data is not required to show “closed polygon”.<br><br>These instructions are only for docks or piers that follow the coastline or water’s edge, not for docks or piers that |

extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.

Note: Carry through bridges for all linear hydrographic features.

# *Closed Water Body Features*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** WATERBODY
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polygon
**Annotation Subclass:** None

## Description

This polygon feature class will depict closed water body features and will have the associated water elevation available as an attribute.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| SHAPE_AREA | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| WATERBODY_ELEVATION_MS | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| TYPE | Long Integer | No | 1 | HydroP | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Water Body | 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 one-half acres in size or greater.<br><br>"Donuts" will exist where there are islands within a closed water body feature. | Water bodies shall be captured as closed polygons with the water feature to the right. <u>The compiler shall take care to ensure that the z-value remains consistent for all vertices placed on the water body.</u> The field "WATERBODY_ELEVATION_MS" shall be automatically computed from the z-value of the vertices.<br><br>An Island within a Closed Water Body Feature will also have a "donut polygon" compiled in addition to an Island polygon.<br><br>These instructions are only for docks or piers that follow |

the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.

# Road Features

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** ROADBREAKLINE
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polyline
**Annotation Subclass:** None

## Description

This polyline feature class will depict apparent edge or road pavement as breaklines but will not include bridges or overpasses.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Road | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Edge of Pavement | Capture edge of pavement (non-paved or compact surfaces as open to compiler interpretability) on both sides of the road. Runways are not to be included. | DO NOT INCLUDE Bridges or Overpasses within this feature type. Capture apparent edge of pavement (including paved shoulders). Each vertex placed should maintain vertical integrity and data is not required to show "closed polygon". Box culverts should be continued as edge of pavement unless a clear guardrail system is in place; in that case, feature should be shown as bridge / overpass. |

# Bridge and Overpass Features

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** OVERPASS
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polyline
**Annotation Subclass:** None

## Description

This polyline feature class will depict bridges and overpasses as separate entities from the edge of pavement feature class.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Bridge | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Bridge Overpass | Feature should show edge of bridge or overpass. | Capture apparent edge of pavement on bridges or overpasses. Do not capture guard rails or non-drivable surfaces such as sidewalks. Capture edge of drivable pavement only. Each vertex placed should maintain vertical integrity and data is not required to show “closed polygon”. Box culverts should be captured in this feature class if a clear guardrail system is in place; otherwise, show as edge-of-pavement. |

# Soft Features

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** SOFTFEATURE
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polyline
**Annotation Subclass:** None

## Description

This polyline feature class will depict soft changes in the terrain to support better hydrological modeling of the LiDAR data and sub-sequent contours.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Soft | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Soft Breakline | Supplemental breaklines where LiDAR mass points are not sufficient to create a hydrologically correct DTM. Soft features shall include ridges, valleys, top of banks, etc.<br><br>Soft features may also include natural Embankments that act as small ponding areas. Top of Banks can also be included in the soft breakline class so long as it does not define the edge of a water feature. | Capture breaklines to depict soft changes in the elevation. If the elevation changes are easily visible, go light on the breakline capture. Each vertex placed should maintain vertical integrity. |

## *Island Features*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** ISLAND
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polygon
**Annotation Subclass:** None

### Description

This polygon feature class will depict natural and man-made islands as closed polygons.

### 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| SHAPE_AREA | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Island | 0 | 0 | | Assigned by PDS |

### Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Island | Apparent boundary of natural or man-made island feature captured with a constant elevation.<br><br>Island features will be captured for features one-half acres in size or greater. | Island shall take precedence over Coastal Shore Line Features. Islands shall be captured as closed polygons with the land feature to the right. The compiler shall take care to ensure that the z-value remains consistent for all vertices placed around the island.<br><br>These instructions are only for docks or piers that follow the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated |

headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.

# Low Confidence Areas

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** CONFIDENCE
**Contains Z Values:** No
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polygon
**Annotation Subclass:** None

## Description

This polygon feature class will depict areas where the ground is obscured by dense vegetation meaning that the resultant contours may not meet the required accuracy specifications.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| SHAPE_AREA | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| TYPE | Long Integer | No | 1 | Obscure | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Low Confidence Area | Apparent boundary of vegetated areas that are considered obscured to the extent that adequate vertical data cannot be clearly determined to accurately define the DTM. These features are for reference only to indicate areas where the vertical data may not meet the data accuracy requirements due to heavy vegetation. | Capture as closed polygon with the obscured area to the right of the line. Compiler does not need to worry about z-values of vertices; feature class will be 2-D only. |

Note: Area must be ½ acre or larger. Only outline areas where you are not sure about vegetative penetration of the LiDAR data. This is not the same as a traditional obscured area.

# Masspoints

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** MASSPOINT
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Point
**Annotation Subclass:** None

## Description

This feature class depicts masspoints as determined by the LiDAR ground points (LAS Class 2).

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| TYPE | Long Integer | No | 1 | Masspoint | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Masspoint | Only the bare earth classification (Class 2) shall be loaded into the MASSPOINT feature class. | None. Data should be loaded from LAS Class 2 (Ground) |

# *1 Foot Contours*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** CONTOUR_1FT
**Contains Z Values:** No
**Z Resolution:** N/A
**Z Tolerance:** N/A

**Feature Type:** Polyline
**Annotation Subclass:** None

## Description

This polyline feature class will depict 1' contours modeled from the LiDAR ground points and the supplemental breaklines.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| CONTOUR_TYPE_DESC | Long Integer | No | | dCONTOURTYPE | 0 | 0 | 50 | Assigned by PDS |
| CONTOUR_ELEVATION_MS | Double | No | | | 0 | 0 | | Calculated by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Intermediate | A contour line drawn between index contours. Depending on the contour interval there are three or four intermediate contours between the index contours. | They are normally continuous throughout a map, but may be dropped or joined with an index contour where the slope is steep and where there is insufficient space to show all of the intermediate lines. |
| 2 | Supplementary | Supplementary contours are used to portray important relief features that would otherwise not be shown by the index and intermediate contours (basic contours). They are normally added only in areas of low relief, but they may also be used in rugged terrain to emphasize features. Supplementary contours are shown as screened lines so that they are distinguishable from the basic contours, yet not | These dotted lines are placed in areas where elevation change is minimal. If there is a lot of space between Index and Intermediate Contours (as happens where the land is relatively flat), these lines are added to indicate that there *are* elevation measurements, even if they are few and far between.<br><br>If the horizontal distance between two adjacent contours is |

| | | | |
|---|---|---|---|
| | | unduly prominent on the published map. | larger than 1” at map scale (100’), then add appropriate supplemental contours from the 1FT_CONTOUR feature class. Supplemental contours do not have to be continuous but should have a minimum length of 200’. |
| 3 | Depression | Depression contours are closed contours that surround a basin or sink. They are shown by right-angle ticks placed on the contour lines, pointed inward (down slope). Fill contours are a special type of depression contours, used to indicate an area that has been filled to support a road or railway grade. | Use when appropriate. |
| 4 | Index | Index Contours are to be placed at every 5th contour interval (1, 5, 10, etc…) | No special rules |
| 5 | Intermediate Low Confidence | Intermediate contours (Code 1) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 6 | Supplementary Low Confidence | Supplementary contours (Code 2) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 7 | Depression Low Confidence | Depression contours (Code 3) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 8 | Index Low Confidence | Index contours (Code 4) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |

# *2 Foot Contours*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** CONTOUR_2FT
**Contains Z Values:** No
**Z Resolution:** N/A
**Z Tolerance:** N/A

**Feature Type:** Polyline
**Annotation Subclass:** None

## Description

This polyline feature class will depict 1' contours modeled from the LiDAR ground points and the supplemental breaklines.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| CONTOUR_TYPE_DESC | Long Integer | No | | dCONTOURTYPE | 0 | 0 | 50 | Assigned by PDS |
| CONTOUR_ELEVATION_MS | Double | No | | | 0 | 0 | | Calculated by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Intermediate | A contour line drawn between index contours. Depending on the contour interval there are three or four intermediate contours between the index contours. | They are normally continuous throughout a map, but may be dropped or joined with an index contour where the slope is steep and where there is insufficient space to show all of the intermediate lines. |
| 2 | Supplementary | Supplementary contours are used to portray important relief features that would otherwise not be shown by the index and intermediate contours (basic contours). They are normally added only in areas of low relief, but they may also be used in rugged terrain to emphasize features. Supplementary contours are shown as screened lines so that they are | These dotted lines are placed in areas where elevation change is minimal. If there is a lot of space between Index and Intermediate Contours (as happens where the land is relatively flat), these lines are added to indicate that there *are* elevation measurements, even if they are few and far between. |

| | | | |
|---|---|---|---|
| | | distinguishable from the basic contours, yet not unduly prominent on the published map. | If the horizontal distance between two adjacent contours is larger than 1” at map scale (100’), then add appropriate supplemental contours from the 1FT_CONTOUR feature class. Supplemental contours do not have to be continuous but should have a minimum length of 200’. |
| 3 | Depression | Depression contours are closed contours that surround a basin or sink. They are shown by right-angle ticks placed on the contour lines, pointed inward (down slope). Fill contours are a special type of depression contours, used to indicate an area that has been filled to support a road or railway grade. | Use when appropriate. |
| 4 | Index | Index Contours are to be placed at every 5$^{th}$ contour interval (1, 5, 10, etc…) | No special rules |
| 5 | Intermediate Low Confidence | Intermediate contours (Code 1) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 6 | Supplementary Low Confidence | Supplementary contours (Code 2) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 7 | Depression Low Confidence | Depression contours (Code 3) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |
| 8 | Index Low Confidence | Index contours (Code 4) that are located in low confidence area should be cut to the low confidence boundary and should be reclassified to this code. | No special collection rules are necessary as this is a geo-processing task. |

# Ground Control

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** GROUNDCONTROL
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Point
**Annotation Subclass:** None

## Description

This feature class depicts the points used in the acquisition and calibration of the LiDAR and aerial photography collected by Aero-Metric, Sanborn and Terrapoint.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| TYPE | Long Integer | No | 1 | Control | 0 | 0 | | Assigned by PDS |
| POINTID | String | Yes | | | | | 12 | Assigned by PDS |
| X_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| Y_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| Z_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Control Point | Primary or Secondary PDS control points used for either base station operations or in the calibration and adjustment of the control. | None. |

# *Vertical Accuracy Test Points*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** VERTACCTESTPTS
**Contains Z Values:** Yes
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Point
**Annotation Subclass:** None

## Description

This feature class depicts the points used by PDS to test the vertical accuracy of the data produced.

## 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| POINTID | String | Yes | | | | | 12 | Assigned by PDS |
| X_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| Y_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| Z_COORD | Double | Yes | | | 0 | 0 | | Assigned by PDS |
| LANDCOVER | Long Integer | No | 1 | dLANDCOVERTYPE | 0 | 0 | | Assigned by PDS |

## Feature Definition

| Code | Description | Definition | Capture Rules |
|---|---|---|---|
| 1 | Bare-Earth and Low Grass | None. | None. |
| 2 | Brush Lands and Low Trees | None. | None. |
| 3 | Forested Areas Fully Covered by Trees | None. | None. |
| 4 | Urban Areas | None. | None. |

## *Footprint (Tile Boundaries)*

**Feature Dataset:** TOPOGRAPHIC
**Contains M Values:** No
**XY Resolution:** Accept Default Setting
**XY Tolerance:** 0.003

**Feature Class:** FOOTPRINT
**Contains Z Values:** No
**Z Resolution:** Accept Default Setting
**Z Tolerance:** 0.001

**Feature Type:** Polygon
**Annotation Subclass:** None

### Description

This polygon feature class includes the Florida 5,000' x 5,000' tiles for each countywide geodatabase produced.

### 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 |
| DATESTAMP_DT | Date | Yes | | | 0 | 0 | 8 | Assigned by PDS |
| SHAPE_LENGTH | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| SHAPE_AREA | Double | Yes | | | 0 | 0 | | Calculated by PDS |
| CELLNUM | String | No | | | 0 | 0 | 8 | Assigned by PDS |

## *Contact Information*

Any questions regarding this document should be addressed to:

Brian Mayfield, C.P., GISP, G.L.S.
Associate / Sr. Project Manager
Dewberry
8401 Arlington Blvd.
Fairfax, VA 22031
(703) 849-0254 – voice
(703) 340-4141 – cell
bmayfield@dewberry.com

# Appendix D: LiDAR Processing Report

## FLORIDA DIVISION OF EMERGENCY MANAGEMENT

## GULF and western FRANKLIN COUNTIES, FL

## LiDAR Acquisition July, 2007

## LiDAR Processing Report

Prepared by:

AERO-METRIC, Inc.
4020 Technology Parkway
Sheboygan, WI 53083-6049
Phone: (920) 457-3631
FAX: (920) 457-0410

## EXECUTIVE SUMMARY

AERO-METRIC, INC. acquired accurate Light Detection and Ranging (LiDAR) data for an area covering Gulf and western Franklin counties, Florida. Using AERO-METRIC's Optech 3100ea LiDAR system, data was collected at 1000 meters above ground level along 333 pre-planned flight lines at a pulse rate of 100,000 points per second. Airborne GPS and IMU trajectories for the LiDAR sensor where also acquired during the time of flight.

LiDAR data acquisition surveys were completed for the project site area, under a surveying and mapping contract entered into on July 11$^{th}$, 2007 between Dewberry & Davis LLC and AERO-METRIC, INC.

The information maintains all standards published by the Florida Baseline Specifications for Orthophotography and LiDAR, dated October 17, 2006 and Federal Emergency Management Agency's (FEMA) Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying, April 2003.

table of contents

# 1 INTRODUCTION

This report contains a summary of the LiDAR data acquisition and processing for Gulf and western Franklin Counties, Florida.

## 1.1 Contact Info

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

AERO-METRIC, Inc.
4020 Technology Parkway
Sheboygan, WI 53083-6049

Attention: Robert Merry (Geomatics Manager)
Telephone: 920-457-3631
FAX: 920-457-0410
Email: rmerry@aerometric.com

## 1.2 Purpose

The LiDAR acquisition, bare-earth data set, breaklines, and contours were performed to develop a highly detailed ground surface dataset for use by the Florida Division of Emergency Management (FDEM).

## 1.3 Project Location

This project covered the entire Gulf county and the western portion of Franklin county, Florida as defined by the USGS DLG county boundary polygon.

## 1.4 Time Period

LiDAR data acquisition and Airborne GPS control surveys were completed between July 9th and July 22nd, 2007. A total of 22 flight missions were required to cover the project area. See page 10 for a sketch of the acquisition missions and Appendix 1 for each flight log. Ground check point GPS rapid static surveys were completed between June 21st and June 23rd, 2007.

## 1.5 Project Scope

AERO-METRIC, INC. acquired accurate Light Detection and Ranging (LiDAR) data for an area covering Gulf and western Franklin counties, Florida. Using AERO-METRIC's Optech 3100ea LiDAR system, data was collected at 1000 meters above ground level along 333 pre-planned flight lines at a pulse rate of 100,000 points per second. Airborne GPS and IMU trajectories for the LiDAR sensor where also acquired during the time of flight.

AERO-METRIC, Inc also collected 165 ground check points using Rapid Static GPS techniques. These check points were used to verify the processed LiDAR data.

The information maintains all standards published by the Florida Baseline Specifications for Orthophotography and LiDAR, dated October 17, 2006 and Federal Emergency Management Agency's (FEMA) Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying, April 2003.

# 2 LIDAR CALIBRATION

## 2.1 Introduction

The purpose of the LiDAR system calibration is to refine the system parameters in order for the post-processing software (Optech Incorporated's DASHMap, version 1.1) to produce a “point cloud” that best fits the actual ground.

The following report outlines the calibration of the Optech 3100ea LiDAR system flown on July 8, 2007 over the Apalachicola Municipal Airport, Franklin County, Florida.

## 2.2 Calibration Procedures

AERO-METRIC performs two types of calibrations on its Optech 3100ea LiDAR system. The first calibration, system calibration, is performed whenever the LiDAR system is installed in the aircraft. This calibration is performed to define the system parameters affected by the physical misalignment of the system versus aircraft. The second calibration, in-situ calibration, is performed for each mission using that missions data. This calibration is performed to refine the system parameters that are affected by the on site conditions.

## 2.3 System Calibration

The system calibration is performed whenever the LiDAR system is installed in the aircraft. This calibration is performed to define the system parameters affected by the physical misalignment of the system versus aircraft. The main system parameters that are affected are the heading, pitch, roll, and mirror scale.

The system calibration is performed by collecting data over a known test site that incorporates a flat surface and a large, flat roofed building. A ground survey is completed to define the flat surface and the building corners. The processed LiDAR data and ground survey data is input into TerraSolid's TerraMatch software to determine the systematic errors. The system parameters are then corrected according to the determined errors and used in the processing of future LiDAR acquisition missions.

## 2.4 In-situ Calibration

The in-situ calibration is performed for each mission using that missions data. This calibration is performed to refine the system parameters that are affected by the on site conditions.

For each mission, LiDAR data for at least one cross flight is acquired over the mission’s acquisition site. The processed data of the cross flight is compared to the perpendicular flight lines using TerraSolid's TerraMatch software to determine if any systematic errors are present.  In this calibration, the data of individual flight lines are compared against each other and their systematic errors are corrected in the final processed data.

# 3 GEODETIC BASE NETWORK

## 3.1 Network Scope

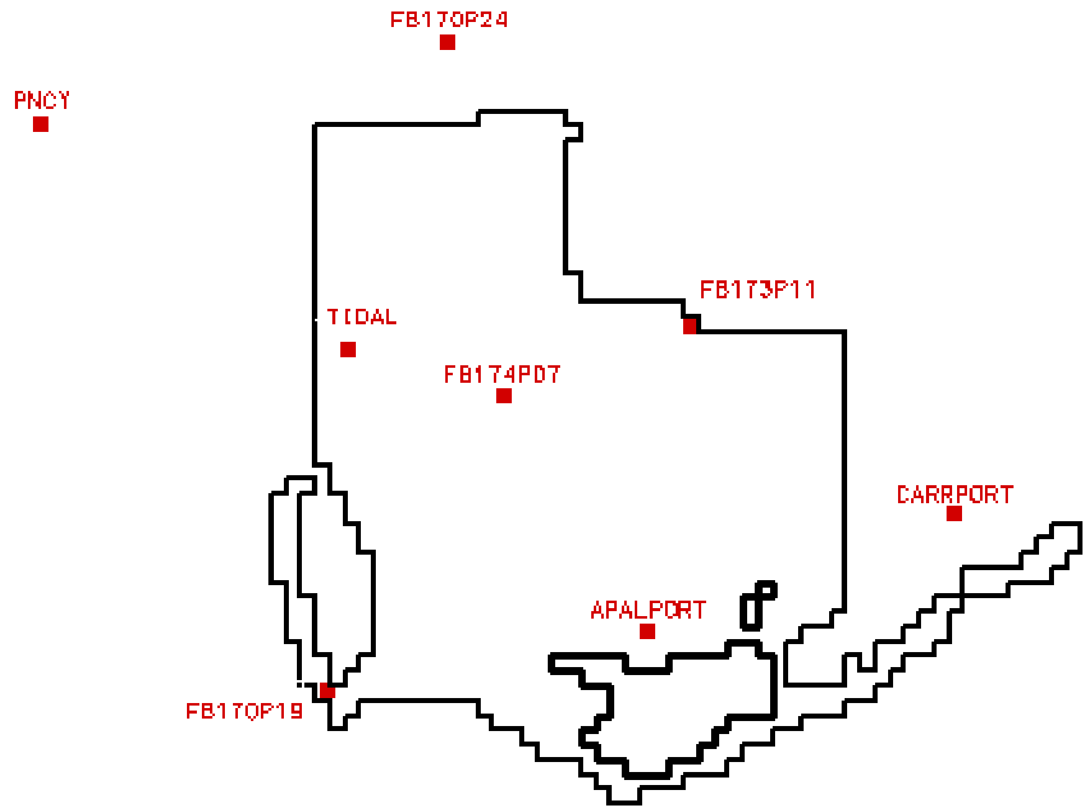
The PDS (Program and Data Solutions) team established a geodetic control network to provide accurate and consistent horizontal and vertical control for LiDAR acquisition using GPS technology.

AERO-METRIC surveyors occupied seven of the geodetic control network monuments (APALPORT, CARRPORT, FB170P19, FB170P24, FB173P11, FB174P07, TIDAL) throughout the acquisition of LiDAR data.  In addition to these control stations, the National Geodetic Survey (NGS) Continuously Operating Reference Station (CORS) PNCY was also used as a base station.

## 3.2 Base Station Use

A minimum of two base stations were used to compute the Airborne GPS and IMU defined LiDAR trajectory per mission.  These base stations were to limit the baselines lengths to the sensor to less than or equal to 20 km.

**Figure 6:  Base Station Location Diagram**


FB170P24
PNCY
FB173P11
TIDAL
FB174PD7
CARRPORT
APALPORT
FB170P19

# 4 LiDAR ACQUISITION & PROCEDURES

## 4.1 Acquisition Time Period

LiDAR data acquisition and Airborne GPS control surveys were completed between July 9th and July 22nd, 2007. A total of 22 flight missions were required to cover the project area. Apalachicola Municipal and Panama City – Bay County International airports were used as bases of operation.

## 4.2 LiDAR Acquisition

A total of 22 flight missions were required to cover the project area. All missions were flown at a nominal 1,000 meters above ground level. The Optech 3100ea sensor was set at a pulse rate of 100000, a scan frequency of 55, and a scan angle of $18^{o}$ each side of center. See page 10 for a sketch of the acquisition missions and Appendix 1 for each flight log.

Airborne GPS and IMU trajectories for the LiDAR sensor where also acquired during the time of flight. A minimum of two base stations were used to compute the Airborne GPS and IMU defined LiDAR trajectory per mission. These base stations were to limit the baselines lengths to the sensor to less than or equal to 20 km.

Each mission was typically four to five hours long. Before take-off, the LiDAR system and the Airborne GPS and IMU system were initiated for a period of five minutes and then again after landing for another five minutes. The missions acquired data according to the planned flight lines and included a minimum of one (usually two) cross flights. The cross flights were flown perpendicular to the planned flight lines and their data used in the in-situ calibration of the sensor.

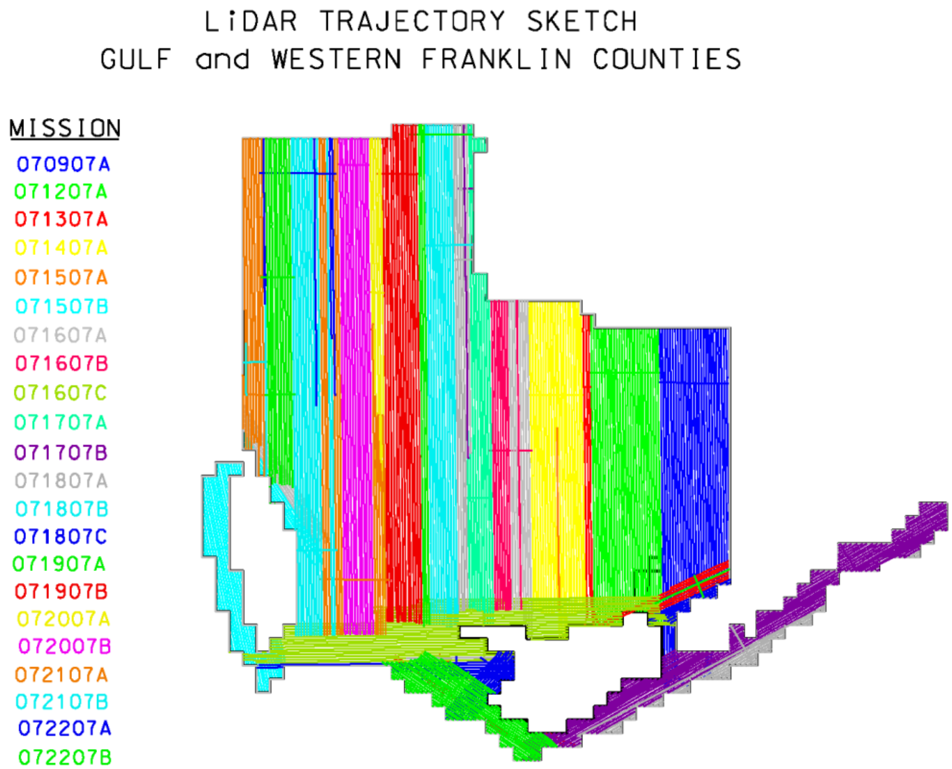
## 4.3 LiDAR Trajectory Processing

The airborne positioning was based on one NGS CORS station: **PANAMA CORS ARP (PNCY)** and six base stations tied to the NGS National Spatial Reference System (NSRS): **APALPORT**, **CARRPORT**, **FB170P19**, **FB173P11**, **FB174P07**, and **TIDAL**.

Horizontal control was based on the North American Datum of 1983/HARN. Vertical was based on the North American Vertical Datum of 1988 (NAVD88).

The ABGPS/IMU and GPS ground base station raw data were processed using the Applanix Corporation's POSPac version 4.31 software. The software was used to compute the position and attitude of the LiDAR sensor at the time of collection. The resulting data was related to the GPS ground network (see description above). At least two base stations were used to derive the solution independently and then their results were compared as a quality control measure. Graphical plots were created to analyze and record the accuracy of the solution for each LiDAR mission. See Appendix 2.1 through 2.7.

**Figure 2: Mission/Flight Line Diagram**



## 5 CHECK POINT SURVEY

The check point survey was performed between June 21st and June 23rd, 2007 using Rapid Static GPS techniques. A total of 165 check points were surveyed across the Gulf and western Franklin counties. The points were collected in varying classifications of ground cover in order to QC the LiDAR data classification process.

The following control stations from the PDS primary control network were used: AS0557 (4980 B01), AS0861 (TIDAL), AS0884 (APALPORT), FB170P19, FB173P11, FB174P07.

GPS measurement computations were done in two stages. Initial computations were done with LEICA Geo Office (LGO), version 4.0. LGO permits the conversion of raw satellite data collected by the receivers to a meaningful coordinate difference between points (baseline solutions). Once the baseline solutions were determined, they were input into the GeoSurv-GeoLab2 series of programs (Geolab version 2.4d). An adjustment was performed for analysis and quality closure. In the final adjustment all the published control values were held in the fully constrained scaled least squares base network adjustment that was used to derive the Ground Control Checkpoints.

The check points were referenced horizontally to NAD83(HARN), Florida State Plane Coordinates, North Zone. The vertical datum was NAVD88. The Units were US Survey Foot.

**Table 1: Check Point Coordinates**

**(Units in US Survey Foot)**

| POINT | EASTING | NORTHING | NAVD88 HT |
|---:|---:|---:|---:|
| 100 | 1803178.329 | 261143.080 | 11.657 |
| 101 | 1803160.757 | 261825.677 | 11.594 |
| 102 | 1804256.723 | 262349.813 | 16.857 |
| 103 | 1804493.061 | 266106.203 | 16.588 |
| 104 | 1801629.655 | 262576.443 | 15.223 |
| 105 | 1801899.913 | 262918.798 | 18.566 |
| 106 | 1802569.535 | 263837.793 | 18.215 |
| 107 | 1817002.445 | 371175.052 | 27.011 |
| 108 | 1817131.933 | 371505.008 | 27.818 |
| 109 | 1816602.423 | 371072.949 | 27.277 |
| 110 | 1816845.458 | 369185.692 | 27.395 |
| 111 | 1817106.950 | 366307.007 | 29.514 |
| 112 | 1753832.624 | 348503.522 | 20.548 |
| 113 | 1753794.353 | 348319.795 | 21.027 |
| 114 | 1753665.541 | 348516.806 | 20.712 |
| 115 | 1748446.362 | 338179.934 | 19.321 |
| 116 | 1749062.155 | 339504.026 | 18.888 |
| 117 | 1749550.999 | 340549.273 | 19.560 |

| POINT | EASTING | NORTHING | NAVD88 HT |
|---|---|---|---|
| 118 | 1750139.823 | 341361.161 | 20.102 |
| 119 | 1751968.422 | 345018.211 | 17.415 |
| 120 | 1755594.133 | 352180.674 | 24.029 |
| 121 | 1693161.958 | 364118.468 | 6.109 |
| 122 | 1693315.688 | 364055.584 | 6.631 |
| 123 | 1691639.606 | 364079.538 | 9.777 |
| 124 | 1690331.045 | 362474.167 | 5.876 |
| 125 | 1695806.920 | 363979.794 | 8.405 |
| 126 | 1700206.613 | 364650.626 | 8.661 |
| 127 | 1700605.765 | 363592.216 | 15.075 |
| 128 | 1702341.917 | 362668.422 | 12.113 |
| 129 | 1704762.942 | 361427.220 | 10.597 |
| 130 | 1694027.475 | 247914.189 | 1.102 |
| 131 | 1684346.389 | 271878.436 | 8.445 |
| 132 | 1684969.894 | 269266.666 | 5.840 |
| 133 | 1685713.938 | 266822.757 | 11.863 |
| 134 | 1686932.942 | 263750.280 | 13.222 |
| 135 | 1688502.017 | 260249.470 | 15.400 |
| 136 | 1690423.584 | 254948.001 | 11.644 |
| 137 | 1692525.345 | 250470.034 | 5.230 |
| 138 | 1694202.189 | 247308.603 | 5.030 |
| 139 | 1696063.219 | 247149.201 | 5.728 |
| 140 | 1699831.197 | 246569.143 | 5.646 |
| 141 | 1823149.887 | 224053.915 | 14.908 |
| 142 | 1823434.916 | 224755.072 | 3.993 |
| 143 | 1824218.225 | 225060.446 | 3.766 |
| 144 | 1825830.262 | 225373.516 | 4.711 |
| 145 | 1824801.393 | 225898.016 | 2.192 |
| 146 | 1826729.089 | 225812.009 | 5.476 |
| 200 | 1803224.258 | 261084.586 | 11.283 |
| 201 | 1803245.186 | 261771.760 | 11.506 |
| 202 | 1804195.007 | 262404.849 | 16.207 |
| 203 | 1804433.104 | 264316.325 | 18.287 |
| 204 | 1804444.885 | 266124.212 | 14.925 |
| 205 | 1801567.338 | 262537.041 | 13.077 |
| 206 | 1802609.203 | 263844.672 | 17.720 |
| 207 | 1816844.805 | 369204.688 | 27.487 |
| 208 | 1817030.168 | 368213.092 | 29.360 |
| 209 | 1817104.860 | 366278.897 | 30.518 |
| 210 | 1748383.377 | 338217.844 | 14.921 |
| 211 | 1749045.984 | 339485.548 | 18.504 |
| 212 | 1749558.932 | 340571.130 | 18.491 |
| 213 | 1749486.626 | 340594.630 | 18.750 |
| 214 | 1750220.007 | 341501.669 | 20.007 |
| 215 | 1750074.033 | 341561.994 | 17.989 |
| 216 | 1751992.654 | 344993.588 | 11.030 |
| 217 | 1700256.888 | 363837.258 | 14.442 |

| POINT | EASTING | NORTHING | NAVD88 HT |
|---|---|---|---|
| 218 | 1694588.251 | 364189.701 | 9.662 |
| 219 | 1690346.974 | 362463.803 | 6.617 |
| 220 | 1695817.750 | 363955.732 | 10.157 |
| 221 | 1700634.952 | 363643.292 | 16.063 |
| 222 | 1702394.423 | 362714.307 | 11.608 |
| 223 | 1704738.917 | 361438.821 | 11.161 |
| 224 | 1694071.881 | 247996.266 | 0.712 |
| 225 | 1684278.170 | 271853.400 | 7.858 |
| 226 | 1685712.954 | 266792.593 | 12.949 |
| 227 | 1686865.170 | 263711.520 | 10.486 |
| 228 | 1688470.521 | 260309.962 | 15.794 |
| 229 | 1690393.437 | 254981.705 | 12.126 |
| 230 | 1692551.687 | 250415.149 | 3.192 |
| 231 | 1694245.916 | 247323.472 | 4.124 |
| 232 | 1696006.319 | 247126.248 | 6.985 |
| 233 | 1699857.345 | 246518.936 | 5.587 |
| 234 | 1823409.637 | 224782.776 | 3.973 |
| 235 | 1824220.715 | 225037.670 | 3.415 |
| 236 | 1824762.968 | 225861.809 | 2.116 |
| 237 | 1826733.049 | 225775.903 | 5.125 |
| 300 | 1804239.764 | 262271.559 | 15.180 |
| 301 | 1804290.955 | 262323.960 | 14.314 |
| 302 | 1804430.174 | 264293.093 | 17.405 |
| 303 | 1804451.519 | 266124.461 | 15.469 |
| 304 | 1801552.168 | 262525.292 | 13.632 |
| 305 | 1802604.794 | 263886.073 | 17.900 |
| 306 | 1817066.166 | 371097.673 | 26.060 |
| 307 | 1817150.470 | 371434.969 | 27.949 |
| 308 | 1816596.295 | 371036.548 | 27.825 |
| 309 | 1816776.517 | 369194.642 | 27.306 |
| 310 | 1816935.165 | 368189.684 | 29.688 |
| 311 | 1753782.322 | 348391.829 | 20.636 |
| 312 | 1748367.825 | 338235.226 | 17.064 |
| 313 | 1749573.522 | 340585.533 | 18.793 |
| 314 | 1750042.428 | 341575.144 | 17.776 |
| 315 | 1750011.720 | 341393.067 | 18.668 |
| 316 | 1700155.304 | 363778.180 | 14.131 |
| 317 | 1694538.458 | 364199.475 | 9.314 |
| 318 | 1691570.344 | 364076.470 | 10.105 |
| 319 | 1691609.894 | 364146.339 | 9.035 |
| 320 | 1690339.169 | 362481.798 | 6.732 |
| 321 | 1695851.795 | 363963.084 | 9.770 |
| 322 | 1700597.439 | 363578.531 | 15.564 |
| 323 | 1702413.590 | 362758.976 | 11.722 |
| 324 | 1704706.699 | 361436.902 | 11.053 |
| 325 | 1705804.174 | 361555.894 | 10.371 |
| 326 | 1684908.910 | 269291.699 | 5.673 |

| POINT | EASTING | NORTHING | NAVD88 HT |
|---:|---:|---:|---:|
| 327 | 1685700.136 | 266813.613 | 12.776 |
| 328 | 1686951.223 | 263675.309 | 10.666 |
| 329 | 1688518.283 | 260198.089 | 15.702 |
| 330 | 1690426.878 | 254885.176 | 12.464 |
| 331 | 1696021.103 | 247123.485 | 7.710 |
| 332 | 1699878.205 | 246534.674 | 5.344 |
| 333 | 1823430.579 | 224798.120 | 4.058 |
| 334 | 1824235.843 | 225051.955 | 3.530 |
| 335 | 1825756.408 | 225417.997 | 3.701 |
| 336 | 1824774.868 | 225917.179 | 2.648 |
| 337 | 1826715.185 | 225869.017 | 4.724 |
| 400 | 1803127.821 | 261074.494 | 14.508 |
| 401 | 1803198.985 | 261840.297 | 13.415 |
| 402 | 1804255.227 | 262363.366 | 16.742 |
| 403 | 1804378.898 | 264310.682 | 18.835 |
| 404 | 1804504.278 | 266088.749 | 17.992 |
| 405 | 1801618.296 | 262559.560 | 15.420 |
| 406 | 1801896.383 | 262965.147 | 18.976 |
| 407 | 1802512.068 | 263880.978 | 18.812 |
| 408 | 1817177.087 | 371438.877 | 28.855 |
| 409 | 1816586.898 | 371056.240 | 28.304 |
| 410 | 1816878.331 | 369214.898 | 28.629 |
| 411 | 1817131.851 | 366290.075 | 32.070 |
| 412 | 1753677.743 | 348369.749 | 23.005 |
| 413 | 1748426.654 | 338219.570 | 20.023 |
| 414 | 1749104.438 | 339485.847 | 19.590 |
| 415 | 1751947.825 | 344996.603 | 17.917 |
| 416 | 1700208.601 | 363816.956 | 16.056 |
| 417 | 1700217.079 | 363845.726 | 15.843 |
| 418 | 1694521.450 | 364164.701 | 10.384 |
| 419 | 1691586.761 | 364112.251 | 9.997 |
| 420 | 1692290.936 | 363856.297 | 61.896 |
| 421 | 1692736.851 | 363891.034 | 72.270 |
| 422 | 1695810.181 | 364004.708 | 11.440 |
| 423 | 1700213.371 | 364638.926 | 8.937 |
| 424 | 1700610.667 | 363598.482 | 15.397 |
| 425 | 1702345.011 | 362648.412 | 13.035 |
| 426 | 1684347.520 | 271933.196 | 8.944 |
| 427 | 1684929.576 | 269254.570 | 6.690 |
| 428 | 1685736.576 | 266819.033 | 15.187 |
| 429 | 1686919.202 | 263731.179 | 13.615 |
| 430 | 1688496.853 | 260310.631 | 17.608 |
| 431 | 1690461.603 | 254907.824 | 12.874 |
| 432 | 1692568.616 | 250438.069 | 5.568 |
| 433 | 1694200.368 | 247293.593 | 5.466 |
| 434 | 1696085.794 | 247160.303 | 6.594 |
| 435 | 1699841.085 | 246550.718 | 7.238 |

| POINT | EASTING | NORTHING | NAVD88 HT |
|---:|---:|---:|---:|
| 436 | 1823229.506 | 224029.785 | 14.370 |
| 437 | 1823442.705 | 224770.764 | 4.298 |
| 438 | 1824213.884 | 225080.629 | 4.400 |
| 439 | 1825820.751 | 225392.643 | 5.118 |
| 440 | 1824806.892 | 225887.419 | 2.628 |
| 441 | 1826710.215 | 225834.312 | 4.537 |

# 6 FINAL LiDAR PROCESSING

## 6.1 LiDAR Processing

The ABGPS/IMU post processed data along with the LiDAR raw measurements were processed using Optech Incorporated's DASHMap version 1.1 software. This software was used to match the raw LiDAR measurements with the computed ABGPS/IMU positions and attitudes of the LiDAR sensor. The result was a "point cloud" of LiDAR measured points referenced to the ground control system. Each point was then classified into categories.

Although the data was collected using a scan width of $18^{o}$ each side of centerline, the last $2^{o}$ were removed during the processing of the "point cloud" in order to remove any exaggerated effects of mirror scale at the edges of the scan.

The LiDAR point cloud classification involved importing the point cloud data in TerraSolid's TerraScan software that is integrated with Bentley's MicroStation V8. The data was partitioned into 5,000ft by 5,000ft tiles to organize the massive amount of data into manageable units. TerraMatch was used to calibrate the data by removing systematic errors found between flight lines (in-situ calibration). After the fine tuning of the calibration, TerraScan was used to classify the points to identify primarily the ground (bare-earth surface) and then other classes such as trees, brush, tall grass, etc. This software computes the classifications using algorithms, with customized parameters to best fit the project area. Several areas of varying relief and planimetric features are inspected to verify the final ground surface. Once the automatic processing is completed, as a quality control measure, AERO-METRIC meticulously reviews the generated bare-earth surface data to insure that proper classification was achieved. Any further manual editing and classification is done using TerraScan.

## 6.2 Check Point Validation

The ground check point coordinates were input into TerraScan. TerraScan then computed the vertical differences between the surveyed elevation and the LiDAR derived elevation for each point. A report listing the differences and common statistics was created. The LiDAR data is corrected for any systematic elevation difference and TerraScan is run again to create the final report listing.

## 6.3 Horizontal Accuracy Check

Ten horizontal check points were surveyed on the runway surface at the Apalachicola Municipal airport. These check points were located at the corners of select painted stripes and runway numbering.

Coordinates of the check points were extracted from the LiDAR intensity data and compared to their field surveyed coordinates.

A 95% horizontal confidence level of 2.6 ft was computed from the coordinate differences. See Table 2 below.

**Table 2: Horizontal Accuracy Check Point Differences**

**(Units in US Survey Foot)**

| Point ID | | Field Surveyed Values | | LiDAR Intensity Values | | Residuals | |
|---|---|---|---|---|---|---|---|
| ID | Note | E | N | E | N | V(E) | V(N) |
| 317 | XY | 1802451.102 | 263151.191 | 1802452.513 | 263149.277 | -1.411 | 1.914 |
| 401 | XY | 1802398.568 | 263157.150 | 1802399.065 | 263155.983 | -0.497 | 1.167 |
| 402 | XY | 1802391.779 | 263164.052 | 1802392.162 | 263163.083 | -0.383 | 0.969 |
| 403 | XY | 1802363.673 | 263192.765 | 1802364.156 | 263192.666 | -0.483 | 0.099 |
| 404 | XY | 1802356.774 | 263199.755 | 1802357.450 | 263199.372 | -0.676 | 0.383 |
| 405 | XY | 1802348.901 | 263247.222 | 1802348.772 | 263245.326 | 0.129 | 1.896 |
| 407 | XY | 1802385.170 | 263227.977 | 1802385.851 | 263226.787 | -0.681 | 1.189 |
| 408 | XY | 1802427.000 | 263185.369 | 1802426.282 | 263185.369 | 0.718 | -0.001 |
| 409 | XY | 1802443.078 | 263143.125 | 1802443.835 | 263141.782 | -0.757 | 1.343 |
| 410 | XY | 1802438.895 | 263139.115 | 1802440.285 | 263137.246 | -1.390 | 1.869 |

### 6.4 LiDAR Breakline and Contour Production

AERO-METRIC used GeoCue software to develop LiDAR stereo models of Gulf and western Franklin Counties so the LiDAR derived data could be viewed in 3-D stereo using DAT/EM System's Summit Evolution softcopy photogrammetric software. Using LiDARgrammetry procedures with LiDAR intensity imagery, AERO-METRIC stereo-compiled breaklines in accordance with the Data Dictionary at Appendix C. The LiDARgrammetry was performed under the direct supervision of an ASPRS Certified Photogrammetrist. The breaklines conform with data format requirements outlined by the FDEM Baseline Specifications.

Using proprietary procedures developed by AERO-METRIC, the 2-foot and 1-foot contours were compiled from the breaklines and LiDAR data in accordance with the Data Dictionary at Appendix C. The contours conform with data format requirements outlined by the FDEM Baseline Specifications.

### 6.5 LiDAR Data Delivery

LiDAR data was delivered to Dewberry as three major data sets. Those data sets were: 1) LiDAR classified mass points, 2) nine types of breaklines, and 3) 1ft and 2ft contours produced from the mass points and breaklines.

The mass points were delivered according to LAS 1.1 specifications and classified into the following LAS codes:

Class 1 – Unclassified, including vegetation, buildings, bridges, piers
Class 2 – Ground points (used for contours)
Class 7 – Noise
Class 9 – Water
Class 12 – Overlap points deliberately removed

The nine types of breaklines, produced in accordance with the Data Dictionary at Appendix C, are as follows:

1. Coastal shoreline features
2. Single-line hydrographic features
3. Dual-line hydrographic features
4. Closed water body features
5. Road edge-of-pavement features
6. Bridge and overpass features
7. Soft breakline features
8. Island features
9. Low confidence areas.

The 1ft and 2ft contours were also produced in accordance with the Data Dictionary at Appendix C.

