Dewberry®

PROJECT REPORT

For the

NRCS Virginia LiDAR Project

USGS Contract:

G10PC00013

Task Order Number:

G11PD00336

Prepared for:
USGS

Prepared by:
Dewberry
1000 Ashley Blvd., Suite 801
Tampa, Florida 33602-3718

Report Date: February 17, 2012

Table of Contents

Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS NRCS Virginia project area.

The LiDAR data were processed to a bare-earth digital terrain model (DTM). Detailed breaklines and bare-earth Digital Elevation Models (DEMs) were produced for the project area. Data was formatted according to tiles with each tile covering an area of 5000 ft by 5000 ft. A total of 1,327 tiles were produced for the project encompassing an area of approximately 1,071 sq. miles.

The Project Team

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry processed the LAS tiles to the initial ground classification. BAE Systems then performed the manual LAS classification, breakline collection, and production of the bare-earth DEMs. Dewberry was responsible for the final quality review of all project deliverables, including vertical accuracy testing. Dewberry prepared the final project reports and metadata.

Dewberry's IES offices completed ground surveying for the project and delivered surveyed checkpoints. Their task was to acquire surveyed checkpoints for the project to use in independent testing of the vertical accuracy of the LiDAR-derived surface model. Note that a separate Survey Report was created for this portion of the project.

The Atlantic Group completed LiDAR data acquisition and data calibration for 1,071 square miles covering the project area.

Survey Area

The project area addressed by this report falls within the Virginia counties of Augusta, Waynesboro, Staunton, Harrisonburg, Rockingham, and Shenandoah Counties.

Date of Survey

The LiDAR aerial acquisition was conducted from Apr. 7, 2011 thru April 30, 2011.

Datum Reference

Data produced for the project were delivered in the following reference system.

Horizontal Datum: The horizontal datum for the project is North American Datum of 1983 (NAD 83) HARN

Vertical Datum: The Vertical datum for the project is North American Vertical Datum of 1988 (NAVD88)

Coordinate System: Virginia State Plane Coordinate System, North Zone

Units: Horizontal units are in US Survey Feet, Vertical units are in Feet.

Geiod Model: Geoid09 (Geoid 09 was used to convert ellipsoid heights to orthometric heights).

LiDAR Vertical Accuracy

For the USGS NRCS Virginia LiDAR Project, the tested $RMSE_z$ for checkpoints in open terrain equaled **0.24 ft** compared with the 0.31 ft specification; and the FVA computed using $RMSE_z$ x 1.9600 was equal to **0.47 ft**, compared with the 0.61 ft specification.

For the USGS NRCS Virginia LiDAR Project, the tested CVA computed using the 95th percentile was equal to **0.95 ft,** compared with the 1.21 ft specification.

Project Deliverables

The deliverables for the project are listed below.

1. Raw Point Cloud Data (Swaths)
2. Classified Point Cloud Data (Tiled)
3. Bare Earth Surface (Raster DEM – IMG Format)
4. Control & Accuracy Checkpoint Report & Points
5. Metadata
6. Project Report (Acquisition, Processing, QC)
7. Project Extents, Including a shapefile derived from the LiDAR Deliverable
8. Breakline Data (File GDB)
9. Intensity Imagery (Tiled)

1 Project Tiling Footprint

One thousand three hundred and twenty-seven (1,327) tiles were delivered for the project. Each tile's extent is 5000 feet by 5000 feet.

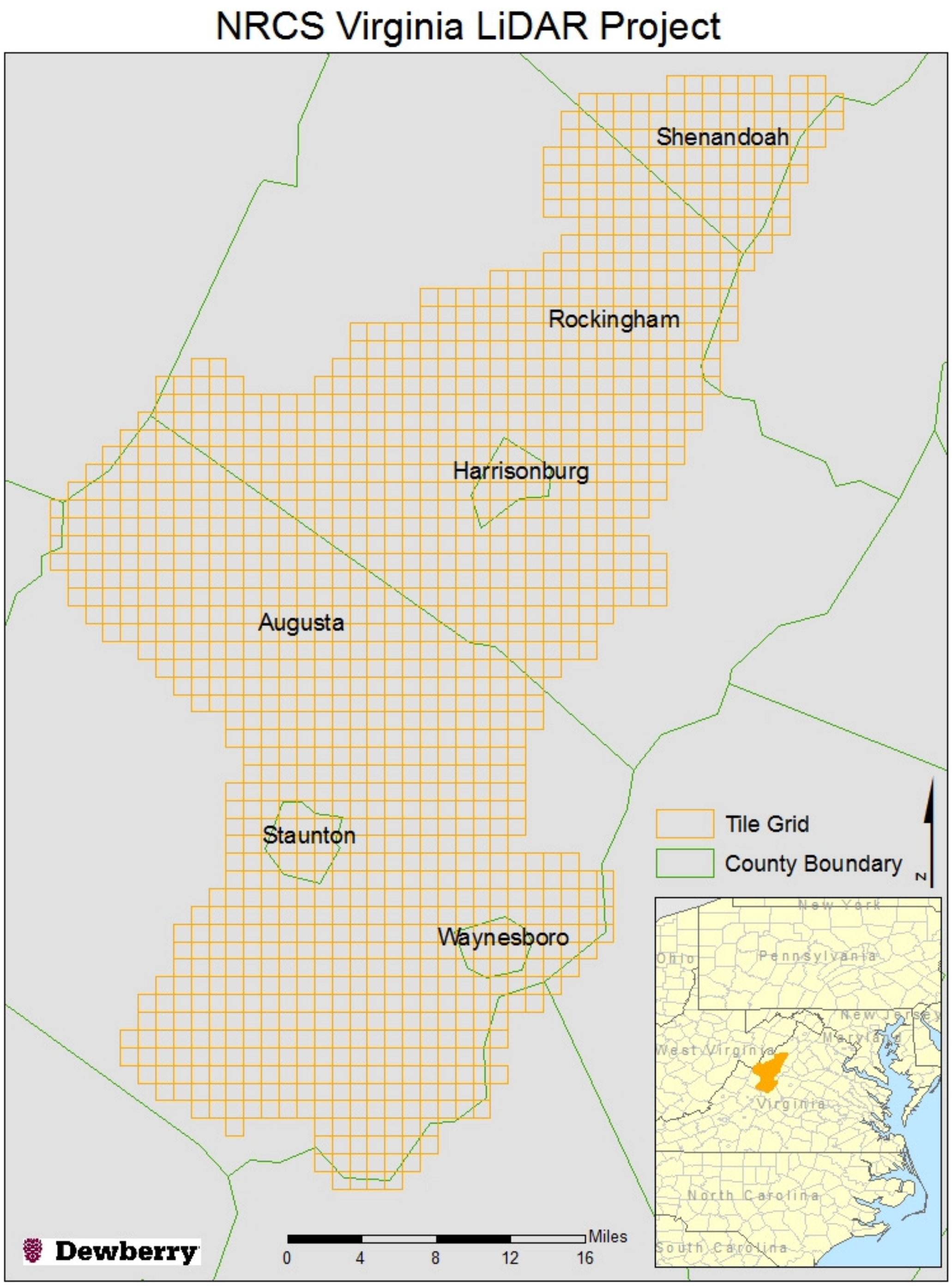


Figure 1: Project Map

1.1 List of delivered tiles (1,327):

LAS_N16_2841_30
LAS_N16_2842_40
LAS_N16_2842_30
LAS_N16_2843_40
LAS_N16_2850_20
LAS_N16_2851_10
LAS_N16_2851_20
LAS_N16_2852_10
LAS_N16_2852_20
LAS_N16_2853_10
LAS_N16_2853_20
LAS_N16_2850_40
LAS_N16_2850_30
LAS_N16_2851_40
LAS_N16_2851_30
LAS_N16_2852_40
LAS_N16_2852_30
LAS_N16_2853_40
LAS_N16_2853_30
LAS_N16_2854_40
LAS_N16_2769_20
LAS_N16_2860_10
LAS_N16_2860_20
LAS_N16_2861_10
LAS_N16_2861_20
LAS_N16_2862_10
LAS_N16_2862_20
LAS_N16_2863_10
LAS_N16_2863_20
LAS_N16_2864_10
LAS_N16_2864_20
LAS_N16_2667_30
LAS_N16_2668_40
LAS_N16_2769_30
LAS_N16_2860_40
LAS_N16_2860_30
LAS_N16_2861_40
LAS_N16_2861_30
LAS_N16_2862_40
LAS_N16_2862_30
LAS_N16_2863_40
LAS_N16_2863_30
LAS_N16_2864_40
LAS_N16_2864_30
LAS_N16_2865_40
LAS_N16_2677_10
LAS_N16_2677_20
LAS_N16_2678_10
LAS_N16_2678_20
LAS_N16_2679_10
LAS_N16_2779_10
LAS_N16_2779_20
LAS_N16_2870_10
LAS_N16_2870_20
LAS_N16_2871_10
LAS_N16_2871_20
LAS_N16_2872_10
LAS_N16_2872_20
LAS_N16_2873_10
LAS_N16_2873_20
LAS_N16_2874_10
LAS_N16_2874_20
LAS_N16_2875_10
LAS_N16_2875_20
LAS_N16_2676_30
LAS_N16_2677_40
LAS_N16_2677_30
LAS_N16_2678_40
LAS_N16_2678_30
LAS_N16_2679_40
LAS_N16_2679_30
LAS_N16_2778_30
LAS_N16_2779_40
LAS_N16_2779_30
LAS_N16_2870_40
LAS_N16_2870_30
LAS_N16_2871_40
LAS_N16_2871_30
LAS_N16_2872_40
LAS_N16_2872_30
LAS_N16_2873_40
LAS_N16_2873_30
LAS_N16_2874_40
LAS_N16_2874_30
LAS_N16_2875_40
LAS_N16_2875_30
LAS_N16_2876_40
LAS_N16_2876_30
LAS_N16_2686_20
LAS_N16_2687_10
LAS_N16_2687_20
LAS_N16_2688_10
LAS_N16_2688_20
LAS_N16_2689_10
LAS_N16_2689_20
LAS_N16_2780_10
LAS_N16_2780_20
LAS_N16_2781_10
LAS_N16_2788_10
LAS_N16_2788_20
LAS_N16_2789_10
LAS_N16_2789_20
LAS_N16_2880_10
LAS_N16_2880_20
LAS_N16_2881_10
LAS_N16_2881_20
LAS_N16_2882_10
LAS_N16_2882_20
LAS_N16_2883_10
LAS_N16_2883_20
LAS_N16_2884_10
LAS_N16_2884_20
LAS_N16_2885_10
LAS_N16_2885_20
LAS_N16_2886_10
LAS_N16_2886_20
LAS_N16_2686_40
LAS_N16_2686_30
LAS_N16_2687_40
LAS_N16_2687_30
LAS_N16_2688_40
LAS_N16_2688_30
LAS_N16_2689_40
LAS_N16_2689_30
LAS_N16_2780_40
LAS_N16_2780_30
LAS_N16_2781_40
LAS_N16_2781_30
LAS_N16_2787_30
LAS_N16_2788_40
LAS_N16_2788_30
LAS_N16_2789_40
LAS_N16_2789_30
LAS_N16_2880_40
LAS_N16_2880_30
LAS_N16_2881_40
LAS_N16_2881_30
LAS_N16_2882_40
LAS_N16_2882_30
LAS_N16_2883_40
LAS_N16_2883_30
LAS_N16_2884_40
LAS_N16_2884_30
LAS_N16_2885_40

LAS_N16_2885_30
LAS_N16_2886_40
LAS_N16_2886_30
LAS_N16_2887_40
LAS_N16_2696_10
LAS_N16_2696_20
LAS_N16_2697_10
LAS_N16_2697_20
LAS_N16_2698_10
LAS_N16_2698_20
LAS_N16_2699_10
LAS_N16_2699_20
LAS_N16_2790_10
LAS_N16_2790_20
LAS_N16_2791_10
LAS_N16_2791_20
LAS_N16_2792_10
LAS_N16_2797_20
LAS_N16_2798_10
LAS_N16_2798_20
LAS_N16_2799_10
LAS_N16_2799_20
LAS_N16_2890_10
LAS_N16_2890_20
LAS_N16_2891_10
LAS_N16_2891_20
LAS_N16_2892_10
LAS_N16_2892_20
LAS_N16_2893_10
LAS_N16_2893_20
LAS_N16_2894_10
LAS_N16_2894_20
LAS_N16_2895_10
LAS_N16_2895_20
LAS_N16_2896_10
LAS_N16_2896_20
LAS_N16_2897_10
LAS_N16_2695_30
LAS_N16_2696_40
LAS_N16_2696_30
LAS_N16_2697_40
LAS_N16_2697_30
LAS_N16_2698_40
LAS_N16_2698_30
LAS_N16_2699_40
LAS_N16_2699_30
LAS_N16_2790_40
LAS_N16_2790_30
LAS_N16_2791_40
LAS_N16_2791_30
LAS_N16_2792_40
LAS_N16_2792_30
LAS_N16_2793_40
LAS_N16_2793_30
LAS_N16_2794_40
LAS_N16_2794_30
LAS_N16_2795_40
LAS_N16_2796_30
LAS_N16_2797_40
LAS_N16_2797_30
LAS_N16_2798_40
LAS_N16_2798_30
LAS_N16_2799_40
LAS_N16_2799_30
LAS_N16_2890_40
LAS_N16_2890_30
LAS_N16_2891_40
LAS_N16_2891_30
LAS_N16_2892_40
LAS_N16_2892_30
LAS_N16_2893_40
LAS_N16_2893_30
LAS_N16_2894_40
LAS_N16_2894_30
LAS_N16_2895_40
LAS_N16_2895_30
LAS_N16_2896_40
LAS_N16_2896_30
LAS_N16_3606_10
LAS_N16_3606_20
LAS_N16_3607_10
LAS_N16_3607_20
LAS_N16_3608_10
LAS_N16_3608_20
LAS_N16_3609_10
LAS_N16_3609_20
LAS_N16_3700_10
LAS_N16_3700_20
LAS_N16_3701_10
LAS_N16_3701_20
LAS_N16_3702_10
LAS_N16_3702_20
LAS_N16_3703_10
LAS_N16_3703_20
LAS_N16_3704_10
LAS_N16_3704_20
LAS_N16_3705_10
LAS_N16_3705_20
LAS_N16_3706_10
LAS_N16_3706_20
LAS_N16_3707_10
LAS_N16_3707_20
LAS_N16_3708_10
LAS_N16_3708_20
LAS_N16_3709_10
LAS_N16_3709_20
LAS_N16_3800_10
LAS_N16_3800_20
LAS_N16_3801_10
LAS_N16_3801_20
LAS_N16_3802_10
LAS_N16_3802_20
LAS_N16_3803_10
LAS_N16_3803_20
LAS_N16_3804_10
LAS_N16_3804_20
LAS_N16_3805_10
LAS_N16_3805_20
LAS_N16_3806_10
LAS_N16_3606_40
LAS_N16_3606_30
LAS_N16_3607_40
LAS_N16_3607_30
LAS_N16_3608_40
LAS_N16_3608_30
LAS_N16_3609_40
LAS_N16_3609_30
LAS_N16_3700_40
LAS_N16_3700_30
LAS_N16_3701_40
LAS_N16_3701_30
LAS_N16_3702_40
LAS_N16_3702_30
LAS_N16_3703_40
LAS_N16_3703_30
LAS_N16_3704_40
LAS_N16_3704_30
LAS_N16_3705_40
LAS_N16_3705_30
LAS_N16_3706_40
LAS_N16_3706_30
LAS_N16_3707_40
LAS_N16_3707_30
LAS_N16_3708_40
LAS_N16_3708_30
LAS_N16_3709_40
LAS_N16_3709_30
LAS_N16_3800_40
LAS_N16_3800_30
LAS_N16_3801_40
LAS_N16_3801_30
LAS_N16_3802_40
LAS_N16_3802_30

LAS_N16_3803_40
LAS_N16_3803_30
LAS_N16_3804_40
LAS_N16_3804_30
LAS_N16_3805_40
LAS_N16_3805_30
LAS_N16_3806_40
LAS_N16_3616_10
LAS_N16_3616_20
LAS_N16_3617_10
LAS_N16_3617_20
LAS_N16_3618_10
LAS_N16_3618_20
LAS_N16_3619_10
LAS_N16_3619_20
LAS_N16_3710_10
LAS_N16_3710_20
LAS_N16_3711_10
LAS_N16_3711_20
LAS_N16_3712_10
LAS_N16_3712_20
LAS_N16_3713_10
LAS_N16_3713_20
LAS_N16_3714_10
LAS_N16_3714_20
LAS_N16_3715_10
LAS_N16_3715_20
LAS_N16_3716_10
LAS_N16_3716_20
LAS_N16_3717_10
LAS_N16_3717_20
LAS_N16_3718_10
LAS_N16_3718_20
LAS_N16_3719_10
LAS_N16_3719_20
LAS_N16_3810_10
LAS_N16_3810_20
LAS_N16_3811_10
LAS_N16_3811_20
LAS_N16_3812_10
LAS_N16_3812_20
LAS_N16_3813_10
LAS_N16_3813_20
LAS_N16_3814_10
LAS_N16_3814_20
LAS_N16_3815_10
LAS_N16_3815_20
LAS_N16_3816_10
LAS_N16_3616_40
LAS_N16_3616_30
LAS_N16_3617_40
LAS_N16_3617_30
LAS_N16_3618_40
LAS_N16_3618_30
LAS_N16_3619_40
LAS_N16_3619_30
LAS_N16_3710_40
LAS_N16_3710_30
LAS_N16_3711_40
LAS_N16_3711_30
LAS_N16_3712_40
LAS_N16_3712_30
LAS_N16_3713_40
LAS_N16_3713_30
LAS_N16_3714_40
LAS_N16_3714_30
LAS_N16_3715_40
LAS_N16_3715_30
LAS_N16_3716_40
LAS_N16_3716_30
LAS_N16_3717_40
LAS_N16_3717_30
LAS_N16_3718_40
LAS_N16_3718_30
LAS_N16_3719_40
LAS_N16_3719_30
LAS_N16_3810_40
LAS_N16_3810_30
LAS_N16_3811_40
LAS_N16_3811_30
LAS_N16_3812_40
LAS_N16_3812_30
LAS_N16_3813_40
LAS_N16_3813_30
LAS_N16_3814_40
LAS_N16_3814_30
LAS_N16_3815_40
LAS_N16_3815_30
LAS_N16_3816_40
LAS_N16_3624_20
LAS_N16_3625_10
LAS_N16_3625_20
LAS_N16_3626_10
LAS_N16_3626_20
LAS_N16_3627_10
LAS_N16_3627_20
LAS_N16_3628_10
LAS_N16_3628_20
LAS_N16_3629_10
LAS_N16_3629_20
LAS_N16_3720_10
LAS_N16_3720_20
LAS_N16_3721_10
LAS_N16_3721_20
LAS_N16_3722_10
LAS_N16_3722_20
LAS_N16_3723_10
LAS_N16_3723_20
LAS_N16_3724_10
LAS_N16_3724_20
LAS_N16_3725_10
LAS_N16_3725_20
LAS_N16_3726_10
LAS_N16_3726_20
LAS_N16_3727_10
LAS_N16_3727_20
LAS_N16_3728_10
LAS_N16_3728_20
LAS_N16_3729_10
LAS_N16_3729_20
LAS_N16_3820_10
LAS_N16_3820_20
LAS_N16_3821_10
LAS_N16_3821_20
LAS_N16_3822_10
LAS_N16_3822_20
LAS_N16_3823_10
LAS_N16_3823_20
LAS_N16_3824_10
LAS_N16_3824_20
LAS_N16_3825_10
LAS_N16_3825_20
LAS_N16_3826_10
LAS_N16_3826_20
LAS_N16_3624_40
LAS_N16_3624_30
LAS_N16_3625_40
LAS_N16_3625_30
LAS_N16_3626_40
LAS_N16_3626_30
LAS_N16_3627_40
LAS_N16_3627_30
LAS_N16_3628_40
LAS_N16_3628_30
LAS_N16_3629_40
LAS_N16_3629_30
LAS_N16_3720_40
LAS_N16_3720_30
LAS_N16_3721_40
LAS_N16_3721_30
LAS_N16_3722_40
LAS_N16_3722_30
LAS_N16_3723_40

LAS_N16_3723_30
LAS_N16_3724_40
LAS_N16_3724_30
LAS_N16_3725_40
LAS_N16_3725_30
LAS_N16_3726_40
LAS_N16_3726_30
LAS_N16_3727_40
LAS_N16_3727_30
LAS_N16_3728_40
LAS_N16_3728_30
LAS_N16_3729_40
LAS_N16_3729_30
LAS_N16_3820_40
LAS_N16_3820_30
LAS_N16_3821_40
LAS_N16_3821_30
LAS_N16_3822_40
LAS_N16_3822_30
LAS_N16_3823_40
LAS_N16_3823_30
LAS_N16_3824_40
LAS_N16_3824_30
LAS_N16_3825_40
LAS_N16_3825_30
LAS_N16_3826_40
LAS_N16_3826_30
LAS_N16_3827_40
LAS_N16_3634_10
LAS_N16_3634_20
LAS_N16_3635_10
LAS_N16_3635_20
LAS_N16_3636_10
LAS_N16_3636_20
LAS_N16_3637_10
LAS_N16_3637_20
LAS_N16_3638_10
LAS_N16_3638_20
LAS_N16_3639_10
LAS_N16_3639_20
LAS_N16_3730_10
LAS_N16_3730_20
LAS_N16_3731_10
LAS_N16_3731_20
LAS_N16_3732_10
LAS_N16_3732_20
LAS_N16_3733_10
LAS_N16_3733_20
LAS_N16_3734_10
LAS_N16_3734_20
LAS_N16_3735_10
LAS_N16_3735_20
LAS_N16_3736_10
LAS_N16_3736_20
LAS_N16_3737_10
LAS_N16_3737_20
LAS_N16_3738_10
LAS_N16_3738_20
LAS_N16_3739_10
LAS_N16_3739_20
LAS_N16_3830_10
LAS_N16_3830_20
LAS_N16_3831_10
LAS_N16_3831_20
LAS_N16_3832_10
LAS_N16_3832_20
LAS_N16_3833_10
LAS_N16_3833_20
LAS_N16_3834_10
LAS_N16_3834_20
LAS_N16_3835_10
LAS_N16_3835_20
LAS_N16_3836_10
LAS_N16_3836_20
LAS_N16_3837_10
LAS_N16_3837_20
LAS_N16_3838_10
LAS_N16_3634_40
LAS_N16_3634_30
LAS_N16_3635_40
LAS_N16_3635_30
LAS_N16_3636_40
LAS_N16_3636_30
LAS_N16_3637_40
LAS_N16_3637_30
LAS_N16_3638_40
LAS_N16_3638_30
LAS_N16_3639_40
LAS_N16_3639_30
LAS_N16_3730_40
LAS_N16_3730_30
LAS_N16_3731_40
LAS_N16_3731_30
LAS_N16_3732_40
LAS_N16_3732_30
LAS_N16_3733_40
LAS_N16_3733_30
LAS_N16_3734_40
LAS_N16_3734_30
LAS_N16_3735_40
LAS_N16_3735_30
LAS_N16_3736_40
LAS_N16_3736_30
LAS_N16_3737_40
LAS_N16_3737_30
LAS_N16_3738_40
LAS_N16_3738_30
LAS_N16_3739_40
LAS_N16_3739_30
LAS_N16_3830_40
LAS_N16_3830_30
LAS_N16_3831_40
LAS_N16_3831_30
LAS_N16_3832_40
LAS_N16_3832_30
LAS_N16_3833_40
LAS_N16_3833_30
LAS_N16_3834_40
LAS_N16_3834_30
LAS_N16_3835_40
LAS_N16_3835_30
LAS_N16_3836_40
LAS_N16_3836_30
LAS_N16_3837_40
LAS_N16_3837_30
LAS_N16_3838_40
LAS_N16_3644_10
LAS_N16_3644_20
LAS_N16_3645_10
LAS_N16_3645_20
LAS_N16_3646_10
LAS_N16_3646_20
LAS_N16_3647_10
LAS_N16_3647_20
LAS_N16_3648_10
LAS_N16_3648_20
LAS_N16_3649_10
LAS_N16_3649_20
LAS_N16_3740_10
LAS_N16_3740_20
LAS_N16_3741_10
LAS_N16_3741_20
LAS_N16_3742_10
LAS_N16_3742_20
LAS_N16_3743_10
LAS_N16_3743_20
LAS_N16_3744_10
LAS_N16_3744_20
LAS_N16_3745_10
LAS_N16_3745_20
LAS_N16_3746_10
LAS_N16_3746_20
LAS_N16_3747_10

LAS_N16_3747_20
LAS_N16_3748_10
LAS_N16_3748_20
LAS_N16_3749_10
LAS_N16_3749_20
LAS_N16_3840_10
LAS_N16_3840_20
LAS_N16_3841_10
LAS_N16_3841_20
LAS_N16_3842_10
LAS_N16_3842_20
LAS_N16_3843_10
LAS_N16_3843_20
LAS_N16_3844_10
LAS_N16_3844_20
LAS_N16_3845_10
LAS_N16_3845_20
LAS_N16_3846_10
LAS_N16_3846_20
LAS_N16_3847_10
LAS_N16_3847_20
LAS_N16_3848_10
LAS_N16_3644_30
LAS_N16_3645_40
LAS_N16_3645_30
LAS_N16_3646_40
LAS_N16_3646_30
LAS_N16_3647_40
LAS_N16_3647_30
LAS_N16_3648_40
LAS_N16_3648_30
LAS_N16_3649_40
LAS_N16_3649_30
LAS_N16_3740_40
LAS_N16_3740_30
LAS_N16_3741_40
LAS_N16_3741_30
LAS_N16_3742_40
LAS_N16_3742_30
LAS_N16_3743_40
LAS_N16_3743_30
LAS_N16_3744_40
LAS_N16_3744_30
LAS_N16_3745_40
LAS_N16_3745_30
LAS_N16_3746_40
LAS_N16_3746_30
LAS_N16_3747_40
LAS_N16_3747_30
LAS_N16_3748_40
LAS_N16_3748_30
LAS_N16_3749_40
LAS_N16_3749_30
LAS_N16_3840_40
LAS_N16_3840_30
LAS_N16_3841_40
LAS_N16_3841_30
LAS_N16_3842_40
LAS_N16_3842_30
LAS_N16_3843_40
LAS_N16_3843_30
LAS_N16_3844_40
LAS_N16_3844_30
LAS_N16_3845_40
LAS_N16_3845_30
LAS_N16_3846_40
LAS_N16_3846_30
LAS_N16_3847_40
LAS_N16_3847_30
LAS_N16_3848_40
LAS_N16_3655_10
LAS_N16_3655_20
LAS_N16_3656_10
LAS_N16_3656_20
LAS_N16_3657_10
LAS_N16_3657_20
LAS_N16_3658_10
LAS_N16_3658_20
LAS_N16_3659_10
LAS_N16_3659_20
LAS_N16_3750_10
LAS_N16_3750_20
LAS_N16_3751_10
LAS_N16_3751_20
LAS_N16_3752_10
LAS_N16_3752_20
LAS_N16_3753_10
LAS_N16_3753_20
LAS_N16_3754_10
LAS_N16_3754_20
LAS_N16_3755_10
LAS_N16_3755_20
LAS_N16_3756_10
LAS_N16_3756_20
LAS_N16_3757_10
LAS_N16_3757_20
LAS_N16_3758_10
LAS_N16_3758_20
LAS_N16_3759_10
LAS_N16_3759_20
LAS_N16_3850_10
LAS_N16_3850_20
LAS_N16_3851_10
LAS_N16_3851_20
LAS_N16_3852_10
LAS_N16_3852_20
LAS_N16_3853_10
LAS_N16_3853_20
LAS_N16_3854_10
LAS_N16_3854_20
LAS_N16_3855_10
LAS_N16_3855_20
LAS_N16_3856_10
LAS_N16_3856_20
LAS_N16_3857_10
LAS_N16_3857_20
LAS_N16_3858_10
LAS_N16_3858_20
LAS_N16_3859_10
LAS_N16_3656_40
LAS_N16_3656_30
LAS_N16_3657_40
LAS_N16_3657_30
LAS_N16_3658_40
LAS_N16_3658_30
LAS_N16_3659_40
LAS_N16_3659_30
LAS_N16_3750_40
LAS_N16_3750_30
LAS_N16_3751_40
LAS_N16_3751_30
LAS_N16_3752_40
LAS_N16_3752_30
LAS_N16_3753_40
LAS_N16_3753_30
LAS_N16_3754_40
LAS_N16_3754_30
LAS_N16_3755_40
LAS_N16_3755_30
LAS_N16_3756_40
LAS_N16_3756_30
LAS_N16_3757_40
LAS_N16_3757_30
LAS_N16_3758_40
LAS_N16_3758_30
LAS_N16_3759_40
LAS_N16_3759_30
LAS_N16_3850_40
LAS_N16_3850_30
LAS_N16_3851_40
LAS_N16_3851_30
LAS_N16_3852_40
LAS_N16_3852_30

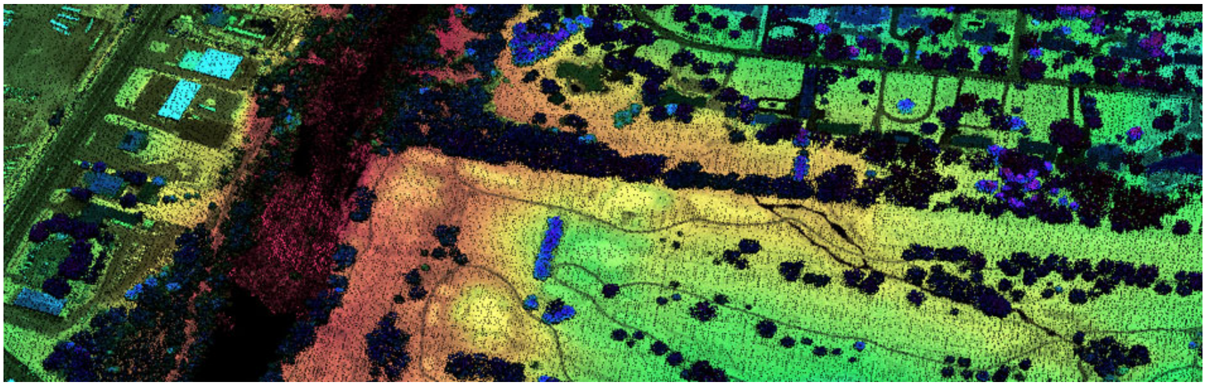
LAS_N16_3853_40
LAS_N16_3853_30
LAS_N16_3854_40
LAS_N16_3854_30
LAS_N16_3855_40
LAS_N16_3855_30
LAS_N16_3856_40
LAS_N16_3856_30
LAS_N16_3857_40
LAS_N16_3857_30
LAS_N16_3858_40
LAS_N16_3858_30
LAS_N16_3859_40
LAS_N16_3666_10
LAS_N16_3666_20
LAS_N16_3667_10
LAS_N16_3667_20
LAS_N16_3668_10
LAS_N16_3668_20
LAS_N16_3669_10
LAS_N16_3669_20
LAS_N16_3760_10
LAS_N16_3760_20
LAS_N16_3761_10
LAS_N16_3761_20
LAS_N16_3762_10
LAS_N16_3762_20
LAS_N16_3763_10
LAS_N16_3763_20
LAS_N16_3764_10
LAS_N16_3764_20
LAS_N16_3765_10
LAS_N16_3765_20
LAS_N16_3766_10
LAS_N16_3766_20
LAS_N16_3767_10
LAS_N16_3767_20
LAS_N16_3768_10
LAS_N16_3768_20
LAS_N16_3769_10
LAS_N16_3769_20
LAS_N16_3860_10
LAS_N16_3860_20
LAS_N16_3861_10
LAS_N16_3861_20
LAS_N16_3862_10
LAS_N16_3862_20
LAS_N16_3863_10
LAS_N16_3863_20
LAS_N16_3864_10
LAS_N16_3864_20
LAS_N16_3865_10
LAS_N16_3865_20
LAS_N16_3866_10
LAS_N16_3866_20
LAS_N16_3867_10
LAS_N16_3867_20
LAS_N16_3868_10
LAS_N16_3868_20
LAS_N16_3869_10
LAS_N16_3666_40
LAS_N16_3666_30
LAS_N16_3667_40
LAS_N16_3667_30
LAS_N16_3668_40
LAS_N16_3668_30
LAS_N16_3669_40
LAS_N16_3669_30
LAS_N16_3760_40
LAS_N16_3760_30
LAS_N16_3761_40
LAS_N16_3761_30
LAS_N16_3762_40
LAS_N16_3762_30
LAS_N16_3763_40
LAS_N16_3763_30
LAS_N16_3764_40
LAS_N16_3764_30
LAS_N16_3765_40
LAS_N16_3765_30
LAS_N16_3766_40
LAS_N16_3766_30
LAS_N16_3767_40
LAS_N16_3767_30
LAS_N16_3768_40
LAS_N16_3768_30
LAS_N16_3769_40
LAS_N16_3769_30
LAS_N16_3860_40
LAS_N16_3860_30
LAS_N16_3861_40
LAS_N16_3861_30
LAS_N16_3862_40
LAS_N16_3862_30
LAS_N16_3863_40
LAS_N16_3863_30
LAS_N16_3864_40
LAS_N16_3864_30
LAS_N16_3865_40
LAS_N16_3865_30
LAS_N16_3866_40
LAS_N16_3866_30
LAS_N16_3867_40
LAS_N16_3867_30
LAS_N16_3868_40
LAS_N16_3868_30
LAS_N16_3869_40
LAS_N16_3677_10
LAS_N16_3678_10
LAS_N16_3678_20
LAS_N16_3679_10
LAS_N16_3679_20
LAS_N16_3770_10
LAS_N16_3770_20
LAS_N16_3771_10
LAS_N16_3771_20
LAS_N16_3772_10
LAS_N16_3772_20
LAS_N16_3773_10
LAS_N16_3773_20
LAS_N16_3774_10
LAS_N16_3774_20
LAS_N16_3775_10
LAS_N16_3775_20
LAS_N16_3776_10
LAS_N16_3776_20
LAS_N16_3777_10
LAS_N16_3777_20
LAS_N16_3778_10
LAS_N16_3778_20
LAS_N16_3779_10
LAS_N16_3779_20
LAS_N16_3870_10
LAS_N16_3870_20
LAS_N16_3871_10
LAS_N16_3871_20
LAS_N16_3872_10
LAS_N16_3872_20
LAS_N16_3873_10
LAS_N16_3873_20
LAS_N16_3874_10
LAS_N16_3874_20
LAS_N16_3875_10
LAS_N16_3875_20
LAS_N16_3876_10
LAS_N16_3876_20
LAS_N16_3877_10
LAS_N16_3877_20
LAS_N16_3878_10
LAS_N16_3878_20
LAS_N16_3879_10
LAS_N16_3879_20
LAS_N16_3679_40

LAS_N16_3679_30
LAS_N16_3770_40
LAS_N16_3770_30
LAS_N16_3771_40
LAS_N16_3771_30
LAS_N16_3772_40
LAS_N16_3772_30
LAS_N16_3773_40
LAS_N16_3774_40
LAS_N16_3774_30
LAS_N16_3775_40
LAS_N16_3775_30
LAS_N16_3776_40
LAS_N16_3776_30
LAS_N16_3777_40
LAS_N16_3777_30
LAS_N16_3778_40
LAS_N16_3778_30
LAS_N16_3779_40
LAS_N16_3779_30
LAS_N16_3870_40
LAS_N16_3870_30
LAS_N16_3871_40
LAS_N16_3871_30
LAS_N16_3872_40
LAS_N16_3872_30
LAS_N16_3873_40
LAS_N16_3873_30
LAS_N16_3874_40
LAS_N16_3874_30
LAS_N16_3875_40
LAS_N16_3875_30
LAS_N16_3876_40
LAS_N16_3876_30
LAS_N16_3877_40
LAS_N16_3877_30
LAS_N16_3878_40
LAS_N16_3878_30
LAS_N16_3879_40
LAS_N16_3879_30
LAS_N16_3689_10
LAS_N16_3689_20
LAS_N16_3780_10
LAS_N16_3780_20
LAS_N16_3781_10
LAS_N16_3781_20
LAS_N16_3782_10
LAS_N16_3782_20
LAS_N16_3783_10
LAS_N16_3787_10
LAS_N16_3787_20
LAS_N16_3788_10
LAS_N16_3788_20
LAS_N16_3789_10
LAS_N16_3789_20
LAS_N16_3880_10
LAS_N16_3880_20
LAS_N16_3881_10
LAS_N16_3881_20
LAS_N16_3882_10
LAS_N16_3882_20
LAS_N16_3883_10
LAS_N16_3883_20
LAS_N16_3884_10
LAS_N16_3884_20
LAS_N16_3885_10
LAS_N16_3885_20
LAS_N16_3886_10
LAS_N16_3886_20
LAS_N16_3887_10
LAS_N16_3887_20
LAS_N16_3888_10
LAS_N16_3888_20
LAS_N16_3889_10
LAS_N16_3889_20
LAS_N16_3689_30
LAS_N16_3780_40
LAS_N16_3780_30
LAS_N16_3781_40
LAS_N16_3781_30
LAS_N16_3782_40
LAS_N16_3782_30
LAS_N16_3783_40
LAS_N16_3788_30
LAS_N16_3789_40
LAS_N16_3789_30
LAS_N16_3880_40
LAS_N16_3880_30
LAS_N16_3881_40
LAS_N16_3881_30
LAS_N16_3882_40
LAS_N16_3882_30
LAS_N16_3883_40
LAS_N16_3883_30
LAS_N16_3884_40
LAS_N16_3884_30
LAS_N16_3885_40
LAS_N16_3885_30
LAS_N16_3886_40
LAS_N16_3886_30
LAS_N16_3887_40
LAS_N16_3887_30
LAS_N16_3888_40
LAS_N16_3888_30
LAS_N16_3889_40
LAS_N16_3889_30
LAS_N16_3980_40
LAS_N16_3981_30
LAS_N16_3982_40
LAS_N16_3982_30
LAS_N16_3983_40
LAS_N16_3790_10
LAS_N16_3790_20
LAS_N16_3791_10
LAS_N16_3791_20
LAS_N16_3792_10
LAS_N16_3792_20
LAS_N16_3793_10
LAS_N16_3799_10
LAS_N16_3799_20
LAS_N16_3890_10
LAS_N16_3890_20
LAS_N16_3891_10
LAS_N16_3891_20
LAS_N16_3892_10
LAS_N16_3892_20
LAS_N16_3893_10
LAS_N16_3893_20
LAS_N16_3894_10
LAS_N16_3894_20
LAS_N16_3895_10
LAS_N16_3895_20
LAS_N16_3896_10
LAS_N16_3896_20
LAS_N16_3897_10
LAS_N16_3897_20
LAS_N16_3898_10
LAS_N16_3898_20
LAS_N16_3899_10
LAS_N16_3899_20
LAS_N16_3990_10
LAS_N16_3990_20
LAS_N16_3991_20
LAS_N16_3992_10
LAS_N16_3992_20
LAS_N16_3993_10
LAS_N16_3993_20
LAS_N16_3994_10
LAS_N16_3790_30
LAS_N16_3791_40
LAS_N16_3791_30
LAS_N16_3792_40
LAS_N16_3792_30

LAS_N16_3799_40
LAS_N16_3799_30
LAS_N16_3890_40
LAS_N16_3890_30
LAS_N16_3891_40
LAS_N16_3891_30
LAS_N16_3892_40
LAS_N16_3892_30
LAS_N16_3893_40
LAS_N16_3893_30
LAS_N16_3894_40
LAS_N16_3894_30
LAS_N16_3895_40
LAS_N16_3895_30
LAS_N16_3896_40
LAS_N16_3896_30
LAS_N16_3897_40
LAS_N16_3897_30
LAS_N16_3898_40
LAS_N16_3898_30
LAS_N16_3899_40
LAS_N16_3899_30
LAS_N16_3990_40
LAS_N16_3990_30
LAS_N16_3991_40
LAS_N16_3991_30
LAS_N16_3992_40
LAS_N16_3992_30
LAS_N16_3993_40
LAS_N16_3993_30
LAS_N16_3994_40
LAS_N16_3994_30
LAS_N16_4701_10
LAS_N16_4701_20
LAS_N16_4702_10
LAS_N16_4702_20
LAS_N16_4800_10
LAS_N16_4800_20
LAS_N16_4801_10
LAS_N16_4801_20
LAS_N16_4802_10
LAS_N16_4802_20
LAS_N16_4803_10
LAS_N16_4803_20
LAS_N16_4804_10
LAS_N16_4804_20
LAS_N16_4805_10
LAS_N16_4805_20
LAS_N16_4806_10
LAS_N16_4806_20
LAS_N16_4807_10
LAS_N16_4807_20
LAS_N16_4808_10
LAS_N16_4808_20
LAS_N16_4809_10
LAS_N16_4809_20
LAS_N16_4900_10
LAS_N16_4900_20
LAS_N16_4901_10
LAS_N16_4901_20
LAS_N16_4902_10
LAS_N16_4902_20
LAS_N16_4903_10
LAS_N16_4903_20
LAS_N16_4904_10
LAS_N16_4904_20
LAS_N16_4800_30
LAS_N16_4801_40
LAS_N16_4801_30
LAS_N16_4802_40
LAS_N16_4802_30
LAS_N16_4803_40
LAS_N16_4803_30
LAS_N16_4804_40
LAS_N16_4804_30
LAS_N16_4805_40
LAS_N16_4805_30
LAS_N16_4806_40
LAS_N16_4806_30
LAS_N16_4807_40
LAS_N16_4807_30
LAS_N16_4808_40
LAS_N16_4808_30
LAS_N16_4809_40
LAS_N16_4809_30
LAS_N16_4900_40
LAS_N16_4900_30
LAS_N16_4901_40
LAS_N16_4901_30
LAS_N16_4902_40
LAS_N16_4902_30
LAS_N16_4903_40
LAS_N16_4903_30
LAS_N16_4904_40
LAS_N16_4904_30
LAS_N16_4810_20
LAS_N16_4811_10
LAS_N16_4811_20
LAS_N16_4812_10
LAS_N16_4813_10
LAS_N16_4813_20
LAS_N16_4814_10
LAS_N16_4814_20
LAS_N16_4815_10
LAS_N16_4815_20
LAS_N16_4816_10
LAS_N16_4816_20
LAS_N16_4817_10
LAS_N16_4817_20
LAS_N16_4818_10
LAS_N16_4818_20
LAS_N16_4819_10
LAS_N16_4819_20
LAS_N16_4910_10
LAS_N16_4910_20
LAS_N16_4911_10
LAS_N16_4911_20
LAS_N16_4912_10
LAS_N16_4912_20
LAS_N16_4913_10
LAS_N16_4913_20
LAS_N16_4914_10
LAS_N16_4914_20
LAS_N16_4810_30
LAS_N16_4811_40
LAS_N16_4811_30
LAS_N16_4813_30
LAS_N16_4814_40
LAS_N16_4814_30
LAS_N16_4815_40
LAS_N16_4815_30
LAS_N16_4816_40
LAS_N16_4816_30
LAS_N16_4817_40
LAS_N16_4817_30
LAS_N16_4818_40
LAS_N16_4818_30
LAS_N16_4819_40
LAS_N16_4819_30
LAS_N16_4910_40
LAS_N16_4910_30
LAS_N16_4911_40
LAS_N16_4911_30
LAS_N16_4912_40
LAS_N16_4912_30
LAS_N16_4913_40
LAS_N16_4913_30
LAS_N16_4914_40
LAS_N16_4914_30
LAS_N16_4824_20
LAS_N16_4825_10
LAS_N16_4825_20
LAS_N16_4826_10

LAS_N16_4826_20
LAS_N16_4827_10
LAS_N16_4827_20
LAS_N16_4828_10
LAS_N16_4828_20
LAS_N16_4829_10
LAS_N16_4829_20
LAS_N16_4920_10
LAS_N16_4920_20
LAS_N16_4921_10
LAS_N16_4921_20
LAS_N16_4922_10
LAS_N16_4922_20
LAS_N16_4923_10
LAS_N16_4923_20
LAS_N16_4924_10
LAS_N16_4924_20
LAS_N16_4925_10
LAS_N16_4825_30
LAS_N16_4826_40
LAS_N16_4826_30
LAS_N16_4827_40
LAS_N16_4827_30
LAS_N16_4828_40
LAS_N16_4828_30
LAS_N16_4829_40
LAS_N16_4829_30
LAS_N16_4920_40
LAS_N16_4920_30
LAS_N16_4921_40
LAS_N16_4921_30
LAS_N16_4922_40
LAS_N16_4922_30
LAS_N16_4923_40
LAS_N16_4923_30
LAS_N16_4924_40
LAS_N16_4924_30
LAS_N16_4925_40
LAS_N16_4836_20
LAS_N16_4837_10
LAS_N16_4837_20
LAS_N16_4838_10
LAS_N16_4838_20
LAS_N16_4839_10
LAS_N16_4839_20
LAS_N16_4930_10
LAS_N16_4930_20
LAS_N16_4931_10
LAS_N16_4931_20
LAS_N16_4932_10
LAS_N16_4932_20
LAS_N16_4933_10
LAS_N16_4933_20
LAS_N16_4934_10
LAS_N16_4934_20
LAS_N16_4935_10
LAS_N16_4838_40
LAS_N16_4838_30
LAS_N16_4839_40
LAS_N16_4839_30
LAS_N16_4930_40
LAS_N16_4930_30
LAS_N16_4931_40
LAS_N16_4931_30
LAS_N16_4932_40
LAS_N16_4932_30
LAS_N16_4933_40
LAS_N16_4933_30
LAS_N16_4934_40
LAS_N16_4934_30
LAS_N16_4935_40
LAS_N16_4940_10
LAS_N16_4940_20
LAS_N16_4941_10
LAS_N16_4941_20
LAS_N16_4942_10
LAS_N16_4942_20
LAS_N16_4943_10
LAS_N16_4943_20
LAS_N16_4944_10
LAS_N16_4944_20
LAS_N16_4945_10
LAS_N16_4940_30
LAS_N16_4941_40
LAS_N16_4941_30
LAS_N16_4942_40
LAS_N16_4942_30
LAS_N16_4943_40
LAS_N16_4943_30
LAS_N16_4944_40
LAS_N16_4944_30
LAS_N16_4945_40
LAS_N16_4951_10
LAS_N16_4951_20
LAS_N16_4952_10
LAS_N16_4952_20
LAS_N16_4953_10
LAS_N16_4953_20
LAS_N16_4954_10
LAS_N16_4954_20
LAS_N16_4952_30
LAS_N16_4953_40
LAS_N16_4953_30
LAS_N16_4954_40
LAS_N16_4954_30
LAS_N16_4955_40
LAS_N16_4963_20
LAS_N16_4964_10
LAS_N16_4964_20
LAS_N16_4965_10
LAS_N16_4964_40
LAS_N16_4964_30

2 LiDAR Acquisition Report



ACQUISITION REPORT – Virginia LIDAR ACQUISITION

Augusta & Rockingham Virginia

21 June 2011

Prepared for

DEWBERRY
1000 N. Ashley Dr., Suite 801
Tampa, FL 33602
813.225.1325

Prepared by

ATLANTIC GROUP
2223 Drake Avenue SW
Huntsville, AL 35805
256.971.9991
www.theatlgrp.com

Revisions

Information shown for each revision supersedes the previous version.

Original Version: Josh Helton, LiDAR Manager	Date: 06/21/2011
Draft.	
Revision 1: Andy Lucero, Project Manager	Date: 06/30/2011
Modified for syntax.	
Revision 2:	Date:
Revision 3:	Date:
Revision 4:	Date:

Table of Contents

SCOPE OF WORK

The Atlantic Group acquired LiDAR data over an Area of Interest (AOI) covering all or portions of Augusta and Rockingham Counties Virginia. The acquisition plan entailed a nominal point spacing of 2 points per meter square and a side lap of 55% between flight lines. The AOI covers 1072 square miles.

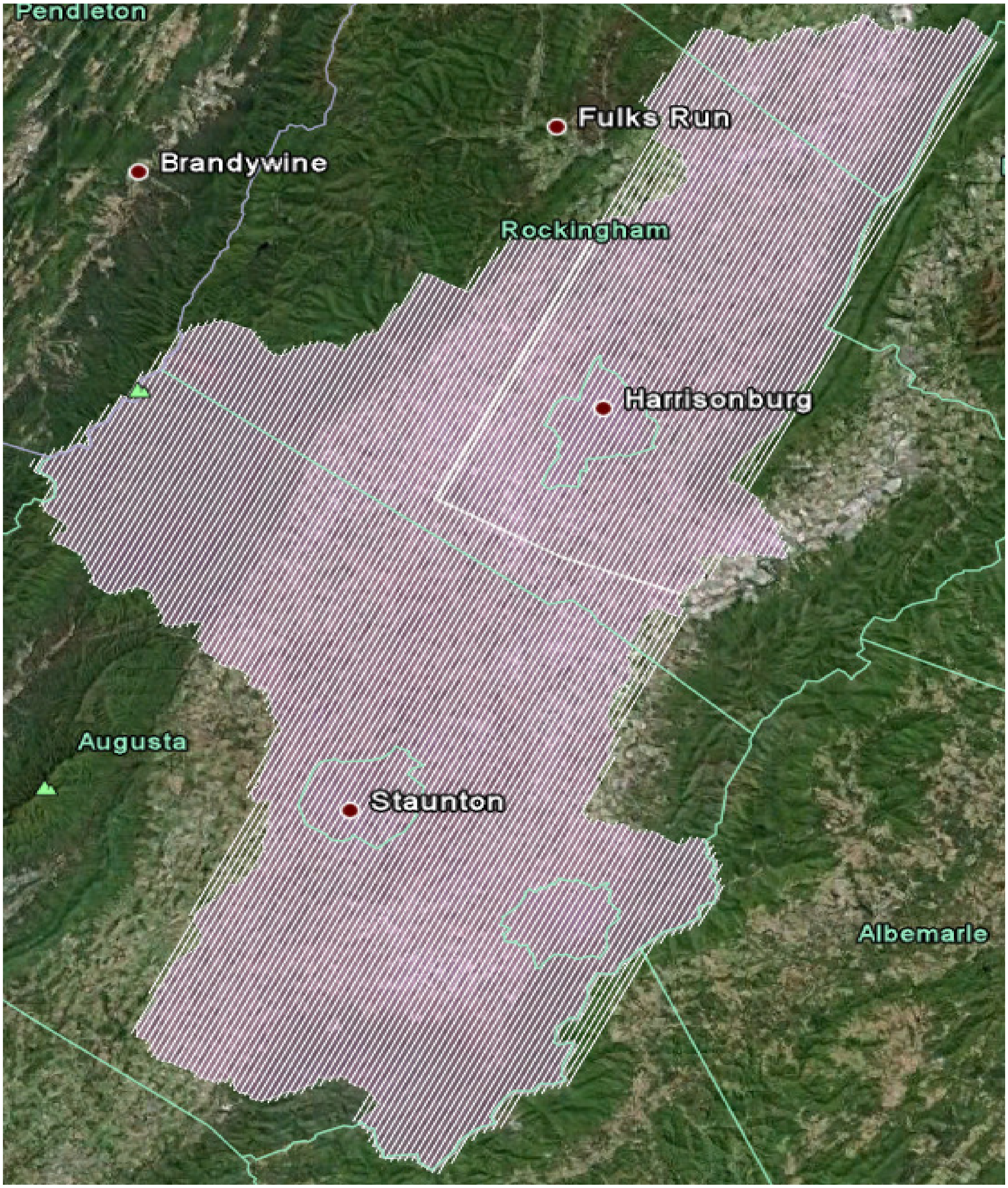


Fig. 1 Flight plan

LiDAR ACQUISITION DETAILS

Collections (Lifts): 19

Collection Dates: 2011 April 7,14,15,17,18,19,20,21,24,25,26,and 30

Field of View (FOV): 45 degrees

Average Point Density (planned): 0.7 m

Flight Level(s): 1000 / 3280 m/ft

Sensor Type: Optech Gemini **Sensor Serial Number(s):** 08SEN113

All acquired LiDAR data was initially quality controlled after every mission for coverage and further verified for content and adherence to flight plan at Atlantic production facilities Huntsville, AL. All data was accepted for processing.

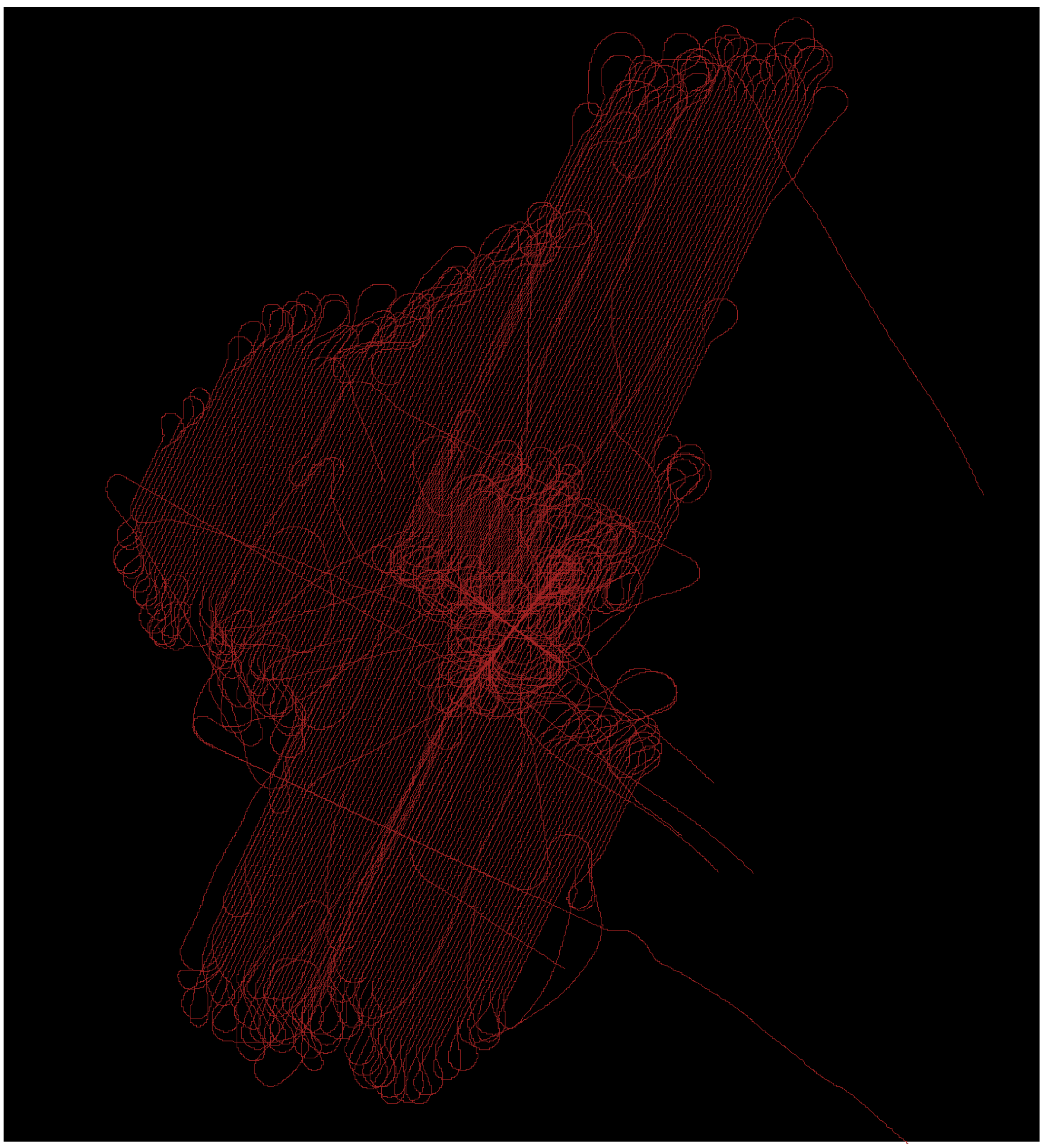


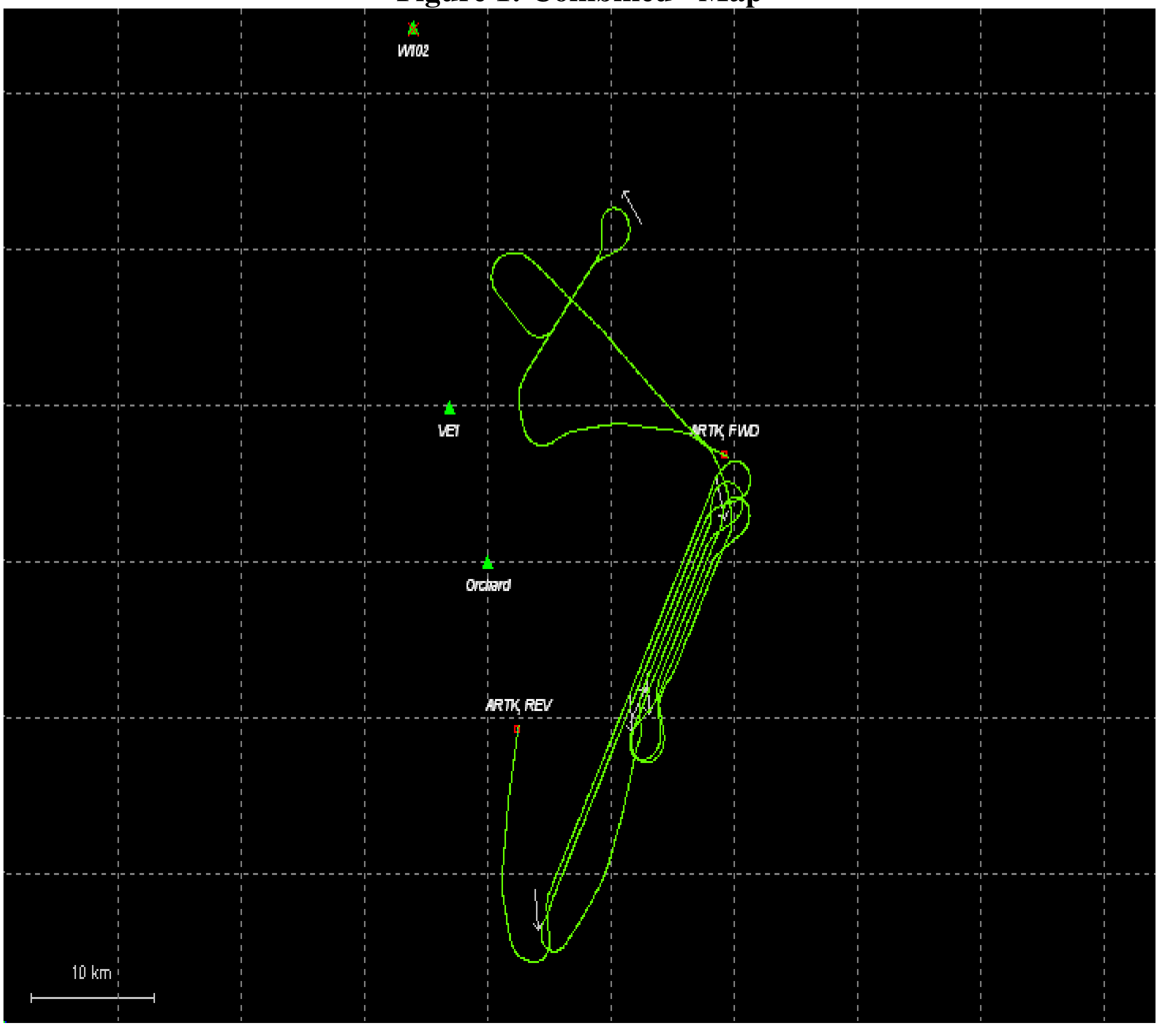
Fig. 2 AOI

Virginia Flight

Output Results for JD097F01

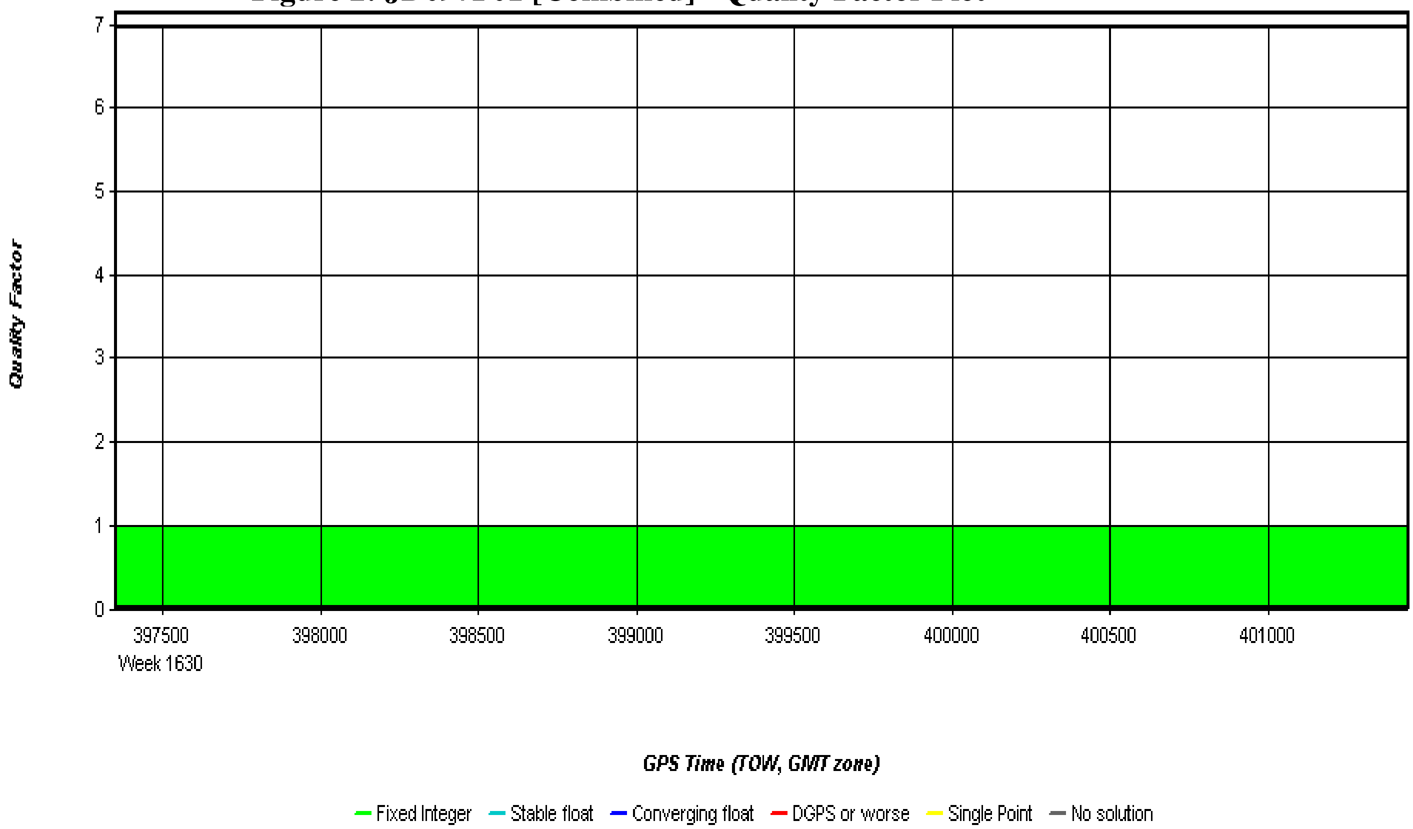
POSGNSS Version 5.20.1209
06/02/2011

Figure 1: Combined - Map



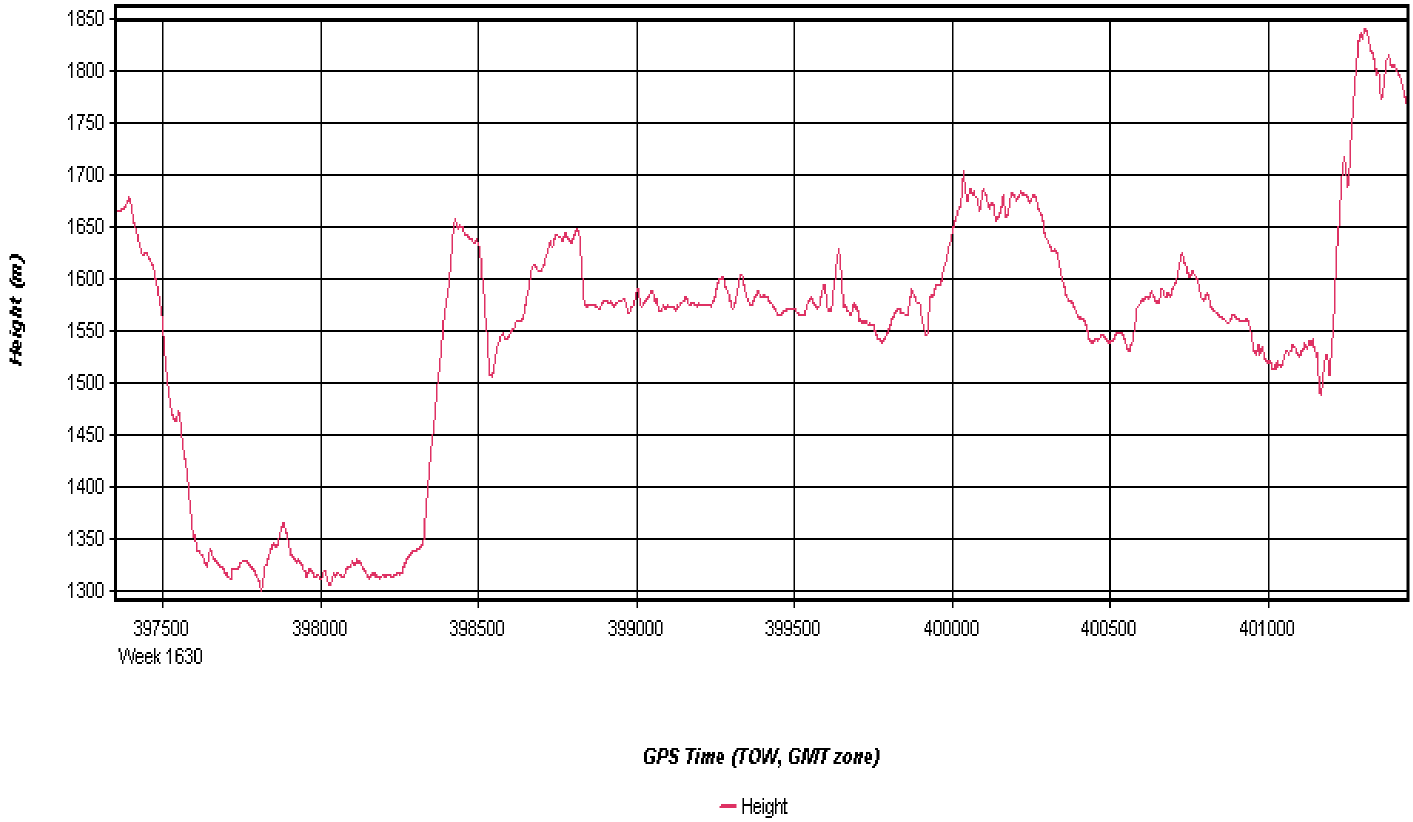
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 2: JD097F01 [Combined] - Quality Factor Plot



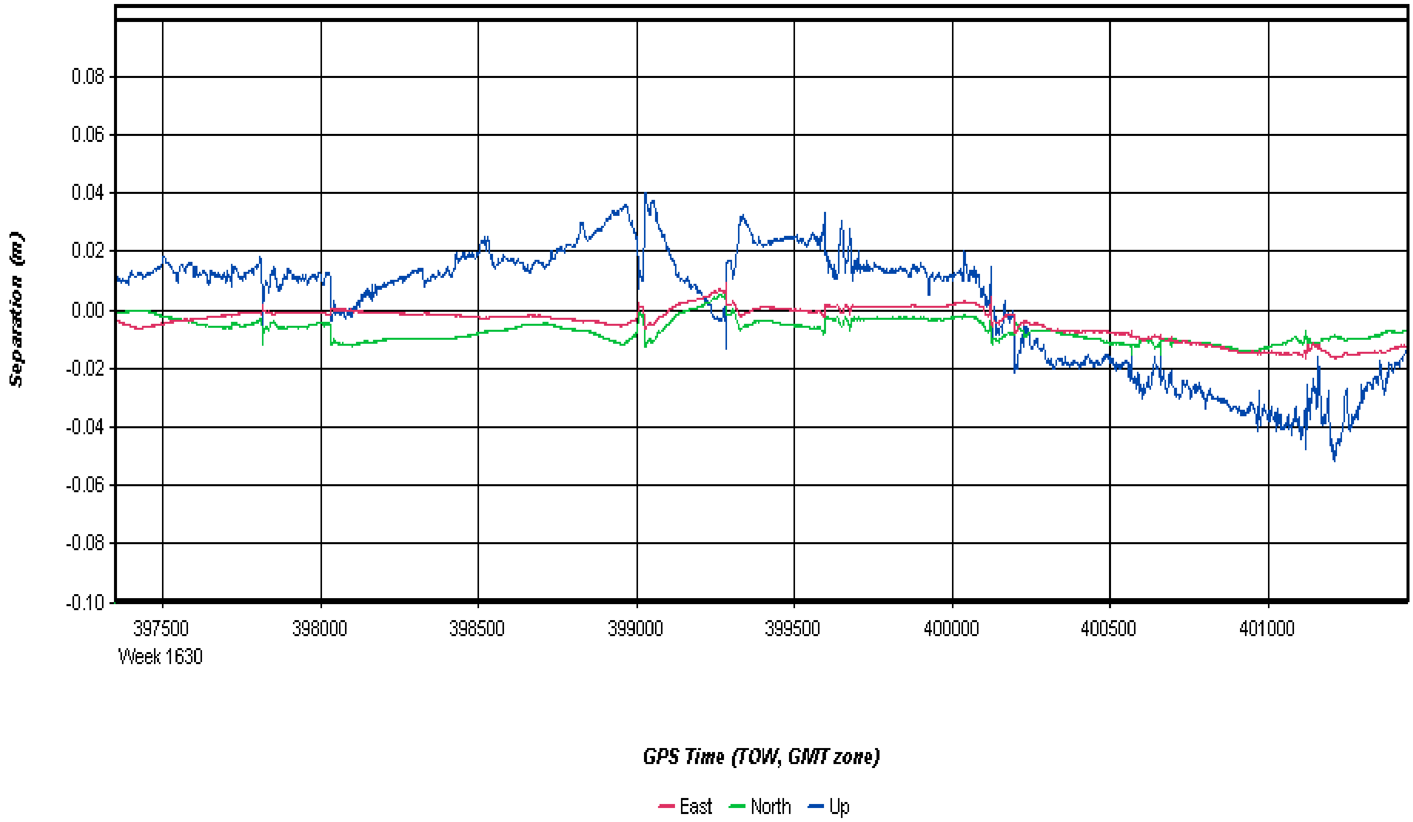
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 3: JD097F01 [Combined] - Height Profile Plot



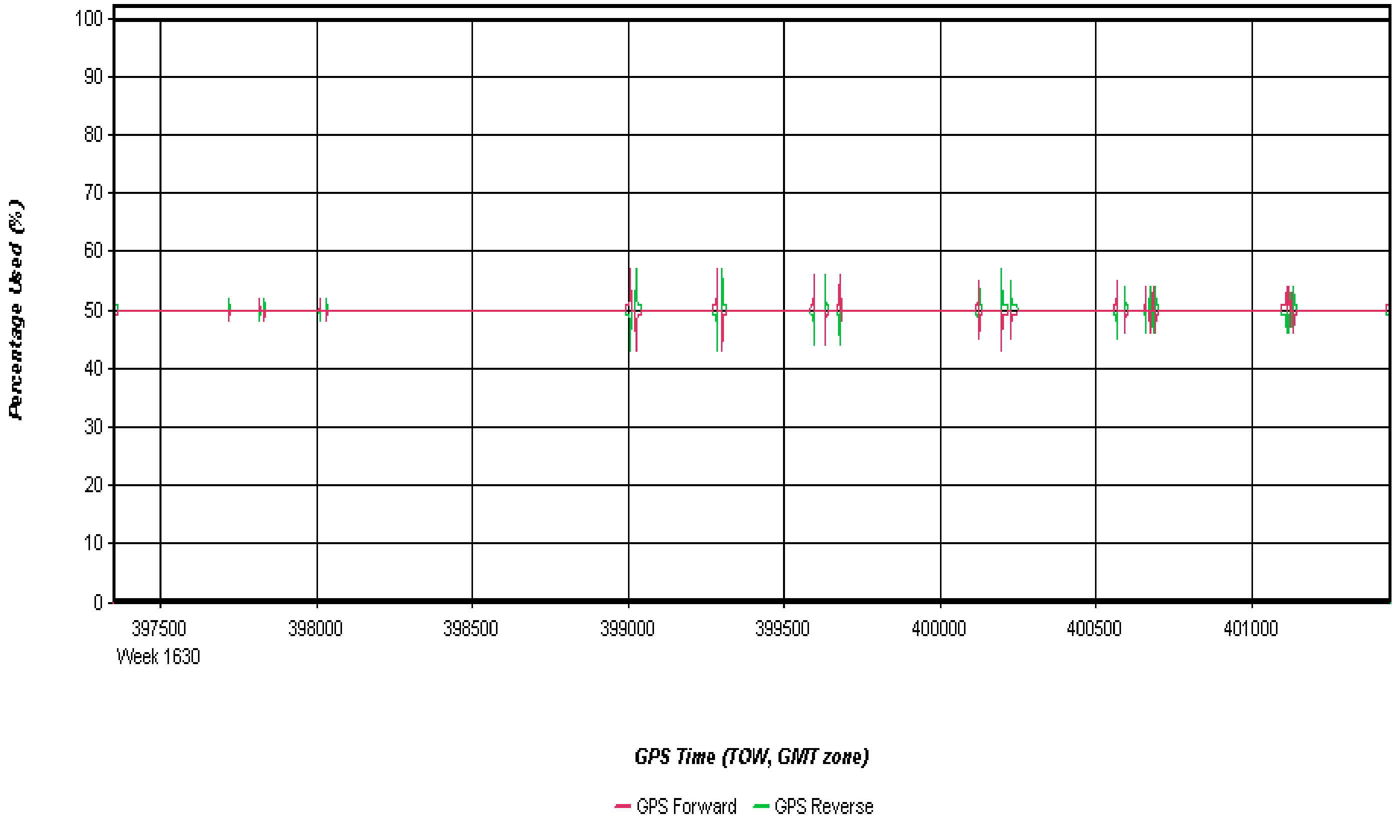
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 4: JD097F01 [Combined] - Forward/Reverse or Combined Separation Plot



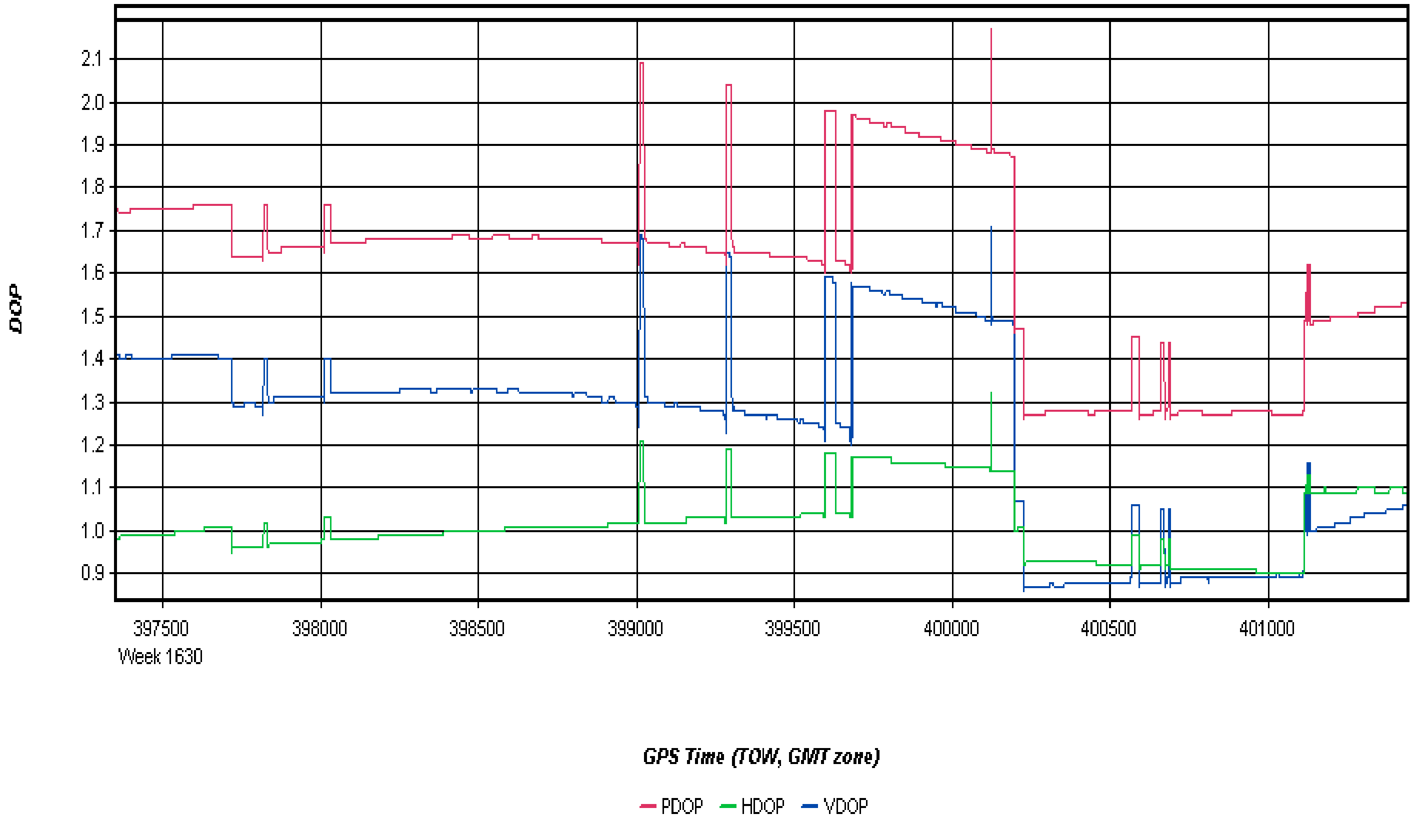
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 5: JD097F01 [Combined] - Forward/Reverse or Combined Weighting Plot



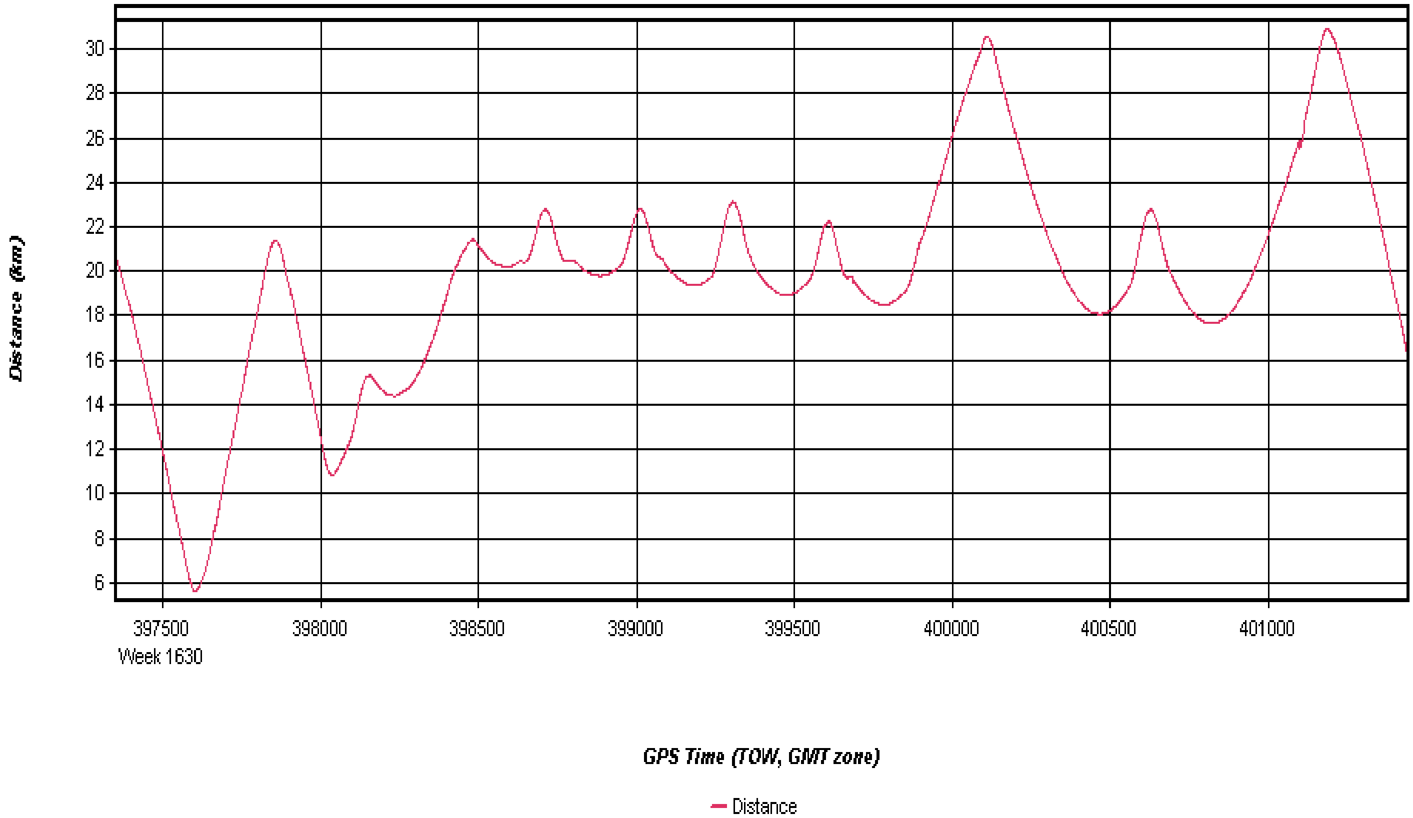
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 6: JD097F01 [Combined] - PDOP, HDOP, VDOP Plots



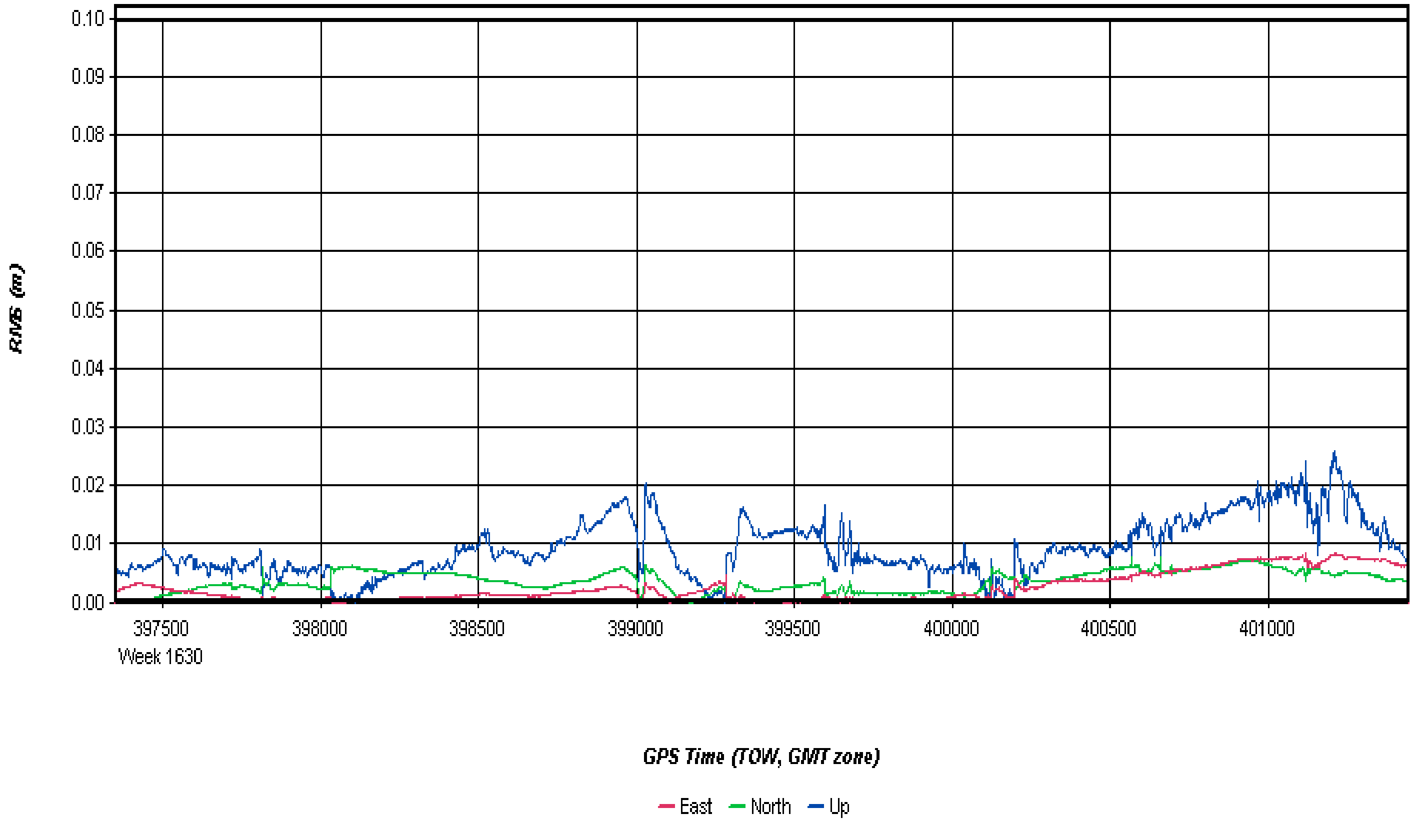
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 7: JD097F01 [Combined] - Horizontal Distance Separation (km)



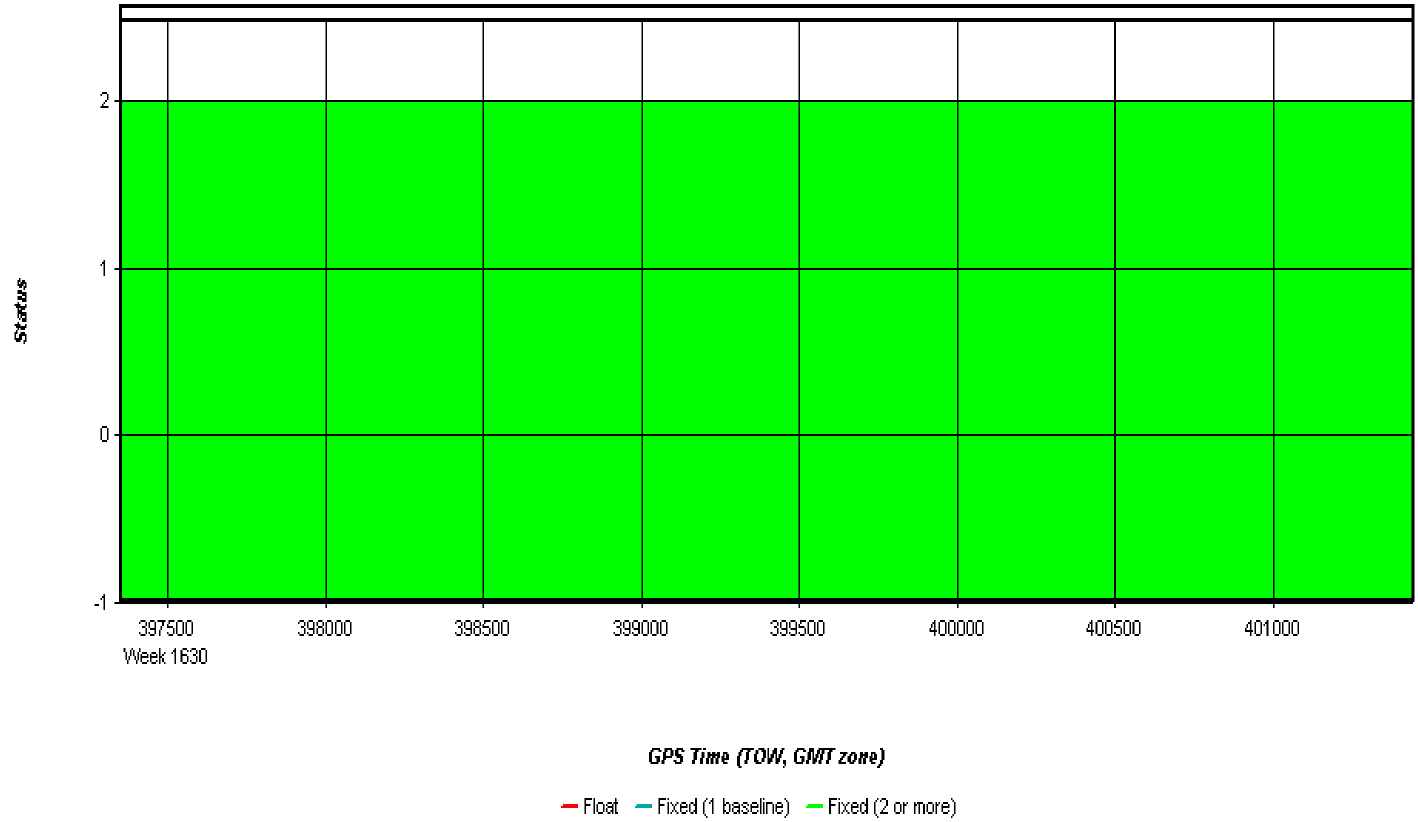
Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 8: JD097F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

Figure 9: JD097F01 [Combined] - Float or Fixed Ambiguity



Process	Run (10)	by Unknown	on 05/26/2011	at 09:28:53

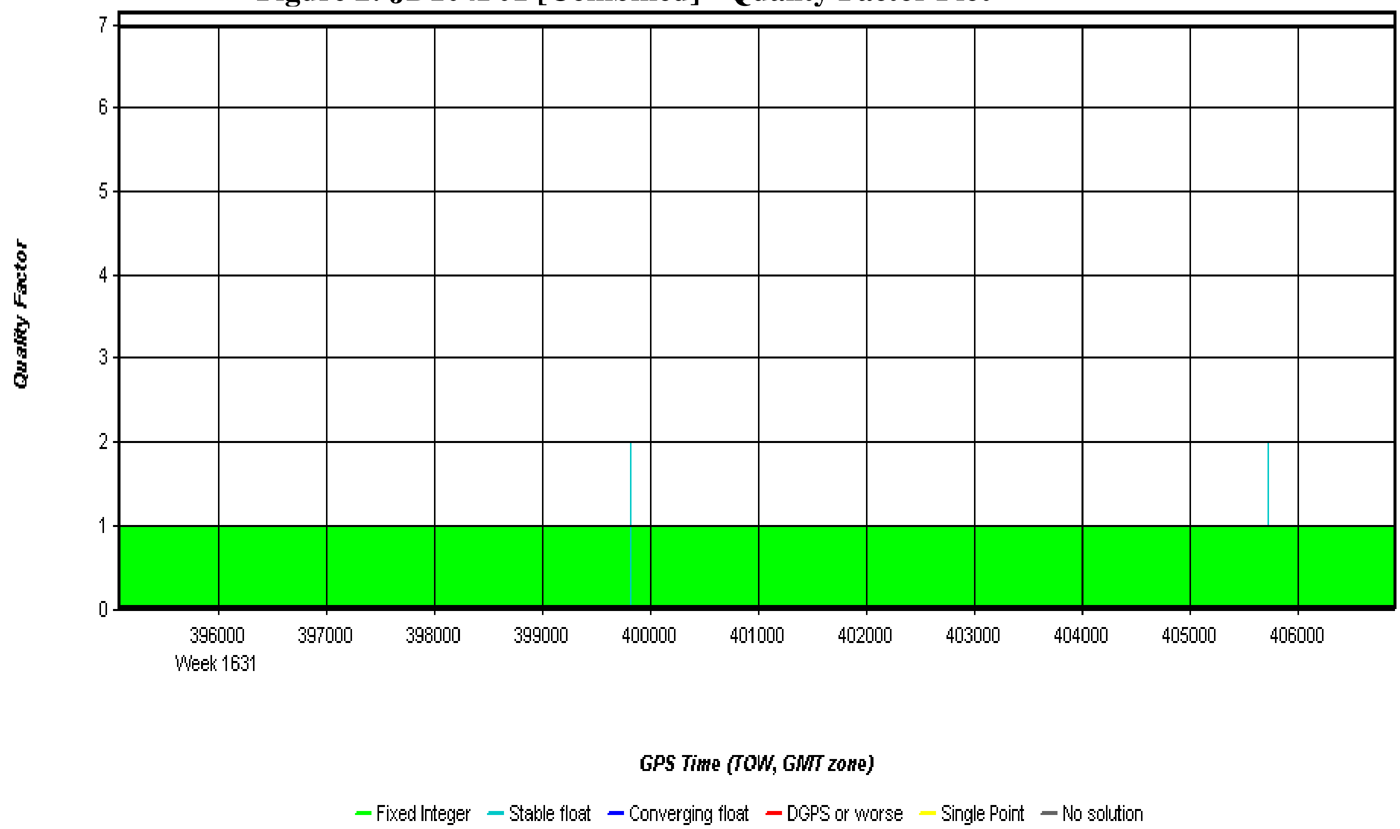
Output Results for JD104F01

POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map

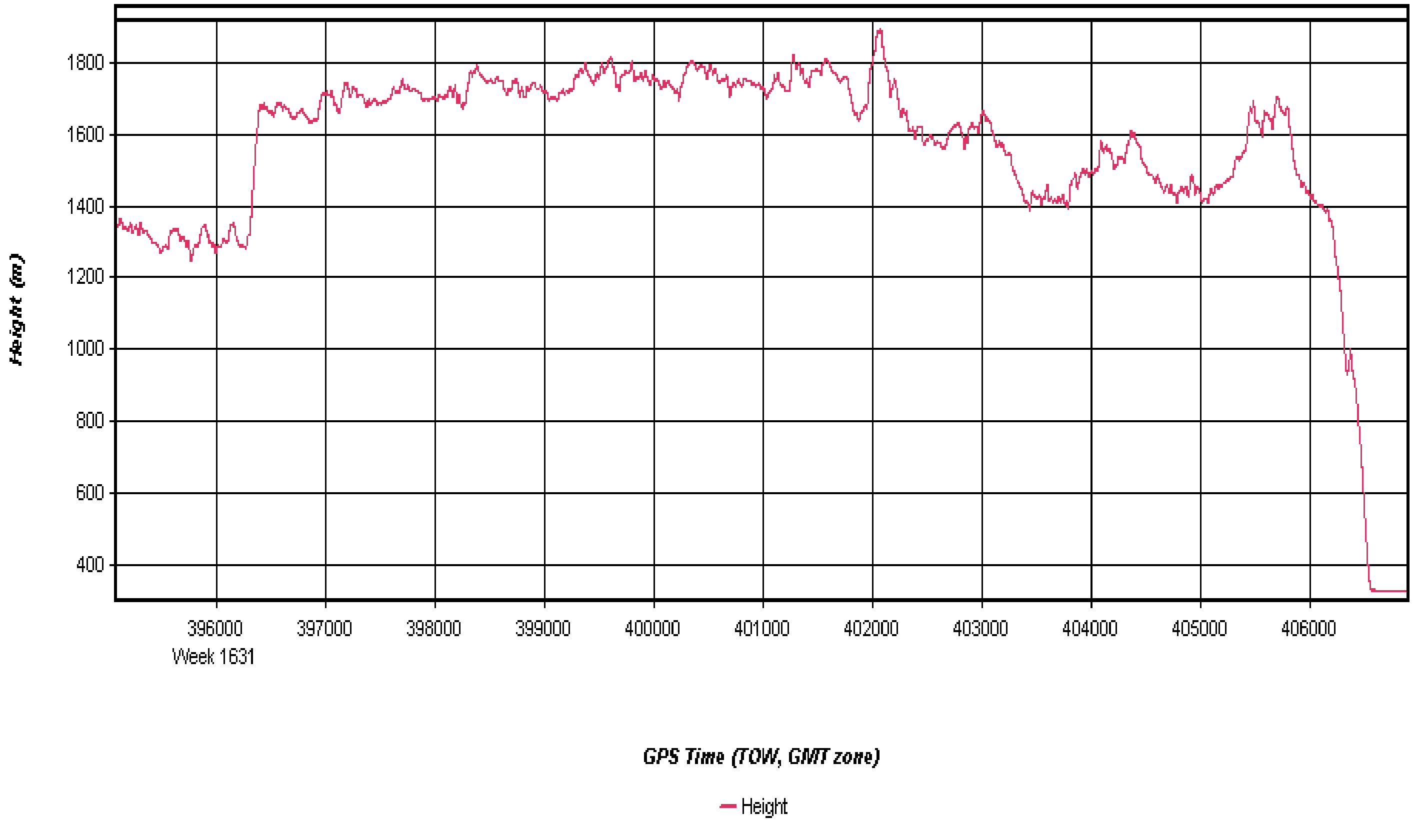
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 2: JD104F01 [Combined] - Quality Factor Plot



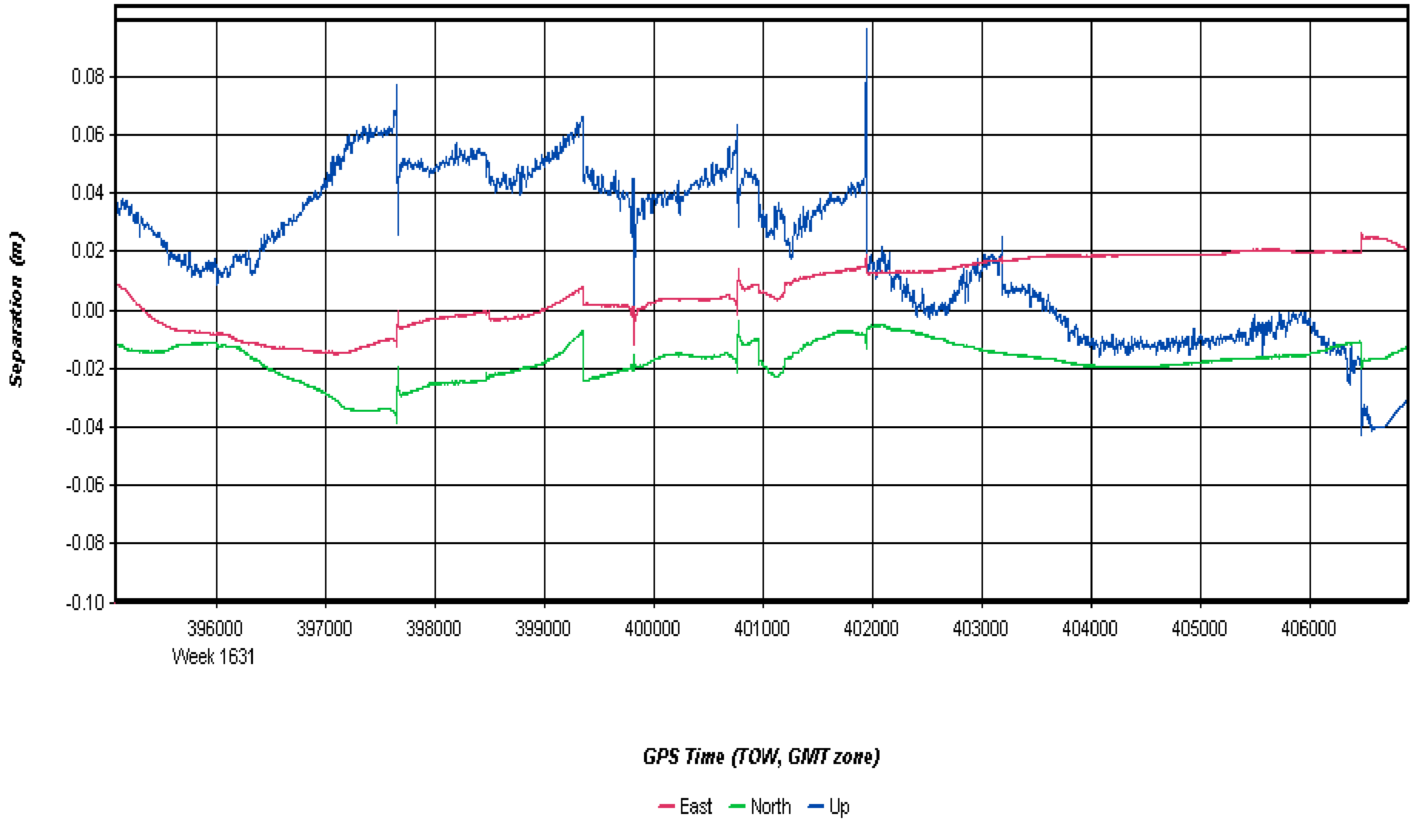
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 3: JD104F01 [Combined] - Height Profile Plot



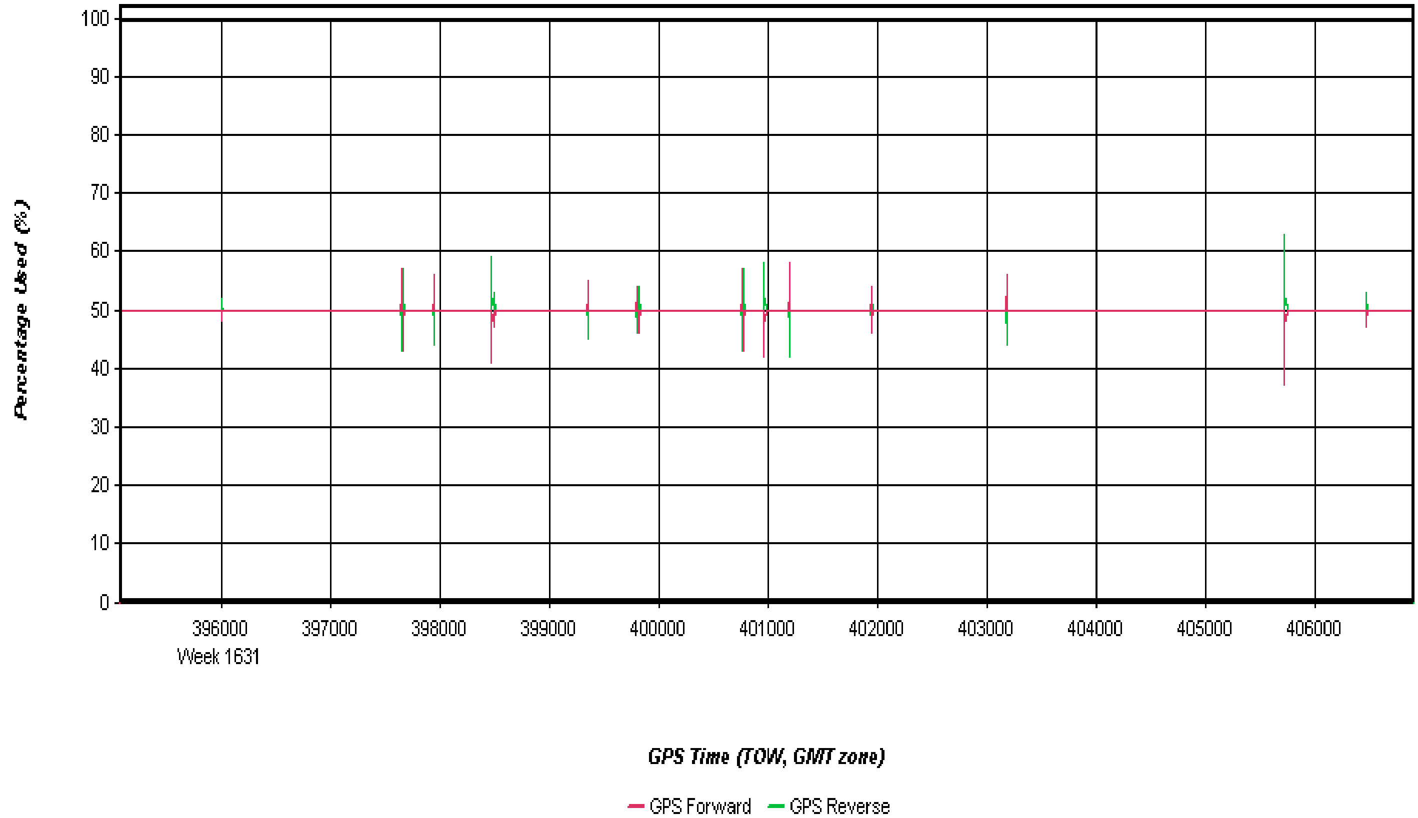
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 4: JD104F01 [Combined] - Forward/Reverse or Combined Separation Plot



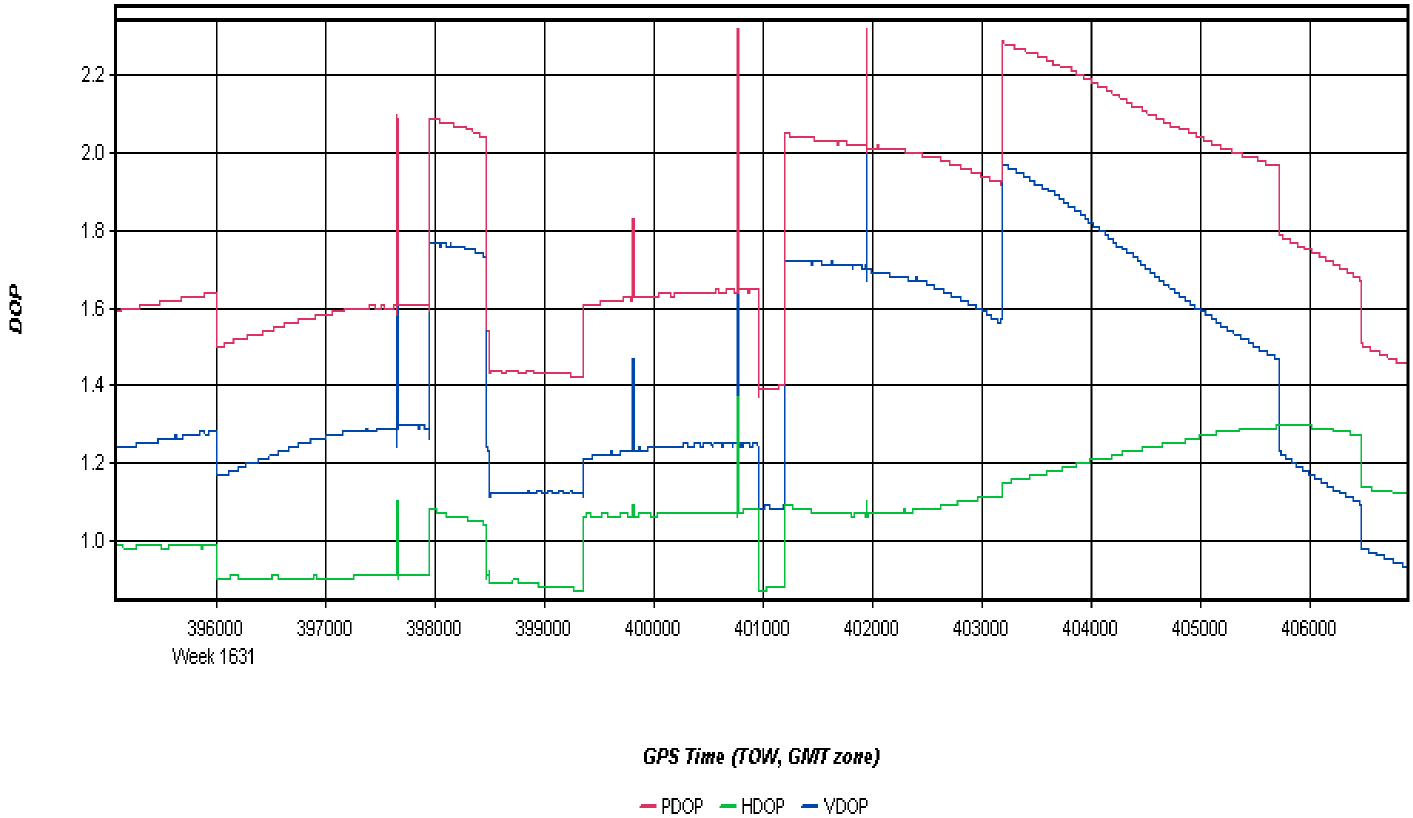
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 5: JD104F01 [Combined] - Forward/Reverse or Combined Weighting Plot



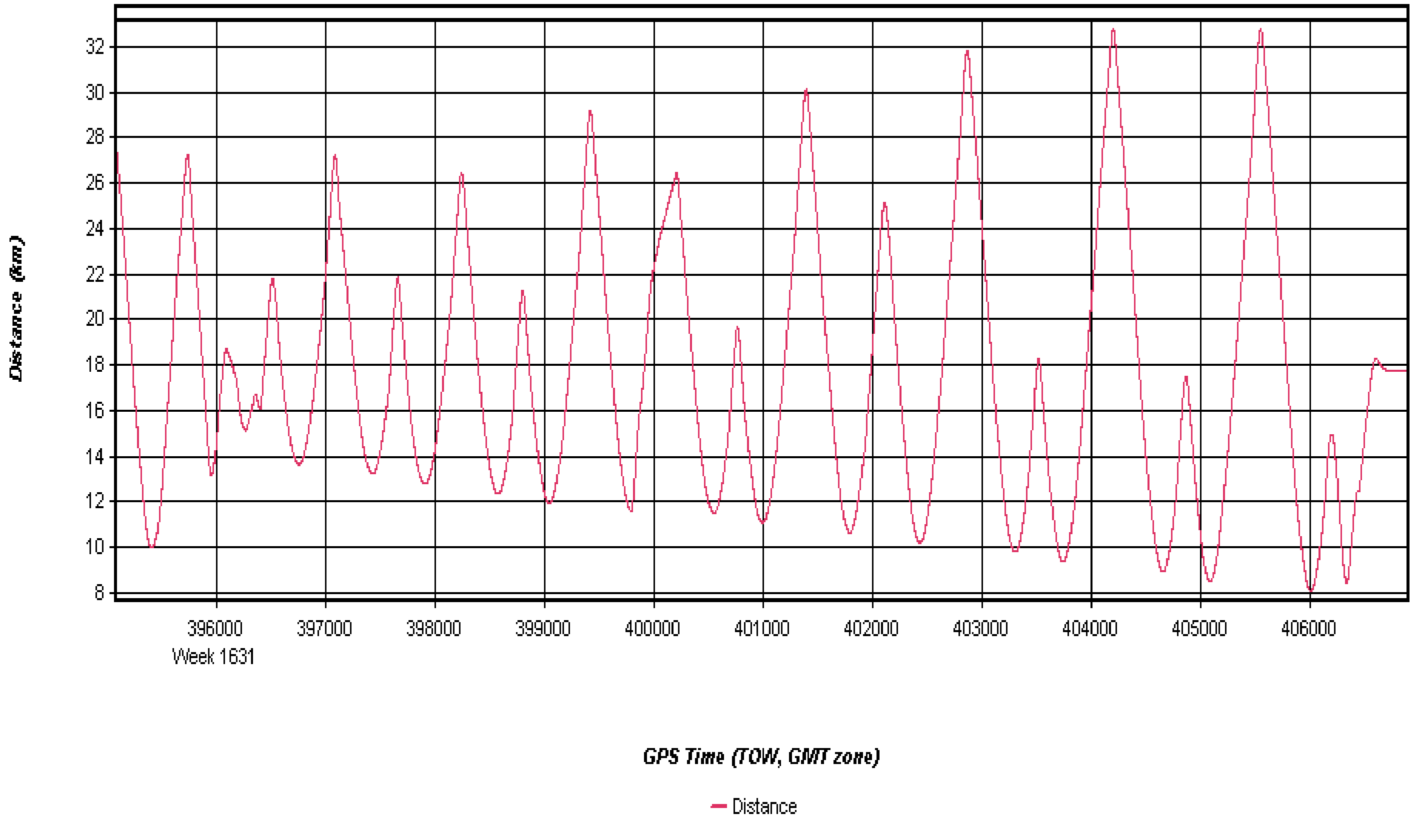
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 6: JD104F01 [Combined] - PDOP, HDOP, VDOP Plots



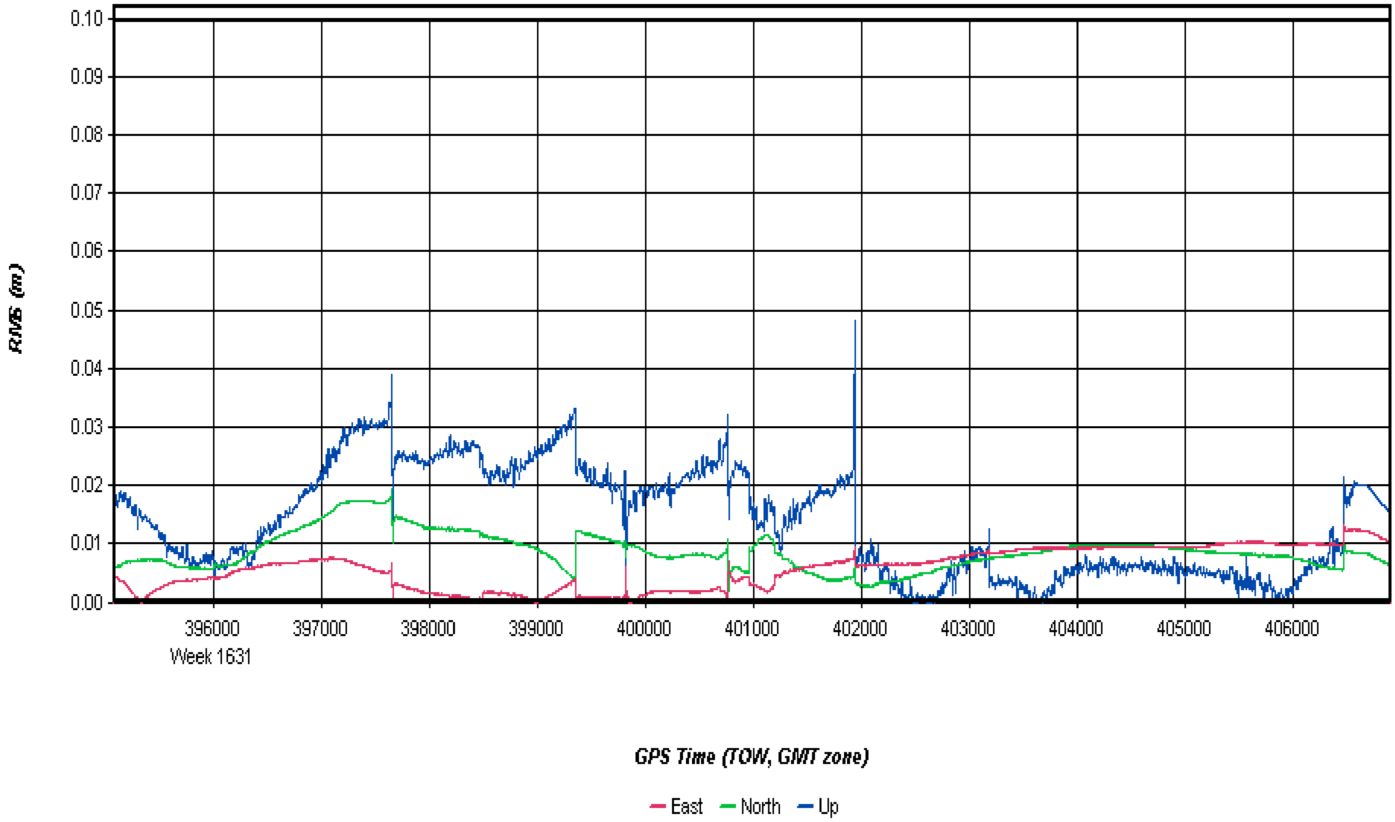
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 7: JD104F01 [Combined] - Horizontal Distance Separation (km)



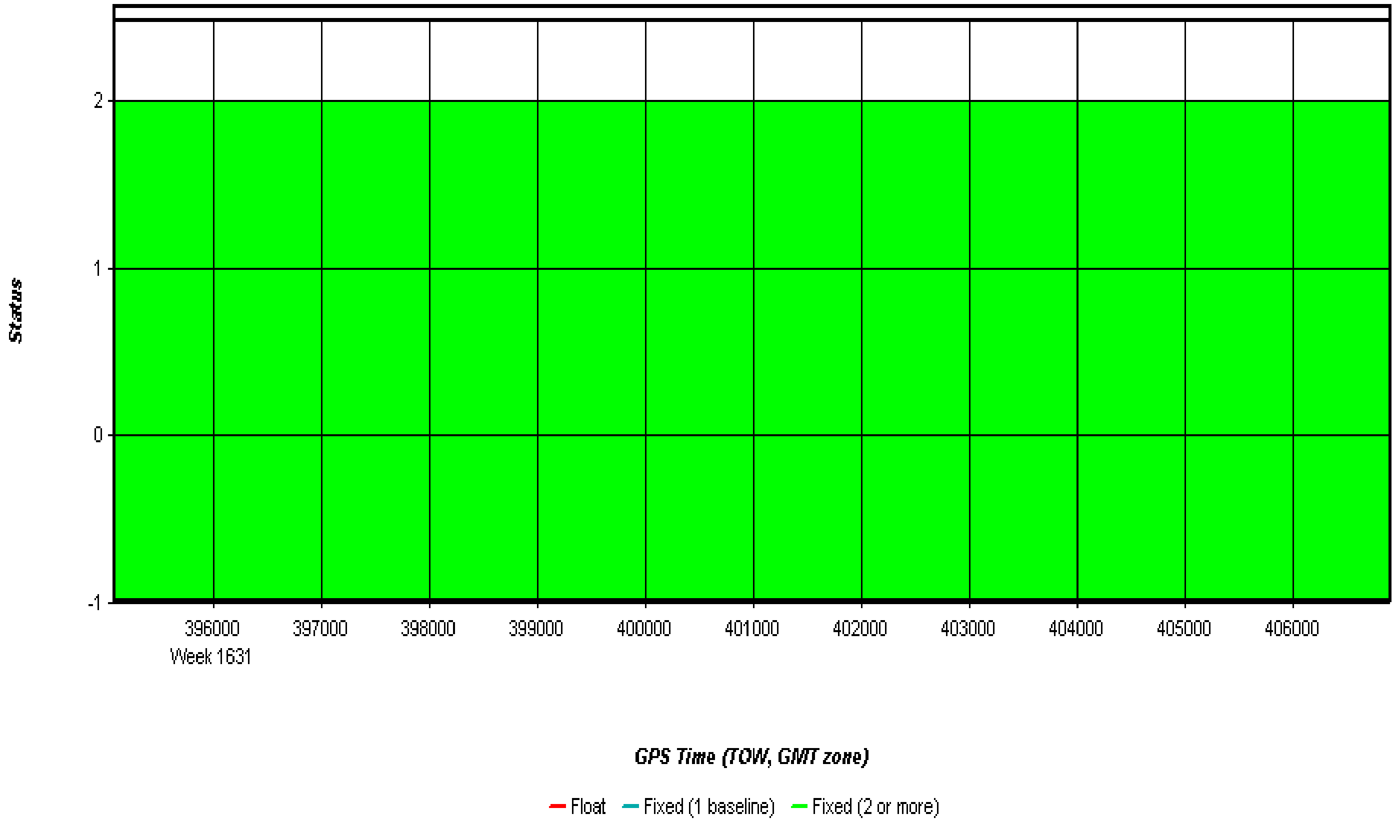
Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 8: JD104F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

Figure 9: JD104F01 [Combined] - Float or Fixed Ambiguity



Process	Run (16)	by Unknown	on 06/16/2011	at 12:13:59

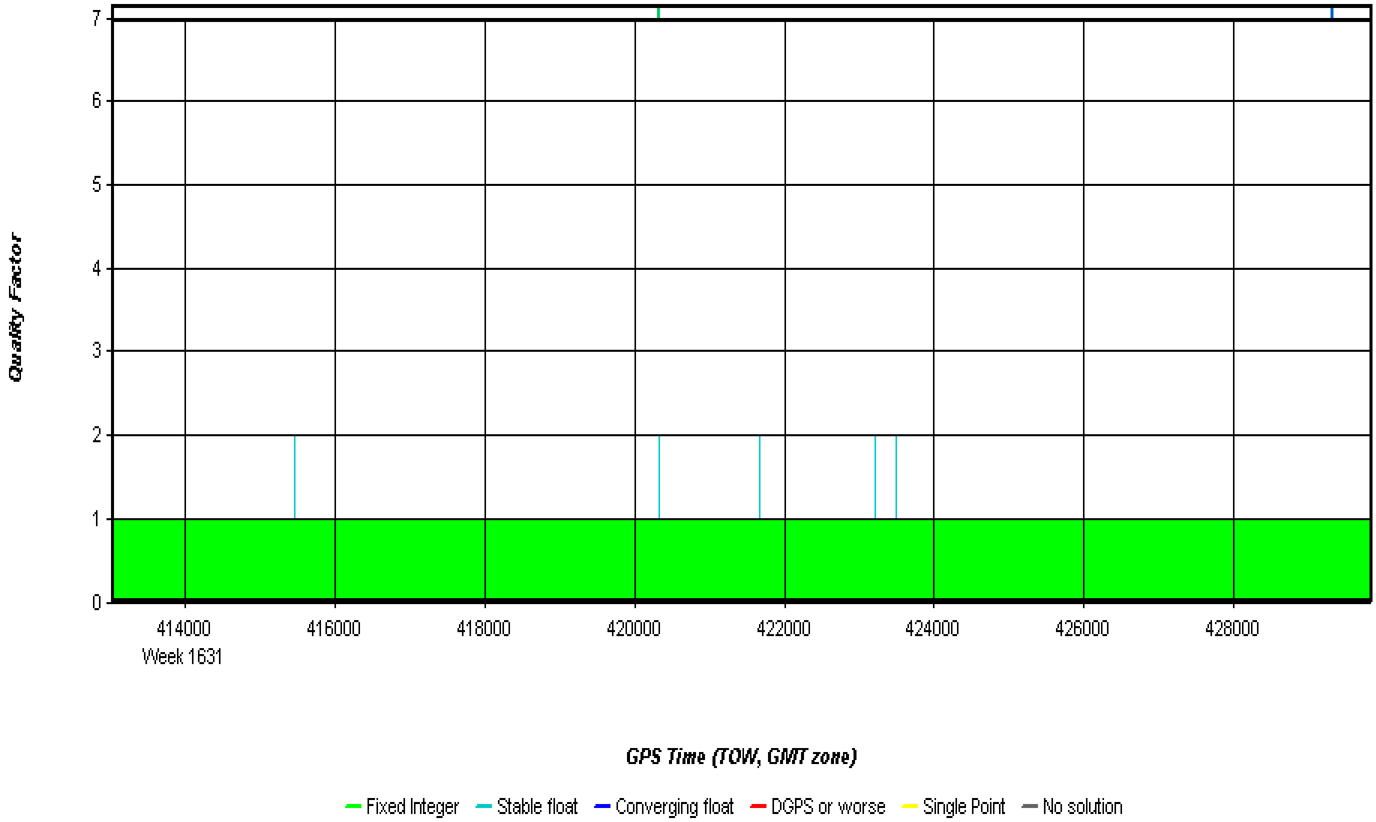
Output Results for JD104F02

POSGNSS Version 5.20.1209
06/02/2011

Figure 1: Combined - Map

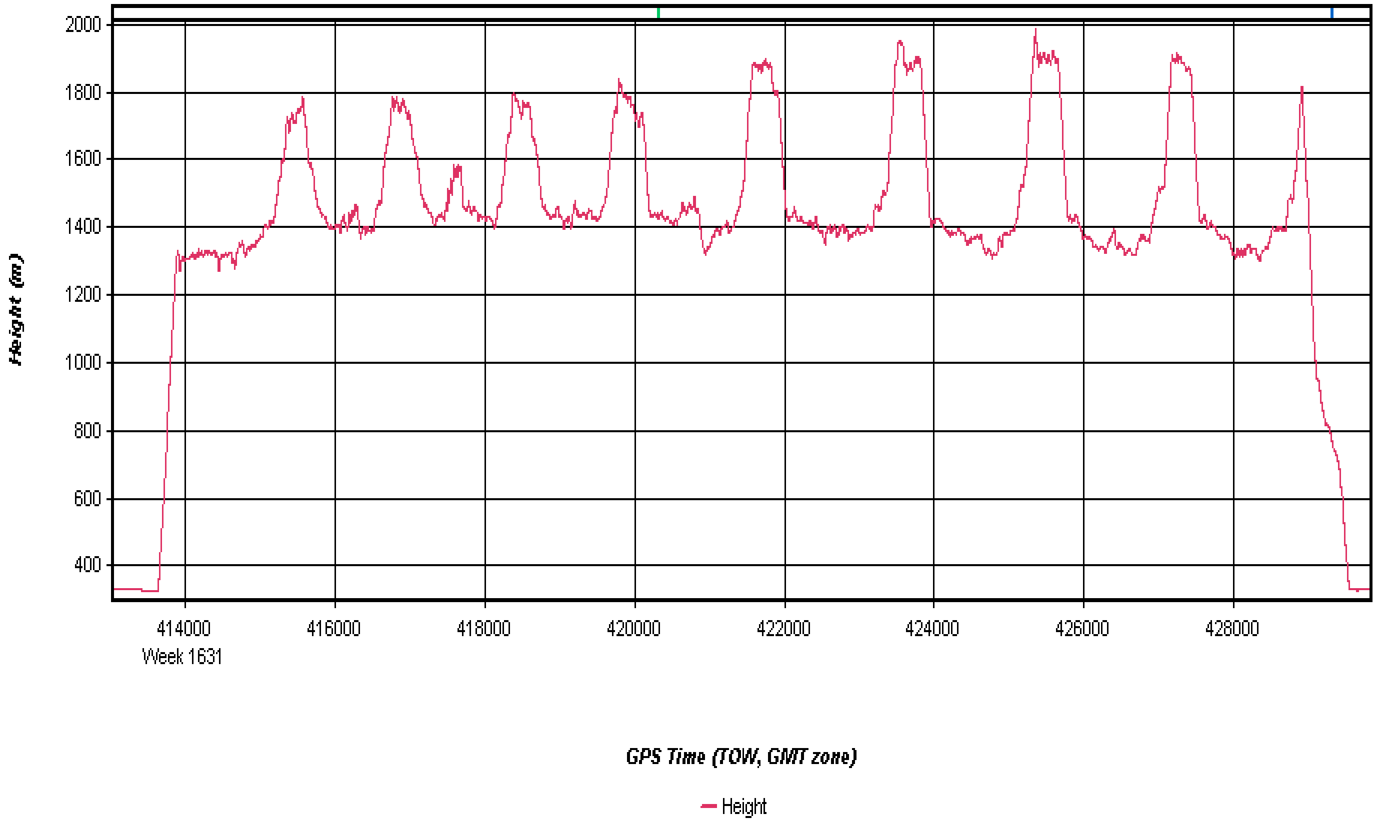
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 2: JD104F02 [Combined] - Quality Factor Plot



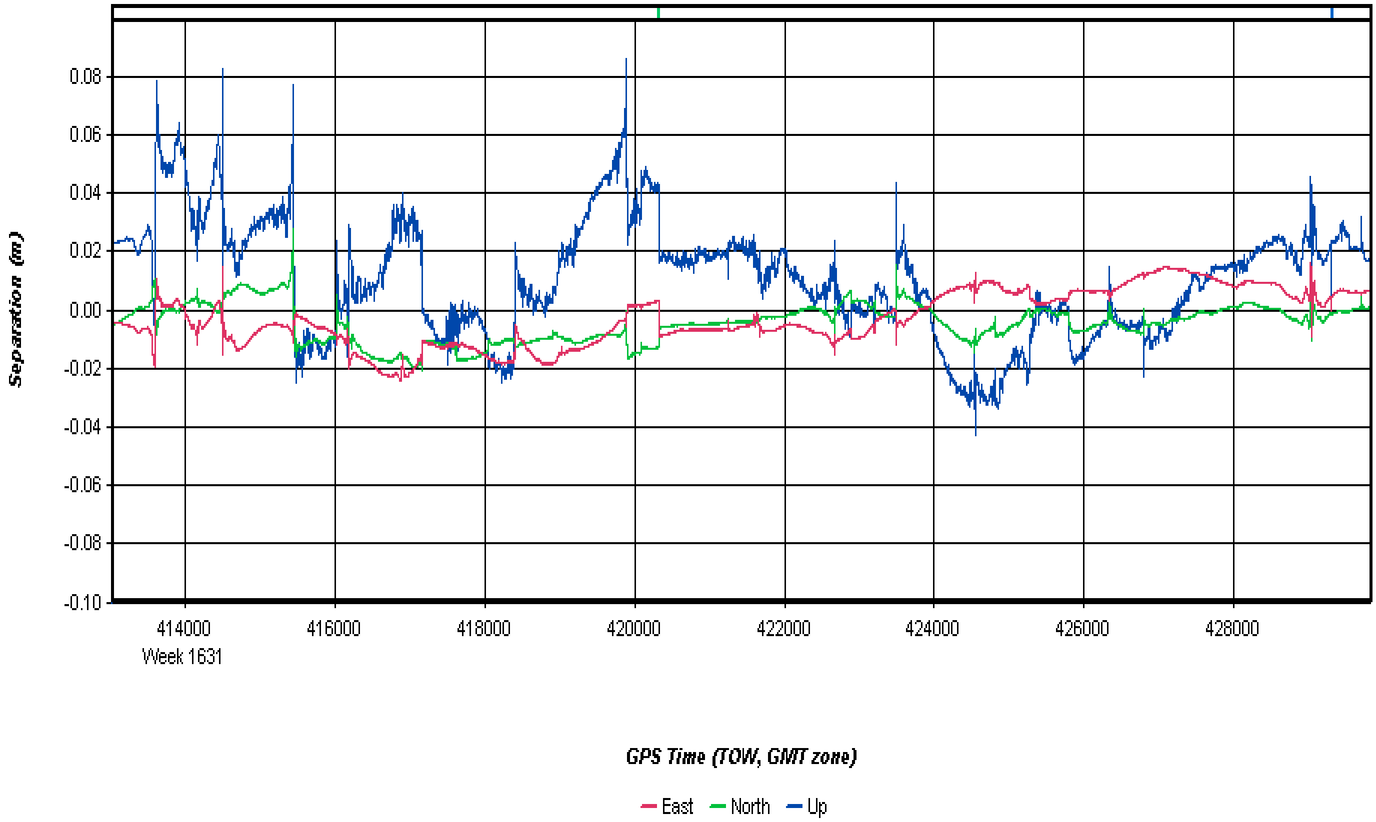
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 3: JD104F02 [Combined] - Height Profile Plot