## LIDAR FLIGHT LOG

Rev 1.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PROJECT NUMBER: 1-070414 | | | | | | | | | | |
| PILOT: IRWIN | | OPERATOR: MERRY | | | | | DATE: 7/9/07 (UTC Time) | | | |
| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
| | | | | | | | | | | |
| 60709071 | | | | | | | 19:04 | | 218 | AAF → SITE |
| | | | | | | | 19:16 | | | |
| ~~230~~ | 230 | 359 | 155 | 55 | 18 | 1000 ~~2220~~ | 19:29 | 19:35 | | |
| ~~214~~ | 215 | 179 | 157 | 55 | 18 | \| | 19:38 | 19:44 | | |
| | 229 | 359 | 157 | 55 | 18 | \| | 19:48 | 19:54 | | |
| | 214 | 179 | 150 | 55 | 18 | \| | 19:57 | 20:04 | | |
| | 228 | 359 | 148 | | | | 20:08 | 20:14 | | |
| | 213 | 179 | 152 | | | | 20:17 | 20:24 | | |
| | 227 | 359 | 147 | | | | 20:28 | 20:34 | | |
| | 212 | 179 | 144 | | | | 20:38 | 20:44 | | |
| | 226 | 359 | 148 | | | | 20:49 | 20:54 | | |
| | 211 | 179 | 152 | | | | 20:58 | 21:04 | | |
| | 225 | 359 | 150 | | | | 21:08 | 21:14 | | |
| | 210 | 179 | 148 | | | | 21:18 | 21:25 | | |
| | 224 | 359 | 148 | | | | 21:28 | 21:34 | | |
| | 209 | 179 | 147 | | | | 21:37 | 21:45 | | |
| | 223 | 359 | 150 | | | | 21:48 | 21:54 | | |
| | 208 | 179 | 148 | | | | 21:57 | 22:05 | | |
| | 222 | 359 | 153 | | | | 22:09 | 22:15 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| Ø | 333 | 28 | 305 | 5.0 | 0.7 | SCT/BKN 3300 VIS 7/8 MILES | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul 10 07 10:06a

# LIDAR FLIGHT LOG

Rm 2

**PROJECT NUMBER:** L-070414

**PILOT:** Irwin **OPERATOR:** Merry **DATE:** 7/9/07 (UTC Time)

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| L0709071 Cont. | | | | | | | | | | |
| | 207 | 179 | 150 | 55 | 18 | 1000 | 22:17 | 22:27 | 218 | |
| | 221 | 359 | 152 | | | | 22:31 | 22:37 | | |
| | ~~218~~ | | | | | | | | | |
| | 206 | 179 | 149 | | | | 22:41 | 22:49 | | |
| | 220 | 359 | 155 | | | | 22:54 | 23:00 | | |
| | 205 | 179 | 151 | | | | 23:03 | 23:12 | | |
| | 219 | 359 | 156 | | | | 23:16 | 23:22 | | |
| | 216 | 179 | 153 | | | | 23:26 | 23:34 | | |
| | 218 | 359 | 155 | | | | 23:37 | 23:43 | | |
| | 217 | 179 | 152 | | | | 23:48 | 23:54 | | |
| | ~~X-A~~ | | | | | | | | | |
| | 204 | 359 | | | | | 23:57 | 24:08 | | |
| | X-A | | | | | | 24:11 | 24:13 | | |
| | 203 | 179 | | | | | 24:20 | 24:29 | | Site → AAF |
| | | | | | | | | 24:38 | | |
| | | | | | | | 24:40 | 24:45 | | 5 min Static |
| | | | | | | | | | | |
| | | | | | | | | | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| Ø | 333 | | | | | | |

JUL 10 07 10:07a

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM

RM3

**PROJECT NUMBER:** 1-070414

**PILOT:** IRWIN **OPERATOR:** MERRY **DATE:** 7/9/07 (UTC TIMES)

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| L0703072 | | | | | | | 02:15 | | | |
| ABORTED | | | | | | | 03:18 | | | "NO ALTM MSG RECEIVED"!! |
| SEE Comments | | | | | | | | 03:40 | | AAF → PFN |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | | | | | 1.5 | | |
| | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul 10 07 10:07a

# LIDAR FLIGHT LOG

ALTM RM1

PROJECT NUMBER: 1-070414

PILOT: IRWIN OPERATOR: MERRY DATE: 7/12/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L0712071 | | | | | | | | | | |
| | | | | | | | 17:09 | 17:15 | 215 | .5min Static |
| | | | | | | | 17:22 | | | PEN → SITE |
| | X-Fit | | | 55 | 18 | 1000 | 17:40 | 17:43 | | |
| | 202 | 179 | 152 | | | | 17:49 | 17:57 | | |
| Ø Extreme S END | 188 | 359 | 148 | | | | 18:01 | 18:09 | | Eye Safety Shutoff @ Beginning Line Refly South End |
| | 201 | 179 | 153 | | | | 18:13 | 18:21 | | |
| | 187 | 359 | 149 | | | | 18:24 | 18:30 | | |
| | 200 | 179 | 153 | | | | 18:34 | 18:41 | | |
| | 186 | 359 | 150 | | | | 18:45 | 18:52 | | |
| | 199 | 179 | 153 | | | | 18:55 | 19:03 | | |
| | 185 | 359 | 149 | | | | 19:08 | 19:14 | | |
| | 198 | 179 | 154 | | | | 19:17 | 19:25 | | |
| | 184 | 359 | 157 | | | | 19:28 | 19:35 | | |
| | 197 | 179 | 158 | | | | 19:38 | 19:46 | | |
| | 183 | 359 | 156 | | | | 19:50 | 19:56 | | |
| | 196 | 179 | 153 | | | | 20:00 | 20:06 | | |
| | 182 | 359 | 149 | | | | 20:10 | 20:17 | | |
| | 195 | 179 | 154 | | | | 20:20 | 20:26 | | |
| | 181 | 359 | 152 | | | | 20:30 | 20:36 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ○ | 333 | | | 4.9 | 0.6 | Bkn 4000 Vis 8-9 | |
| | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM RMZ

PROJECT NUMBER: i-070414

PILOT: Irwin OPERATOR: Mear DATE: 7/12/07 (UTC Times)

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L0712071 (Cont) | | | | | | | | | | |
| | | | | | | | | | | |
| ✓ | 194 | 179 | 154 | 55 | 18 | 1000 | 20:39 | 20:45 | 215 | |
| | 180 | 359 | 154 | | | | 20:49 | 20:56 | | |
| | 193 | 179 | 153 | | | | 20:59 | 21:06 | | |
| | 179 | 359 | 150 | | | | 21:09 | 21:15 | | |
| | 192 | 179 | 159 | | | | 21:19 | 21:26 | | |
| | 178 | 359 | 153 | | | | 21:29 | 21:36 | | |
| | 191 | 179 | 158 | | | | 21:40 | 21:47 | | |
| | 177 | 359 | 156 | | | | 21:50 | 21:57 | | |
| | 190 | 179 | 157 | | | | 22:00 | 22:07 | | |
| | 176 | 359 | 150 | | | | 22:09 | 22:17 | | |
| | 189 | 179 | 155 | | | | 22:20 | 22:27 | | |
| 5 Gnd Refl | 188 | 359 | | | | | 22:31 | 22:33 | | |
| | | | | | | | | 22:39 | | Site → AAF |
| | | | | | | | 22:42:47 | 22:47 | | 5 min Static |
| | | | | | | | | 22:49 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ○ | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM RM3

**PROJECT NUMBER:** I-070419

**PILOT:** Irwin **OPERATOR:** Merry **DATE:** 7/12/07

| MISSION | LINE NO. & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| L0712072 | | | | | | 0:30 | | 218 | |
| | | | | | | | | | AAF → SITE |
| | | | | | | | 0157 | | Aborted Rt Engine |
| | | | | | | | | | Rough Mag |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | 333 | Ø | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM

Rmi

**PROJECT NUMBER:** 1-070414

**PILOT:** IRWIN **OPERATOR:** MERRY **DATE:** 7/13/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L0713071 | | | | | | | | | | |
| | | | | | | | 0:27 | 0:32 | 218 | 5 min Static |
| | | | | | | | 0:36 | | | PFN → Site |
| ⊗ | X-Alt | | | 55 | 18 | 1000 | 01:07 | 01:09 | | |
| ⊗ | 283 | 304 | 149 | | | | 01:14 | 01:16 | | |
| ⊗ | 273 | 124 | 159 | | | | 01:20 | 01:24 | | |
| ⊗ | 282 | 304 | 150 | | | | 01:29 | 01:30 | | |
| ⊗ | 272 | 124 | 154 | | | | 01:35 | 01:39 | | |
| ⊗ | 281 | 304 | 153 | | | | 01:44 | 01:46 | | |
| | 271 | 124 | | | | | 01:51 | | | Eye Safety Shut off Mid of Line |
| | ~~280~~ | ~~304~~ | | | | | | | | |
| | 271 | 124 | 154 | | | | 02:07 | | | Clouds Moving to |
| | | | | | | | | | | ANOTHER AREA |
| ⊗ | 322 | 65 | 154 | | | | 02:16 | 02:17 | | |
| ⊗ | 327 | 245 | 145 | | | | 02:21 | 02:24 | | |
| ⊗ | 323 | 65 | 158 | | | | 02:28 | 02:30 | | |
| ⊗ | 328 | 245 | 149 | | | | 02:34 | 02:36 | | |
| ⊗ | 324 | 65 | 158 | | | | 02:40 | 02:43 | | |
| | 329 | | | | | | 02:46 | | | Clouds |
| ⊗ | 326 | 65 | 150 | | | | 02:51 | 02:53 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ○ | 333 | 15 | | 2.9 | 0.9 | Vis 7<br>Bren 3000 | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul. 14. 2007 12:40AM Courtyard No. 7462

## LIDAR FLIGHT LOG

ALTM

Rm 2

PROJECT NUMBER: 1-070414

PILOT: IRWIN OPERATOR: MERRY DATE: 7/13/07 (UTC TIMES)

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L0712071 Cont | | | | | | | | | | |
| | | | | | | | | | | |
| Ø | 325 | 245 | 150 | 55 | 18 | 1000 | | 03:00 | | Cloud on East End |
| | 329 | 65 | 154 | | | | 03:04 | | | Clouds |
| | | | | | | | | | | Moving Back to |
| | | | | | | | | | | Original Area |
| | 280 | | | | | | 3:44 | | | Clouds |
| | | | | | | | | | | Moving. |
| Ø | 175 | 359 | 154 | | | | 3:19 | 3:26 | | RFL @ LAT 29-49-55 & |
| Ø | 173 | 179 | 154 | | | | 3:31 | 3:38 | | 30-1-47 |
| Ø | 174 | 359 | 153 | | | | 3:42 | 3:49 | | |
| Ø | 175 | 179 | 154 | | | | 3:55 | 3:56 | | |
| | x-fit | | | | | | 3:59 | 4:00 | | |
| | | | | | | | | 4:21 | | Site → PFN |
| | | | | | | | 04:24:54 | 04:29 | | 5 min Static |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

L071407A

ALTM TP1

PROJECT NUMBER: 1070414

PILOT: DAVE I. OPERATOR: Tom DATE: 07/14/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | Taxi @ 16:46 REMARKS T.O. 16:50 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | | | | | 11:24 | 12:06 | COT | FERRY: PFN → SITE |
| L071407A | 2 | TEST | FIRES | | | | | | 218 | |
| XFLT | 172 | E | 150 | 55 | 18 | ±1000m | 17:07 | 17:11 | | |
| | 172 | S | 155± | | | | 17:17 | 17:24 | | |
| | 159 | N | 150 | | | | 17:28 | 17:36 | | |
| | 171 | S | 155→160 | | | | | 17:48 | | |
| | 158 | N | 155± | | | | 17:51 | 17:58 | | |
| | 170 | S | 150→160 | | | | 18:02 | 18:10 | | |
| | 157 | N | 155± | | | | 18:13 | 18:21 | | XTRA S. END CROSS FOR E/W. LINES |
| | 169 | S | | | | | 18:25 | 18:33 | | |
| | 156 | N | 157± | | | | 18:36 | 18:43 | | |
| | 168 | S | | | | | 18:47 | 18:54 | | |
| | 155 | N | 155± | | | | 18:58 | 19:05 | | |
| | 167 | S | | | | | 19:08 | 19:16 | | SMOKE N. END |
| | 154 | N | 156 | | | | 19:19 | 19:26 | | |
| | 166 | S | 155 | | | | 19:30 | 19:36 | | RAIN JUST TO N. |
| | 165 | N | 153± | | | | 19:44 | 19:51? | | RAIN @ 19:57± / EYE SAFETY @ 300 ft |
| | 153 | S | 156± | | | | 19:55 | 20:02 | | |
| | 164 | N | 156± | | | | 20:06 | 20:13 | | |
| | 152 | S | 154± | | | | 20:18 | 20:24 | | LATE (ST) + BUMP ON TOUCH PAD; POSS SHORT EMMISSION |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 20 | ? | 4.5 | 1.7 | LITTLE SUN: VERY LITTLE; VARIOUS CLOUDS; SOME OCC RAIN | |
| 1070414 | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM TP2

PROJECT NUMBER: 1070414

PILOT: DAVE I. OPERATOR: Tom DATE: 7/14/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071407A | 163 | N | 153 | 55 | 18 | 1000m | 20:28 | | 218 | TURB S. END / RAIN EXTREME N. END |
| ⊗ | 165 | N | 155± | | | | 20:43 | 20:44 | | |
| ⊗ | 152 | S | 154 | | | | 20:46 | 20:47 | | |
| | 160 | S | 155± | | | | 20:55 | 21:02 | | |
| ⊘ | 162 | N | 152 | | | | 21:05 | 21:07 | | ESS: CLOUD |
| ⊘ | 162 | N | | | | | | 21:19 | | |
| | 161 | S | 158 | | | | 21:18 | 21:25 | | ~~ESS: CLOUD~~ |
| ⊘ | 162 | N | | | | | | | | ESS: CLOUD |
| ⊘ | 162 | S | | | | | 21:35 | | | " " 1000' GAP @ 29:44:45 |
| | | | | | | | 4:54 | 5:18 | ✱ | FERRY: SITE → AAF .4 |
| | | | | | | | 6:54 | 7:30 | | FERRY: AAF → PFN .6 |
| | | | | | | | | | | HEAVY RAIN, LIGHT / TSRM JUST |
| | | | | | | | | | | WEST 2 MILES OF PFN @ LANDING |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | | | | | | | ✱ LOW CLOUDS FORMED @ 1,700' OVER ENTIRE SITE, HEAVY RAIN TO WEST... RTB |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

## LIDAR FLIGHT LOG

TP1

PROJECT NUMBER: 1070414 L071507A

PILOT: DAVE I. OPERATOR: Tom DATE: 7/15/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | | | | | 8:36 | 9:18 | | FERRY: PEN → SITE .7 |
| L071507A | | | 2 TEST | FIRES | | | 14:19 | 14:20 | | CLOUDS EVERYWHERE & BUILDING |
| ⊗ | 162 | S | 150 | 55 | 18 | 1000m | 14:27 | 14:28 | | RFT OF (m) COVERAGE FROM 7/15/07 |
| | | | | | | | 9:30 | 10:04 | | FERRY: SITE → PEN .6 |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 1/32 | LOTS | .2 | 1.3 | | |
| 1070414 | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM TP2

**PROJECT NUMBER:** 1070414    L071507B

**PILOT:** DAVE I.   **OPERATOR:** Tom   **DATE:** 7/15/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | COT TIME START | GPS TIME STOP | TRANZPAK | To. 23:51 REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | 2 TESTS | 00:04 | To 00:05 | | PM 6:30 | 7:00 | | FERRY: PFN → SITE |
| L071507B | 14 | SE | 157 | 55 | 18° | 1000m | 00:08 | 00:14 | 218 | |
| | 6 | NW | 155 | | | | 00:17 | 00:21 | | |
| | 15 | SE | 158 | | | | 00:25 | 00:31 | | |
| | 5 | NW | 153 | | | | 00:35 | 00:39 | | |
| | 16 | SE | | | | | 00:42 | 00:48 | | |
| | 4 | NW | 151 | | | | 00:52 | 00:56 | | |
| | 13 | SE | | | | | 00:59 | 01:05 | | |
| | 3 | NW | 150 | | | | 01:08 | 01:11 | | |
| | ~~12~~ | ~~SE~~ | ~~150→160~~ | | | | 1:14:26 | 1:14:47 | | Jumped To 13 |
| | 12 | SE | | | | | 01:20 | 01:25 | | |
| | 2 | NW | | | | | | 01:31 | | |
| | 11 | SE | | | | | 01:36 | 01:41 | | |
| | 1 | NW | | | | | 01:46 | 01:48 | | |
| XFLT | 1 | NE | | | | | 01:52 | 01:54 | | |
| | 17 | SE | | | | | 02:01 | 02:06 | | |
| | 7 | NW | | | | | 02:11 | 02:16 | | |
| | 18 | SE | | | | | 02:21 | 02:26 | | |
| | 8 | NW | | | | | 02:30 | 02:35 | | |
| | 19 | SE | | | | | 02:39 | 02:45 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 32 | ? | 5.1 | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI, 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

(X) ARCH 1

# LIDAR FLIGHT LOG

ALTM

TP3

PROJECT NUMBER: 1070414

PILOT: DAVE I. OPERATOR: Tom DATE: 7/15/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071507B | 9 | NW | 150→160 | 55 | 18° | 1000m | 02:49 | 02:54 | Z18 | SWATH DATA DIDN'T (ST) Immed: [illegible] = OK |
| | 20 | SE | | | | | 02:58 | 03:04 | | POOP@3.24 SE PORTION OF LINE |
| | 10 | NW | | | | | 03:08 | 03:14 | | 3.26 LOWER |
| | 21 | SE | | | | | 03:18 | 03:24 | | POOP 3.11@ (ST) |
| | 23 | NW | | | | | 03:28 | 03:34 | | |
| | 22 | SE | | | | | 03:40 | 03:46 | | |
| | 24 | NW | | | | | 03:50 | 03:51 | | |
| XFLT | 24 | SW | | | | | 03:54 | 03:57 | | |
| | 31 | NW | | | | | 04:09 | 04:12 | | |
| | 35 | SE | | | | | 04:17 | 04:19 | | |
| | 32 | NW | | | | | 04:24 | 04:28 | | |
| | 34 | SE | | | | | 04:32 | 04:35 | | |
| | 33 | NW | | | | | 04:39 | 04:42 | | |
| | 37 | SE | | | | | 04:46 | 04:47 | | |
| | 36 | NW | | | | | 04:51 | 04:53 | | |
| | 38 | SE | | 54 | | | 04:58 | 04:58 | | |
| XFLT | 38 | NE | | | | | | 05:04 | | |
| | | | | | | | 12:06 | 12:36 | | FERRY: SITE → PFN |
| | | | | | | | | | | |
| | | | | | | | | | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | SEE TP2 | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

AREA 4

# LIDAR FLIGHT LOG

PROJECT NUMBER: 1070414    L071607A    TP1

PILOT: DAVE I.    OPERATOR: Tom    DATE: 07-16-07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | CDT TIME GPS START | STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | TEST FIRES | | | 07:07 | 07:08 | | AM 1:42 | 2:06 | 215 | FERRY: FPN → SITE |
| | 30 | SE | ±150 | 55 | 18° | 1000m | 07:12 | 07:16 | | |
| | 27 | NW | | | | | 07:20 | 07:23 | | |
| | 29 | SE | | | | | | 07:31 | | |
| | 26 | NW | | | | | 07:35 | 07:38 | | |
| | 28 | SE | | | | | 07:43 | 07:47 | | |
| | 26 | NW | | | | | 07:51 | 07:54 | | |
| X FLT | 25 | SW | | | | | 08:00 | 08:02 | | |
| | 151 | N | | | | | 08:14 | 08:22 | | |
| | 145 | S | | | | | 08:25 | 08:33 | | |
| | 150 | N | | | | | | 8:46 | | |
| L071607A | 146 | S | | | | | 08:49 | 08:57 | | |
| | 149 | N | | | | | 09:02 | 09:09 | | |
| | 144 | S | | | | | 09:13 | 09:21 | | |
| | 148 | N | | | | | 09:25 | 09:33 | | ALTM-NAV PROGRAM LOCKED-UP |
| L071607B | | | | | | | 4:36 | 4:54 | | FERRY: SITE → AAF |
| | | | | | | | 5:18 | 5:30 | | |
| | 147 | N | ±150 | 55 | 18° | 1000m | 10:32 | 10:40 | | |
| | 143 | S | | | | | 10:44 | 10:51 | | |
| | 140 | | | | | | 10:56 | 11:03 | | |

.4 .3 .2

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: |
|---|---|---|---|---|---|---|
| Ø | 333 | 21 | ? | 3.3 | 1.3 | |
| 1070414 | | | | | | |

NOTES: * SHUT-DOWN, SAVE DATA & REBOOT @ AAF

GAP @ 25% EX SEND BETWEEN LINES 172-173

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul. 16. 2007 10:59AM Courtyard No. 7425 P. 7

# LIDAR FLIGHT LOG

ALTM TP2

PROJECT NUMBER: 1070414

PILOT: DAVE Z. OPERATOR: Tom DATE: 7/16/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L0716078 | 142 | S | 158 | 55 | 18 | 1000m | 11:07? | 11:15 | 215 | |
| | 141 | N | 155± | | | | 11:22? | 11:31 | | EXTRA N. END ... LONG NIGHT |
| | 139 | S | | | | | 11:35 | 11:42 | | |
| | 137 | N | | | | | 11:46 | 11:54 | | |
| | 138 | S | | | | | 11:58 | 12:05 | | |
| XFLT | 151 | | | | | | 12:13 | 12:15 | | |
| | | | | | | | AM 7:18 | 7:42 | | FERRY: SITE → ARN |

.4

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ○ | SEE TP1 | | | | | 137 → 151 | 1.8<br>1.5<br>3.3 |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

## LIDAR FLIGHT LOG

ALTM TP3

PROJECT NUMBER: 1070414 L071607C

PILOT: DAVE I. OPERATOR: Tom DATE: 7/16/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | COT TIME START | GAS STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | 2 TEST | @ | 3:14 + | 3:15 | 9:36 pm | 10:18 | 215 | TAXI @ 9:57 FERRY: PFN → SITE |
| L071607C | 231 | E | 150→155 | 55 | 18° | 1000m | 03:25 | 03:28 | | . - Turg |
| | 238 | W | 148→158 | | | | 03:32 | 03:38 | | |
| | 232 | E | | | | | 03:42 | 03:47 | | |
| | 239 | W | | | | | 03:51 | 03:57 | | |
| | 233 | E | | | | | 04:01 | 04:06 | | |
| | 240 | W | | | | | 04:11 | 04:19 | | |
| | 234 | E | | | | | 04:24 | ? | | |
| | 242 | W | | | | | 04:34 | 04:42 | | |
| | 235 | E | | | | | 04:48 | 04:54 | | |
| | 237 | W | | | | | 04:57 | 05:04 | | |
| | 236 | E | | | | | ? | 05:15 | | |
| | 241 | W | | | | | 05:20 | 05:29 | | |
| | 243 | E | | | | | 05:33 | 05:40 | | |
| | 248 | W | | | | | 05:44 | 05:50 | | |
| | 244 | E | | | | | 05:54 | 06:01 | | |
| | 249 | W | | | | | 06:06 | 06:11 | | |
| | 245 | E | | | | | | 06:22 | | |
| | 250 | W | | | | | 06:26 | 06:32 | | |
| | 246 | E | | | | | 06:36 | 06:43 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 24½ | ? | 4.6 | 1.0 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul. 17. 2007 10:05AM Courtyard No. 7465 P. 3

# LIDAR FLIGHT LOG

ALTM JP4

PROJECT NUMBER: 1070414

PILOT: DAVE I OPERATOR: Tom DATE: 7/16/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071607C | 251 | W | 148→158 | 55 | 18° | 1000m | | 06:53 | 215 | |
| | 247 | E | | | | | 6:58 | 07:05 | | |
| | 255 | W | | | | | 7:08 | 07:14 | | |
| | 262 | E | | | | | 07:18 | 0724 | | |
| | 253 | W | | | | | 07:28 | 07:35 | | |
| | 254 | E | | | | | 07:39 | 7:43 | | ESS --- LOW Fuel X FLT |
| XFLT | 254 | N | | | | | 07:48 | 07:50 | | ONE (1) E.SS. ON X FLT |
| | | | | | | | 07:54 | | | |
| | | | | | | | Am 2:54 | 3:12 | | FERRY: SITE → AAF .3 |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | SEE TP3 | | | | 1.0 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM

TPL

**PROJECT NUMBER:** 1070414 L071707A

**PILOT:** DAVE I. **OPERATOR:** Tom P. **DATE:** 07-17-07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | CDT TIME GPS START | STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071707A | | 2TEST | FIRE | @ ± | 9:33 | AM | 4:12 | 4:36 | 215 | FERRY: AAF → SITE |
| | 136 | N | 148→158 | 55 | 18° | 1000m | 9:41 | 9:52 | | |
| | 130 | S | 147→151 | 54.5 | | | 9:56 | 10:08 | | |
| | 135 | N | 156 ± | 55 | | | 10:13 | 10:24 | | |
| | 131 | S | 150 ±± | 55 | | | 10:28 | 10:41 | | cu FORMING/sun's up |
| | 134 | N | | | | | 10:45 | 10:56 | | |
| | 132 | S | | | | | | 11:11 | | |
| | 133 | N | | | | | | 11:27 | | |
| XFLT | 136 | W | | | | | | 11:30 | | |
| | 129 | S | | | | | 11:38 | 11:49 | | |
| Ø S 1/2 | 128 | N | | | | | 11:53 | 11:58 | | E.S.S.: CLOUDS S 11.5 MILES = GOOD |
| Ø S 1/3 | 127 | S | | | | | 12:03 | 12:07 | | S. 10.9 MILES GOOD |
| XFLT | 127 | E | | | | | 12:12 | 12:13 | | CLOUDS NOW EVERYWHERE |
| | | | | | | | AM | | | |
| | | | | | | | 7:12 | 7:48 | | FERRY: SITE → PFN |

.4

.6

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | | 8+2 PARTIALS | | 2.5 | 1.0 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

No. 7465 P. 1

..L. 17. 2007 10:04AM Courtyard

# LIDAR FLIGHT LOG

ALTM 2 TPZ

PROJECT NUMBER: 1070414 L071707B

PILOT: DAVE I. OPERATOR: Tom DATE: 7/17/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | GPS TIME START | GPS TIME STOP | TRANZPAK | REMARKS T.O. 01:10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | 2 TESTS | | | | 7:54 | 8:42 | 218 | FERRY: PFN → SITE |
| L071707B | 127 | E | 165 | 55 | 18° | 1000m | 265,140 / 139 | 01:40 | | XFLT |
| | 127 | S | 153? | | | | 01:46 | 01:54 | | |
| | 300 | NE | 158± | | | | | 02:12 | | |
| | 299 | SW | | | | | 02:16 | 02:20 | | |
| | 298 | NE | | | | | | 02:26 | | |
| | 297 | SW | | | | | 02:31 | 02:32 | | |
| | 296 | NE | | | | | 02:34 | 02:37 | | |
| XFLT | 296 | SE | | | | | | 02:43 | | E.S.S. AFTER THRU BLOCK |
| | 302 | SW | | | | | 02:49 | 03:00 | | PDOP UP TO 3.27 |
| | 301 | NE | | | | | 03:05 | 03:14 | | " " 3.26 |
| | 303 | SW | | | | | | 03:29 | | PDOP < 3.0 : 6000 |
| | 308 | NE | | | | | 03:34 | 03:46 | | |
| | 304 | SW | | | | | 03:49 | 04:00 | | |
| | 309 | NE | | | | | 04:05 | 04:16 | | |
| | 305 | SW | | | | | 04:19 | 04:31? | | |
| | 310 | NE | | | | | 04:34 | 04:36 | | |
| | 306 | SW | | | | | | 05:01 | | |
| 312 5:34 – 5:45 | 311 | NE | | | | | | 05:15 | | |
| 313 5:49 – 5:59 | 307 | SW | | | | | 05:19 | 05:30 | | 9:24 21:24 EDT → 05:06 EDT |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: 01:24 Z 9:06 ZULU |
|---|---|---|---|---|---|---|---|
| ⊘ | ~~18~~ 333 | 18 | ? | 4.3 | 1.1 | | |
| 1070414 | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul. 18. 2007 3:38PM Courtyard No. 7524 P. 1

# LIDAR FLIGHT LOG

ALTM TPL

PROJECT NUMBER: 1070414

PILOT: DAVE I. OPERATOR: Tom DATE: 7/18/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1070414 | | | 2 TEST FIRES | | | COT AM | 2:06 | 2:36 | 218 | FERRY: AAF → SITE |
| L0718071A | 314 | NE | 155± | 55 | 18° | 1000m | | 07:44 | | |
| | 316 | SW | | | | | 07:48 | 07:54 | | |
| | 315 | NE | | | | | 08:00 | 08:10 | | |
| | 317 | SW | | | | | 08:14 | 08:20 | | |
| | 318 | NE | | | | | | 08:30 | | |
| | 319 | SW | | | | | 8:34 | 8:35 | | |
| | 320 | NE | | | | | 08:38 | 08:39 | | |
| | 320 | SW | | | | | 8:43 | 8:45 | | |
| XFLT | 321 | NW | | | | | | ? | | |
| ½ | 254 | W | | | | | 08:57 | 08:57 | | LEFT OVER FOR E.S.S. from 7/17 |
| XFLT | 254 | N | | | | | | | | |
| | 126 | N | | | | | 9:06 | 9:17 | | BAD PDOP @ (57): 3.82 |
| ½ | 128 | S | | | | | 9:22 | 9: | | |
| | 125 | N | | | | | 9:37 | 9:40 | | |
| | 124 | S | | | | | 9:53 | 10:05 | | A LITTLE PINK IN THE EAST |
| | 123 | N | | | | | 10:09 | 10:22 | | GROUND FOG FORMING |
| XFLT | 122 | SE | | | | | 10:31 | ~~5:54~~ | | RTB FOR FOG IN AREA |
| | | | | | | | | 5:54 | | FERRY: SITE → AAF |
| | | | | | | | | | | |

.5

.4

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: |
|---|---|---|---|---|---|---|
| O | 333 | 13 | ? | 2.9 | .9 | |
| 1070414 | | | | | | |

NOTES: STANDBY @ AAF 6AM → 9AM FOR FOG TO BURN OFF

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

ALTM TP2

PROJECT NUMBER: 1070404 L071807B

PILOT: DAVE T. OPERATOR: Tom DATE: 07/18/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | AM COT | 9:00 | 9:36 | 215 | FERRY: AAF → SITE |
| L071807B | 118 | N | ±155 | 55 | 18° | 1000m | 14:39 | 14:51 | | CLOUDS VIC. by SHORELINE |
| | 119 | S | | | | | 14:56 | 15:07 | | |
| | 122 | N | | | | | 15:12 | 15:24 | | |
| | 120 | S | | | | | 15:28 | 15:40 | | |
| | 121 | N | | | | | 15:45 | 15:57 | | JUST UNDER CLOUDS @ ST: LOC RWR |
| | 117 | S | | | | | 16:01 | 16:13 | | TURB To MOD TURB: JUST UNDER CLOUD |
| | 116 | N | | | | | 16:21 | 16:33 | | |
| | 115 | S | | | | | 16:37 | 16: | | |
| | 114 | N | | | | | 16:54 | 16:06 | | |
| | 113 | S | | | | | 17:10 | 17:22 | | |
| | 112 | N | | | | | 17:26 | 17:38 | | |
| XFLT | 112 | E | | | | | 17:44 | 17:46 | | |
| | | | | | | COT PM | 12:48 | 1:18 | | |

.6

.5

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 11 | ? | 3.2 | 1.1 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

# LIDAR FLIGHT LOG

L071807C

ALTM TP3

PROJECT NUMBER: 1070414

PILOT: DAVE F. OPERATOR: TOM DATE: 7/18/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071807C | 3TEST @ | | ± 02:09 | 1st = | E.S.S. | COT PM | 8:30 | 9:18 | 215 | FERRY: PFN → SITE |
| | 329 | NE | 155± | 55 | 18° | 1000m | 02:22 | 02:25 | | 2:22:39 (234) OI CLIPPED A VALUE NOT RED |
| AREA #8 | 333 | SW | | | | | 02:28? | 02:30 | | |
| | 330 | NE | | | | | 02:34 | 02:36 | | |
| | 332 | SW | | | | | 02:40 | 02:41 | | |
| ⊗ | 331 | NE | | | | | 02:46 | 02:47 | | |
| XFLT | 333 | NW | | | | | | 2:53? | | BAD POOP: 3.27 |
| | 256 | W | | | | | 02:58 | 03:04 | | " " 3.24 OR LESS |
| | 257 | E | | | | | 03:09 | 03:? | | POOP 3.04 TO GREEN |
| AREA #4 | 261 | W | | | | | 03:19 | 03:24 | | |
| | 258 | E | | | | | 03:25 | 03:27 | | |
| | 262 | W | | | | | 03:31 | 03:33 | | |
| ⊗ | 259 | E | | | | | 03:37 | 03:39 | | |
| | 260 | W | | | | | 03:44 | 03:46? | | |
| XFLT | 262 | N | | | | | 03:50 | 03:52 | | |
| AREA #U | 290 | SW | | | | | 03:58 | 04:00 | | |
| | 284 | NE | | | | | 04:04 | 04:05 | | |
| | 291 | SW | | | | | 04:09 | 04:11 | | |
| | 285 | NE | | | | | 04:15 | 04:16? | | |
| ⊗ | 292 | SW | | | | | 04:19 | 04:21 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 24 | 94/89 | 2.9 | 1.4 | | ~~X~~ HOLD @ PFN ON GRND by ATC |
| 1070414 | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

MIDNIGHT TO 5PM & 7:30 → MIDNIGHT

Jul. 19. 2007 2:02AM Courtyard No. 7532 P. 1

(5)

# LIDAR FLIGHT LOG

ALTM TP4

PROJECT NUMBER: 1070414 L071807C cont.

PILOT: DAVE Z. OPERATOR: Tom DATE: 07/18/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071807C | 286 | NE | 155± | 55 | 18° | 1000m | 04:24 | 04:26? | 215 | |
| | 293 | SW | | | | | 04:30 | 04:31 | | |
| AREA #6 | 287 | NE | | | | | ? | 04:36 | | |
| | 294 | SW | | | | | 04:40 | 04:41 | | |
| | 288 | NE | | | | | 04:? | 04:49 | | |
| (X) | 295 | SW | | | | | 04:50 | 04:51 | | |
| | 289 | NE | | | | | 04:56 | ?. | | |
| XFLT | 295 | NW | | | | | | 05:06? | | |
| XFLT | 284 | SE | | | | | 05:08 | 05:09 | | |
| | | | | | | | 12:12 | 12:54 | | FERRY: SITE → PFN |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

.7

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| O | SEE TP3 | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

(18) 16:35 – 21:31

# LIDAR FLIGHT LOG

L071907A

PROJECT NUMBER: 1070414

PILOT: CAM — OPERATOR: Tom — DATE: 07/19/07

TP1

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071907A | | | 2TEST | STRIPS | @ 1 | 17:00 | ~~11:00~~ | | | FERRY: NO FUEL |
| | ~~266~~ | | | | | | 11:30 | 12:12 | 215 | FERRY: PEN → SITE T.O. 11:49 |
| | 266 | SE | 155 ± | 55 | 18° | 1000m | 17:11 | 17:15 | | 15mile LEAD-IN |
| | 275 | NW | | | | | 17:19 | 17:23 | | Roll |
| | 265 | SE | | | | | 17:26 | 17:30 | | |
| | 274 | NW | | | | | 17:34 | 17:38 | | |
| | 264 | SE | | | | | | 17:43 | | |
| | 273 | NW | | | | | 17:49 | 17:53 | | |
| | 263 | SE | | | | | 17:57 | 17:58 | | |
| | 272 | NW | | | | | 18:04 | 18:09 | | |
| | 267 | SE | | | | | 18:13 | 18:18 | | |
| | 276 | NW | | | | | 18:22 | 18:26 | | |
| | 268 | SE | | | | | 18:31 | 18:36 | | |
| | 277 | NW | | | | | 18:40 | 18:43 | | |
| | 269 | SE | | | | | 18:48 | 18:53 | | |
| | 278 | NW | | | | | 18:? | 19:01 | | |
| | 270 | SE | | | | | 19:05 | 19:10 | | |
| | 271 | NW | | | | | 19:14 | 19:19 | | |
| | 279 | SE | | | | | 19:23 | 19:27 | | |
| | 282 | NW | | | | | 19:31 | 19:32 | | |

265 / 264 / 283 / .7

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊘ | 333 | 24 | 70 | 4.0 | 1.1 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

12–3   5:00 → MIDNIGHT   19.0 +3 = 18.0

Jul. 19. 2007 11:28PM Courtyard No. 7539 P. 3

# LIDAR FLIGHT LOG

PROJECT NUMBER: 1070414 L071907A CONT' TP2

ALTM

PILOT: CAM OPERATOR: Tom DATE: 07/19/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | 280 | SE | 155± | 55 | 18° | 1000M | 19:37 | 19:40 | 215 | |
| | 283 | NW | | | | | 19:44 | 19:45 | | |
| | 281 | SE | | | | | 19:50 | 19:52 | | |
| XFLT | 283 | SW | | | | | | 19:59 | | |
| RFT | 325 | NE | | | | | 20:07 | 20:09 | | RFT FOF E.S.S. GAP by ROB |
| XFLT | 333 | NW | | | | | 20:12 | 20:14 | | 3:45 minutes to spare on TIDA |
| | 111 | N | | | | | 20:23 | 20:35 | | |
| | 110 | S | | | | | 20:39 | 20:51 | | |
| | 109 | N | | | | | 20:55 | 21:06 | | |
| XFLT | 111 | W | | | | | | 21:12 | | |
| | | | | | | CDT Pm | 4:12 | 4:36 | | FERRY: SITE → |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: |
|---|---|---|---|---|---|---|
| O | SEE TP1 | | | | | |
| | | | | | | |

NOTES: ALL TIDE/SHORE AREAS SHOULD BE DONE @ THIS TIME!!!

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

7/19 7/20
22:41 – 03:33

# LIDAR FLIGHT LOG

ALTM

TP3

PROJECT NUMBER: 1070414 L071907 B

PILOT: CAM OPERATOR: Tom DATE: 7/19/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | T.O. 22:53 REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L071907B | 3 TESTS | 1ST = E.S.S. | | | | COT PM | 5:30 | 6:06 | 218 | FERRY: PFN → SITE |
| | 108 | S | ± 155 | 55 | 18° | 1000m | | 23:08 | 23:20 | 23:15:05 234 OI CLIPPED A VALUE 10 MILE LEAD-IN / SOME CU VIC ON S.END |
| | 107 | N | | | | | 23:24 | 23:36 | | |
| | 106 | S | | | | | 23:41 | 23:53 | | |
| | 105 | N | | | | | 23:57 | 00:09 | | 00:06:51 (234) OI CLIPPED A VALUE |
| | 104 | S | | | | | 00:14 | 00:25 | | |
| | 103 | N | | | | | 00:29 | 00:41 | | A LITTLE HIGH ON S.END PARTED CLOUDS |
| | 102 | S | | | | | 00:44 | 00:56 | | 00:45:18 (234) / CLOUDS ON S. END APPEAR TO BE DISSIPATING |
| | 101 | N | | | | | 01:01 | 01:13 | | |
| | 100 | S | | | | | 01:17 | 01:29 | | |
| | 99 | N | | | | | 01:34 | 01:35 | | E.S.S. |
| ⊘ | 99 | N | | | | | 01:35 | 01:46 | | SEGMENT (m) @ 29°:45 |
| | 98 | S | | | | | 01:51 | 02:03 | | |
| | 97 | N | | | | | 02:08 | 02:19 | | |
| | 96 | S | | | | | 02:24 | 02:36 | | |
| ⊗ | 95 | N | | | | | 02:40 | 02:43 | | 100+m |
| ⊗ REFT | 99 | S | | | | | 02:47 | 02:48 | | POOP 3.24 |
| ⊗ | 95 | N | | | | | 02:53 | 03:05 | | |
| XFLT | 108 | | | | | | 03:09 | 03:10 | | |
| | | | | | | | 10:12 | 10:36 | | FERRY: SITE → PFN |

.6
.9

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY |
|---|---|---|---|---|---|
| ⊘ | 333 | 14 | 56 | 4.1 | 1.0 |

WX:

NOTES:

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com 49.4

Jul. 20. 2007 11:54PM Courtyard No. 7558 P. 1

7/20
13:24 – 15:34

20A

# LIDAR FLIGHT LOG

ALTM

TPL

PROJECT NUMBER: 1070414 | L072007A

PILOT: CAM | OPERATOR: Tom | DATE: 7/20/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L072007A | 2TESTS @ | | ± 13:47 | | | CDT AM | 8:18 | 8:54 | 218 | FERRY: PFN → SITE | .6 |
| ⊘ | 94 | S | 155 ± | 55 | 18 | 1000m | 13:53 | 14:03 | | CU FORMING E.S.S. @ 29:48 ±S. | |
| ⊘ | 93 | N | | | | | 14:09 | 14:19 | | 29°:50 ±S. NEEDed | |
| ⊘ | 92 | S | | | | | 14:23 | 14:34 | | 29:46 ±S. NEEDED | |
| ⊘ | 91 | N | | | | | 14:41 | 14:50 | | 29:50 ± S. NEEDed | |
| ⊘ | 90 | S | | | | | 14:55 | 15:01 | | 29:59 ± S. NEEDED | |
| XFLT | 90 | E | | | | | 15:12 | 15:12 | | | |
| | | | | | | | 10:12 | 10:42 | | FERRY: SITE → PFN | .5 |
| | | | | | | | | | | @ PFN by 7:40CDT | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: |
|---|---|---|---|---|---|---|
| ⊘ | 333 | 5 PARTIALS | 51 +5 PARTIAL | 1.3 | 1.1 | |
| 1070414 | | | | | | |

NOTES: PLANE WAS NOT FUELed AGAIN, IN MORNING... SUGGESTED CAM CALL ORDER IN MORNING OF FLT. PLUGS FOULED.

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-457-2655 E-Mail: amephoto@aerometric.com

12 → 1AM 6AM →

Jul. 20. 2007 11:54PM Courtyard No. 7558 P. 2

# LIDAR FLIGHT LOG

ALTM TP2

PROJECT NUMBER: 1070414 L072007B

PILOT: CAM OPERATOR: TOM DATE: 7/20/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L072007B | 4 | TESTS | 1st E.S.S | 380: 4AM TURNED 22:22 | | | 5:06 | 5:36 42 | | T.O. @ 5:27 |
| | 89 | S | 155 ± | 55 | 18° | 1000m | 22:40:49 | 22:52:49 | 215 | FERRY: PFN → SITE |
| | 88 | N | | | | | | | | 8 MILE LEAD-IN |
| | 87 | S | | | | | 22:57 | 23:09 | | |
| | 86 | N | | | | | 23:14 | 23:25 | | |
| | 85 | S | | | | | 23:35 | 23:43 | | |
| | 84 | N | | | | | 23:47 | 23:59 | | |
| | 83 | S | | | | | 00:04 | 00:16 | | |
| | 82 | N | | | | | 00:20 | 00:32 | | |
| | 81 | S | | | | | 00:37 | 00:48 | | |
| | 80 | N | | | | | 00:53 | 01:05 | | |
| | 79 | S | | | | | 01:09 | 01:21 | | |
| | 78 | N | | | | | 01:26 | 01:38 | | 01:32:09 (234) OI CAV. |
| XFLT | 89 | W | | | | | 01:42 | 01:55 | | LIGHTNING TO N. 25 → 30 MILES |
| | | | | | | | 01:59 | 02:00 | | "SLOWLY" MOVING SOUTH |
| | | | | | | | ~~9:00~~ | 9:24 | | FERRY: SITE → PFN |

.6

.4

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY |
|---|---|---|---|---|---|
| ⊘ | 333 | 12 !! | 39 5 PARTIAL | 3.8 | 1.0 |
| 1070414 | | | | | |

WX: BEAUTIFUL: HAZE W/HZ CIR

T-STORMS TO N... LATER

NOTES: VOLTAGE DOWN TO 23VOLTS ON FINAL ROLL-OUT & TAXI (INITIAL)

22 lines

21A

# LIDAR FLIGHT LOG

ALTM

TPA

PROJECT NUMBER: 1070414 L072107A

PILOT: CAM OPERATOR: Tom DATE: 7/21/07

| MISSION | LINE NO. | Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | TO 8:08 |
| L072107A | 3 | TEST | | | | | 7:48 | 8:18 | 215 | FERRY: PFN → SITE .5 |
| | 77 | S | 155± | 55 | 18° | ±1000m | 13:21 | 13:33 | | |
| | 72 | N | | | | | 13:38 | 13:50 | | |
| | 71 | S | | | | | 13:55 | 14:07 | | 30:09 → 30:10 |
| | 76 | N | | | | | 14:12 | 14:24 | | -DZ @ 30:00 → 30:02 + 30:06 |
| | 70 | S | | | | | 14:29 | 14:41 | | " " |
| SYS OFF FOR DZ + RAW ⊗ | 75 | N | | | | | 14:45 | 14:53 | | " " 29:57 HEAVIER @ 30:00 STOP @ 30:01 |
| ⊗ | 91 | S | | | | | 14:59 | 15:02 | | FLT OF PARTIAL LINE OF 7/20 (TPA/A) |
| ⊗ | 90 | N | | | | | 15:07 | 15:14 | | " -DZ JUST PAST OL AREA " |
| ⊗ | 92 | S | | | | | 15:21 | 15:23 | | "PARTIAL S/20 TPA " E.S.S. PAST SEAM |
| ⊗ | 93 | N | | | | | 15:28 | 15:32 | | |
| ⊗ | 94 | S | | | | | 15:37 | 15:40 | | |
| XFLT | 94 | W | | | | | 15:45 | 15:48 | | |
| * LPR (AREA ONLY) | 40 | N | | | | | 15:52 | 15:59 | | * A VOID IN SWATH DATA @ 29:59:34.96... -DZ N. 3.5NM ± NO ANNUNC. |
| | 39 | S | | | | | 16:06 | 16:10 | | 13 mile LEAD-IN \| CU FORMING N. + W. |
| | 41 | N | | | | | 16:15 | 16:22 | | |
| | 43 | S | | | | | 16:26 | 16:33 | | |
| | 42 | N | | | | | 16:38 | 16:45 | | CLOUDS JUST N. OF PROJ. AREA |
| | 44 | S | | | | | 16:49 | 16:56 | | |
| | → 45 | N | | | | | 17:01 | 17:08 | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: LEFT ALT. INTERMITTENT |
|---|---|---|---|---|---|---|---|
| ∅ | 333 | 14 5 PARTIAL 1 PARA | 25 8 1P | 4.3 | .9 | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

21A CONT.

# LIDAR FLIGHT LOG

TP2

PROJECT NUMBER: 1070414 L072107A CONT.