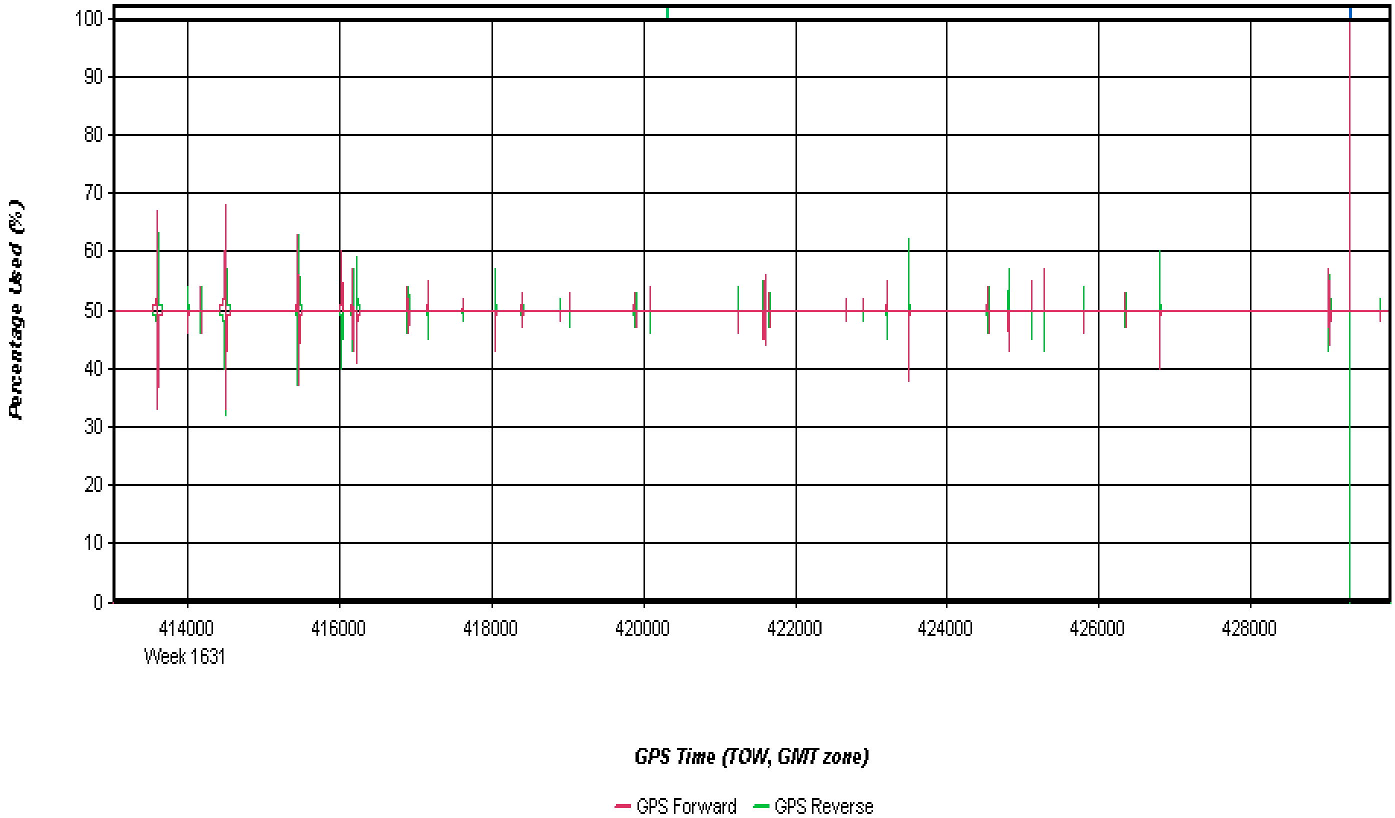
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 4: JD104F02 [Combined] - Forward/Reverse or Combined Separation Plot



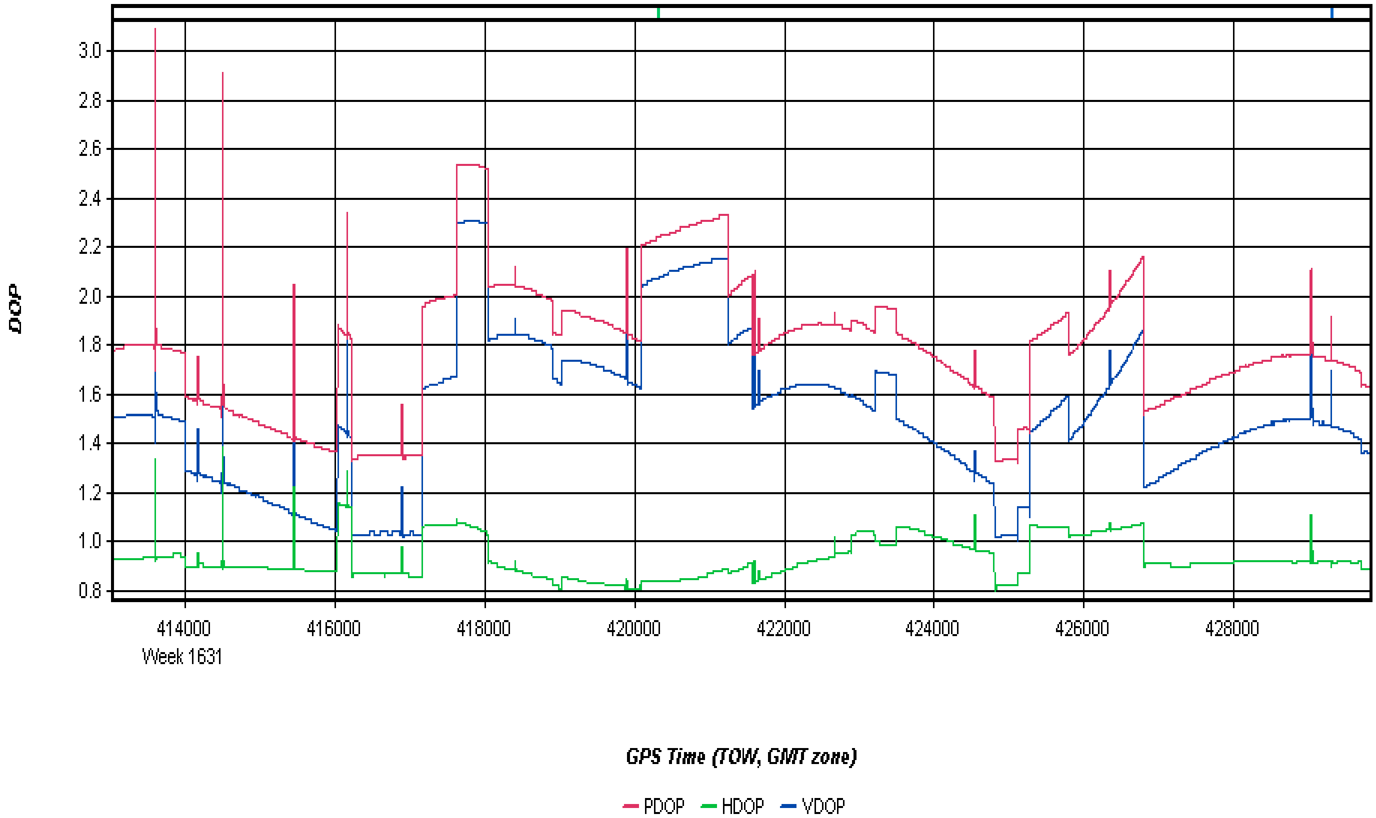
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 5: JD104F02 [Combined] - Forward/Reverse or Combined Weighting Plot



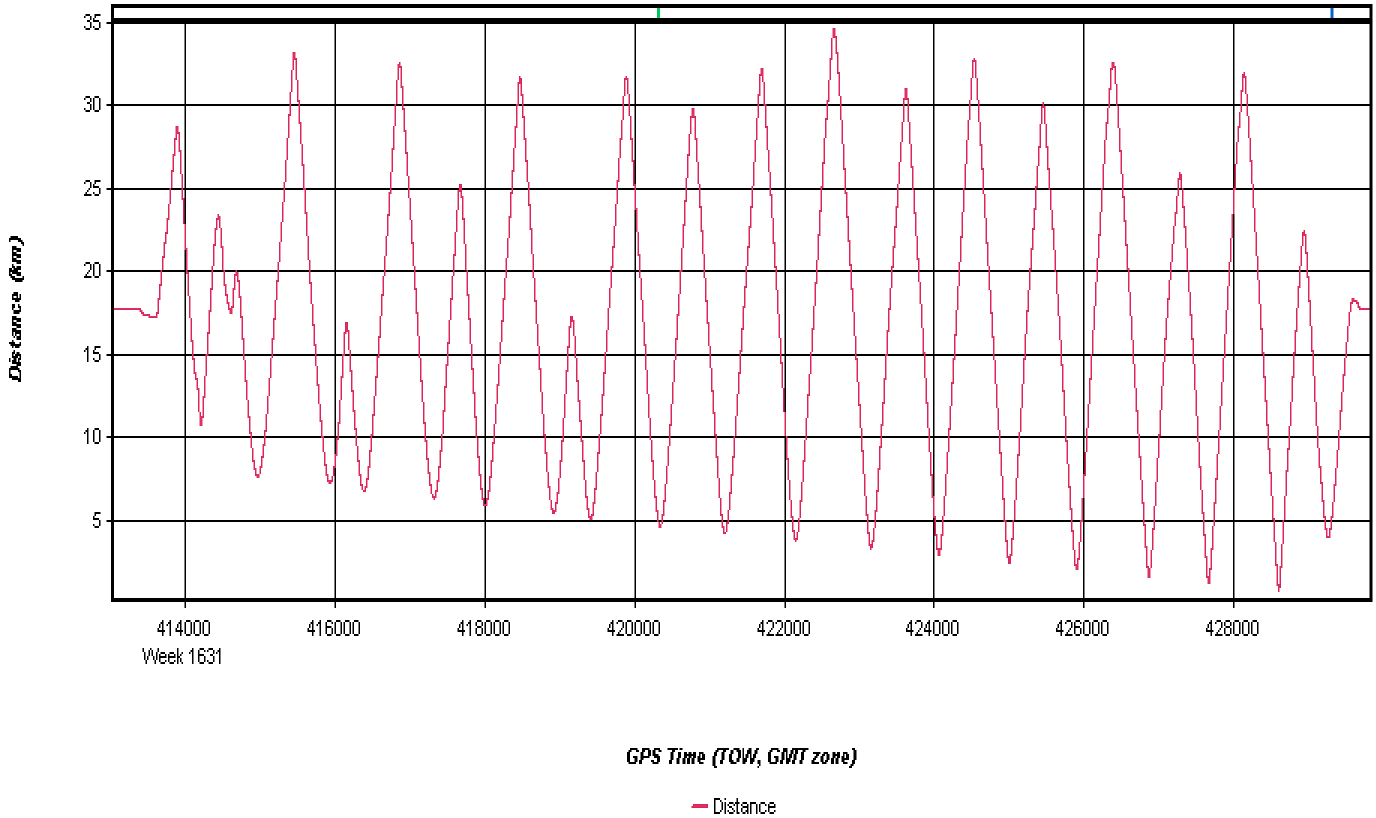
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 6: JD104F02 [Combined] - PDOP, HDOP, VDOP Plots



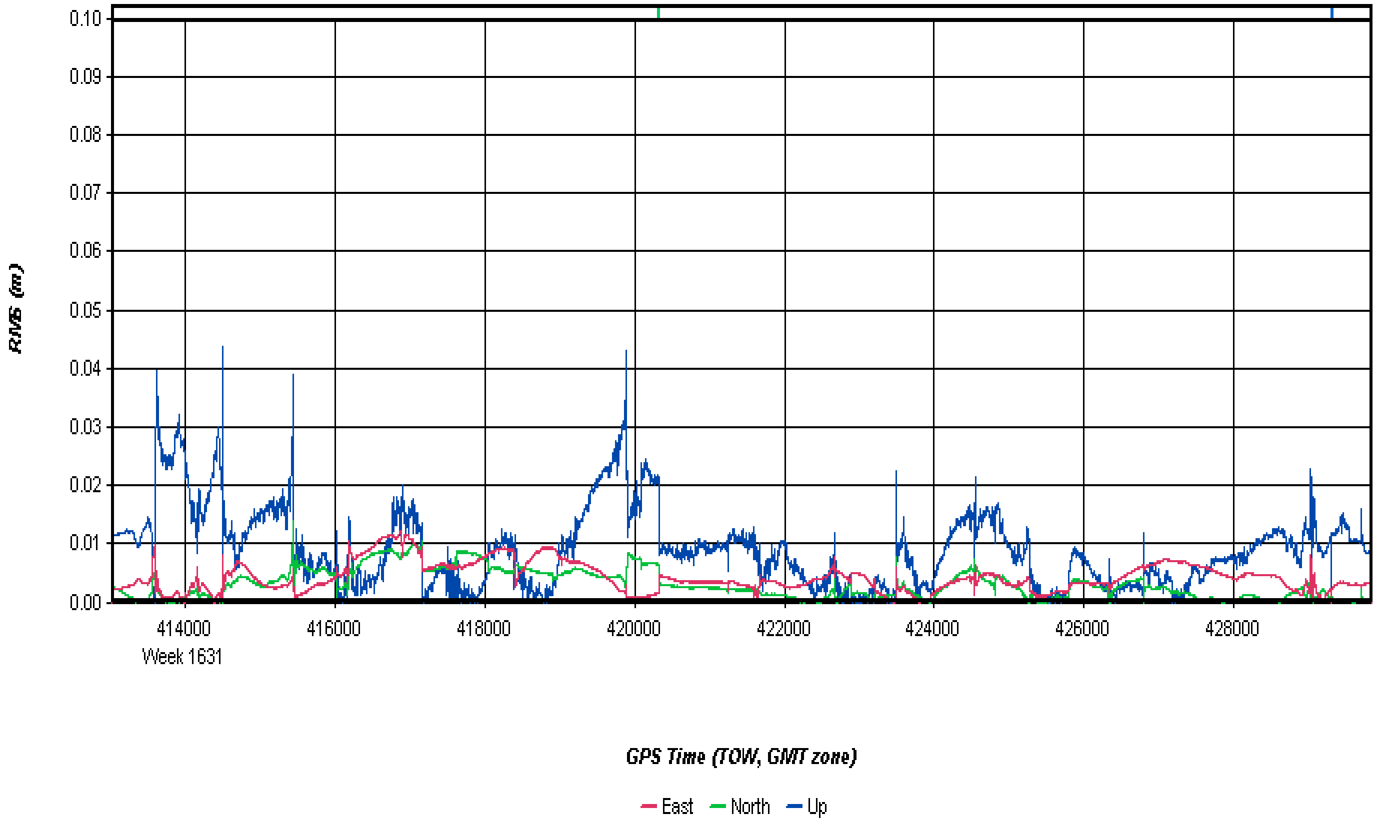
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 7: JD104F02 [Combined] - Horizontal Distance Separation (km)



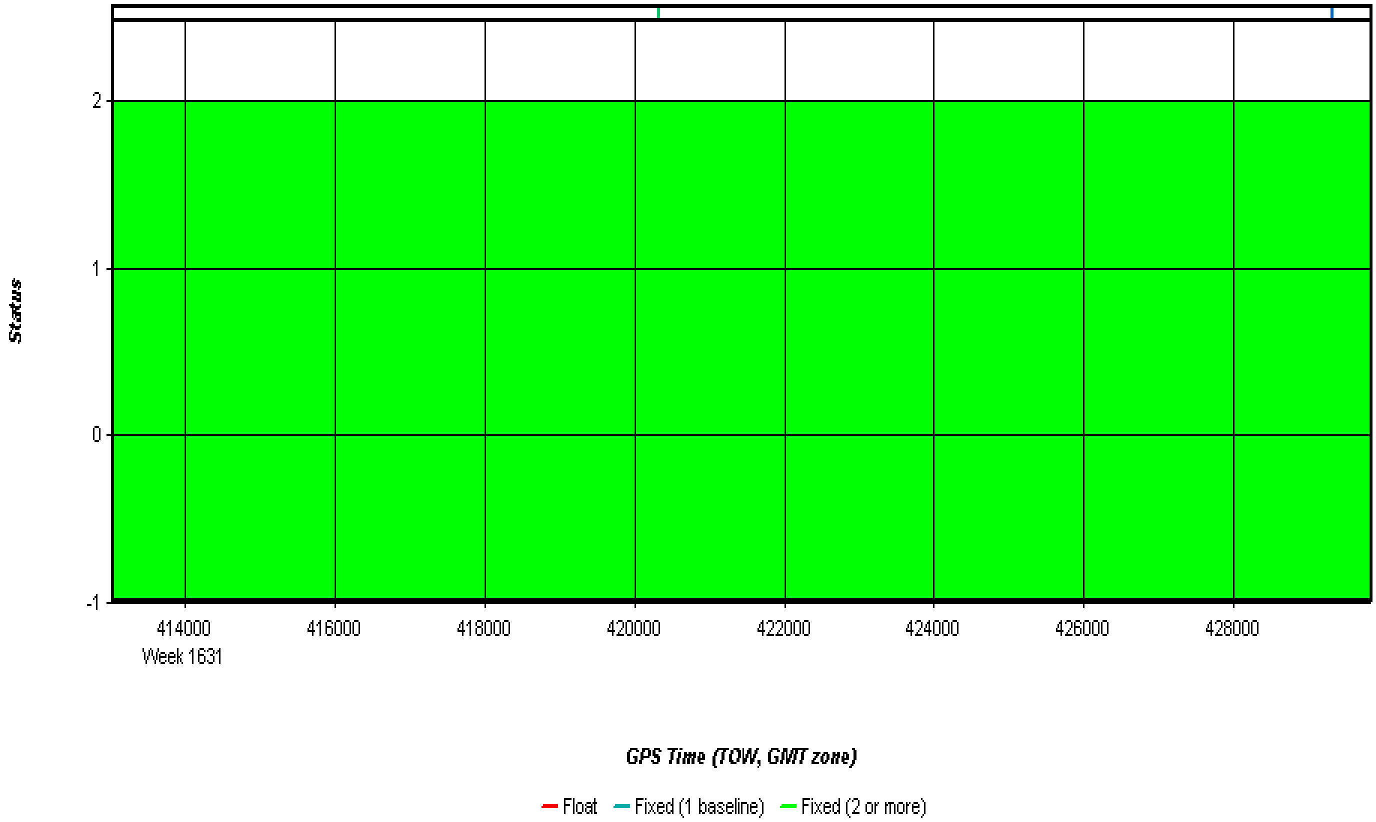
Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 8: JD104F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Figure 9: JD104F02 [Combined] - Float or Fixed Ambiguity

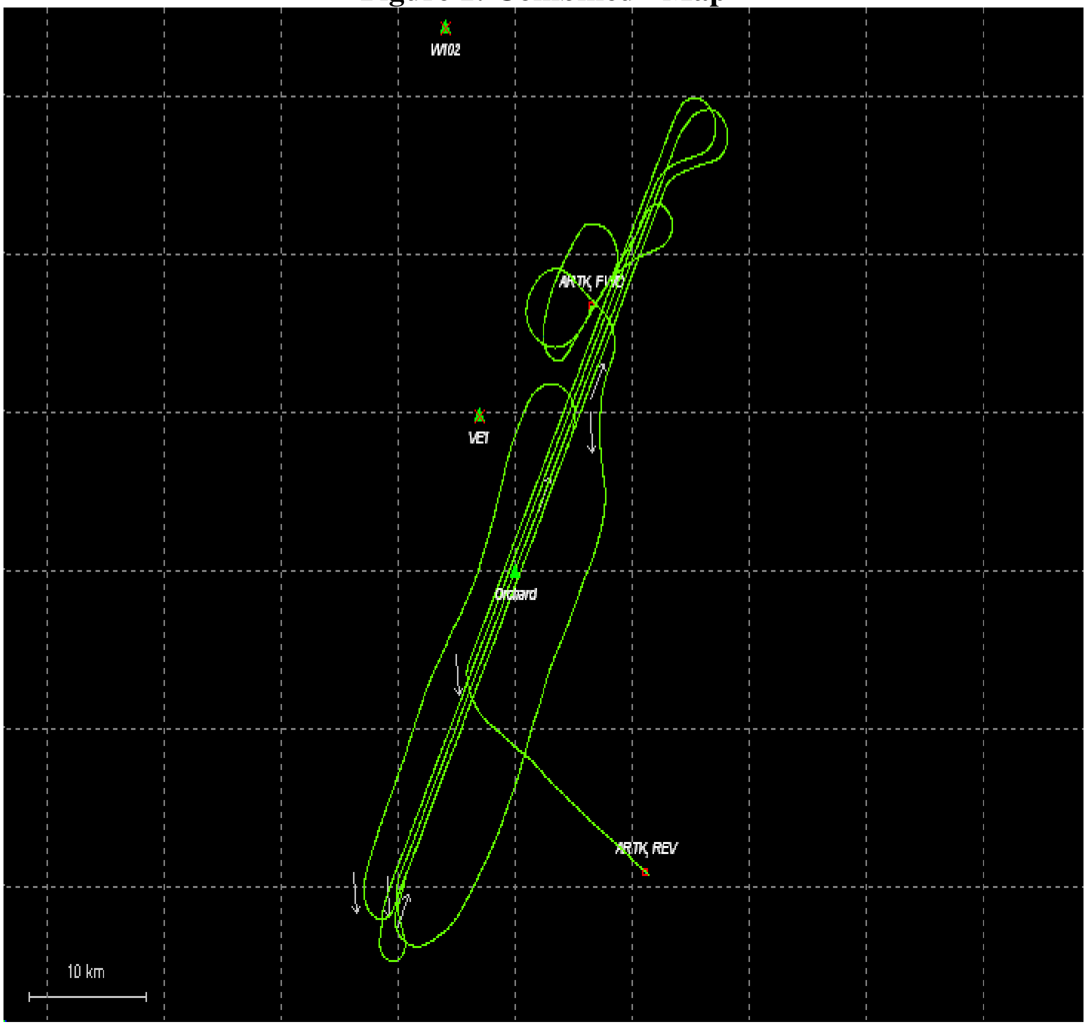


Process	Run (9)	by Unknown	on 05/27/2011	at 07:14:25

Output Results for JD104F03

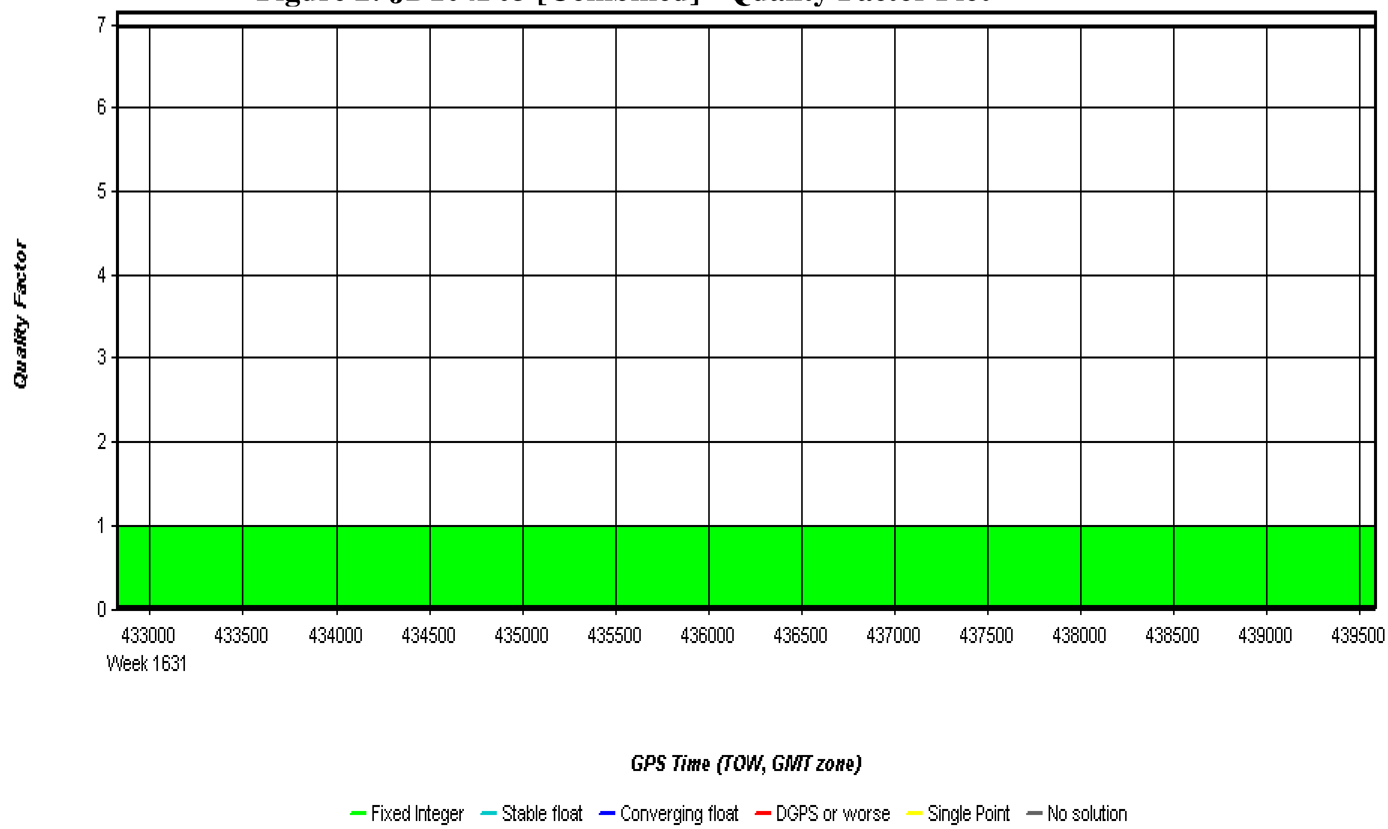
POSGNSS Version 5.20.1209
06/02/2011

Figure 1: Combined - Map



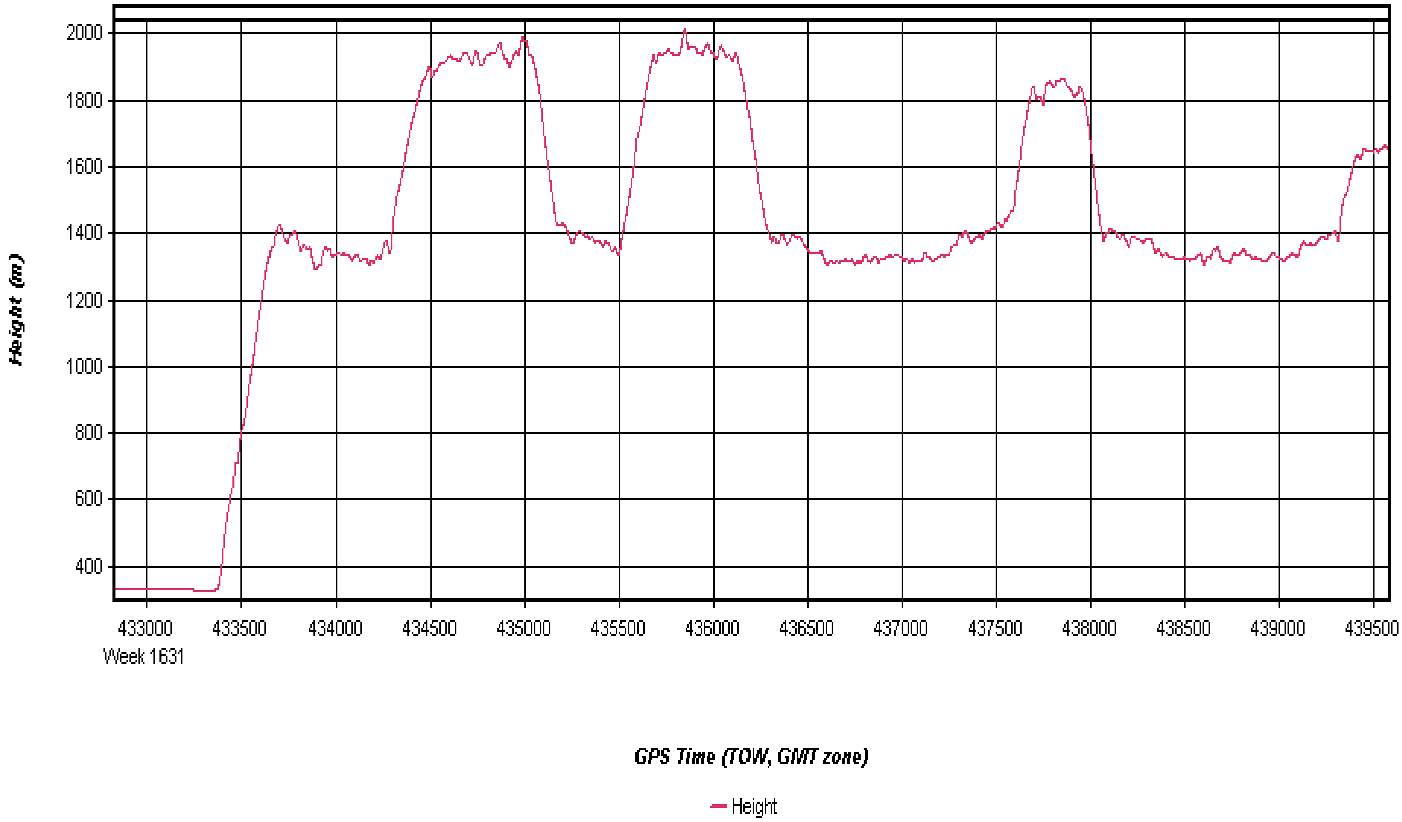
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 2: JD104F03 [Combined] - Quality Factor Plot



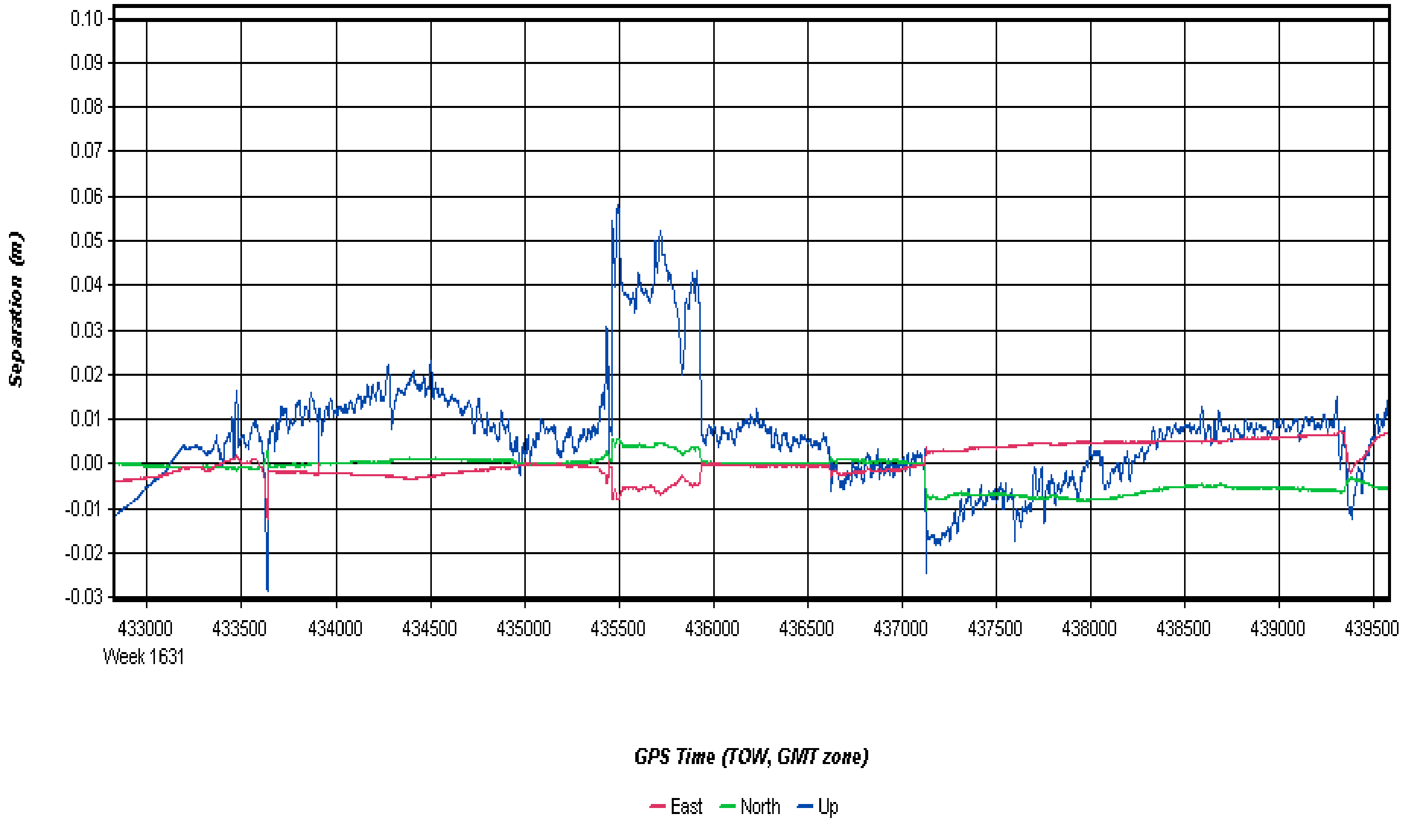
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 3: JD104F03 [Combined] - Height Profile Plot



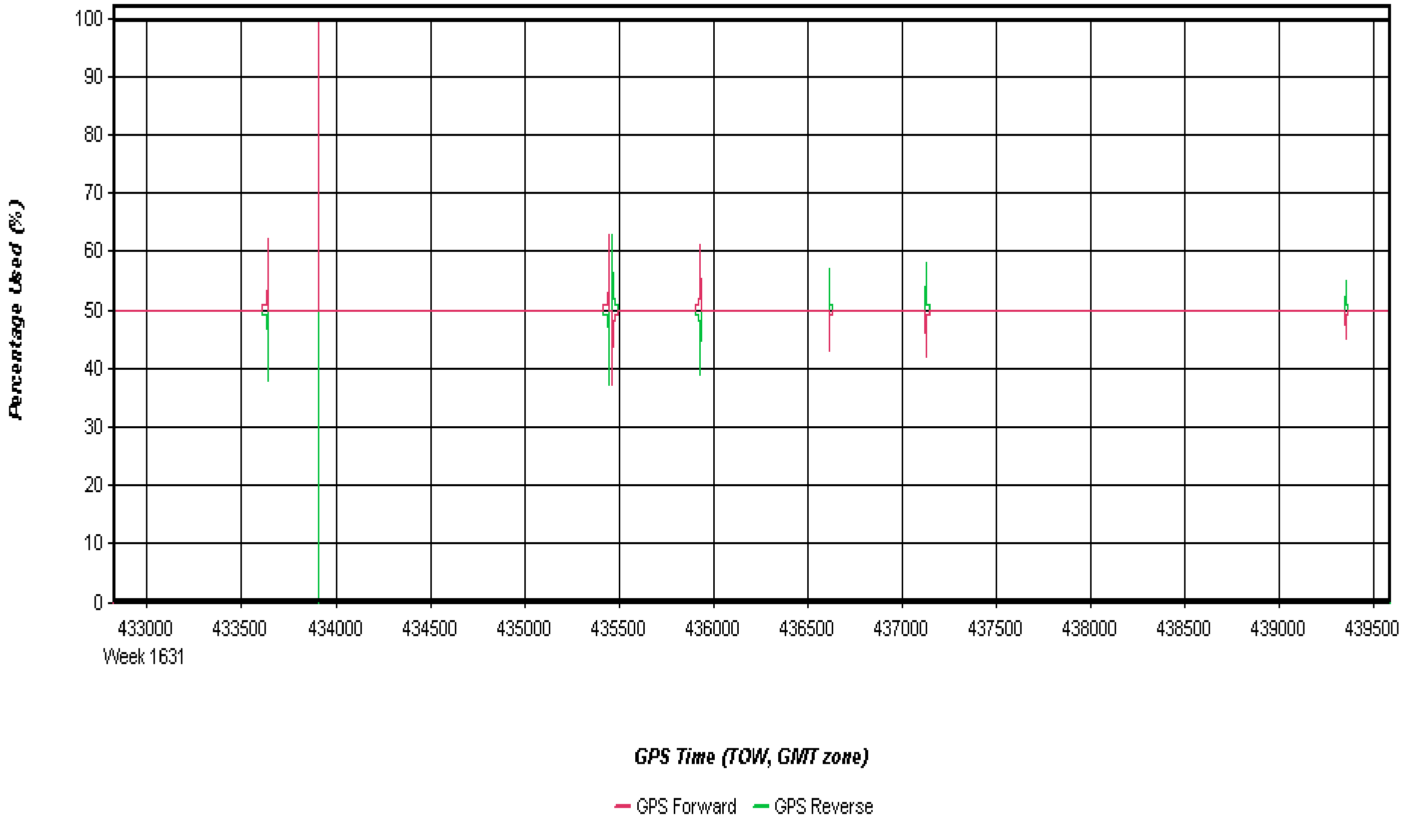
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 4: JD104F03 [Combined] - Forward/Reverse or Combined Separation Plot



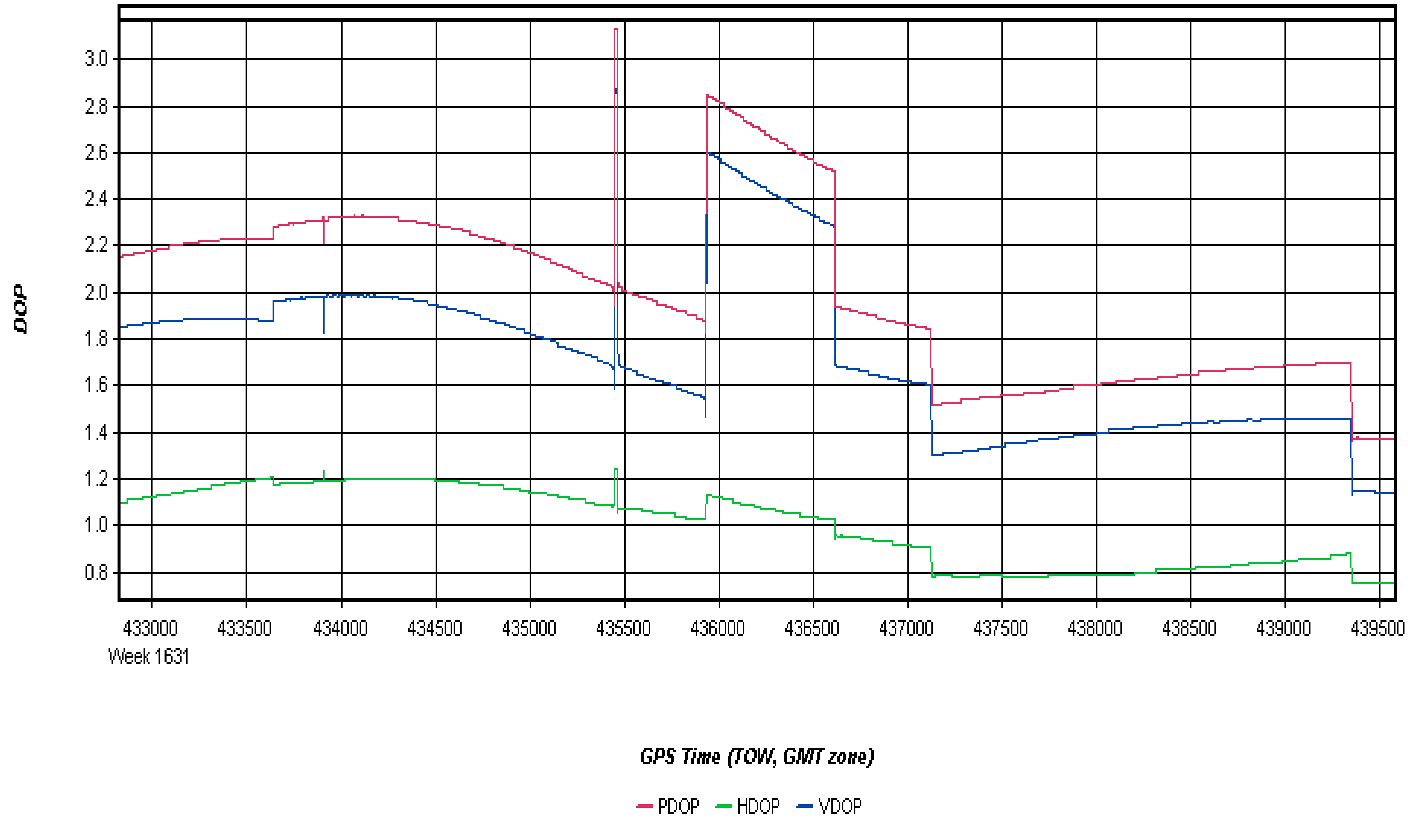
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 5: JD104F03 [Combined] - Forward/Reverse or Combined Weighting Plot



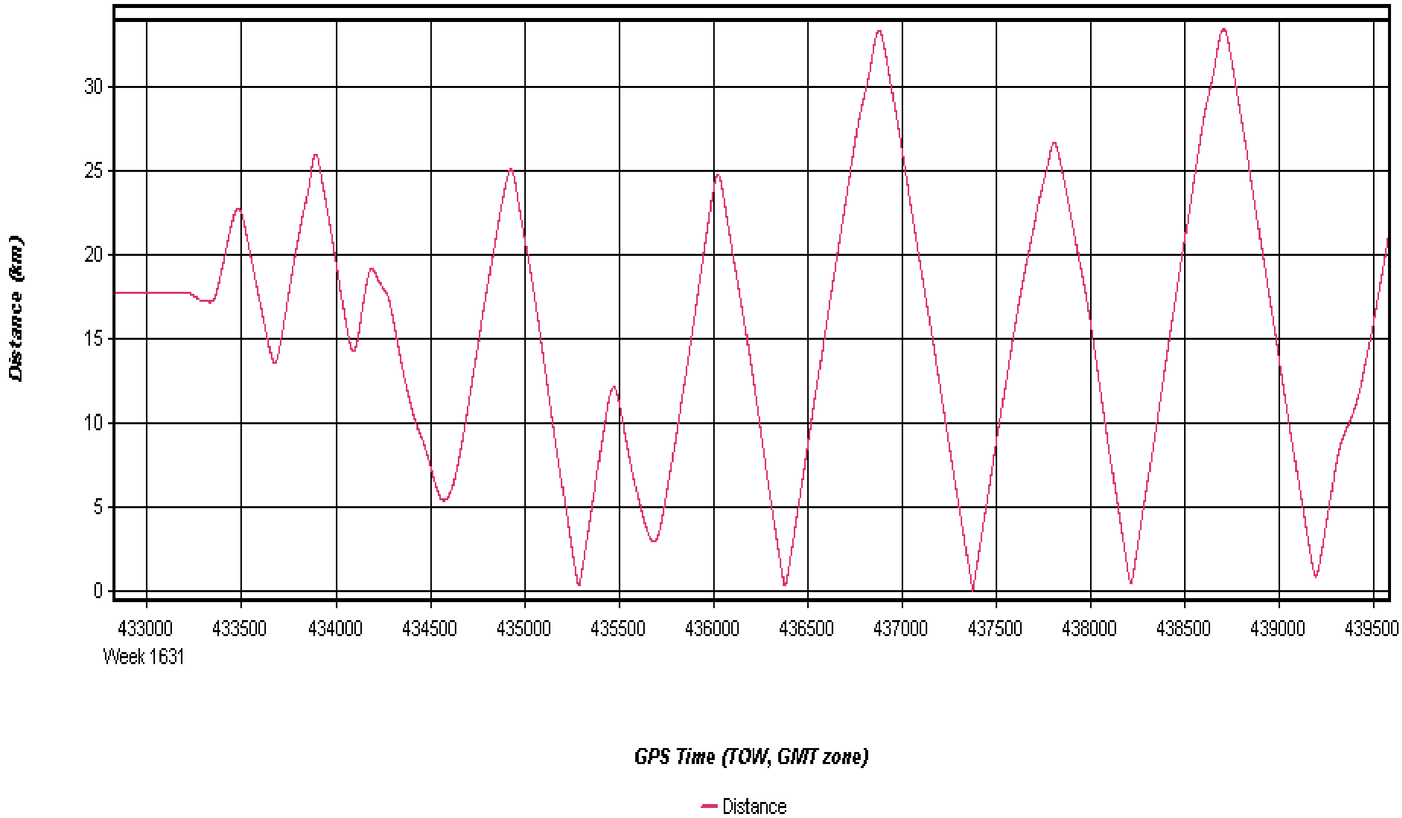
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 6: JD104F03 [Combined] - PDOP, HDOP, VDOP Plots



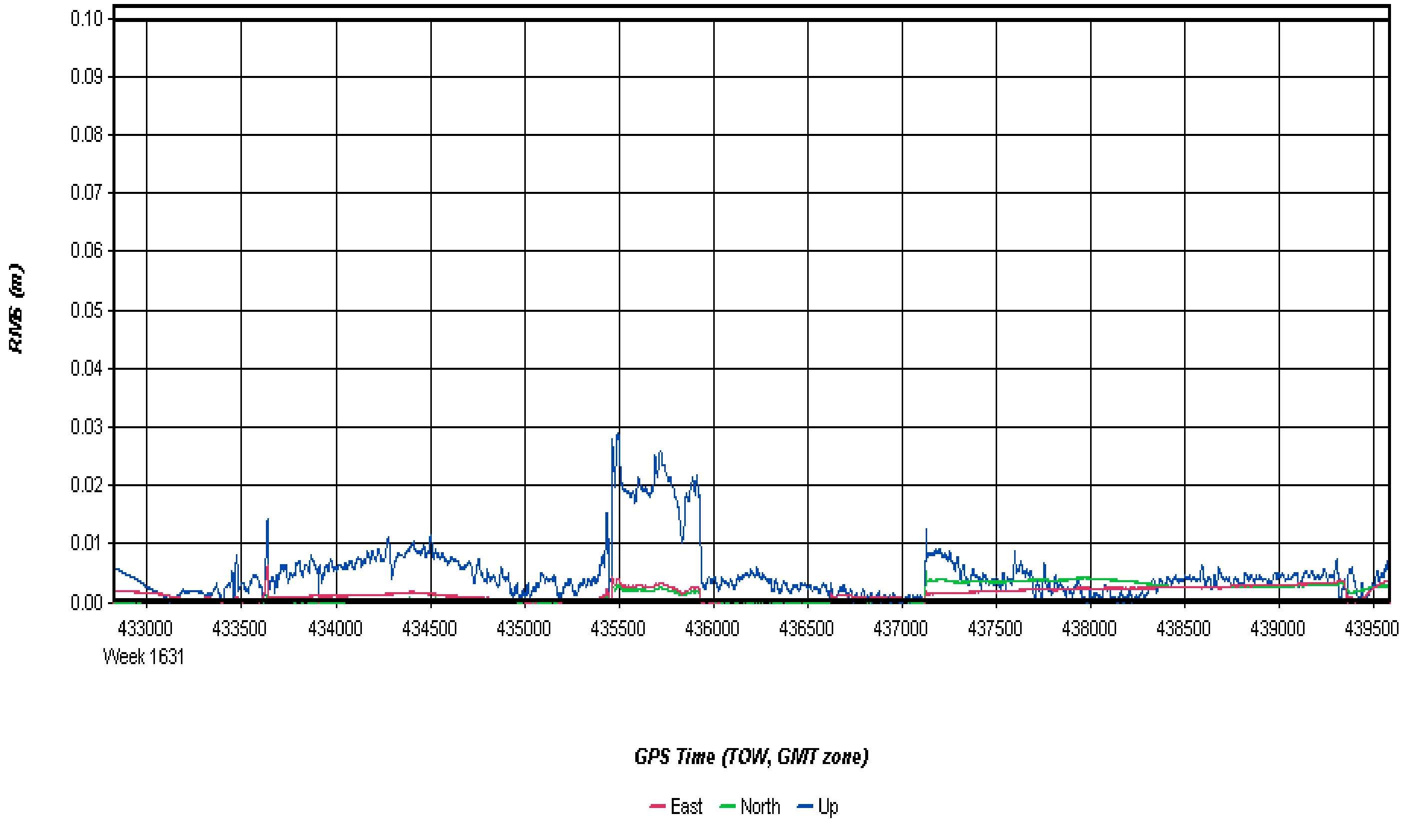
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 7: JD104F03 [Combined] - Horizontal Distance Separation (km)



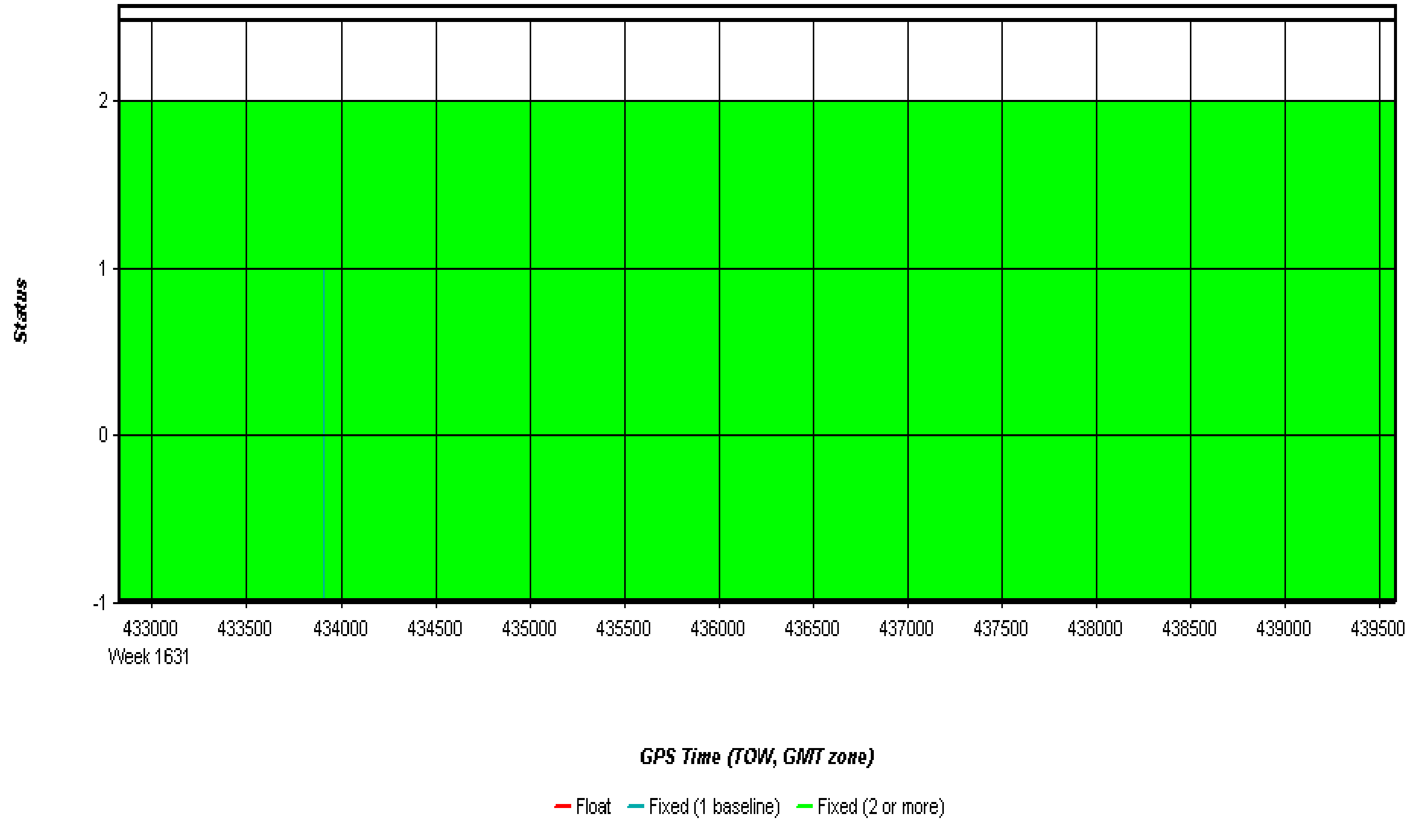
Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 8: JD104F03 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Figure 9: JD104F03 [Combined] - Float or Fixed Ambiguity

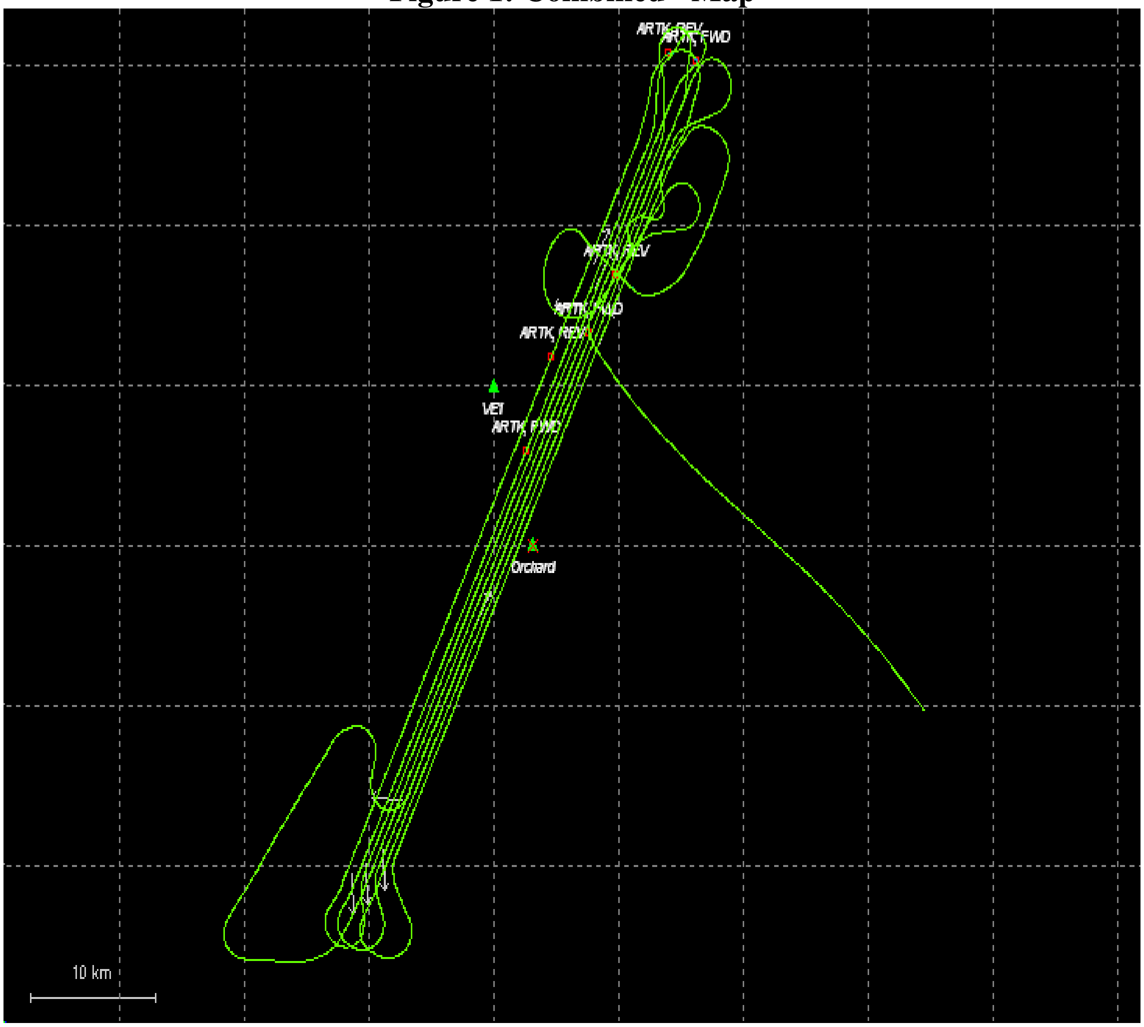


Process	Run (2)	by Unknown	on 05/31/2011	at 12:58:32

Output Results for JD105F01

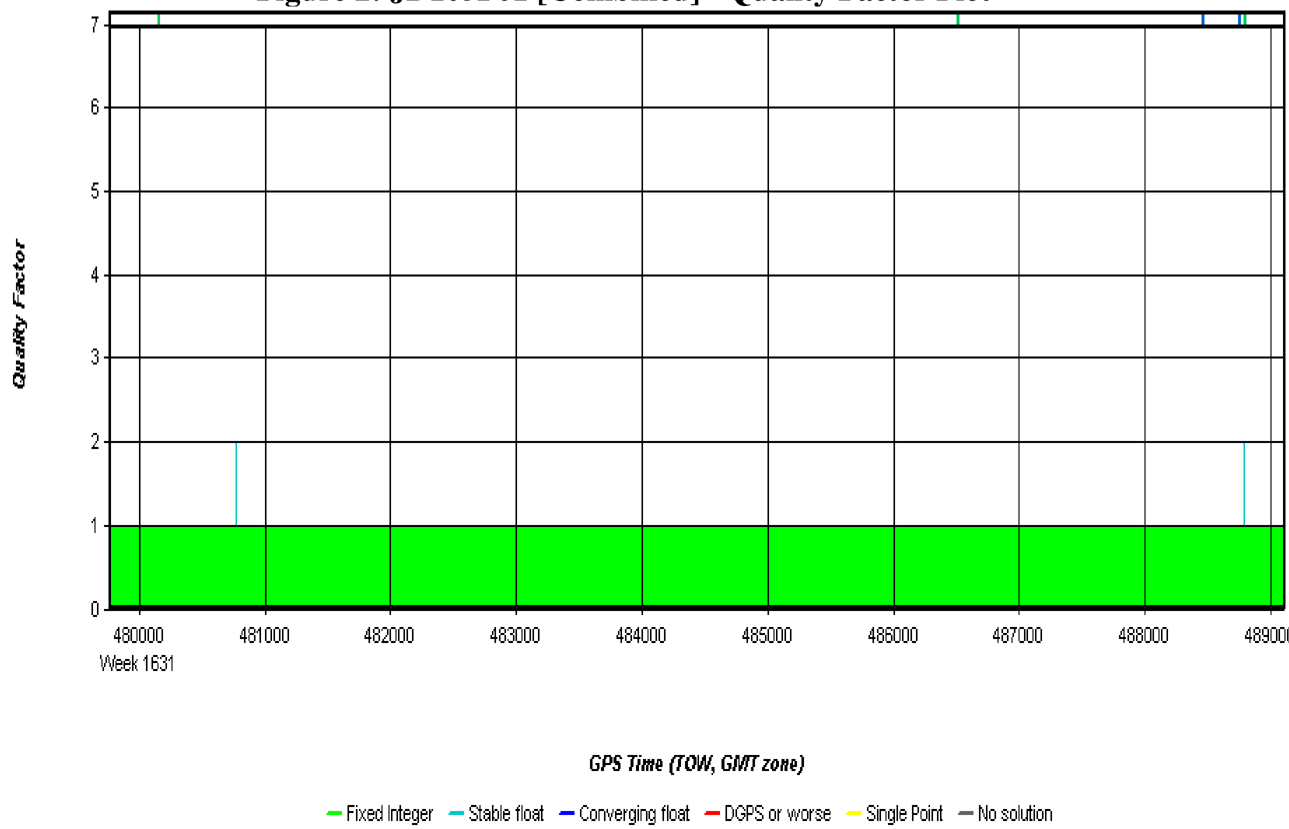
POSGNSS Version 5.20.1209
06/02/2011

Figure 1: Combined - Map



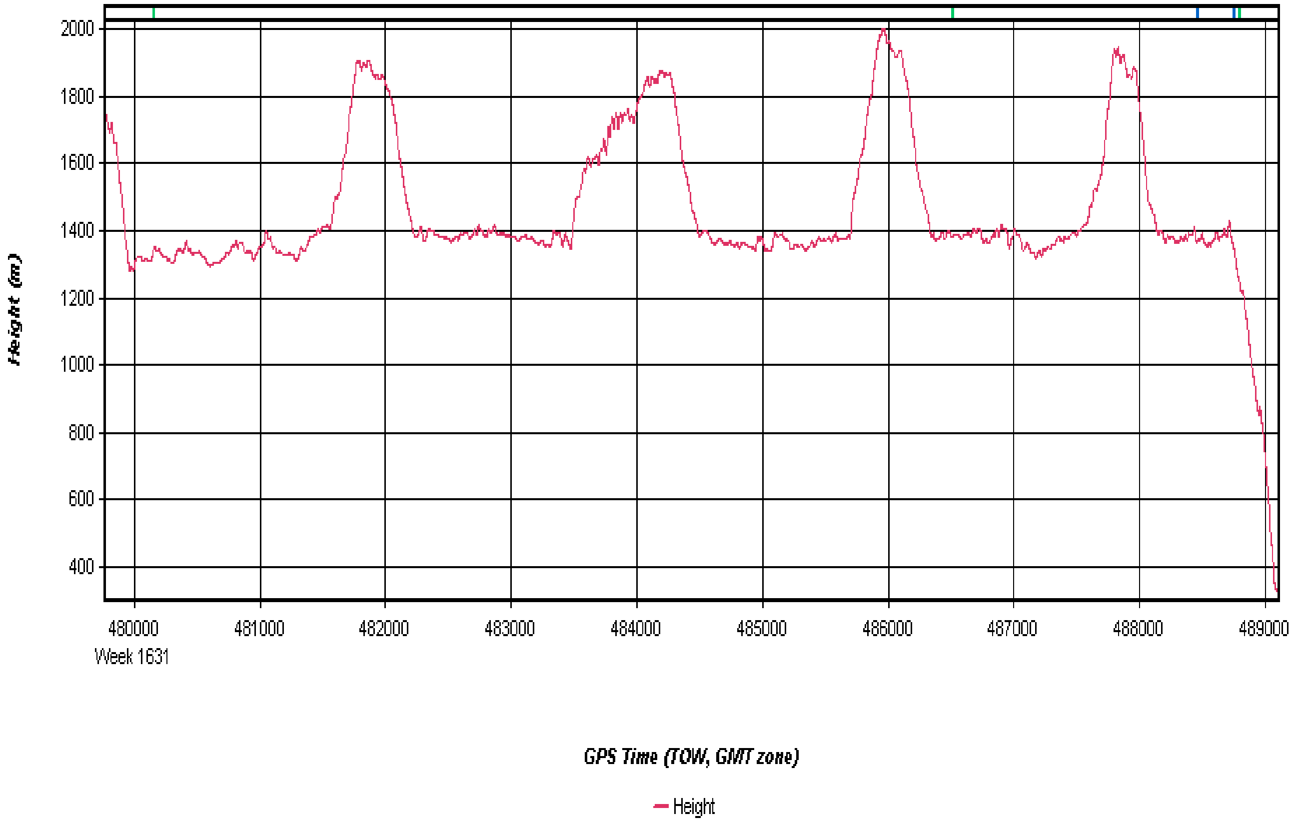
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 2: JD105F01 [Combined] - Quality Factor Plot



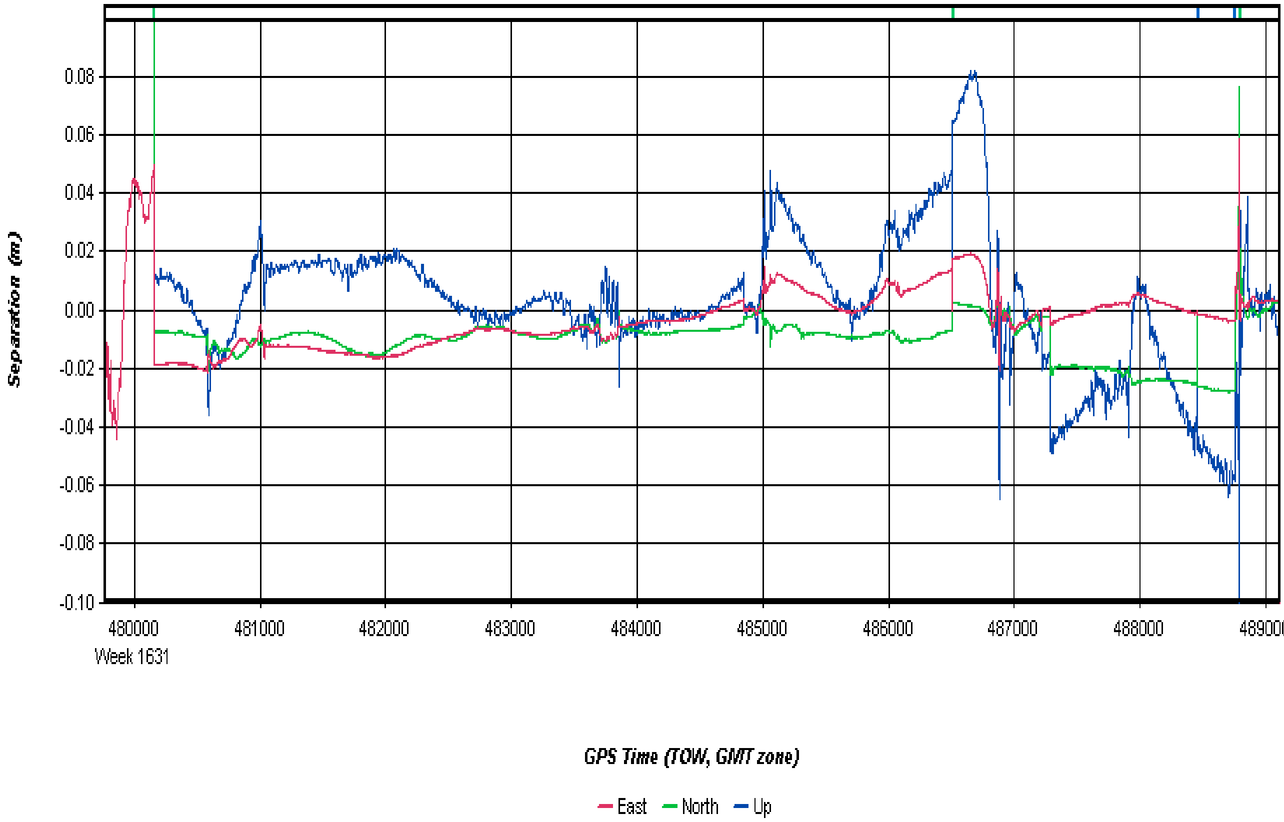
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 3: JD105F01 [Combined] - Height Profile Plot