PILOT: CAM OPERATOR: Tom DATE: 7/21/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L072107A | 46 | S | ±155 | 55 | 18° | 1000m | 17:12 | 17:20 | 215 | |
| XFLT | 39 | E | | | | | 17:24 | 17:25 | | |
| | 47 | N | | | | | 17:30 | 17:38 | | |
| | | | | | | | 12:36 | 1:00 | | FERRY: SITE → PFN |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: AO ZN 20073 FZUK |
|---|---|---|---|---|---|---|---|
| O | SEE TP1 | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

Jul. 21. 2007 10:51PM Courtyard No. 7561 P. 2

No. 7561 P. 3

Jul. 21. 2007 10:51PM Courtyard

1/21
18:38 – 23:12

21B

# LIDAR FLIGHT LOG

ALTM

TP3

PROJECT NUMBER: 104044 L072107B

PILOT: CAM OPERATOR: Tom DATE: 7/21/07

| MISSION | LINE NO. & Hdg | | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L072107B | | 2 TAST | FERES | | | | 1:30 | 2:00 | 218 | FERRY: PFN → SITE .5 |
| | 62 | S | ±155 | 180k | ±35 | 1000m | 19:02 | 19:14 | | JUST UNDER CU CLOUDS - TOMOD TWO |
| | 65 | N | | | | | 19:19 | 19:31 | | |
| | 61 | S | | | | | 19:36 | 19:48 | | |
| | 64 | N | | | | | 19:52 | 20:05 | | |
| | 60 | S | | | | | 20:08 | 20:20 | | |
| | ~~62~~ | | | | | | 20:25 | 20:25 | | NEEDed AN ENTER BUTTON DEPRESSION TO MAKE LINE CHANGE...6+MSEC LEAD [illegible] |
| | 63 | N | | | | | 20:32 | [illegible] | | |
| | 59 | S | | | | | 20:48 | 21:00 | | TIDE AREAS ARE COMPLETE... AGAIN |
| | 69 | N | | | | | 21:05 | 21:17 | | |
| | 66 | S | | | | | 21:21 | 21:33 | | |
| | 73 | N | | | | | 21:37 | 21:49 | | PDOP: 3.1 DZ 29:59, 30:05, 30:11 |
| | 67 | S | | | | | 21:53 | 22:05 | | PDOP ↑ 3.37 |
| Ø | 74 | N | | | | | 22:09 | 22:16 | | PDOP 2.2 ↓ OFF@30:01 SHUT-DOWN DUE TO PRECIP AHEAD |
| Ø | 68 | S | | | | | 22:20 | 22:26 | | 30:00 |
| XFLT | 75 | W | | | | | 22:31 | 22:33 | | |
| Ø | 48 | N | | | | | 22:35 | 22:40 | | |
| | ~~46~~ | S | NP | GOOD | | | 22:43 | 22:43 | | SHORT EMAIS. |
| | 40 | N | | | | | 22:47 | 22:47 | | |
| XFLT | 40 | E | | | | | 22:50 | 22:51 | | 5:54 → 6:18 FERRY: SITE → PFN |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| Ø | 333 | 12 3P.5 | | 3.9 | .9 | | 24 VOLTS ON LANDING, AGAIN |
| 1070414 | | | | | | | |

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

7/22
13:05 – 15:01

22A
218

# LIDAR FLIGHT LOG

L072207A

TPA

ALTM

PROJECT NUMBER: 1070414

PILOT: CAM   OPERATOR: Tom   DATE: 7/22/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | T.O. 8:24 REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L072207A | | | 2 TESTS | @ | 13:36 | | 8:00 | ~~8:26~~ | 8:42 | FERRY: PFN → SITE |
| | ✓ ⊗ 68 | S | 155 ± | 55 | 18° | 1000m | 49 320 13:42 | 49 740 13:49 | 218 | "CLOUDS ON SITE", RTENG PROBLEM *: |
| | ⊗ 75 | N | | | | | 49980 13:53 | 50 280 13:58 | | RTB, NO RTB .... MAGS = BOTH |
| | ⊗ 74 | S | | | | | 50 520 14:02 | 50 820 14:07 | | E.S.S. AFTER SEAM: GOOD LINE |
| XFLT | 75 | W | | | | | 14:14 | 14:17 | | |
| | ~~48~~ | | | | | | 14:23 | 14:23 | | ENTER!! SHORT EMISS. N.G.! |
| | ⊘ 48 | S | | | | | 14:29 | 14:33 | | E.S.S. JUST 1300' SHORT OF NEEDED |
| | ⊗ 48 | S | | | | | 14:39 | 14:40 | | * |
| | | | | | | | 9:42 | 10:06 | | FERRY: SITE → PFN |

.7

.4

2.1 hrs ON SITE 1.3hrs
201NM 37.32 Km
49 (35.43 Km) 58 (39.21 Km)

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: |
|---|---|---|---|---|---|---|
| ⊘ | 333 | 4P | 10 | 1.0 | 1.1 | |

NOTES: PLUGS FOULED
* MAGS TO BOTH FOR T.O. HELPS
FLAPS UP FOR CLIMB/CRUISE? " "

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com 6:30 AM →

Jul. 22. 2007 5:34PM Courtyard No. 7567 P. 1

# LIDAR FLIGHT LOG

218

TP2

ALTM

PROJECT NUMBER: 1070414 L072207B

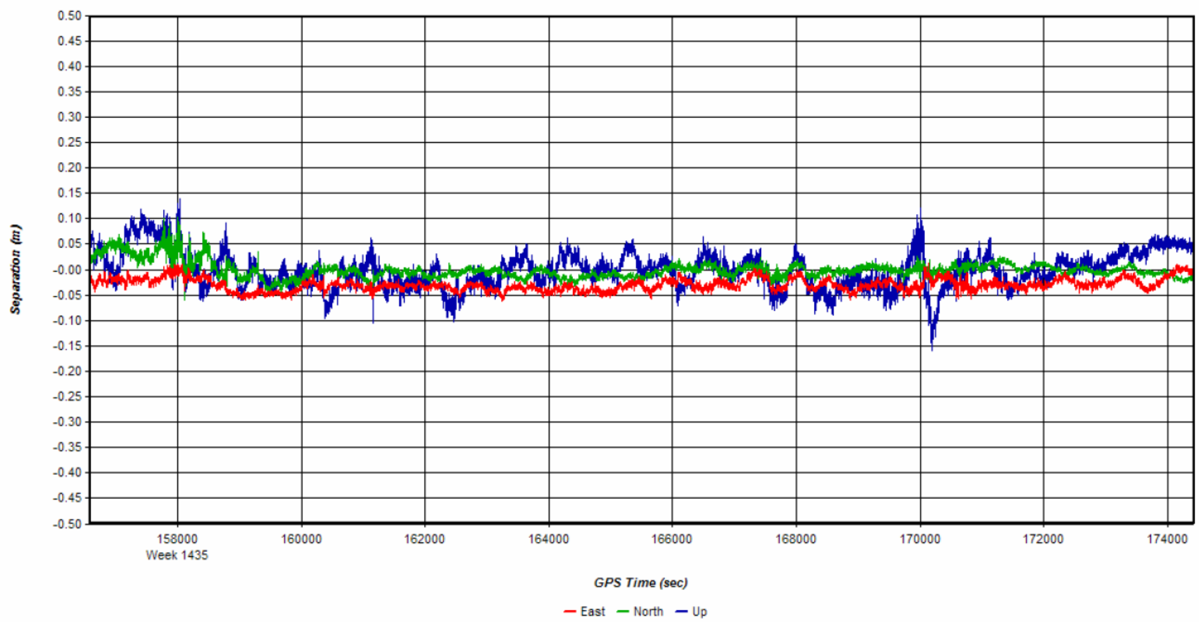
PILOT: CAM OPERATOR: Tom DATE: 7/22/07

| MISSION | LINE NO. | & Hdg | GND SPEED (KTS) | SCAN FREQ | SCAN ANGLE | ALT (m) | TIME START | TIME STOP | TRANZPAK | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| L072207B | | 2 TESTS @ 1643 | | | | | 11:18 | 11:48 | 218 | .5 |
| | 58 | S | 155± | 55 | 18° | ±1000m | 16:47 | 16:56 | | LOWER CLOUDS JUST TO WEST |
| | 57 | N | | | | | 17:01 | 17:10 | | |
| | 56 | S | | | | | 17:14 | 17:23 | | |
| | 55 | N | | | | | 17:27 | 17:35 | | |
| | 54 | S | | | | | 17:40 | 17:48 | | |
| | 53 | N | | | | | 17:53 | 18:01 | | |
| | | | | | | | | | | |
| | 52 | S | | | | | 18:05 | 18:13 | | |
| | 51 | N | | | | | 18:17 | 18:25 | | LT. RAIN IN TURN |
| | 50 | S | | | | | 18:29 | 18:36 | | S. END LOW. 950m / VERT CLOUD BELOW FLT HT |
| | 49 | N | | | | | 18:41 | 18:49 | | |
| | 50 | S | | | | | 19:02 | 19:04 | | RAIN S. END (−E.S.S.) |
| XFLT | 50 | W | | | | | 19:08 | 19:10 | | |
| | 50 | N | | | | | 19:16 | 19:20 | | REFLY FOR LESS RAIN .37 |
| | | | | | | | 2:18 | 7:48 | | FERRY: SITE → PFN .5 |
| XFLT | 49 | E | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| STATUS | TOTAL LINES | FLOWN | LEFT | AIRCRAFT SITE | AIRCRAFT FERRY | WX: | NOTES: |
|---|---|---|---|---|---|---|---|
| ⊗ | 333 | 10/333 | ⊗ | 2.5 | 1.0 | CU JUST ABOVE FLT ALT | LOW VOLTAGE ON ROLL-OUT |
| 1070414 | | | | | | | 3) 21 2951 |

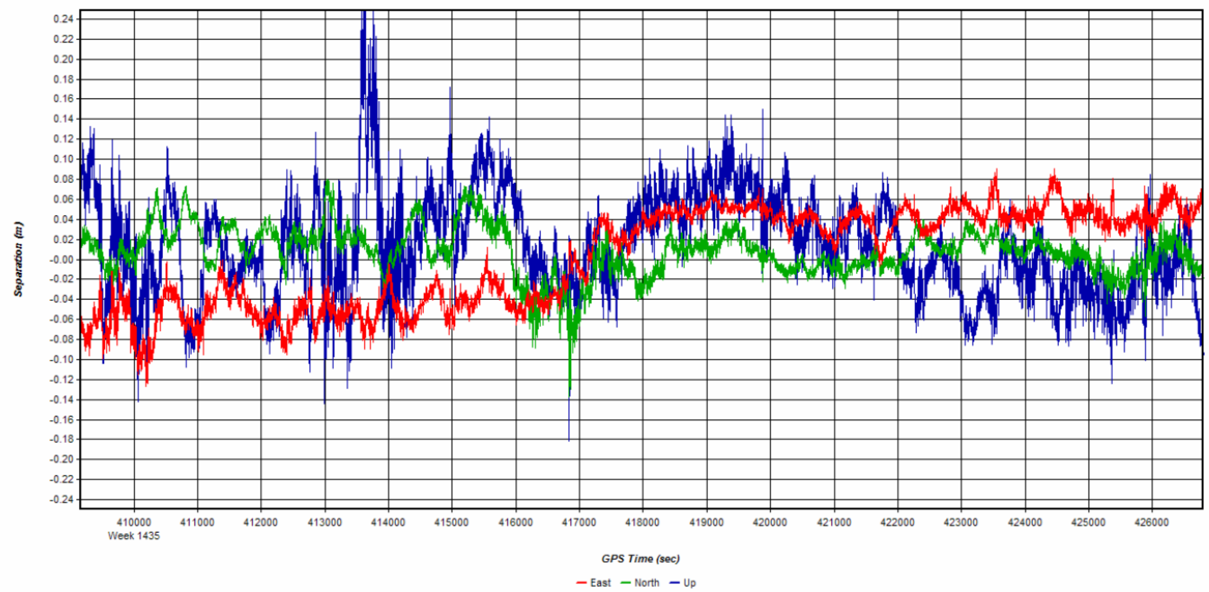
AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 E-Mail: amephoto@aerometric.com

**Separation Plot**
APALPORT, CARRPORT, FB170P19, and FB173P11
L0709071



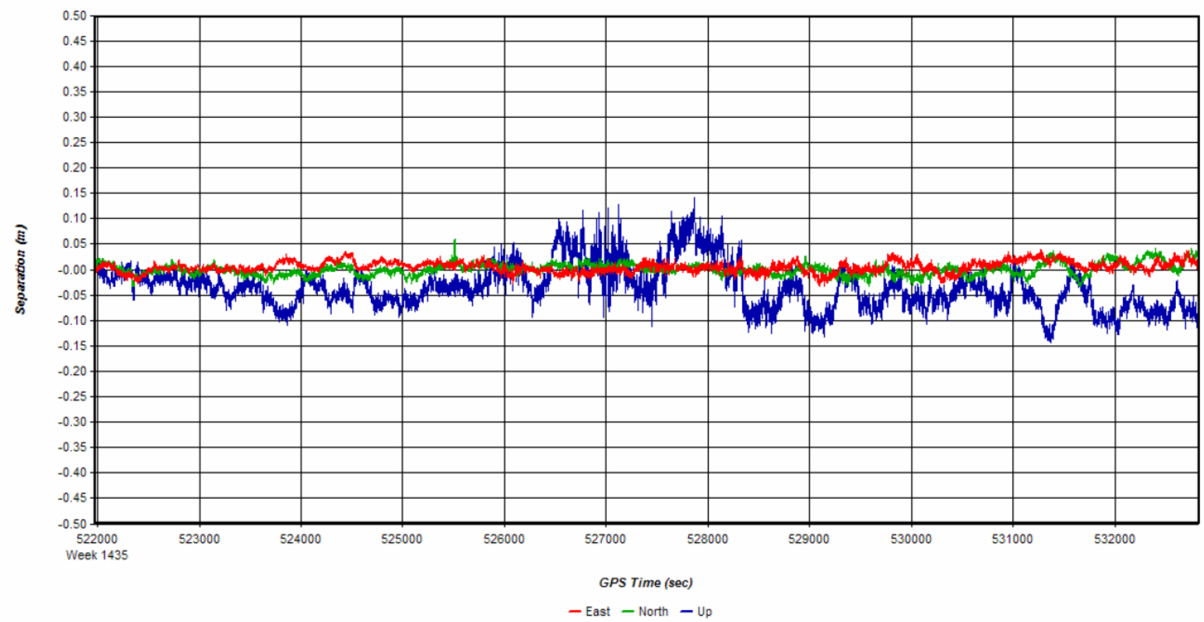

N280MB_70906_SEP_APALPORT_CARRPORT-Rev_FB170P19_FB173P11-Cmb.doc

**Separation Plot**
**APALPORT, FB173P11, FB174P07, PNCY, and TIDAL**
**L0712071**



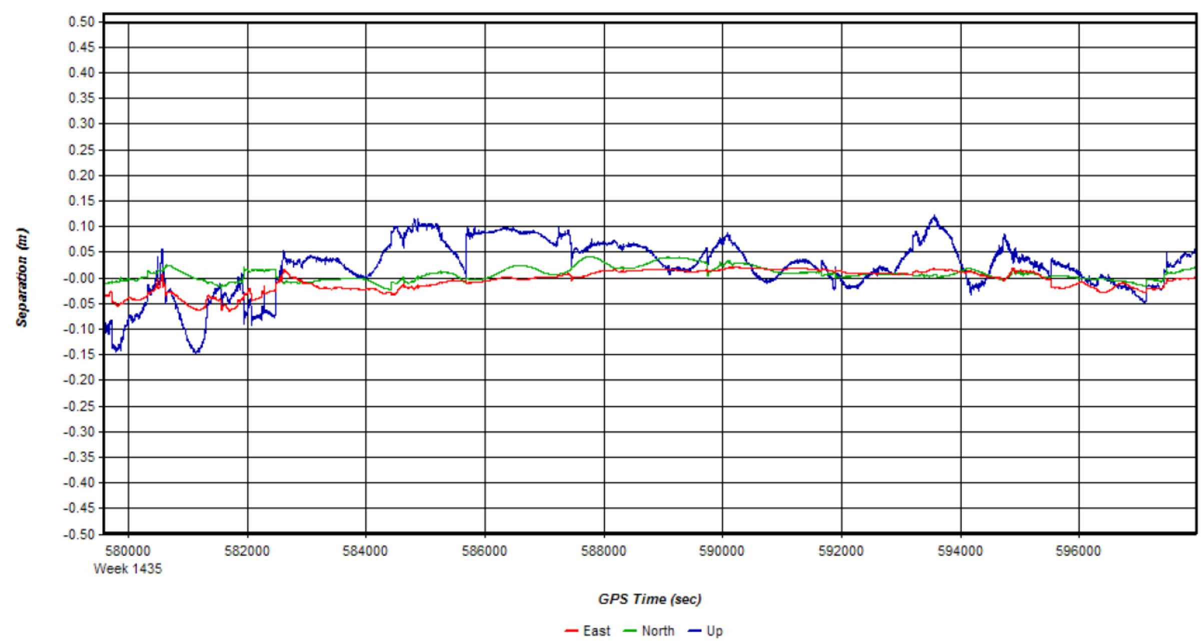

N280MB_71206_Sep_APALPORT_FB173P11_FB174P07_PNCY_TIDAL-Cmb.doc

**Separation Plot**
APALPORT, CARRPORT, and FB174P07
L0713071



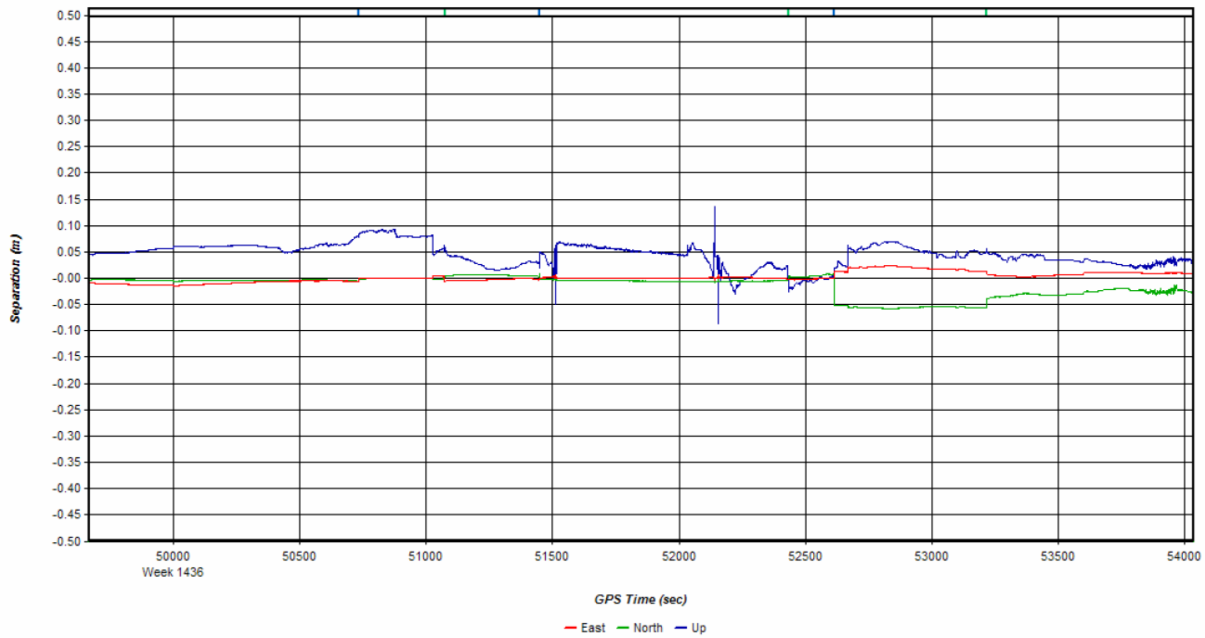

N280MB_71306_SEP_APALPORT-Fwd_CARRPORT-Fwd_FB174P07-Cmb.doc

**Separation Plot**
APALPORT and FB174P07
L071407A



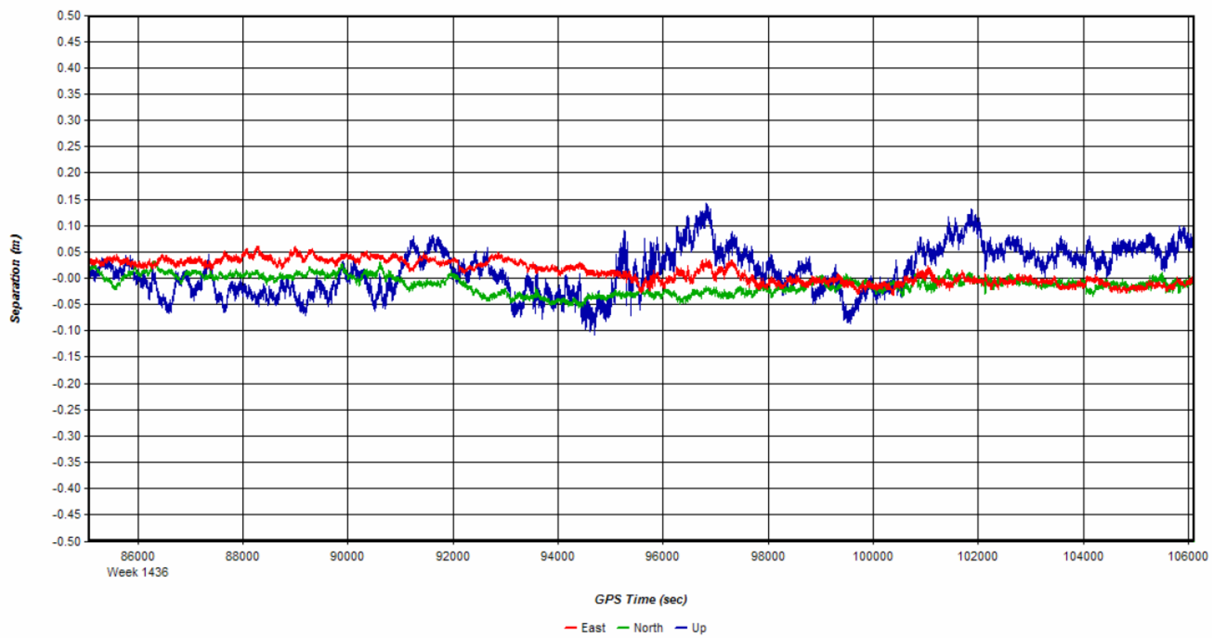

N280MB_L071407A_SEP_APALPORT_FB174P07-Cmb.doc

**Separation Plot**
**FB170P19, FB174P07, and PNCY**
**L071507A**




N280MB_L071507a_SEP_FB170P19_FB174P07_PNCY-Cmb.doc

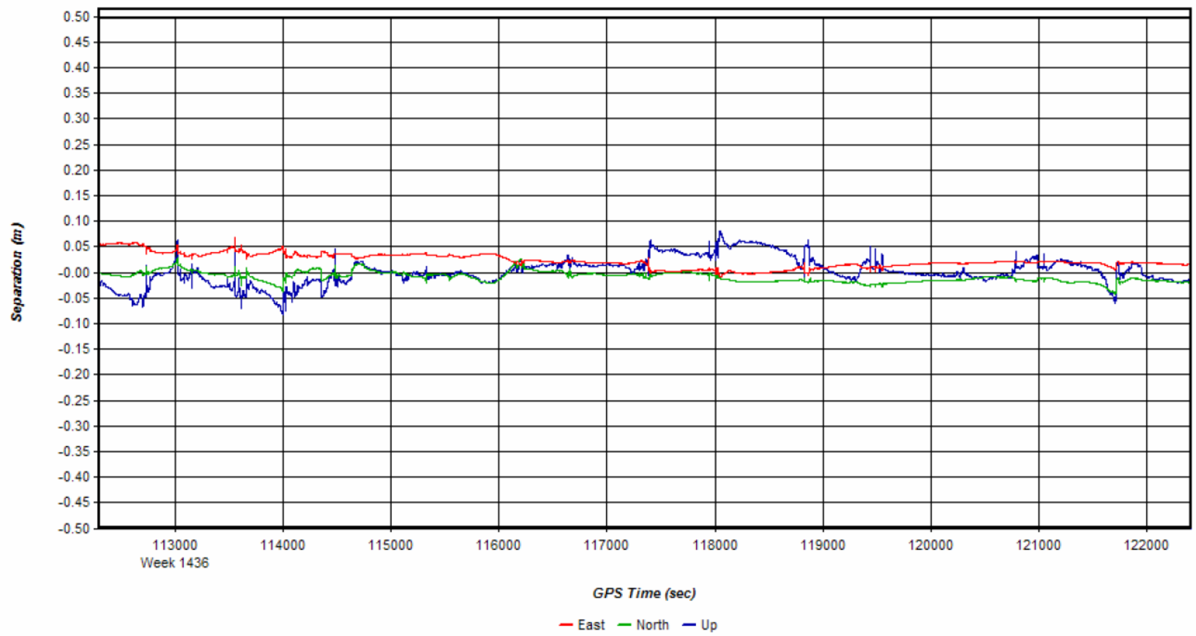
## Separation Plot
**FB170P19-Cmb, FB174P07-Rev, and PNCY-Rev**
**L071507B**