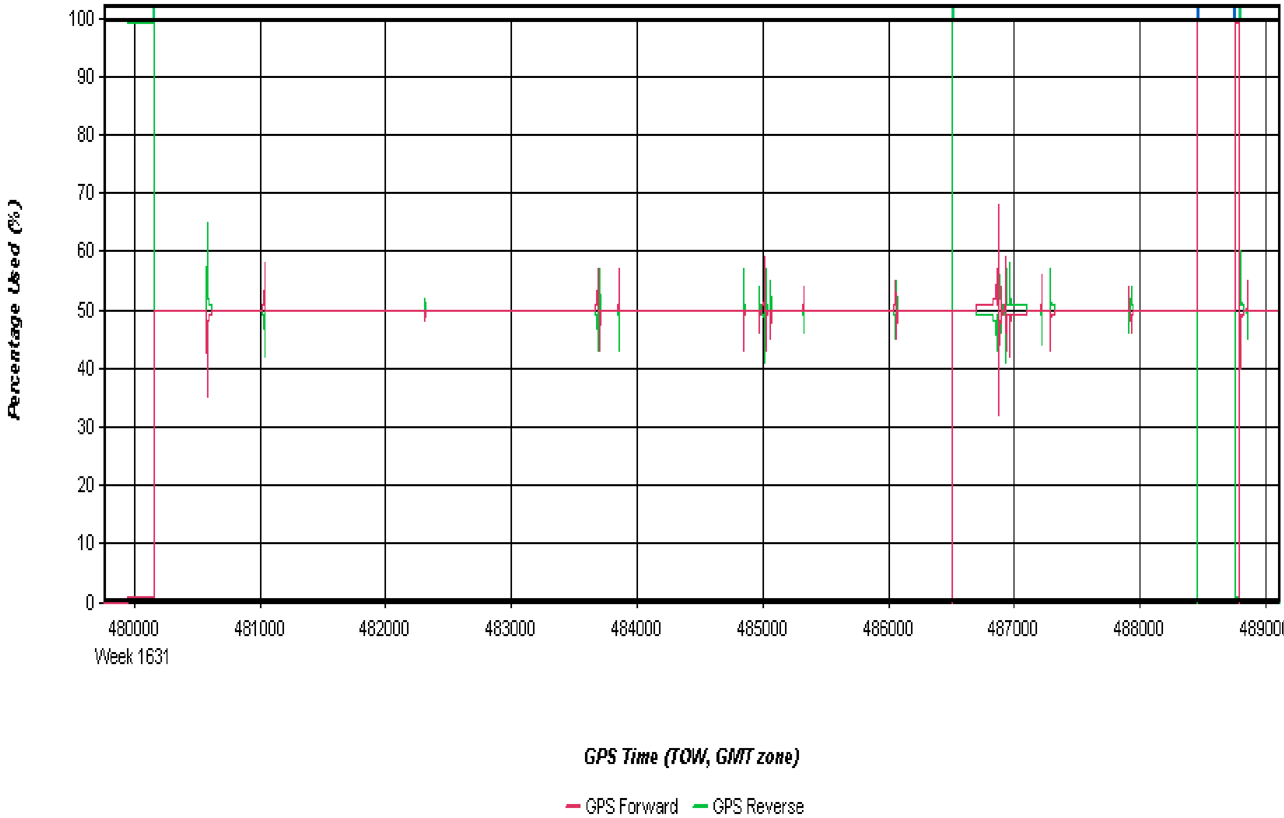
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 4: JD105F01 [Combined] - Forward/Reverse or Combined Separation Plot



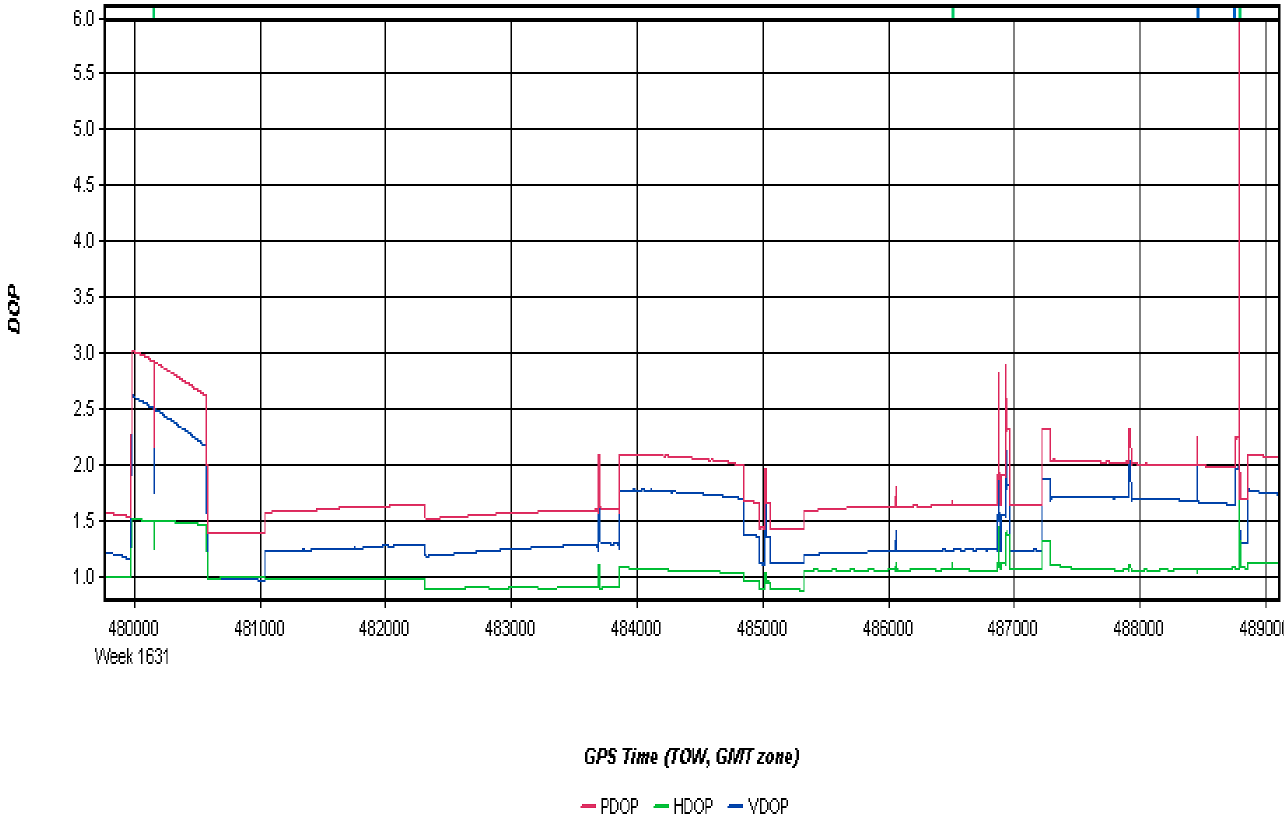
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 5: JD105F01 [Combined] - Forward/Reverse or Combined Weighting Plot



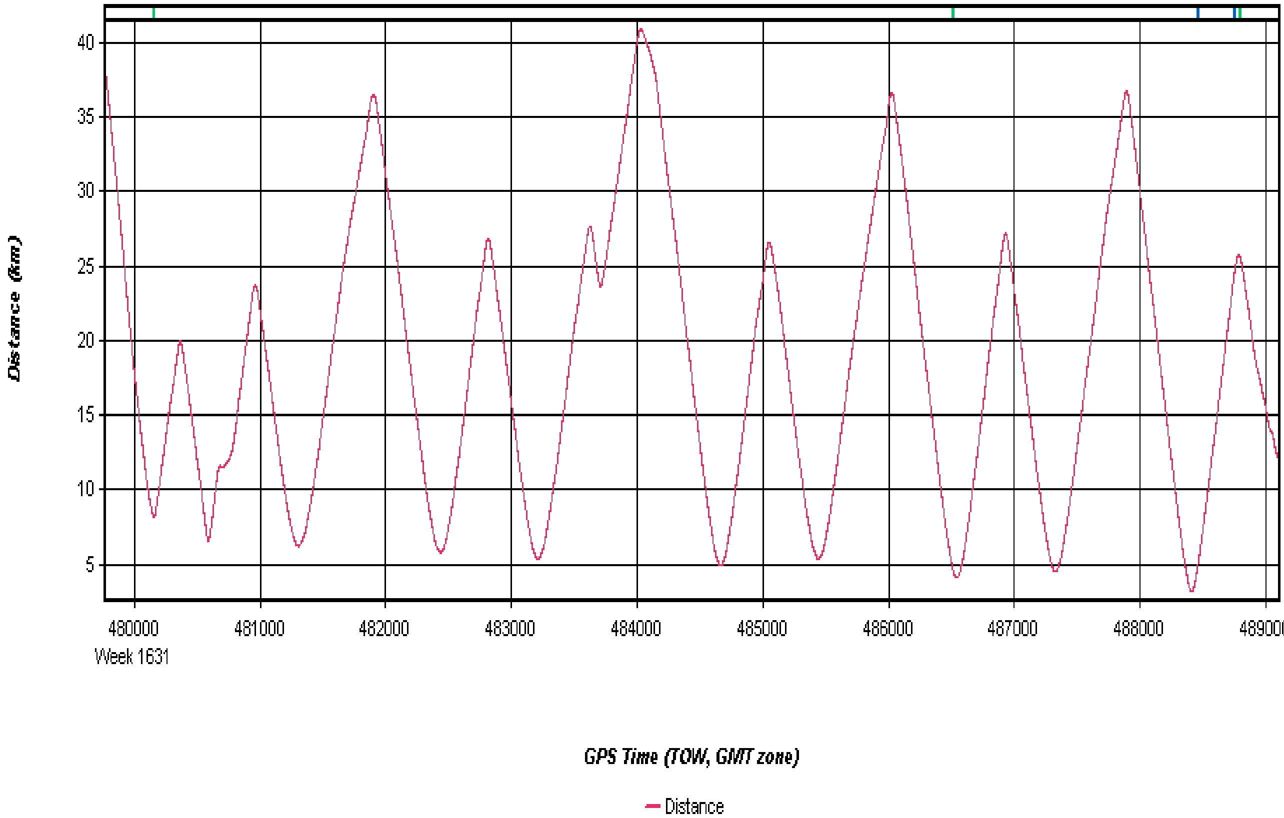
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 6: JD105F01 [Combined] - PDOP, HDOP, VDOP Plots



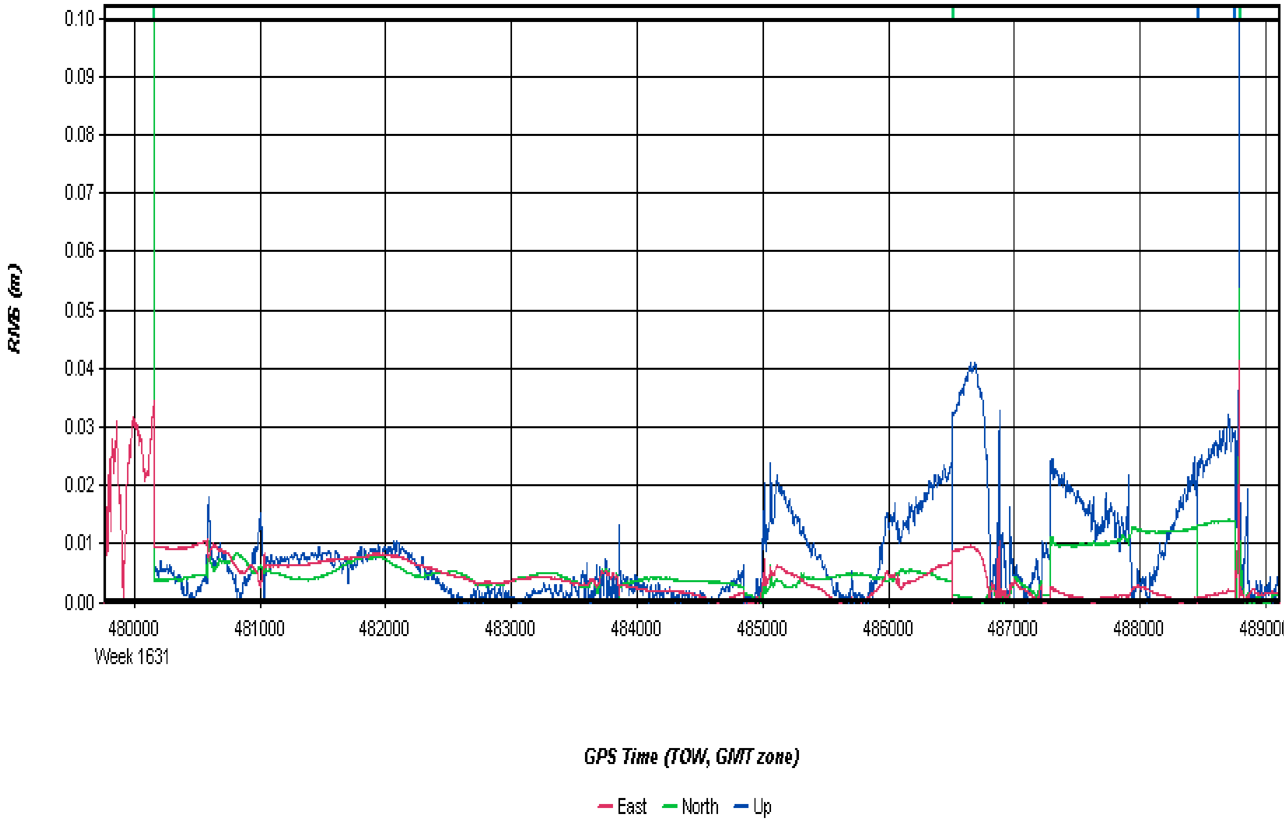
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 7: JD105F01 [Combined] - Horizontal Distance Separation (km)



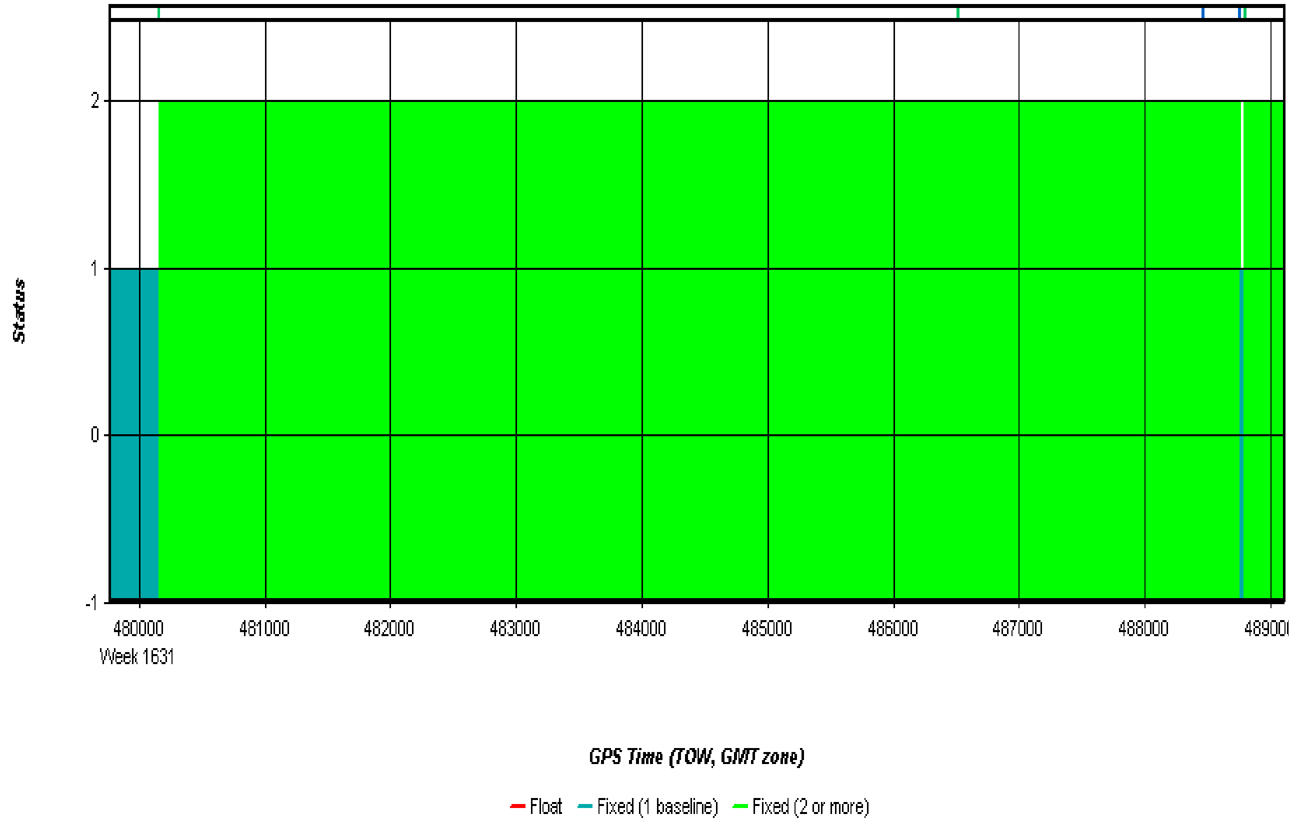
Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 8: JD105F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Figure 9: JD105F01 [Combined] - Float or Fixed Ambiguity

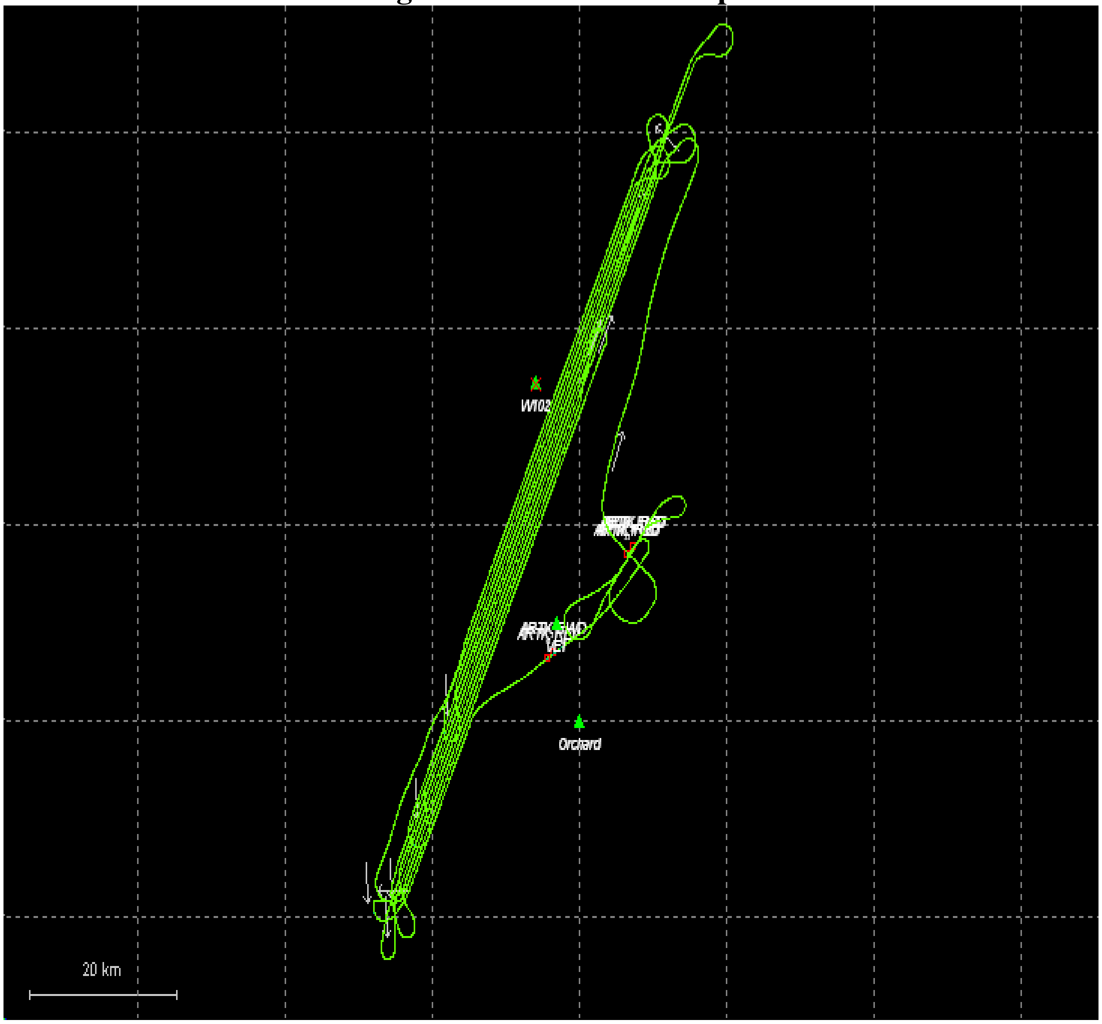


Process	Run (29)	by Unknown	on 05/31/2011	at 15:37:29

Output Results for JD107F01

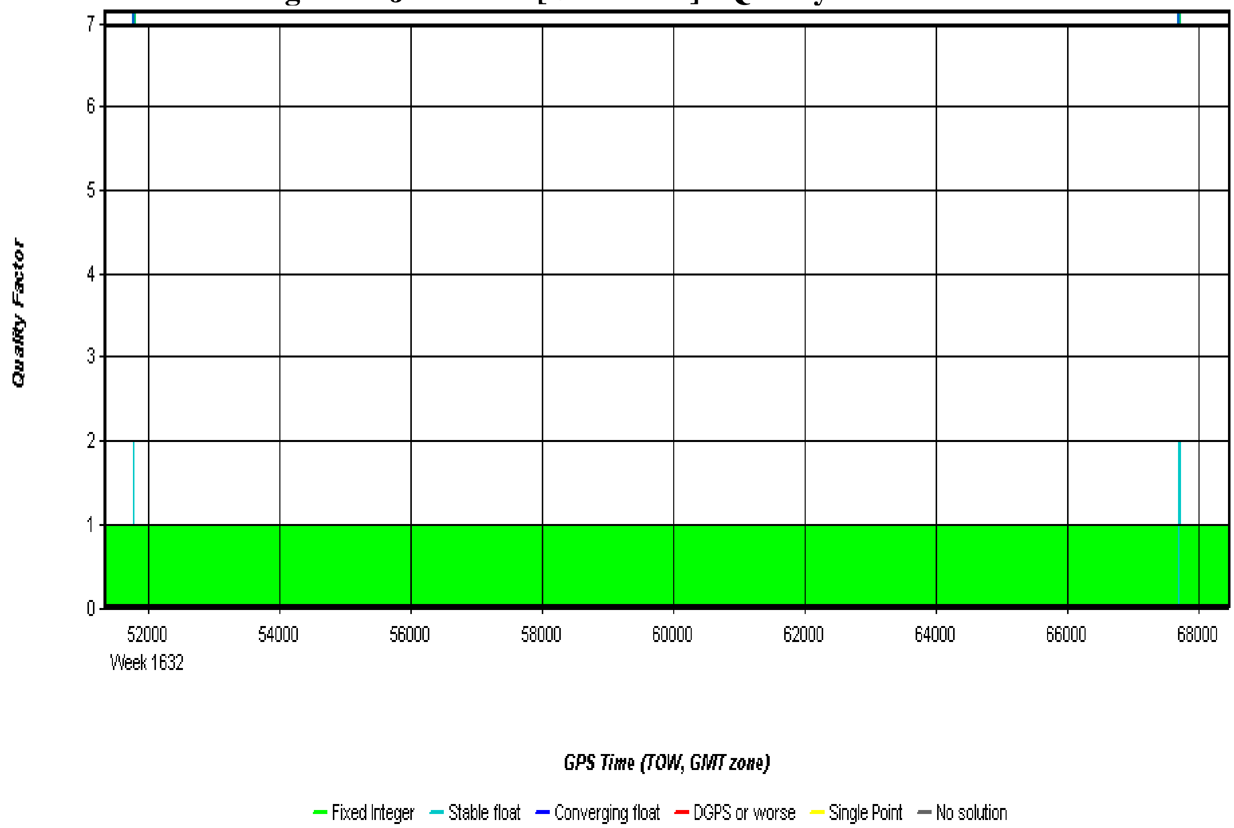
POSGNSS Version 5.20.1209
06/02/2011

Figure 1: Combined - Map



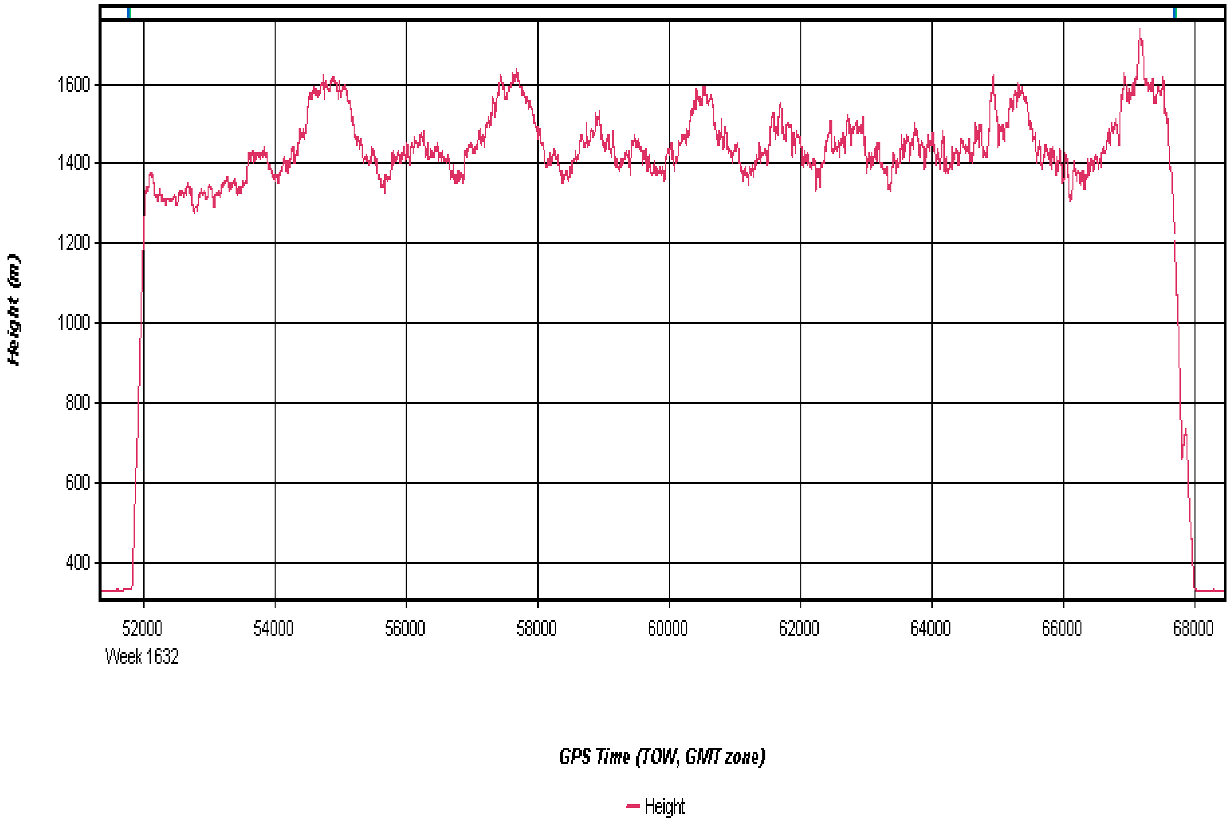
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 2: JD107F01 [Combined] - Quality Factor Plot



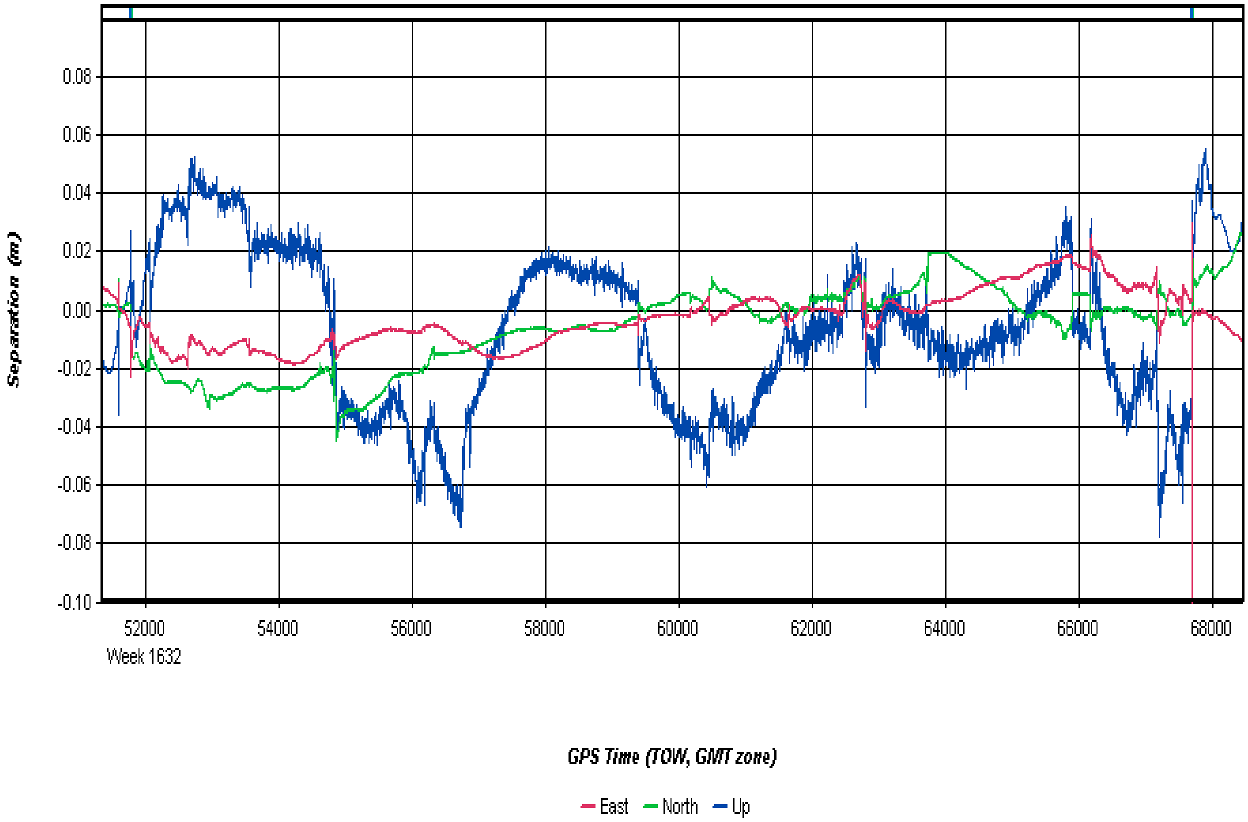
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 3: JD107F01 [Combined] - Height Profile Plot



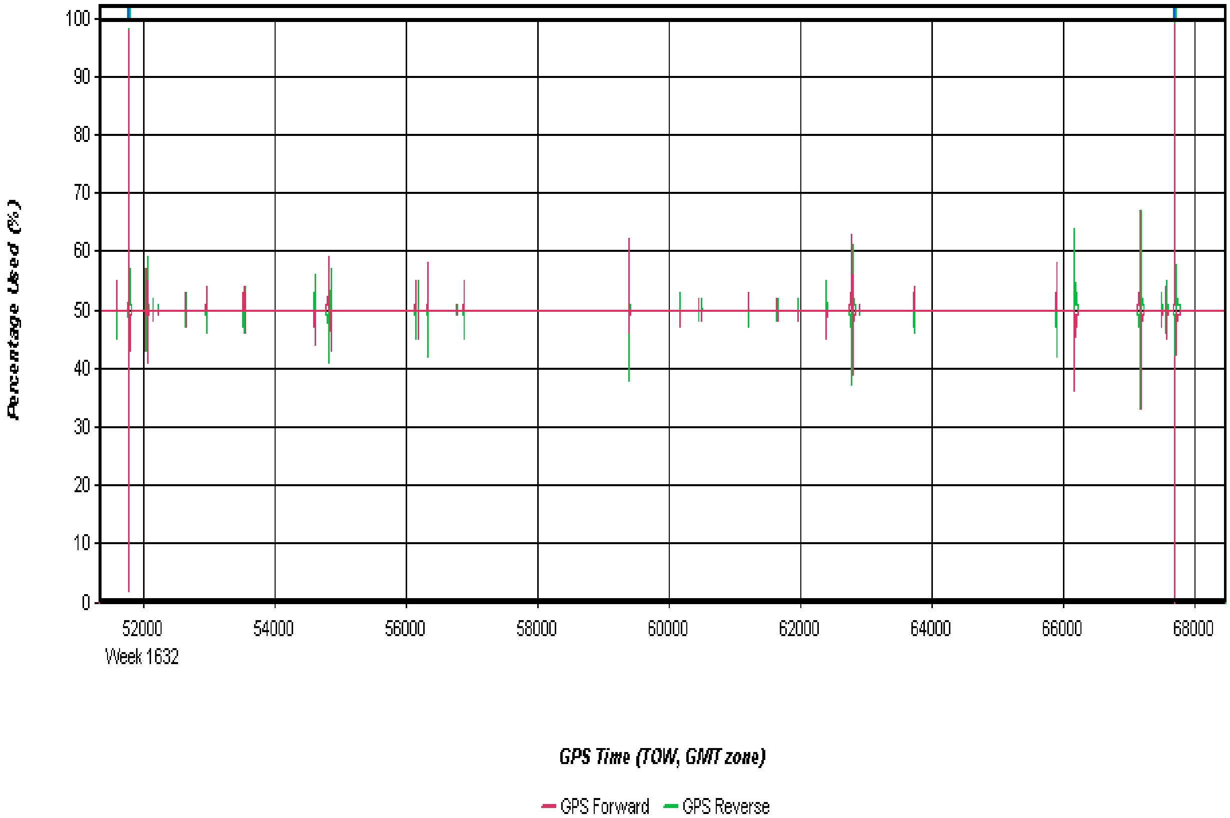
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 4: JD107F01 [Combined] - Forward/Reverse or Combined Separation Plot



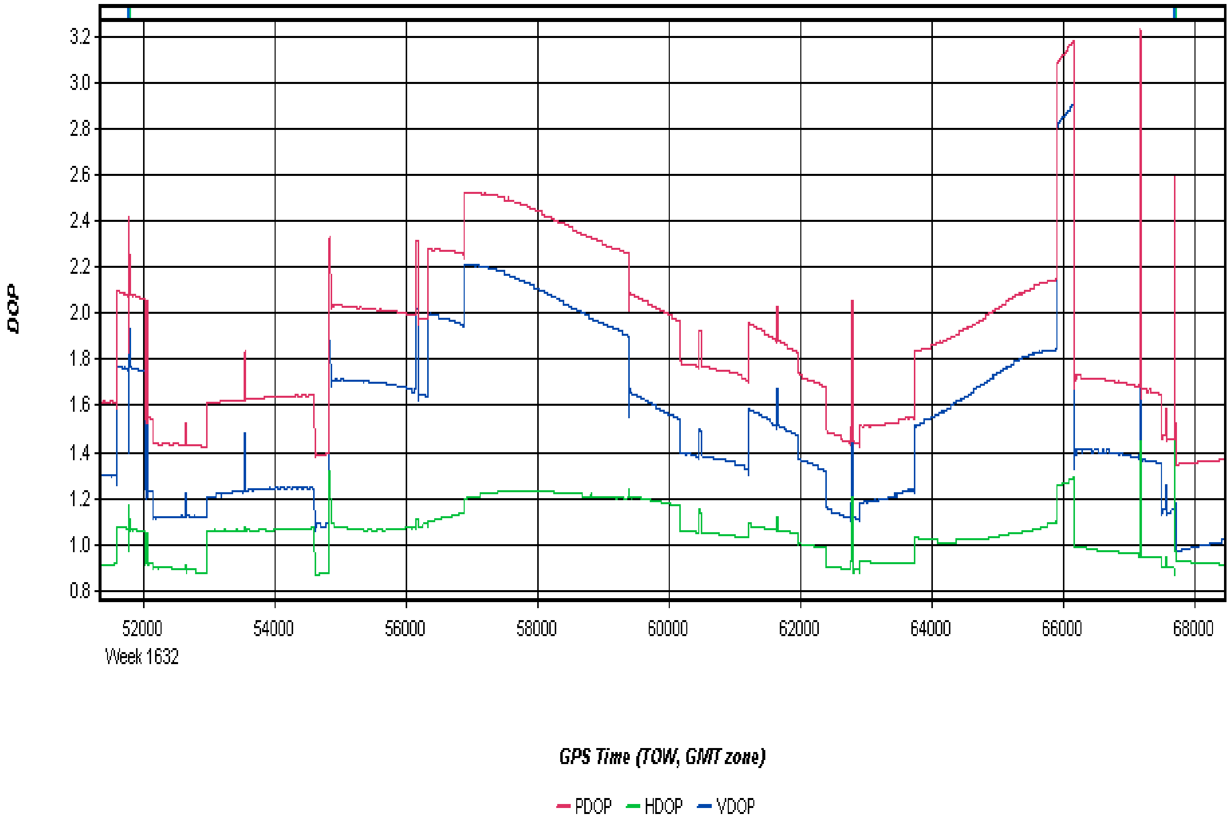
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 5: JD107F01 [Combined] - Forward/Reverse or Combined Weighting Plot



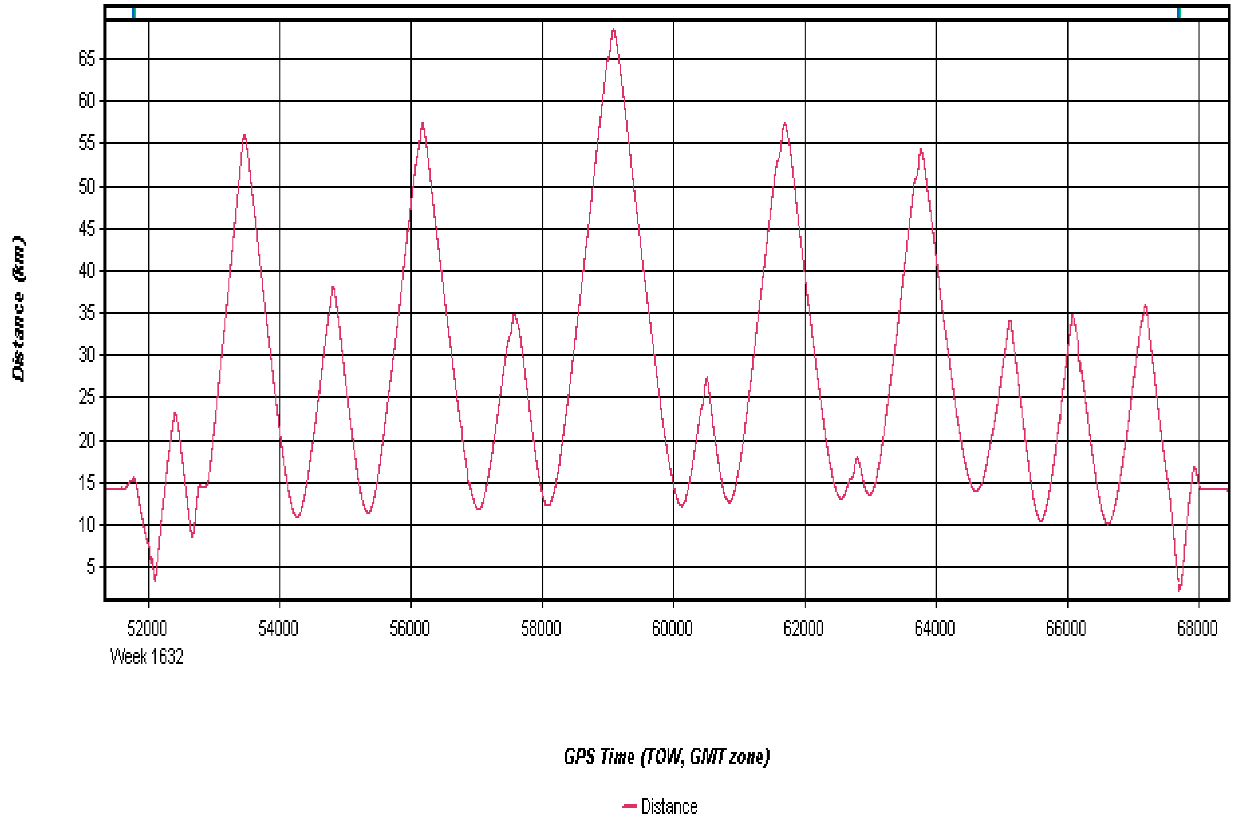
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 6: JD107F01 [Combined] - PDOP, HDOP, VDOP Plots



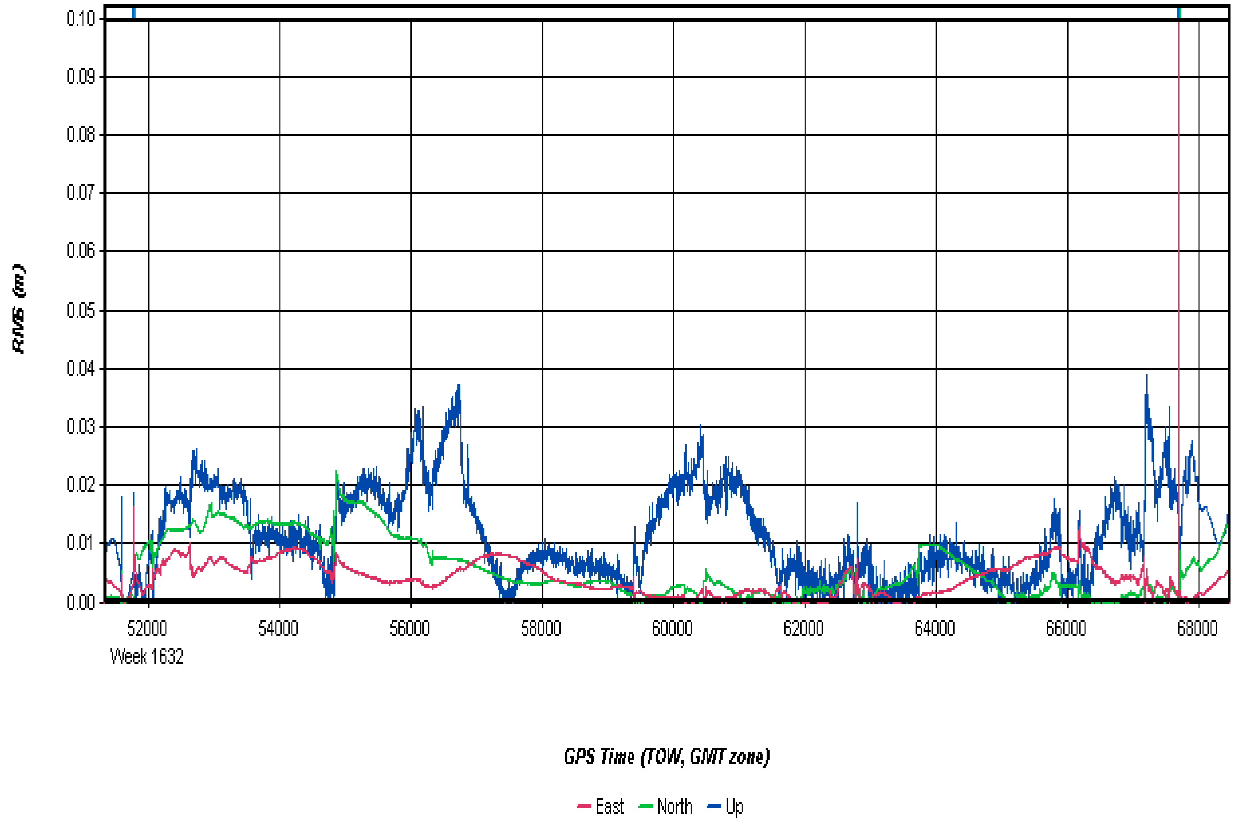
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 7: JD107F01 [Combined] - Horizontal Distance Separation (km)



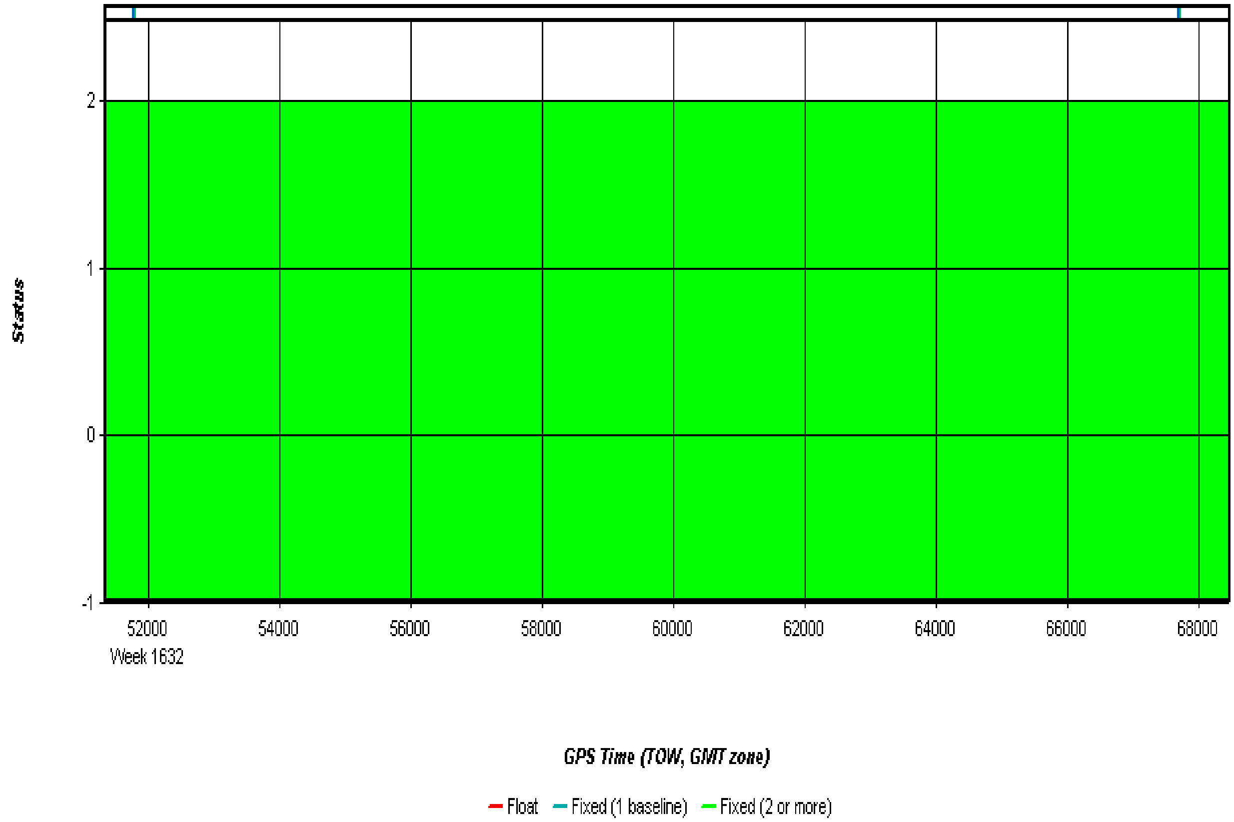
Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 8: JD107F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Figure 9: JD107F01 [Combined] - Float or Fixed Ambiguity

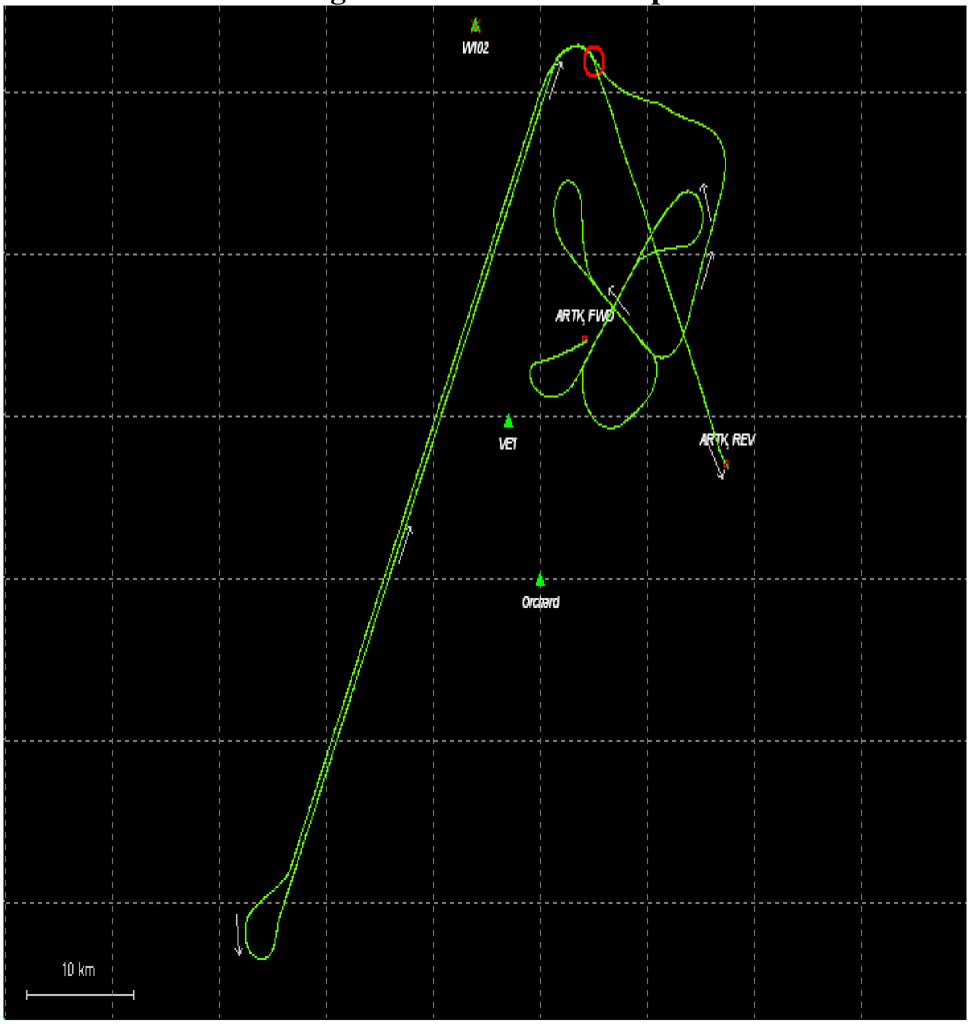


Process	Run (9)	by Unknown	on 05/31/2011	at 16:28:12

Output Results for JD107F02

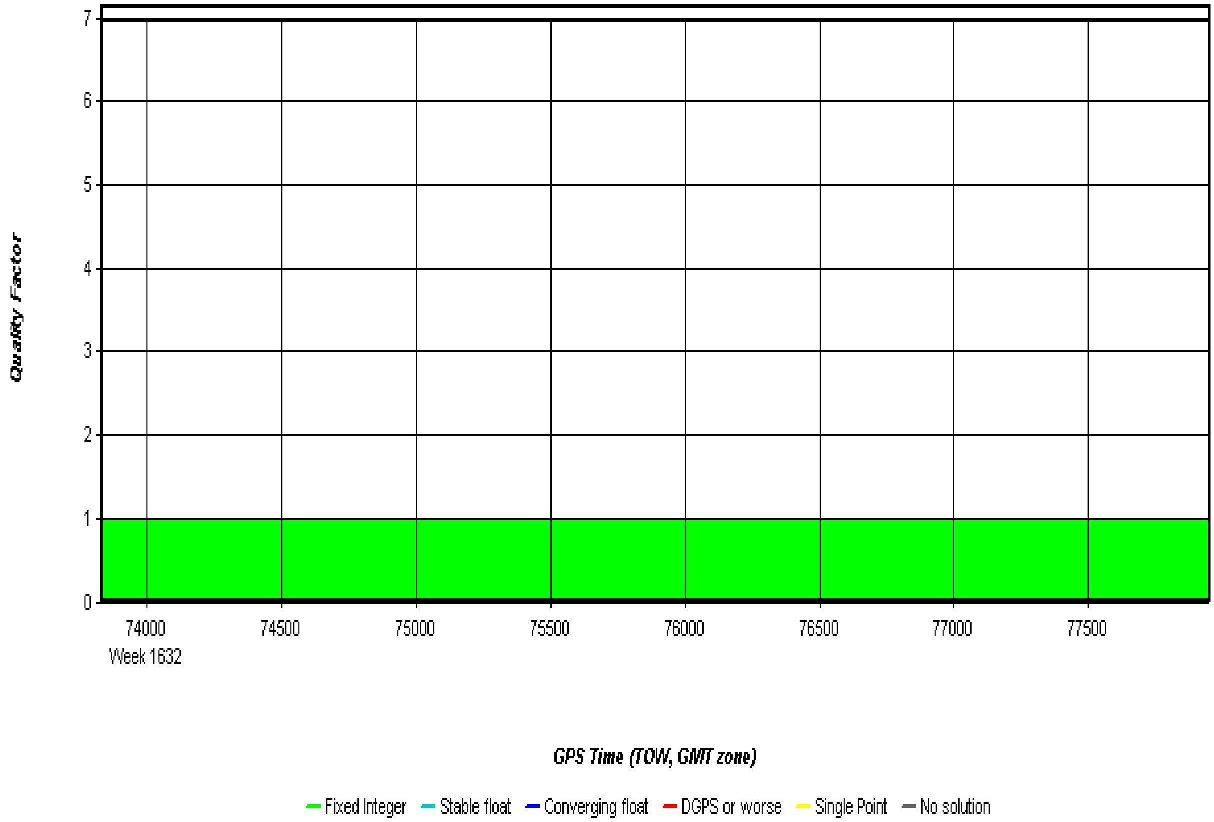
POSGNSS Version 5.20.1209
06/01/2011

Figure 1: Combined - Map



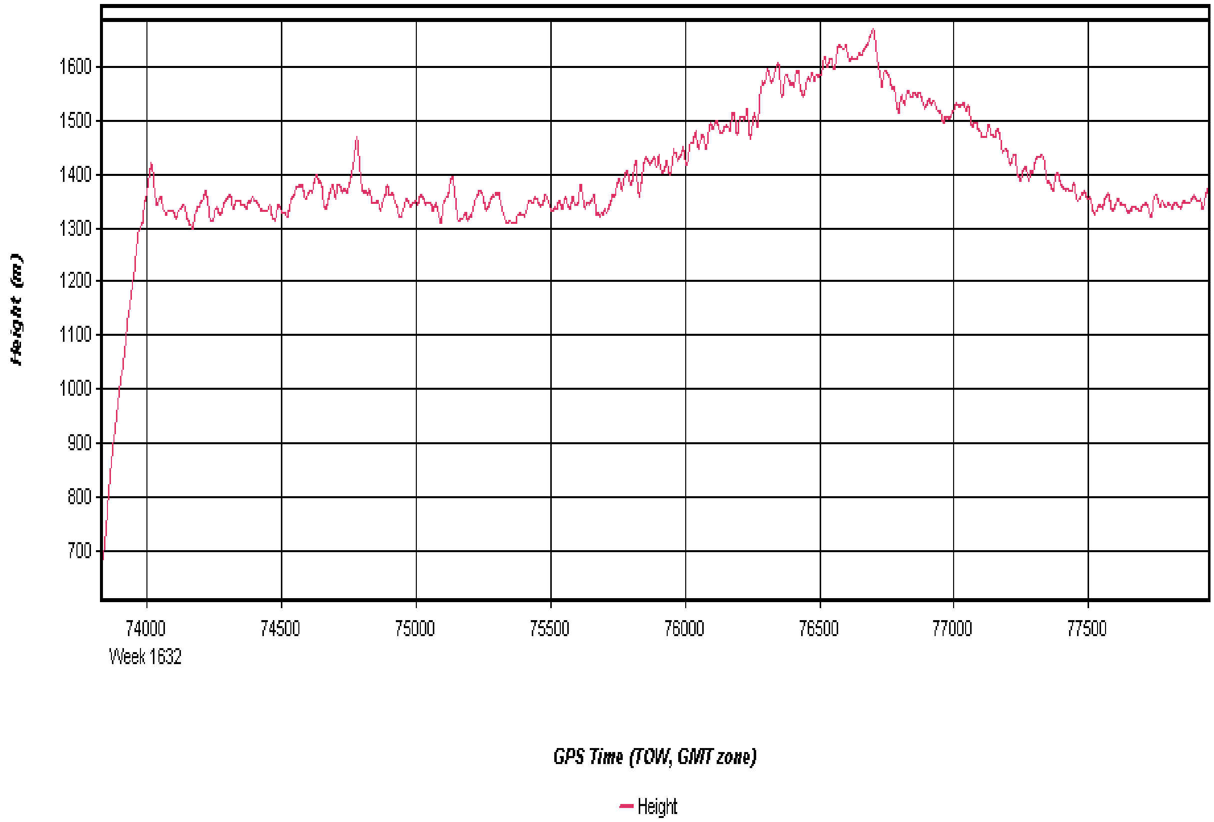
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 2: JD107F02 [Combined] - Quality Factor Plot



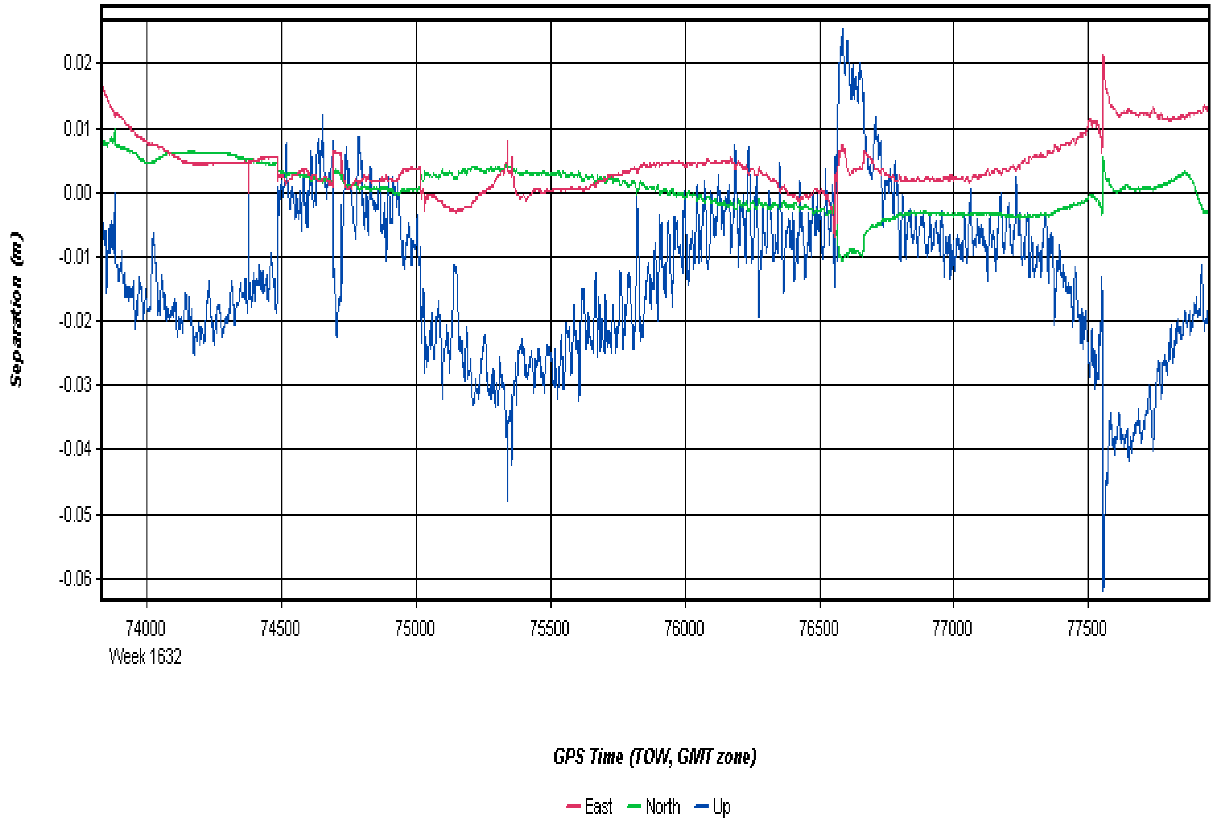
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 3: JD107F02 [Combined] - Height Profile Plot



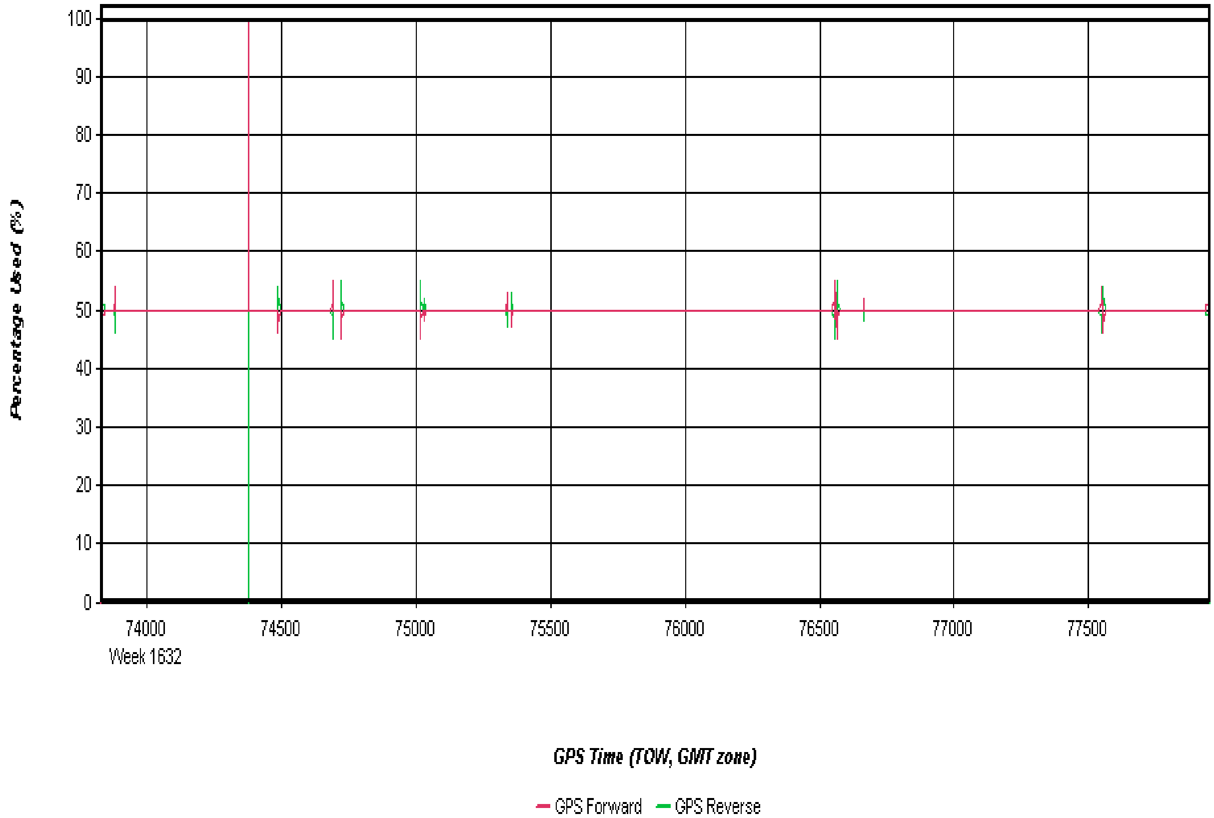
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 4: JD107F02 [Combined] - Forward/Reverse or Combined Separation Plot



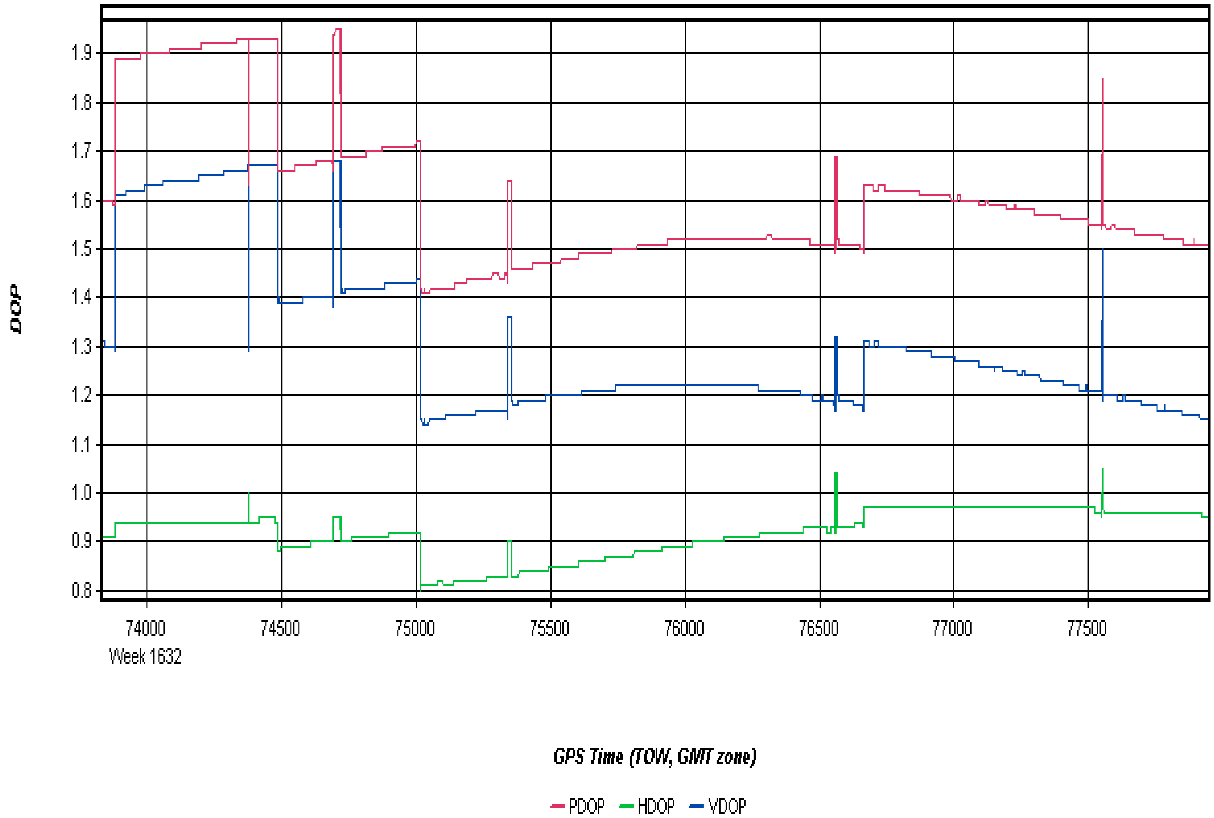
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 5: JD107F02 [Combined] - Forward/Reverse or Combined Weighting Plot



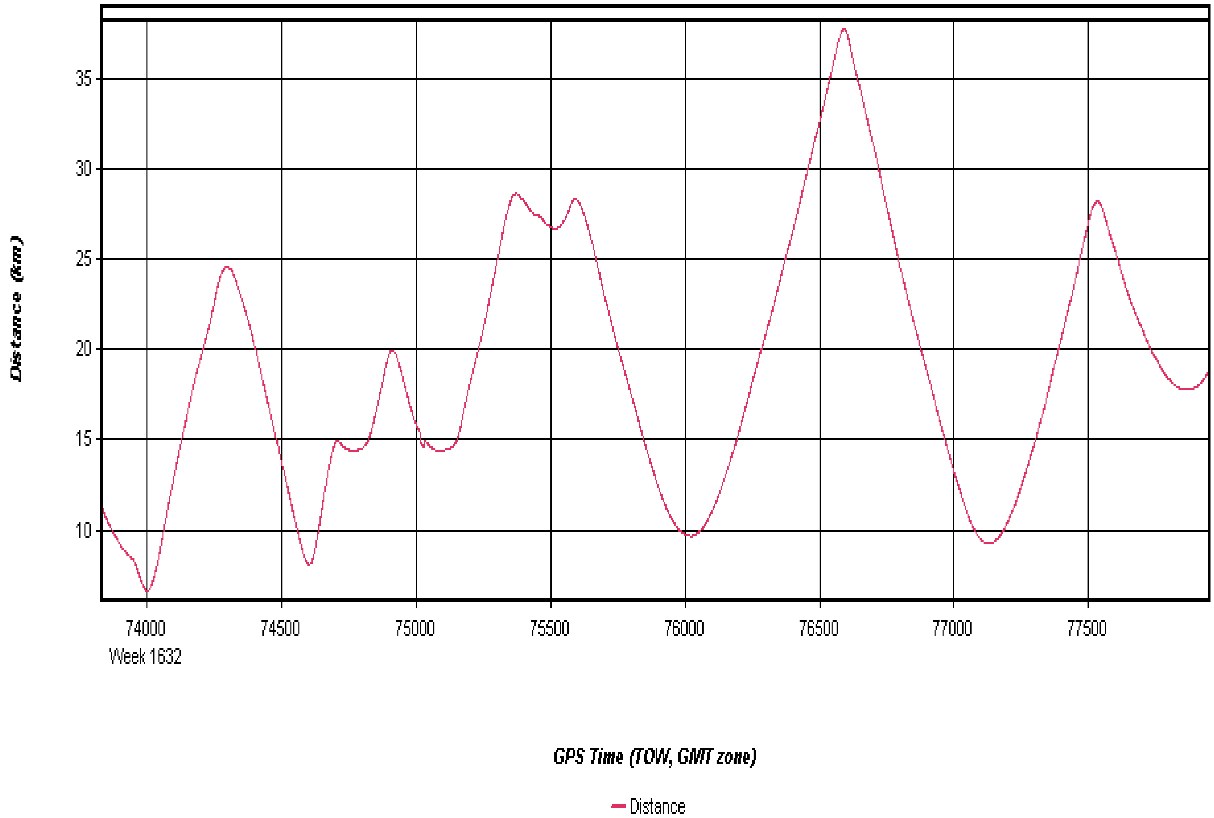
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 6: JD107F02 [Combined] - PDOP, HDOP, VDOP Plots



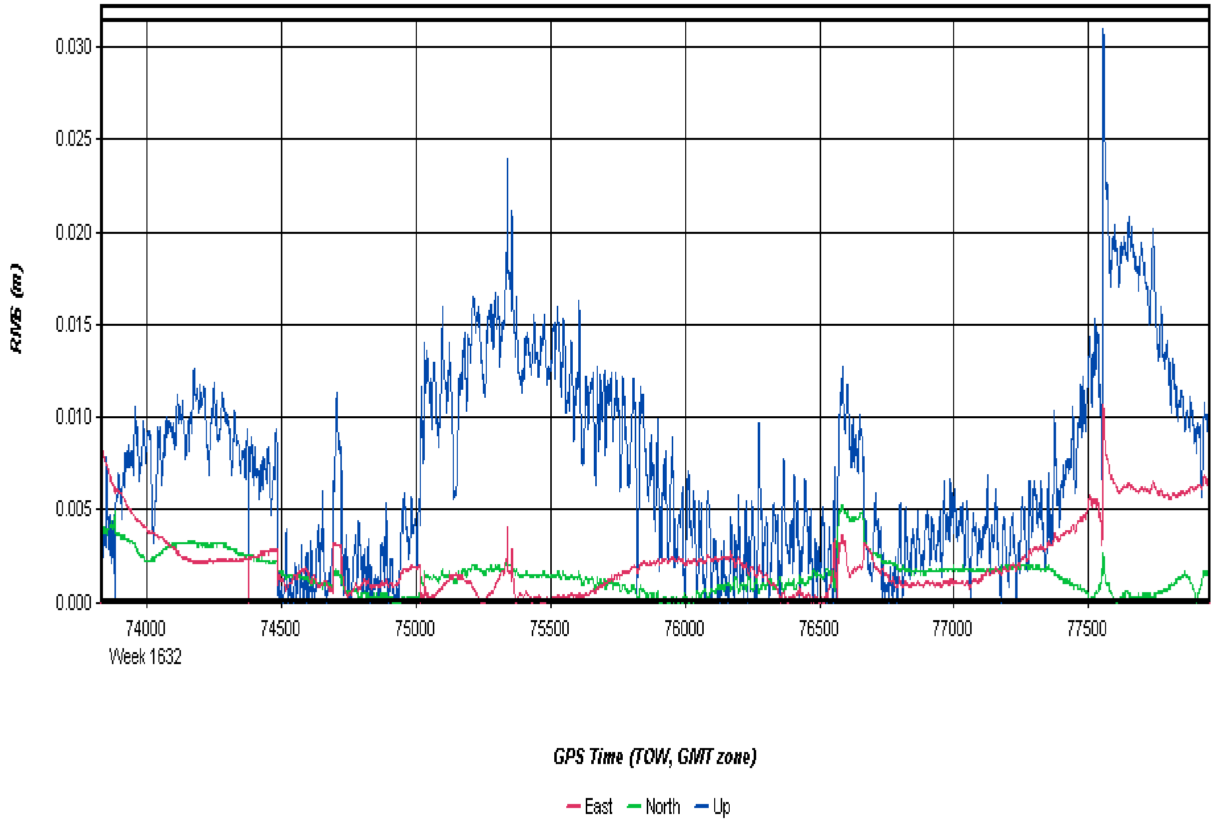
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 7: JD107F02 [Combined] - Horizontal Distance Separation (km)



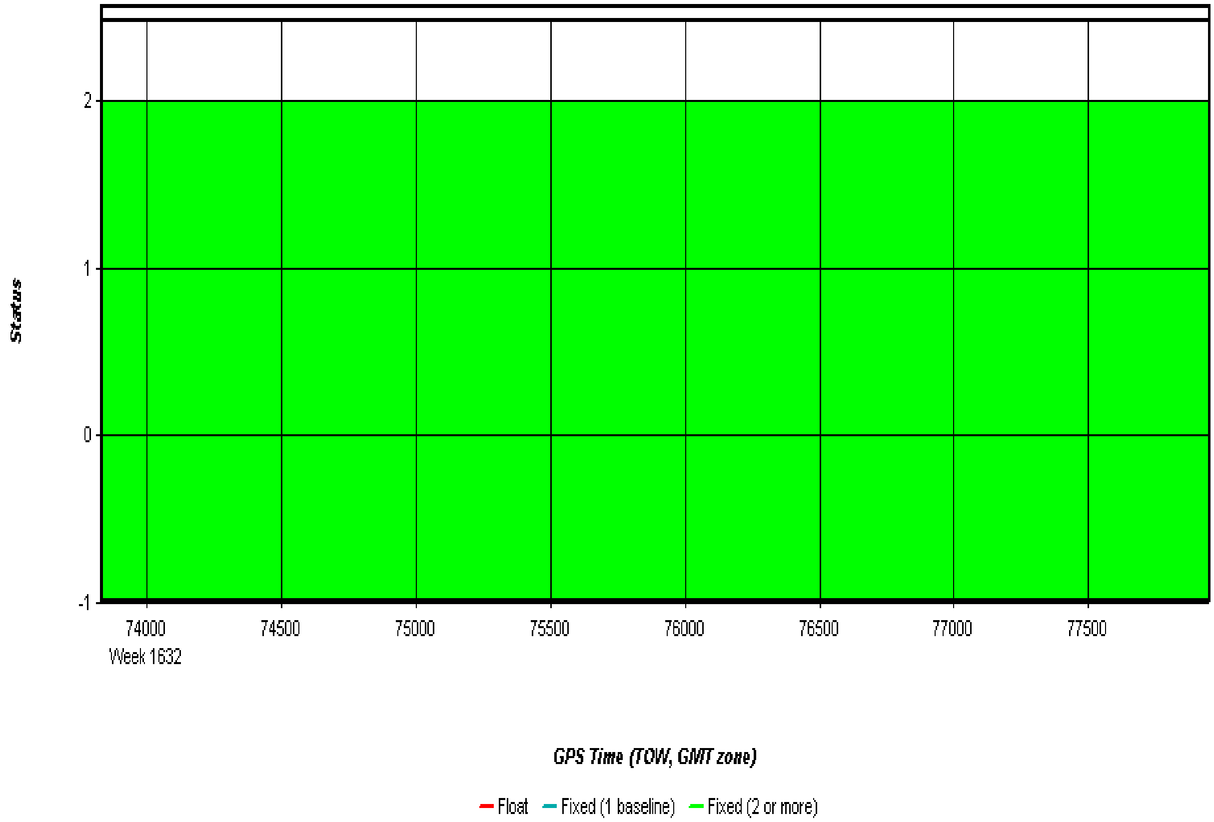
Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 8: JD107F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

Figure 9: JD107F02 [Combined] - Float or Fixed Ambiguity



Process	Run (10)	by Unknown	on 06/01/2011	at 07:18:38

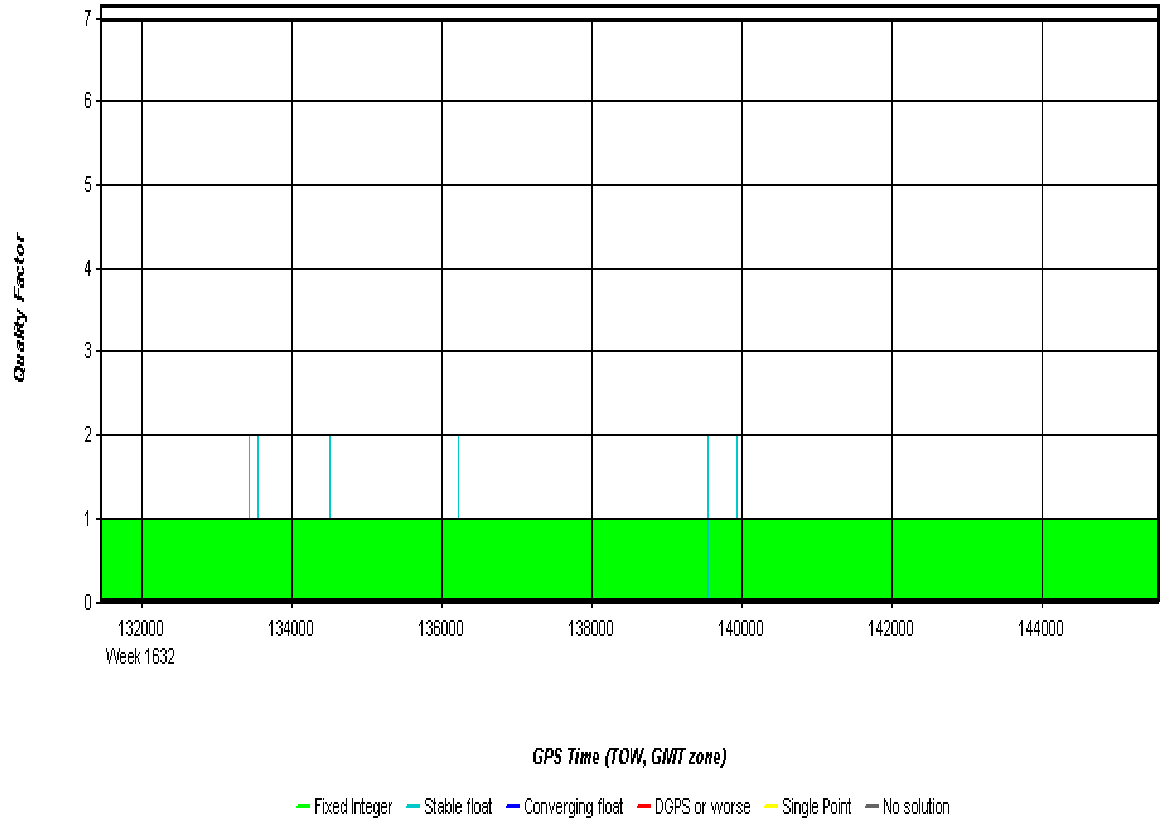
Output Results for JD108F01

POSGNSS Version 5.20.1209
06/13/2011

Figure 1: Combined - Map

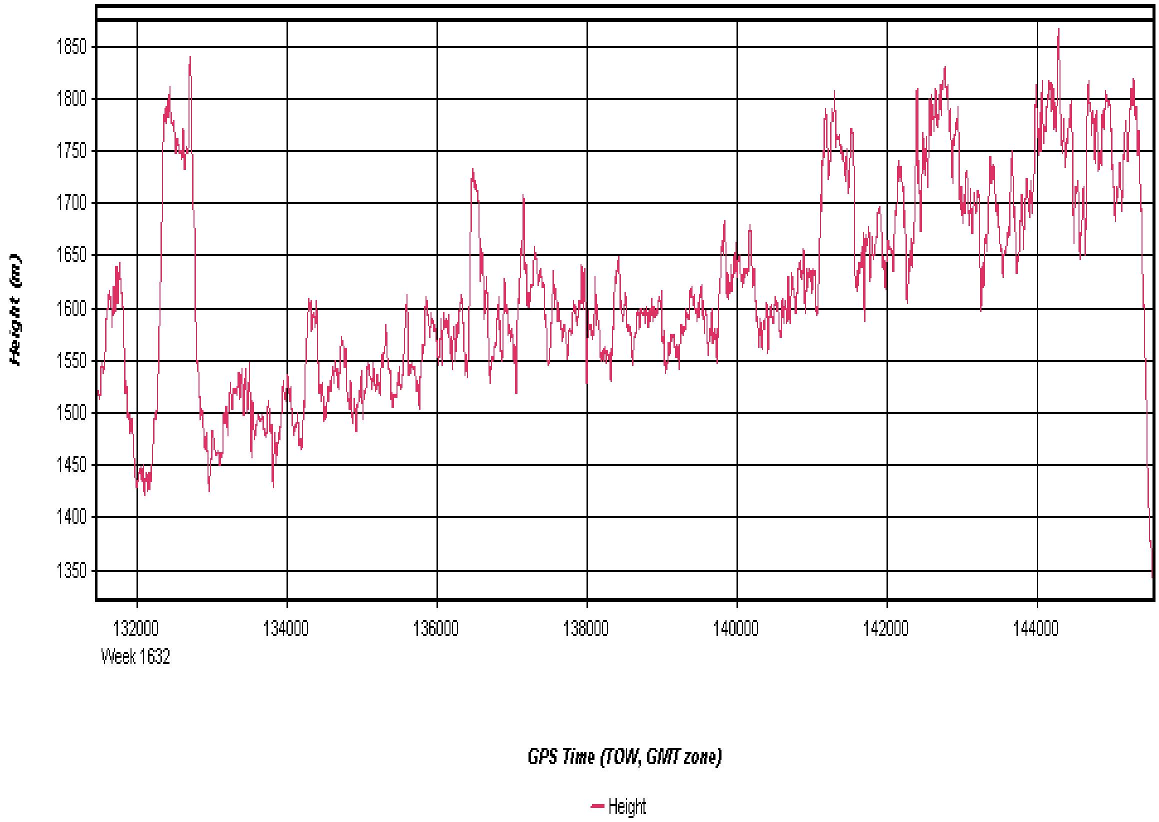
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 2: JD108F01 [Combined] - Quality Factor Plot



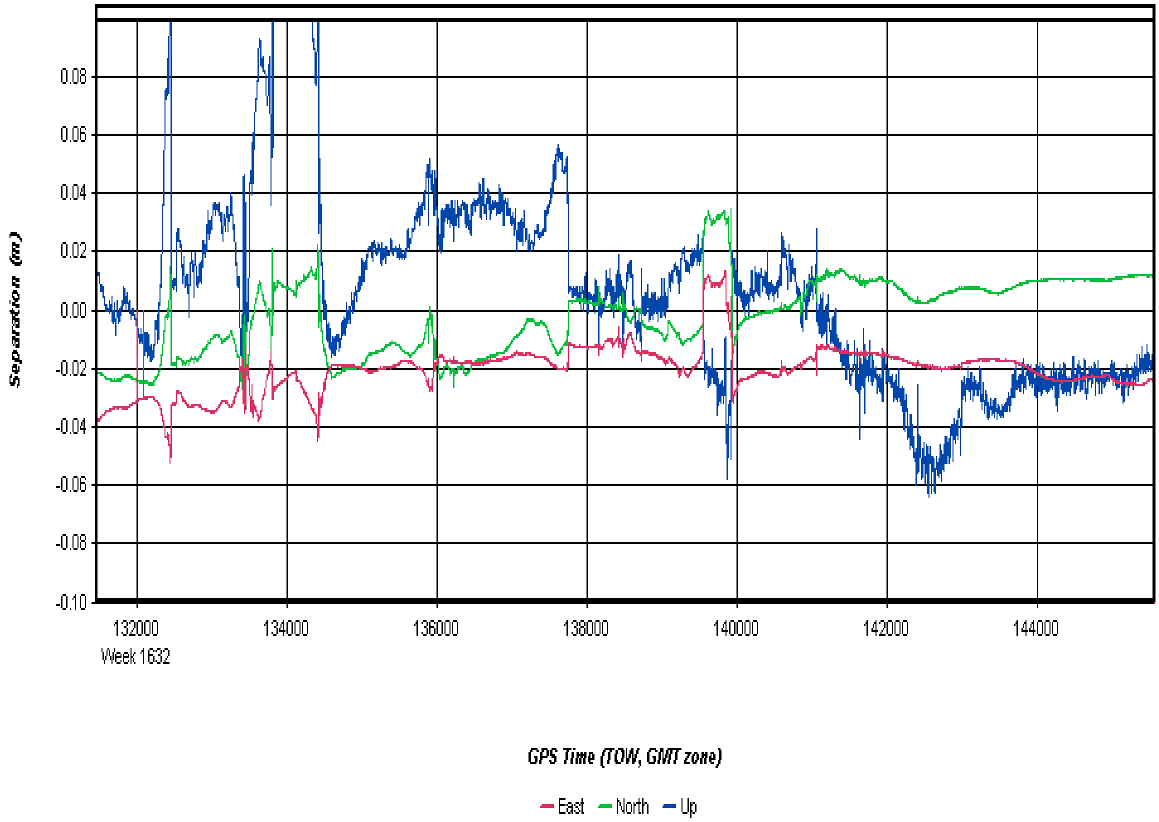
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 3: JD108F01 [Combined] - Height Profile Plot



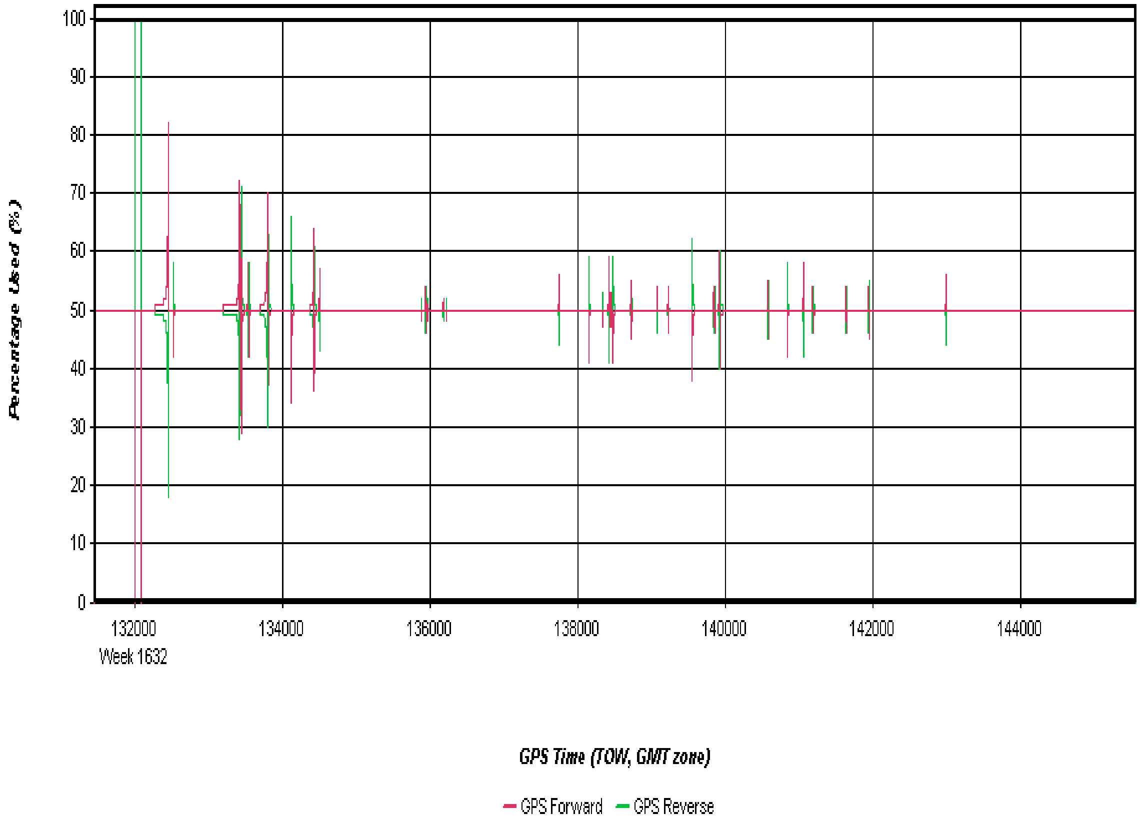
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 4: JD108F01 [Combined] - Forward/Reverse or Combined Separation Plot



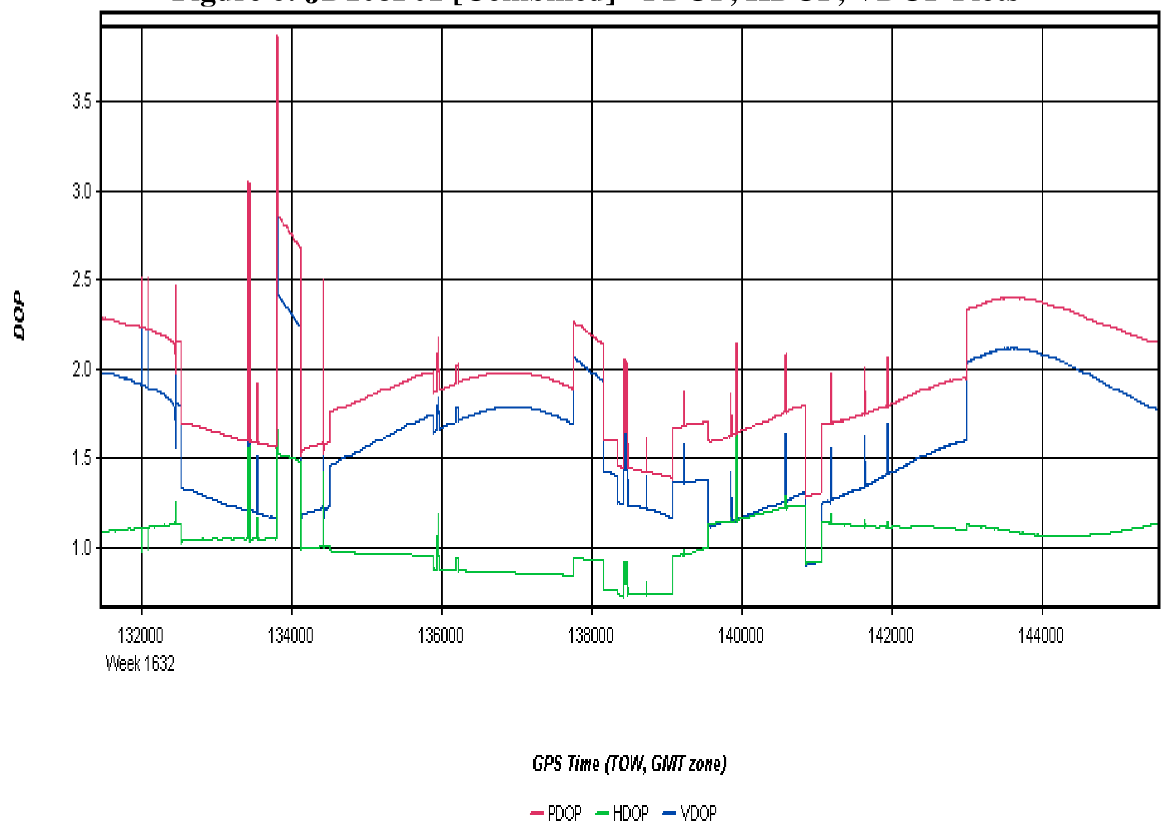
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 5: JD108F01 [Combined] - Forward/Reverse or Combined Weighting Plot



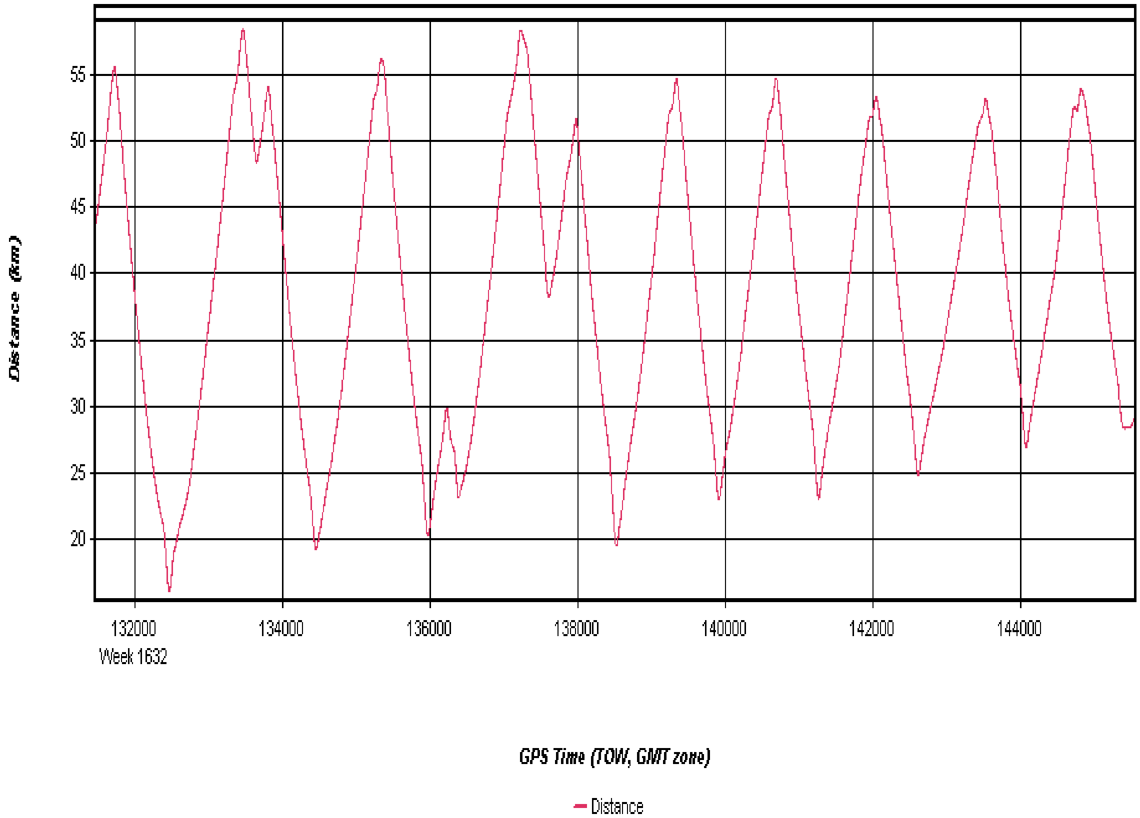
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 6: JD108F01 [Combined] - PDOP, HDOP, VDOP Plots



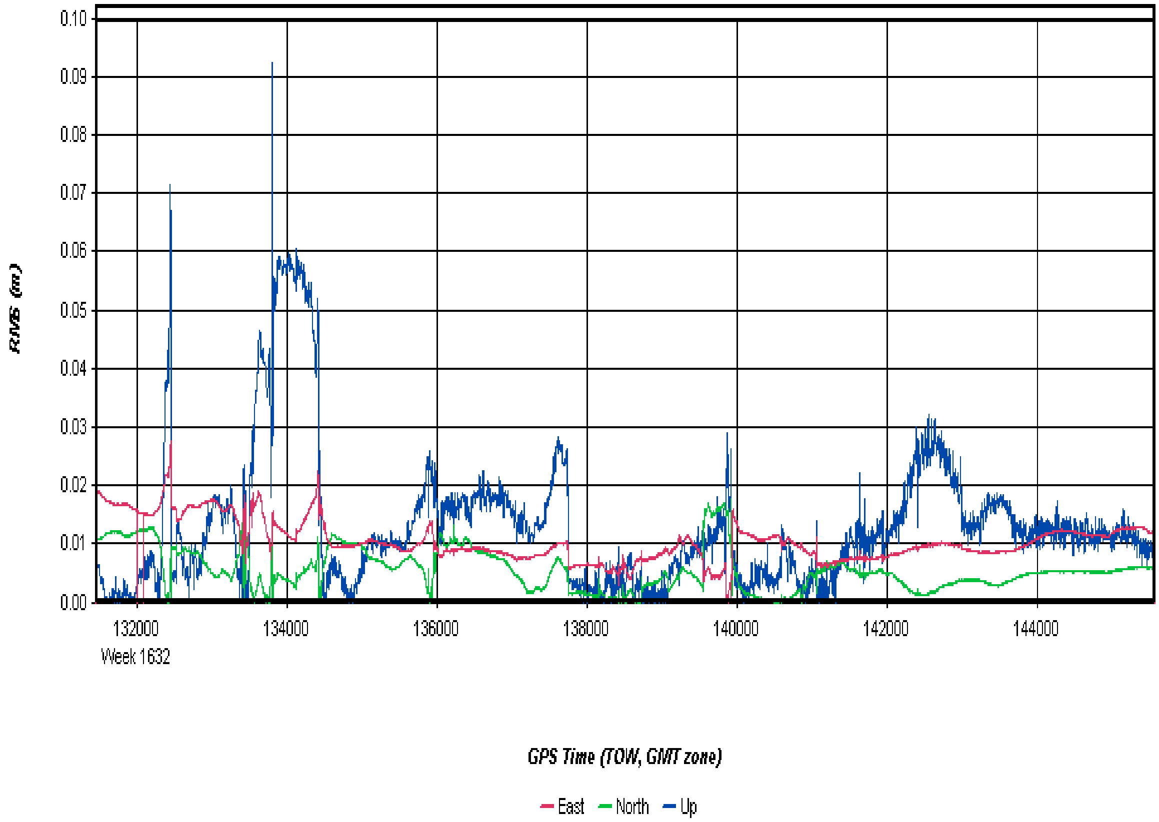
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 7: JD108F01 [Combined] - Horizontal Distance Separation (km)



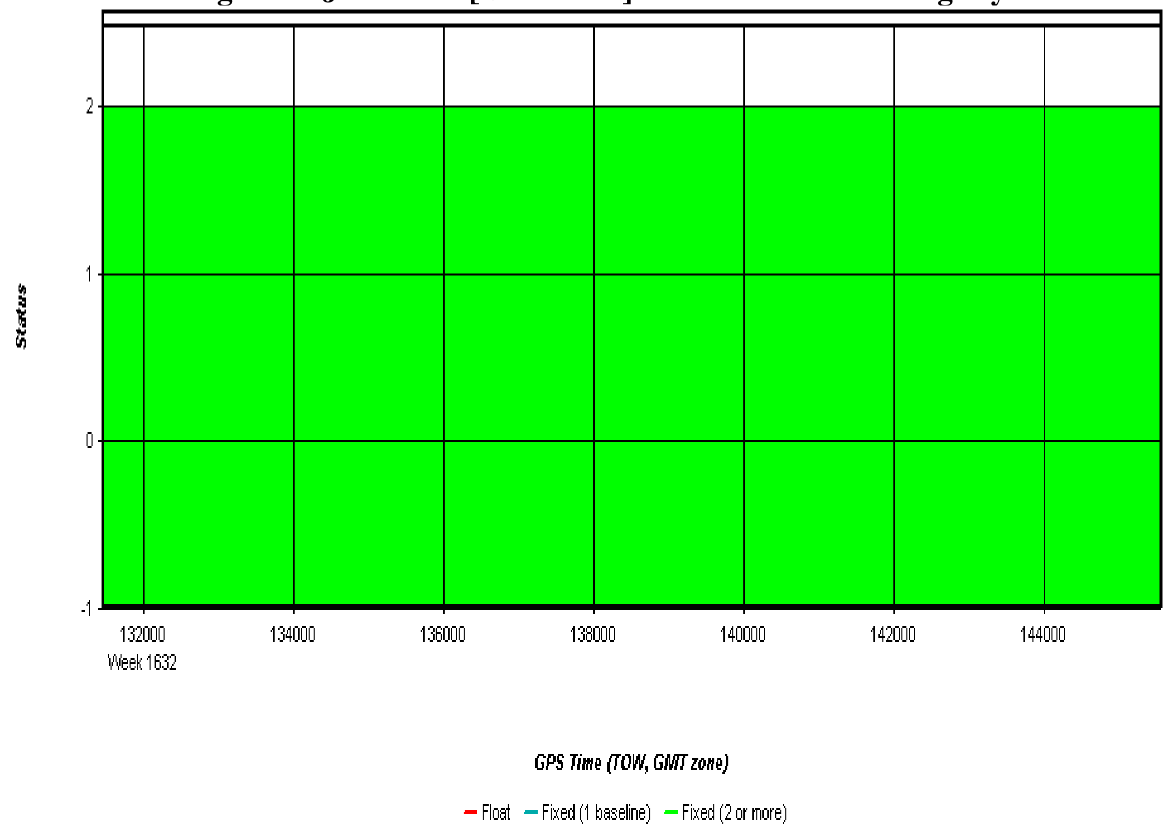
Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 8: JD108F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Figure 9: JD108F01 [Combined] - Float or Fixed Ambiguity

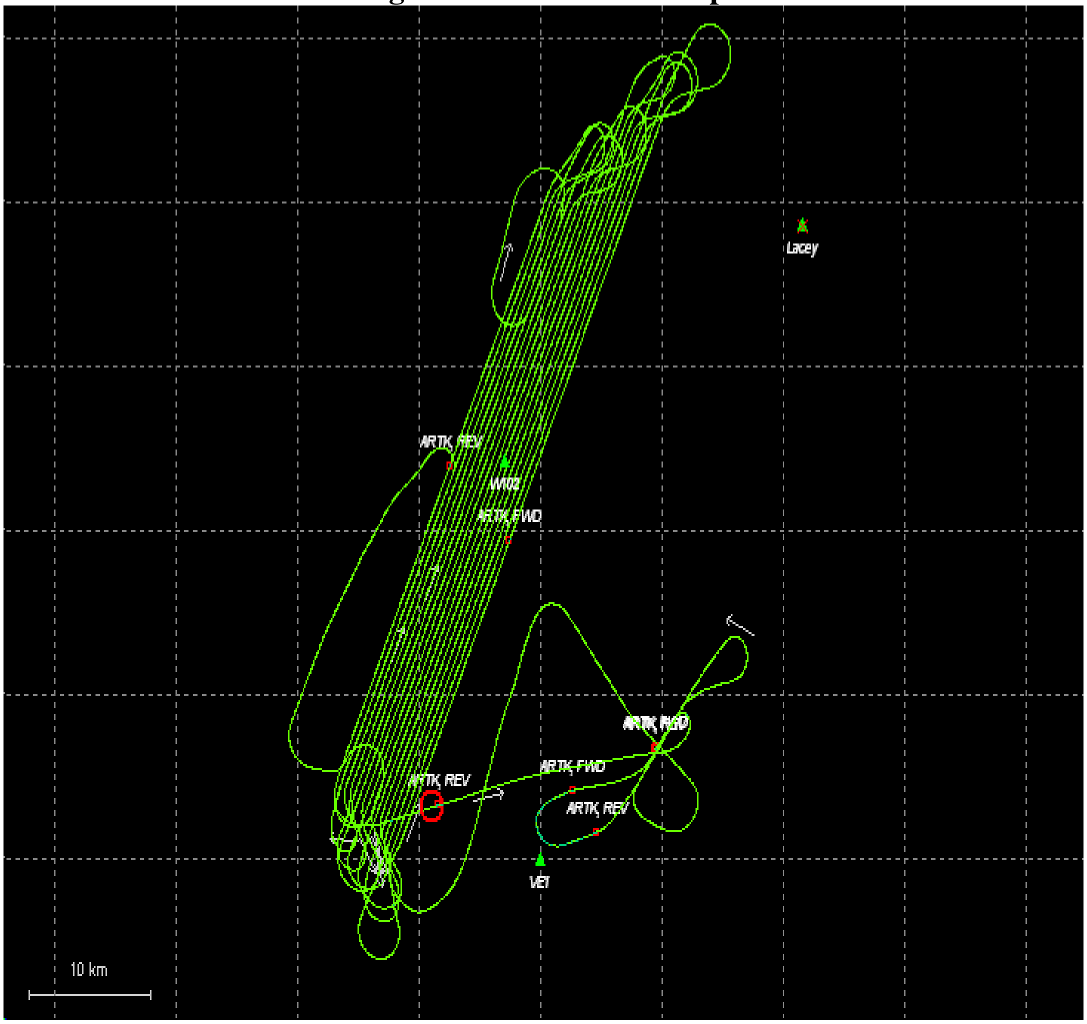


Process	Run (3)	by Unknown	on 06/02/2011	at 11:21:33

Output Results for JD108F02

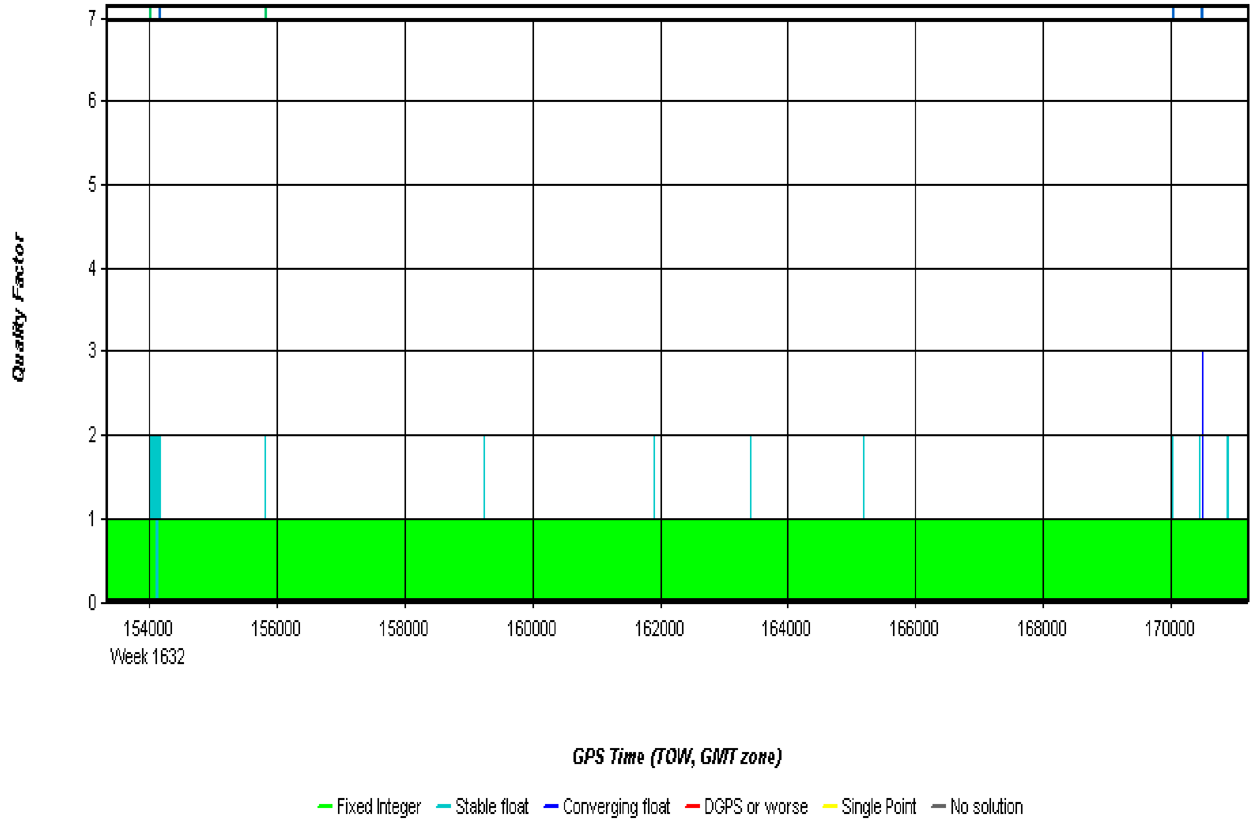
POSGNSS Version 5.20.1209
06/03/2011

Figure 1: Combined - Map



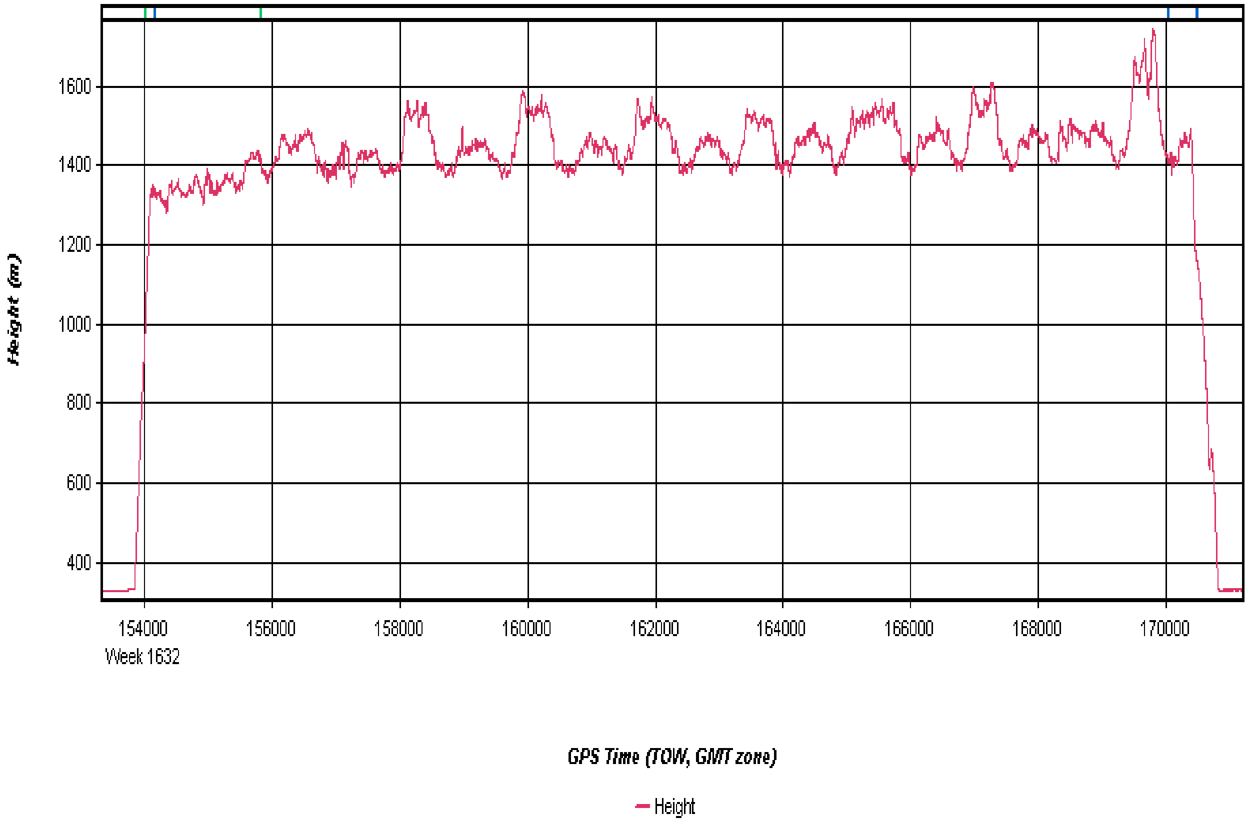
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 2: JD108F02 [Combined] - Quality Factor Plot



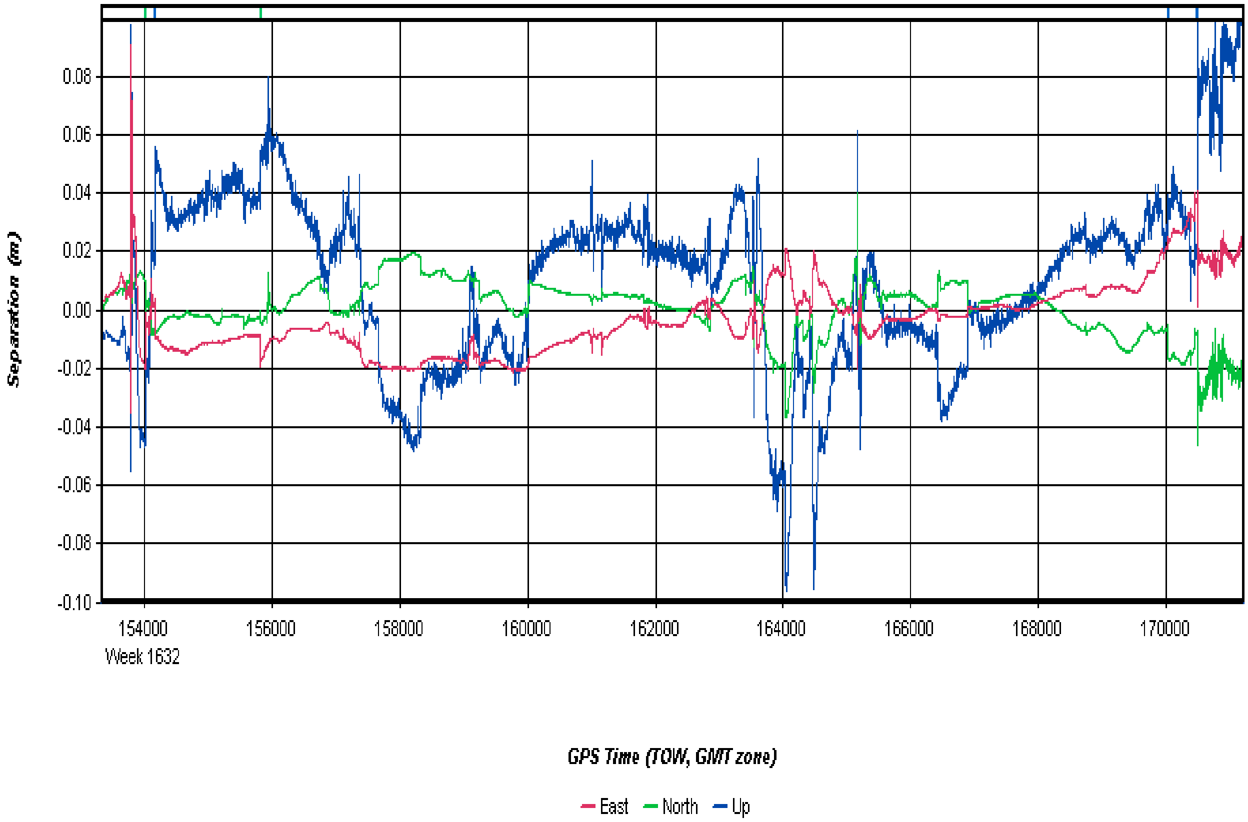
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 3: JD108F02 [Combined] - Height Profile Plot



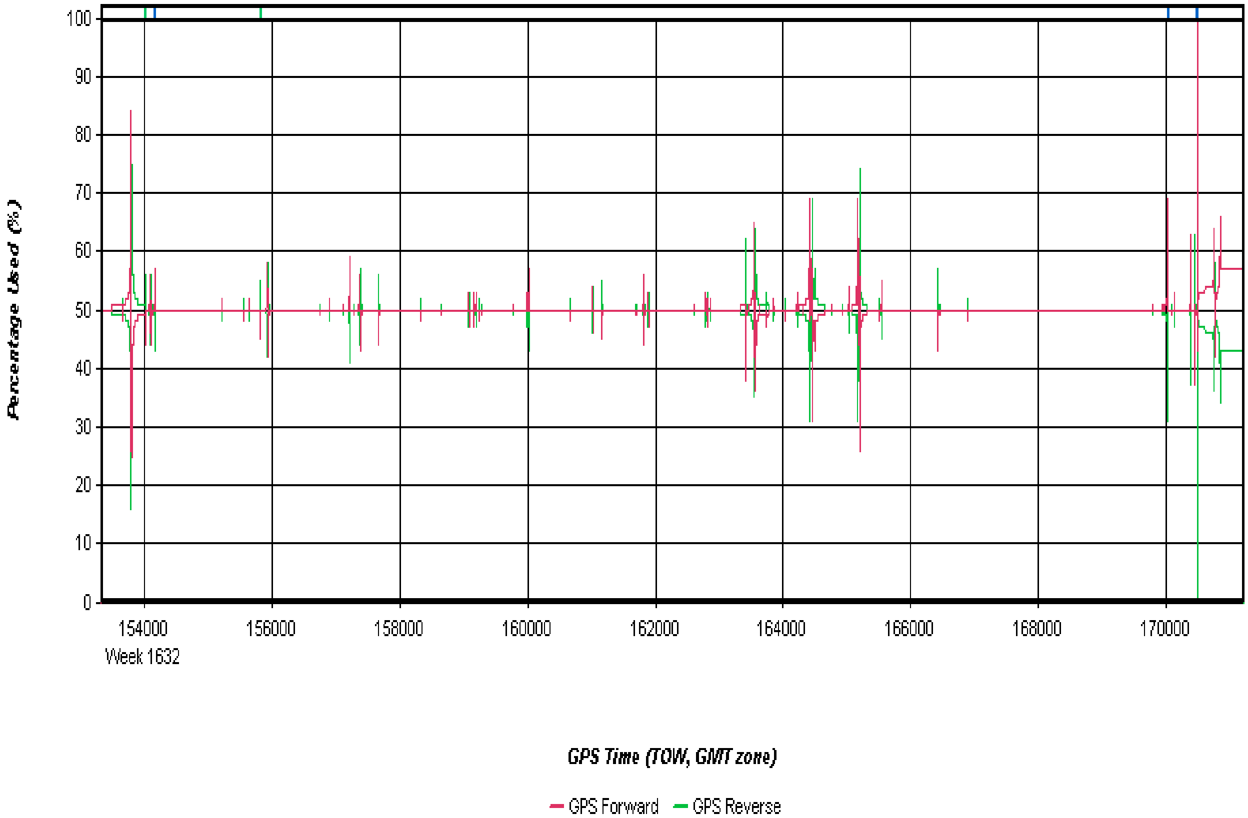
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 4: JD108F02 [Combined] - Forward/Reverse or Combined Separation Plot



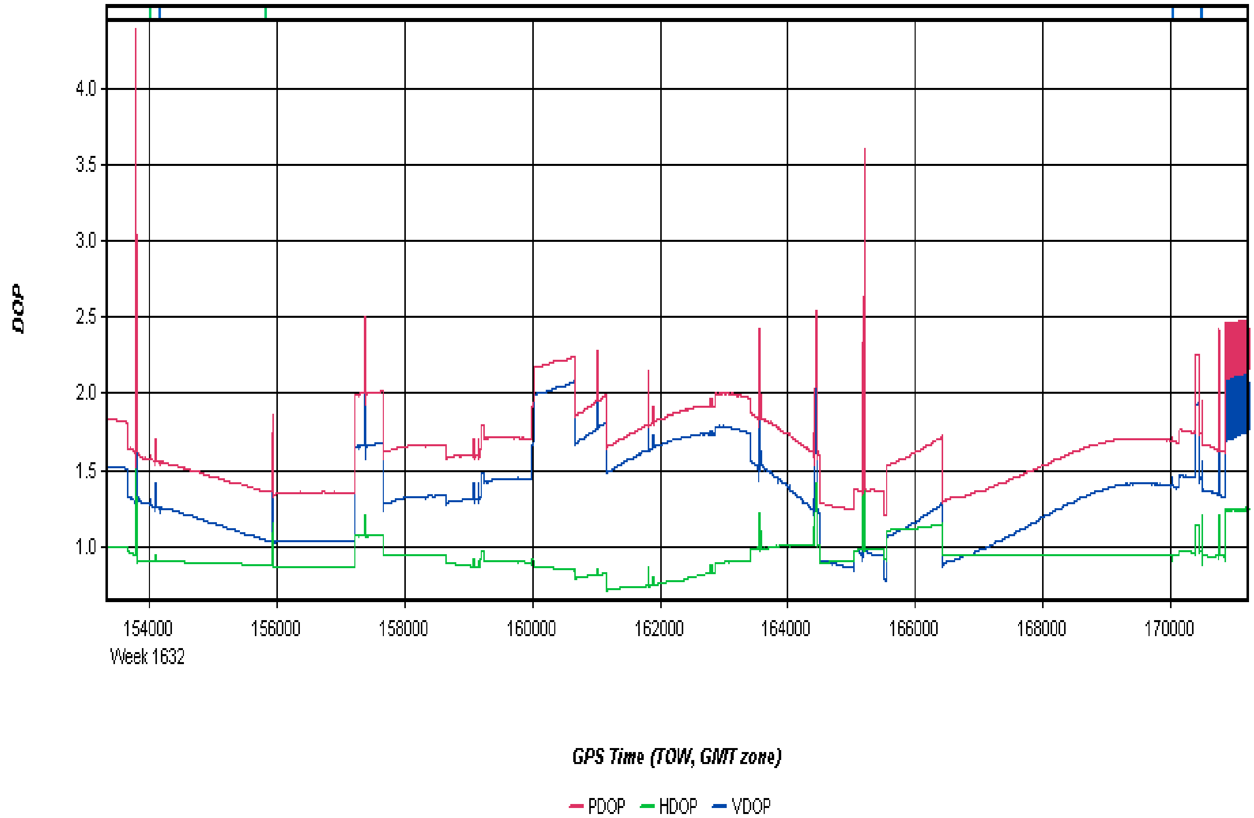
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 5: JD108F02 [Combined] - Forward/Reverse or Combined Weighting Plot



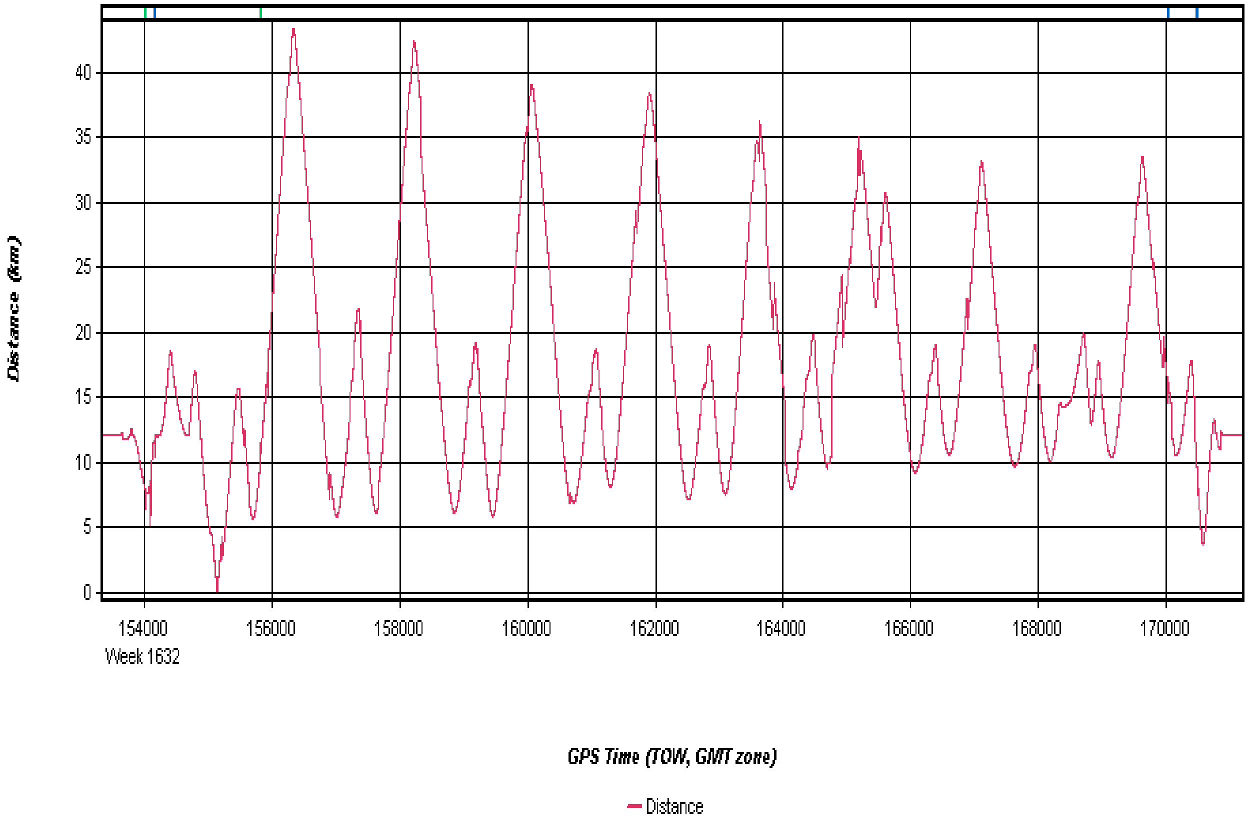
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 6: JD108F02 [Combined] - PDOP, HDOP, VDOP Plots



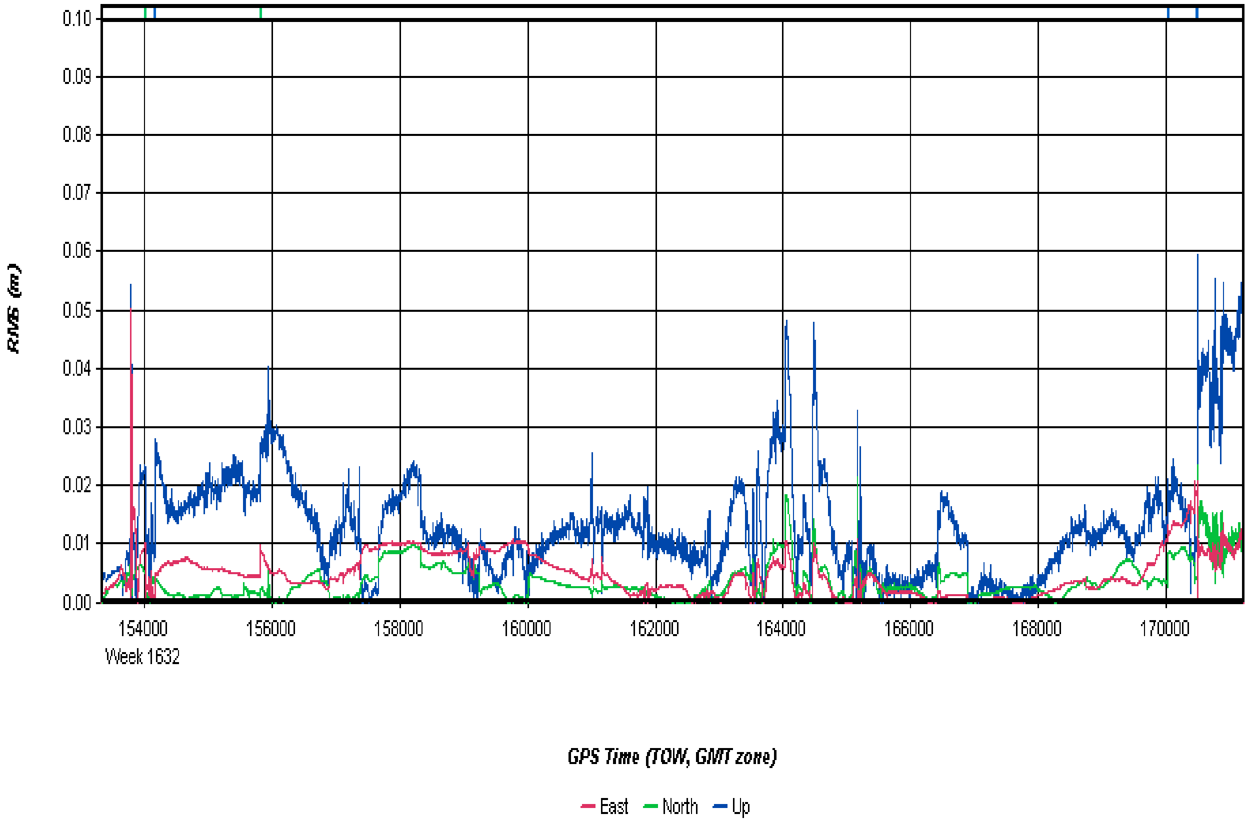
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 7: JD108F02 [Combined] - Horizontal Distance Separation (km)