N280MB_L071507B_SEP_FB170P19-Cmb_FB174P07-Rev_PNCY-Rev.doc

## Separation Plot

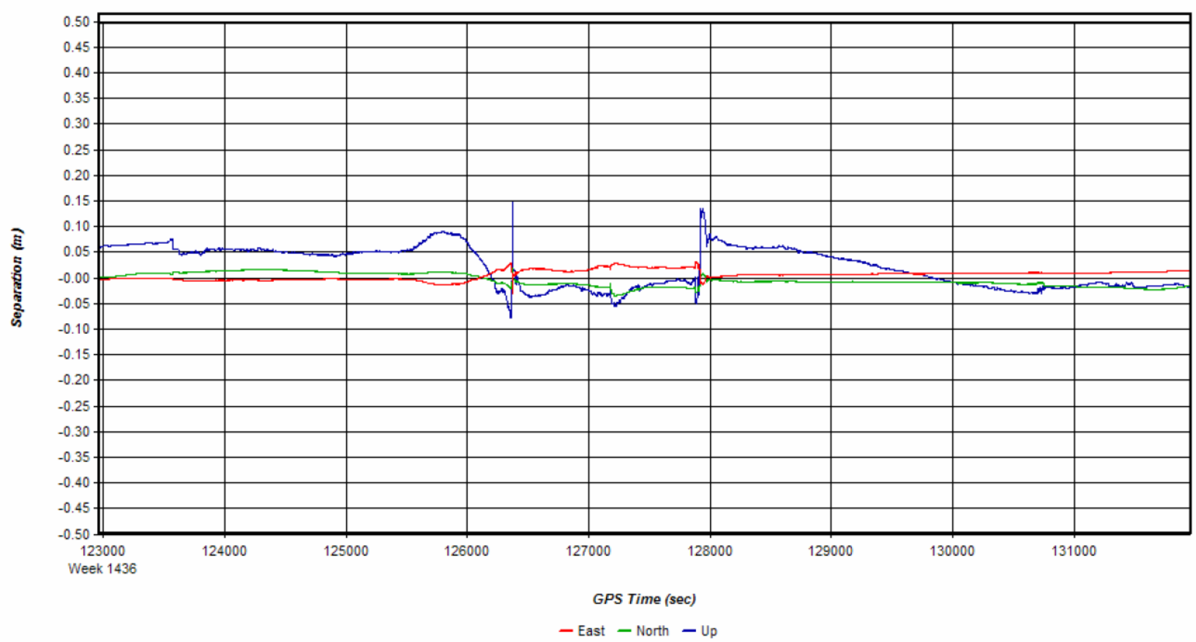
**L071607A**




N280MB_L071607A_SEP_FB170P19_FB174P07_PNCY-Cmb.doc

## Separation Plot

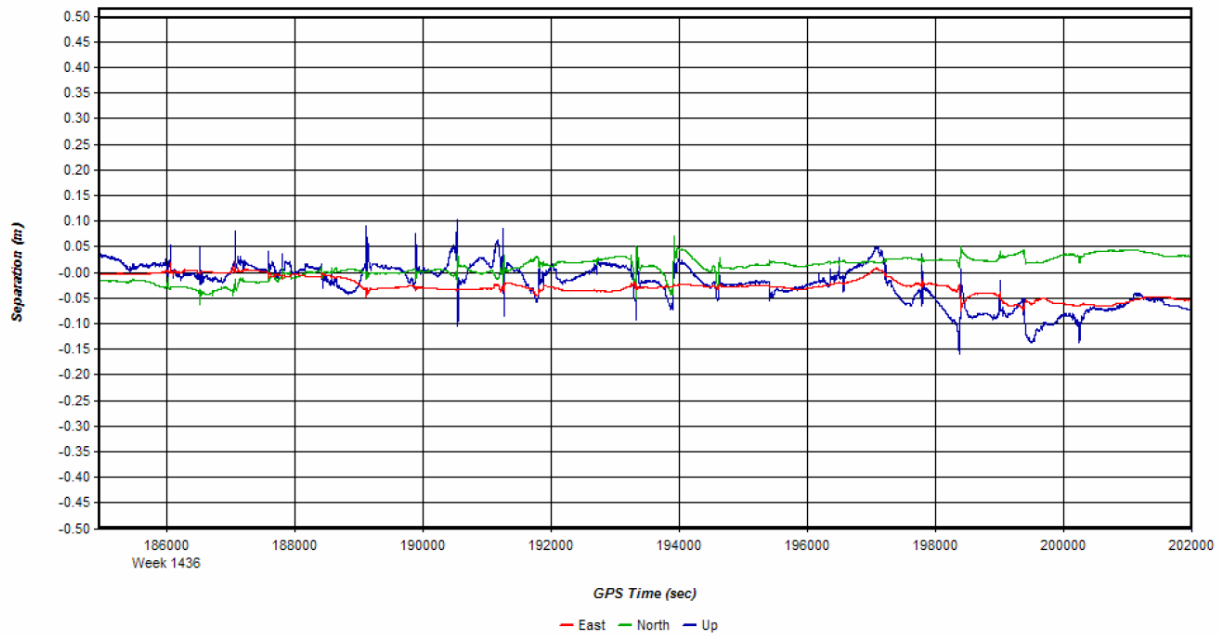
**L071607B**




N280MB_L071607B_SEP_FB170P19_FB174P07_PNCY-Cmb.doc

## Separation Plot

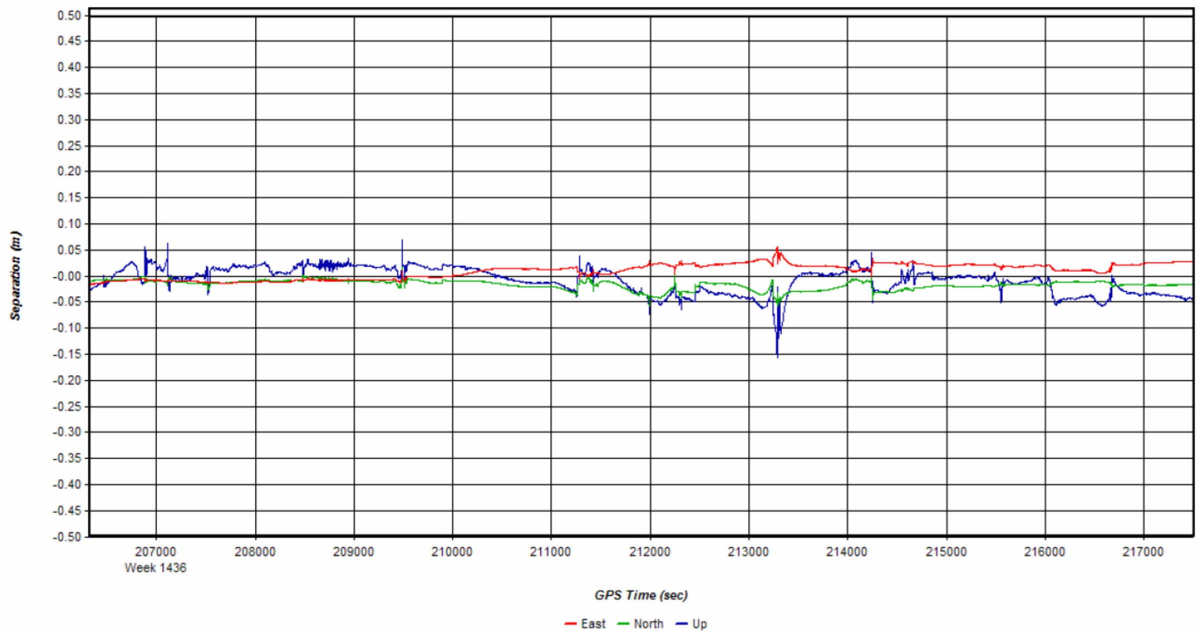
**L071607C**




N280MB_L071607C_SEP_FB170P19_FB174P07_PNCY-Cmb.doc

## Separation Plot

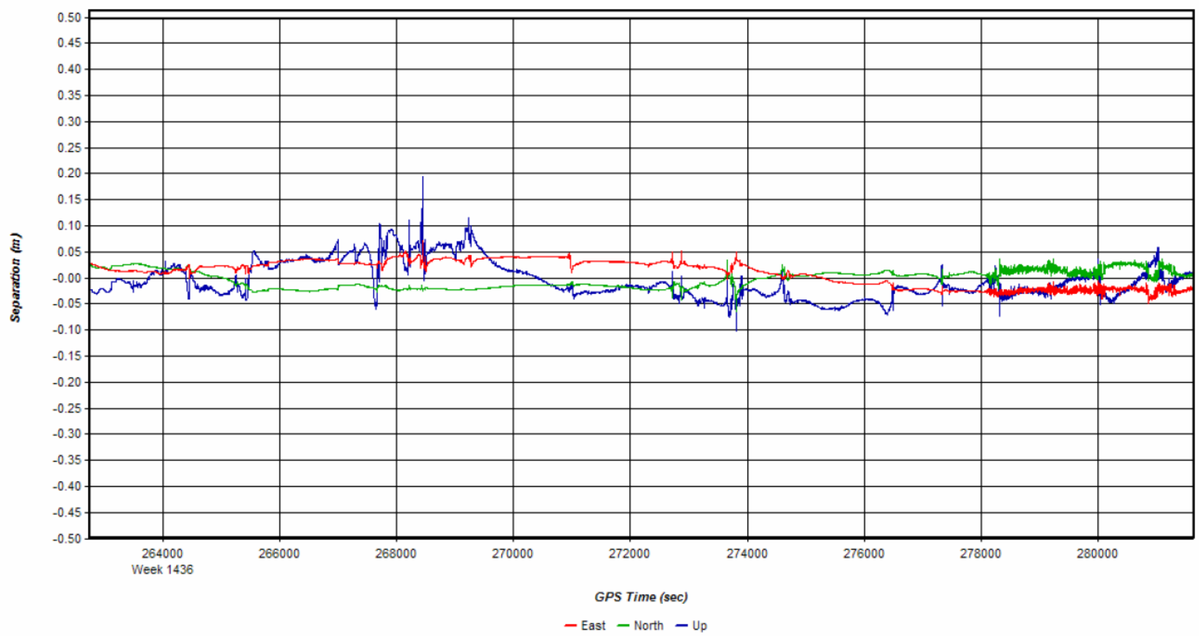
**L071707A**




N280MB_L071707A_SEP_FB170P19_FB174P07_PNCY-Cmb.doc

## Separation Plot

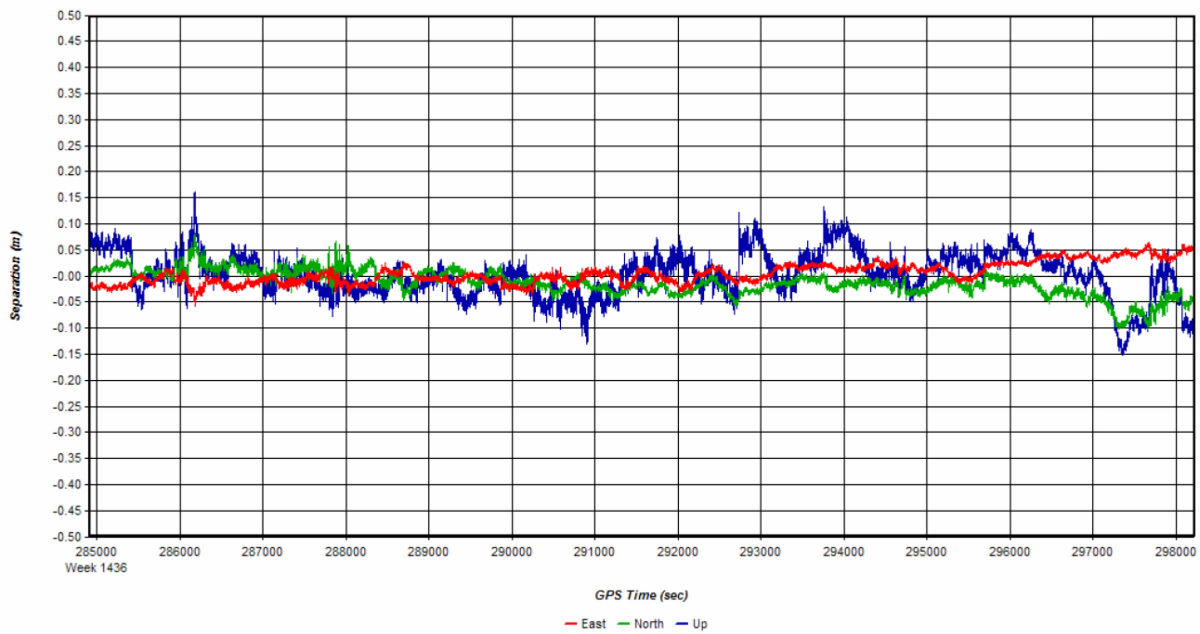
**L071707B**




N280MB_L071707B_SEP_CARRPORT_FB170P19_PNCY-Cmb.doc

## Separation Plot

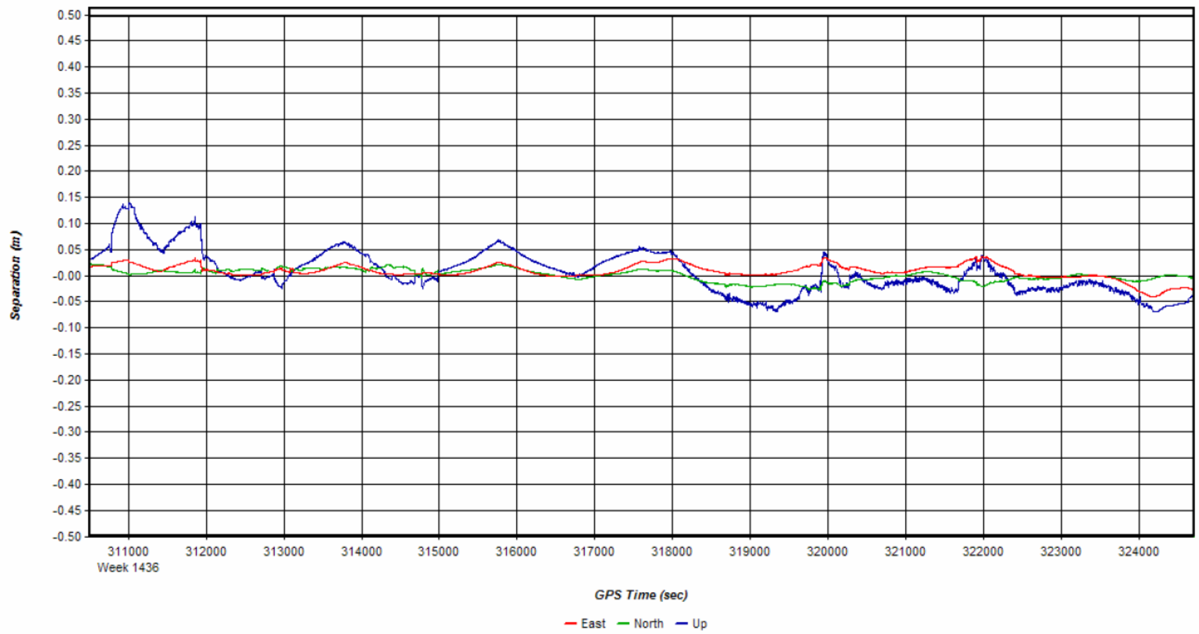
**L071807A**




N280MB_L071807A_SEP_FB170P19-Fwd_FB174P07-Rev.doc

## Separation Plot

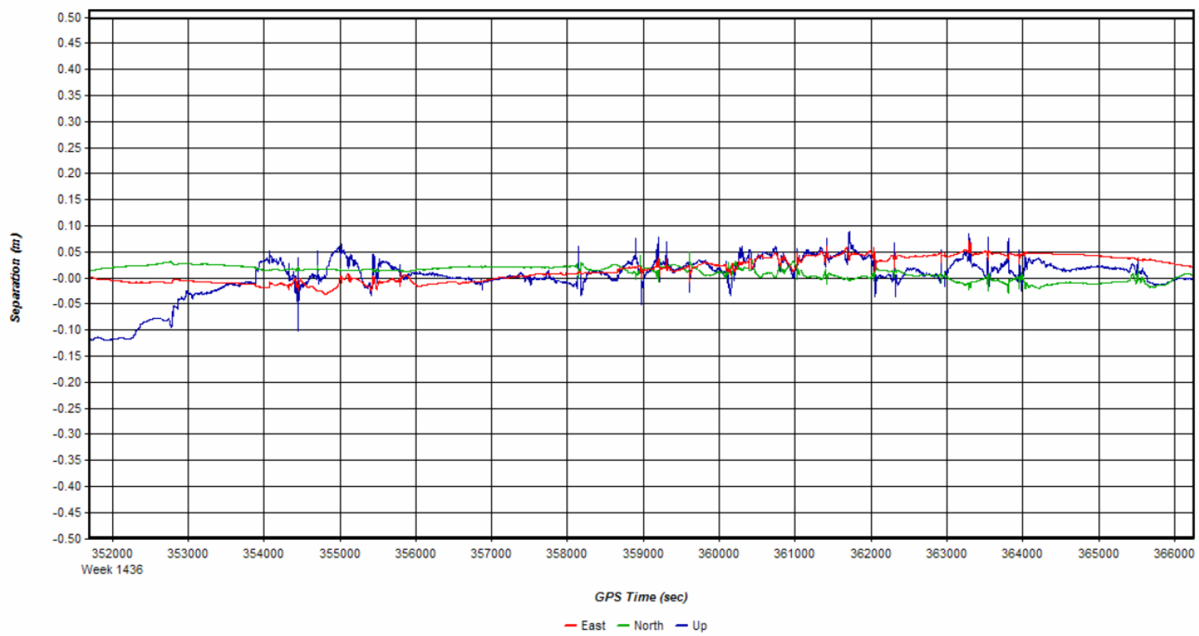
**L071807B**




N280MB_L071807B_SEP_FB170P19_FB173P11_FB174P07_PNCY-Cmb.doc

## Separation Plot

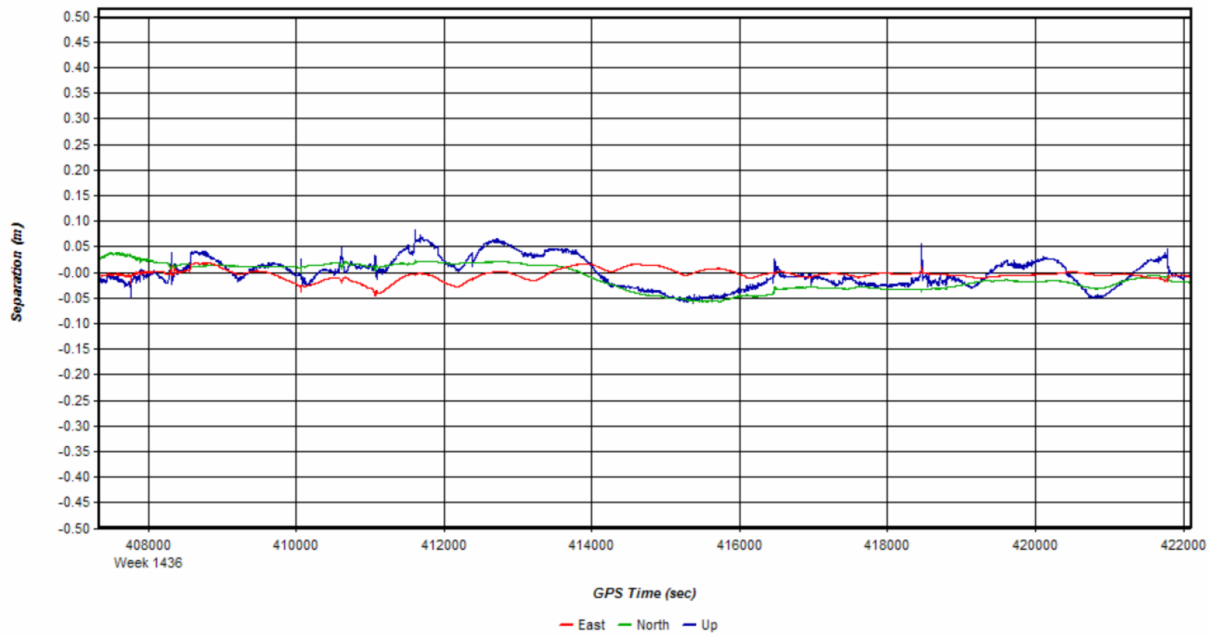
**L071807C**




N280MB_L071807C_SEP_APALPORT_CARRPORT_FB170P19_FB173P11_FB174P07_PNCY_TIDAL-Cmb.doc

## Separation Plot

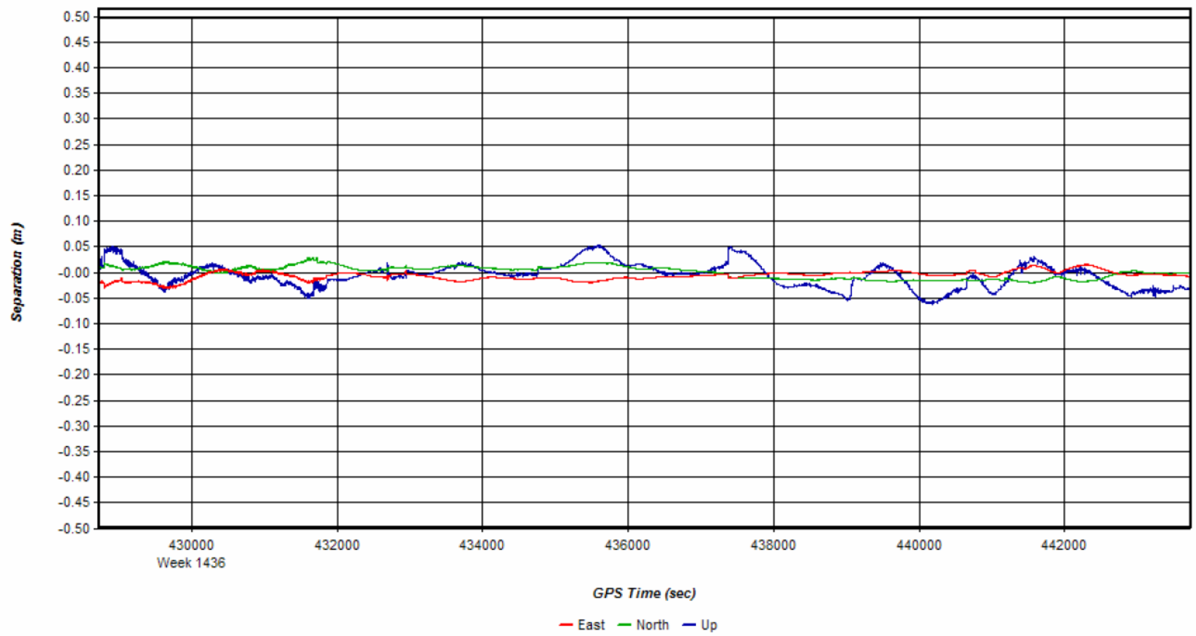
**L071907A**




N280MB_L071907A_SEP_APALPORT_FB170P19_FB174P07-Cmb.doc

## Separation Plot

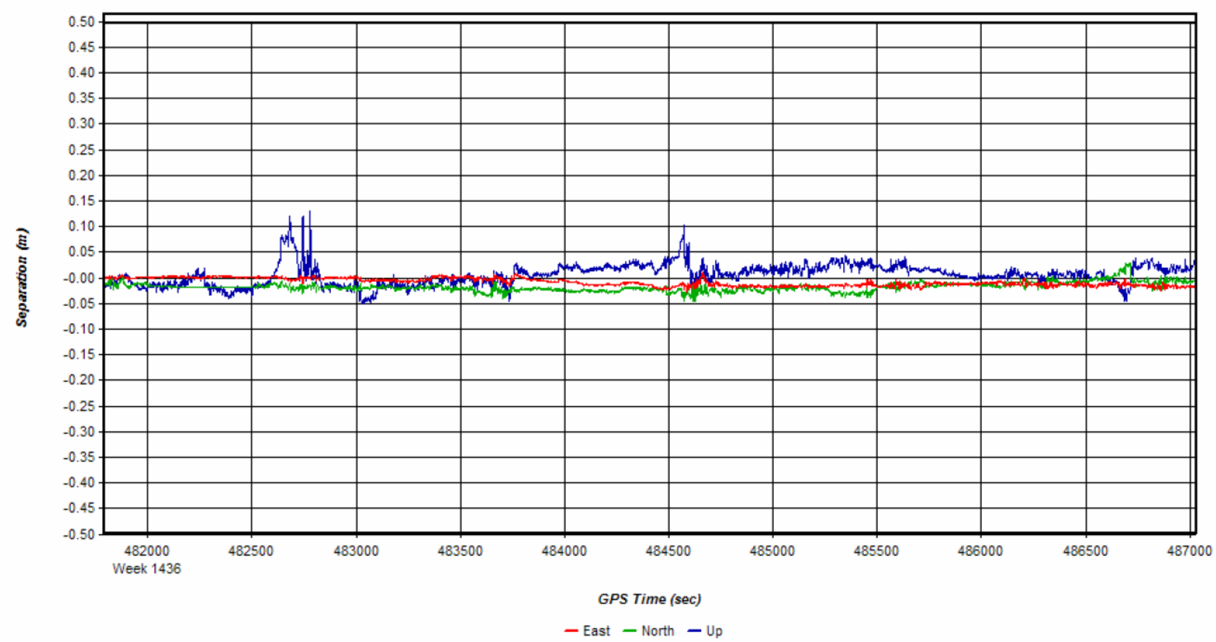
**L071907B**




N280MB_L071907B_SEP_APALPORT_FB170P19_FB174P07-Cmb.doc

## Separation Plot

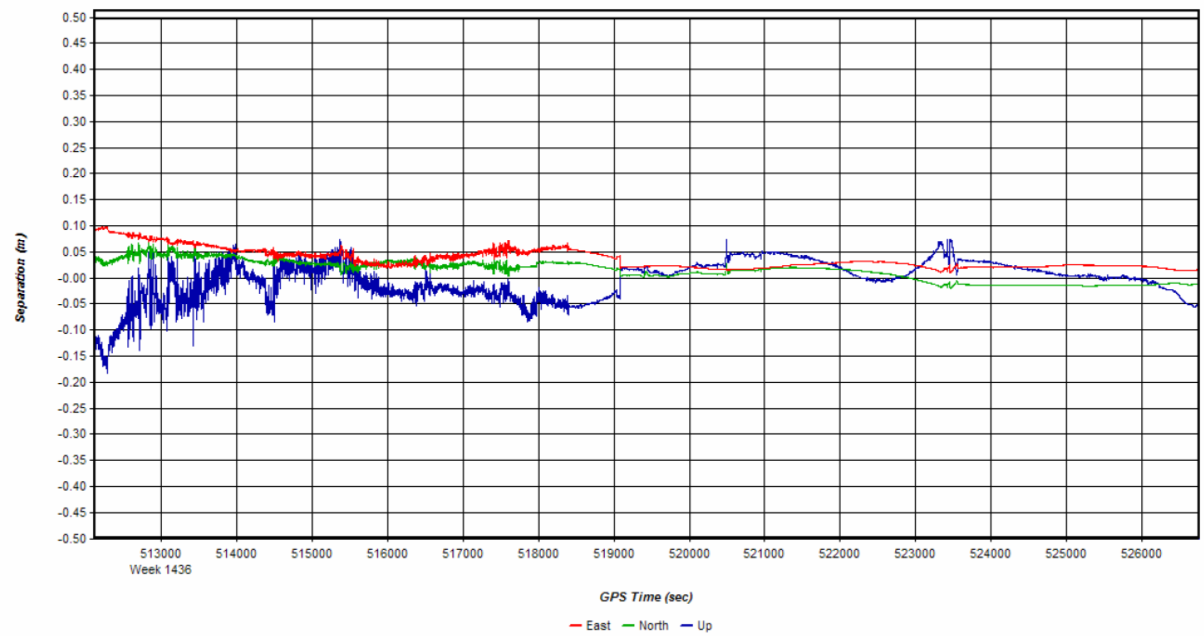
**L072007A**




N280MB_L072007A_SEP_APALPORT_FB170P19_PNCY_TIDAL-Cmb.doc

## Separation Plot

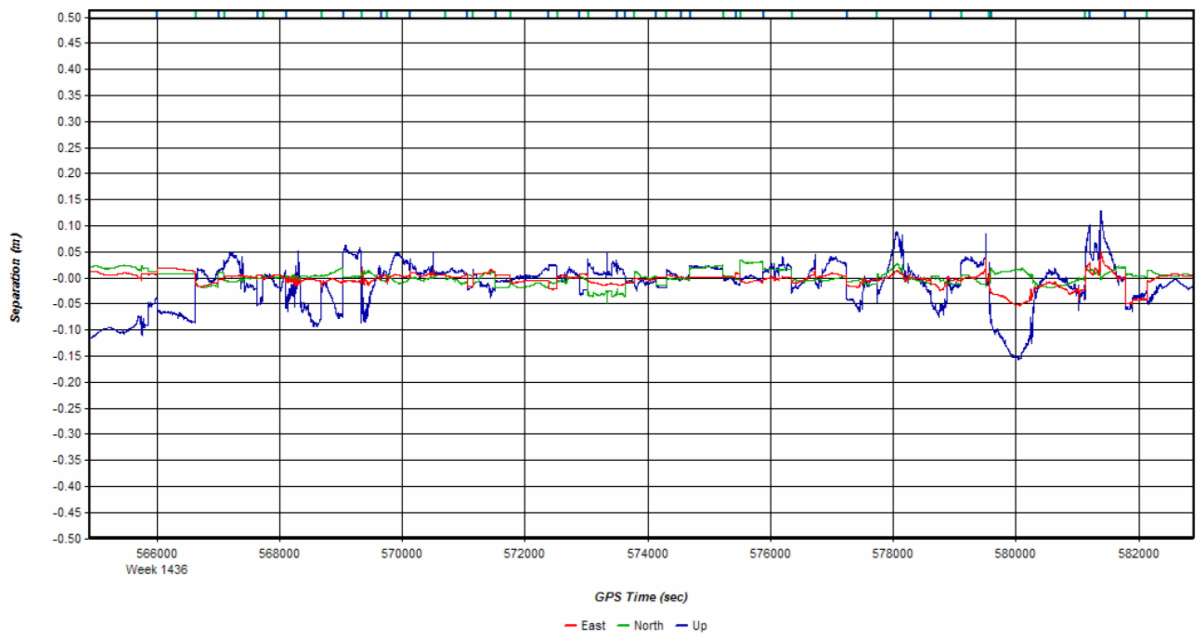
**L072007B**




N280MB_L072007B_SEP_APALPORT_FB170P19_PNCY_TIDAL-Cmb.doc

## Separation Plot

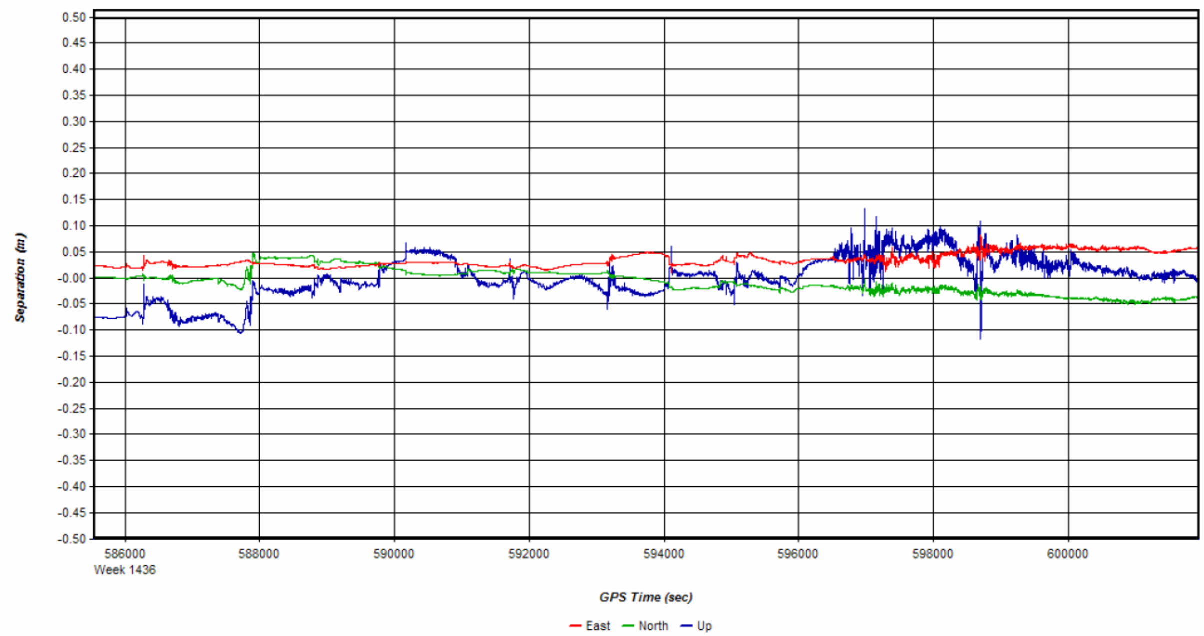
**L072107A**




N280MB_L072107A_SEP_APALPORT_FB170P19_FB174P07_PNCY_TIDAL-Cmb.doc

## Separation Plot

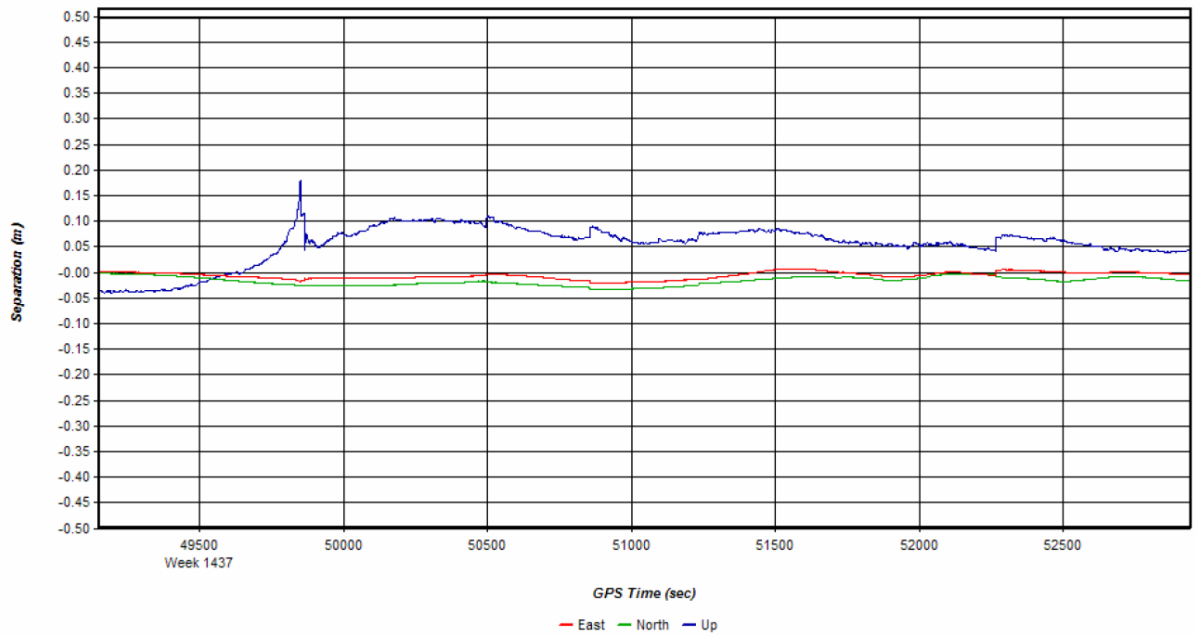
**L072107B**




N280MB_L072107B_SEP_APALPORT_PNCY_TIDAL-Cmb.doc

## Separation Plot

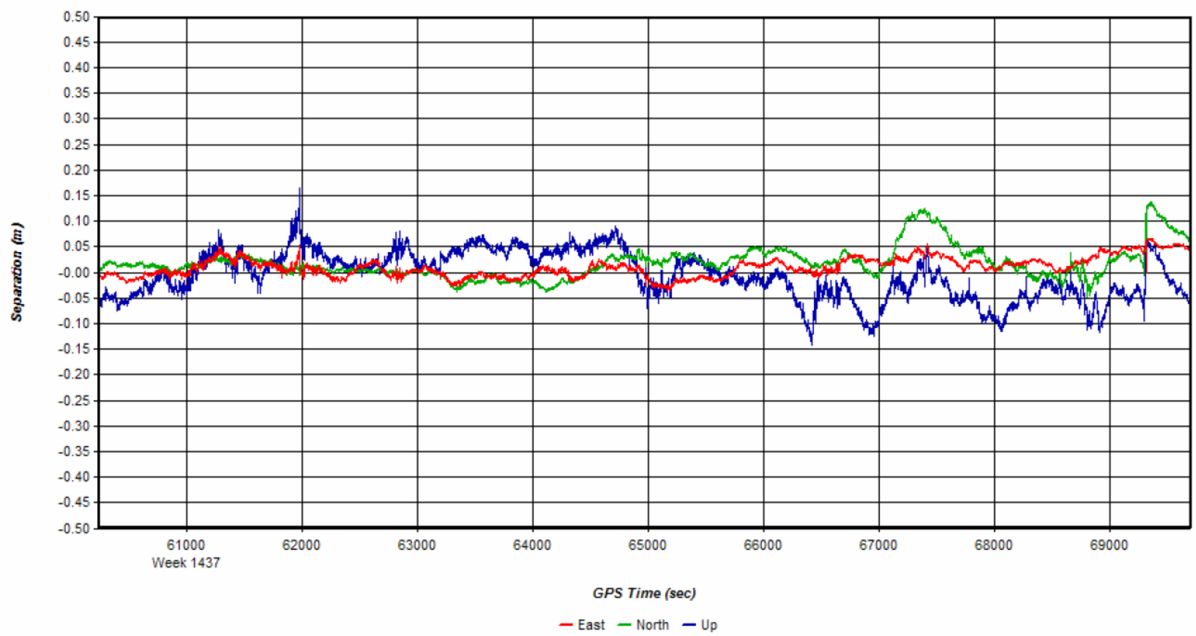
**L072207A**



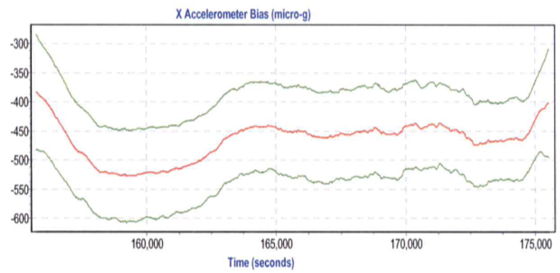

N280MB_L072207A_SEP_FB174P07_PNCY-Cmb.doc

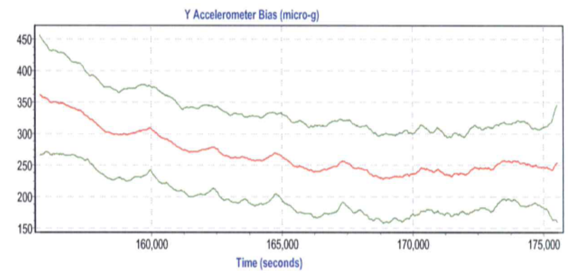
## Separation Plot

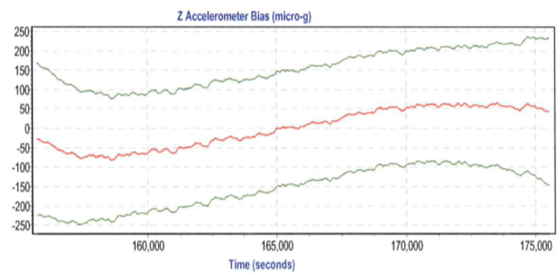
**L072207B**

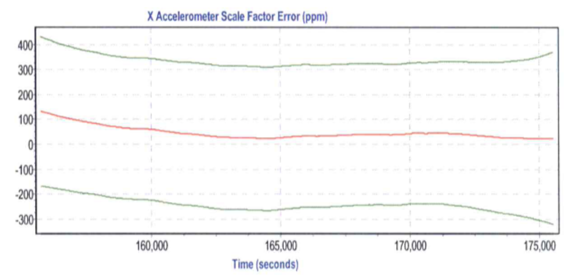


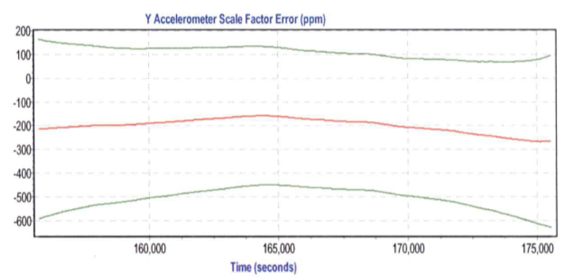

N280MB_L072207B_SEP_PNCY-Fwd_TIDAL-Rev.doc



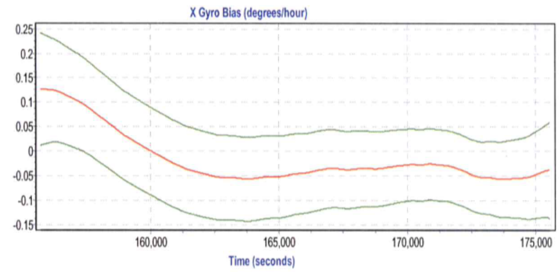



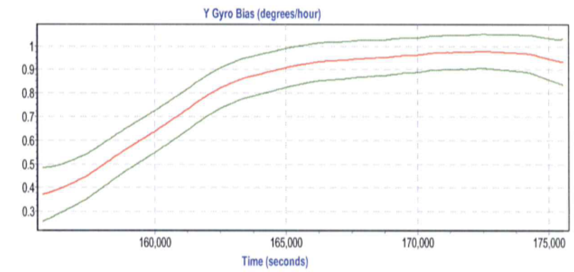



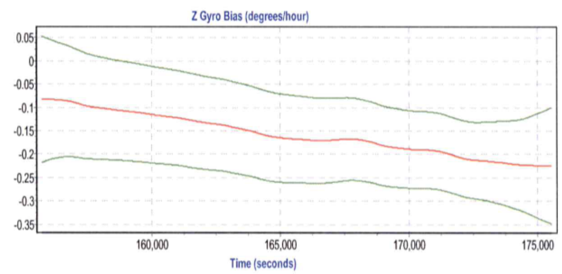



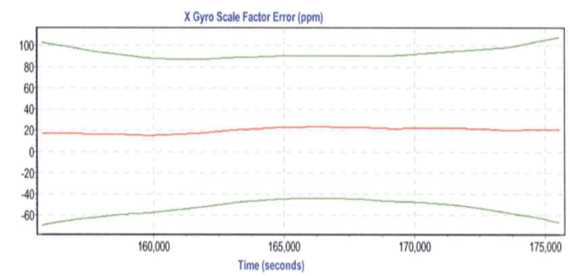


F:\1070414\REPORT\L0709071\GPS_IMU_Data\Proc\smers_01.out
F:\1070414\REPORT\L0709071\GPS_IMU_Data\Proc\smrms_01.out

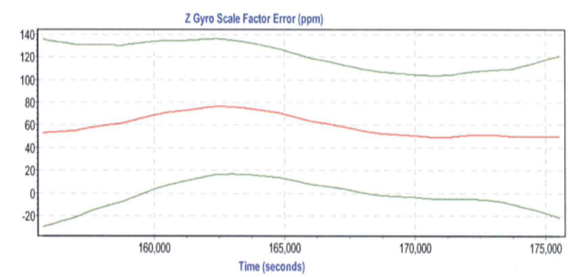






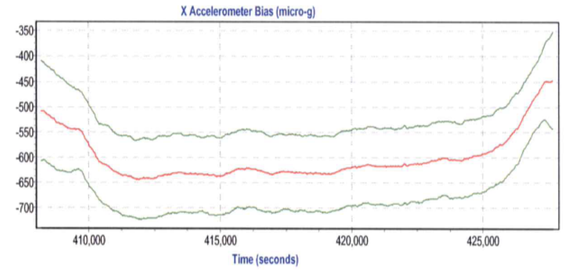

F:\1070414\REPORT\L0709071\GPS_IMU_Data\Proc\smers_01.out
F:\1070414\REPORT\L0709071\GPS_IMU_Data\Proc\smrms_01.out

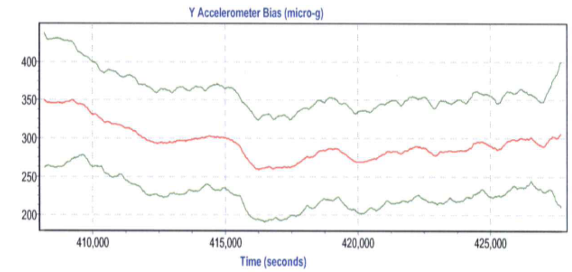
POSPac Version 4.3

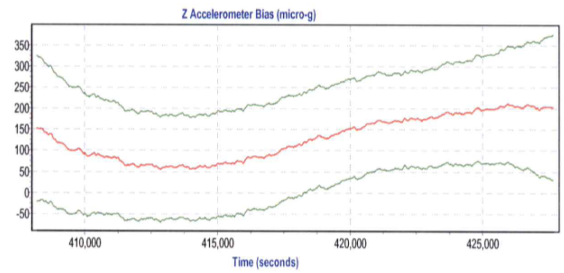
Sensor Errors

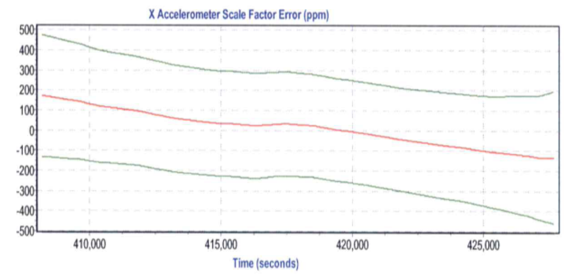
- 1 -

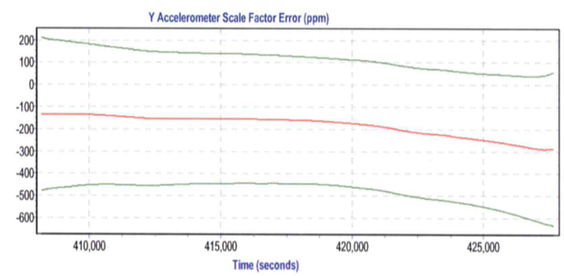
10/11/2007 - 11:35:59 PM

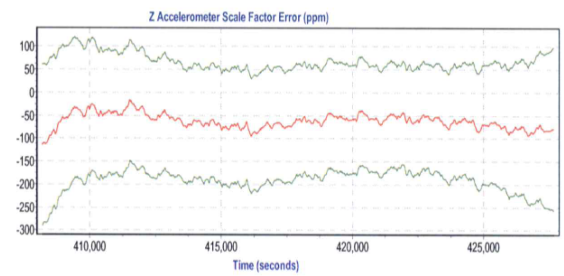


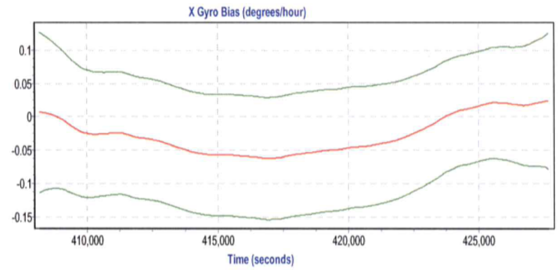



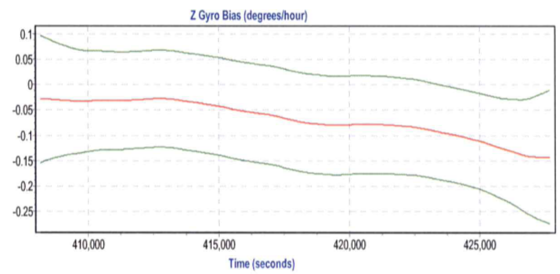



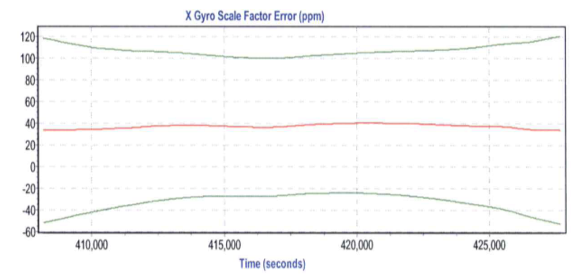



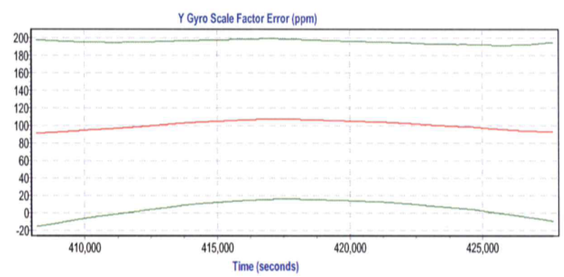

F:\1070414\REPORT\L0712071\GPS_IMU_Data\Proc\smers_02.out
F:\1070414\REPORT\L0712071\GPS_IMU_Data\Proc\smrms_02.out

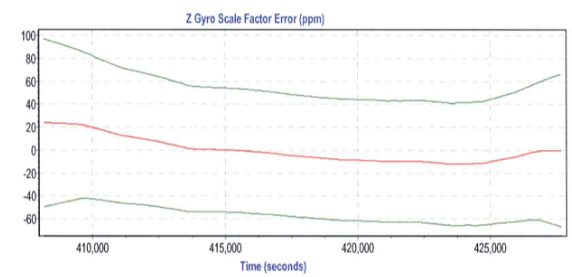






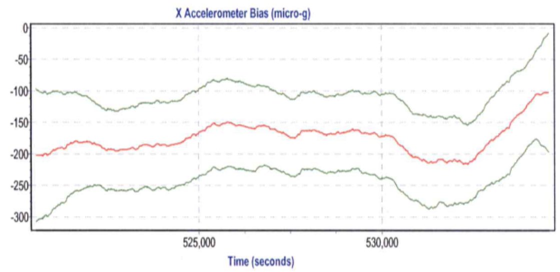



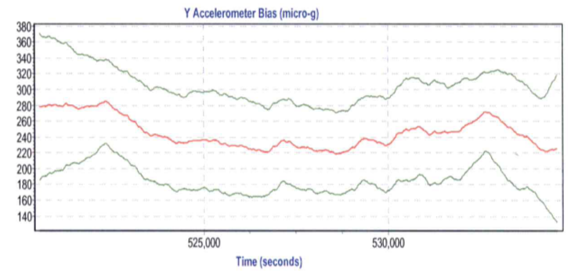



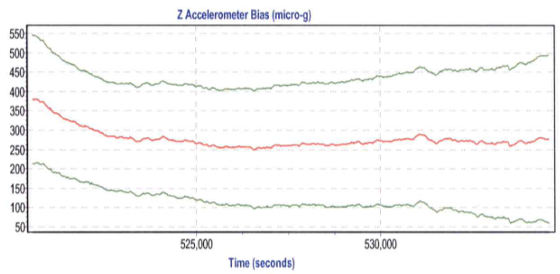



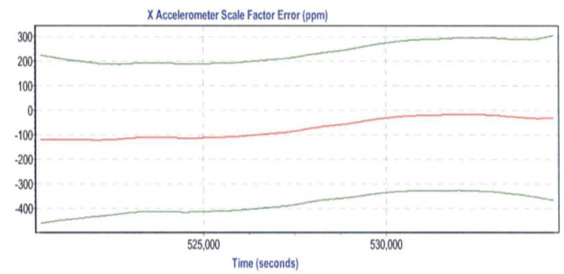

F:\1070414\REPORT\L0712071\GPS_IMU_Data\Proc\smers_02.out

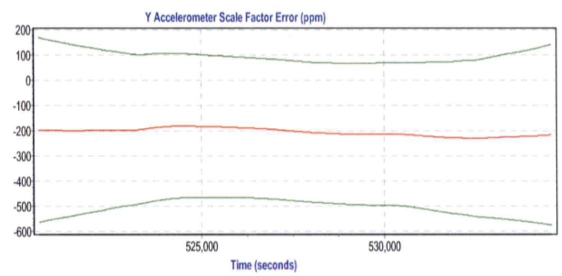
F:\1070414\REPORT\L0712071\GPS_IMU_Data\Proc\smrms_02.out

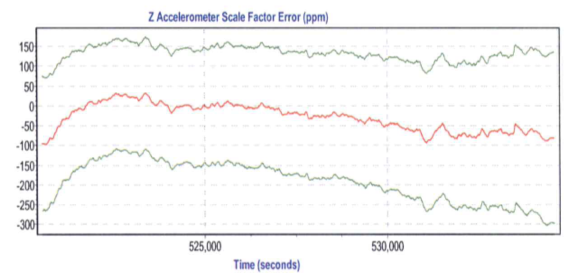


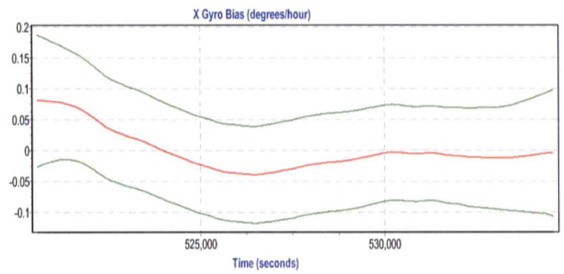



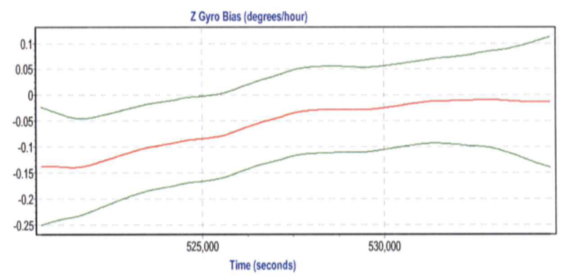



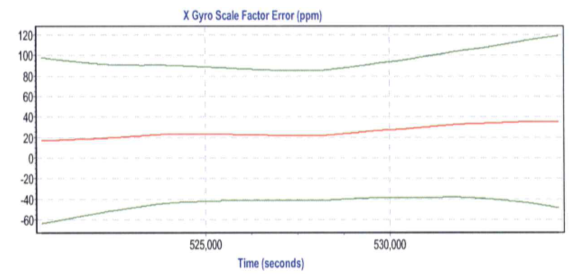



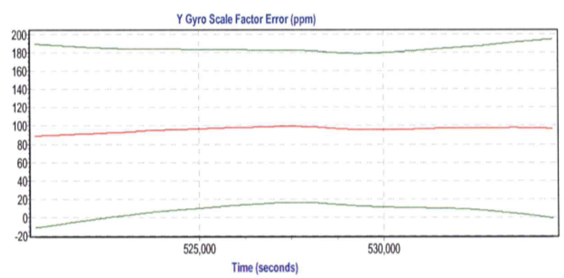

F:\1070414\REPORT\L0713071\GPS_IMU_Data\Proc\smers_02.out
F:\1070414\REPORT\L0713071\GPS_IMU_Data\Proc\smrms_02.out







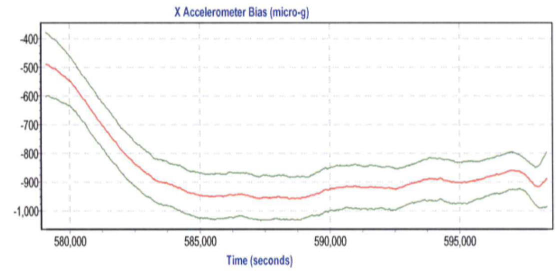



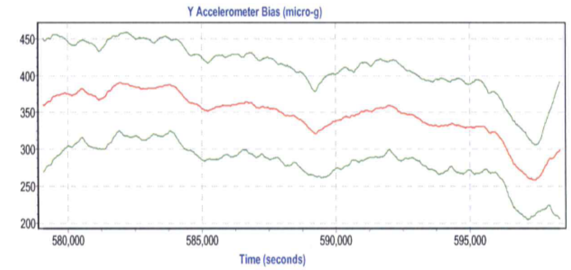


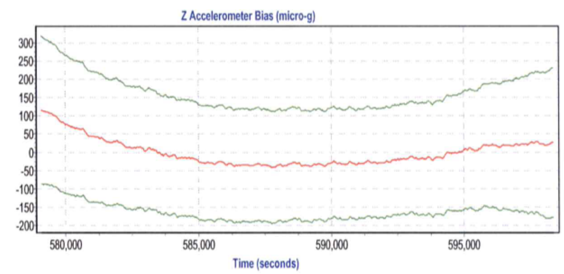
F:\1070414\REPORT\L0713071\GPS_IMU_Data\Proc\smers_02.out
F:\1070414\REPORT\L0713071\GPS_IMU_Data\Proc\smrms_02.out

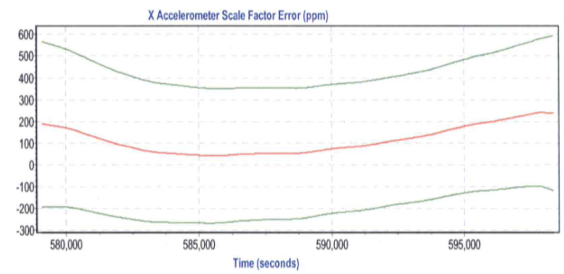
Sensor Errors

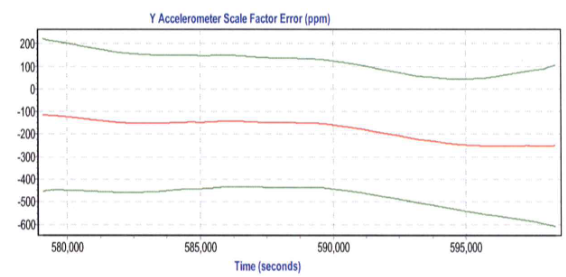
POSPac Version 4.3 - 1 - 10/12/2007 - 10:53:20 PM

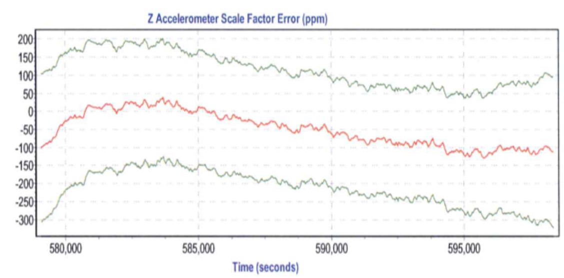


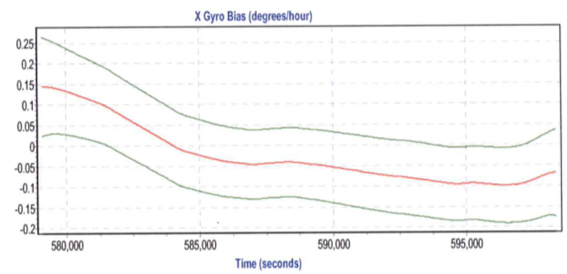



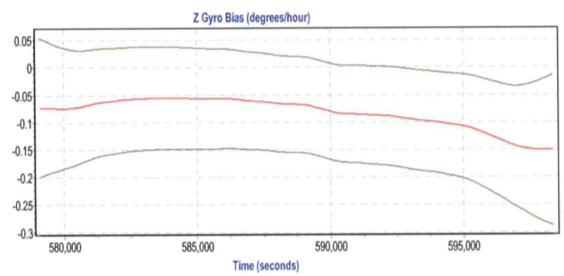



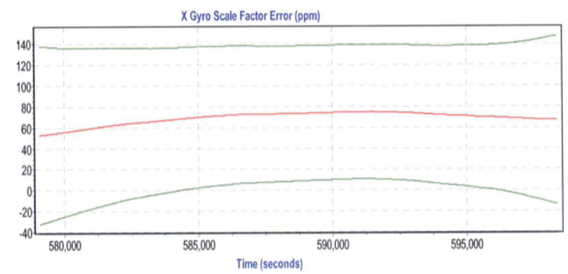




F:\1070414\REPORT\L071407A\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071407A\GPS_IMU_DATA\Proc\smrms_02.out



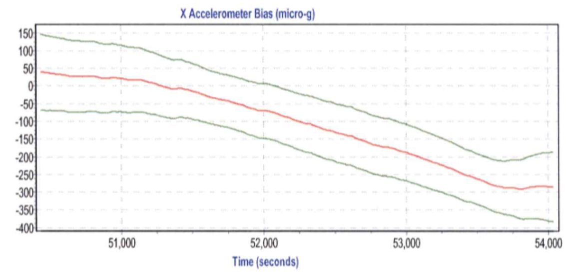


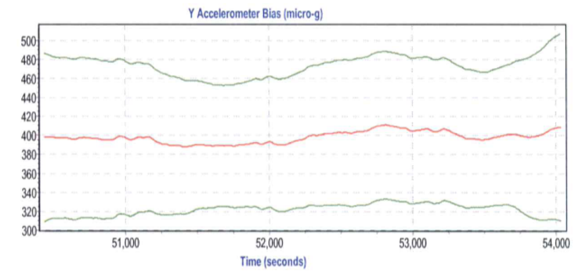


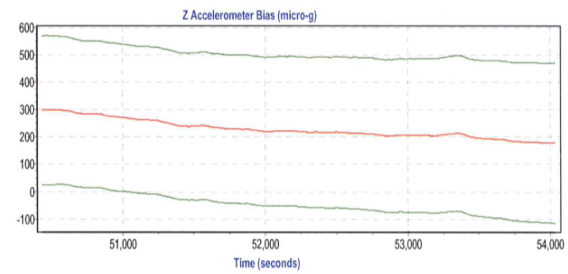



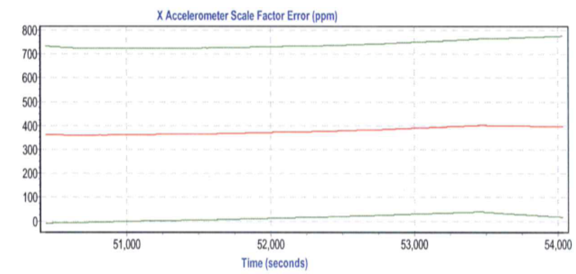


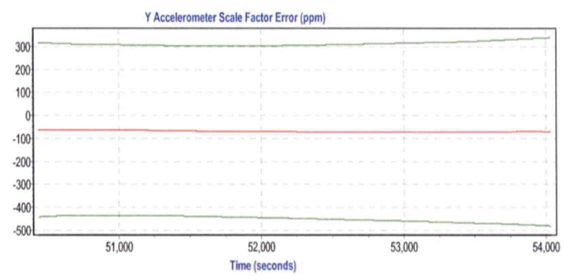

F:\1070414\REPORT\L071407A\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071407A\GPS_IMU_DATA\Proc\smrms_02.out

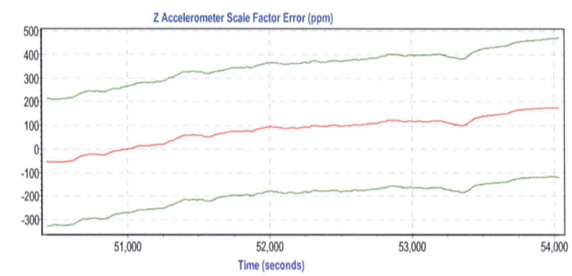


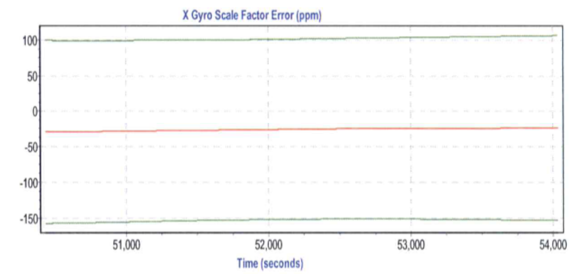




F:\1070414\REPORT\L071507A\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071507A\GPS_IMU_DATA\Proc\smrms_02.out





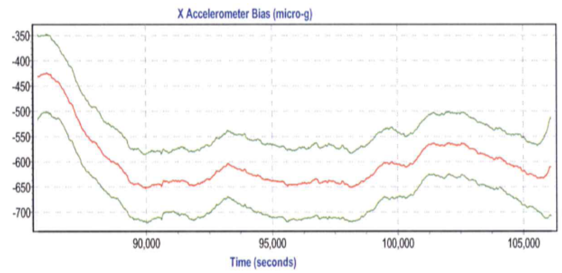

F:\1070414\REPORT\L071507A\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071507A\GPS_IMU_DATA\Proc\smrms_02.out

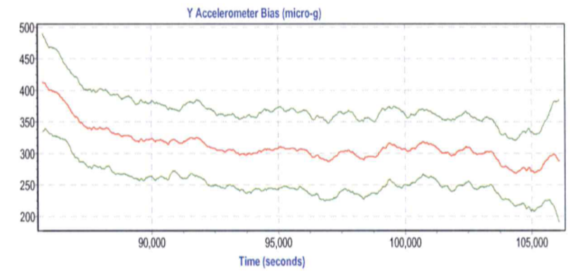
POSPac Version 4.3

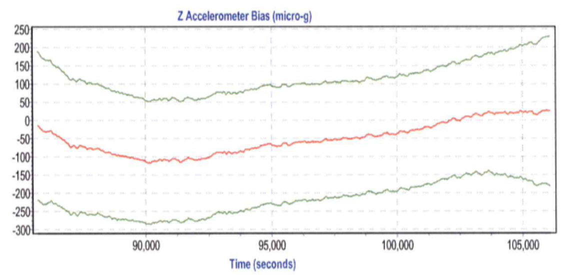
Sensor Errors

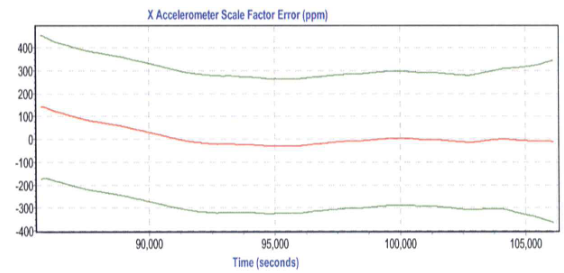
- 1 -

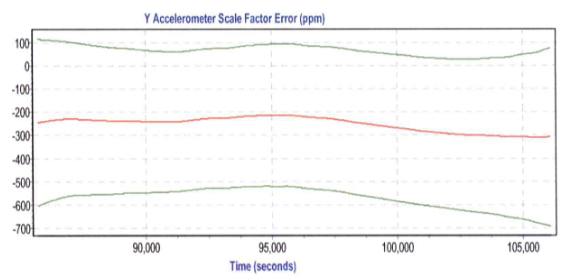
10/12/2007 - 11:40:06 PM

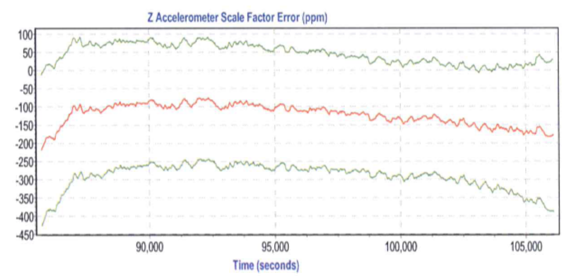


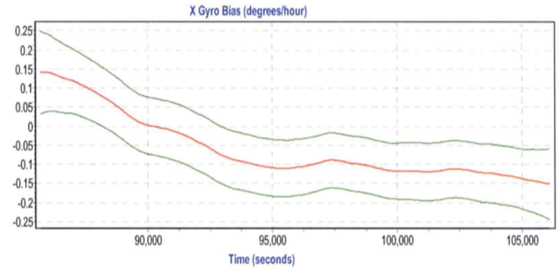

F:\1070414\REPORT\L071507B\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071507B\GPS_IMU_DATA\Proc\smrms_02.out

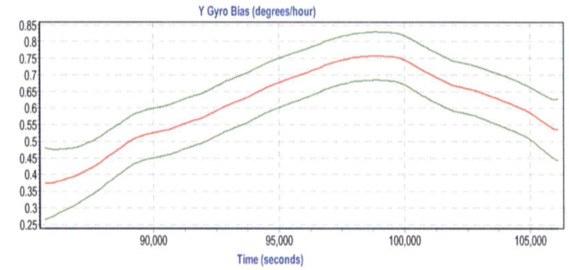
POSPac Version 4.3

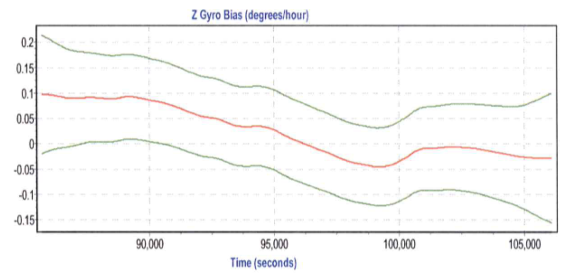
Sensor Errors

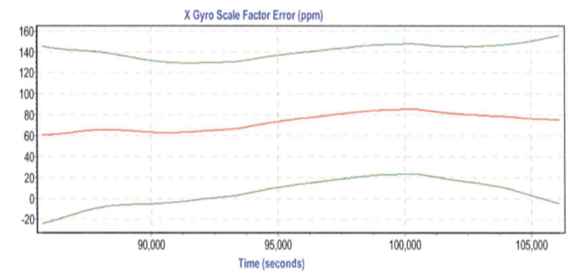
- 2 -

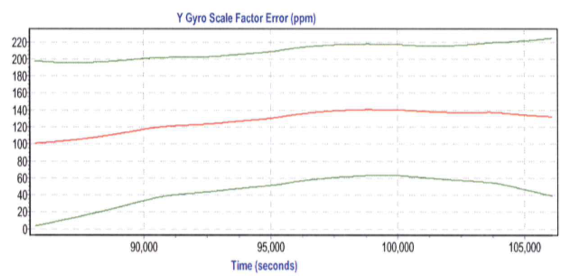
10/12/2007 - 11:40:07 PM

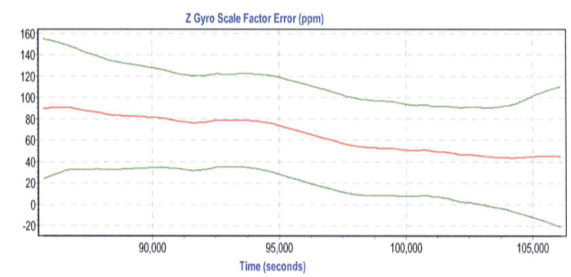


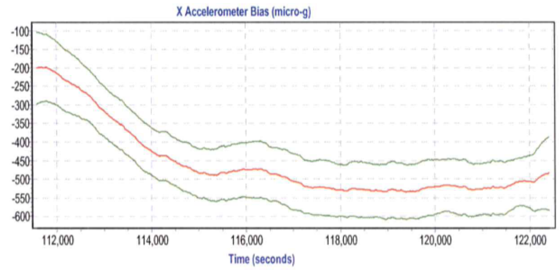



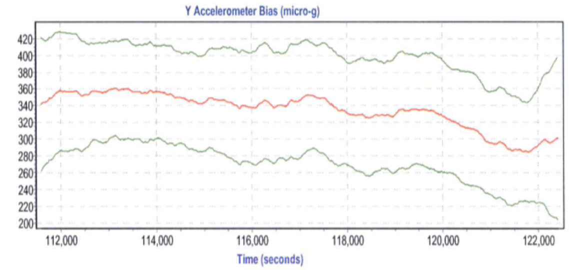



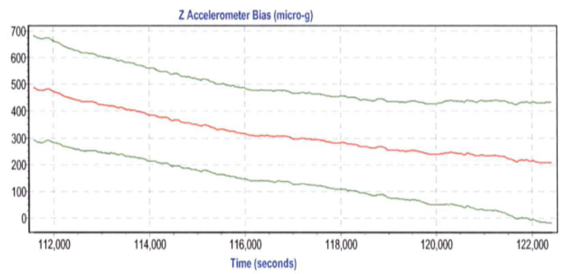



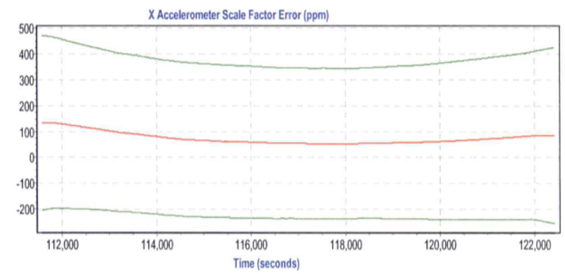



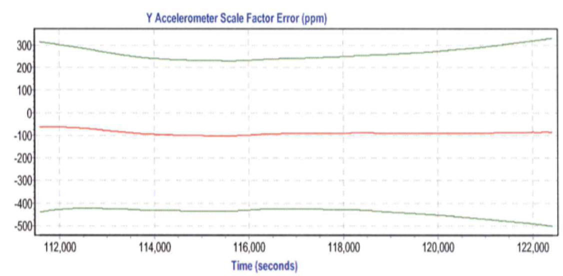

F:\1070414\REPORT\L071507B\GPS_IMU_DATA\Proc\smers_02.out
F:\1070414\REPORT\L071507B\GPS_IMU_DATA\Proc\smrms_02.out

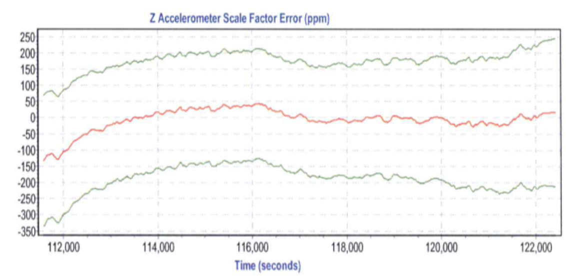


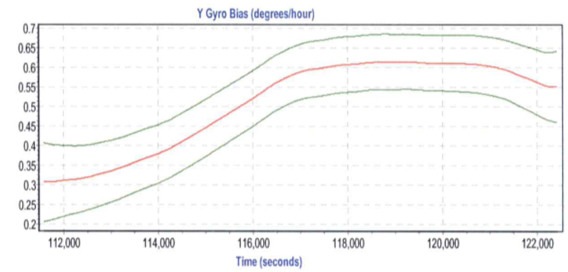



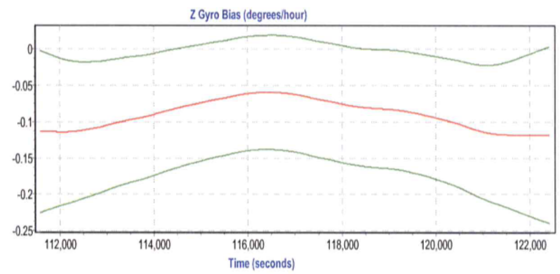



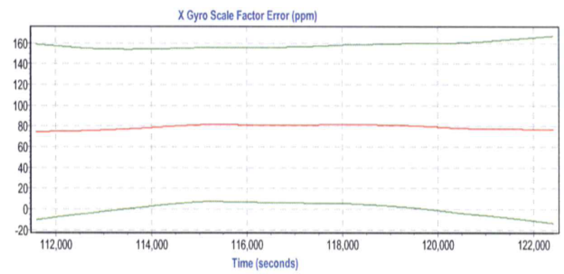



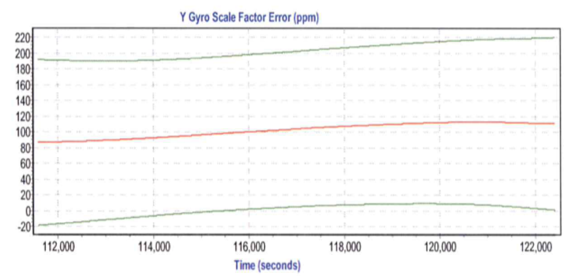



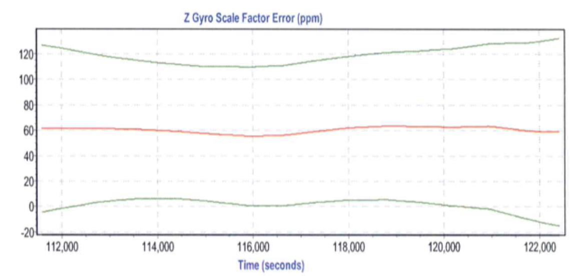

F:\1070414\REPORT\L071607A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607A\GPS_IMU_DATA\Proc\smrms_01.out