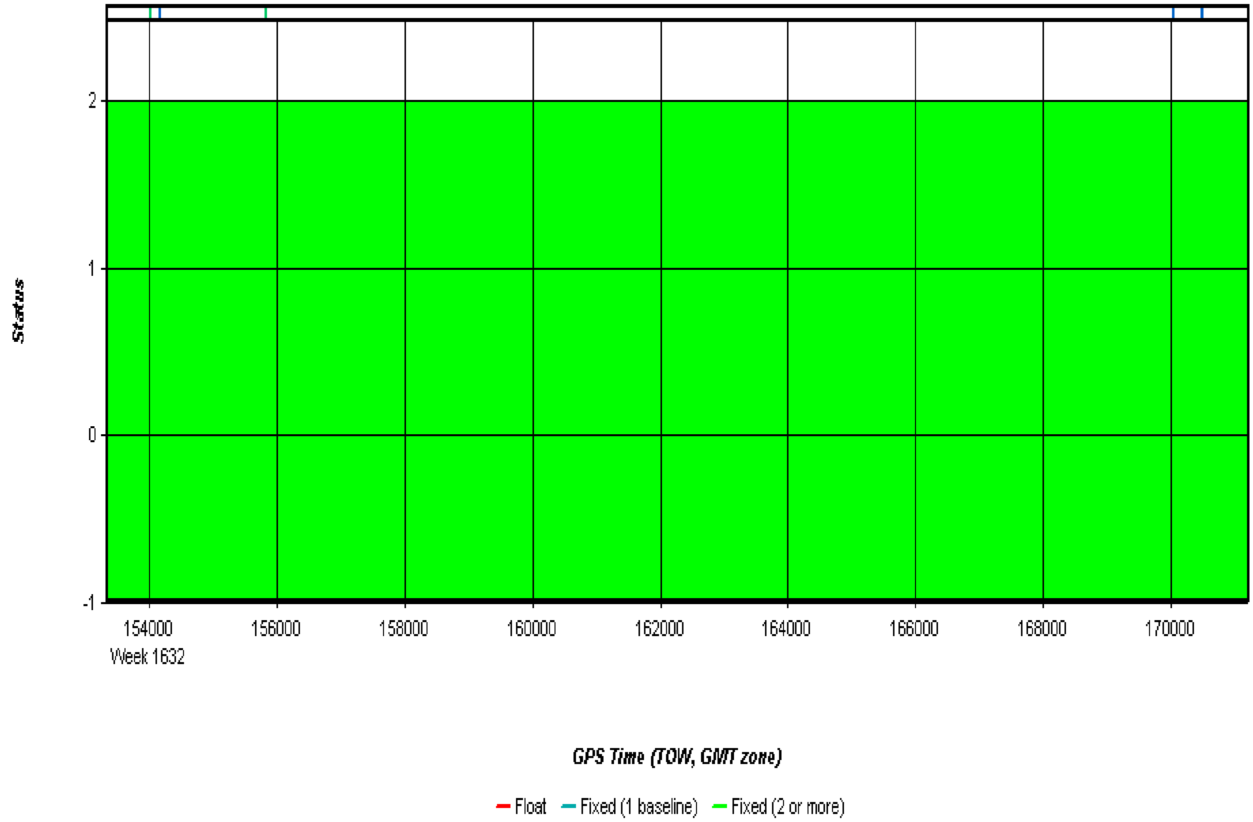
Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 8: JD108F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

Figure 9: JD108F02 [Combined] - Float or Fixed Ambiguity



Process	Run (23)	by Unknown	on 06/02/2011	at 17:33:28

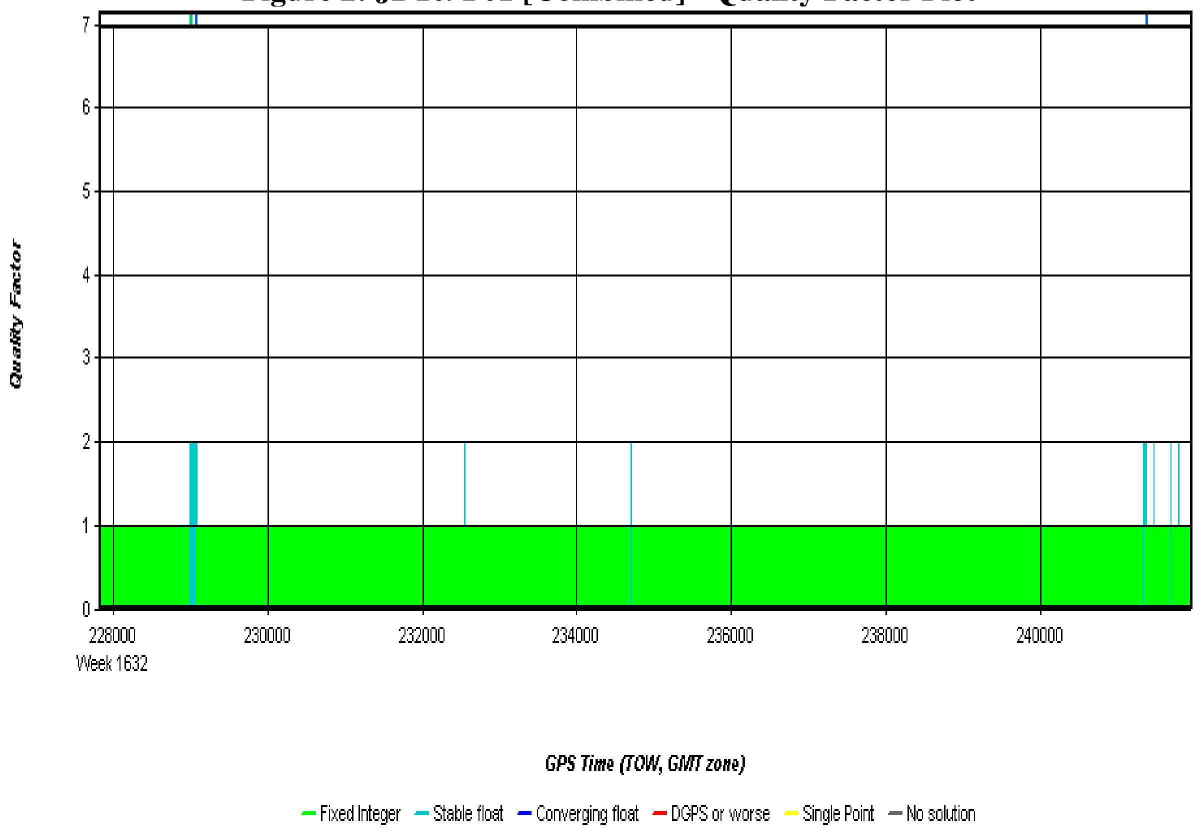
Output Results for JD109F01

POSGNSS Version 5.20.1209
06/13/2011

Figure 1: Combined - Map

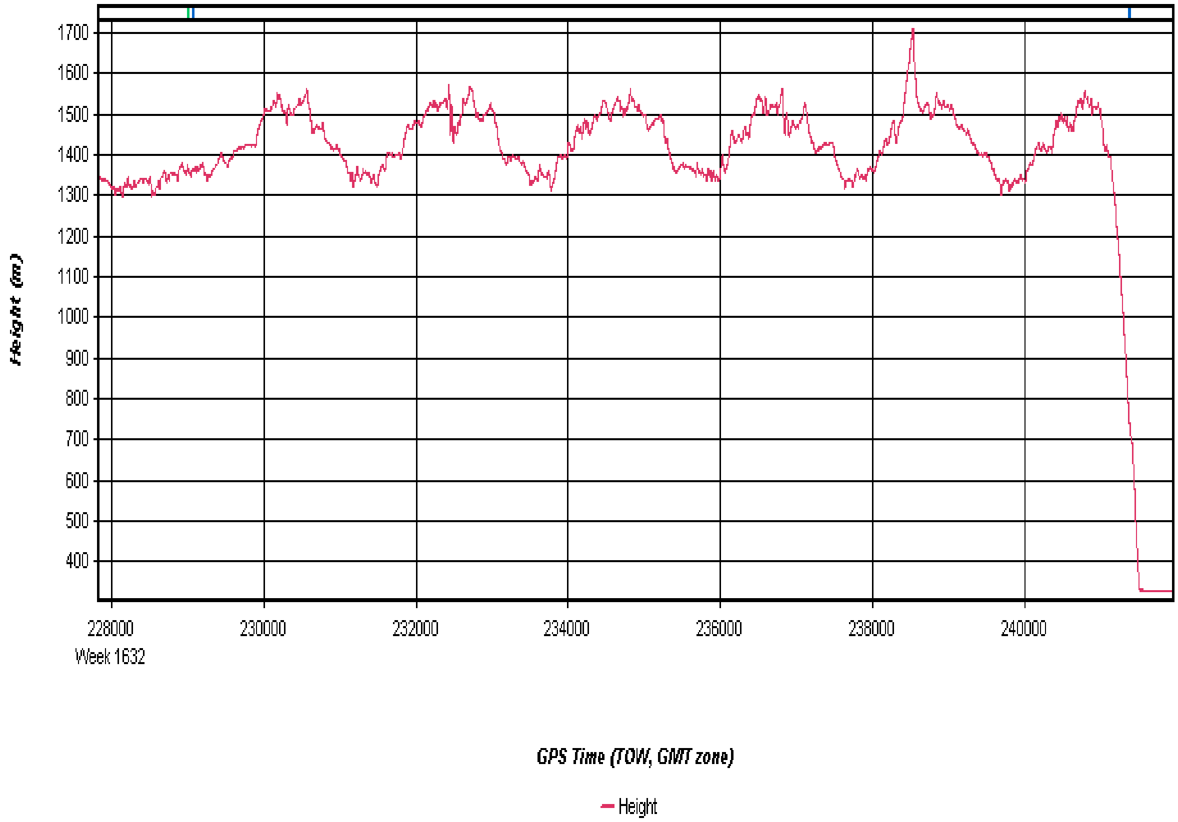
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 2: JD109F01 [Combined] - Quality Factor Plot



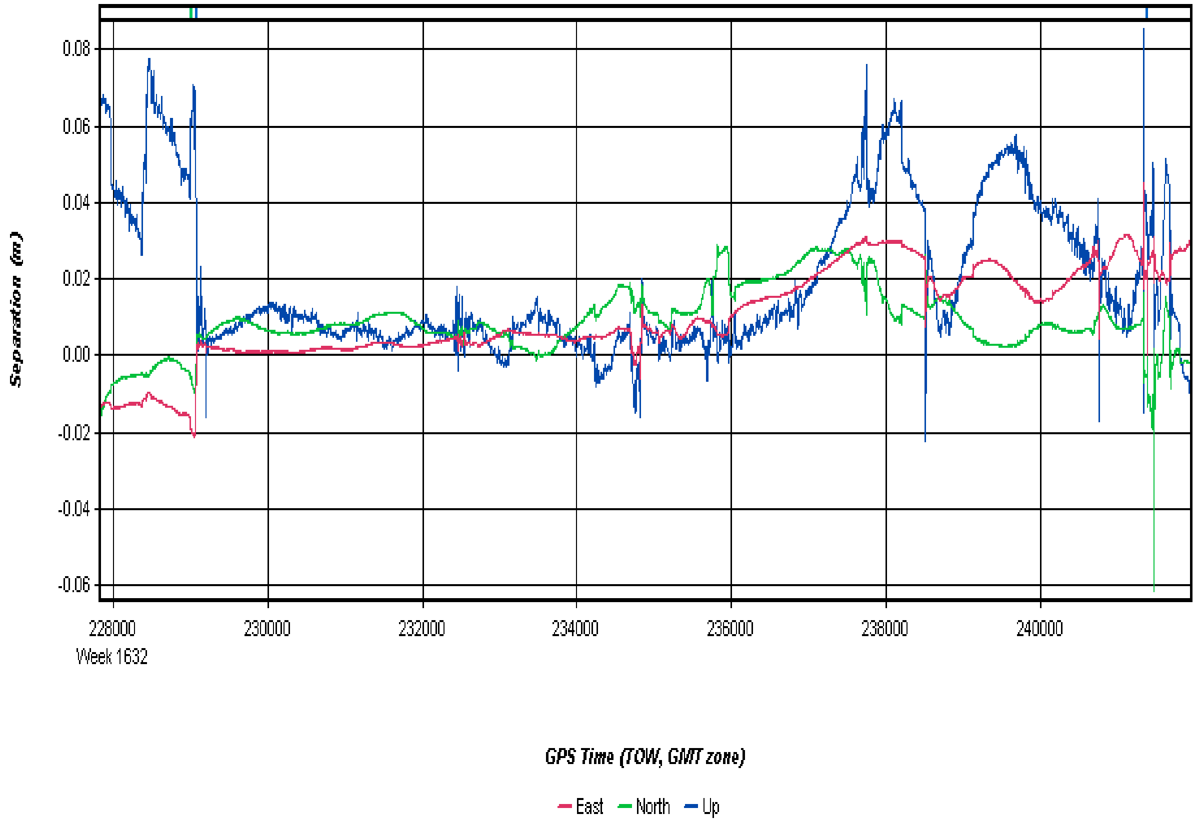
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 3: JD109F01 [Combined] - Height Profile Plot



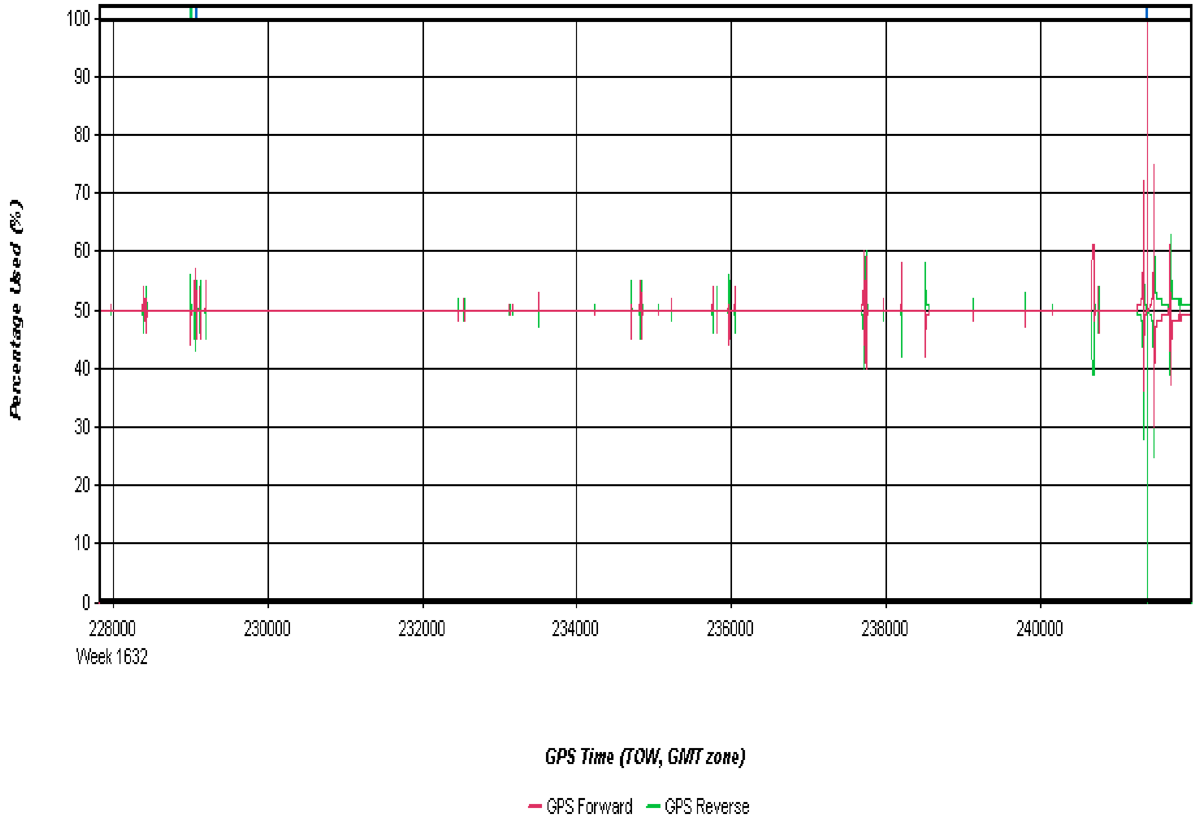
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 4: JD109F01 [Combined] - Forward/Reverse or Combined Separation Plot



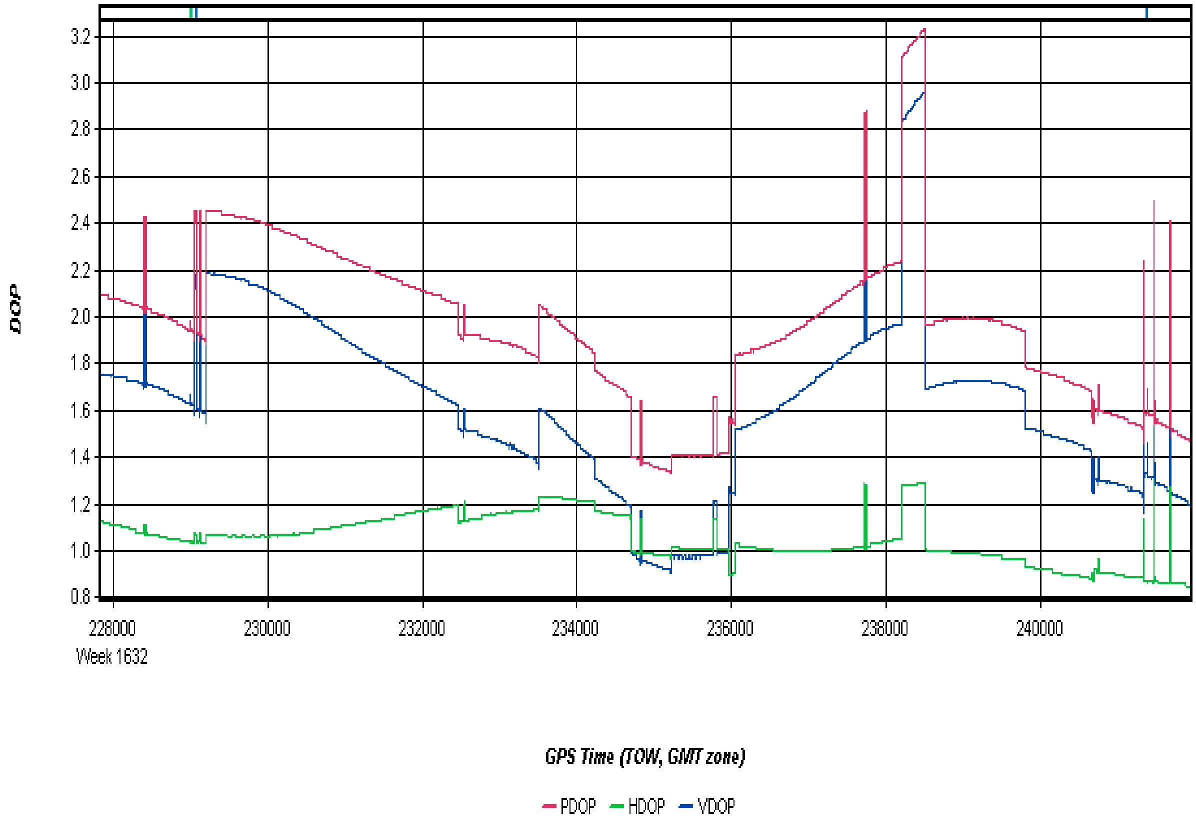
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 5: JD109F01 [Combined] - Forward/Reverse or Combined Weighting Plot



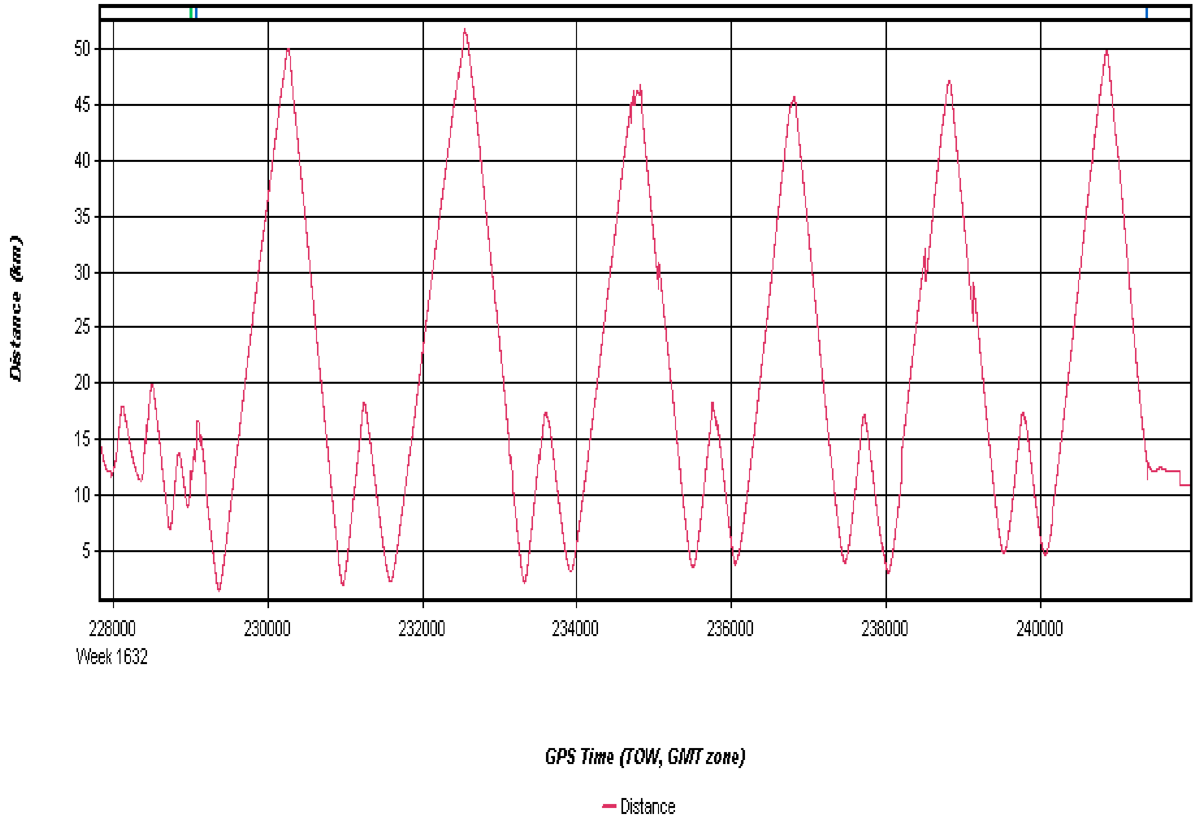
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 6: JD109F01 [Combined] - PDOP, HDOP, VDOP Plots



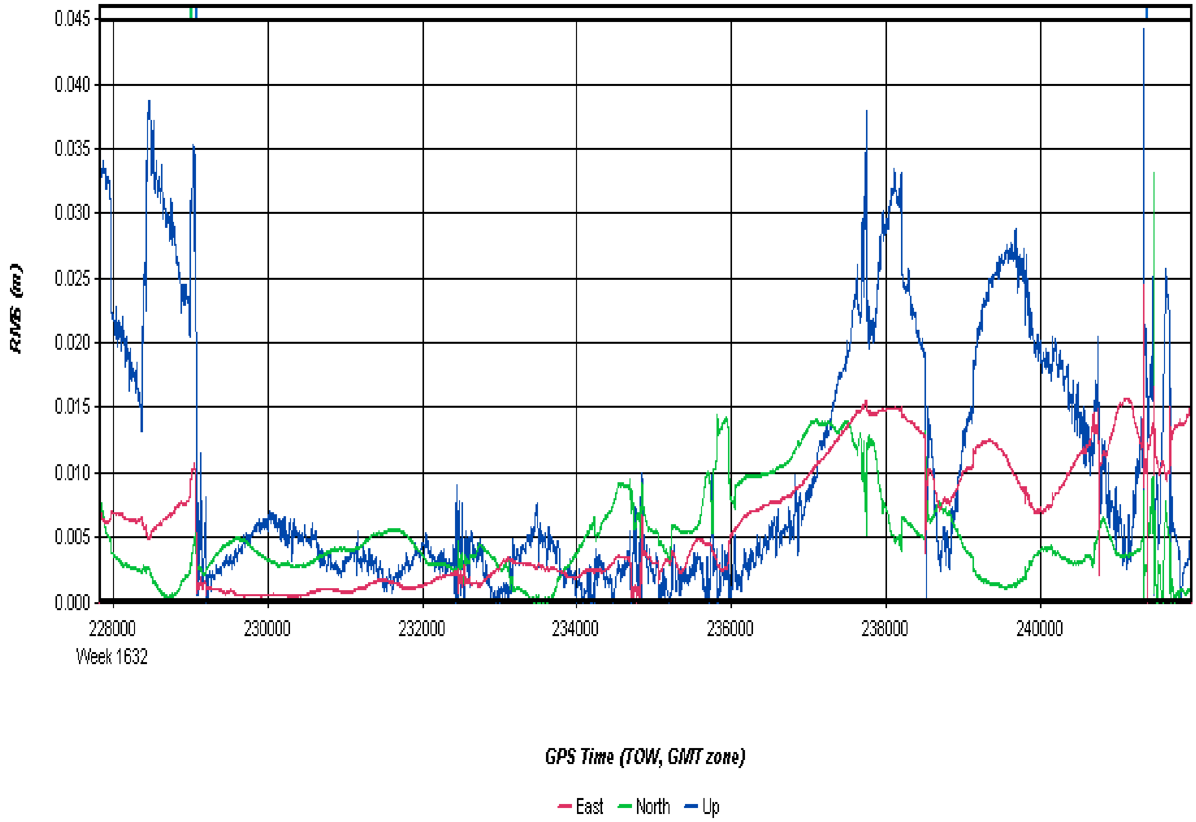
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 7: JD109F01 [Combined] - Horizontal Distance Separation (km)



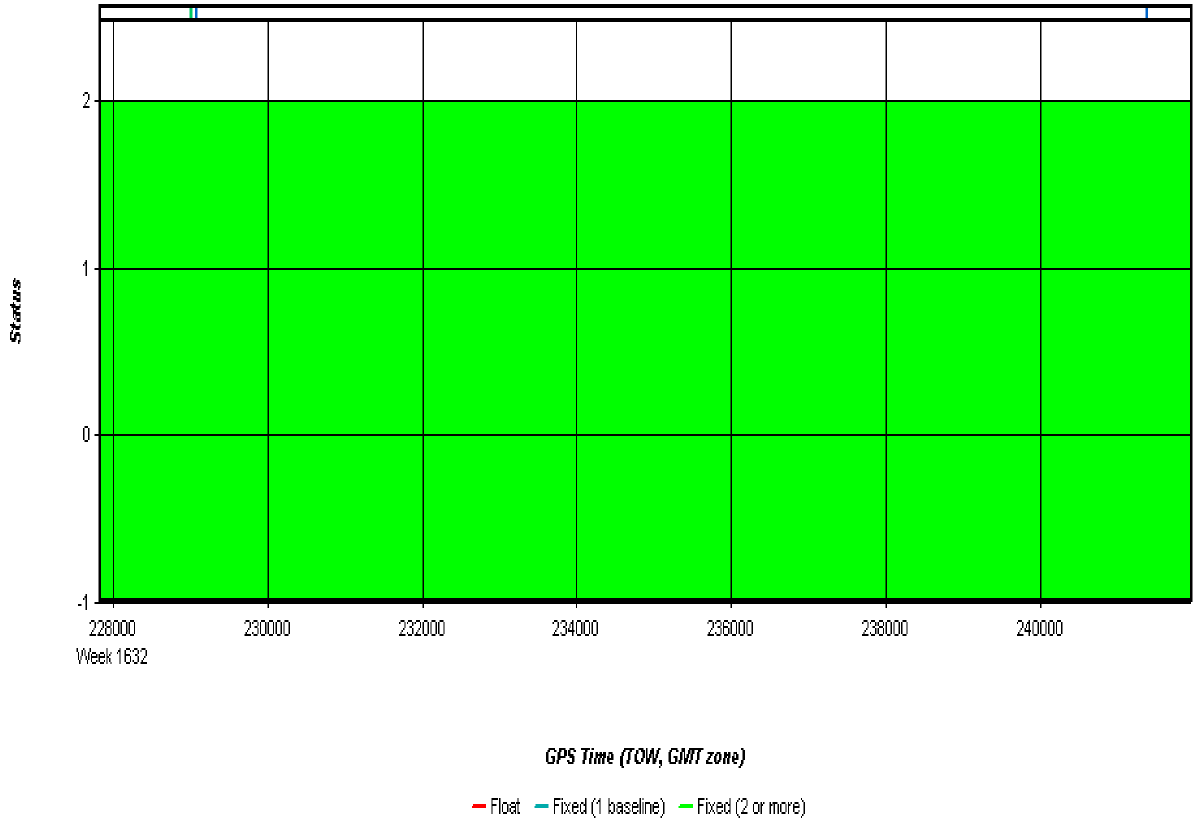
Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 8: JD109F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Figure 9: JD109F01 [Combined] - Float or Fixed Ambiguity

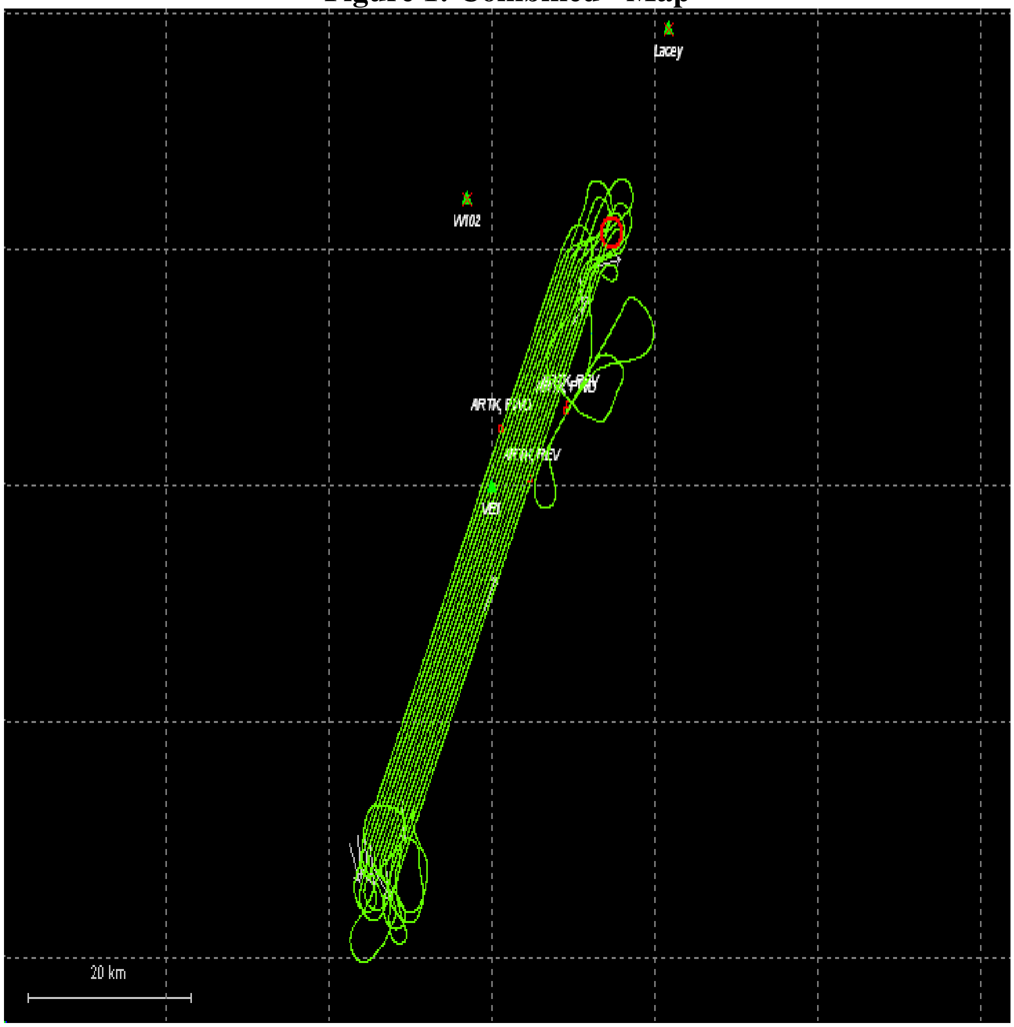


Process	Run (3)	by Unknown	on 06/03/2011	at 12:48:05

Output Results for JD109F02

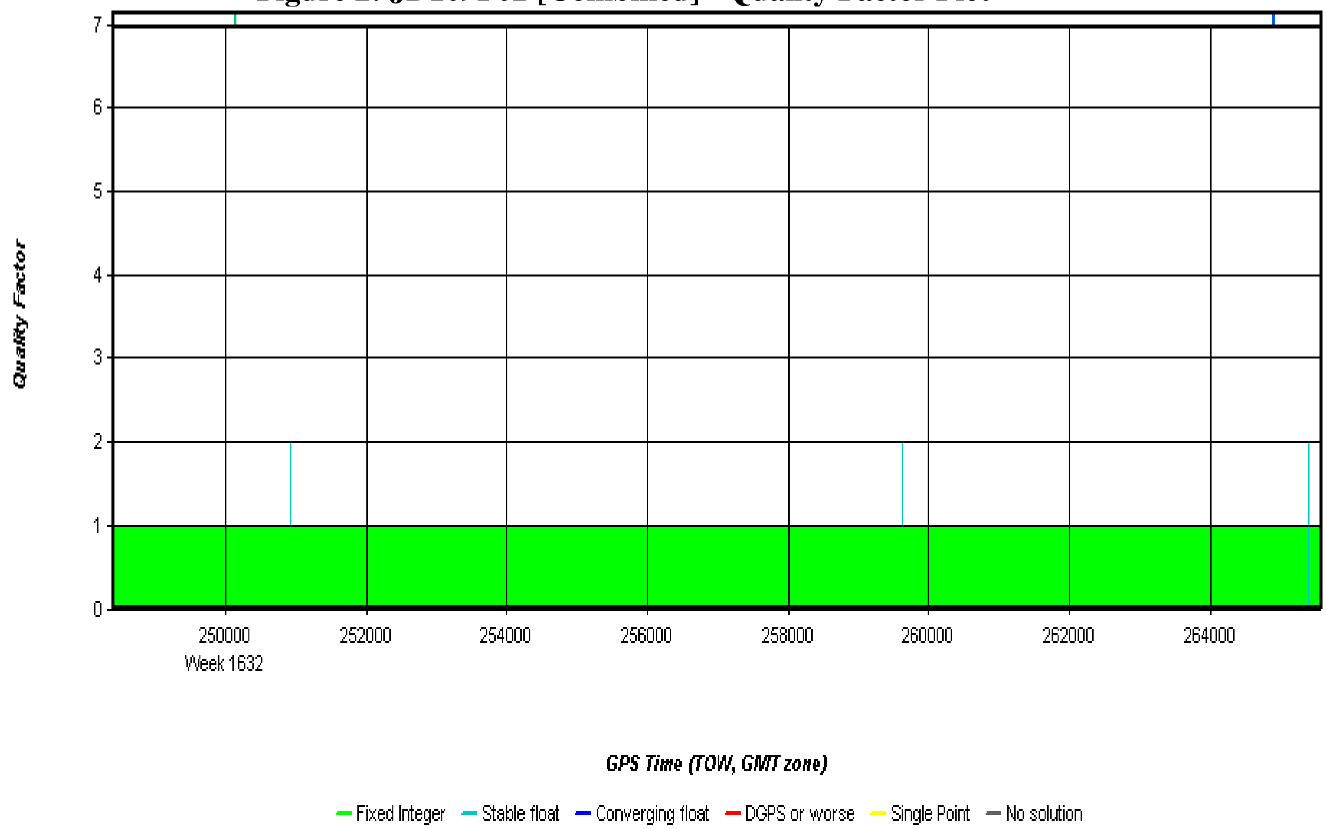
POSGNSS Version 5.20.1209
06/15/2011

Figure 1: Combined - Map



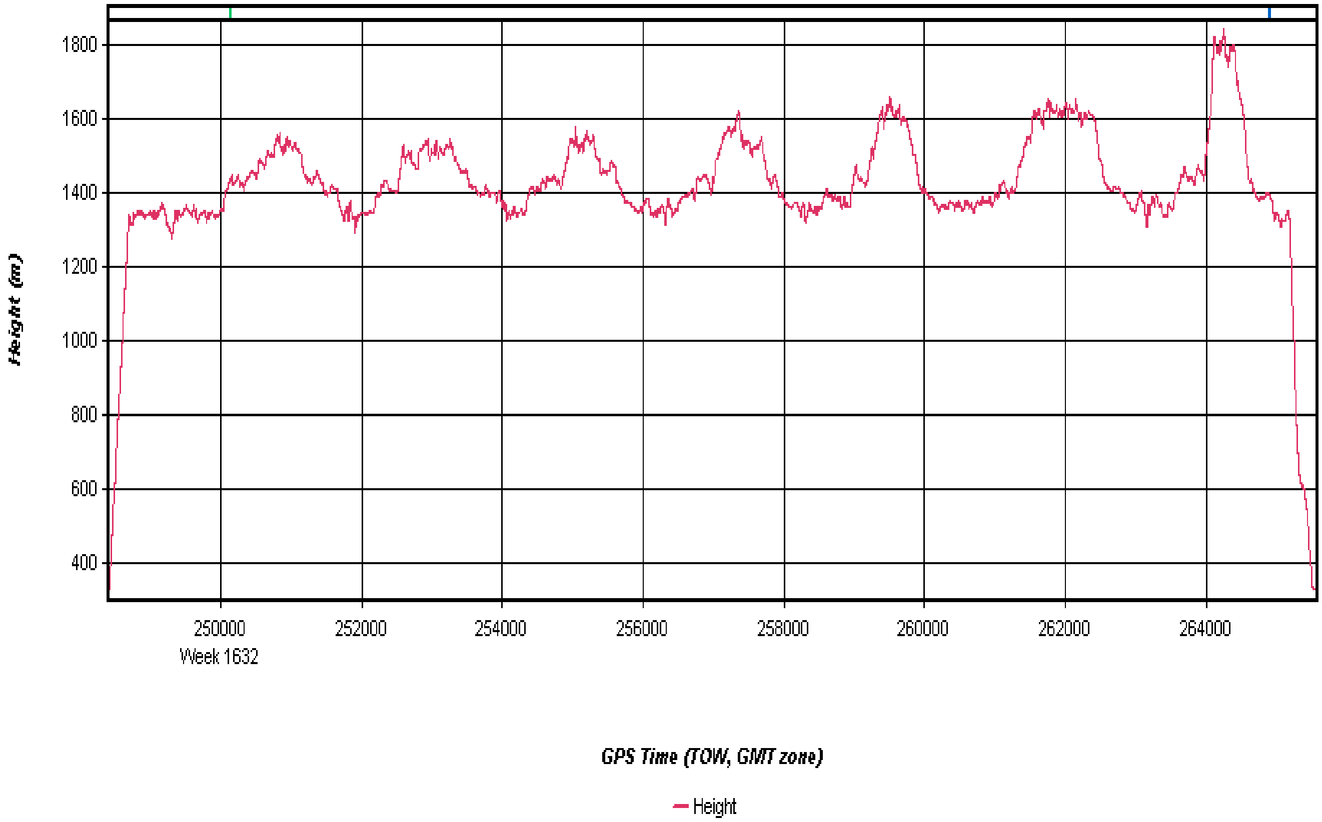
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 2: JD109F02 [Combined] - Quality Factor Plot



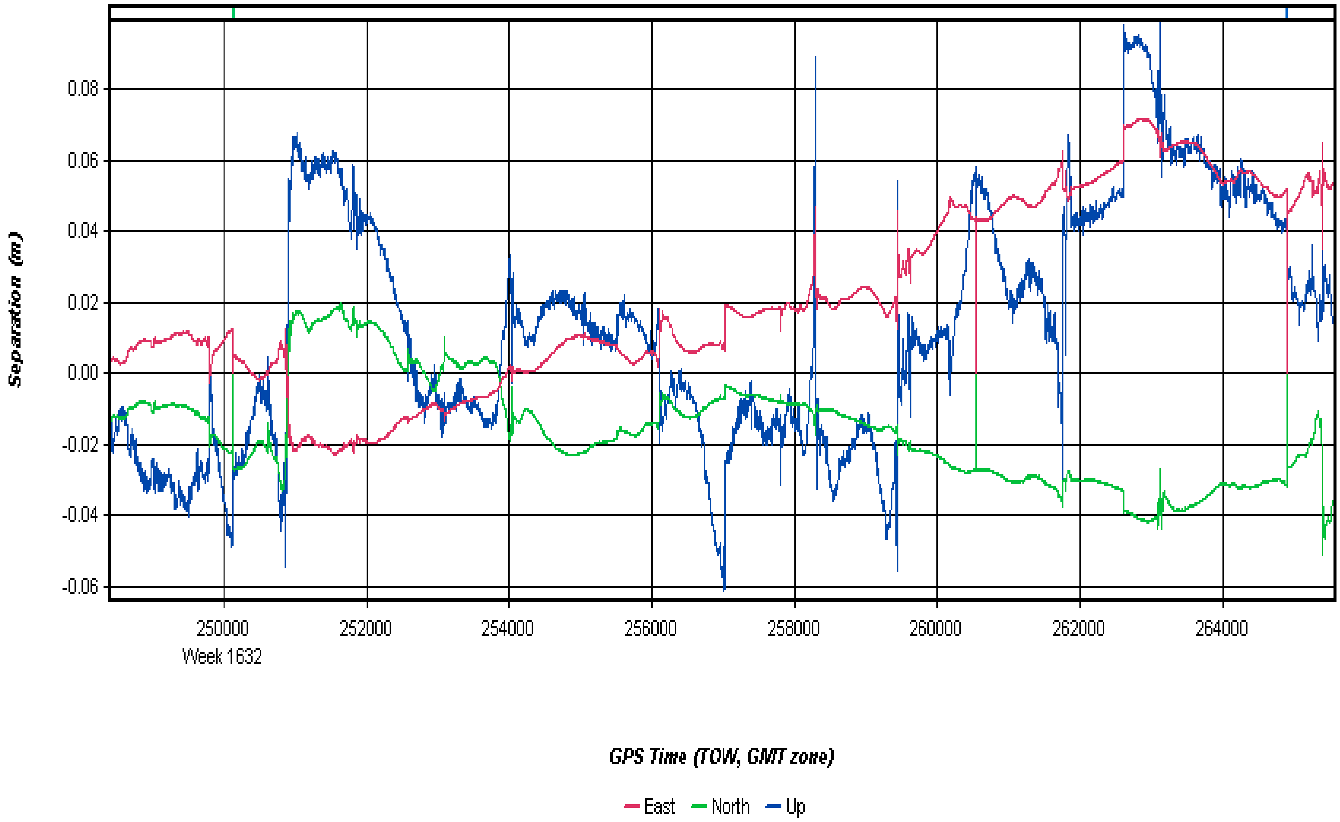
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 3: JD109F02 [Combined] - Height Profile Plot



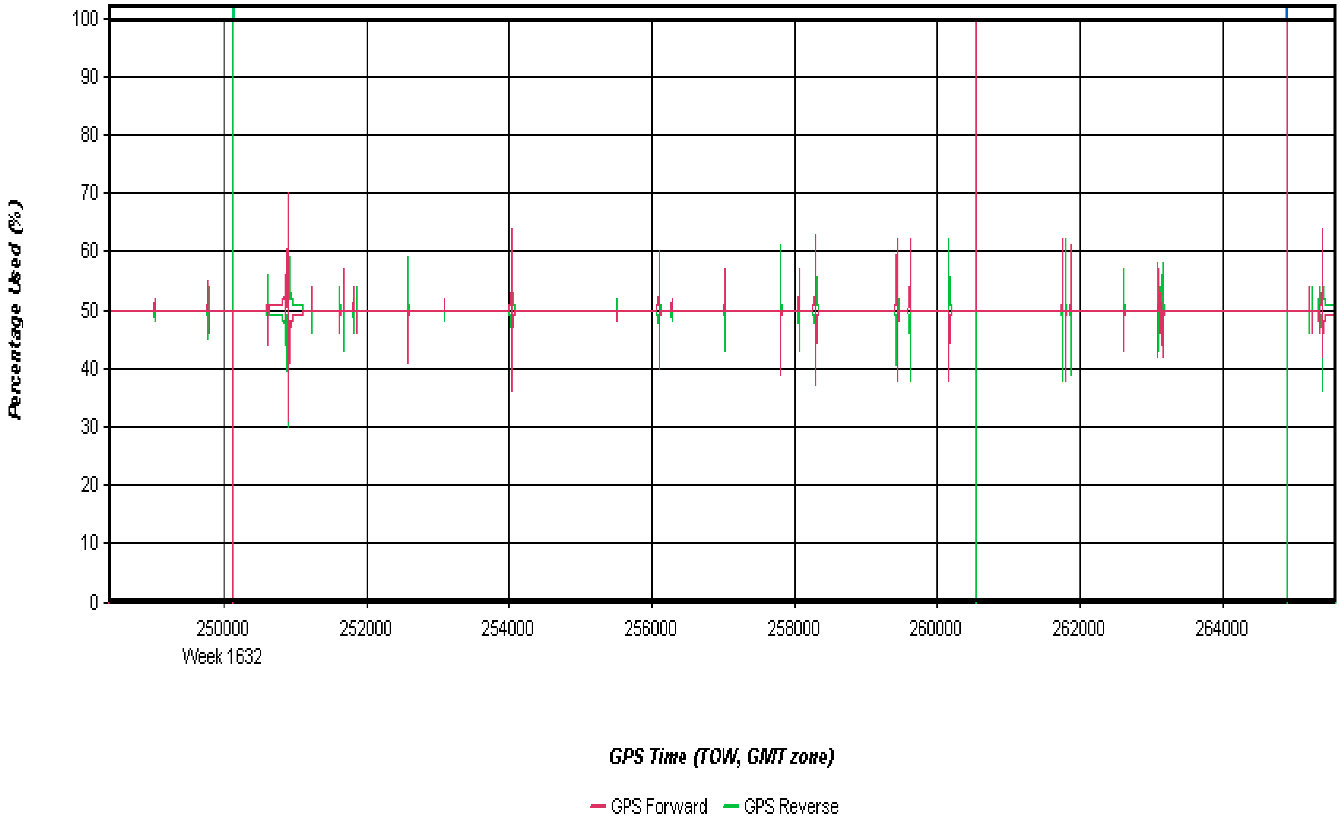
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 4: JD109F02 [Combined] - Forward/Reverse or Combined Separation Plot



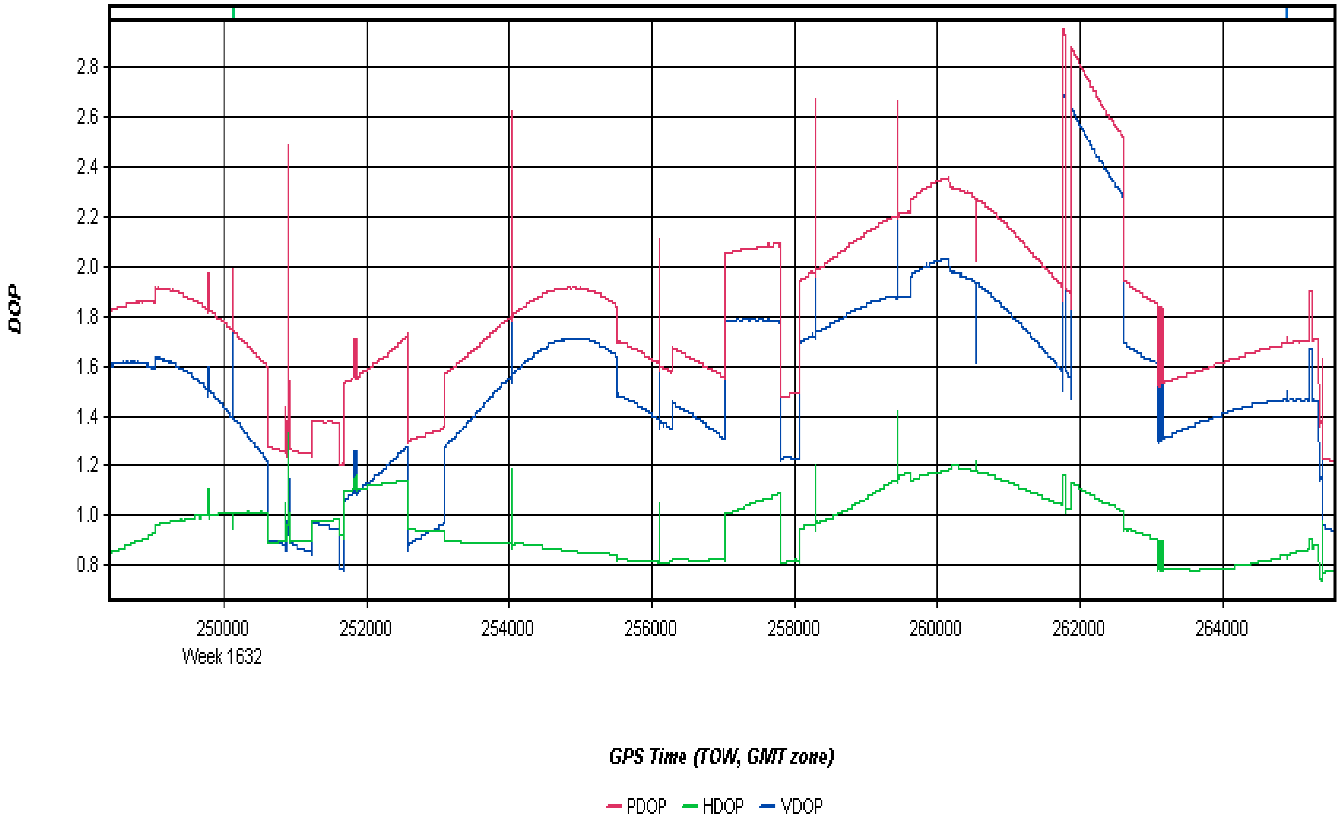
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 5: JD109F02 [Combined] - Forward/Reverse or Combined Weighting Plot



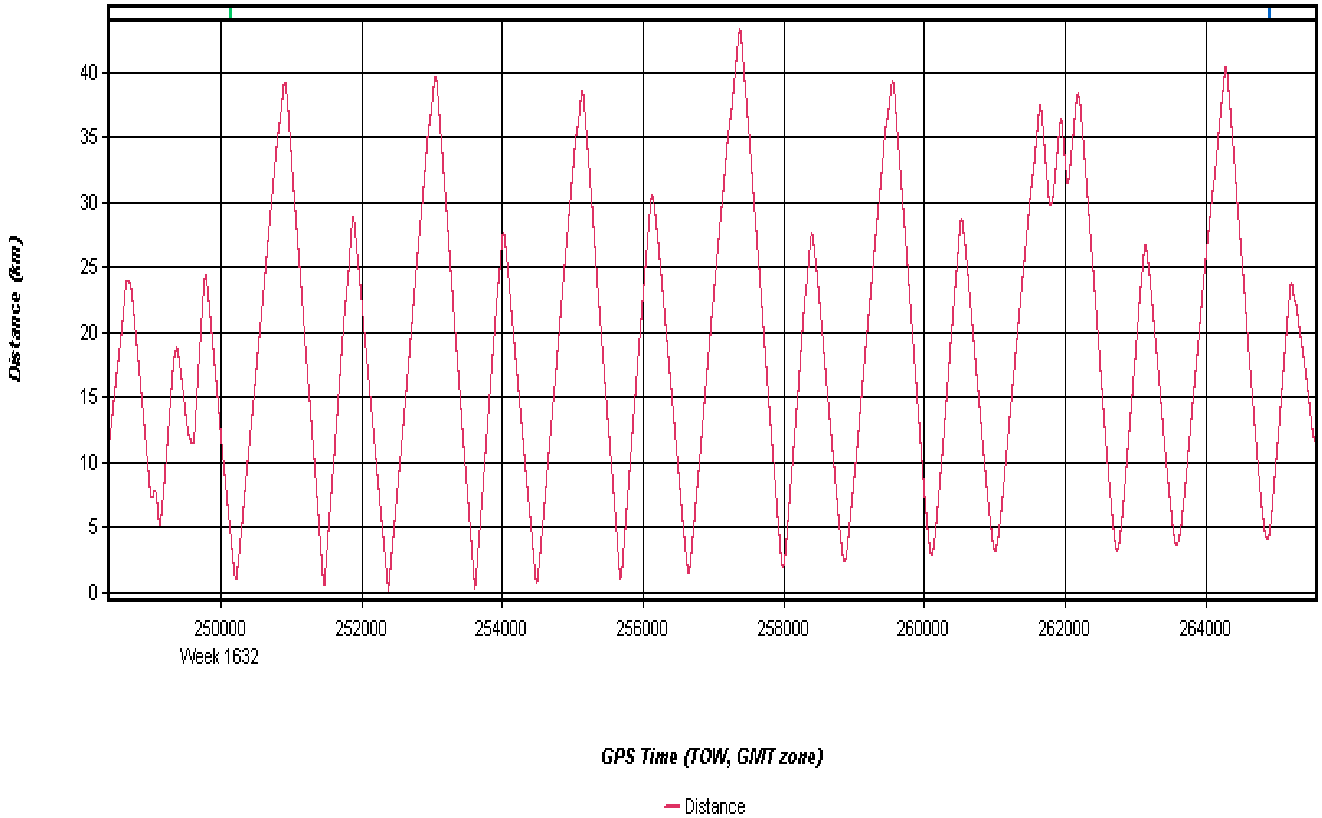
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 6: JD109F02 [Combined] - PDOP, HDOP, VDOP Plots



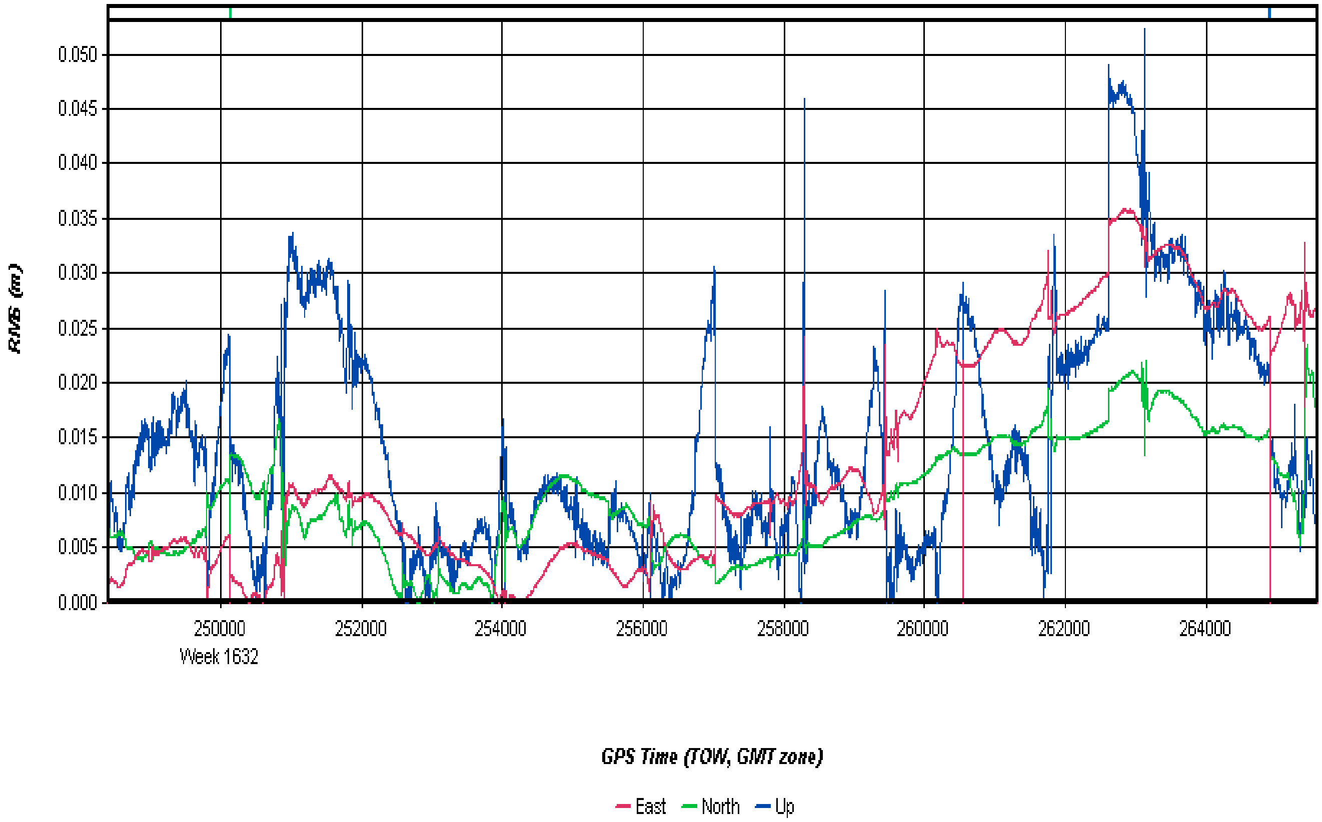
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 7: JD109F02 [Combined] - Horizontal Distance Separation (km)



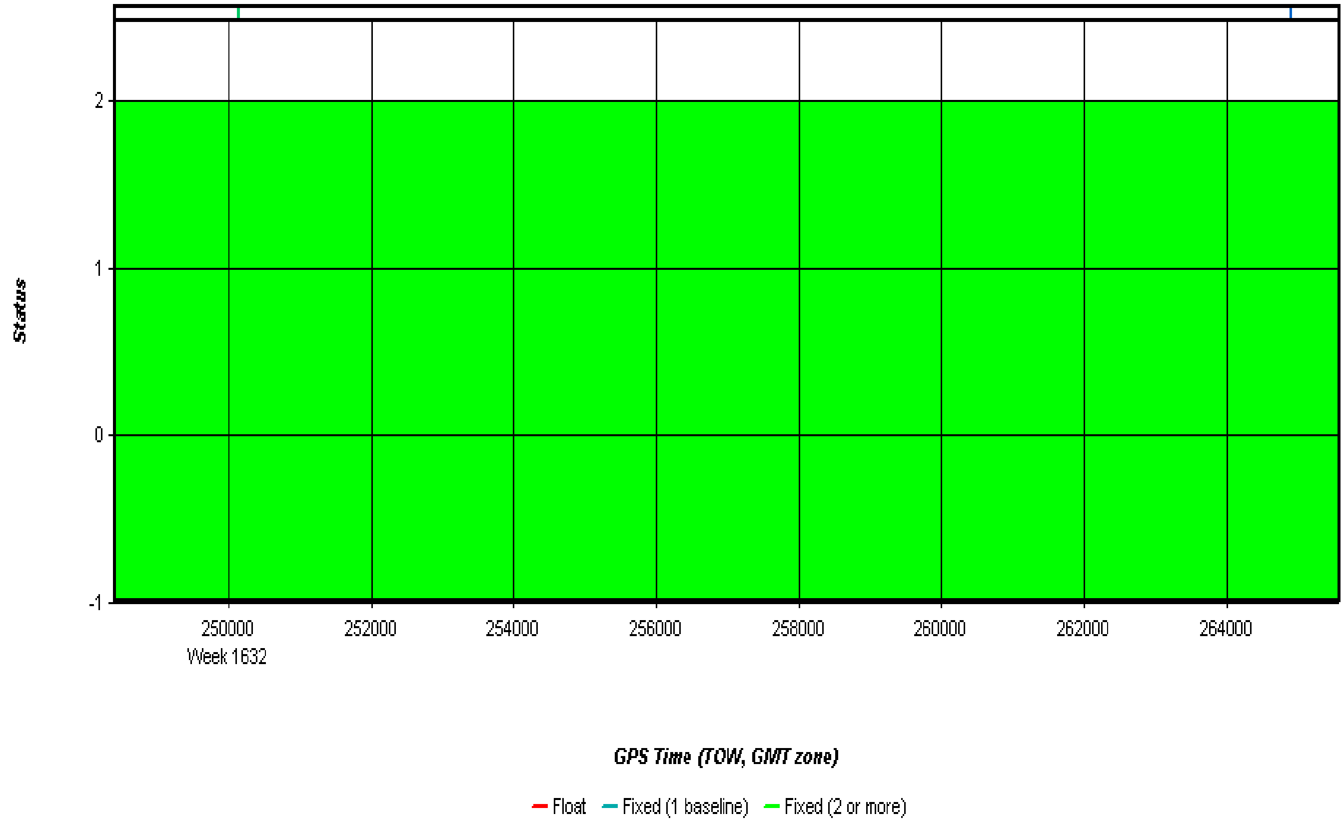
Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 8: JD109F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Figure 9: JD109F02 [Combined] - Float or Fixed Ambiguity

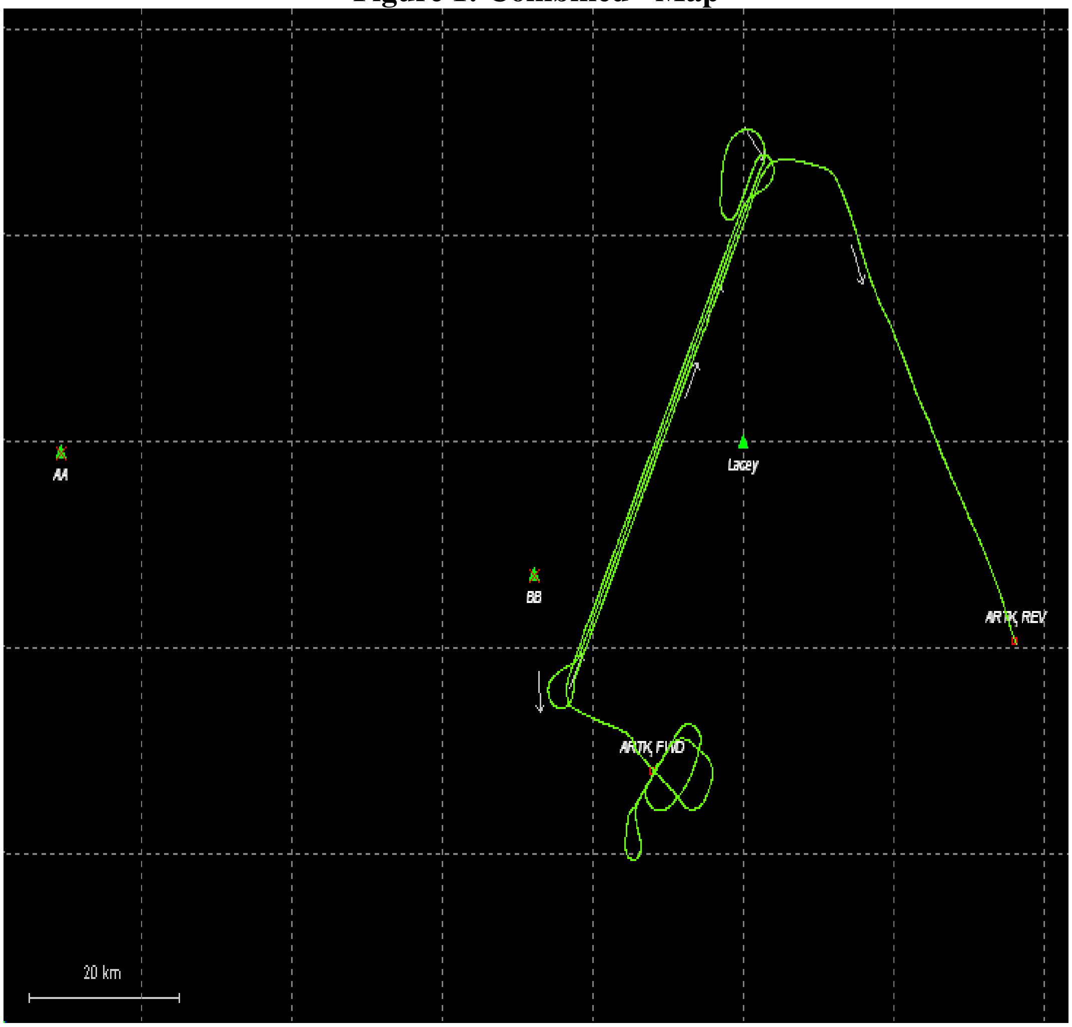


Process	Run (14)	by Unknown	on 06/15/2011	at 12:41:55

Output Results for JD110F01

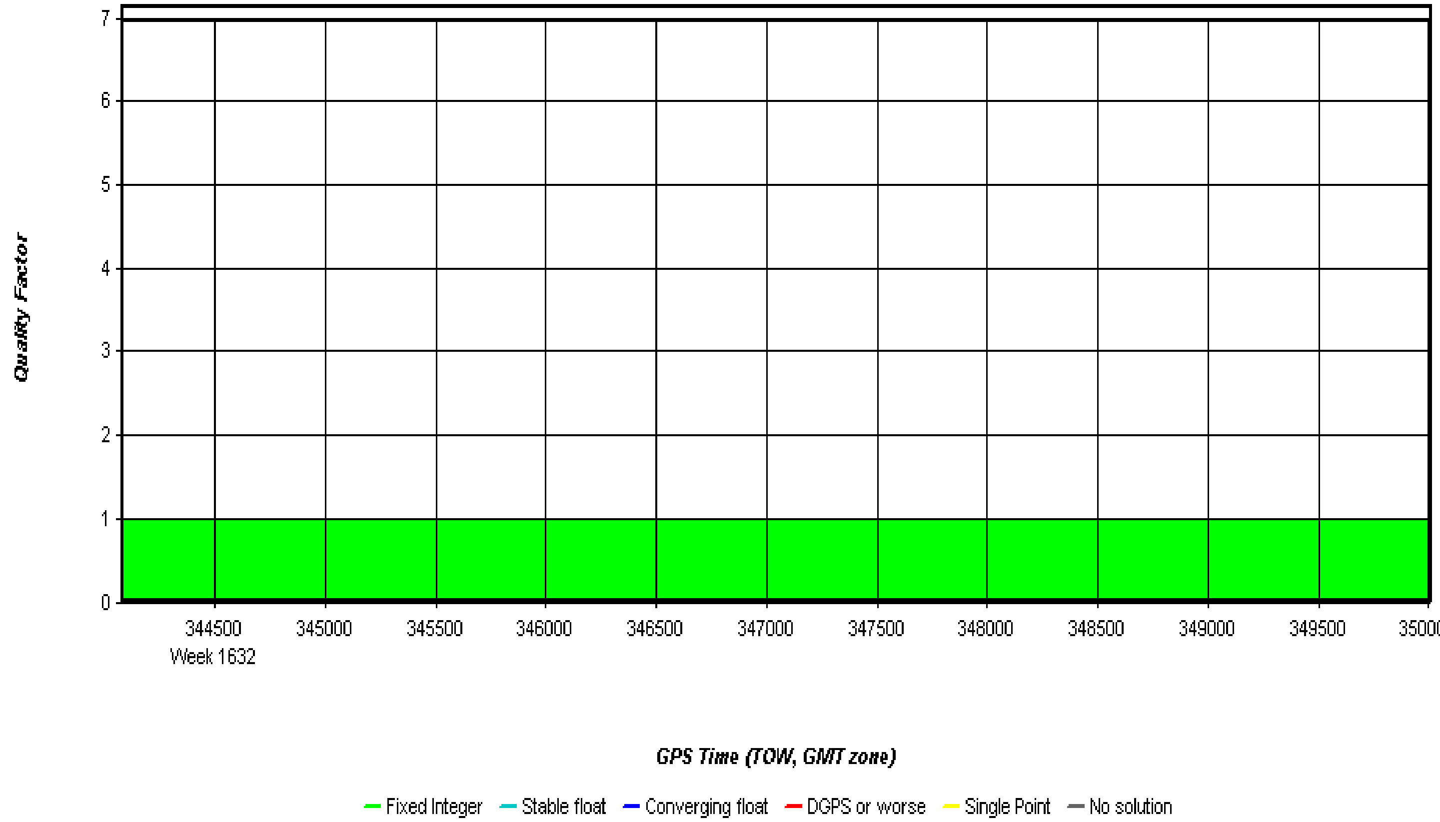
POSGNSS Version 5.20.1209
06/15/2011

Figure 1: Combined - Map



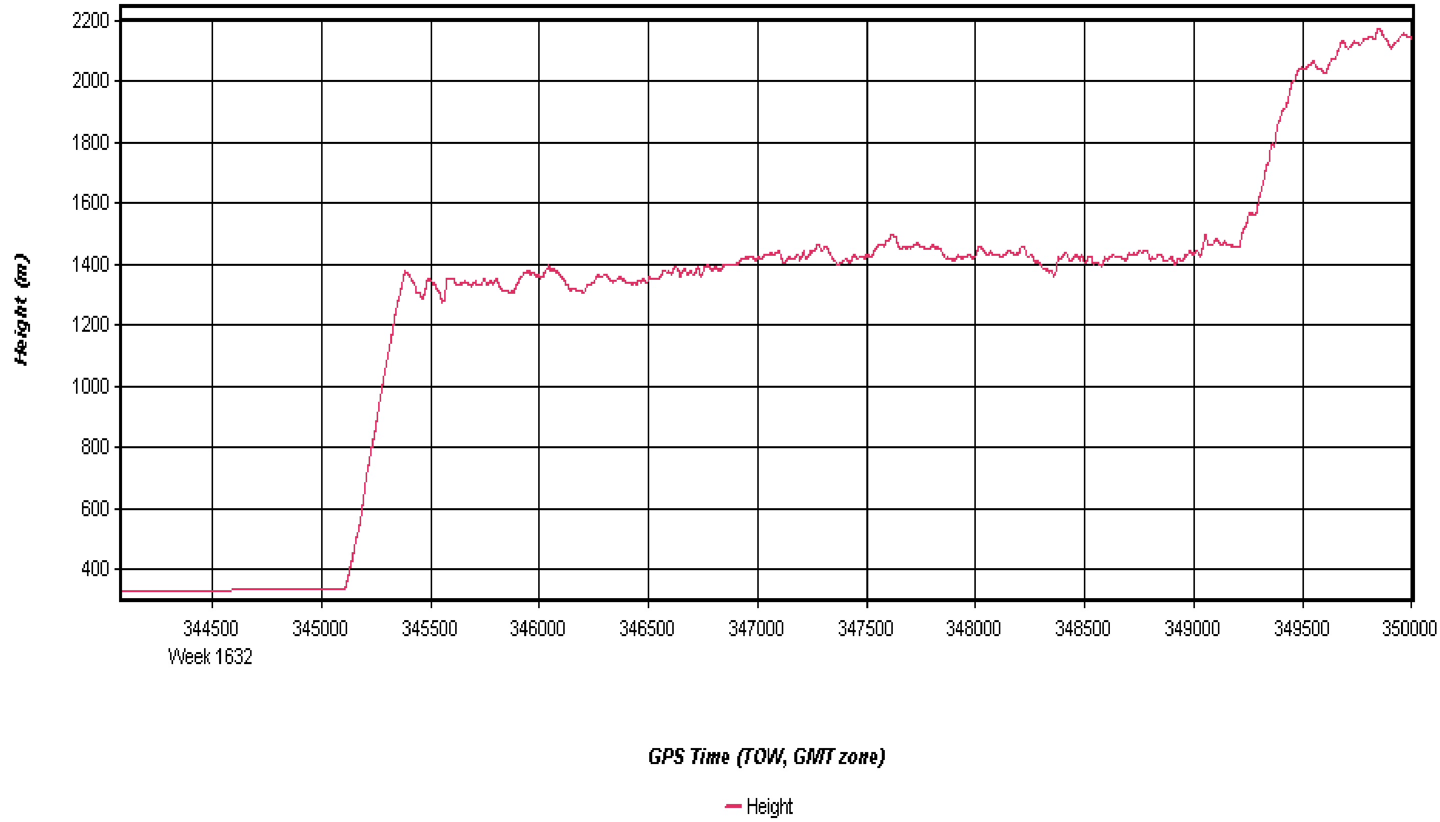
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 2: JD110F01 [Combined] - Quality Factor Plot