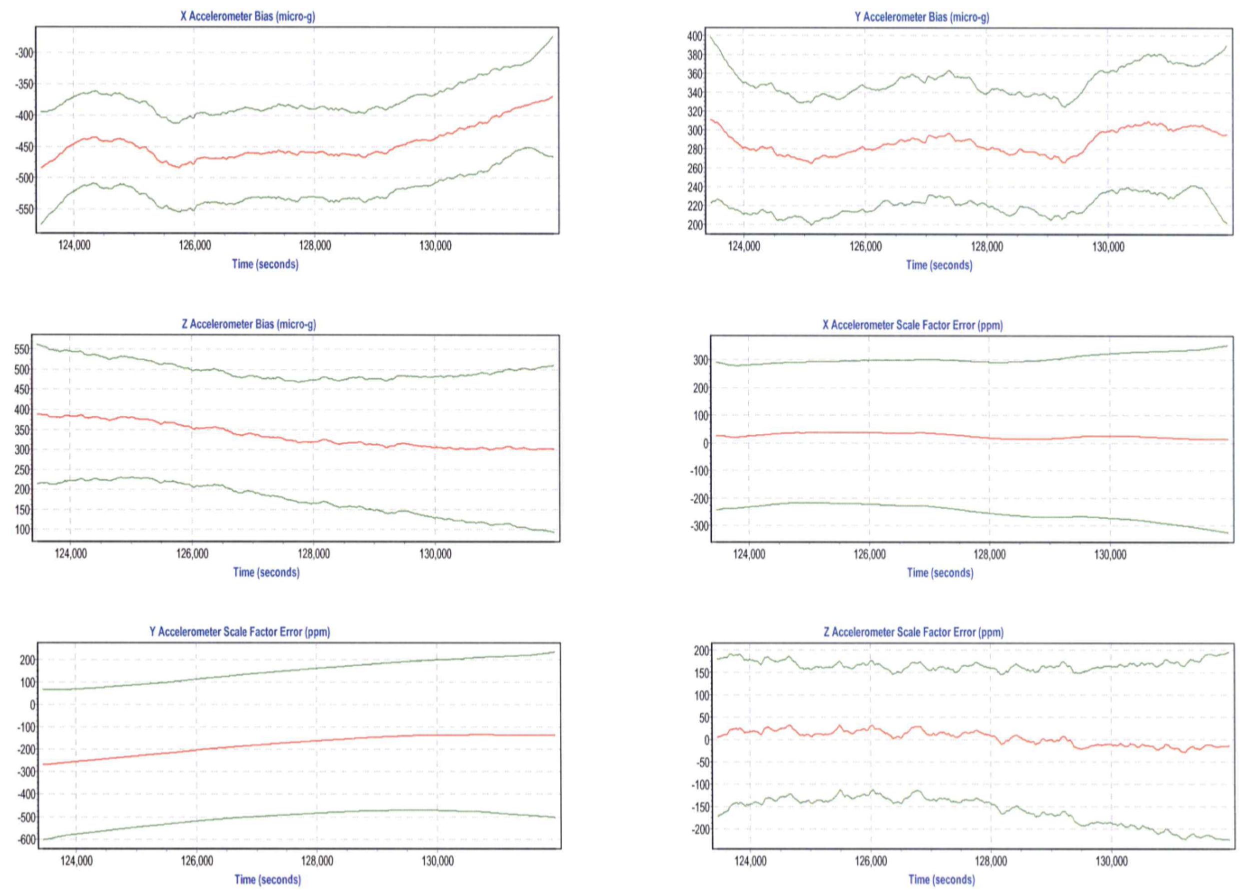



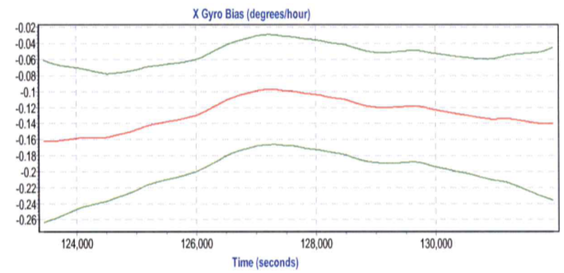



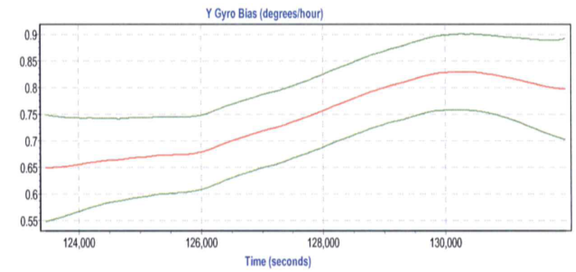



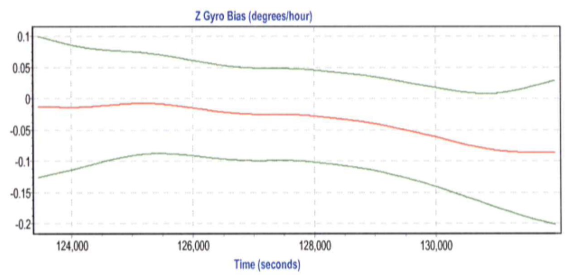

F:\1070414\REPORT\L071607A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607A\GPS_IMU_DATA\Proc\smrms_01.out

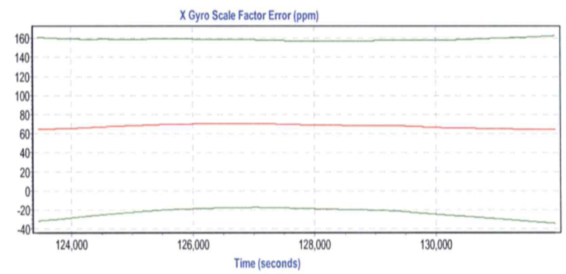


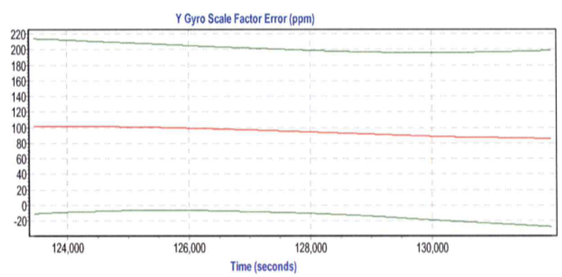

F:\1070414\REPORT\L071607B\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607B\GPS_IMU_DATA\Proc\smrms_01.out

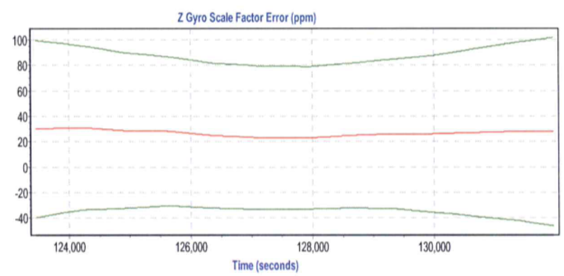


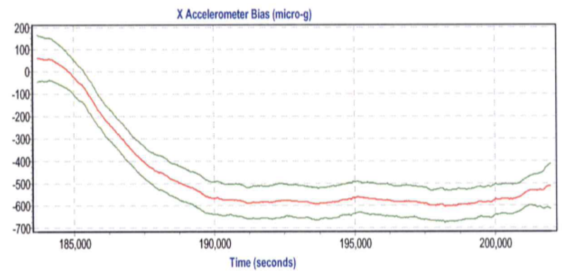



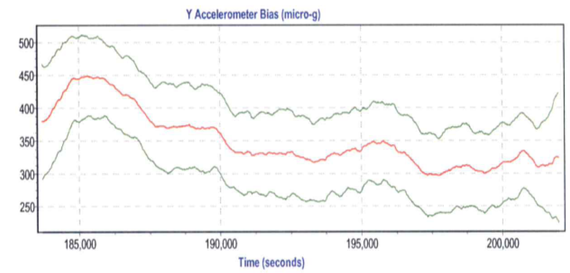



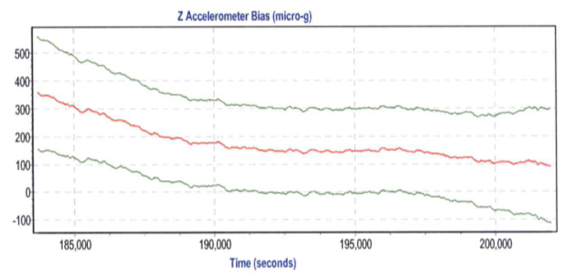



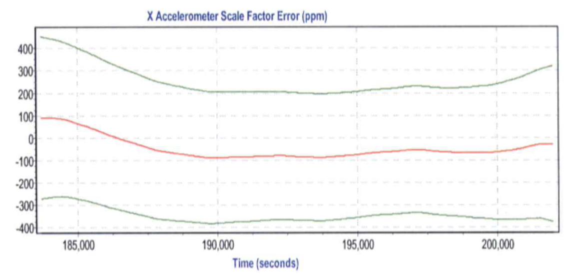



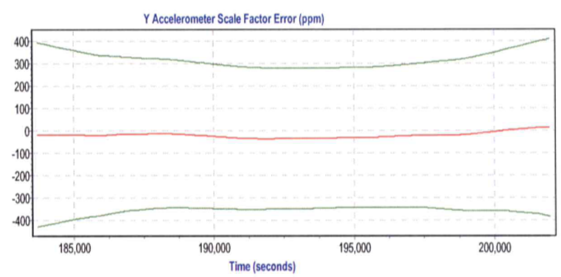

F:\1070414\REPORT\L071607B\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607B\GPS_IMU_DATA\Proc\smrms_01.out

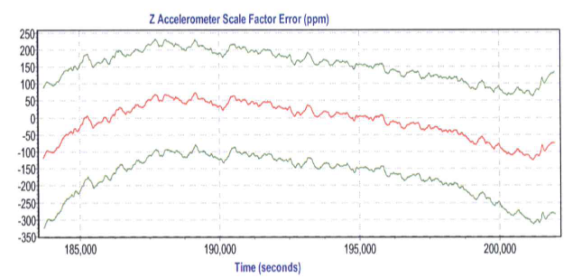


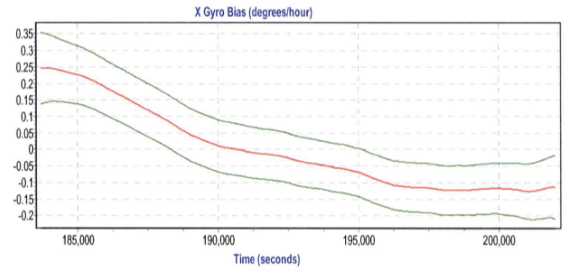



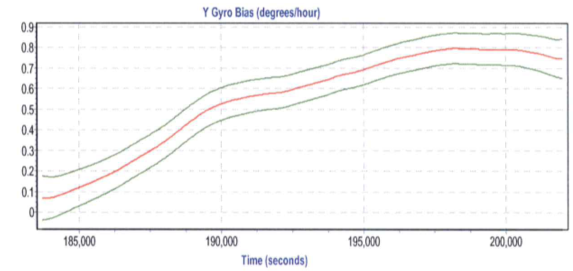



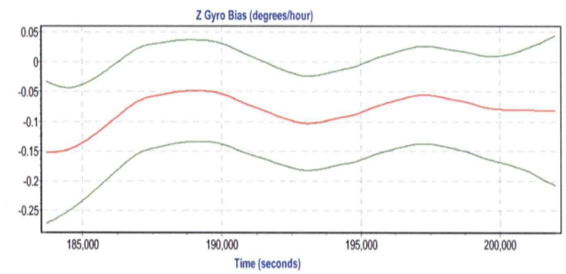



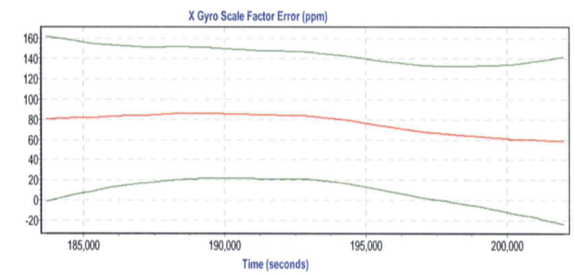




F:\1070414\REPORT\L071607C\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607C\GPS_IMU_DATA\Proc\smrms_01.out

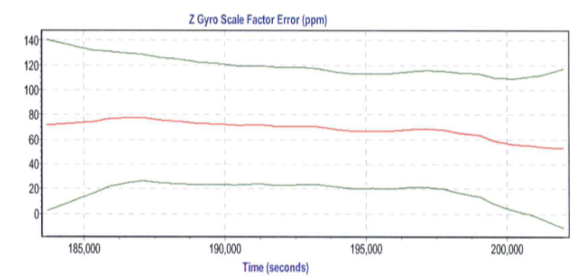


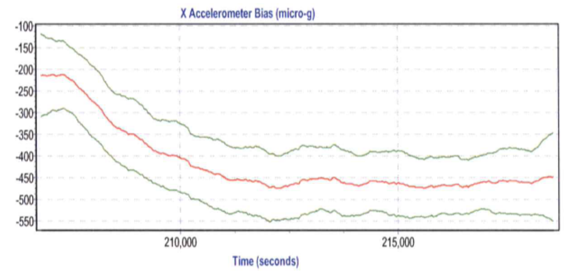



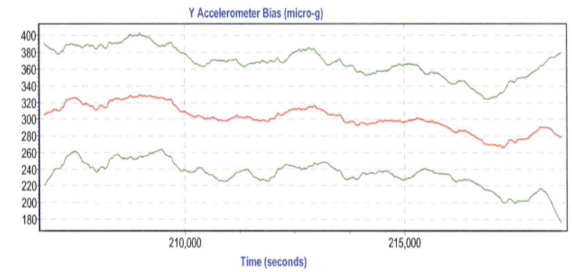



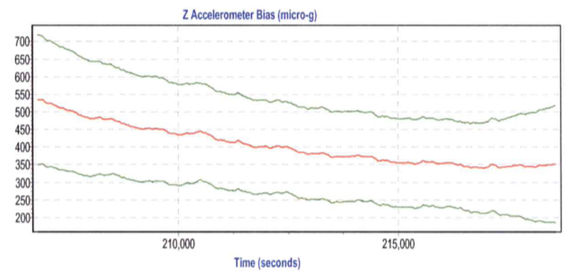


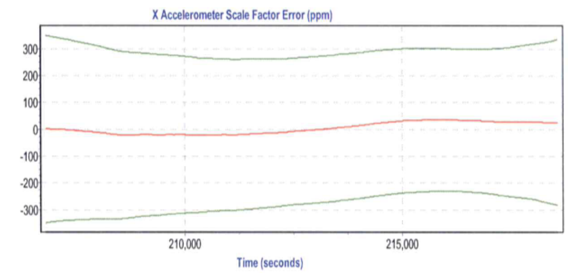


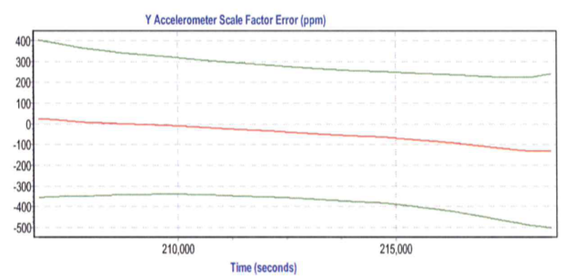

F:\1070414\REPORT\L071607C\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071607C\GPS_IMU_DATA\Proc\smrms_01.out

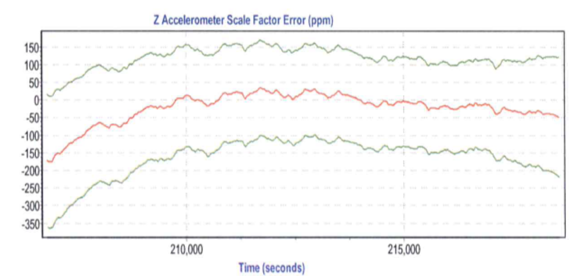


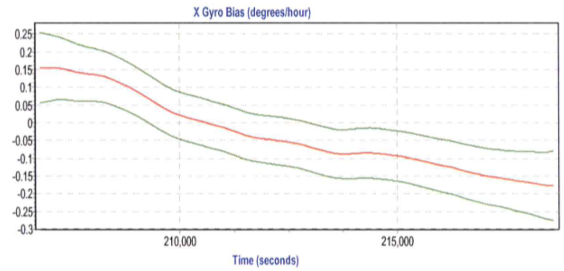



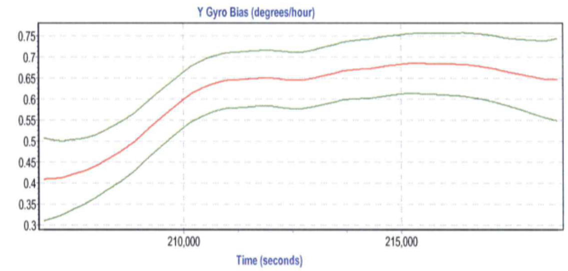



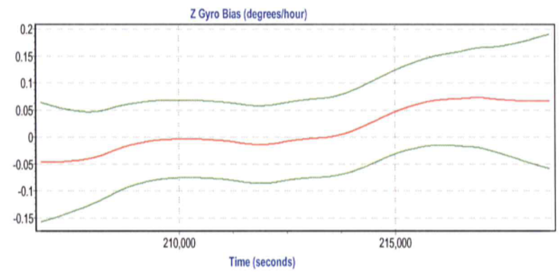



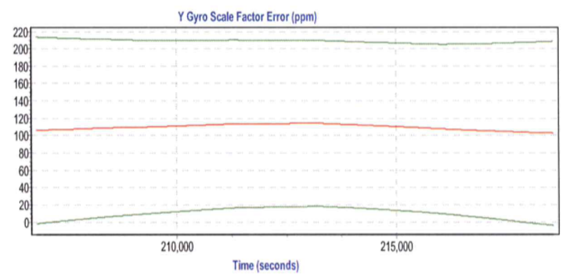

F:\1070414\REPORT\L071707A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071707A\GPS_IMU_DATA\Proc\smrms_01.out

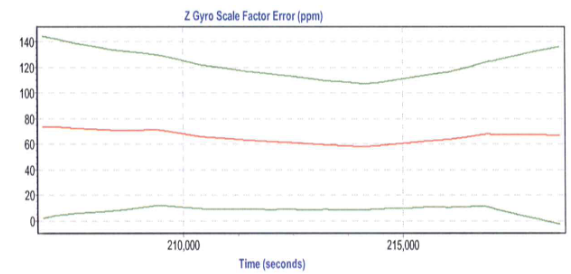




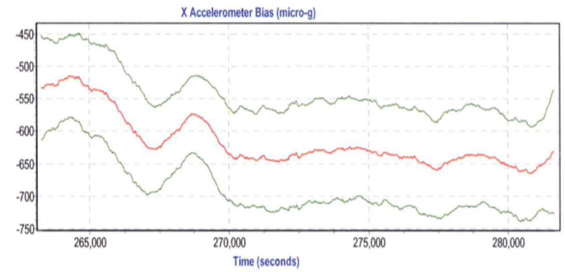


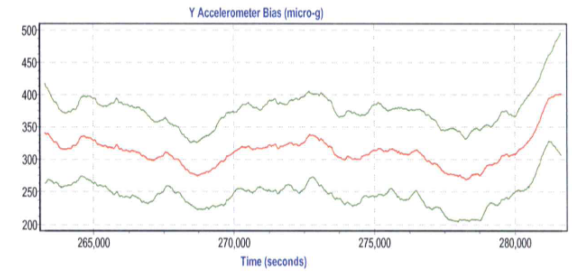



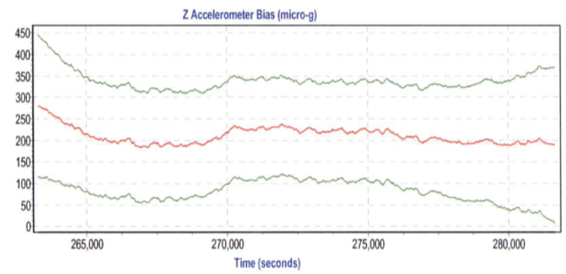

F:\1070414\REPORT\L071707A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071707A\GPS_IMU_DATA\Proc\smrms_01.out

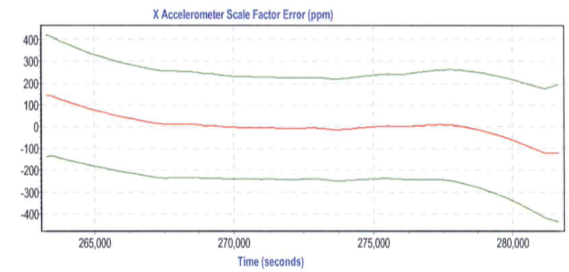
Sensor Errors

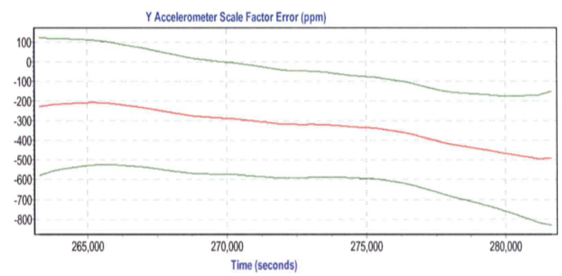
POSPac Version 4.3 - 1 - 10/15/2007 - 6:15:49 PM

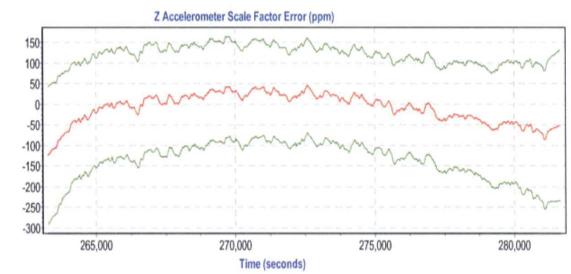


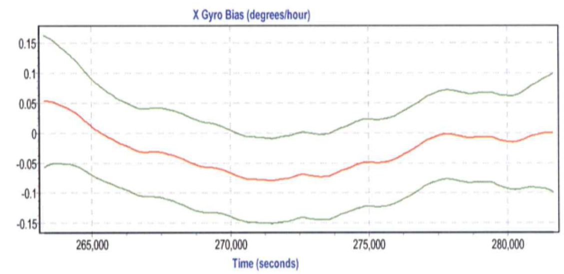



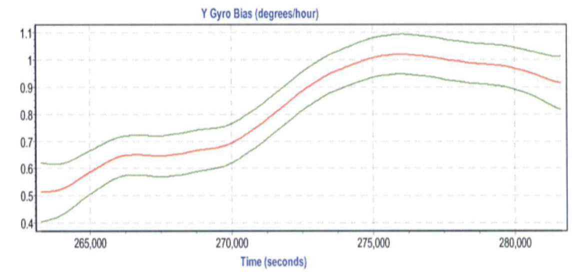



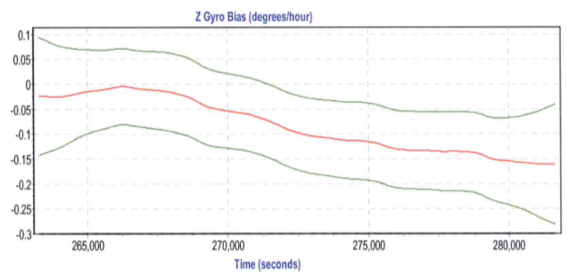



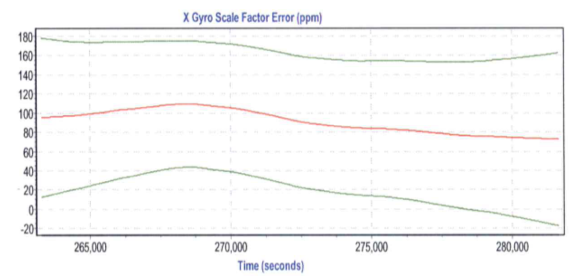




F:\1070414\REPORT\L071707B\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071707B\GPS_IMU_DATA\Proc\smrms_01.out





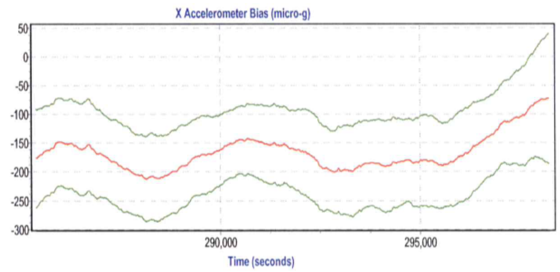

F:\1070414\REPORT\L071707B\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071707B\GPS_IMU_DATA\Proc\smrms_01.out

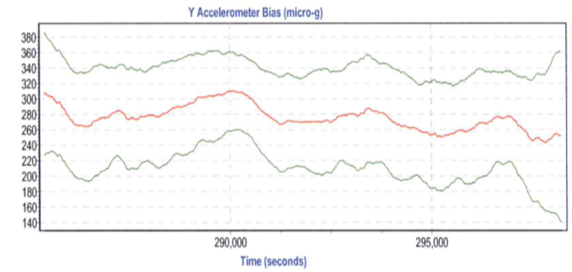
POSPac Version 4.3

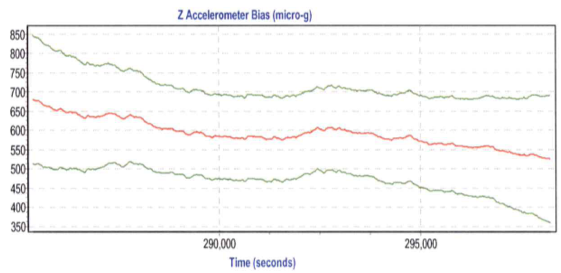
Sensor Errors

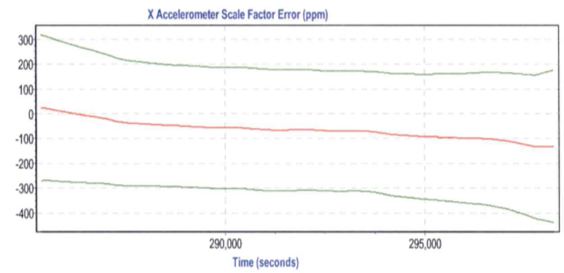
- 1 -

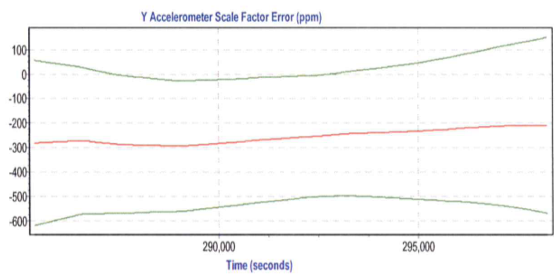
10/15/2007 - 6:29:18 PM

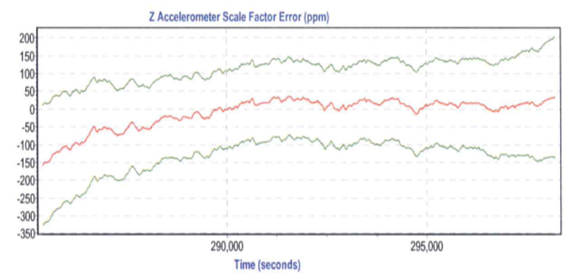



F:\1070414\REPORT\L071807A\GPS_IMU_RAW\Proc\smers_01.out
F:\1070414\REPORT\L071807A\GPS_IMU_RAW\Proc\smrms_01.out

POSPac Version 4.3

Sensor Errors

- 2 -

10/15/2007 - 6:29:18 PM







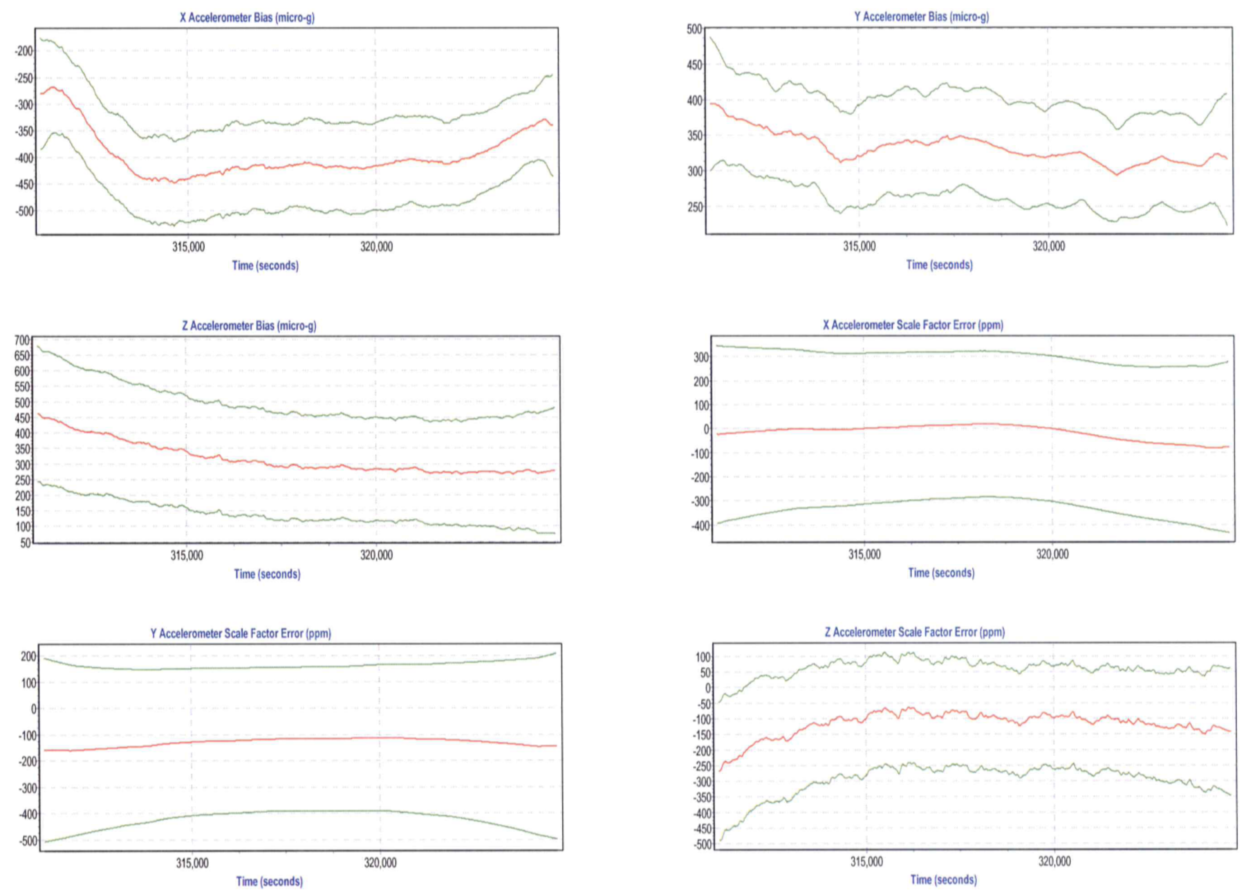
F:\1070414\REPORT\L071807A\GPS_IMU_RAW\Proc\smers_01.out
F:\1070414\REPORT\L071807A\GPS_IMU_RAW\Proc\smrms_01.out

POSPac Version 4.3

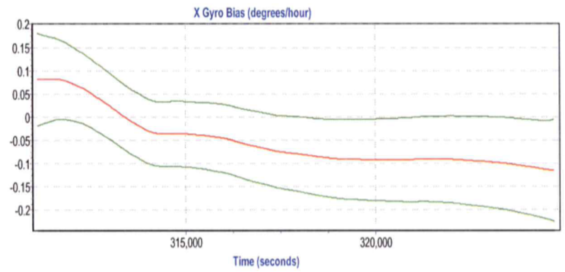
Sensor Errors

- 1 -

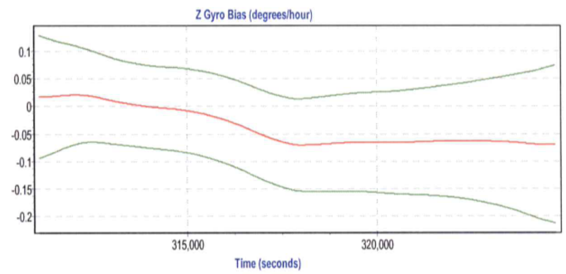
10/15/2007 - 6:39:00 PM



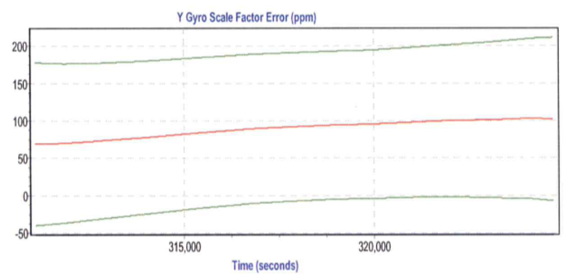

F:\1070414\REPORT\L071807B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071807B\ABGPS_IMU_DATA\Proc\smrms_01.out

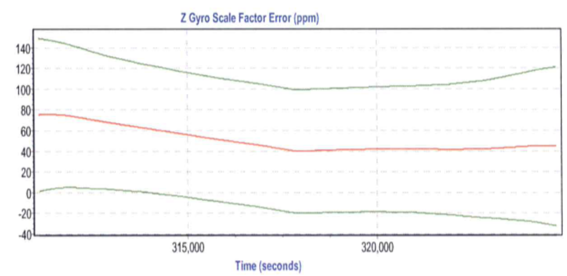










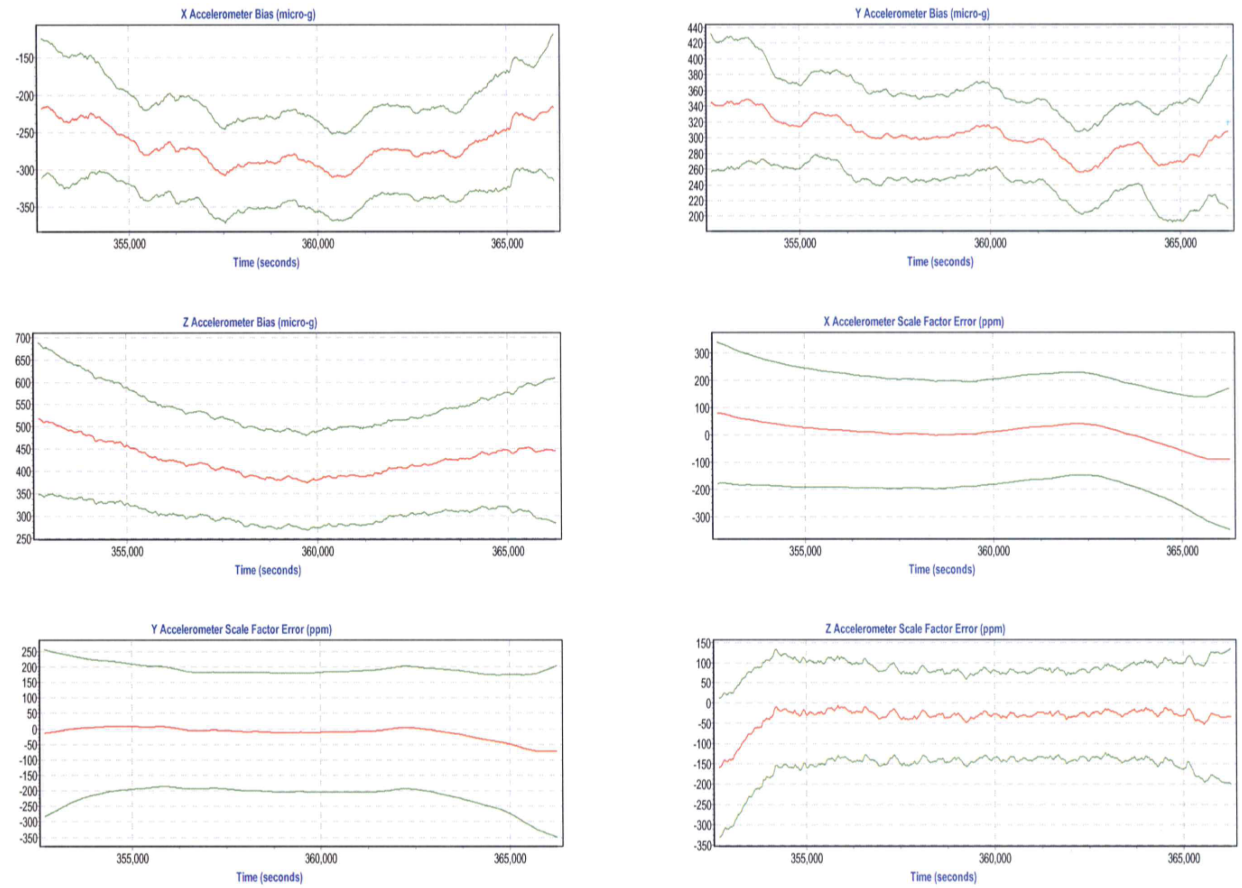

F:\1070414\REPORT\L071807B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071807B\ABGPS_IMU_DATA\Proc\smrms_01.out

POSPac Version 4.3

Sensor Errors

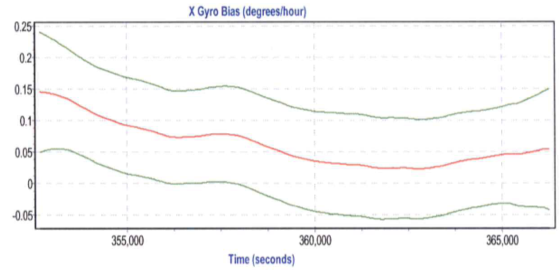
- 1 -

10/15/2007 - 6:45:30 PM

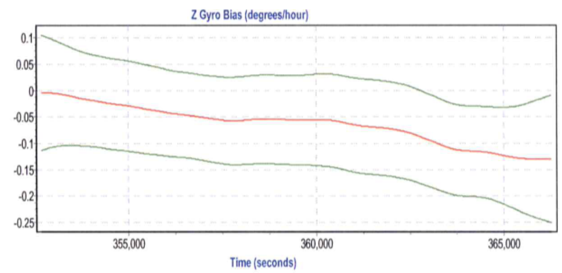


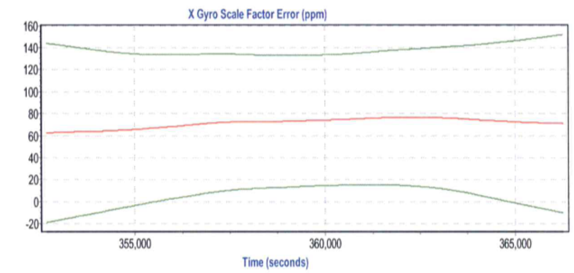

F:\1070414\REPORT\L071807C\ABGPS_IMU_DATA\Proc\smers_01.out

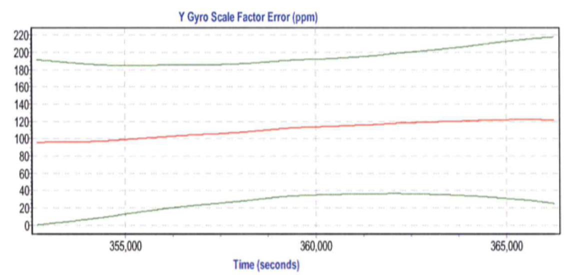
F:\1070414\REPORT\L071807C\ABGPS_IMU_DATA\Proc\smrms_01.out

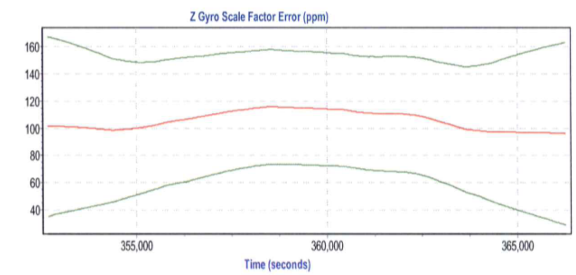






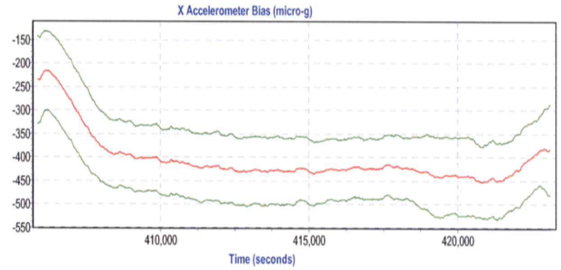

F:\1070414\REPORT\L071807C\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071807C\ABGPS_IMU_DATA\Proc\smrms_01.out

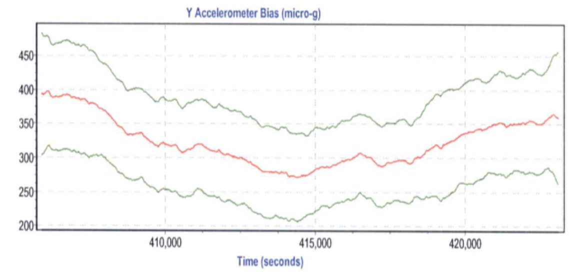
POSPac Version 4.3

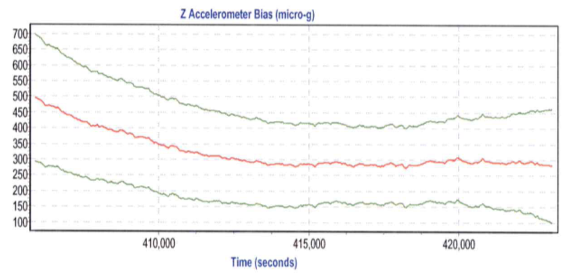
Sensor Errors

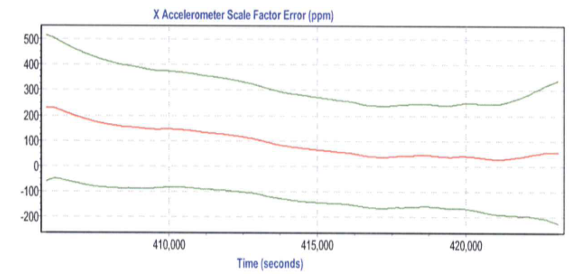
- 1 -

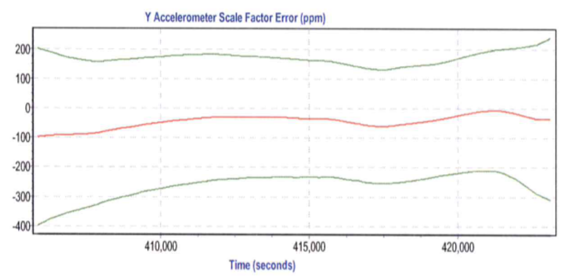
10/15/2007 - 7:35:56 PM

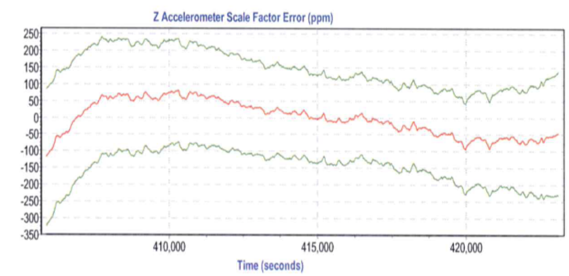


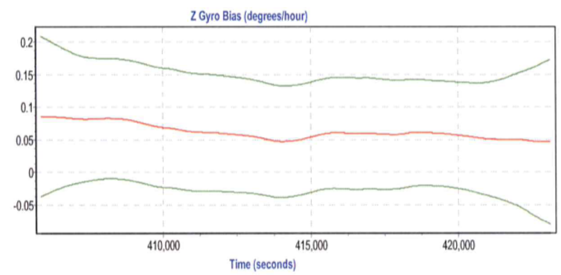



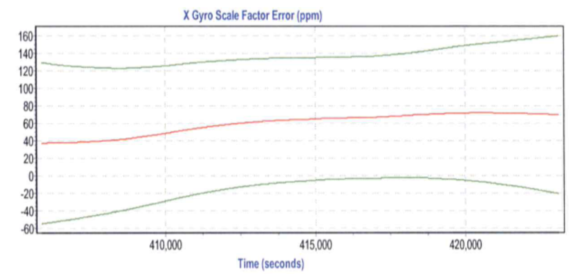



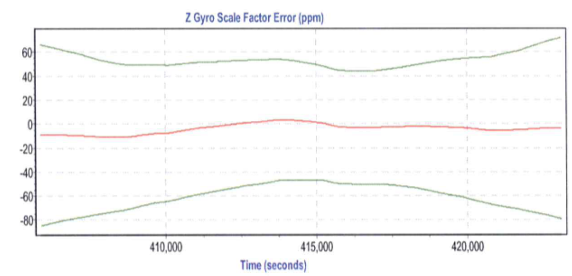

F:\1070414\REPORT\L071907A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071907A\ABGPS_IMU_DATA\Proc\smrms_01.out



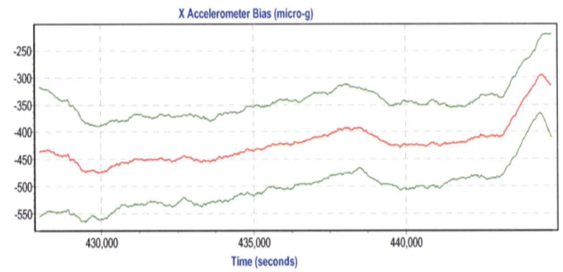


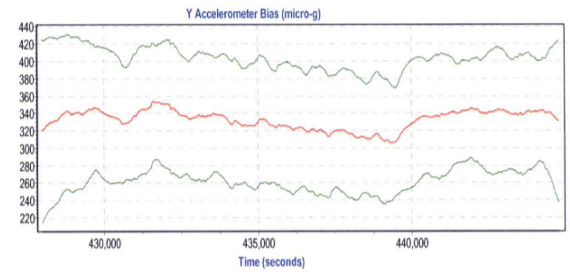



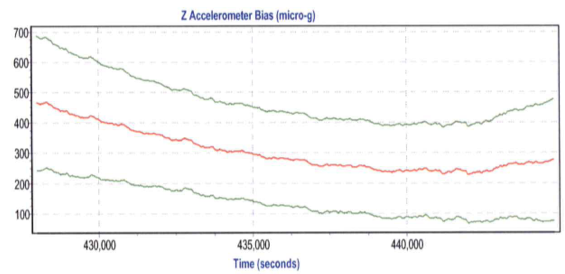


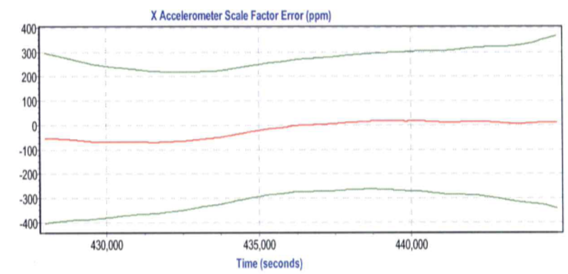


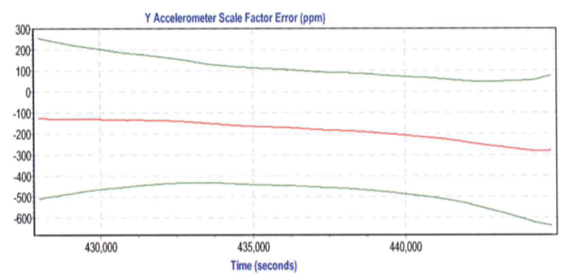

F:\1070414\REPORT\L071907A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071907A\ABGPS_IMU_DATA\Proc\smrms_01.out

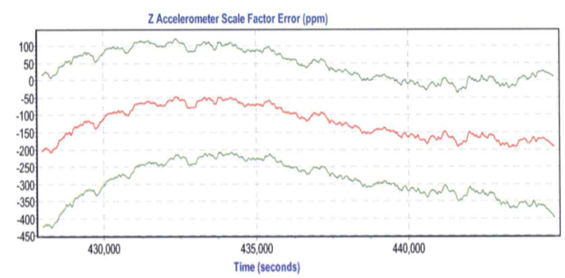


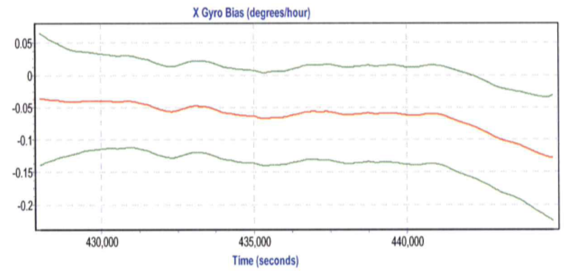



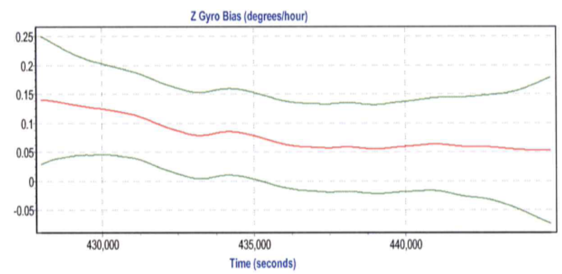



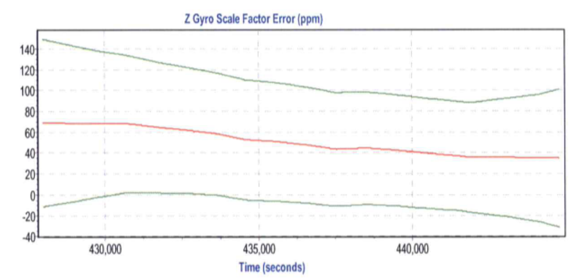

F:\1070414\REPORT\L071907B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071907B\ABGPS_IMU_DATA\Proc\smrms_01.out



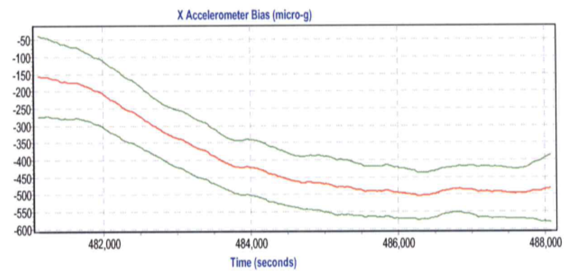


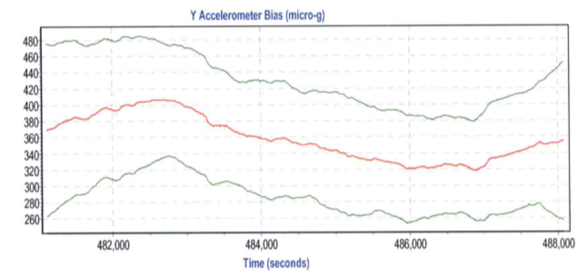


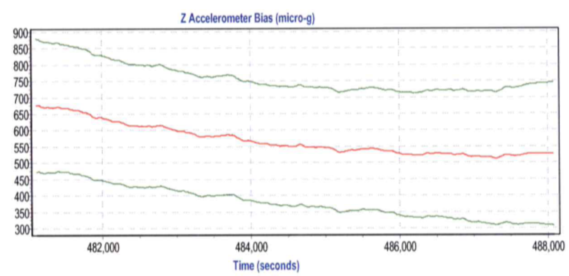


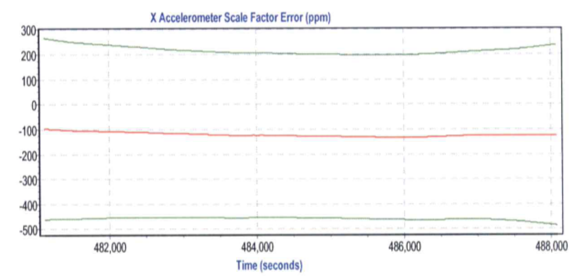



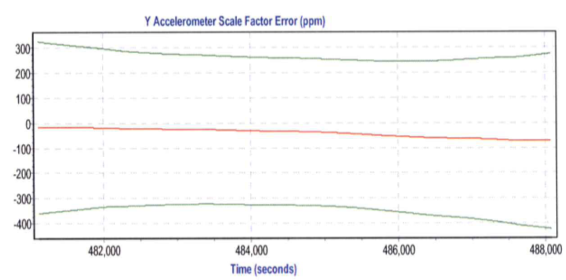

F:\1070414\REPORT\L071907B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L071907B\ABGPS_IMU_DATA\Proc\smrms_01.out

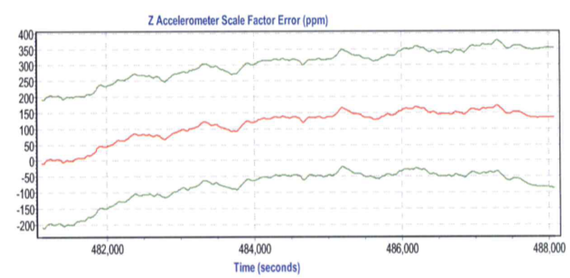


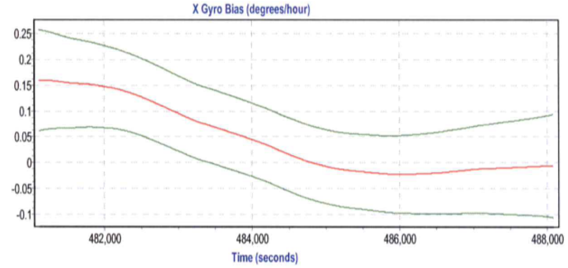



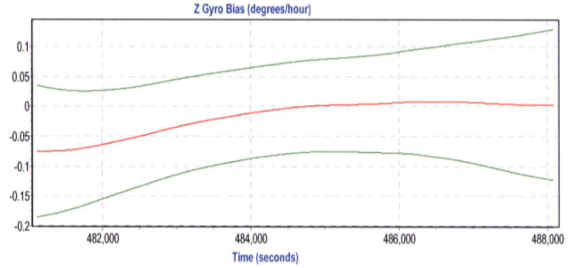

F:\1070414\REPORT\L072007A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072007A\ABGPS_IMU_DATA\Proc\smrms_01.out

X Gyro Bias (degrees/hour)

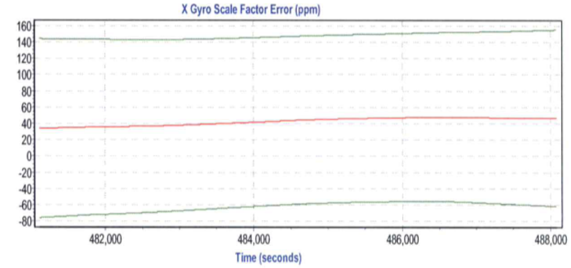



Y Gyro Bias (degrees/hour)


Z Gyro Bias (degrees/hour)

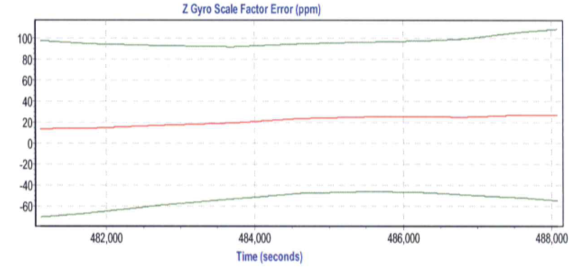



X Gyro Scale Factor Error (ppm)




Y Gyro Scale Factor Error (ppm)


Z Gyro Scale Factor Error (ppm)



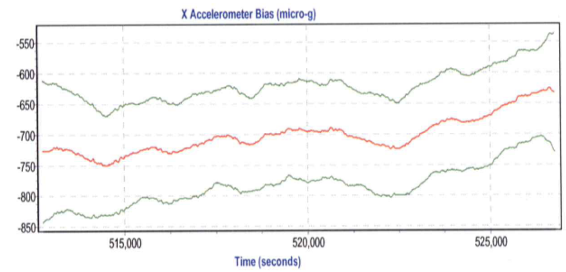

F:\1070414\REPORT\L072007A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072007A\ABGPS_IMU_DATA\Proc\smrms_01.out

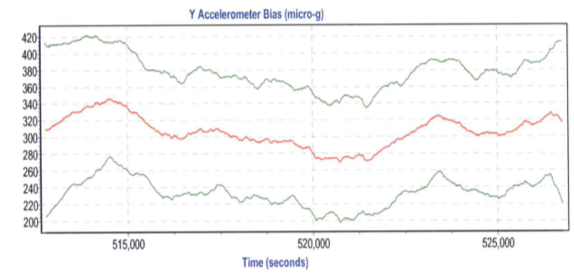
POSPac Version 4.3

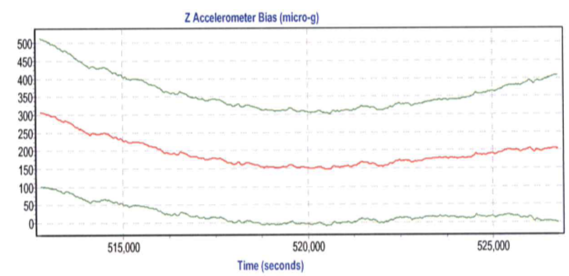
Sensor Errors

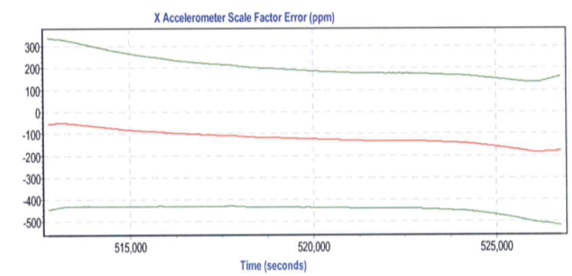
- 1 -

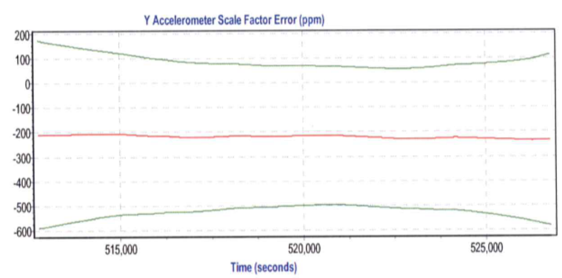
10/15/2007 - 8:03:09 PM

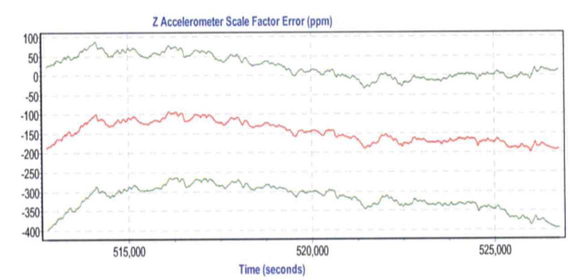


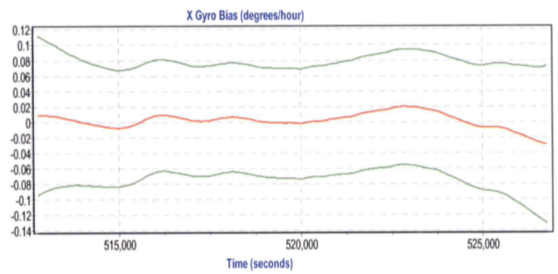



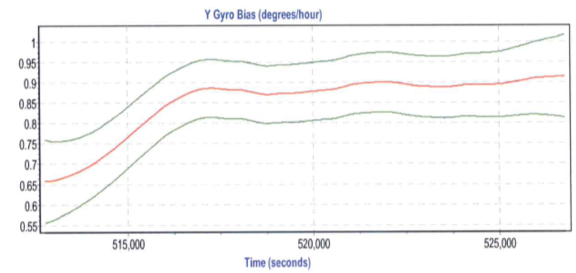



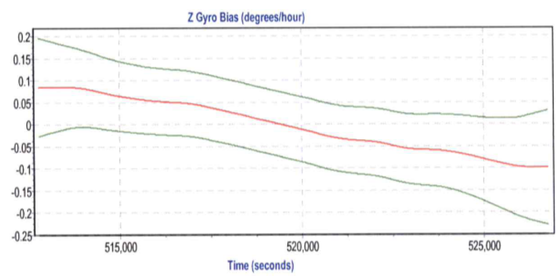



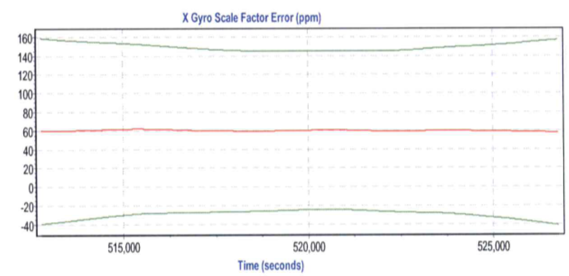

F:\1070414\REPORT\L072007B\ABGPS_IMU_DATA\Proc\smers_01.out

F:\1070414\REPORT\L072007B\ABGPS_IMU_DATA\Proc\smrms_01.out

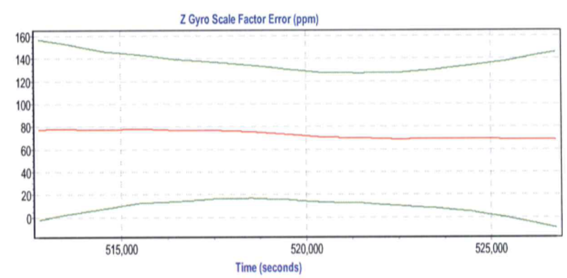


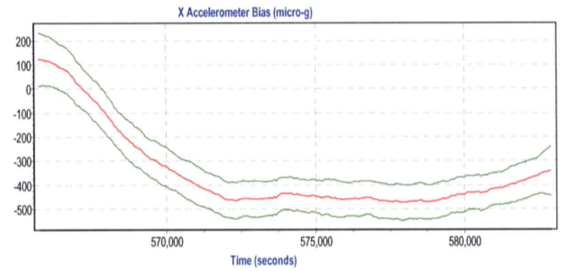



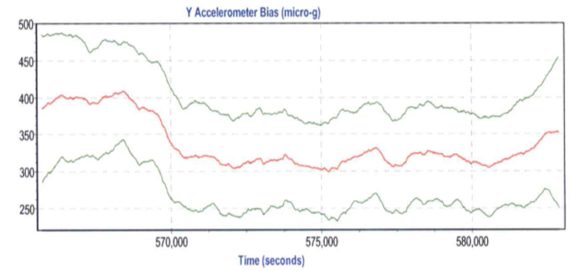



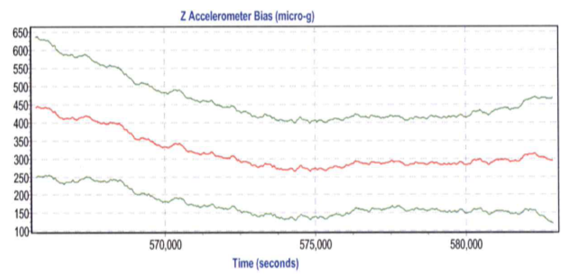


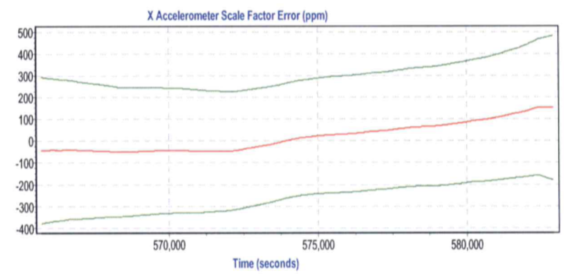


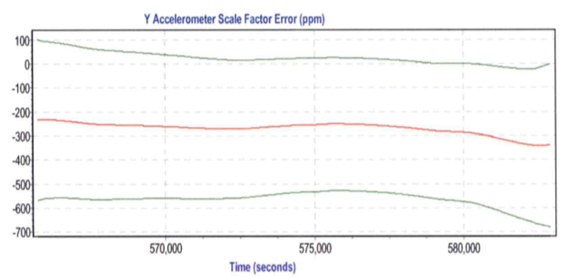

F:\1070414\REPORT\L072007B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072007B\ABGPS_IMU_DATA\Proc\smrms_01.out



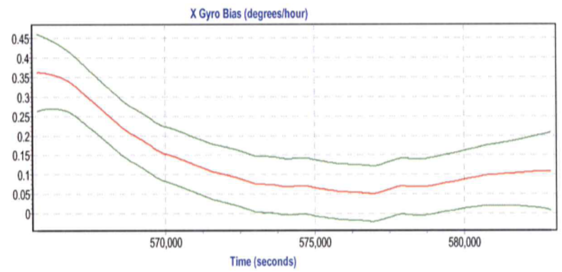



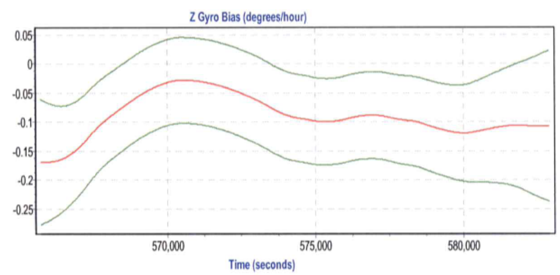





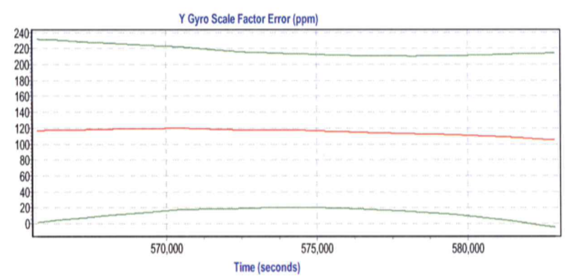
F:\1070414\REPORT\L072107A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072107A\ABGPS_IMU_DATA\Proc\smrms_01.out

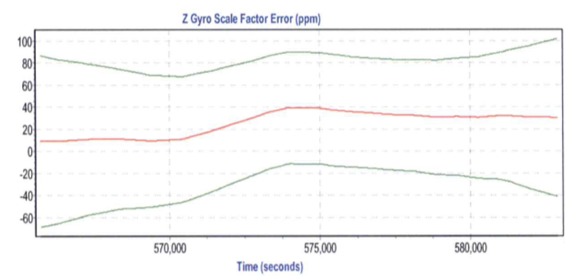




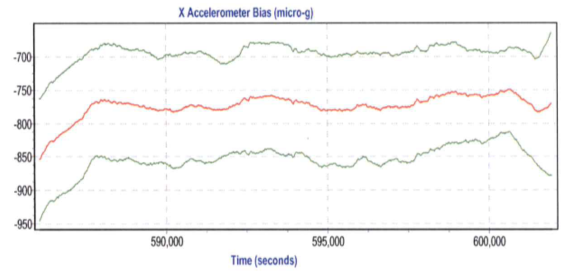


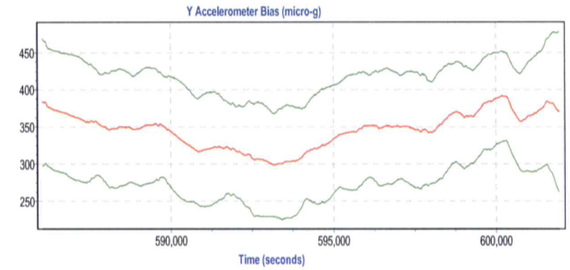


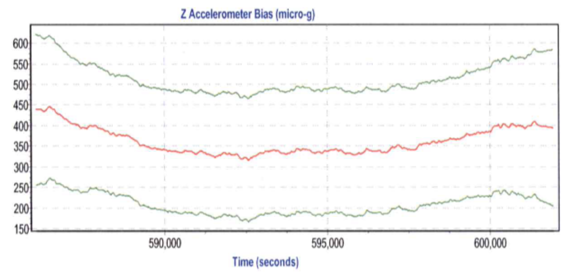


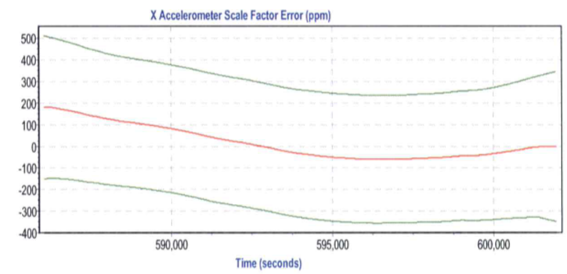



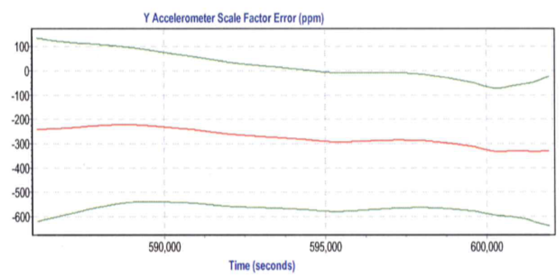

F:\1070414\REPORT\L072107A\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072107A\ABGPS_IMU_DATA\Proc\smrms_01.out

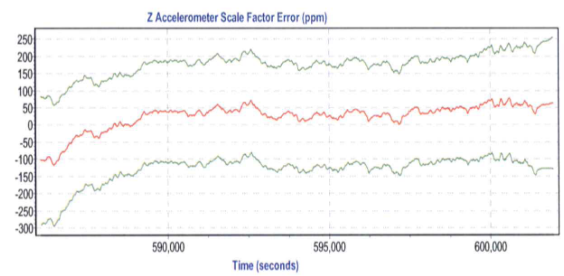


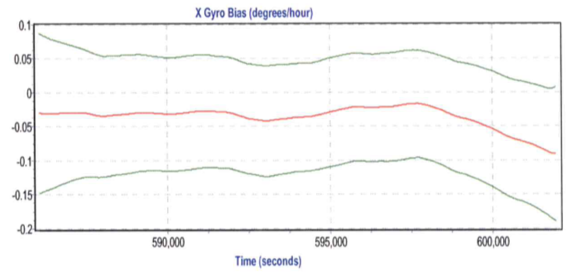

F:\1070414\REPORT\L072107B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072107B\ABGPS_IMU_DATA\Proc\smrms_01.out

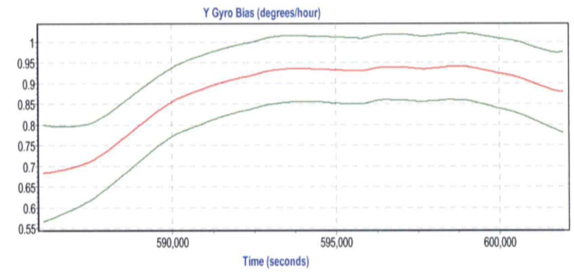
POSPac Version 4.3

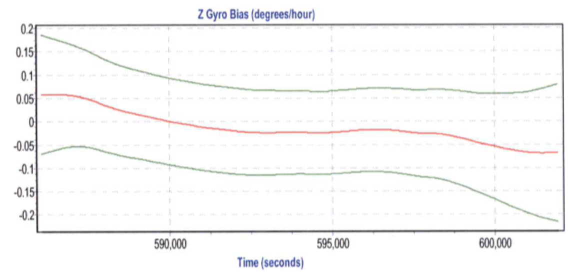
Sensor Errors

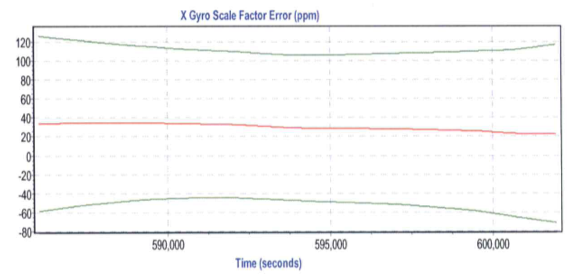
- 2 -

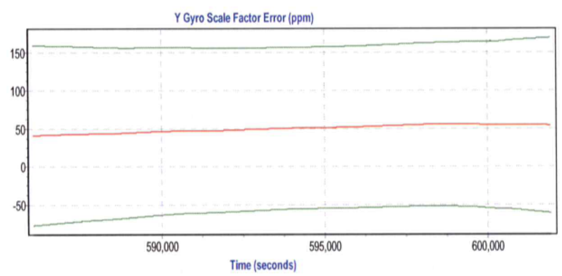
10/15/2007 - 8:20:56 PM

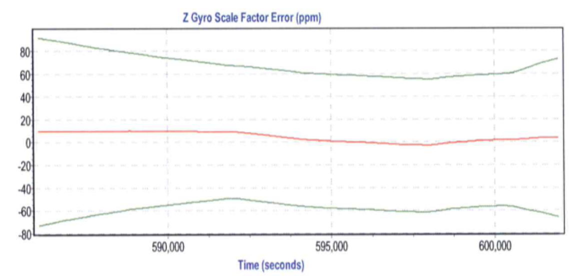


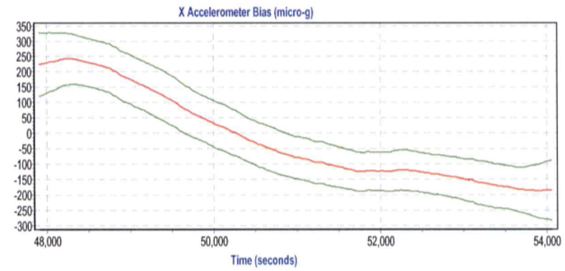



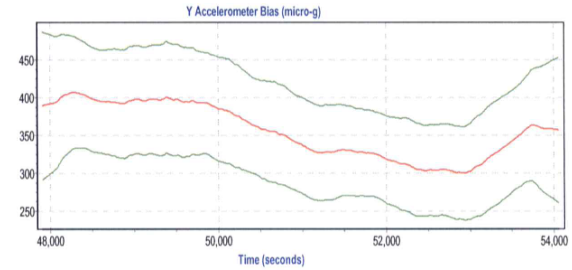



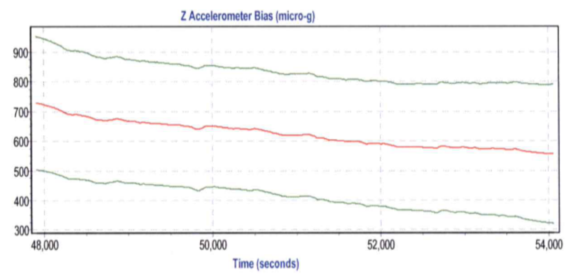

F:\1070414\REPORT\L072107B\ABGPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072107B\ABGPS_IMU_DATA\Proc\smrms_01.out

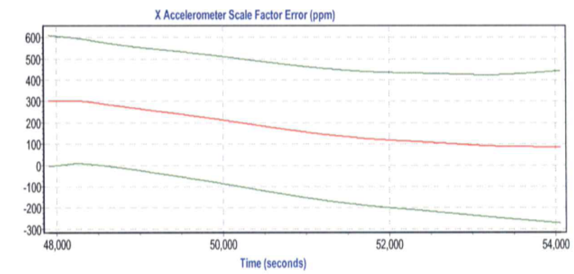
Sensor Errors

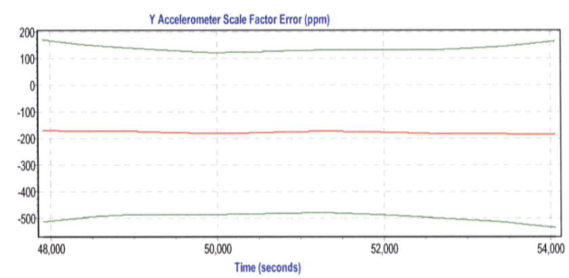
POSPac Version 4.3 - 1 - 10/15/2007 - 8:32:05 PM

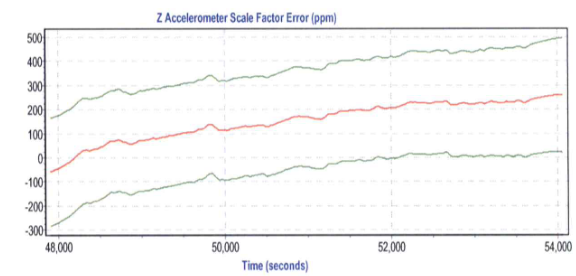


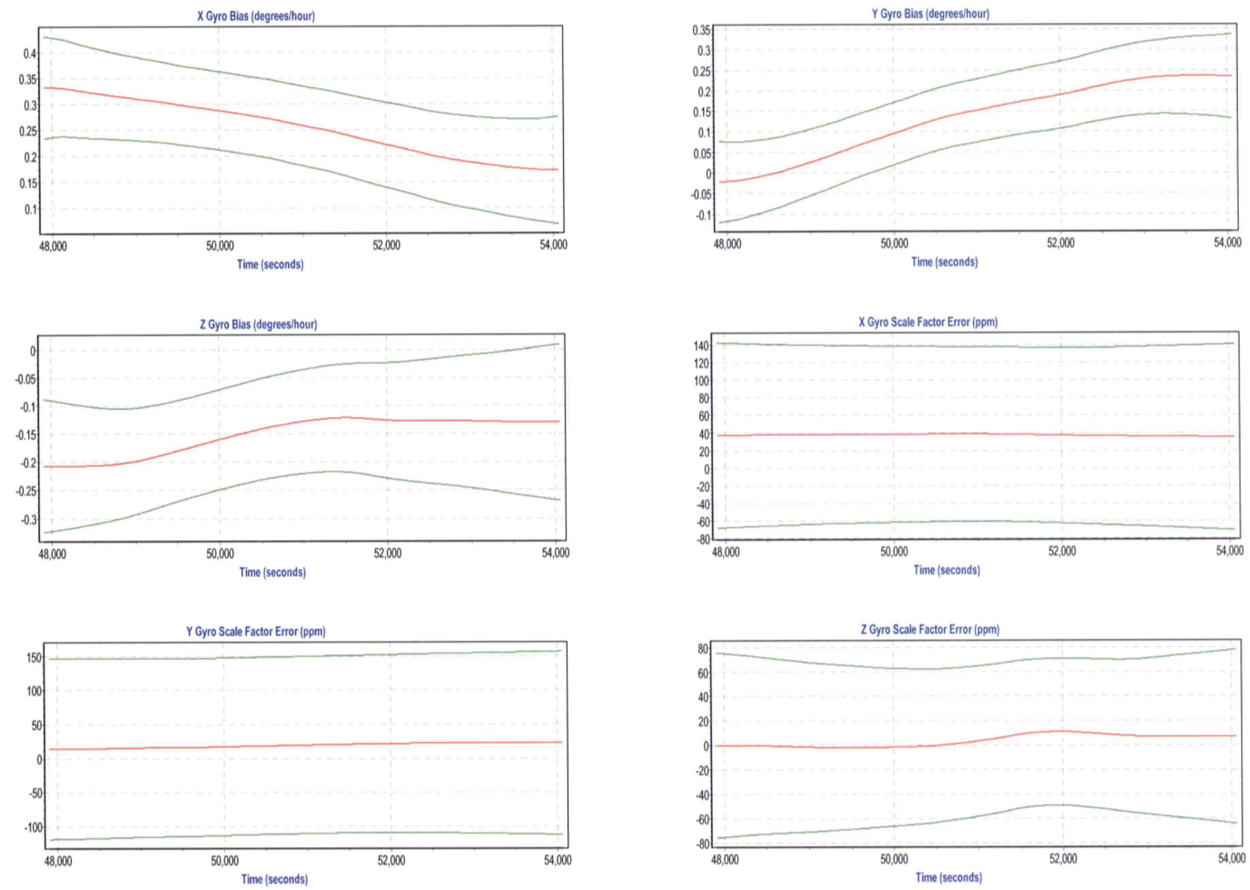




F:\1070414\REPORT\L072207A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072207A\GPS_IMU_DATA\Proc\smrms_01.out




F:\1070414\REPORT\L072207A\GPS_IMU_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072207A\GPS_IMU_DATA\Proc\smrms_01.out

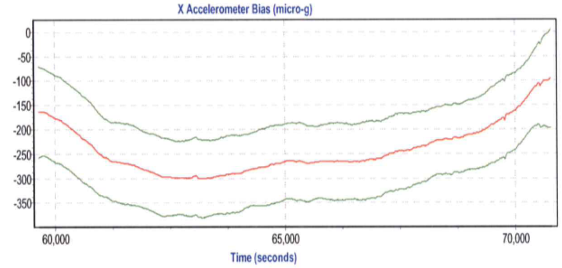
POSPac Version 4.3

Sensor Errors

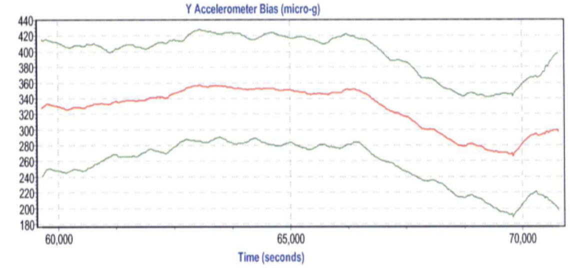
- 1 -

10/15/2007 - 8:42:08 PM

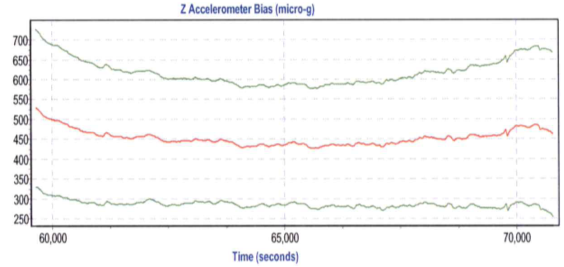
X Accelerometer Bias (micro-g)



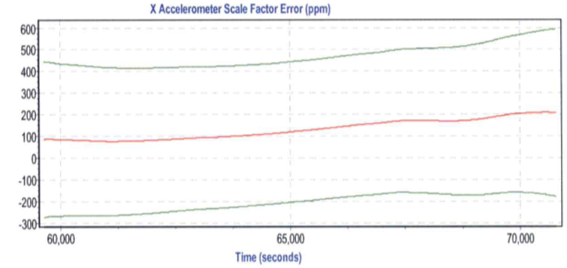

Y Accelerometer Bias (micro-g)



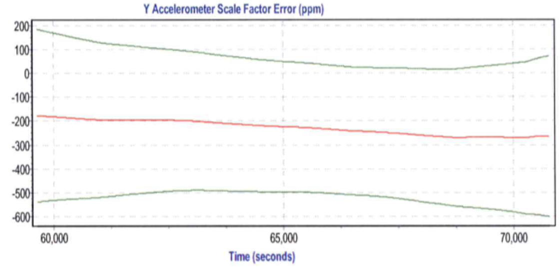

Z Accelerometer Bias (micro-g)



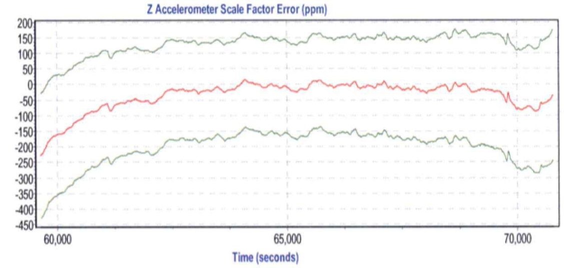

X Accelerometer Scale Factor Error (ppm)



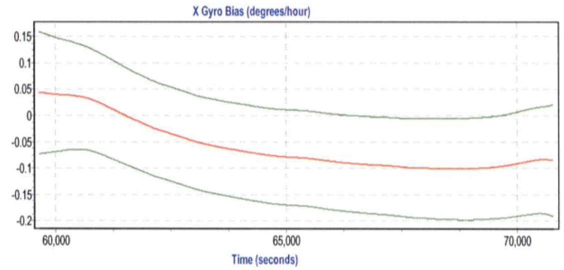

Y Accelerometer Scale Factor Error (ppm)



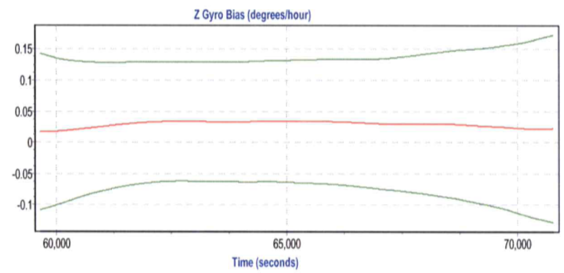

Z Accelerometer Scale Factor Error (ppm)

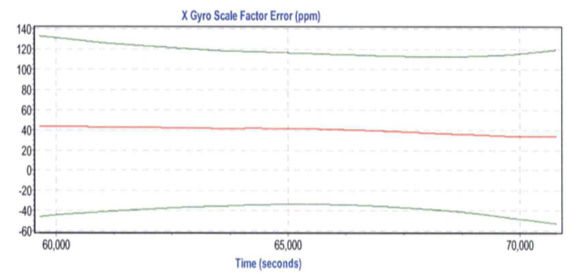


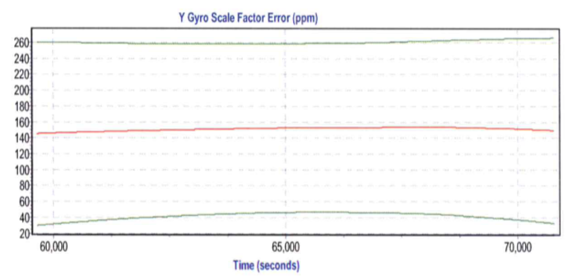

F:\1070414\REPORT\L072207B\ABGPS_RAW_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072207B\ABGPS_RAW_DATA\Proc\smrms_01.out

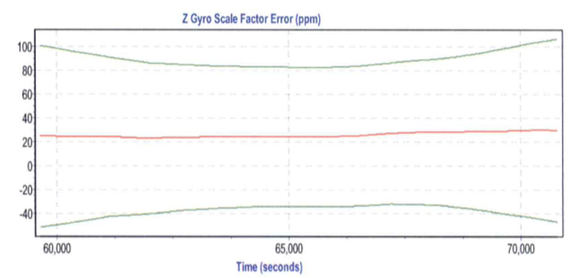







F:\1070414\REPORT\L072207B\ABGPS_RAW_DATA\Proc\smers_01.out
F:\1070414\REPORT\L072207B\ABGPS_RAW_DATA\Proc\smrms_01.out

# Appendix E:  QA/QC Checkpoints and Associated Discrepancies

| Point Number | Land Cover Class | | SPCS NAD83/99 West Zone | | NAVD88 | LIDAR-Z | ΔZ |
|---|---|---|---|---|---|---|---|
| | | | Easting-X (Ft) | Northing-Y (Ft) | Survey Z (Ft) | (Ft) | (Ft) |
| GU001M6 | 1 | BE & Low Grass | 1,695,087.19 | 434,996.83 | 64.37 | 64.21 | -0.16 |
| GU002M2 | 1 | BE & Low Grass | 1,731,811.86 | 433,428.79 | 55.65 | 55.90 | 0.25 |
| GU003M2 | 1 | BE & Low Grass | 1,747,526.15 | 436,972.22 | 57.54 | 57.59 | 0.05 |
| GU004M6 | 1 | BE & Low Grass | 1,765,602.40 | 443,649.94 | 33.27 | 32.96 | -0.31 |
| GU005M4 | 1 | BE & Low Grass | 1,696,570.33 | 409,125.43 | 44.97 | 45.05 | 0.08 |
| GU006M3 | 1 | BE & Low Grass | 1,710,516.37 | 417,593.02 | 55.86 | 55.64 | -0.22 |
| GU007M3 | 1 | BE & Low Grass | 1,740,998.89 | 413,185.37 | 43.26 | 42.84 | -0.42 |
| GU008M3 | 1 | BE & Low Grass | 1,765,668.82 | 419,519.00 | 27.41 | 27.33 | -0.08 |
| GU009M5 | 1 | BE & Low Grass | 1,717,982.57 | 381,276.50 | 23.91 | 23.80 | -0.11 |
| GU010M5 | 1 | BE & Low Grass | 1,728,790.30 | 387,163.91 | 27.91 | 28.02 | 0.11 |
| GU011M2 | 1 | BE & Low Grass | 1,749,048.86 | 395,711.88 | 37.46 | 37.52 | 0.06 |
| GU012M8 | 1 | BE & Low Grass | 1,737,161.02 | 372,388.62 | 23.41 | 23.25 | -0.16 |
| GU013M4 | 1 | BE & Low Grass | 1,758,559.34 | 371,989.29 | 25.80 | 25.81 | 0.01 |
| GU014M6 | 1 | BE & Low Grass | 1,702,342.65 | 362,668.25 | 12.18 | 12.01 | -0.17 |
| GU015M1 | 1 | BE & Low Grass | 1,732,803.99 | 357,501.26 | 19.76 | 19.79 | 0.03 |
| GU016M8 | 1 | BE & Low Grass | 1,768,276.25 | 364,499.08 | 22.32 | 22.29 | -0.03 |
| GU017M8 | 1 | BE & Low Grass | 1,778,305.11 | 355,719.48 | 12.18 | 11.91 | -0.27 |
| GU018M2 | 1 | BE & Low Grass | 1,787,537.19 | 347,355.06 | 8.68 | 8.35 | -0.33 |
| GU019M1 | 1 | BE & Low Grass | 1,697,161.04 | 324,487.07 | 12.78 | 12.83 | 0.05 |
| GU020M3 | 1 | BE & Low Grass | 1,724,435.03 | 336,029.53 | 16.72 | 16.54 | -0.18 |
| GU021M3 | 1 | BE & Low Grass | 1,750,076.57 | 341,482.24 | 17.52 | 17.63 | 0.11 |
| GU022M7 | 1 | BE & Low Grass | 1,762,432.22 | 331,300.92 | 11.90 | 11.89 | -0.01 |
| GU023M3 | 1 | BE & Low Grass | 1,789,636.39 | 327,406.41 | 10.96 | 10.80 | -0.16 |
| GU024M1 | 1 | BE & Low Grass | 1,740,974.21 | 321,502.38 | 10.19 | 10.13 | -0.06 |
| GU025M2 | 1 | BE & Low Grass | 1,774,429.88 | 316,018.73 | 3.91 | 3.59 | -0.32 |
| GU026M1 | 1 | BE & Low Grass | 1,789,484.21 | 309,979.01 | 7.07 | 6.93 | -0.14 |
| GU027M5 | 1 | BE & Low Grass | 1,708,688.78 | 306,853.86 | 4.21 | 4.27 | 0.06 |
| GU028M3 | 1 | BE & Low Grass | 1,726,735.57 | 311,310.45 | 14.25 | 13.98 | -0.27 |
| GU029M1 | 1 | BE & Low Grass | 1,719,516.59 | 288,032.22 | 16.58 | 16.41 | -0.17 |
| GU030M5 | 1 | BE & Low Grass | 1,746,190.91 | 298,741.57 | 5.36 | 5.16 | -0.21 |
| GU031M8 | 1 | BE & Low Grass | 1,731,222.92 | 274,424.36 | 6.95 | 6.60 | -0.35 |
| GU033M1 | 1 | BE & Low Grass | 1,755,127.48 | 273,754.72 | 3.59 | 3.21 | -0.38 |
| GU034M1 | 1 | BE & Low Grass | 1,714,400.20 | 269,372.78 | 4.71 | 4.29 | -0.42 |
| GU035M7 | 1 | BE & Low Grass | 1,681,497.33 | 280,085.13 | 3.88 | 3.98 | 0.10 |
| GU036M11 | 1 | BE & Low Grass | 1,696,080.02 | 247,149.15 | 6.25 | 6.60 | 0.35 |
| GU037M8 | 1 | BE & Low Grass | 1,723,663.33 | 249,994.37 | 7.60 | 7.60 | 0.00 |
| GU038M11 | 1 | BE & Low Grass | 1,736,713.21 | 253,502.74 | 4.71 | 4.71 | 0.00 |
| GU001M1 | 2 | Brush & Low Trees | 1,694,957.57 | 434,906.51 | 63.80 | 63.15 | -0.65 |
| GU002M4 | 2 | Brush & Low Trees | 1,731,787.35 | 433,525.61 | 56.17 | 56.58 | 0.41 |
| GU003M9 | 2 | Brush & Low Trees | 1,747,499.43 | 437,429.44 | 54.42 | 54.62 | 0.20 |
| GU004M3 | 2 | Brush & Low Trees | 1,765,567.18 | 443,561.49 | 32.82 | 32.84 | 0.02 |
| GU005M5 | 2 | Brush & Low Trees | 1,696,557.28 | 409,153.52 | 45.10 | 45.26 | 0.16 |
| GU006M7 | 2 | Brush & Low Trees | 1,710,429.40 | 417,563.80 | 56.88 | 56.59 | -0.30 |
| GU007M6 | 2 | Brush & Low Trees | 1,740,928.80 | 413,323.91 | 42.54 | 42.18 | -0.36 |
| GU008M1 | 2 | Brush & Low Trees | 1,765,779.37 | 419,482.38 | 26.15 | 25.89 | -0.26 |
| GU009M7 | 2 | Brush & Low Trees | 1,718,064.06 | 381,271.51 | 24.93 | 25.01 | 0.08 |
| GU010M6 | 2 | Brush & Low Trees | 1,728,781.98 | 387,185.13 | 29.07 | 29.45 | 0.38 |
| GU011M9 | 2 | Brush & Low Trees | 1,749,169.11 | 395,695.21 | 36.80 | 37.01 | 0.21 |
| GU012M2 | 2 | Brush & Low Trees | 1,737,079.04 | 372,269.53 | 23.40 | 23.51 | 0.11 |
| GU013M8 | 2 | Brush & Low Trees | 1,758,869.81 | 371,751.83 | 26.69 | 26.74 | 0.05 |
| GU014M9 | 2 | Brush & Low Trees | 1,702,367.43 | 362,704.35 | 11.68 | 11.63 | -0.05 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GU015M3 | 2 | Brush & Low Trees | 1,732,824.32 | 357,613.72 | 19.51 | 18.87 | -0.64 |
| GU016M6 | 2 | Brush & Low Trees | 1,768,306.99 | 364,779.72 | 21.80 | 21.98 | 0.18 |
| GU017M7 | 2 | Brush & Low Trees | 1,778,317.00 | 355,690.16 | 13.05 | 12.68 | -0.37 |
| GU018M5 | 2 | Brush & Low Trees | 1,787,552.40 | 347,399.32 | 7.23 | 7.34 | 0.11 |
| GU019M9 | 2 | Brush & Low Trees | 1,697,382.88 | 324,656.33 | 8.21 | 7.88 | -0.33 |
| GU020M2 | 2 | Brush & Low Trees | 1,724,401.70 | 336,007.57 | 15.87 | 15.94 | 0.07 |
| GU021M6 | 2 | Brush & Low Trees | 1,749,938.58 | 341,308.46 | 19.31 | 19.50 | 0.19 |
| GU024M9 | 2 | Brush & Low Trees | 1,741,017.66 | 321,542.24 | 11.51 | 11.31 | -0.20 |
| GU025M5 | 2 | Brush & Low Trees | 1,774,445.27 | 316,107.10 | 3.90 | 3.71 | -0.19 |
| GU026M5 | 2 | Brush & Low Trees | 1,789,561.79 | 310,013.51 | 6.55 | 6.51 | -0.04 |
| GU027M9 | 2 | Brush & Low Trees | 1,708,635.98 | 306,953.68 | 3.80 | 3.67 | -0.13 |
| GU028M4 | 2 | Brush & Low Trees | 1,726,719.98 | 311,309.36 | 14.20 | 14.05 | -0.15 |
| GU029M8 | 2 | Brush & Low Trees | 1,719,356.95 | 288,095.19 | 16.34 | 16.42 | 0.08 |
| GU030M2 | 2 | Brush & Low Trees | 1,746,141.75 | 298,779.88 | 4.54 | 4.49 | -0.05 |
| GU031M3 | 2 | Brush & Low Trees | 1,731,177.44 | 274,428.83 | 6.91 | 6.73 | -0.18 |
| GU033M5 | 2 | Brush & Low Trees | 1,755,182.13 | 273,996.99 | 2.64 | 2.60 | -0.04 |
| GU034M7 | 2 | Brush & Low Trees | 1,714,418.72 | 269,467.58 | 4.43 | 4.22 | -0.21 |
| GU035M10 | 2 | Brush & Low Trees | 1,681,617.69 | 279,926.14 | 4.38 | 4.23 | -0.15 |
| GU036M7 | 2 | Brush & Low Trees | 1,695,451.29 | 247,141.61 | 4.45 | 4.82 | 0.37 |
| GU037M3 | 2 | Brush & Low Trees | 1,723,580.27 | 250,021.10 | 6.83 | 7.00 | 0.17 |
| GU038M1 | 2 | Brush & Low Trees | 1,735,910.97 | 253,435.28 | 5.66 | 5.66 | 0.00 |
| GU001M9 | 3 | Forested | 1,695,011.91 | 434,907.75 | 61.26 | 61.95 | 0.69 |
| GU002M6 | 3 | Forested | 1,731,762.96 | 433,495.53 | 56.96 | 57.40 | 0.44 |
| GU003M8 | 3 | Forested | 1,747,434.33 | 436,931.96 | 58.50 | 58.52 | 0.02 |
| GU004M9 | 3 | Forested | 1,765,722.66 | 443,636.24 | 33.78 | 33.70 | -0.08 |
| GU005M1 | 3 | Forested | 1,696,652.76 | 409,236.79 | 46.51 | 46.71 | 0.20 |
| GU006M9 | 3 | Forested | 1,710,520.87 | 417,523.92 | 56.64 | 56.86 | 0.22 |
| GU007M9 | 3 | Forested | 1,740,891.93 | 413,396.58 | 42.35 | 42.08 | -0.27 |
| GU008M6 | 3 | Forested | 1,765,736.07 | 419,408.85 | 24.70 | 25.91 | 1.21 |
| GU009M9 | 3 | Forested | 1,718,148.15 | 381,244.14 | 24.45 | 24.52 | 0.07 |
| GU010M9 | 3 | Forested | 1,728,632.25 | 387,134.92 | 29.10 | 28.81 | -0.29 |
| GU011M1 | 3 | Forested | 1,748,992.29 | 395,719.75 | 36.80 | 36.99 | 0.19 |
| GU012M6 | 3 | Forested | 1,737,169.49 | 372,412.30 | 23.65 | 23.41 | -0.24 |
| GU013M7 | 3 | Forested | 1,758,499.86 | 372,173.03 | 24.52 | 24.78 | 0.26 |
| GU014M1 | 3 | Forested | 1,702,274.14 | 362,617.21 | 11.61 | 11.86 | 0.25 |
| GU015M6 | 3 | Forested | 1,732,857.70 | 357,619.93 | 18.36 | 18.73 | 0.37 |
| GU016M7 | 3 | Forested | 1,768,490.46 | 364,834.22 | 21.48 | 22.11 | 0.63 |
| GU017M4 | 3 | Forested | 1,778,391.44 | 355,645.41 | 11.91 | 11.29 | -0.62 |
| GU018M7 | 3 | Forested | 1,787,587.52 | 347,360.20 | 6.97 | 7.48 | 0.51 |
| GU019M10 | 3 | Forested | 1,697,335.56 | 324,757.42 | 7.63 | 7.70 | 0.07 |
| GU020M6 | 3 | Forested | 1,724,419.18 | 336,113.53 | 16.81 | 16.10 | -0.72 |
| GU021M9 | 3 | Forested | 1,749,974.31 | 341,480.98 | 18.78 | 19.45 | 0.67 |
| GU022M6 | 3 | Forested | 1,762,567.87 | 331,433.10 | 10.54 | 10.01 | -0.53 |
| GU023M7 | 3 | Forested | 1,789,625.75 | 327,449.39 | 10.24 | 10.10 | -0.14 |
| GU024M10 | 3 | Forested | 1,741,049.43 | 321,561.83 | 11.15 | 11.49 | 0.34 |
| GU025M7 | 3 | Forested | 1,774,372.67 | 316,232.61 | 2.65 | 2.11 | -0.54 |
| GU027M10 | 3 | Forested | 1,708,634.99 | 306,982.36 | 4.12 | 4.00 | -0.12 |
| GU028M7 | 3 | Forested | 1,726,734.63 | 311,231.78 | 14.27 | 13.96 | -0.31 |
| GU030M7 | 3 | Forested | 1,746,214.02 | 298,681.76 | 4.69 | 4.33 | -0.36 |
| GU031M10 | 3 | Forested | 1,731,274.82 | 274,387.50 | 5.23 | 5.95 | 0.72 |
| GU032M6 | 3 | Forested | 1,742,892.89 | 270,031.77 | 9.06 | 9.83 | 0.77 |
| GU033M9 | 3 | Forested | 1,755,033.25 | 273,890.34 | 2.43 | 2.28 | -0.15 |
| GU034M10 | 3 | Forested | 1,714,387.17 | 269,480.57 | 4.62 | 4.91 | 0.29 |
| GU036M10 | 3 | Forested | 1,695,498.58 | 247,118.25 | 5.36 | 5.75 | 0.39 |
| GU037M10 | 3 | Forested | 1,723,683.96 | 249,929.19 | 4.83 | 4.85 | 0.01 |
| GU038M9 | 3 | Forested | 1,736,084.44 | 253,303.31 | 4.60 | 5.41 | 0.81 |
| GU003M4 | 4 | Urban | 1,747,489.04 | 436,875.16 | 57.08 | 56.83 | -0.25 |
| GU006M2 | 4 | Urban | 1,710,515.60 | 417,619.03 | 57.73 | 57.13 | -0.60 |
| GU007M5 | 4 | Urban | 1,740,970.16 | 413,330.52 | 43.43 | 43.18 | -0.25 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GU009M1 | 4 | Urban | 1,717,962.90 | 381,308.03 | 26.80 | 26.83 | 0.03 |
| GU010M2 | 4 | Urban | 1,728,660.89 | 387,062.01 | 30.23 | 30.35 | 0.12 |
| GU011M5 | 4 | Urban | 1,749,123.45 | 395,527.55 | 37.79 | 37.78 | -0.01 |
| GU013M1 | 4 | Urban | 1,758,461.43 | 372,063.36 | 26.23 | 25.89 | -0.34 |
| GU014M4 | 4 | Urban | 1,702,378.75 | 362,610.75 | 13.02 | 12.94 | -0.08 |
| GU016M3 | 4 | Urban | 1,768,341.82 | 364,941.92 | 23.45 | 23.58 | 0.13 |
| GU017M2 | 4 | Urban | 1,778,259.40 | 355,685.99 | 16.16 | 15.60 | -0.56 |
| GU019M4 | 4 | Urban | 1,697,268.20 | 324,612.71 | 14.84 | 14.84 | 0.00 |
| GU021M1 | 4 | Urban | 1,750,001.73 | 341,280.52 | 21.12 | 21.08 | -0.04 |
| GU022M2 | 4 | Urban | 1,762,629.15 | 331,332.18 | 13.58 | 13.44 | -0.14 |
| GU023M4 | 4 | Urban | 1,789,636.35 | 327,425.77 | 11.10 | 10.86 | -0.24 |
| GU024M6 | 4 | Urban | 1,740,948.86 | 321,504.91 | 10.02 | 9.84 | -0.18 |
| GU027M2 | 4 | Urban | 1,708,644.60 | 306,858.03 | 4.63 | 4.57 | -0.06 |
| GU029M5 | 4 | Urban | 1,719,454.58 | 288,045.59 | 16.18 | 15.93 | -0.25 |
| GU031M1 | 4 | Urban | 1,731,187.71 | 274,356.36 | 9.58 | 9.34 | -0.24 |
| GU032M3 | 4 | Urban | 1,742,890.32 | 270,088.70 | 11.22 | 10.83 | -0.39 |
| GU034M4 | 4 | Urban | 1,714,391.39 | 269,409.05 | 6.57 | 6.36 | -0.21 |
| GU035M1 | 4 | Urban | 1,681,424.51 | 280,096.14 | 6.16 | 6.41 | 0.25 |
| GU036M3 | 4 | Urban | 1,695,514.52 | 247,182.10 | 5.70 | 6.03 | 0.33 |
| GU037M5 | 4 | Urban | 1,723,634.80 | 250,005.75 | 7.74 | 7.40 | -0.34 |
| GU038M5 | 4 | Urban | 1,735,969.58 | 253,340.64 | 6.74 | 6.63 | -0.12 |

| 100 % of Totals | # of Points | RMSE (ft) Spec = 0.61 (BE = 0.30) | Mean (ft) | Median (ft) | Min (ft) | Max (ft) |
|---|---|---|---|---|---|---|
| Consolidated | 131 | 0.32 | -0.03 | -0.05 | -0.72 | 1.21 |
| BE & Low Grass | 37 | 0.21 | -0.10 | -0.11 | -0.42 | 0.35 |
| Brush & Low Trees | 35 | 0.26 | -0.04 | -0.04 | -0.65 | 0.41 |
| Forested | 35 | 0.47 | 0.14 | 0.19 | -0.72 | 1.21 |
| Urban | 24 | 0.26 | -0.14 | -0.16 | -0.60 | 0.33 |

| Land Cover Category | # of Points | FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec = 0.60 ft | CVA — Consolidated Vertical Accuracy (95th Percentile) Spec = 1.19 ft | SVA — Supplemental Vertical Accuracy (95th Percentile) Target = 1.19 ft |
|---|---|---|---|---|
| Consolidated | 131 | | 0.66 | |
| BE & Low Grass | 37 | 0.41 | | 0.39 |
| Brush & Low Trees | 35 | | | 0.48 |
| Forested | 35 | | | 0.78 |
| Urban | 24 | | | 0.54 |