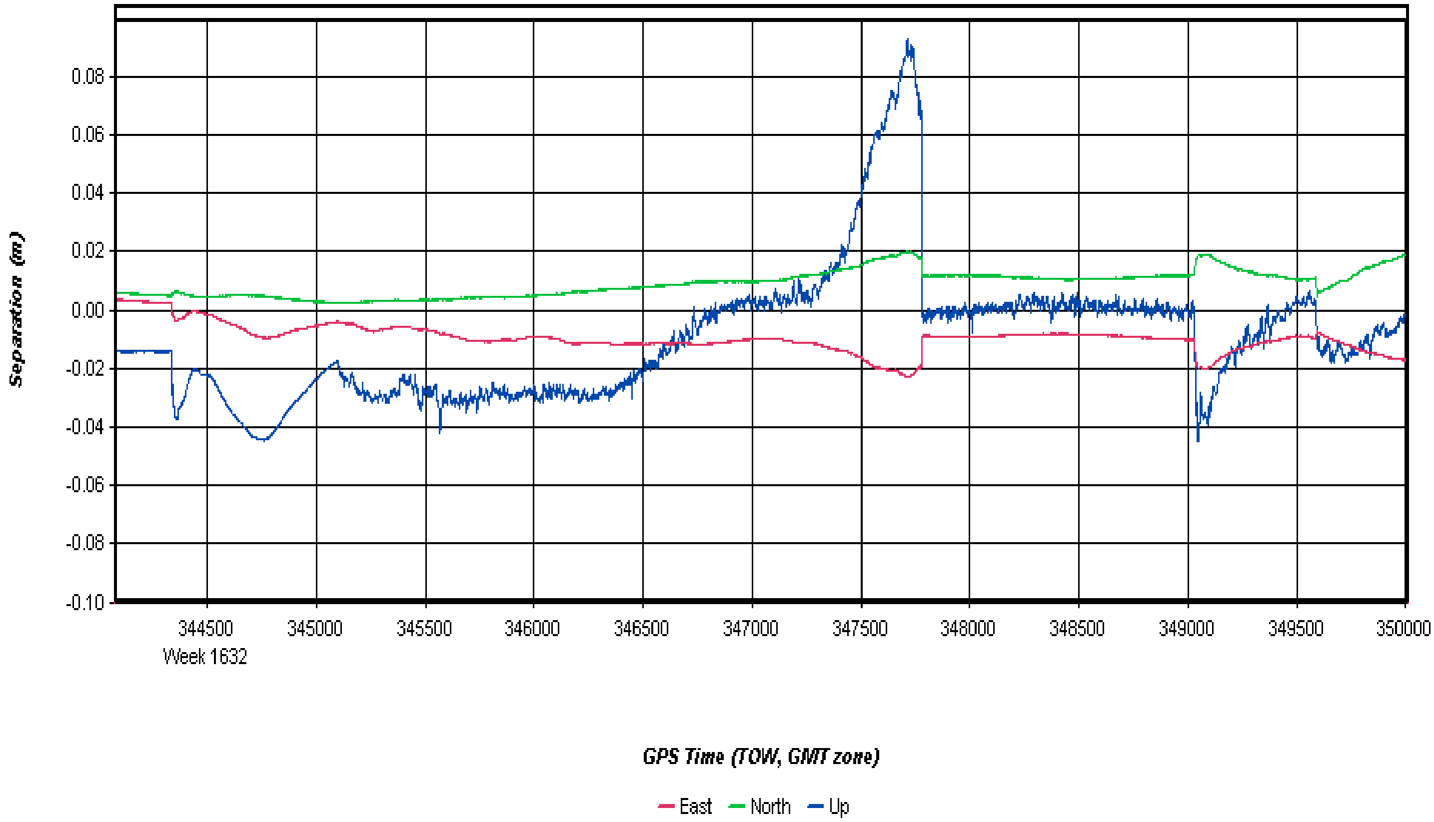
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 3: JD110F01 [Combined] - Height Profile Plot



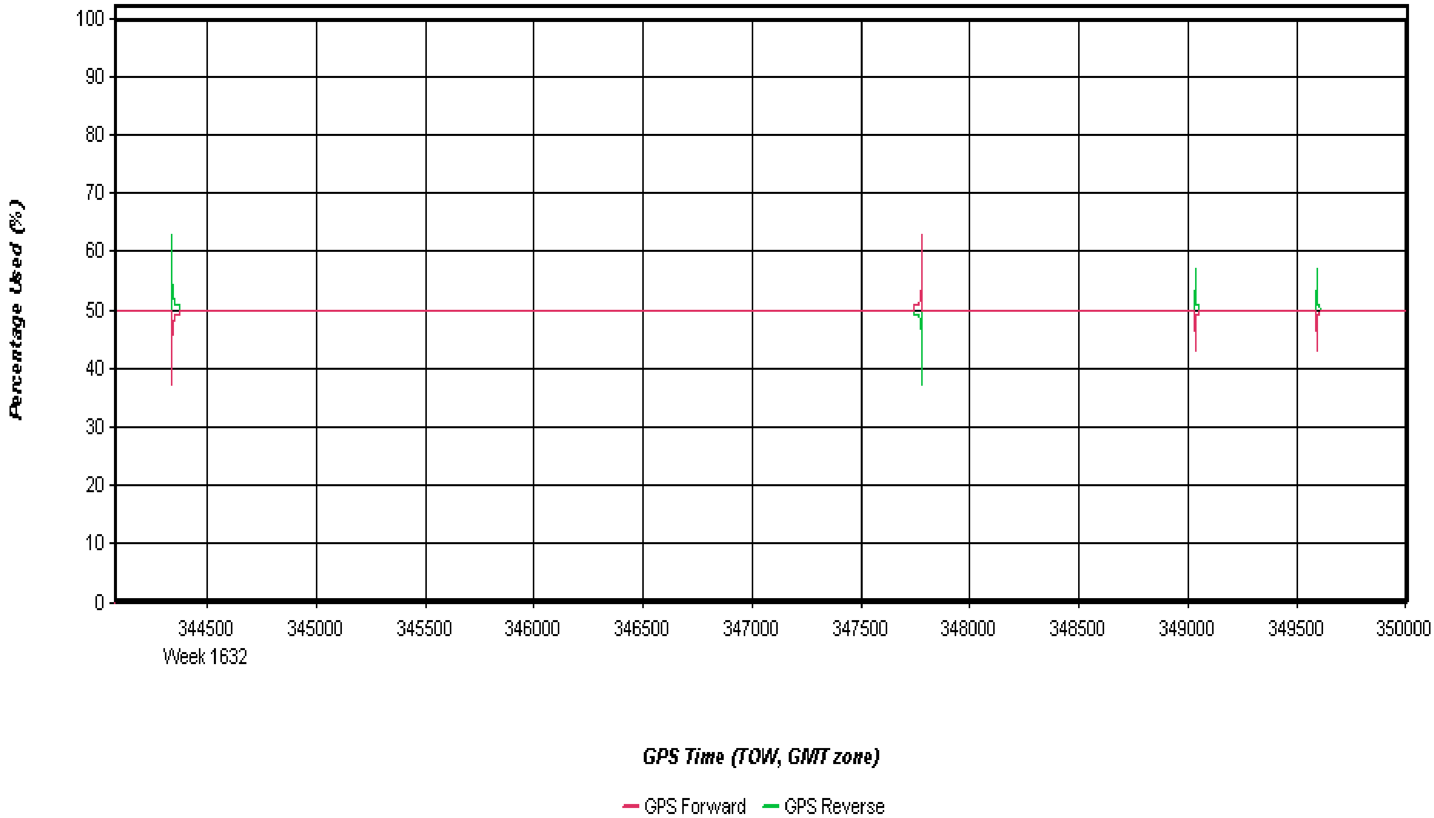
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 4: JD110F01 [Combined] - Forward/Reverse or Combined Separation Plot



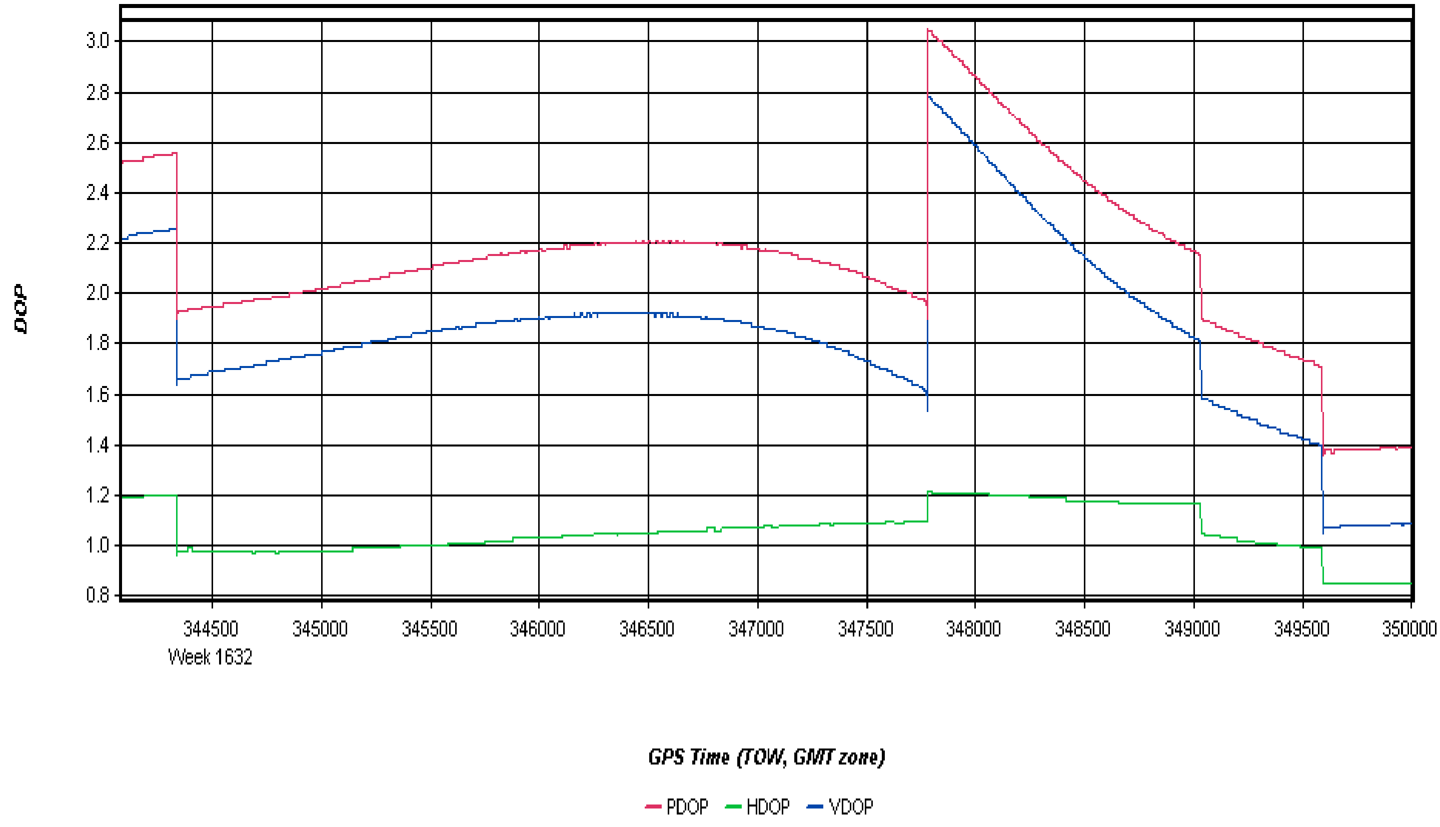
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 5: JD110F01 [Combined] - Forward/Reverse or Combined Weighting Plot



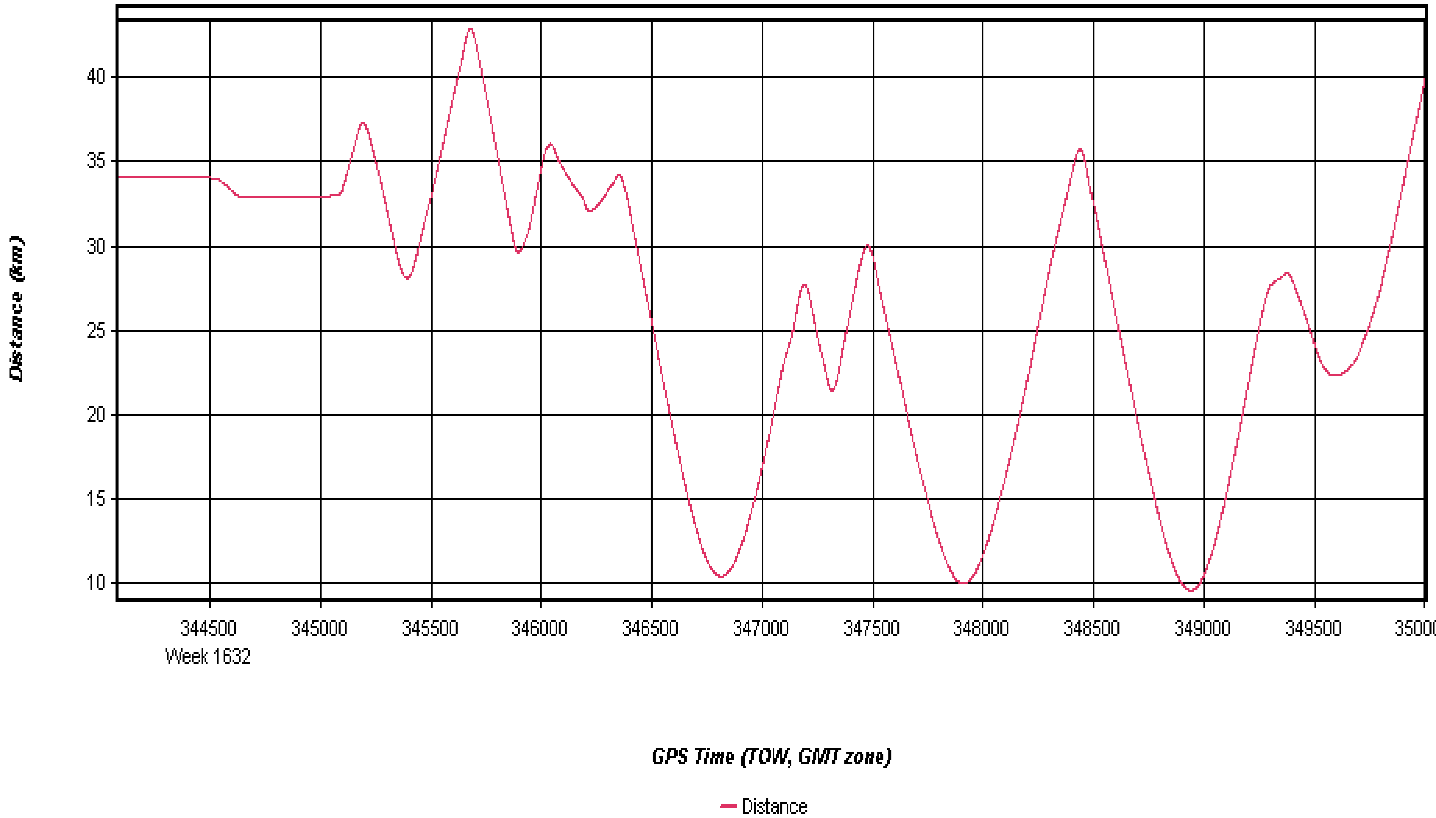
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 6: JD110F01 [Combined] - PDOP, HDOP, VDOP Plots



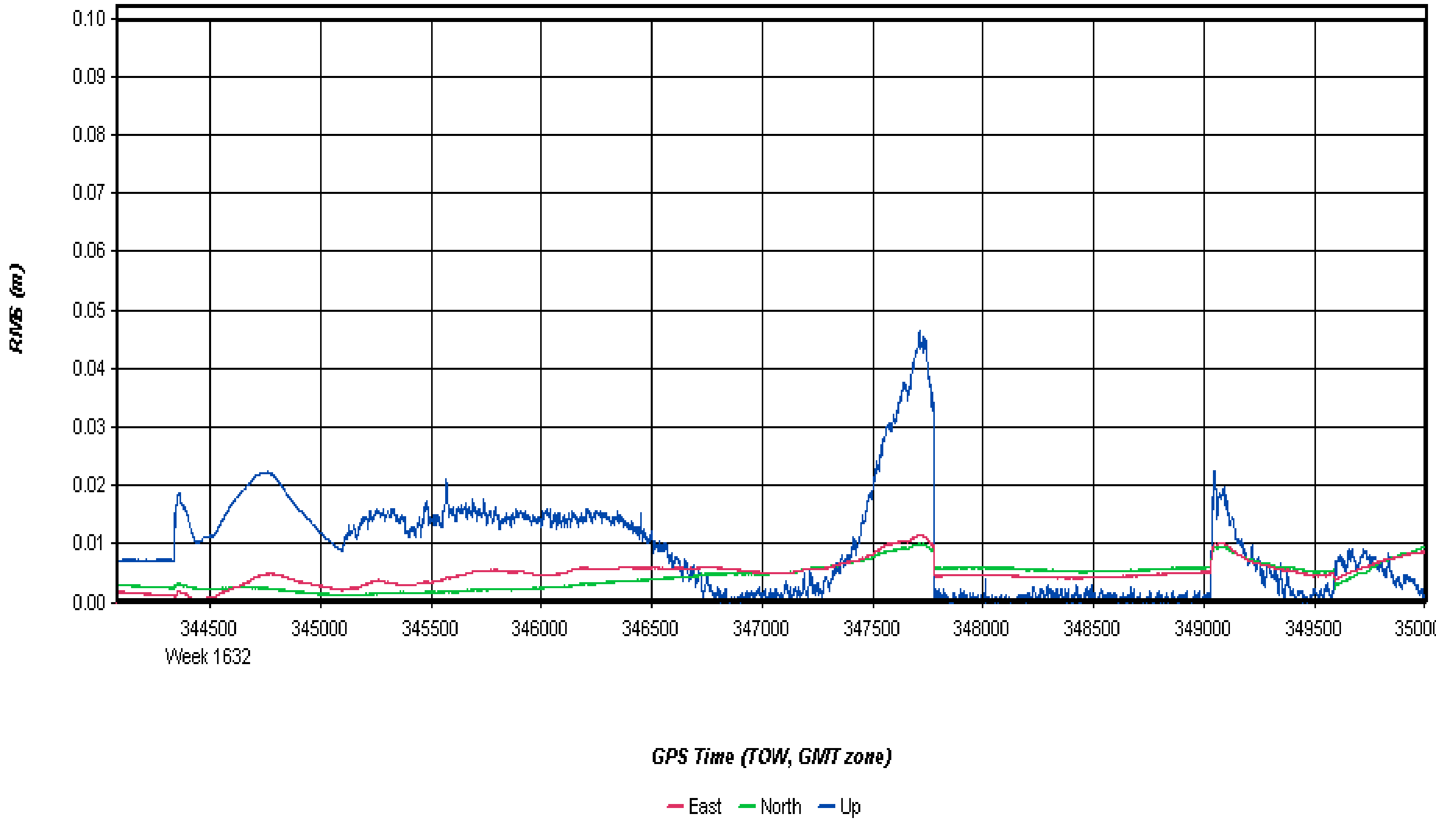
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 7: JD110F01 [Combined] - Horizontal Distance Separation (km)



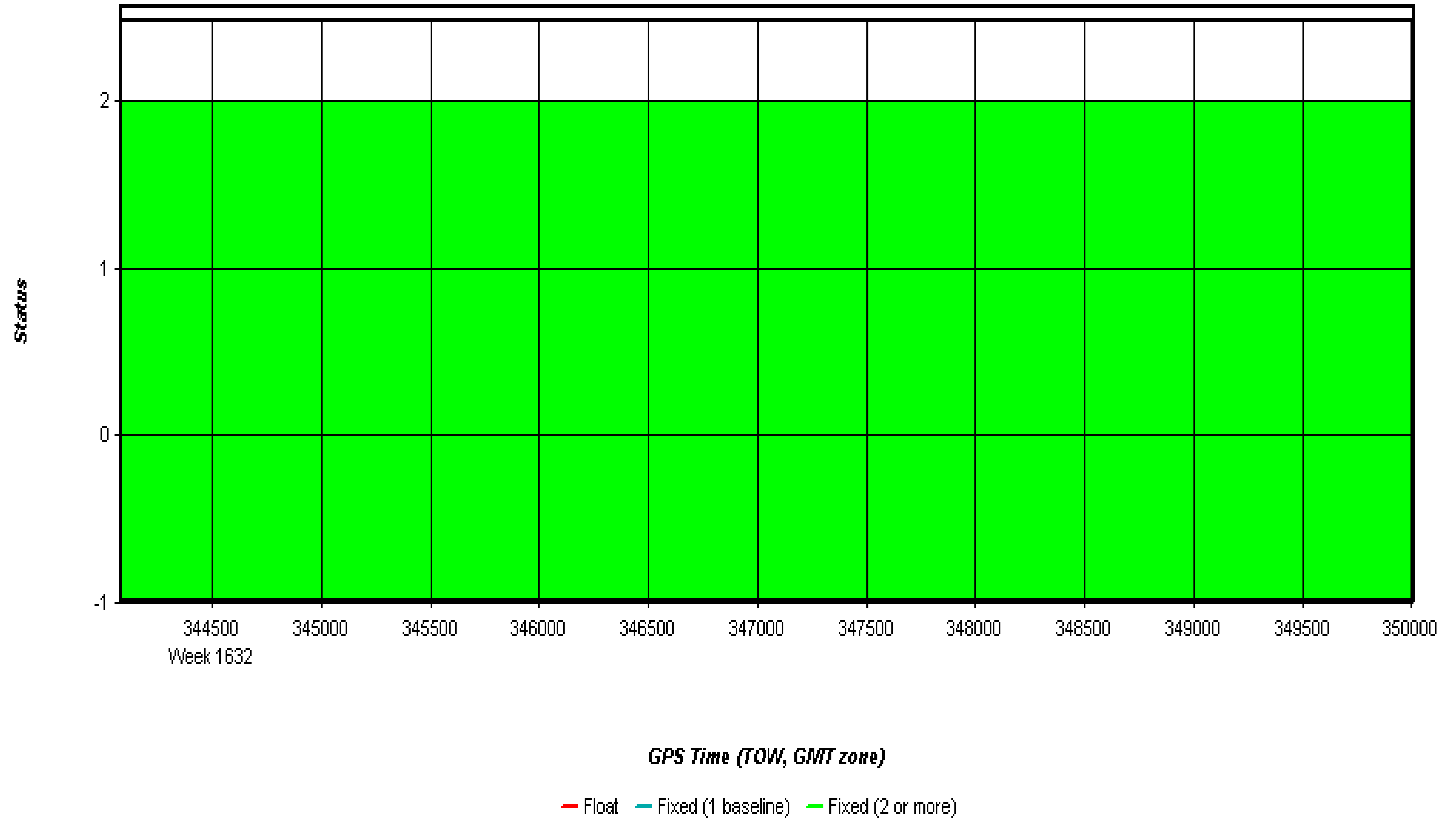
Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 8: JD110F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Figure 9: JD110F01 [Combined] - Float or Fixed Ambiguity

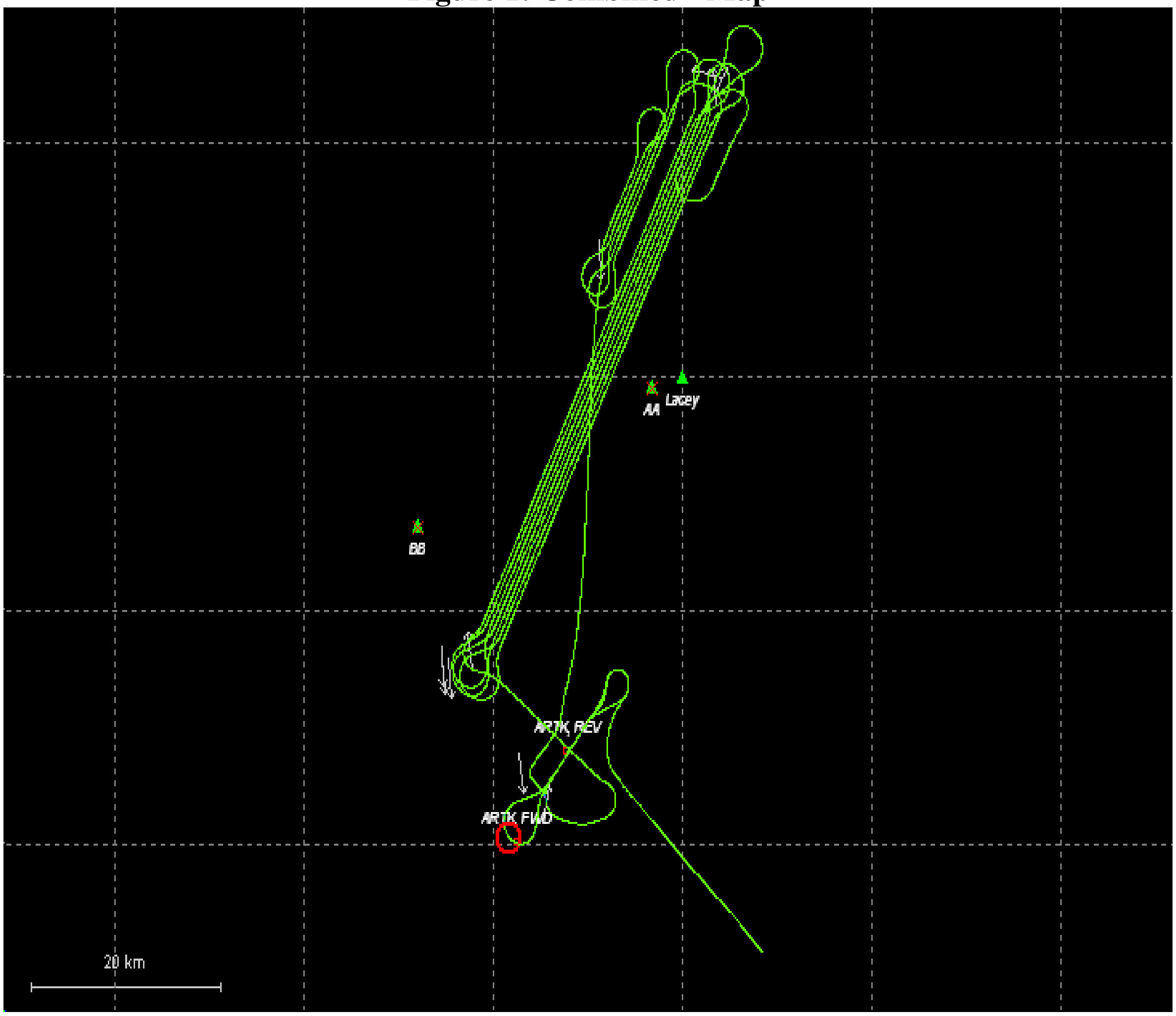


Process	Run (7)	by Unknown	on 06/15/2011	at 14:01:30

Output Results for JD111F01

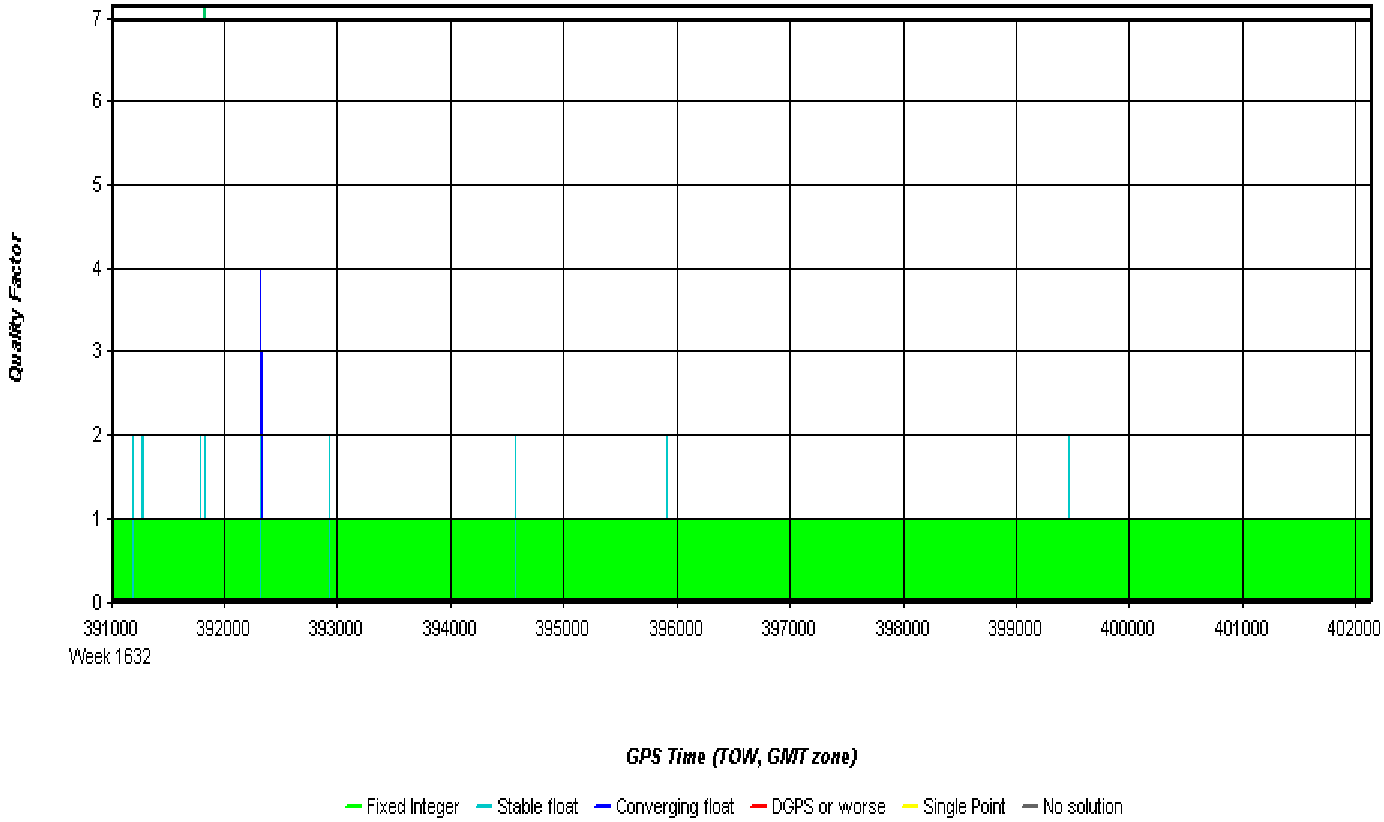
POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map



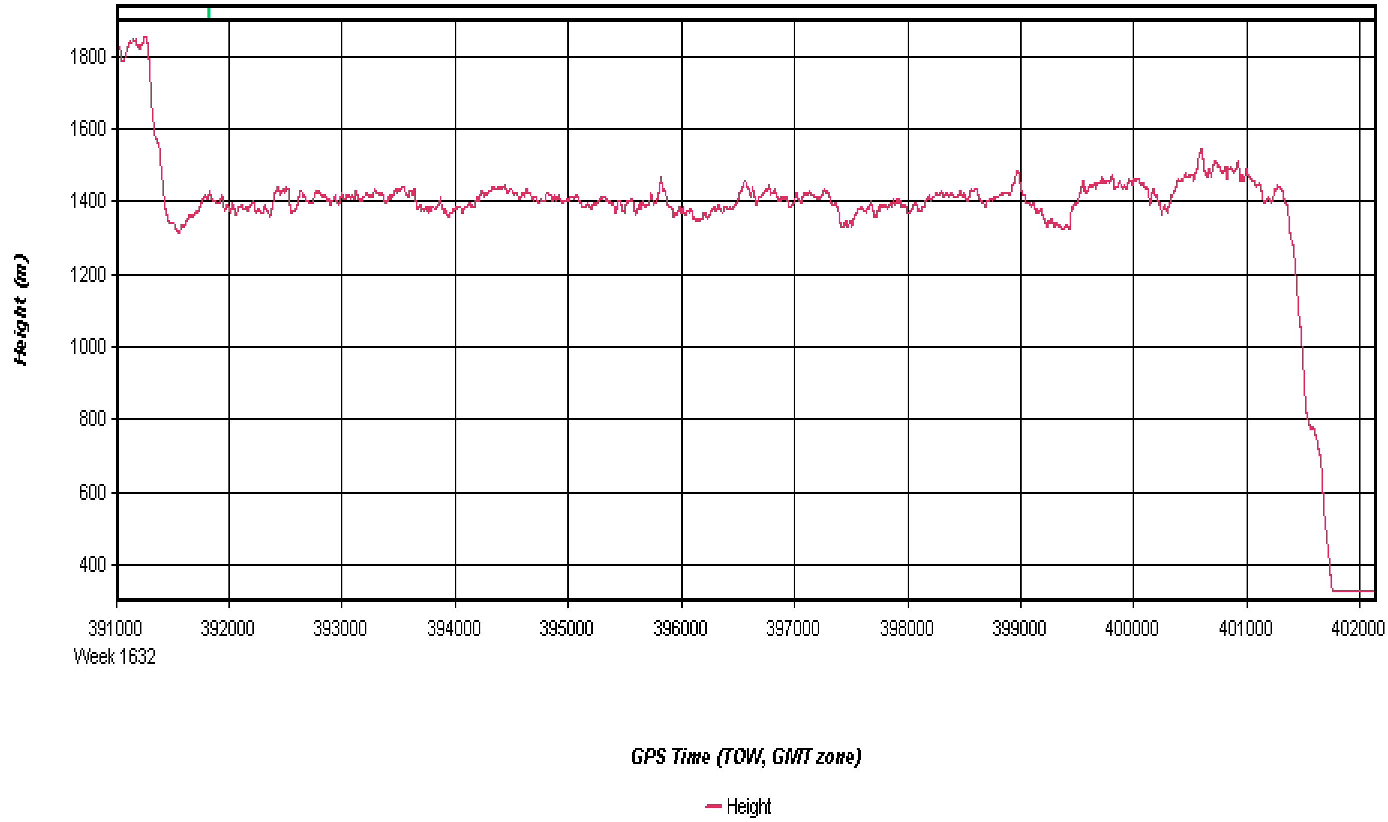
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 2: JD111F01 [Combined] - Quality Factor Plot



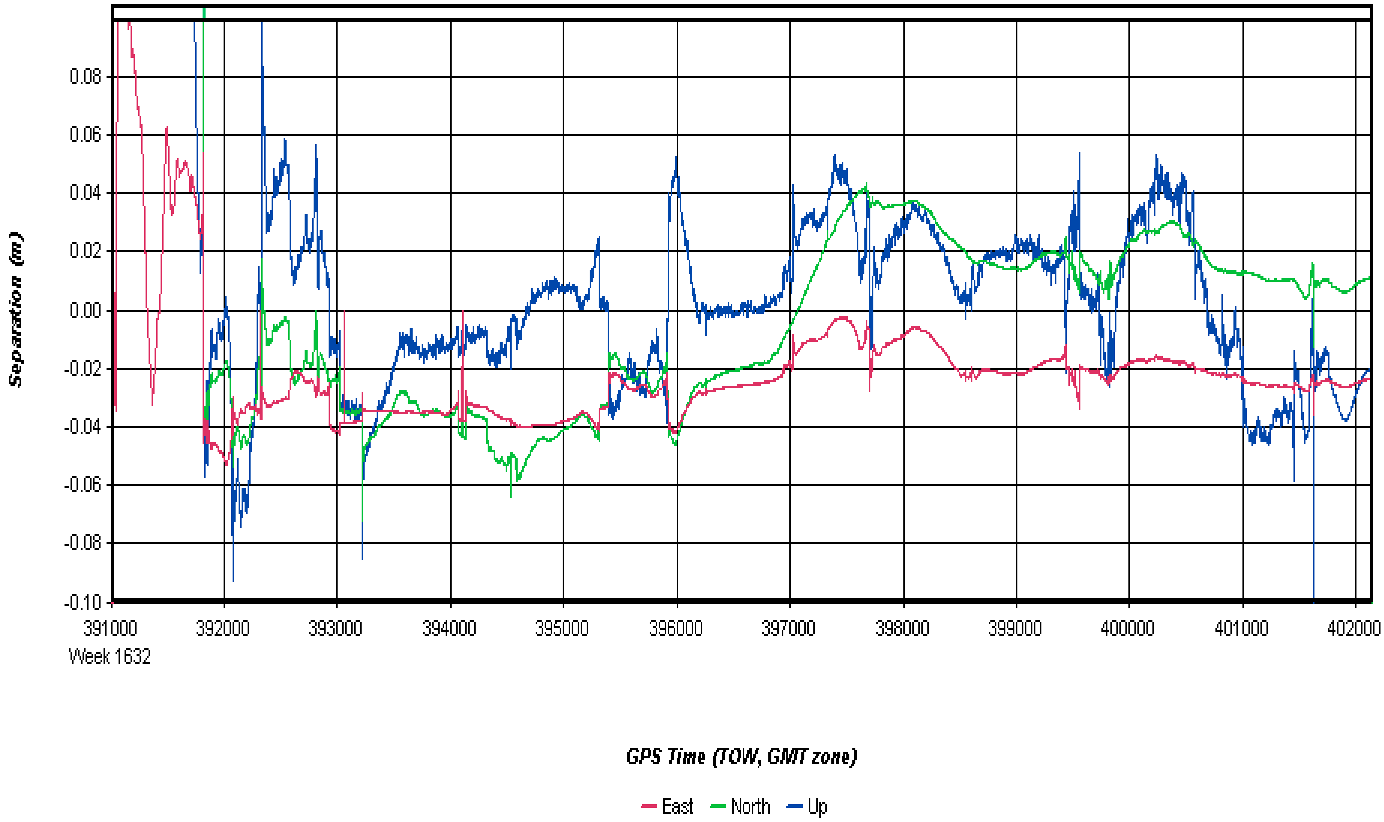
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 3: JD111F01 [Combined] - Height Profile Plot



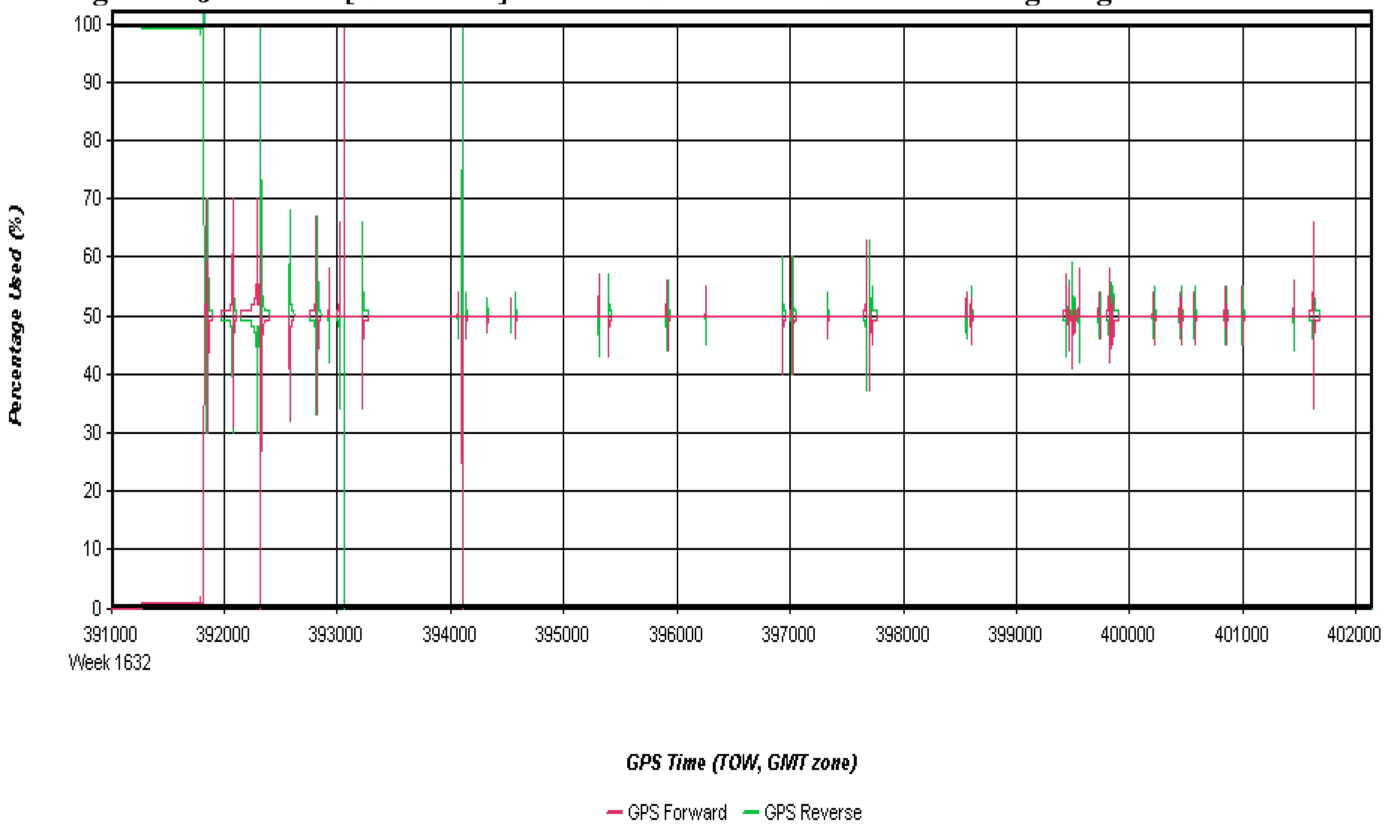
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 4: JD111F01 [Combined] - Forward/Reverse or Combined Separation Plot



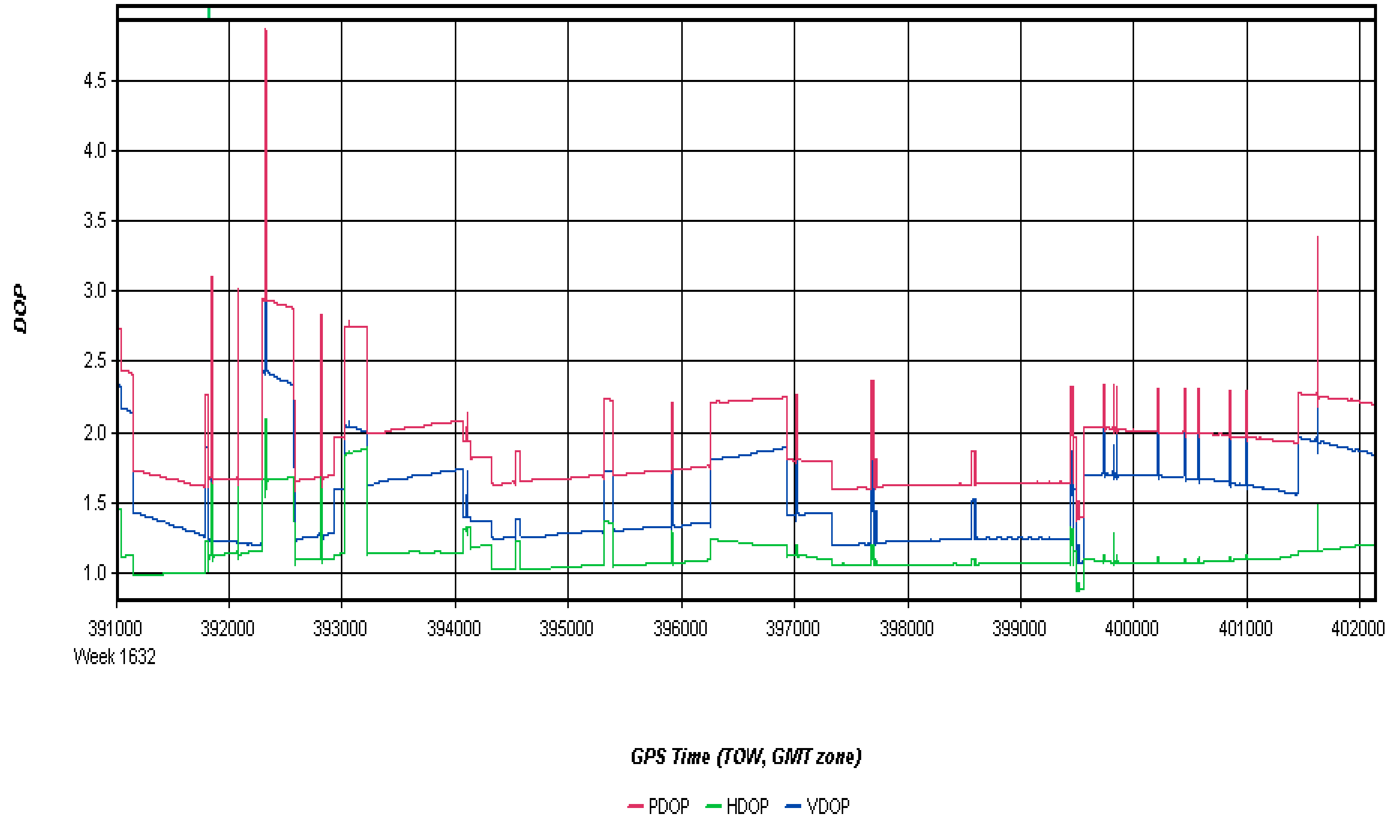
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 5: JD111F01 [Combined] - Forward/Reverse or Combined Weighting Plot



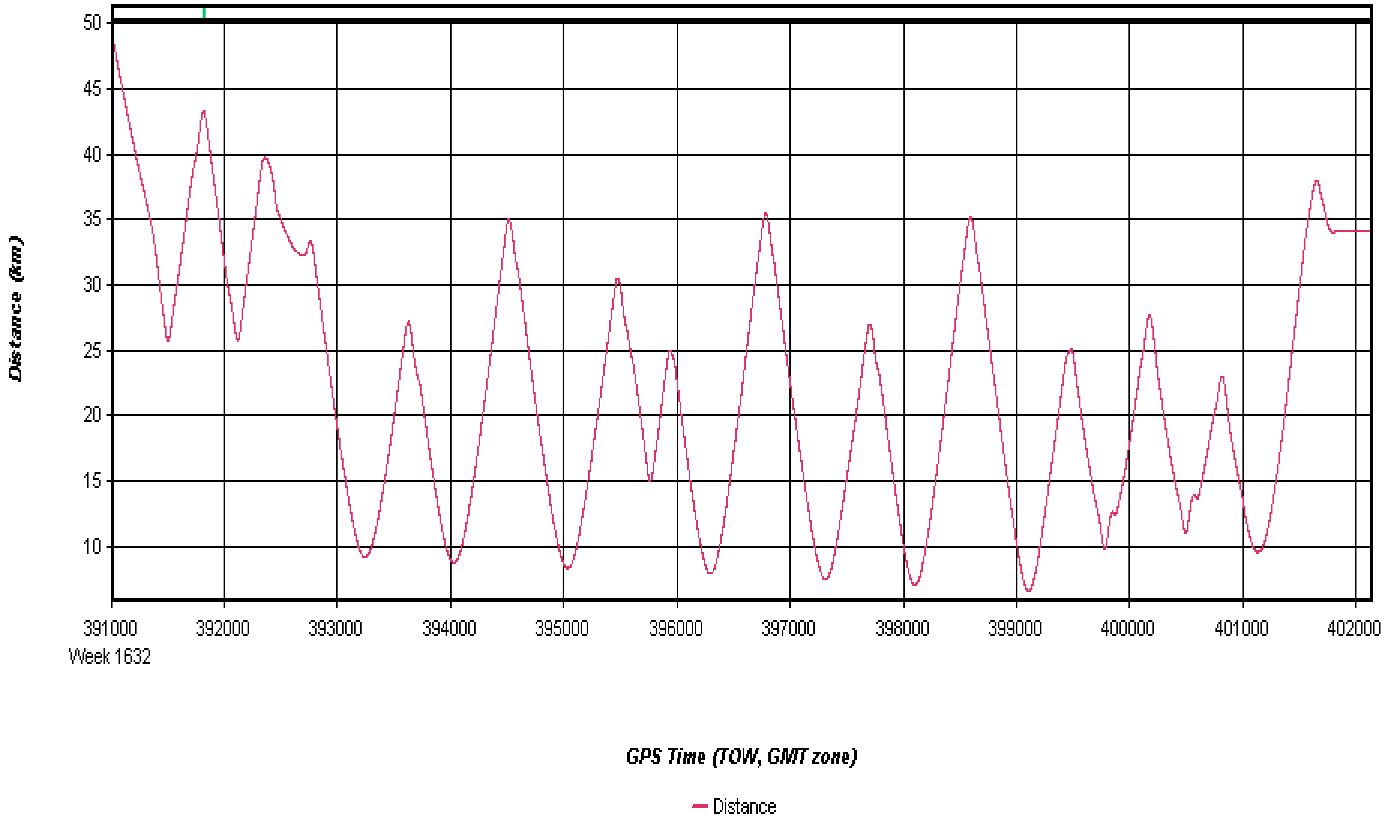
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 6: JD111F01 [Combined] - PDOP, HDOP, VDOP Plots



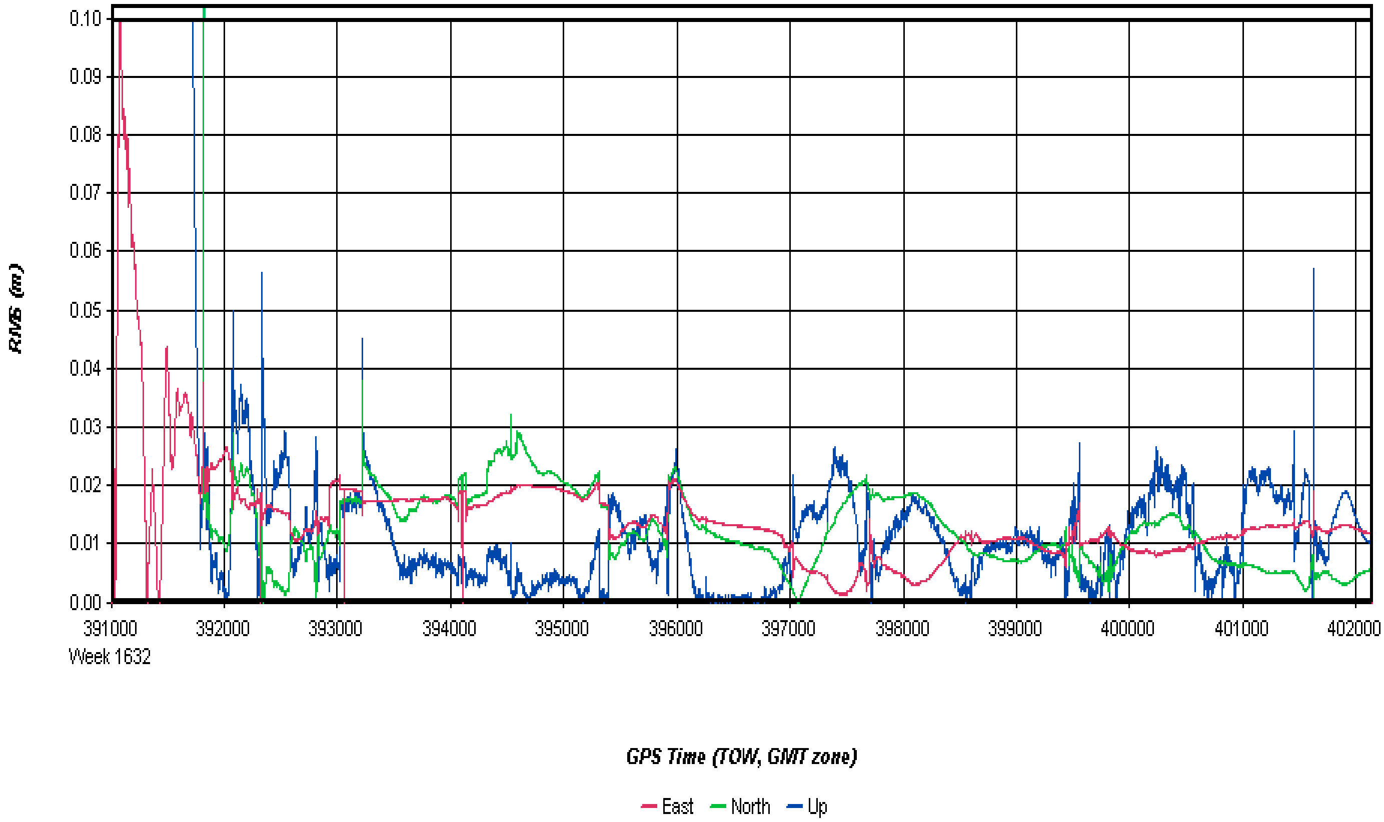
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 7: JD111F01 [Combined] - Horizontal Distance Separation (km)



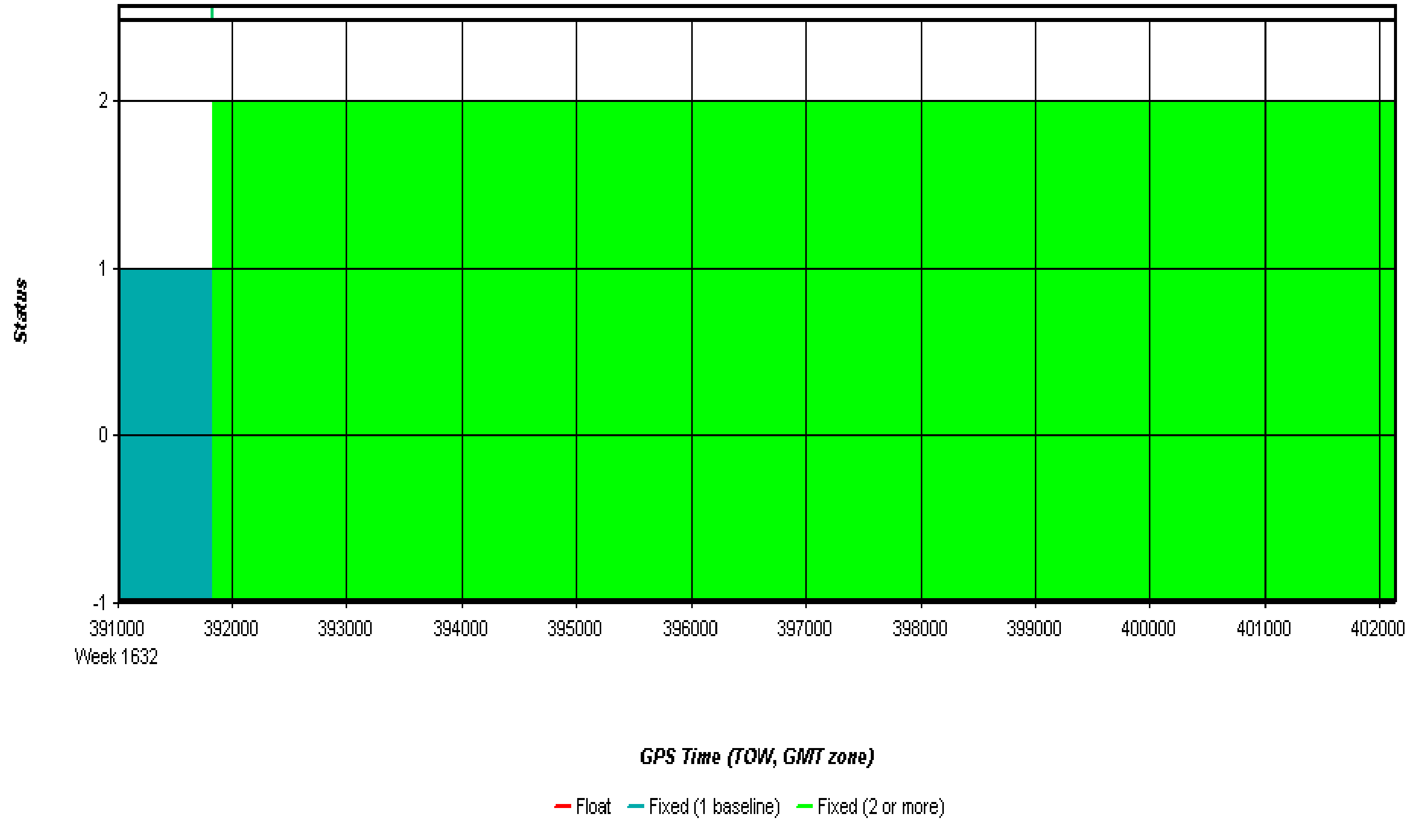
Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 8: JD111F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

Figure 9: JD111F01 [Combined] - Float or Fixed Ambiguity



Process	Run (16)	by Unknown	on 06/16/2011	at 08:16:20

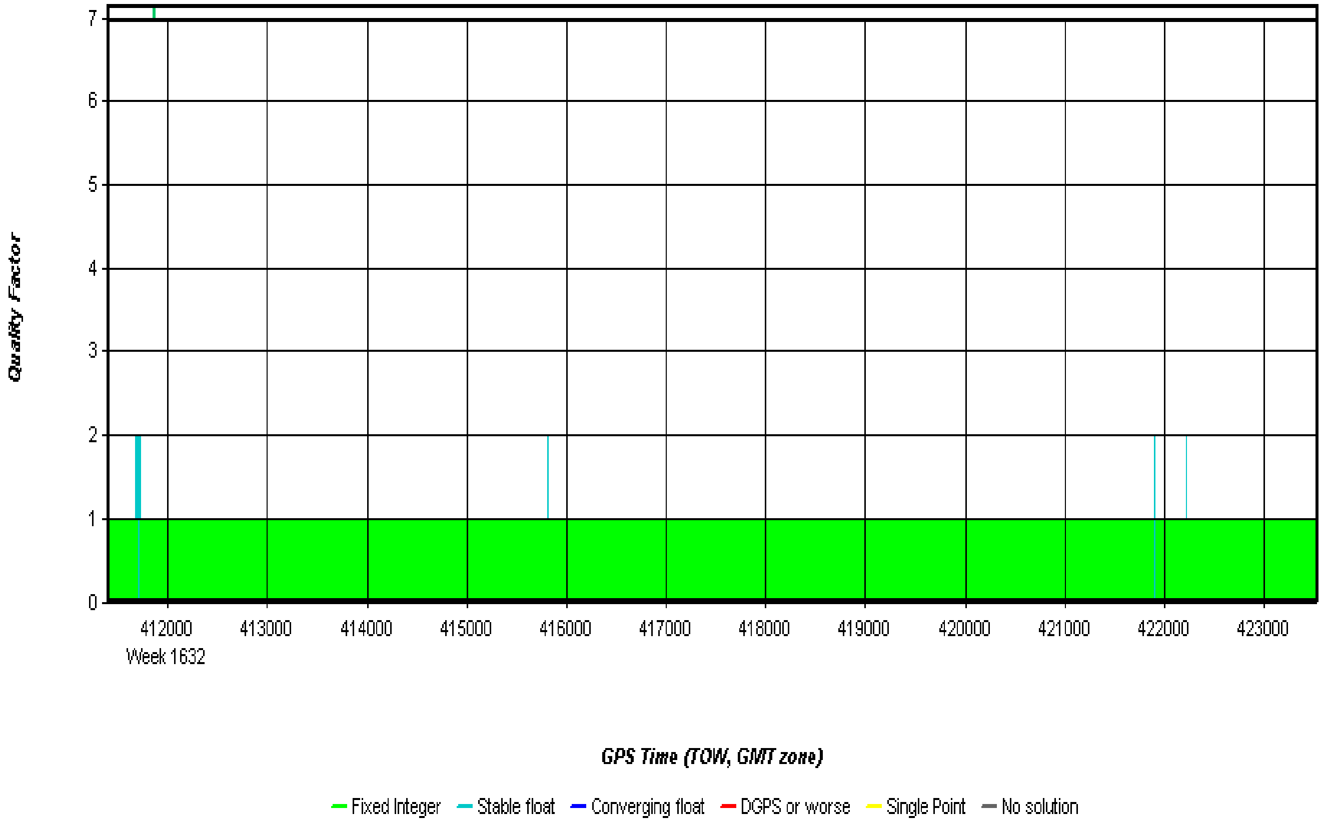
Output Results for JD111F02

POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map

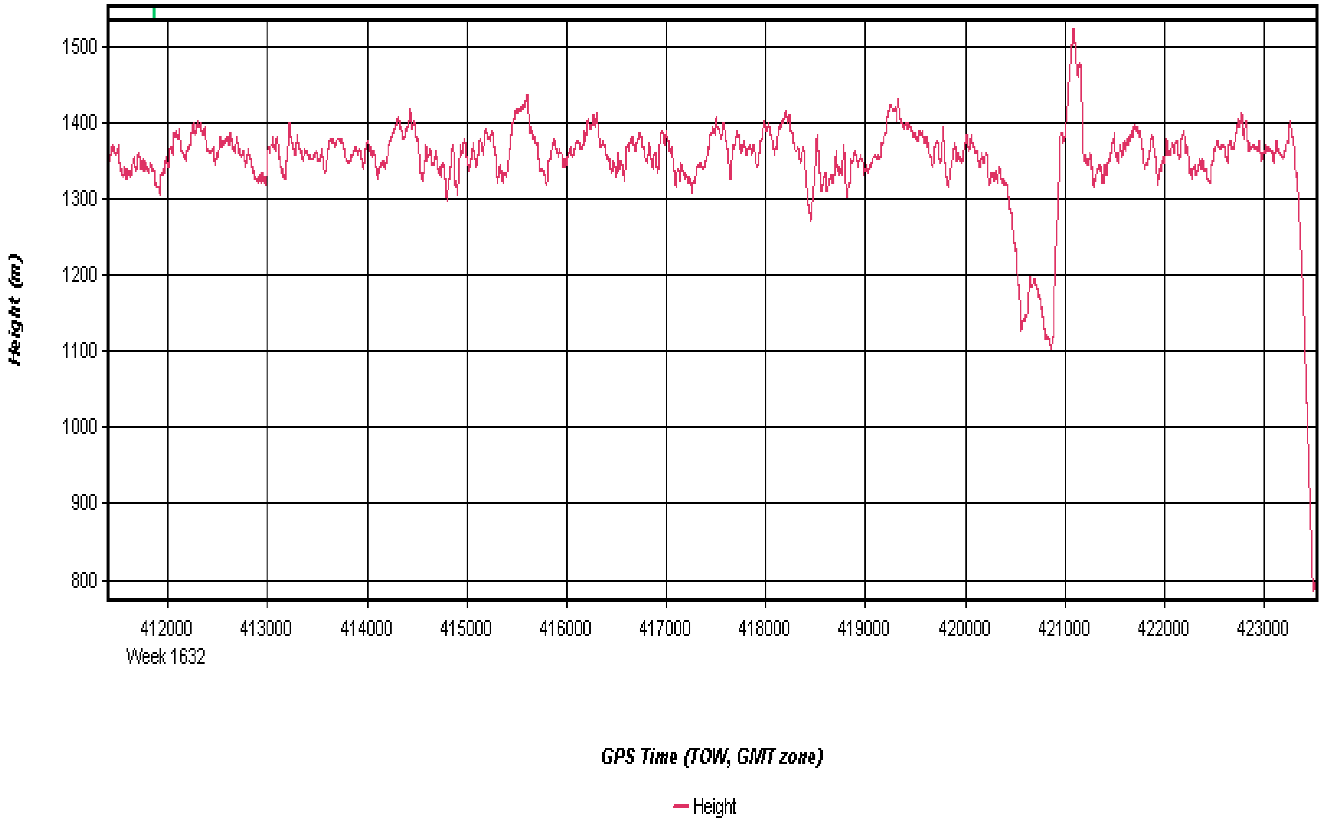
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 2: JD111F02 [Combined] - Quality Factor Plot