# Appendix F: LiDAR Vertical Accuracy Report

**Vertical Accuracy Assessment Report**
**2007 LiDAR Bare-Earth Dataset for**
**Gulf County, Florida**

**Date:** August 22, 2008

**References:** A — State of Florida Division of Emergency Management (FDEM), Contract Number 07-HS-34-14-00-22-469, Task Order Number 20070525-492718a
B — Part 3: *National Standard for Spatial Data Accuracy (NSSDA)*, "Geospatial Positioning Accuracy Standards," published by the Federal Geographic Data Committee (FGDC), 1998
C — Appendix A, *Guidance for Aerial Mapping and Surveying*, "Guidelines and Specifications for Flood Hazard Mapping Partners," published by the Federal Emergency Management Agency (FEMA), April 2003
D — *Guidelines for Digital Elevation Data*, Version 1.0, published by the National Digital Elevation Program (NDEP), May 10, 2004
E — *ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data*, published by the American Society for Photogrammetry and Remote Sensing (ASPRS), May 24, 2004

**Background**
FDEM Guidance: Reference A tasked PDS to validate the bare-earth LiDAR dataset of Gulf County, FL, both quantitatively (for accuracy) and qualitatively (for usability). This report addresses the vertical accuracy assessment only, for which FDEM's major specifications are summarized as follows:

- Vertical accuracy: $\leq$ 0.30 feet $RMSE_z$ = $\leq$ 0.60 feet vertical accuracy at 95% confidence level, tested in flat, non-vegetated terrain only, employing NSSDA procedures in Reference B.
- Validation that the data also satisfies FEMA requirements in Reference C.
- Vertical units (orthometric heights) are in US Survey Feet, NAVD88.

NSSDA Guidance: Section 3.2.2 of Reference B specifies: "A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level allows one point to fail the threshold given in product specifications."

FEMA Guidance: Section A.8.6 of Reference C specifies the following LiDAR testing requirement for data to be used by the National Flood Insurance Program (NFIP): "For the NFIP, TINs (and DEMs derived there from) should normally have a maximum RMSE of 18.5 centimeters, equivalent to 2-foot contours, in flat terrain; and a maximum RMSE of 37 centimeters, equivalent to 4-foot contours, in rolling to hilly terrain. The Mapping Partner shall field verify the vertical accuracy of this TIN to ensure that the 18.5- or 37.0-centimeter RMSE requirement is satisfied for all major vegetation categories that predominate within the floodplain being studied … The assigned Mapping Partner shall separately evaluate and report on the TIN accuracy for the main categories of ground cover in the study area, including the following: [followed by explanations of seven potential categories]… Ground cover Categories 1 through 5 are fairly common everywhere … The assigned Mapping Partner shall select a minimum of 20 test points for each major vegetation category identified. Therefore, a minimum of 60 test points shall be selected for three (minimum) major land cover categories, 80 test points for four major categories, and so on."

Note: for this project PDS followed the FDEM guidelines in Reference A, which stipulates that the vertical accuracy report will be based on a minimum of 30 ground measurements for each of four land cover categories, totaling 120 test points for each 500 square mile area of new topographic data collection. The land cover measurements distributed through each project area will be collected for each of the following land cover categories:

1. Bare-earth and low grass
2. Brush Lands and low trees
3. Forested areas fully covered by trees
4. Urban areas

NDEP and ASPRS Guidance: NDEP guidelines (Reference D) and ASPRS guidelines (Reference E) also recommend a minimum of 60 checkpoints, with up to 100 points preferred. (These guidelines are referenced because FEMA's next update to Appendix A will include these newer NDEP and ASPRS guidelines, now recognizing that vertical errors for LiDAR bare-earth datasets in vegetated terrain do not necessarily follow a normal error distribution as assumed by the NSSDA.)

**Vertical Accuracy Test Procedures**

Ground Truth Surveys: The PDS team established a primary geodetic network covering approximately 6,000 square miles along the panhandle area of Northwest Florida to provide accurate and consistent control throughout the project area, which includes Gulf County. The Primary Network was used to establish base stations to support airborne GPS data acquisition. Two Secondary control networks were established to support the measurement of checkpoints used in the accuracy validation process for newly generated LiDAR and Orthophotography.

Assessment Procedures and Results: The LiDAR accuracy assessment for Gulf County was performed in accordance with References D and E which assume that LiDAR errors in some land cover categories may not follow a normal error distribution. This assessment was also performed in accordance with References B and C which assume that LiDAR bare-earth datasets errors do follow a normal error distribution. Comparisons between the two methods help determine the degree to which *systematic errors* may exist in Gulf County's four major land cover categories: (1) bare-earth and low grass, (2) brush lands and low trees, (3) forested areas fully covered by trees, (4) urban areas. When a LiDAR bare-earth dataset passes testing by both methods, compared with criteria specified in Reference A, the dataset clearly passes all vertical accuracy testing criteria for a digital terrain model (DTM) suitable for FDEM and FEMA requirements.

The relevant testing criteria, as stipulated in Reference A are summarized in Table 1.

**Table 1 — DTM Acceptance Criteria for Gulf County**

| Quantitative Criteria | Measure of Acceptability |
|---|---|
| Fundamental Vertical Accuracy (FVA) in open terrain only = 95% confidence level | 0.60 ft (0.30 ft $RMSE_z$ x 1.96000) for open terrain only |
| | |
| Supplemental Vertical Accuracy (SVA) in individual land cover categories = 95% confidence level | 1.19 ft (based on 95$^{th}$ percentile per land cover category) |
| | |
| Consolidated Vertical Accuracy (CVA) in all land cover categories combined = 95% confidence lever | 1.19 ft (based on combined 95$^{th}$ percentile) |

## Vertical Accuracy Testing in Accordance with NDEP and ASPRS Procedures

References D and E specify the mandatory determination of Fundamental Vertical Accuracy (FVA) and the optional determination of Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA). FVA determines how well the LiDAR sensor performed in category (1), open terrain, where errors are random and normally distributed; whereas SVA determines how well the vegetation classification algorithms worked in land cover categories (2) and (3) where LiDAR elevations are often higher than surveyed elevations and category (4) where LiDAR elevations are often lower.

**FVA** is determined with check points located only in land cover category (1), open terrain (grass, dirt, sand, and/or rocks), where there is a very high probability that the LiDAR sensor will have detected the bare-earth ground surface and where random errors are expected to follow a normal error distribution. The FVA determines how well the calibrated LiDAR sensor performed. With a normal error distribution, the vertical accuracy at the 95% confidence level is computed as the vertical root mean square error ($RMSE_z$) of the checkpoints x 1.9600, as specified in Reference B. For Gulf County, for which floodplains are essentially flat, FDEM required the FVA to be 0.60 ft (18.29 cm) at the 95% confidence level (based on an $RMSE_z$ of 0.30 ft (9.14 cm), equivalent to 1 ft contours).

**CVA** is determined with all checkpoints in all land cover categories combined where there is a possibility that the LiDAR sensor and post-processing may yield elevation errors that do not follow a normal error distribution. CVA at the 95% confidence level equals the 95$^{th}$ percentile error for all checkpoints in all land cover categories combined. FDEM's CVA standard is 1.19 ft at the 95% confidence level. The CVA is accompanied by a listing of the 5% outliers that are larger than the 95$^{th}$ percentile used to compute the CVA; these are always the largest outliers that may depart from a normal error distribution. Here, $Accuracy_z$ differs from CVA because $Accuracy_z$ assumes elevation errors follow a normal error distribution where RMSE procedures are valid, whereas CVA assumes LiDAR errors may not follow a normal error distribution in vegetated categories, making the RMSE process invalid.

**SVA** is determined separately for each individual land cover category, again recognizing that the LiDAR sensor and post-processing may yield elevation errors that do not follow a normal error distribution, and where discrepancies can be used to identify the nature of systematic errors by land cover category. For each land cover category, the SVA at the 95% confidence level equals the 95$^{th}$ percentile error for all checkpoints in each individual land cover category. SVA statistics are calculated individually for bare-earth and low grass, brush lands and low trees, forested areas, and urban areas, in order to facilitate the analysis of the data based on each of these land cover categories that exist within Gulf County. The SVA criteria in Table 1 are target values only and are not mandatory; it is common for some SVA criteria to fail individual target values, yet satisfy FEMA's mandatory CVA criterion.

QA/QC Steps: The primary QA/QC steps used by PDS were as follows:

1. PDS surveyed "ground truth" QA/QC vertical checkpoints in accordance with guidance in references B, C, D and E. Figure 1 shows the location of "cluster areas" where PDS attempted to survey a minimum of 30 QA/QC checkpoints in each of the four land cover categories. Some cluster areas did not include all land cover categories. The final totals were 37 checkpoints in bare-earth and low grass; 35 checkpoints in brush and low trees; 35 checkpoints in forested areas; and 24 checkpoints in urban areas, for a total of 131 checkpoints.
2. Next, PDS interpolated the bare-earth LiDAR DTM to provide the z-value for each of the 131 checkpoints.
3. PDS then computed the associated z-value differences between the interpolated z-value from the LiDAR data and the ground truth survey checkpoints and computed the FVA, CVA and SVA values using procedures in References D and E.

4. The data were analyzed by PDS to assess the accuracy of the data. The review process examined the various accuracy parameters as defined by FDEM guidelines. Also, the overall descriptive statistics of each dataset were computed to assess any trends or anomalies. The following tables, graphs and figures illustrate the data quality.

Figure 1 shows the location of the QA/QC checkpoint clusters within Gulf County. Each point represents a checkpoint cluster. There are nominally four checkpoints in each cluster, one per land cover category.

**Figure 1 — Location of QA/QC Checkpoint Clusters for Gulf County**

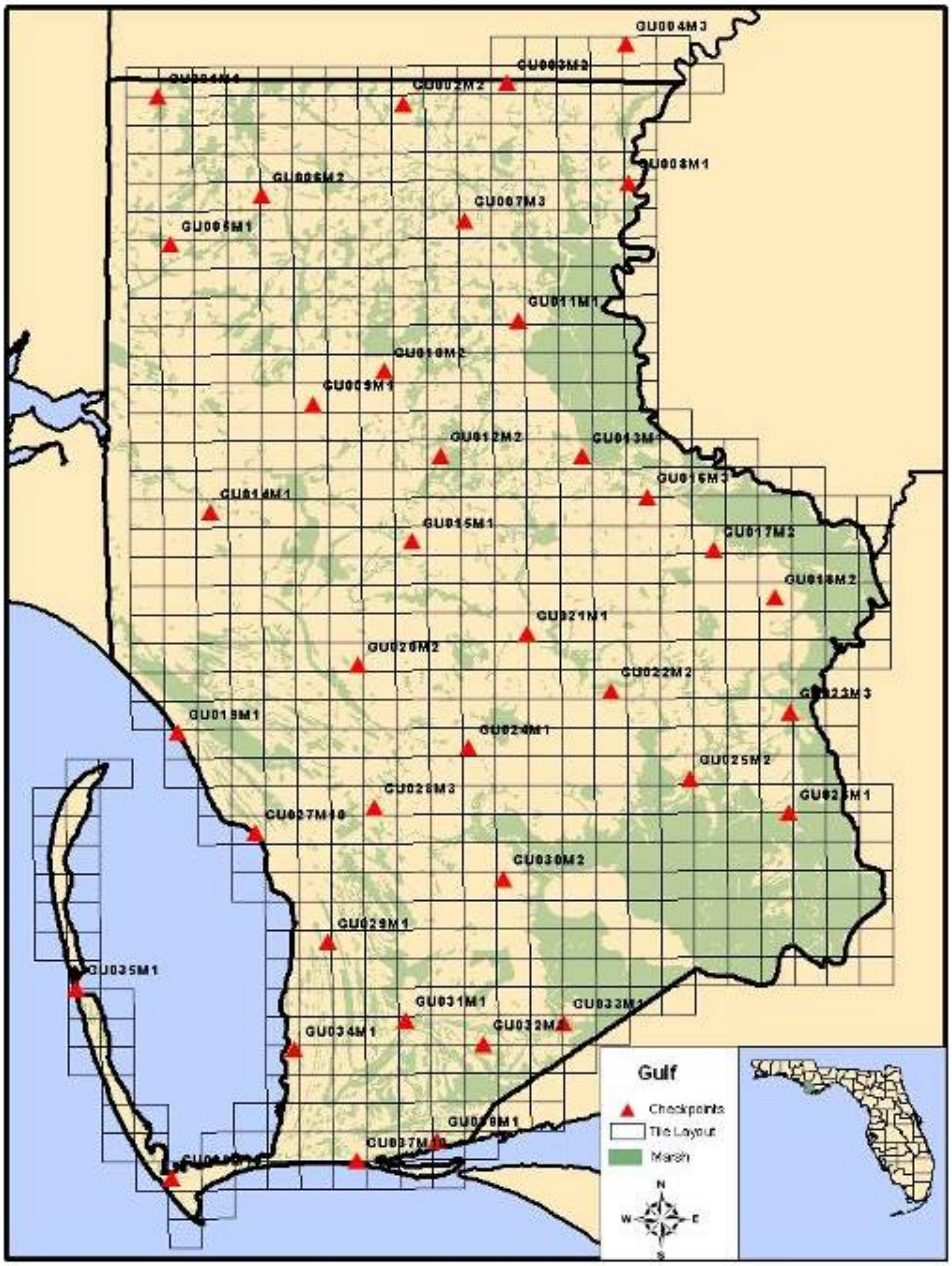


Table 2 summarizes the vertical accuracy by fundamental, consolidated and supplemental methods:

**Table 2 — FVA, CVA and SVA Vertical Accuracy at 95% Confidence Level**

| Land Cover Category | # of Points | FVA — Fundamental Vertical Accuracy ($RMSE_z$ x 1.9600) Spec = 0.60 ft | CVA — Consolidated Vertical Accuracy ($95^{th}$ Percentile) Spec = 1.19 ft | SVA — Supplemental Vertical Accuracy ($95^{th}$ Percentile) Target = 1.19 ft |
|---|---|---|---|---|
| Total Combined | 131 | | 0.66 | |
| BE & Low Grass | 37 | .41 | | 0.39 |
| Brush & Low Trees | 35 | | | 0.48 |
| Forested | 35 | | | 0.78 |
| Urban | 24 | | | 0.54 |

**Fundamental and Consolidated Vertical Accuracy at 95% confidence level, using NDEP/ASPRS methodology:**

The $RMSE_z$ in bare-earth and low grass was within the target criteria of 0.30 ft, and the FVA tested 0.41 ft at the 95% confidence level in open terrain, based on $RMSE_z$ x 1.9600.

Compared with the 1.19 ft specification, CVA tested 0.66 ft at the 95% confidence level in bare-earth and low grass, brush and low trees, forested, and urban areas combined, based on the 95th Percentile. Table 3 lists the 5% outliers larger than the $95^{th}$ percentile error; whereas 5% of the points could have exceeded the 1.19 ft criterion, no points actually exceeded this criterion.

**Table 3 — 5% Outliers Larger than 95th Percentile**

<table>
<tr><th>Land Cover Category</th><th>Elevation Diff. (ft)</th><td rowspan="8">One point had an error larger than the CVA standard (1.9ft), which permits up to 5% of the checkpoints, nominally 6 points of 131, to exceed 1.19 ft</td></tr>
<tr><td>3 - Forested</td><td>1.21</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Compared with the 1.19 ft SVA target values, SVA tested 0.39 ft at the 95% confidence level in bare-earth and low grass; 0.48 ft in brush and low trees; 0.78 ft in forested areas; and 0.54 ft in urban areas, based on the 95th Percentile. Each of the four land cover categories were well within the target value of 1.19 ft.

Figure 2 illustrates the SVA by specific land cover category.

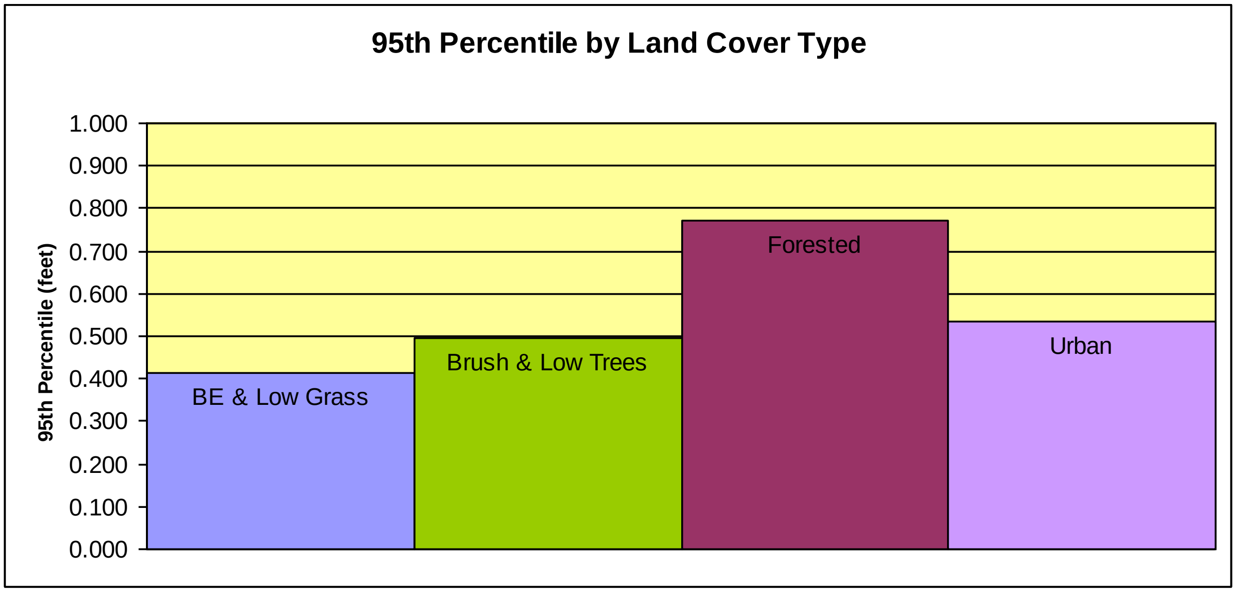



**Figure 2 — Graph of SVA Values by Land Cover**

Figure 3 illustrates the magnitude of the differences between the QA/QC checkpoints and LiDAR data by specific land cover category and sorted from lowest to highest. This shows a normal distribution of points in the bare-earth and low grass category. Only one outlier point, in the forested land cover category, exceeded the 1.19 ft SVA accuracy criteria.

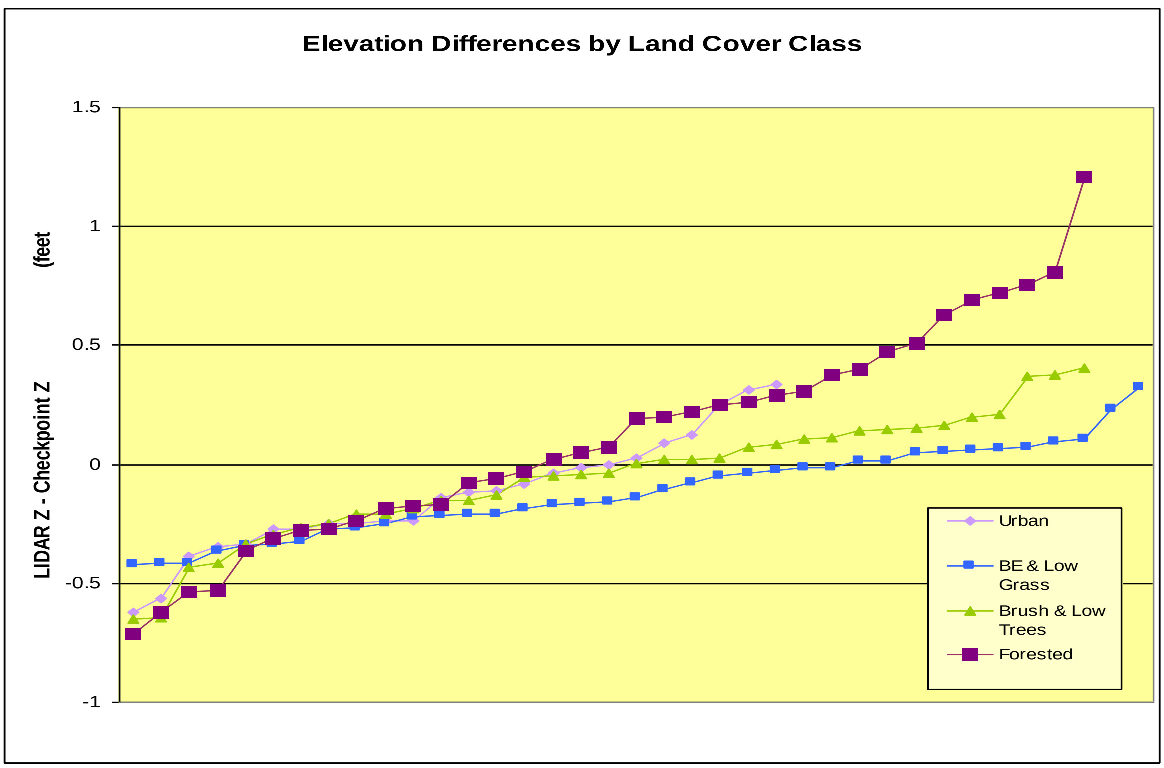



**Figure 3 – Magnitude of Elevation Discrepancies, Sorted from Largest Negative to Largest Positive**

## Vertical Accuracy Testing in Accordance with NSSDA and FEMA Procedures

The NSSDA and FEMA guidelines were both published before it was recognized that LiDAR errors do not always follow a normal error distribution. Future changes to these FGDC and FEMA documents are expected to follow the lead of the NDEP and ASPRS. Nevertheless, to comply with FEMA's current guidelines in Reference C, $RMSE_z$ statistics were computed in all four land cover categories, individually and combined, as well as other statistics that FEMA recommends to help identify any unusual characteristics in the LiDAR data. These statistics are summarized in Figures 4 and 5 and Table 4 below, consistent with Section A.8.6.3 of Reference C.

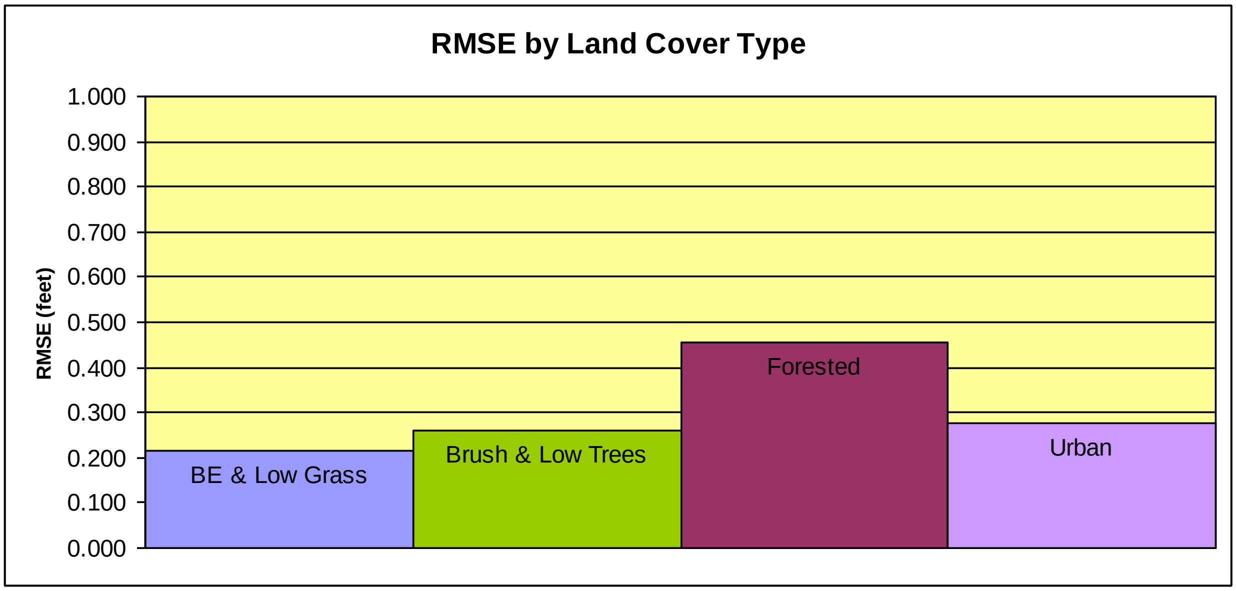



**Figure 4 — $RMSE_z$ statistics by Land Cover Category**

**Table 4 — Overall Descriptive Statistics by Land Cover Category and Consolidated**

| Descriptive Statistics | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Land Cover Category** | **Points** | **RMSE (feet)** | **Mean Error (feet)** | **Median Error (feet)** | **SKEW** | **STDEV (feet)** | **95th Percentile (feet)** |
| Consolidated | 131 | 0.32 | -0.03 | -0.05 | 0.75 | 0.32 | 0.66 |
| BE & Low Grass | 37 | 0.21 | -0.10 | -0.11 | 0.16 | 0.19 | 0.39 |
| Brush & Low Trees | 35 | 0.26 | -0.04 | -0.04 | -0.47 | 0.26 | 0.48 |
| Forested | 35 | 0.47 | 0.14 | 0.19 | 0.14 | 0.46 | 0.78 |
| Urban | 24 | 0.26 | -0.14 | -0.16 | 0.03 | 0.23 | 0.54 |

**Fundamental and Consolidated Vertical Accuracy at 95% confidence level, using NSSDA/FEMA methodology:**

Although the NSSDA and FEMA guidelines predated FVA and CVA terminology, vertical accuracy at the 95% confidence level (called $Accuracy_z$) is computed by the formula $RMSE_z$ x 1.9600. $Accuracy_z$ in open terrain = 0.21ft x 1.9600 = 0.41 ft, satisfying the 0.60 ft FVA standard. $Accuracy_z$ in consolidated categories = 0.32 ft x 1.9600 = 0.66 ft, satisfying the 1.19 ft CVA standard.

Figure 5 illustrates a histogram of the associated elevation discrepancies between the QA/QC checkpoints and elevations interpolated from the LiDAR triangulated irregular network (TIN). The frequency shows the number of discrepancies within each band of elevation differences. Although the discrepancies vary between a low of -0.72 ft and a high of +1.21 ft, the histogram shows that slightly more of the discrepancies are skewed on the positive side of what would be a "bell curve," with mean of zero, if the data were truly normally distributed. Typically the discrepancies tend to skew a bit more to the positive side, because discrepancies in vegetation are typically positive.

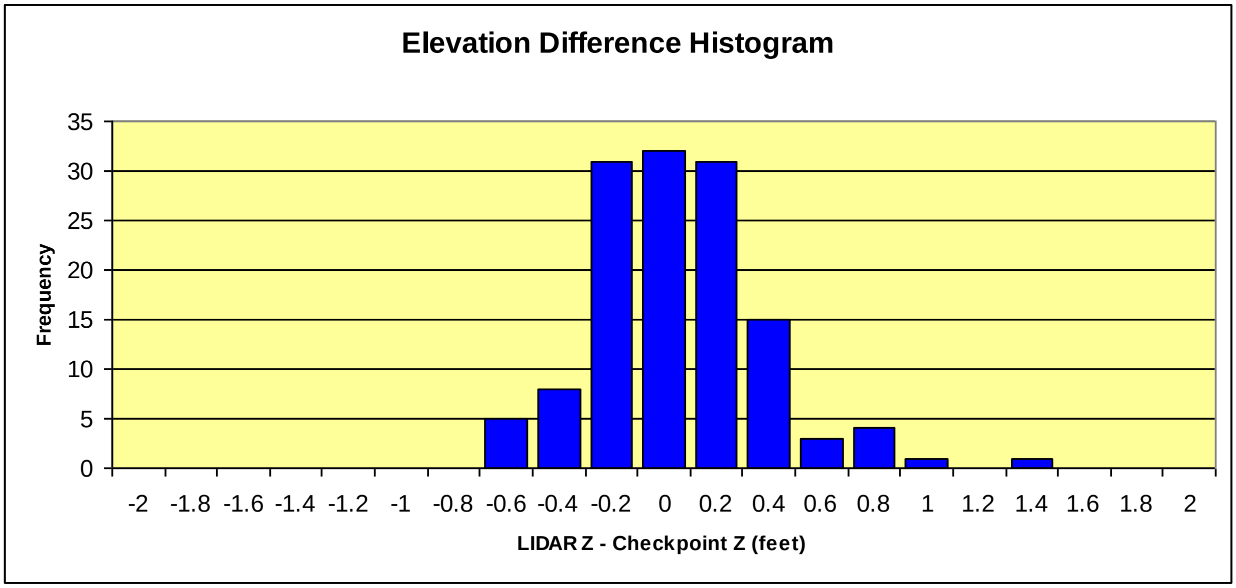


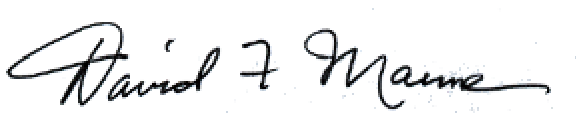

**Figure 5 — Histogram of Elevation Discrepancies within 0.20 ft Bands**

## Conclusions

**Based on the vertical accuracy testing conducted by PDS, the undersigned certifies that the LiDAR dataset for Gulf County, Florida satisfies the criteria established by Reference A:**

- **Based on NSSDA, FEMA, NDEP and ASPRS methodology: Tested 0.41' vertical accuracy at 95% confidence level in open terrain.**

- **Based on NSSDA, FEMA, NDEP and ASPRS methodology: Tested 0.66' vertical accuracy at 95% confidence level in all land cover categories combined.**



David F. Maune, Ph.D., PSM, PS, GS, CP
QA/QC Manager

# Appendix G: LiDAR Qualitative Assessment Report

**References:**

A ─ State of Florida Division of Emergency Management (FDEM), Contract Number 07-HS-34-14-00-22-469, Task Order Number 20070525-492718a

B ─ Part 3: *National Standard for Spatial Data Accuracy (NSSDA)*, “Geospatial Positioning Accuracy Standards,” published by the Federal Geographic Data Committee (FGDC), 1998

C ─ Appendix A, *Guidance for Aerial Mapping and Surveying*, “Guidelines and Specifications for Flood Hazard Mapping Partners,” published by the Federal Emergency Management Agency (FEMA), April 2003

D ─ *Guidelines for Digital Elevation Data*, Version 1.0, published by the National Digital Elevation Program (NDEP), May 10, 2004

E ─ *ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data*, published by the American Society for Photogrammetry and Remote Sensing (ASPRS), May 24, 2004

# Qualitative Assessment

The PDS qualitative assessment utilizes a combination of statistical analysis and interpretative methodology to assess the quality of the data for a bare-earth digital terrain model (DTM). This process looks for anomalies in the data and also identifies areas where man-made structures or vegetation points may not have been classified properly to produce a bare-earth model. Overall the data are of good quality and should satisfy most users for an accurate bare-earth elevation data product.

## Overview

Within this review of the LiDAR data, two fundamental questions were addressed:

- Did the LiDAR system perform to specifications?
- Did the vegetation removal process yield desirable results for the intended bare-earth terrain product?

Mapping standards today address the quality of data by quantitative methods. If the data are tested and found to be within the desired accuracy standard, then the data set is typically accepted. Now with the proliferation of LiDAR, new issues arise due to the vast amount of data. Unlike photogrammetry where point spacing can be eight meters or more, LiDAR point spacing for this project is one meter or less. The end result is that millions of elevation points are measured to a level of accuracy previously unseen for elevation technologies, and vegetated areas are measured that would be nearly impossible to survey by other means. The downside is that with millions of points, the data set is statistically bound to have some errors both in the measurement process and in the vegetation removal process.

As previously stated, the quantitative analysis addresses the quality of the data based on absolute accuracy. This accuracy is directly tied to the comparison of the discreet measurement of the survey checkpoints and that of the interpolated value within the three closest LiDAR points that constitute the vertices of a three-dimensional triangular face of the TIN. Therefore, the end result is that only a small sample of the LiDAR data is actually tested. However there is an increased level of confidence with LiDAR data due to the relative accuracy. This relative accuracy in turn is based on how well one LiDAR point "fits" in comparison to the next contiguous LiDAR measurement. Once the absolute and relative accuracy has been ascertained, the next stage is to address the cleanliness of the data for a bare-earth DTM.

By using survey checkpoints to compare the data, the absolute accuracy is verified, but this also allows us to understand if the vegetation removal process was performed correctly. To reiterate the quantitative approach, if the LiDAR operated correctly in open terrain areas, then it most likely operated correctly in the vegetated areas. This does not mean that the bare-earth was measured, but that the elevations surveyed are most likely accurate (including elevations of treetops, rooftops, etc.). In the event that the LiDAR pulse filtered through the vegetation and was able to measure the true surface (as well as measurements on the surrounding vegetation) then the level of accuracy of the vegetation removal process can be tested as a by-product.

To fully address the data for overall accuracy and quality, the level of cleanliness is paramount. Since there are currently no effective automated testing procedures to measure cleanliness, PDS employs a combination of statistical and visualization processes. This includes creating pseudo image products such as LiDAR orthos produced from the intensity returns, Triangular Irregular Network (TIN)'s, Digital Elevation Models (DEM) and 3-dimensional models. By creating multiple images and using overlay techniques, not only can potential errors be found, but the PDS team can also find where the data meets and exceeds expectations. This report will present representative examples where the LiDAR and post processing had issues as well as examples of where the LiDAR performed well.

# Analysis

## Process

PDS utilizes GeoCue software products as the primary geospatial process management system. GeoCue is a three tier multi-user architecture that uses .NET technology from Microsoft. .NET provides the real-time notification system that provides users with up-to-the second project status, regardless of who makes changes to project entities. GeoCue uses database technology for sorting project metadata. PDS uses Microsoft SQL Server as the database of choice.

The PDS qualitative assessment process flow incorporates the following reviews:

*Statistical Analysis*- A statistical analysis routine is run on the .LAS files upon receipt to verify that the .las files meet project specifications. This routine checks for the presence of Variable Length Records, verifies .las classifications, verifies header records for min/max x,y,z, and parses the .las point file to confirm min/max x,y,z matches the header records. These statistics are run on the all return point data set as well as the bare-earth point data set for every deliverable tile.

*Spatial Reference Checks*- The .las files are imported into the GeoCue processing environment. As part of the URS process workflow the GeoCue import produces a minimum bounding polygon for each data file. This minimum bounding polygon is one of the tools used in conjunction with the statistical analysis to verify spatial reference integrity.

*Data Void/ Gap Checks*-The imported .las files are used to create LiDAR "Orthos". The LiDAR "Orthos" are one of the tools used to verify data coverage. The standard QA process flow uses Data Point Elevation and LiDAR pulse return intensity returns. The intensity returns are used as delivered with no normalization. For Gulf County the final product is a 1 foot pixel produced from the All Return Data Set. The maximum density area allowed to generate the pixel is 16 feet. This product is produced to review the lidar collection to verify data density and to review Data Gaps/Data Voids. It is also used as a reference image during the artifact checks. It is not intended as a final product. (Figures 1 and 2)

Overall, Gulf County met the density requirement.

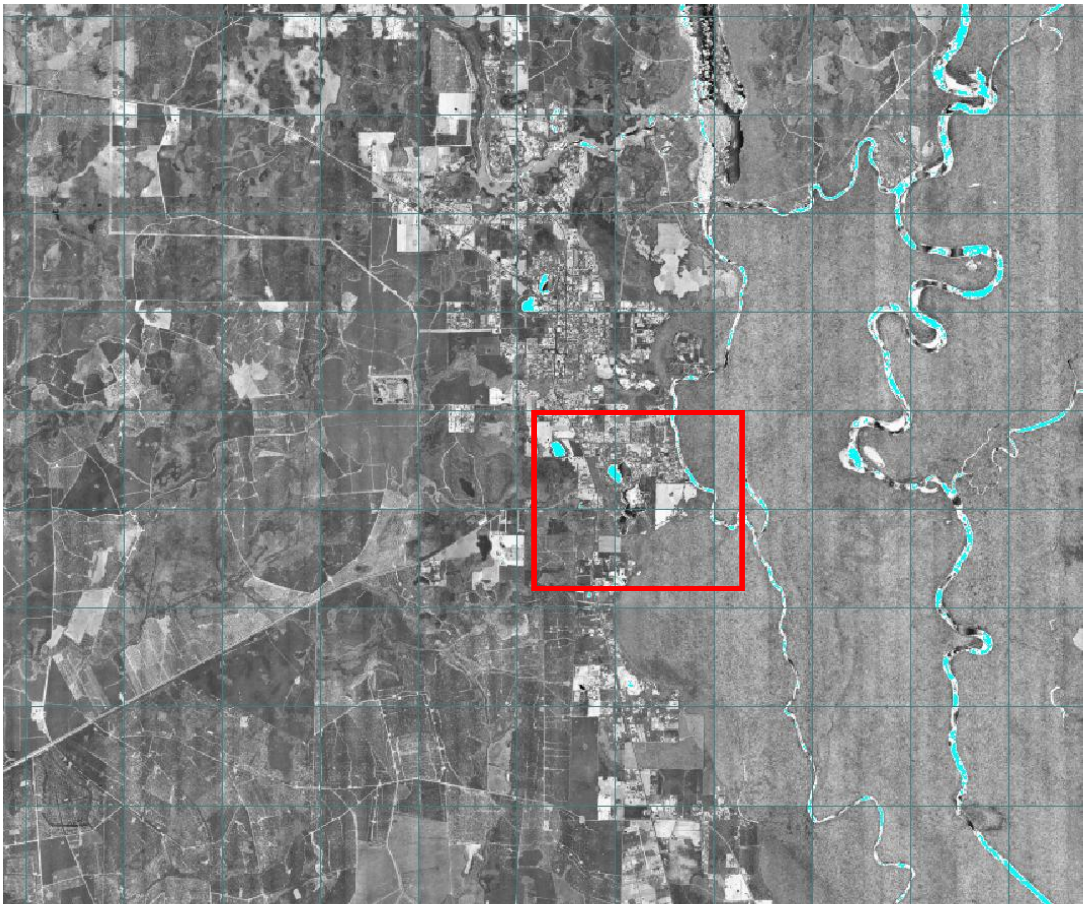


**Figure 4: Lidar Ortho sample from Gulf County. Areas in Blue are acceptable. Data voids are caused by ponds, streams or water bodies.**

**Figure 5: Tiles LID_061740-061741. Zoom showing water bodies**

*Initial Data Verification:* PDS performs an initial 10% random check of the data delivery by looking at each tile individually in great detail utilizing TIN surfaces and profiles. If the data set passes the 10 % the tiles continue through the process work flow where every tile is reviewed. If the data set fails the 10% check it is normally due to a systematic process error and the data set is rejected.

*Data Density/Elevation checks:* The .las files are used to produce a Digital Elevation Model. These DEMs are produced using the software package QT Modeler which produces a 3dimensional data model. This data model is created from the Class 2 ground points using the project density deliverable requirement for unobscured areas.

The QC for Gulf County was done at the most stringent data density requirement. For the FDEM project this requirement was that Lidar point cloud data meet a maximum post spacing of 4 ft in unobscured areas for random point data. Model statistics were produced and characterized by density as well as elevation. This data model is created from class 2 ground points and model statistics are characterized by density, scale, intensity as well as elevation. (Figure 3) The low confidence area polygons are referenced with the density grids to ensure that all low confidence areas are properly identified with a low confidence area polygon. Again, these products are produced for Quality Assessment purposes

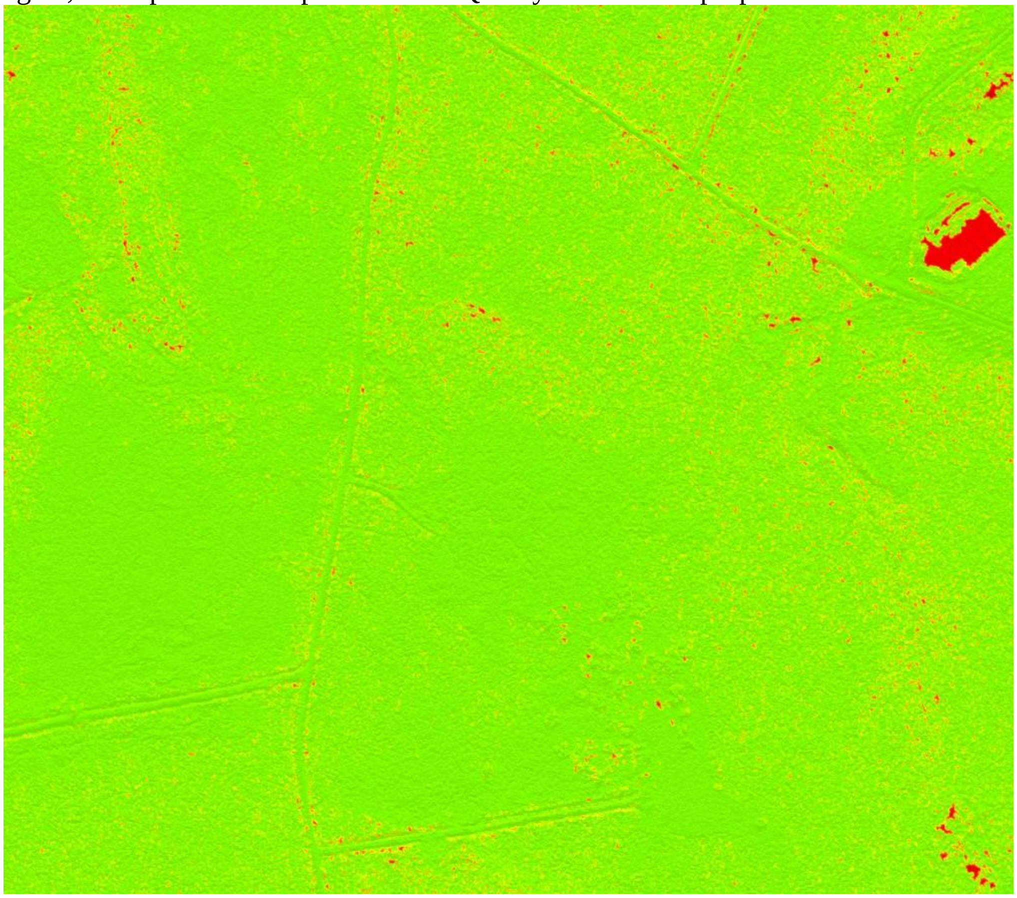


**Figure 6: Sample density grid. Zoom of area with dense vegetation. Density grids were created at a 4 foot cell size using a green to red color ramp. Green areas indicate that the grid meets the 4 foot specification. Yellow to Red indicates that the 4 foot specification is not met.**

*Artifact Anomaly Checks.* The final step is to review every tile for anomalies that may exist in the bare-earth terrain surface. Items that are checked include, but are not limited to: buildings, bridges, vegetation and water points classified as Class 2 points and elevation "steps" that may occur in the overlap between adjacent flight lines.

### General comments and issues.

Gulf County, Florida is characterized by heavy vegetation, marshes and swamp areas. There are few developed and urban areas. There are no national or state forests and the state parks are located off of the mainland (Figure 4).

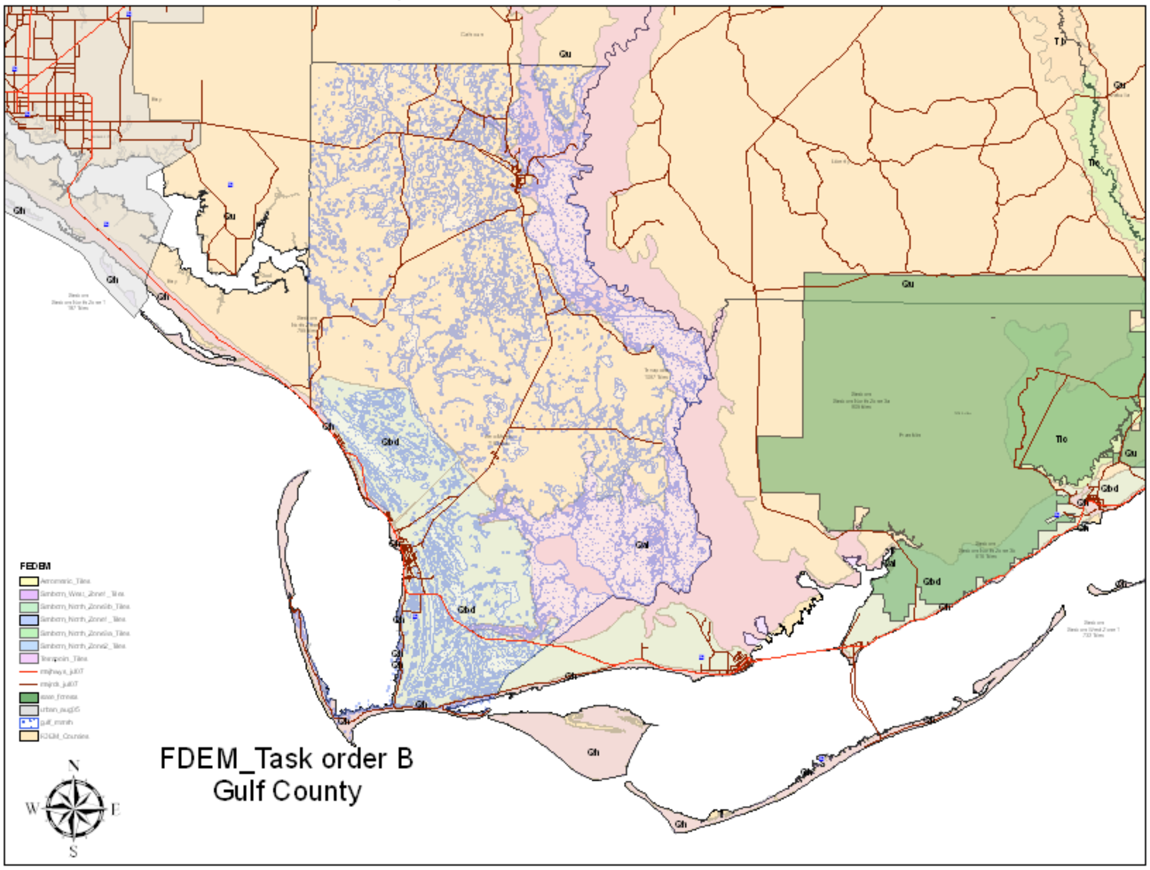



**Figure 7: Map of Gulf County, Florida with marsh areas from Florida Geographic Data Library (FGDL)**

The concern with this lidar collection for the final product is that the lidar should penetrate through the vegetation to produce the contract specifications for open terrain. Because of the heavy vegetation, defined low confidence areas are critical due to the deliverable requirement for topography (contours).

The initial data acquisition was very dense. Overall the acquired point density was around 1 foot. In general, the ground data set was clean in what is defined as low confidence areas or areas of significant heavy vegetation. (See Figure 5 and 6) The algorithms used to classify and filter to ground points were very stringent.  Given the overall physical characteristics of the county this does not seem inappropriate.  There is a fine line in the decision-making process for determining which points to classify as ground. By removing points from the ground classification due to heavy vegetation there is risk of over-smoothing or "flattening" the ground surface which can have a greater impact than leaving points to maintain the ground surface model. (Figure 5 and 6) In addition, due to the lack of significant elevation changes in the physical terrain there are places where there is no visible break in the terrain between the ground surface and what in traditional mapping would be considered a hard breakline feature, for example, roads. Because the project includes the collection of breaklines, this will be compensated for in the road breakline collection. The lidar data contained sporadic issues such as artifacts or small anomalies which is typical of any lidar dataset. The low confidence area polygons and breakline acquisition is an important deliverable for this particular county.

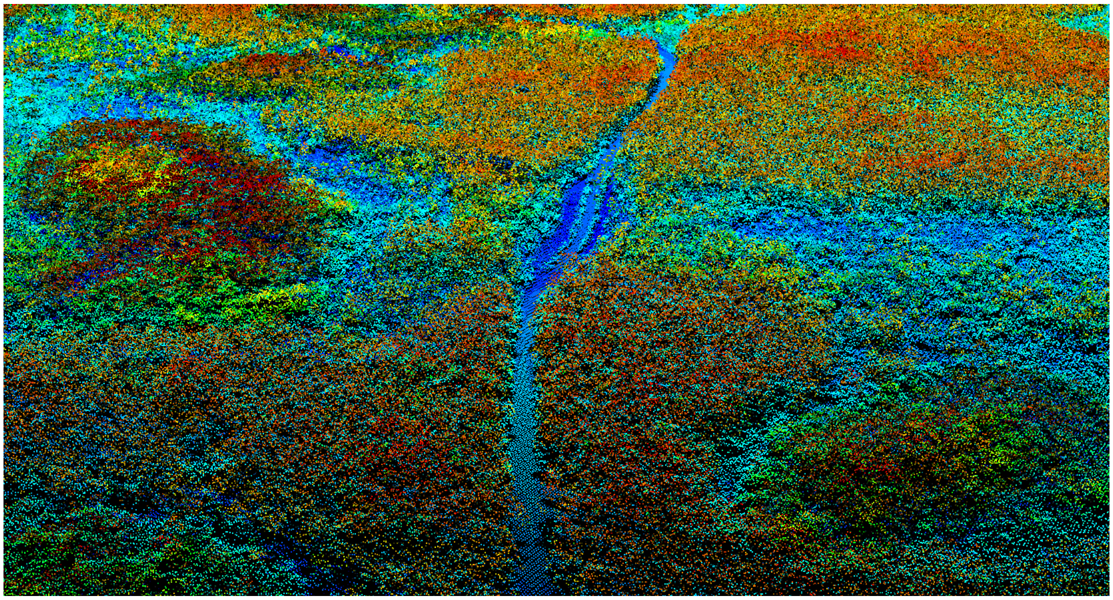


**Figure 8: Tile 060117 example of heavy vegetation in Gulf County, Florida**

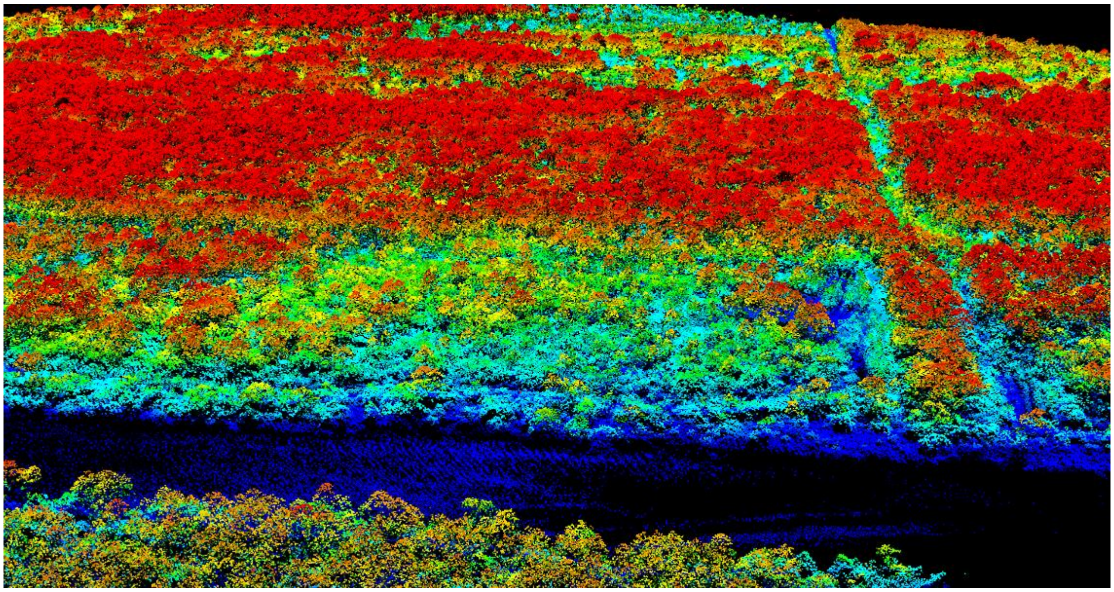


**Figure 9: Tile 070914 example of vegetation along stream channel in Gulf County, Florida**

Examples of impact of vegetation density:

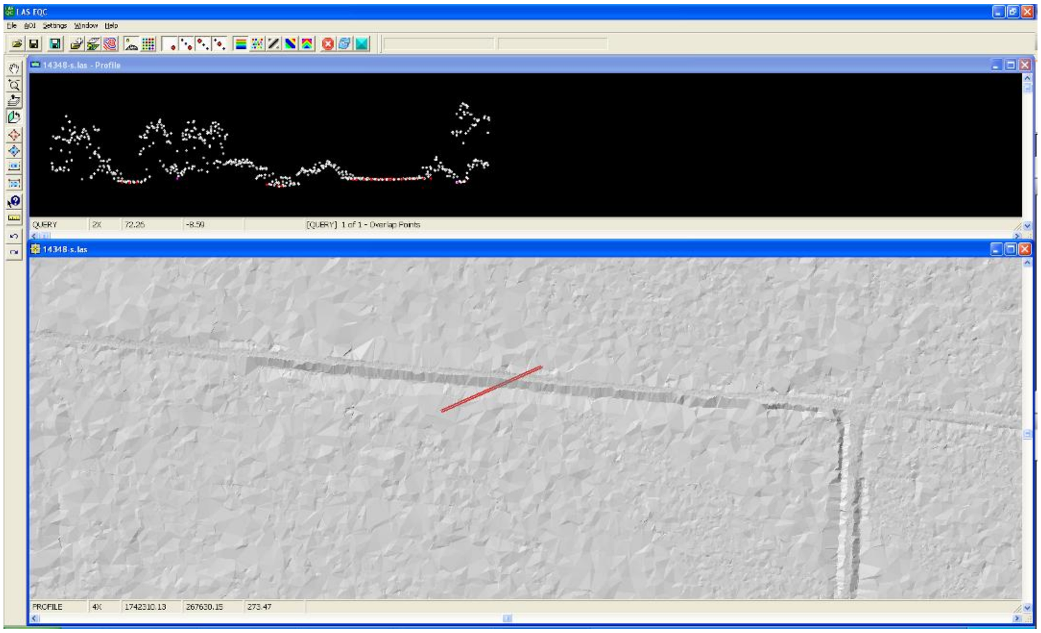


**Figure 10: Tile 075779 example of vegetation at road edge. Dense vegetation growth at road edge did not allow much ground point penetration, breaklines are necessary to define road edges for contour generation.**

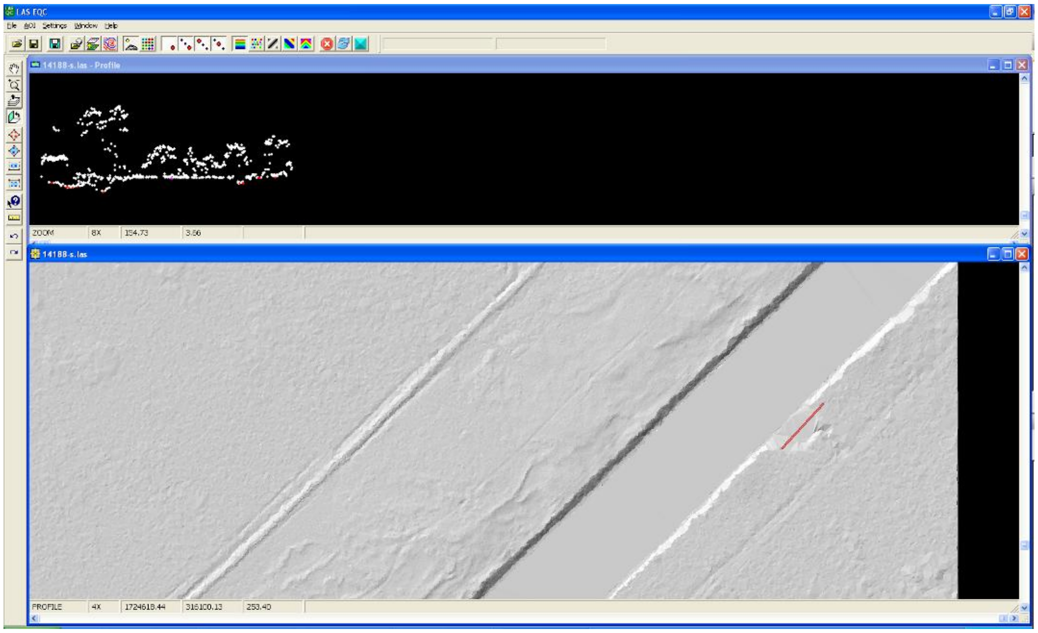


**Figure 11: Tile 07375 example of high vegetation at stream channel edge. Dense vegetation at stream channels caused some areas to be “over-smoothed”. Breakline collection is necessary to clearly define stream channels.**

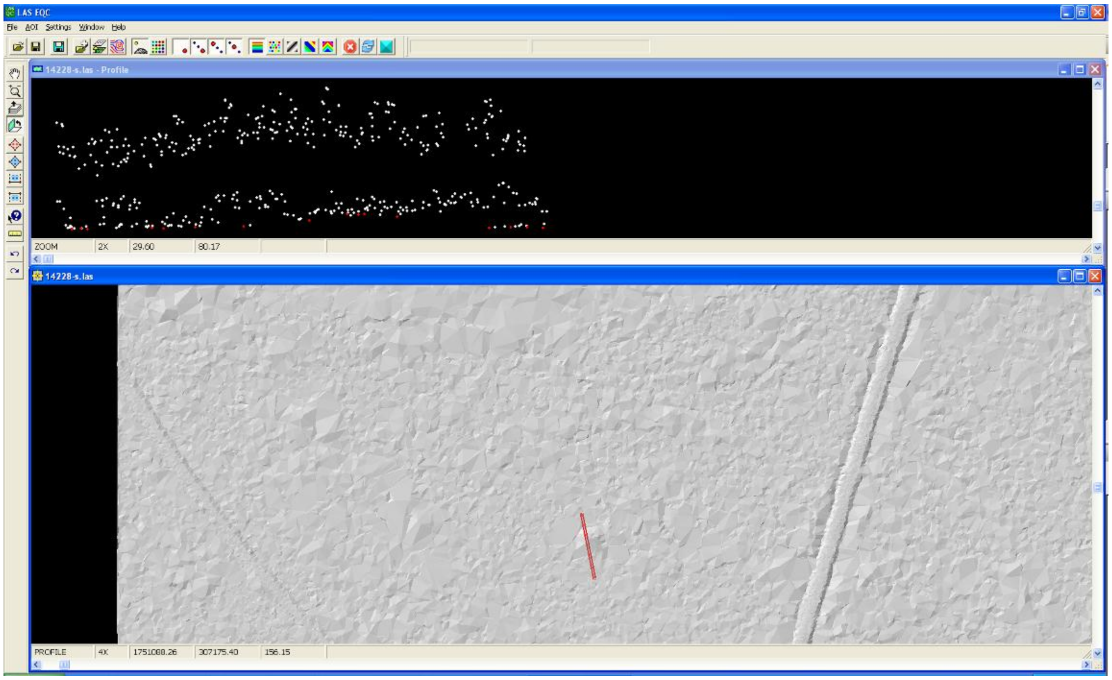



**Figure 12: Tile 071461 example of dense high vegetation and understory causing issues with ground penetration. These areas are defined as low confidence areas.**

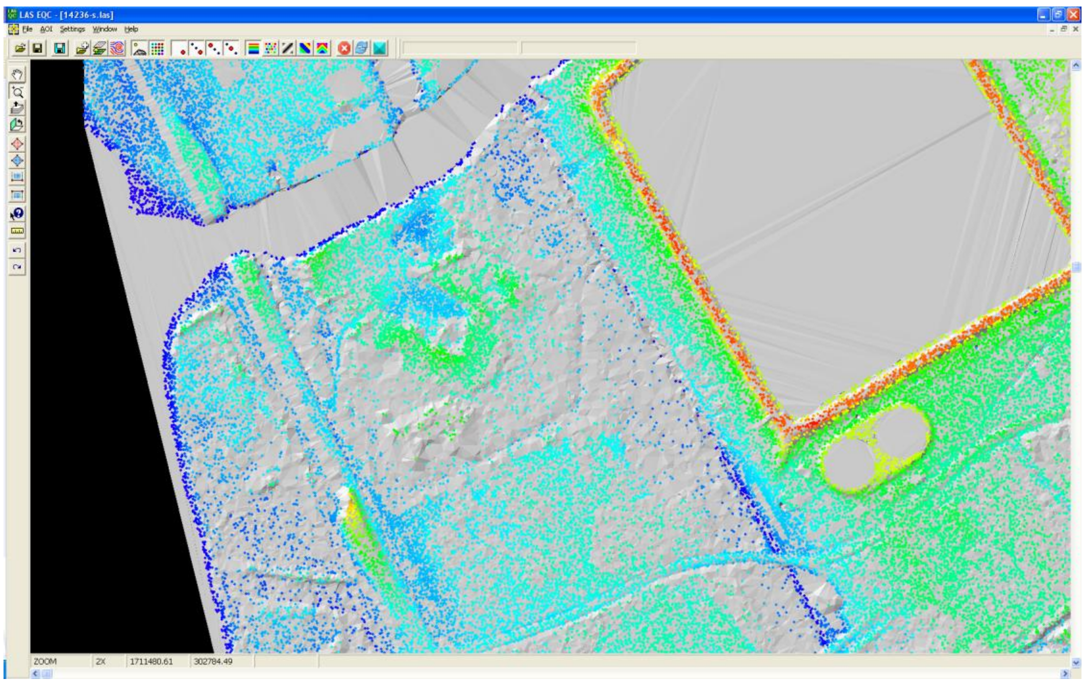



**Figure 13: Tile 071993 example of ground points overlaying the TIN. Lidar ground points coverage maintained the berms and roads in the TIN, but density is impacted in heavily vegetated areas.**

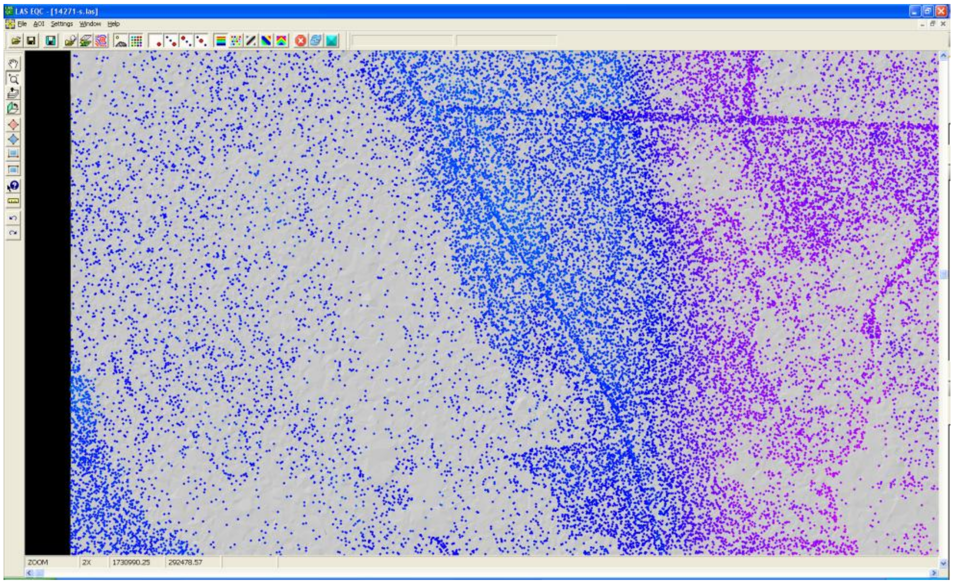


**Figure 14: Tile 073077- Ground points overlayed on TIN. Dense vegetation caused ground penetration issues in possible marsh area.**

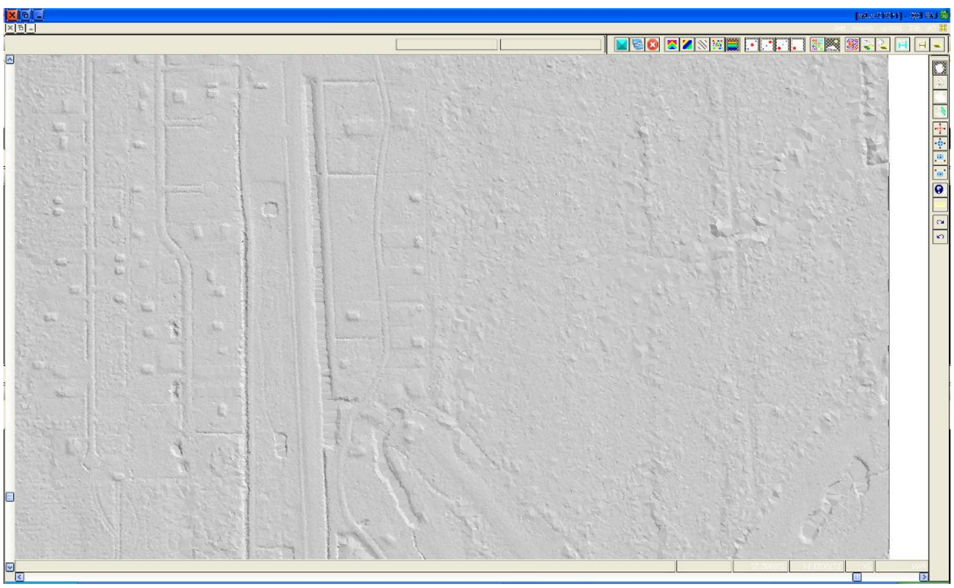


**Figure 15: Tile 074694 Tin created from bare earth file. Roads, driveways, etc. are clearly defined. Areas with heavy vegetation are noisy.**

## Conclusion

Overall the data meets the project specifications. The processing performed well given the low relief and highly vegetated areas. The dense data collection specification helped with vegetation penetration. There are some minor issues but they are not a detriment to a usable data product.

# Appendix H: Breakline/Contour Qualitative Assessment Report

**Coastal Shorelines**

Coastal shorelines are correctly captured as two-dimensional linear features, extracted from the LiDAR data and not from digital orthophotos, except for manmade features with varying heights such as seawalls which are captured as three-dimensional breaklines. Coastal breaklines merge seamlessly with linear hydrographic features. Shorelines continue beneath docks and piers. There is no “stair-stepping” of coastal shorelines. Figure 1 shows example coastal breaklines and contours.

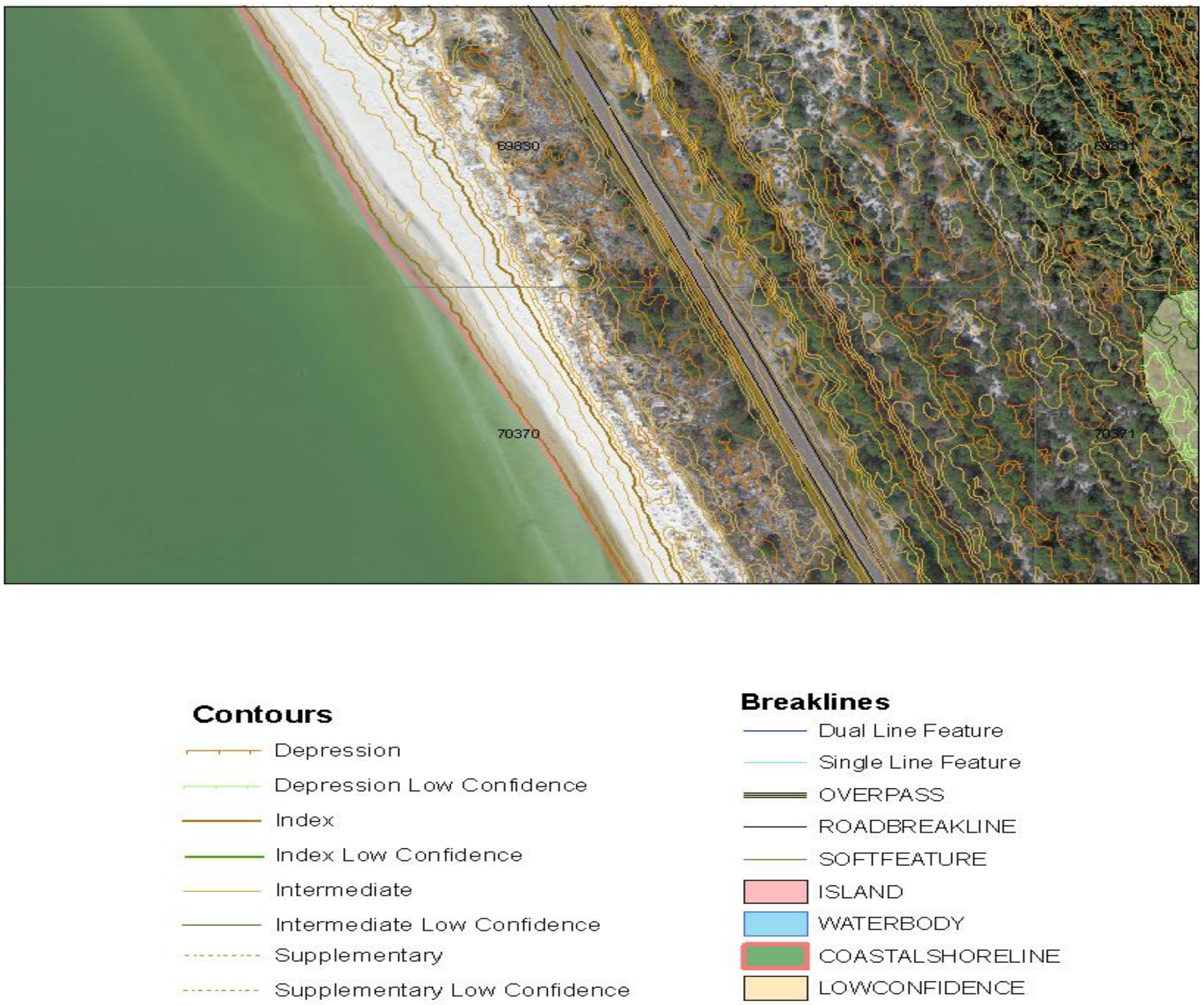



**Figure 1. Example coastal breaklines and contours from tile # 70370**

**Linear Hydrographic Features**

Linear hydrographic features are correctly captured as three-dimensional breaklines – single line features if the average width is 8 feet or less and dual line features if the average width is greater than 8 feet. Each vertex maintains vertical integrity. Figure 2 shows example breaklines and contours of linear hydrographic features.

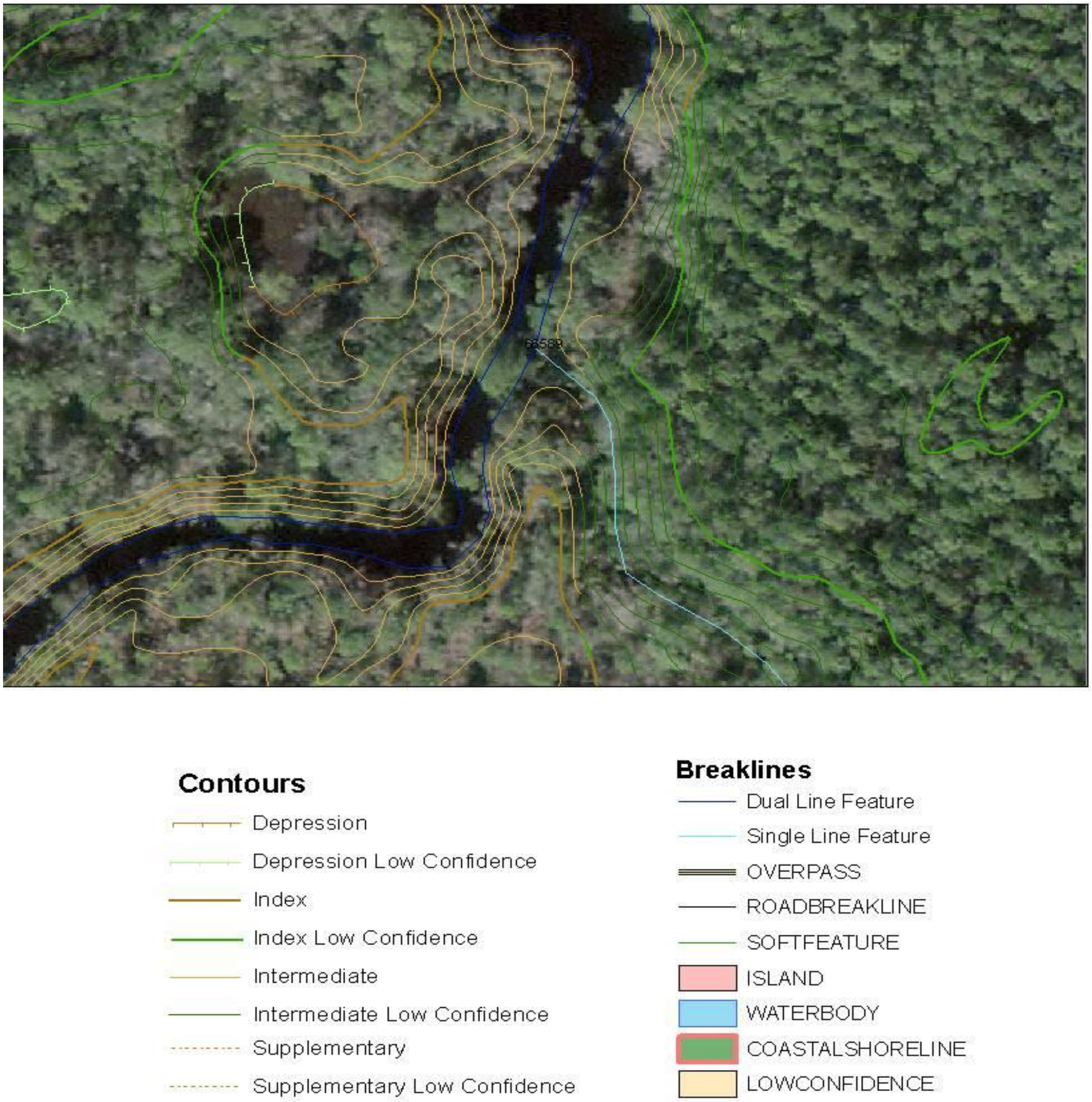



**Figure 2. Example linear hydrographic feature breaklines and contours from tile # 68589**

**Closed Water Body Features**

Closed water body features with an area of one-half acre or greater are correctly captured as two-dimensional closed polygons with a constant elevation that reflects the best estimate of the water elevation at the time of data capture. "Donuts" exist where there are islands within a closed water body feature. Figure 3 shows example breaklines and contours of closed water body features.

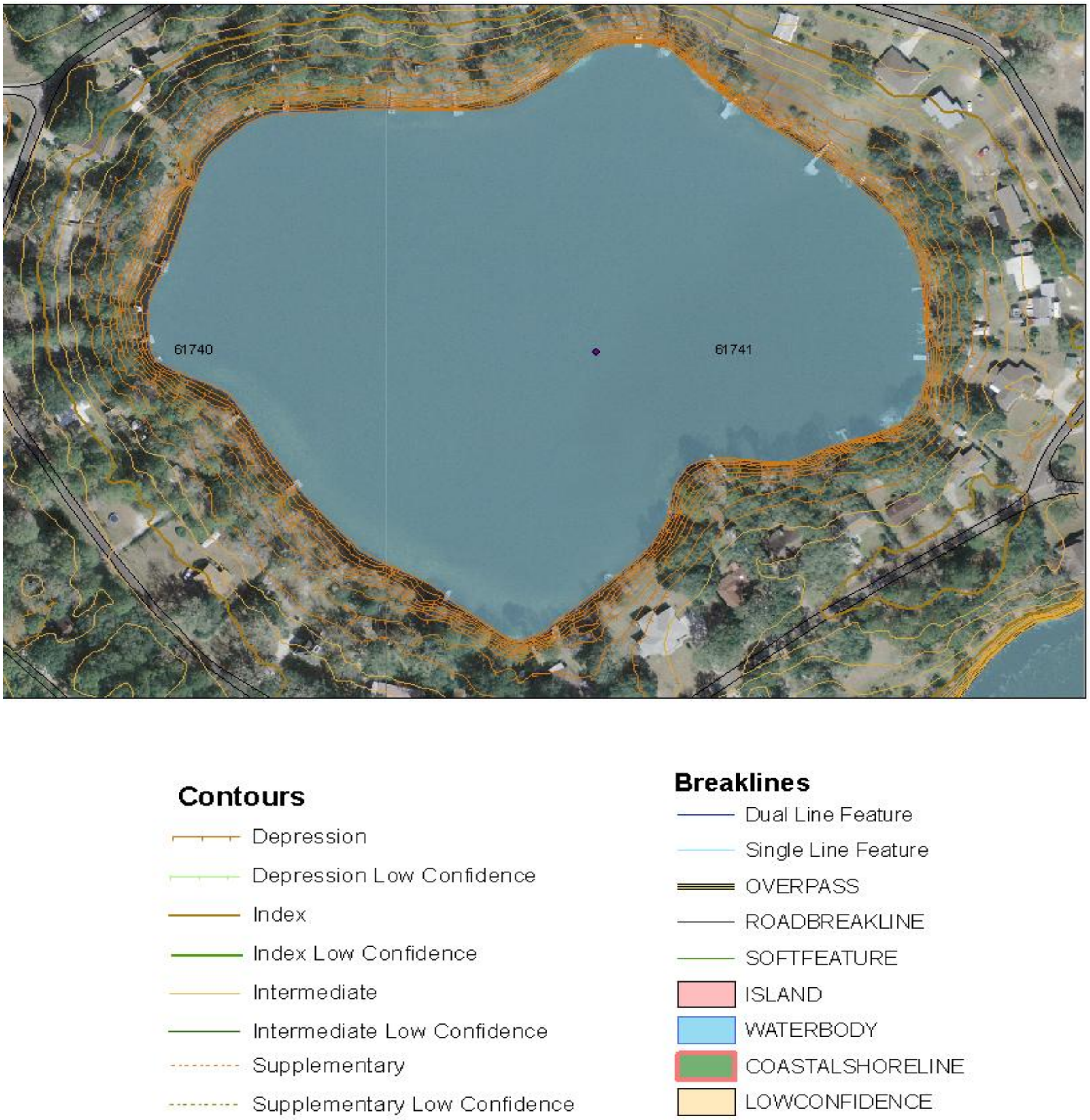



**Figure 3. Example closed water body feature breaklines and contours from tile # 61741 & 61740**

**Road Features**

Road edge of pavement features are correctly captured as three-dimensional breaklines on both sides of paved roads. Box culverts are continued as edge of pavement unless a clear guardrail system is in place; in that case, culverts are captured as a bridge or overpass feature. Each vertex maintains vertical integrity. Figure 4 shows example breaklines and contours of road features.


**Figure 4. Example road feature breaklines and contours from tile 72533**

**Bridge and Overpass Features**

Bridges and overpasses are correctly captured as three-dimensional breaklines, capturing the edge of pavement on the bridge, rather than the elevation of guard rails or other bridge surfaces. Each vertex maintains vertical integrity.  Figure 5 shows example breaklines and contours of bridge and overpass features.


**Figure 5. Example bridge and overpass feature breaklines and contours from tile # 71993**

## Soft Features

Soft features such as ridges, valleys, top of banks, etc. are correctly captured as three-dimensional breaklines so as to support better hydrological modeling of the LiDAR data and contours. Each vertex maintains vertical integrity. Figure 6 shows example breaklines and contours of soft features.

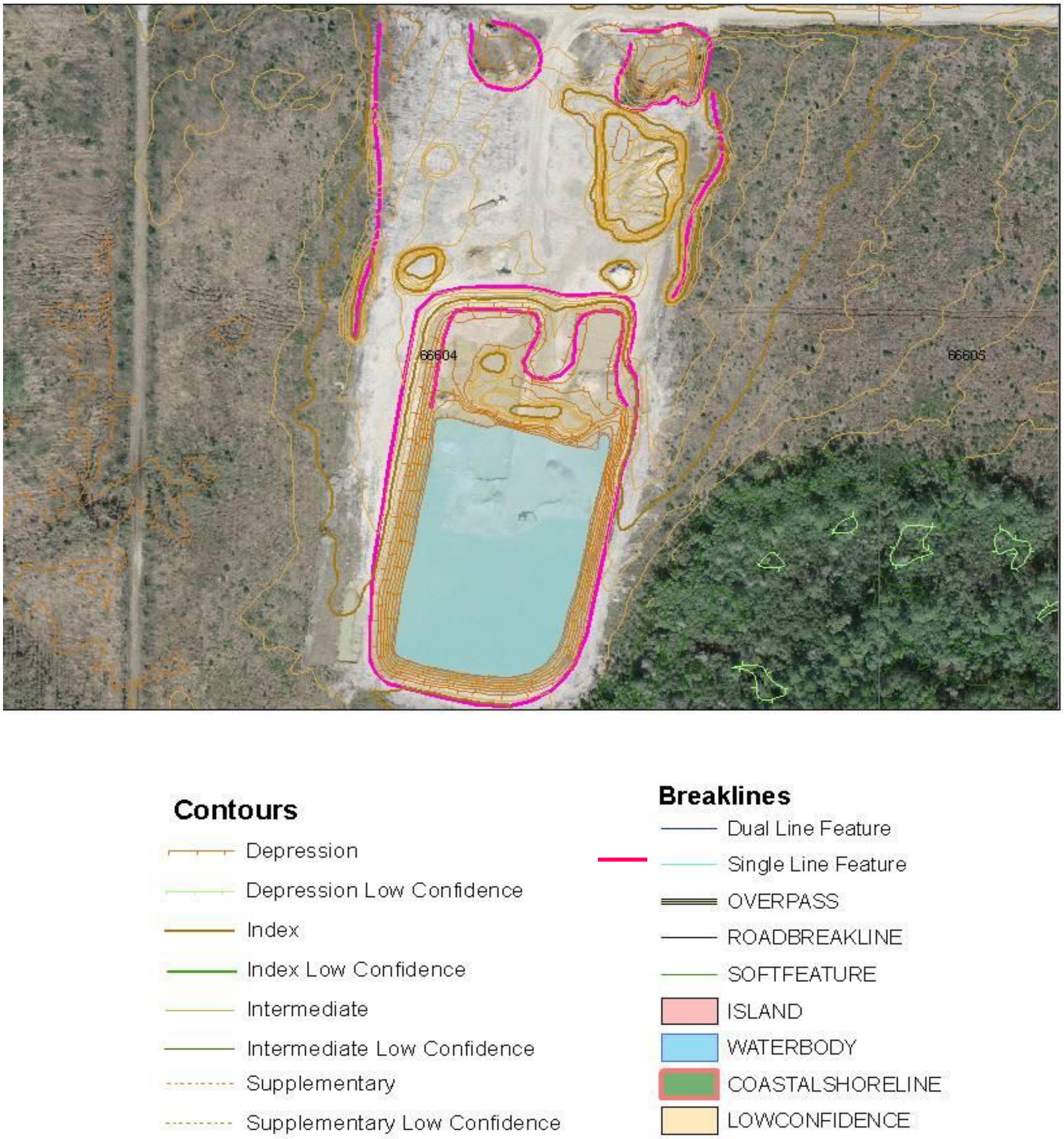



**Figure 6. Example soft feature breaklines and contours from tile # 66604**

**Island Features**

The shoreline of islands within water bodies are correctly captured as two-dimensional breaklines in coastal and/or tidally influenced areas and as three-dimensional breaklines in non-tidally influenced areas for island features one-half acre in size or greater. All natural and man-made islands are depicted as closed polygons with constant elevation. Figure 7 shows example breaklines and contours for island features.

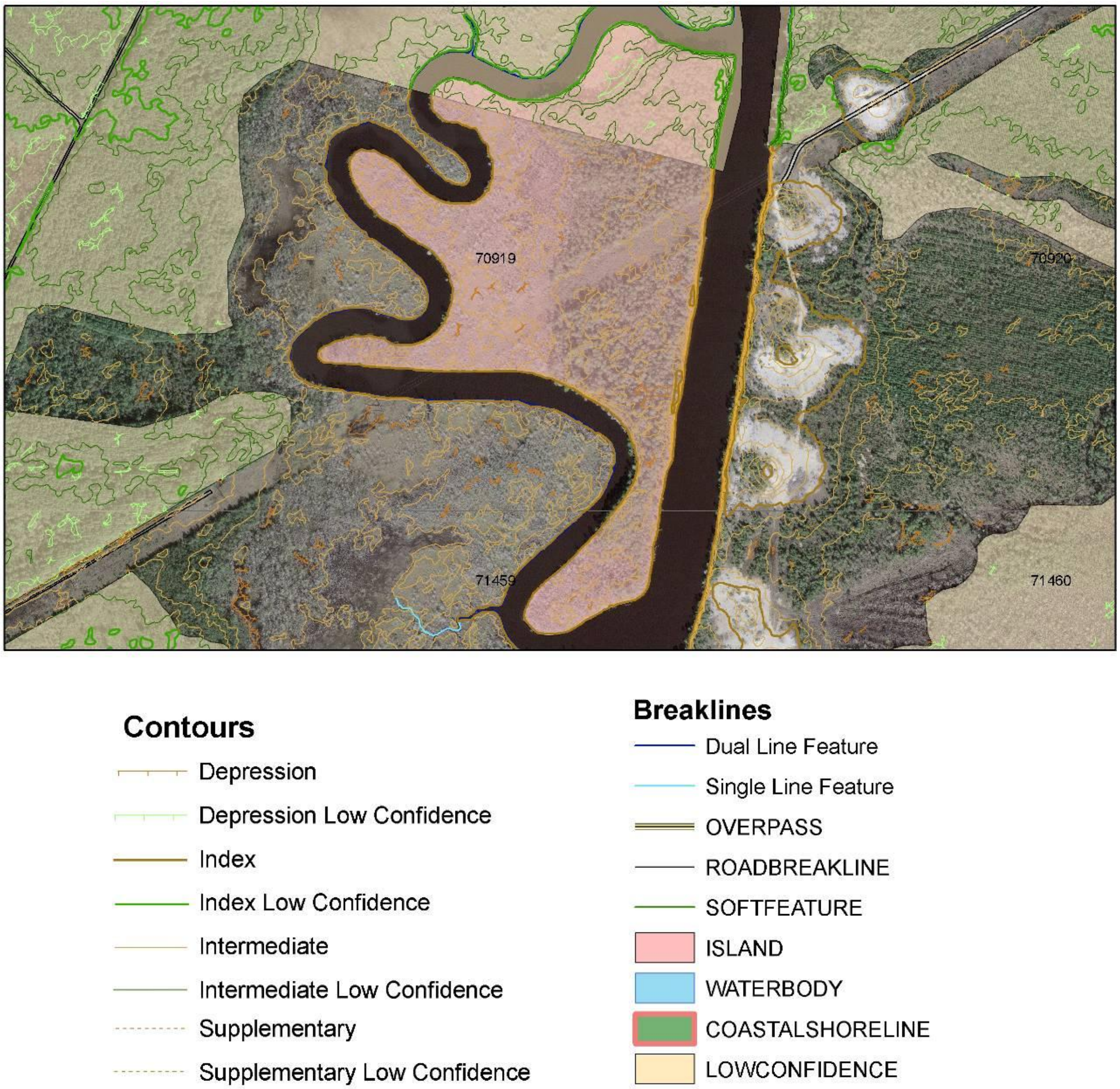



**Figure 7. Example island feature breaklines and contours from tile # 70919**

**Low Confidence Areas**

The apparent boundary of vegetated areas (1/2 acre or larger) that are considered obscured to the extent that adequate vertical data cannot be clearly determined to accurately define the DTM are correctly captured as two-dimensional features with no z-values. Figure 8 shows example breaklines and contours for low confidence areas.

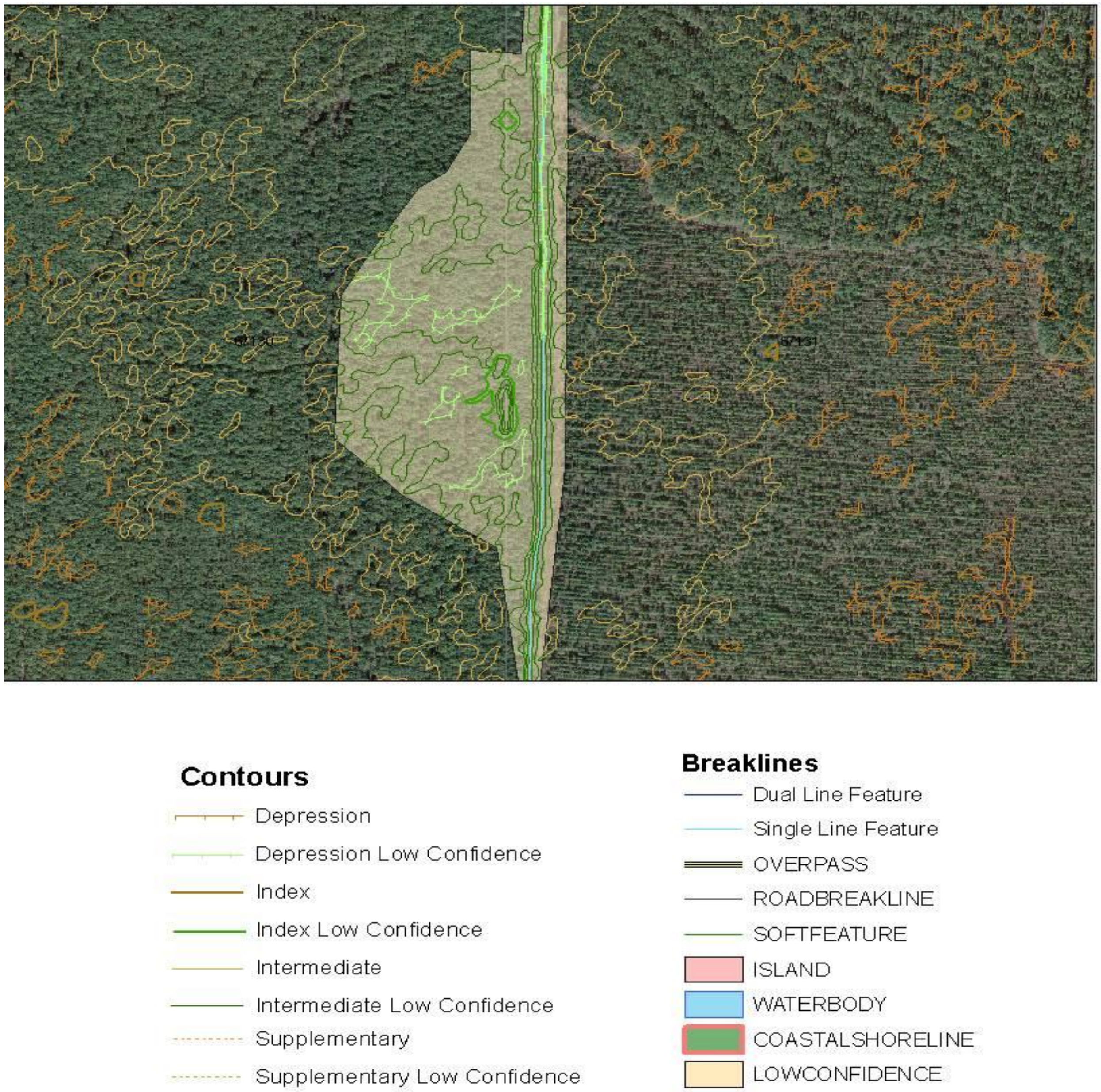



**Figure 8. Example low confidence area feature breaklines and contours from tile # 67130**

# Appendix I:  Geodatabase Structure