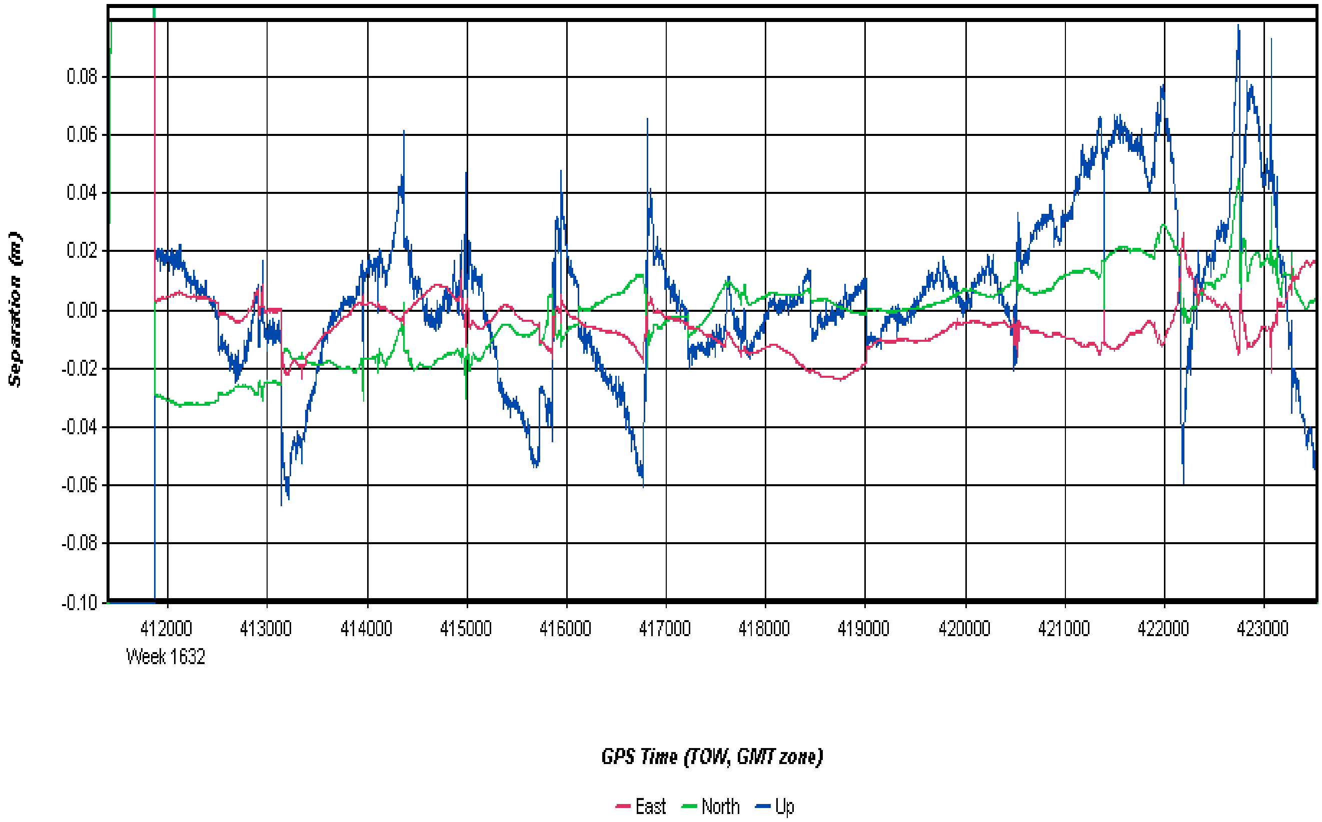
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 3: JD111F02 [Combined] - Height Profile Plot



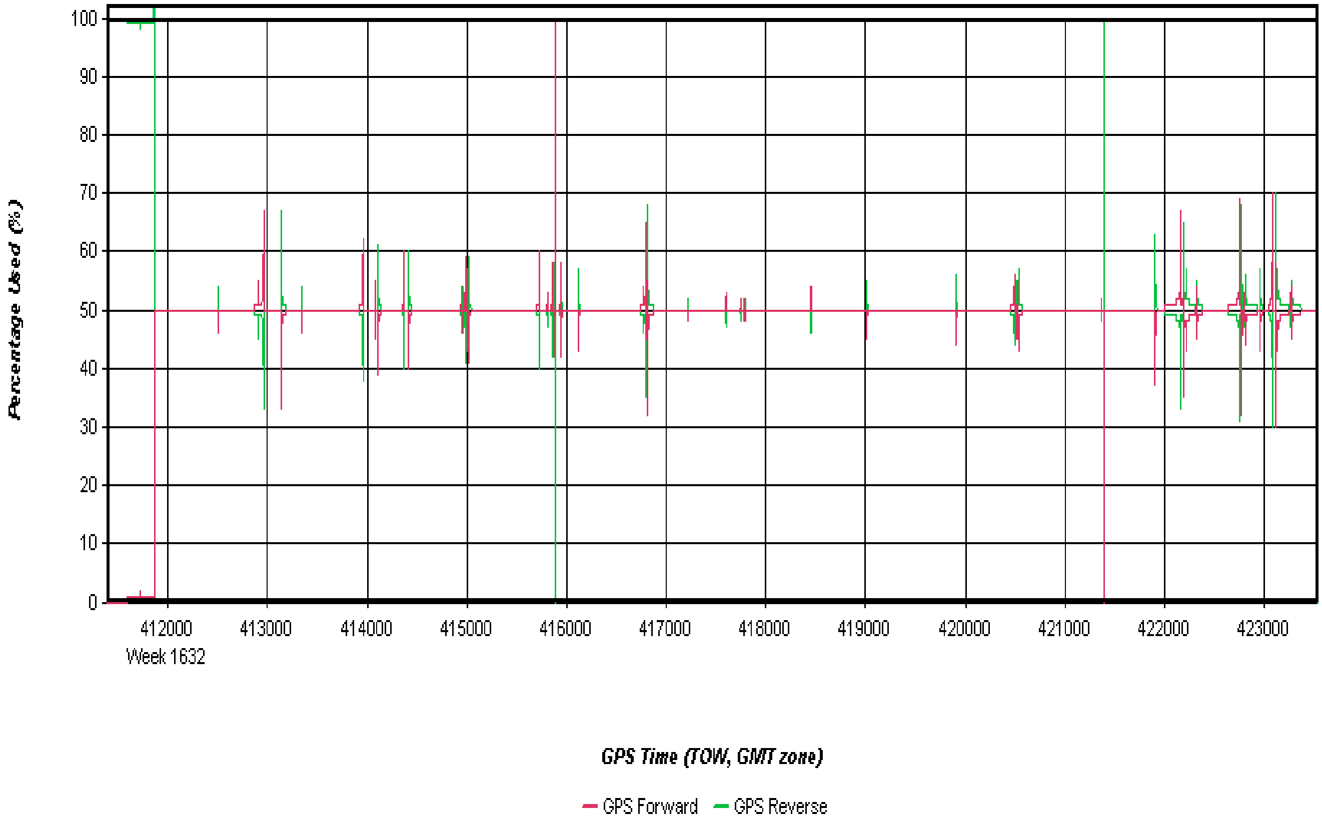
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 4: JD111F02 [Combined] - Forward/Reverse or Combined Separation Plot



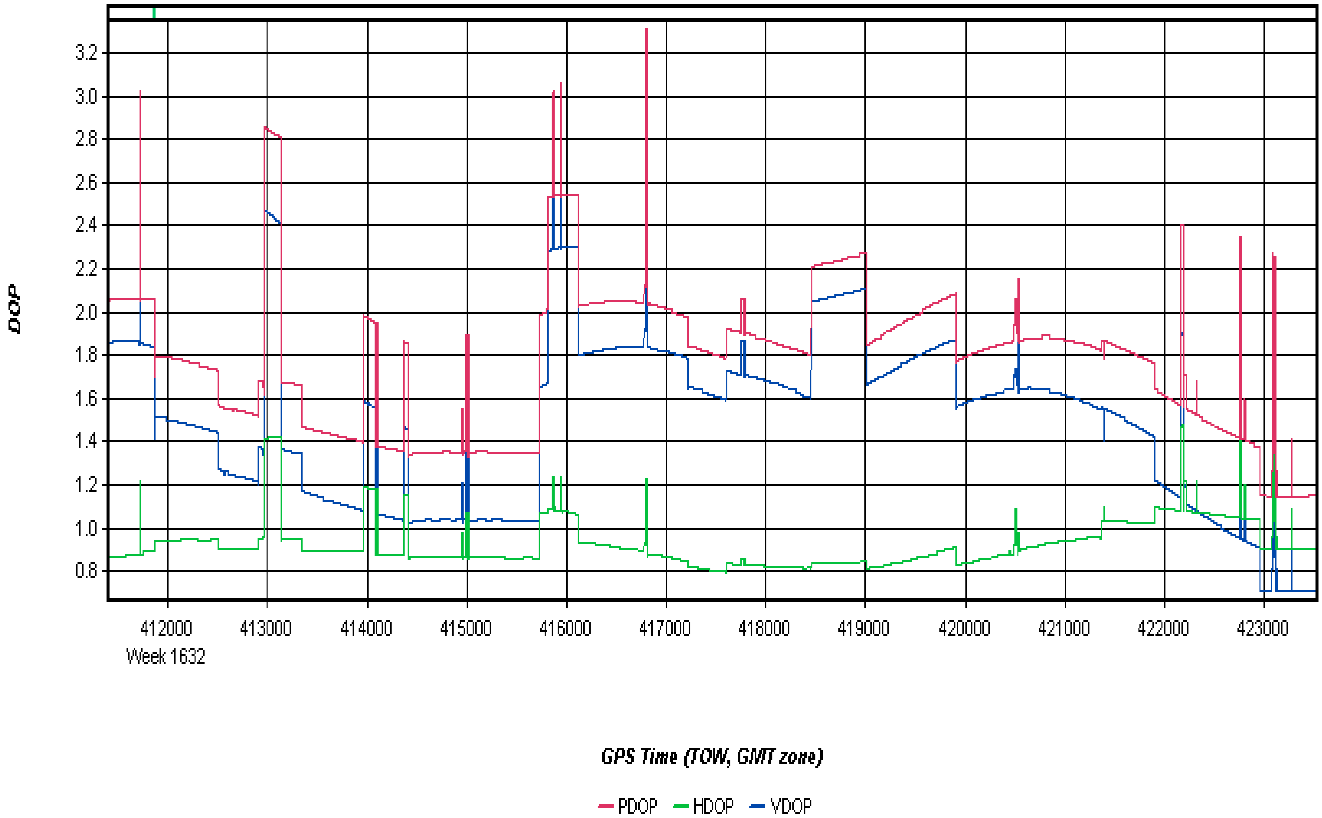
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 5: JD111F02 [Combined] - Forward/Reverse or Combined Weighting Plot



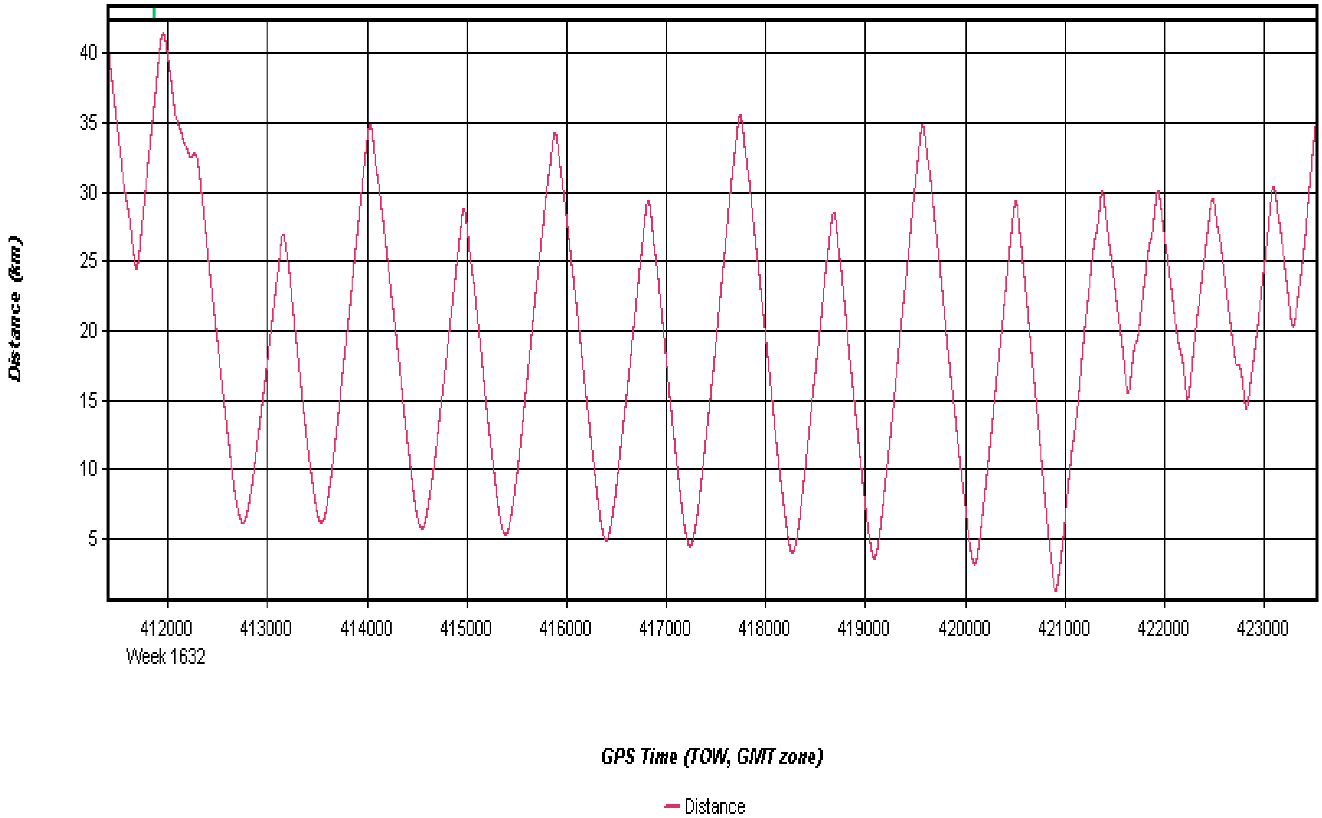
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 6: JD111F02 [Combined] - PDOP, HDOP, VDOP Plots



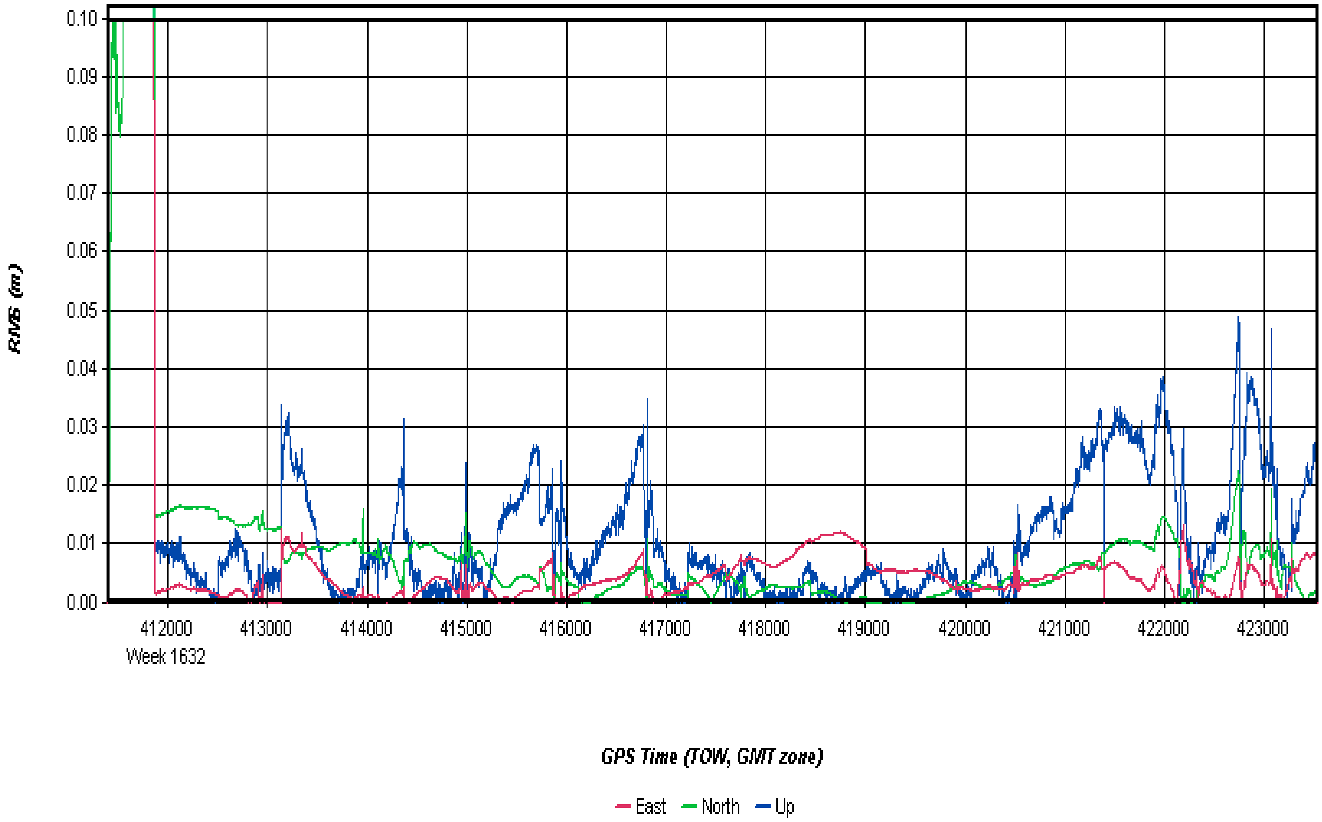
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 7: JD111F02 [Combined] - Horizontal Distance Separation (km)



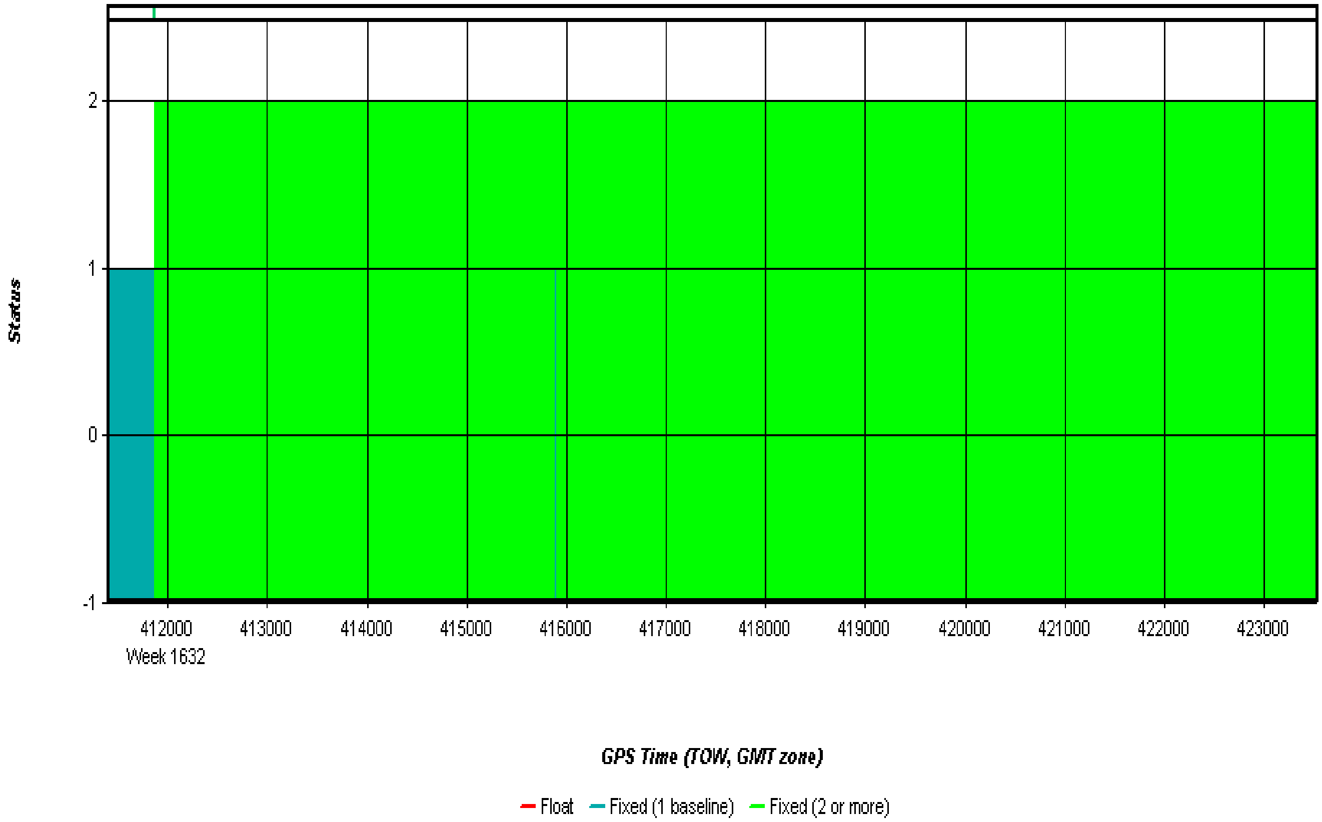
Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 8: JD111F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Figure 9: JD111F02 [Combined] - Float or Fixed Ambiguity

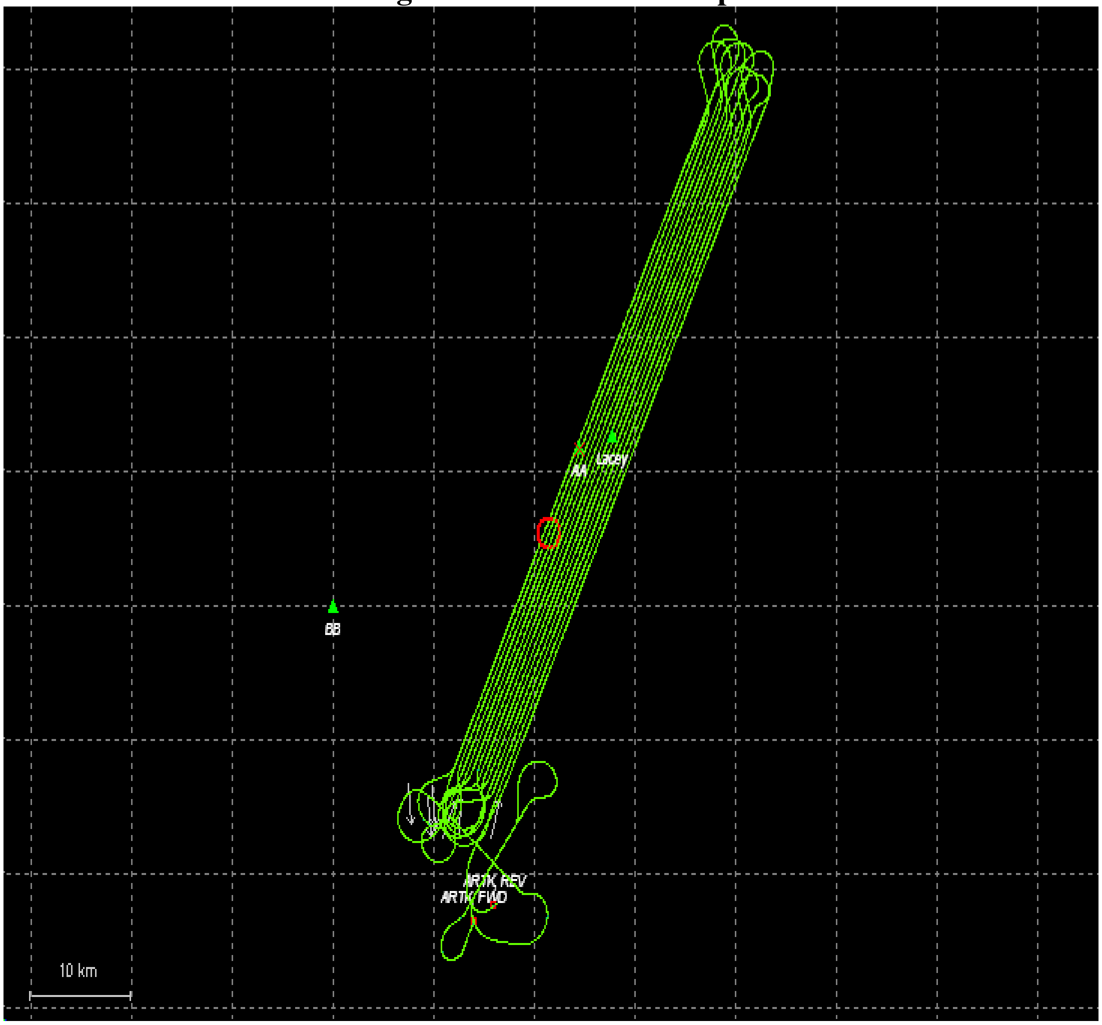


Process	Run (4)	by Unknown	on 06/16/2011	at 08:37:56

Output Results for JD114F01

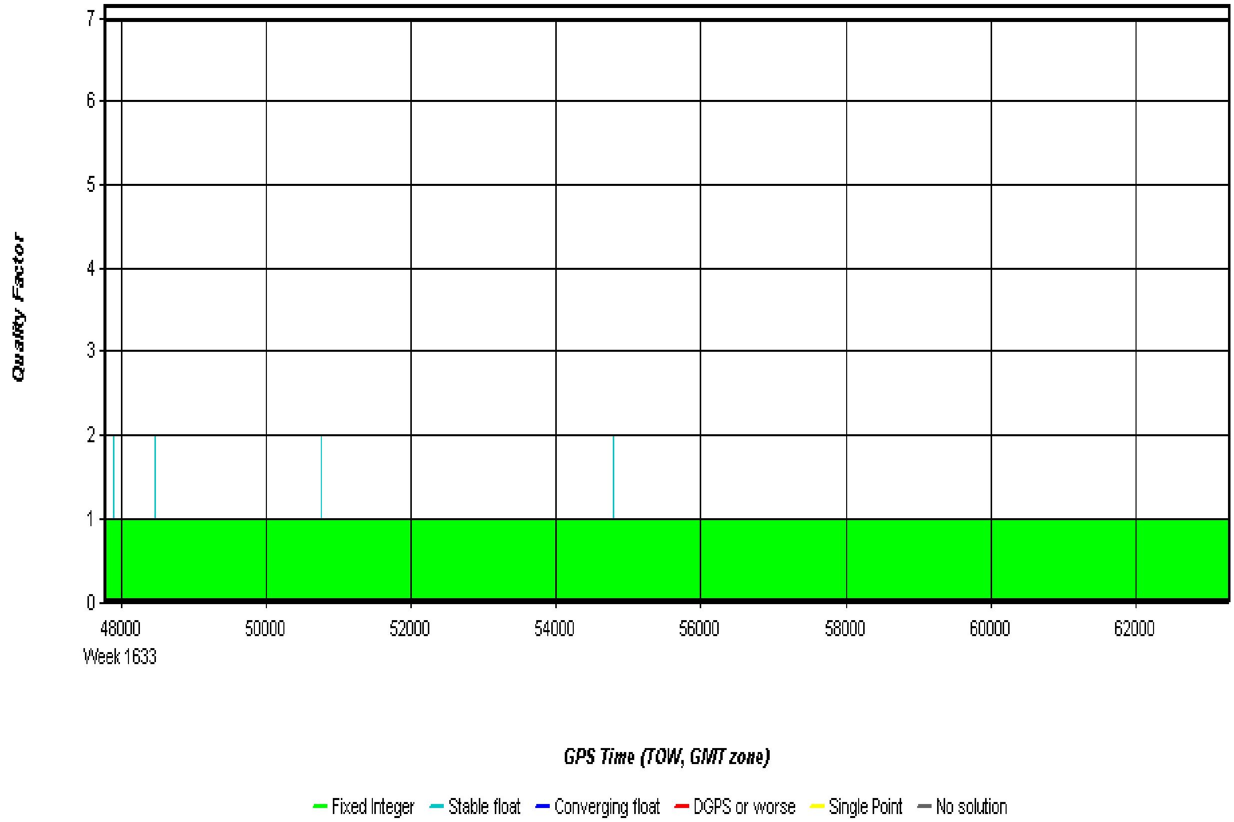
POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map



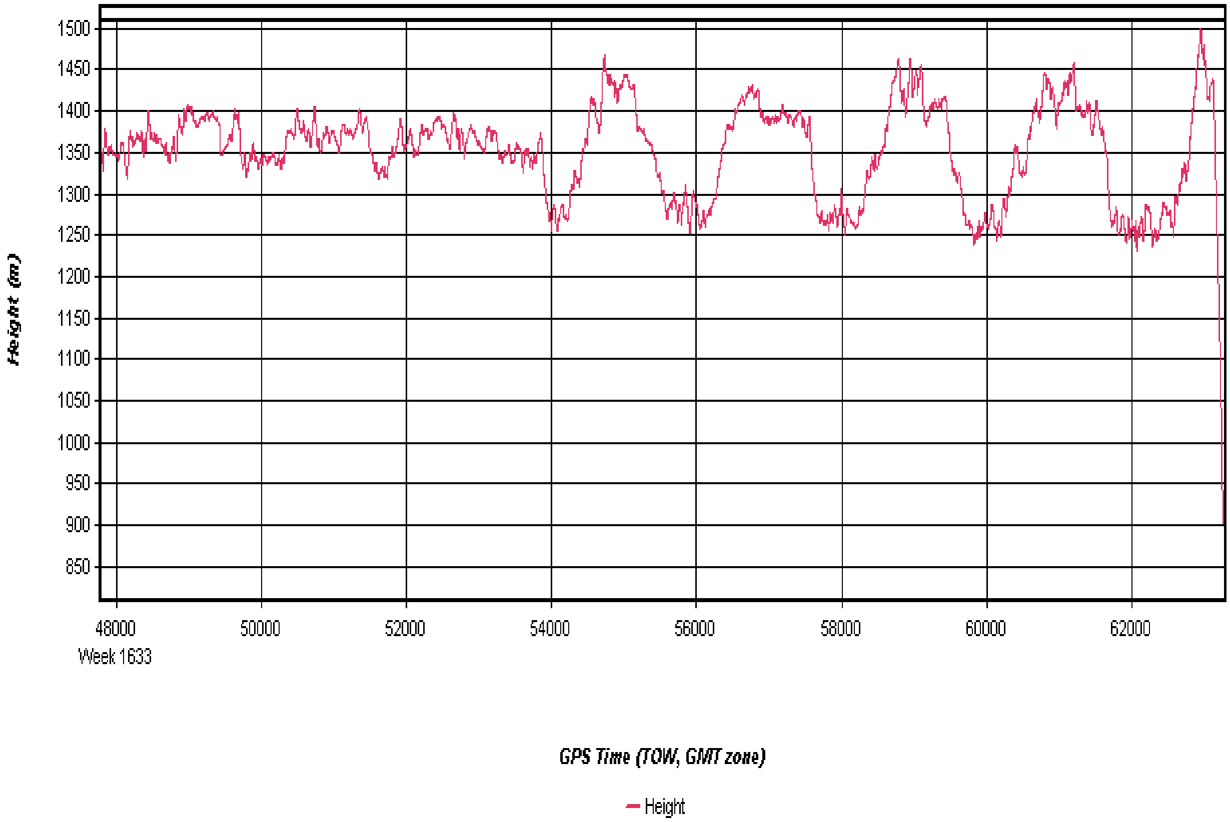
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 2: JD114F01 [Combined] - Quality Factor Plot



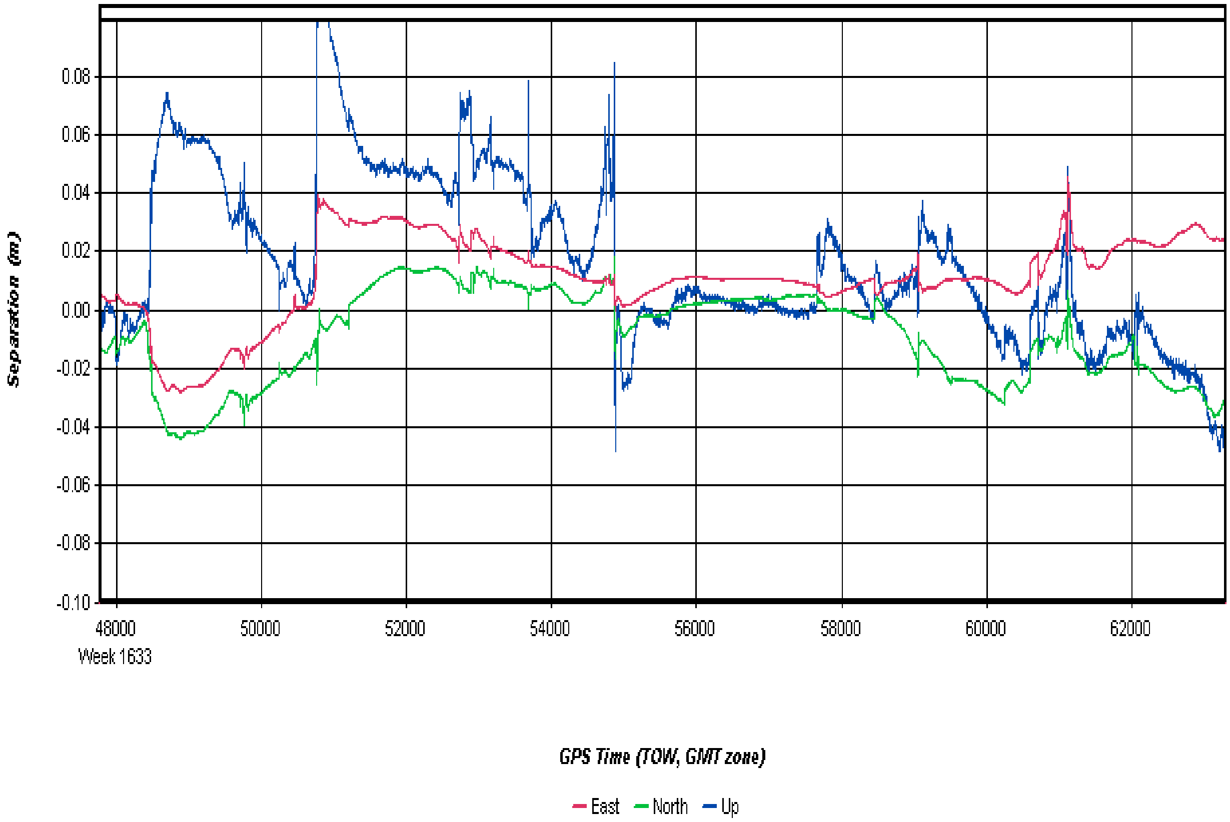
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 3: JD114F01 [Combined] - Height Profile Plot



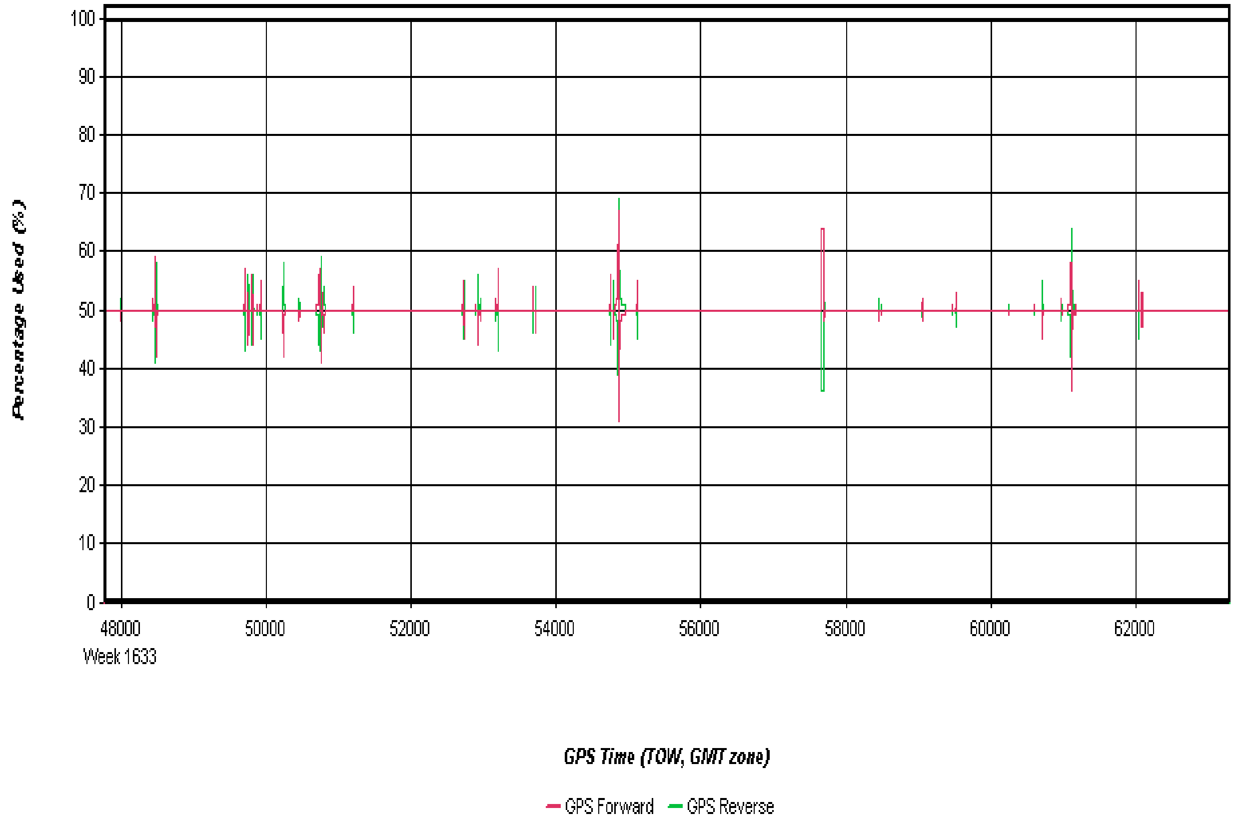
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 4: JD114F01 [Combined] - Forward/Reverse or Combined Separation Plot



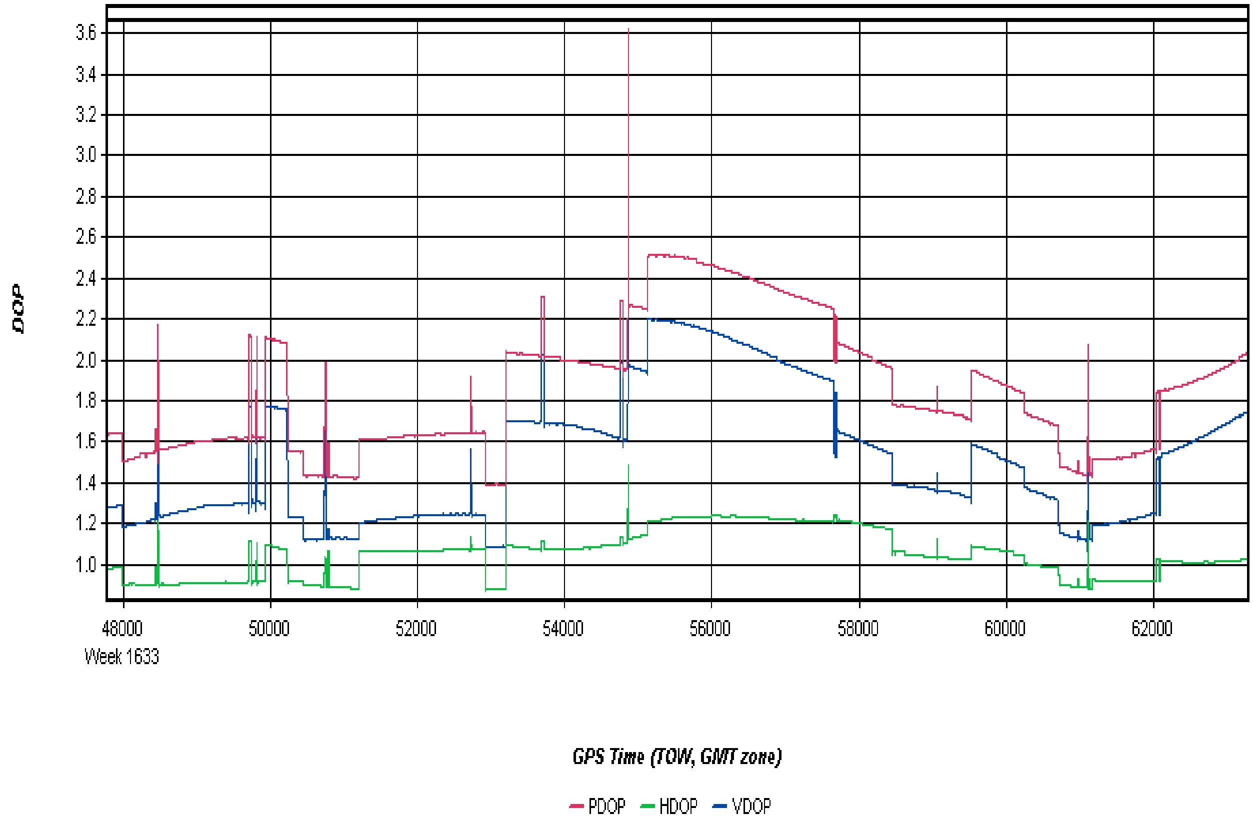
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 5: JD114F01 [Combined] - Forward/Reverse or Combined Weighting Plot



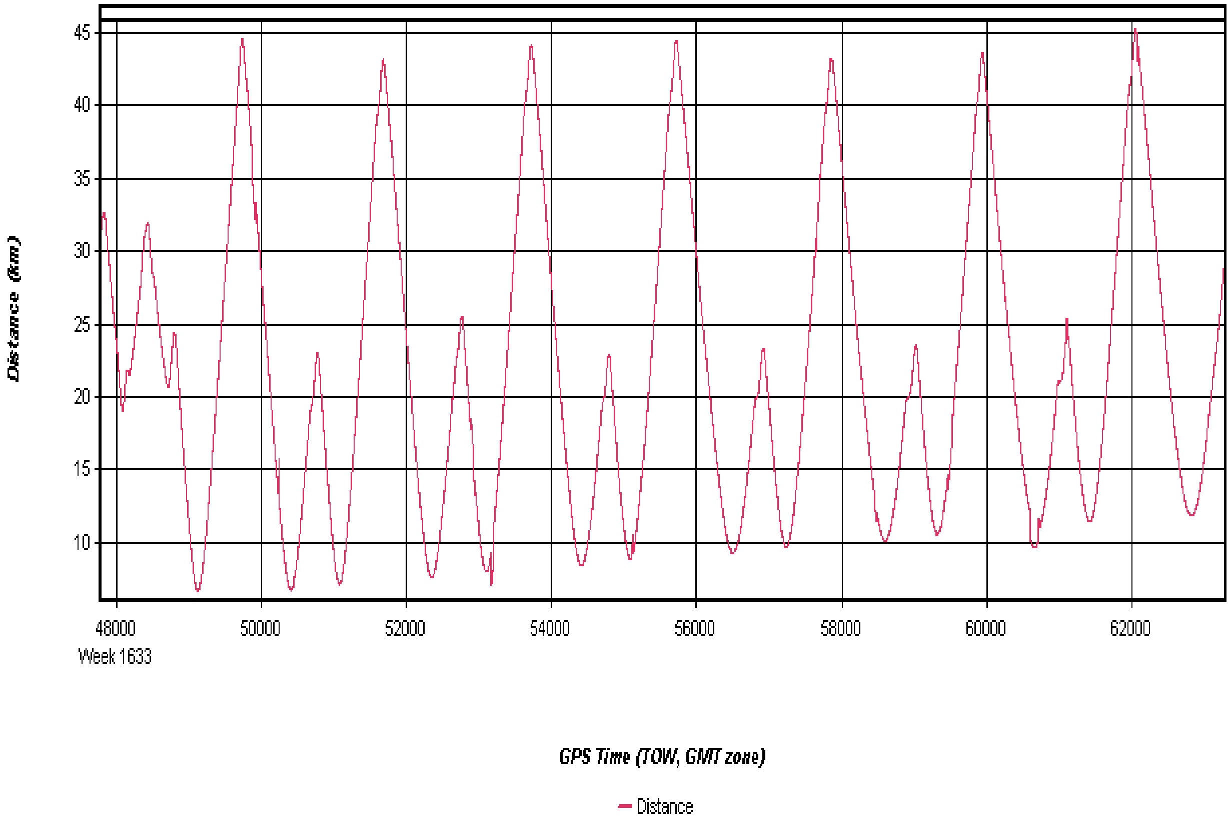
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 6: JD114F01 [Combined] - PDOP, HDOP, VDOP Plots



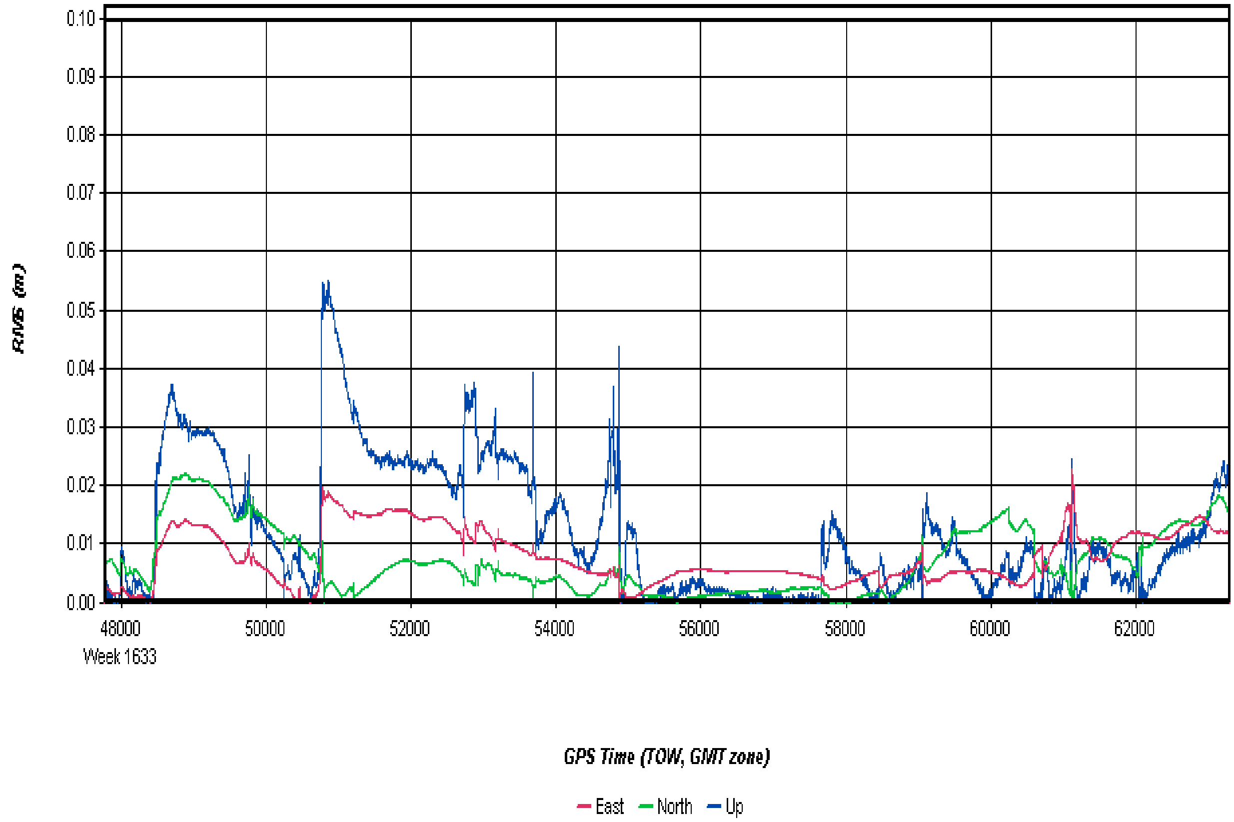
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 7: JD114F01 [Combined] - Horizontal Distance Separation (km)



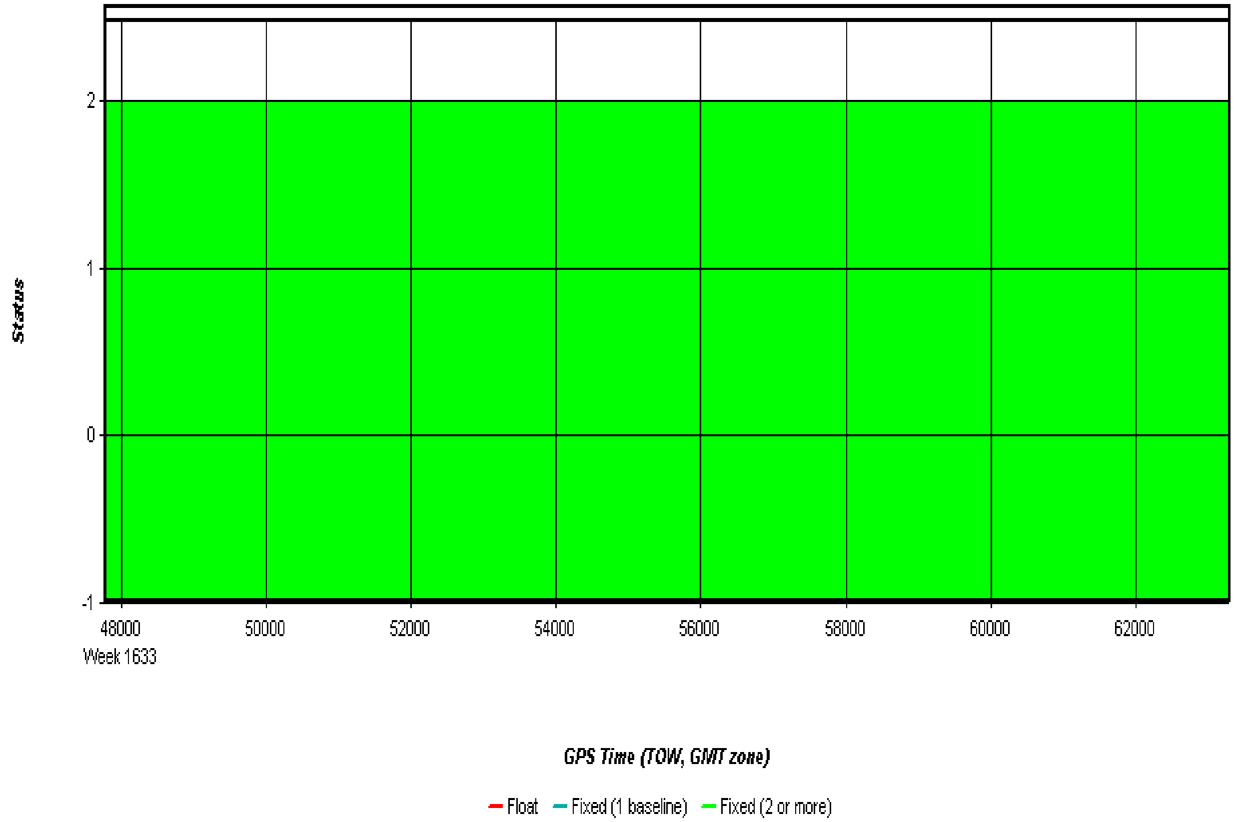
Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 8: JD114F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Figure 9: JD114F01 [Combined] - Float or Fixed Ambiguity

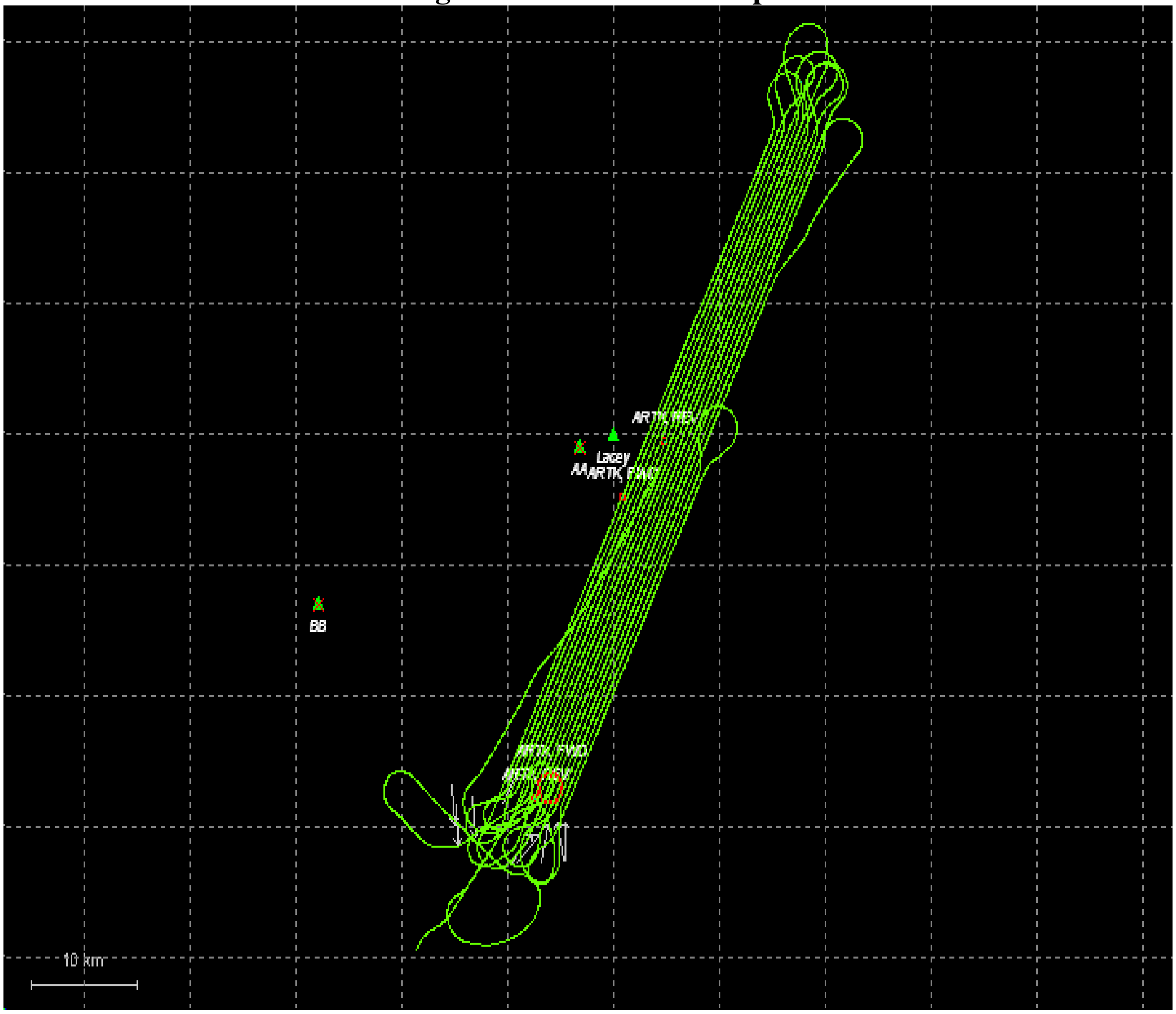


Process	Run (10)	by Unknown	on 06/16/2011	at 09:02:32

Output Results for JD114F02

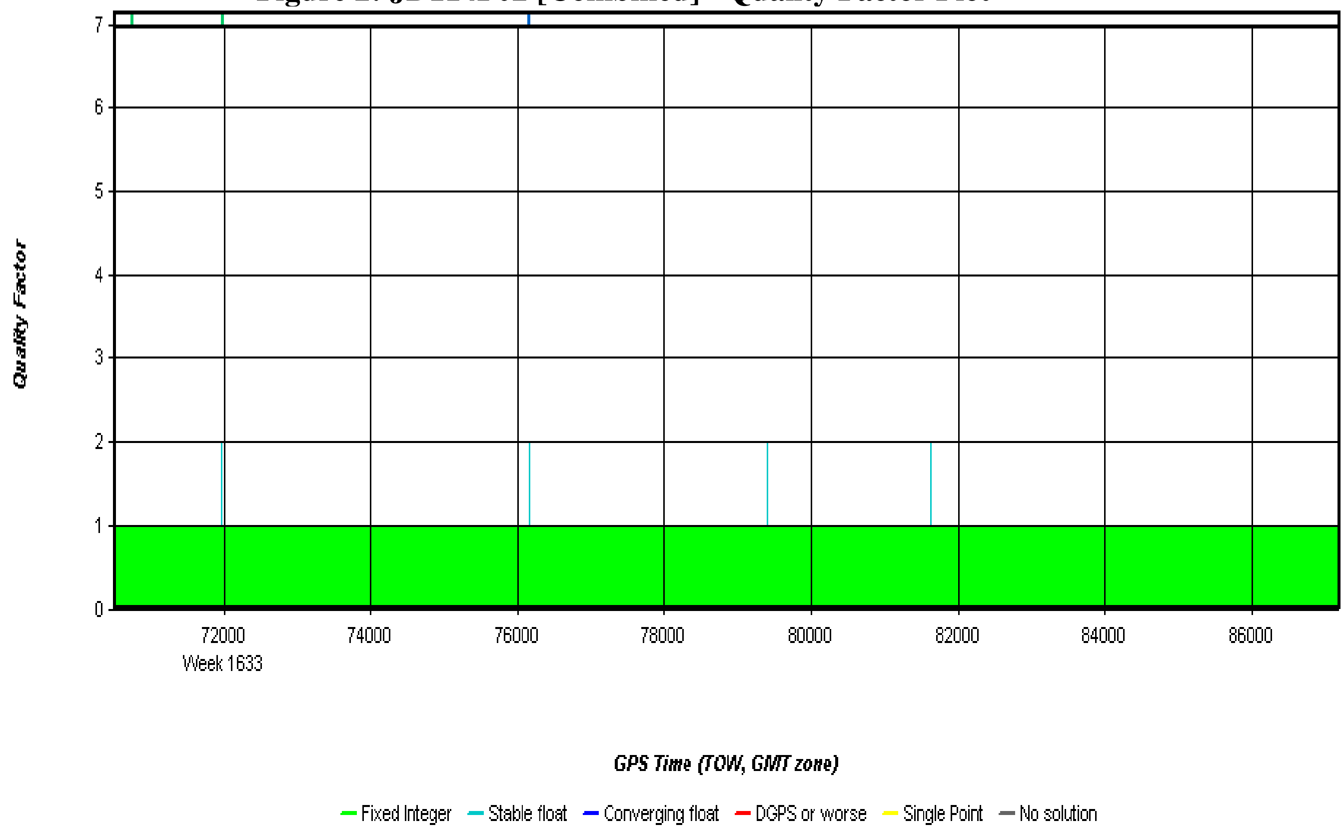
POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map



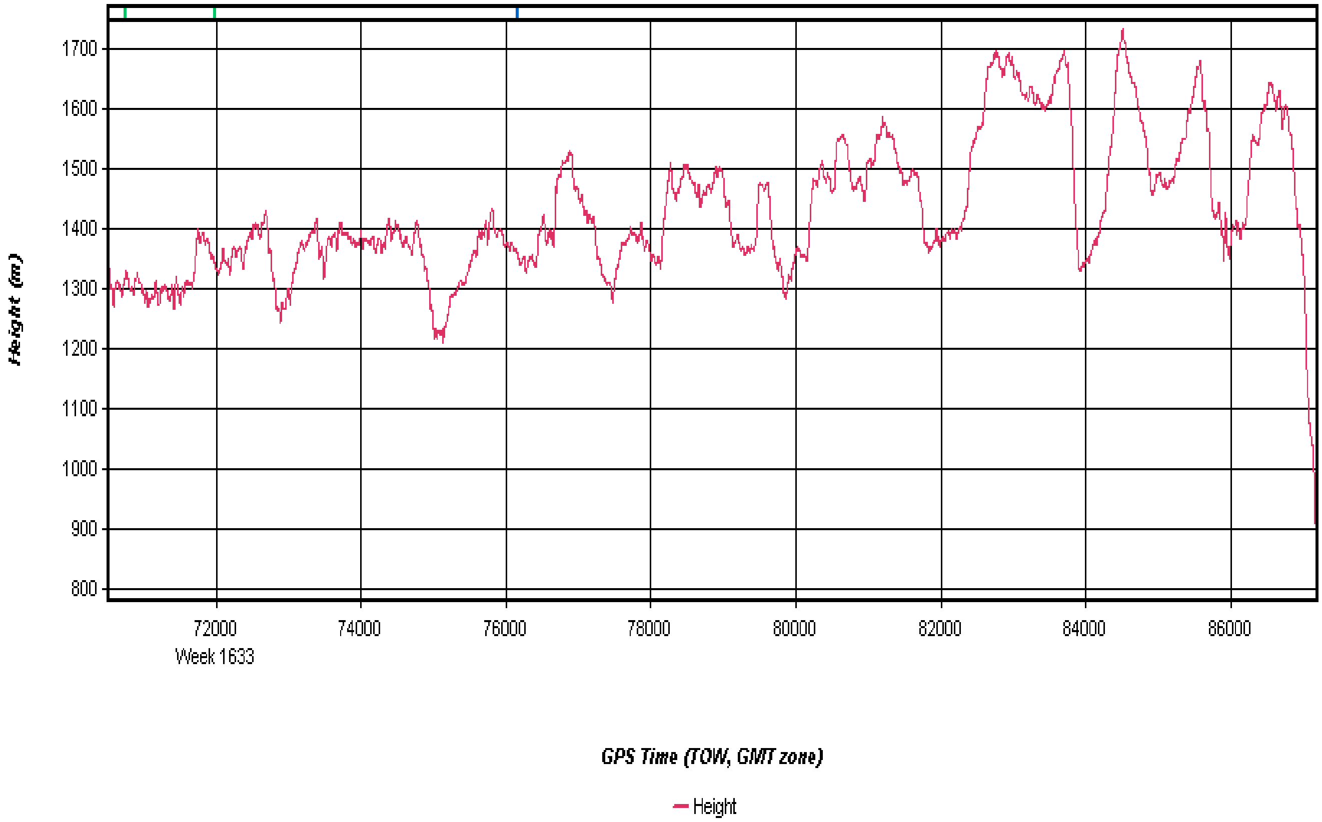
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 2: JD114F02 [Combined] - Quality Factor Plot



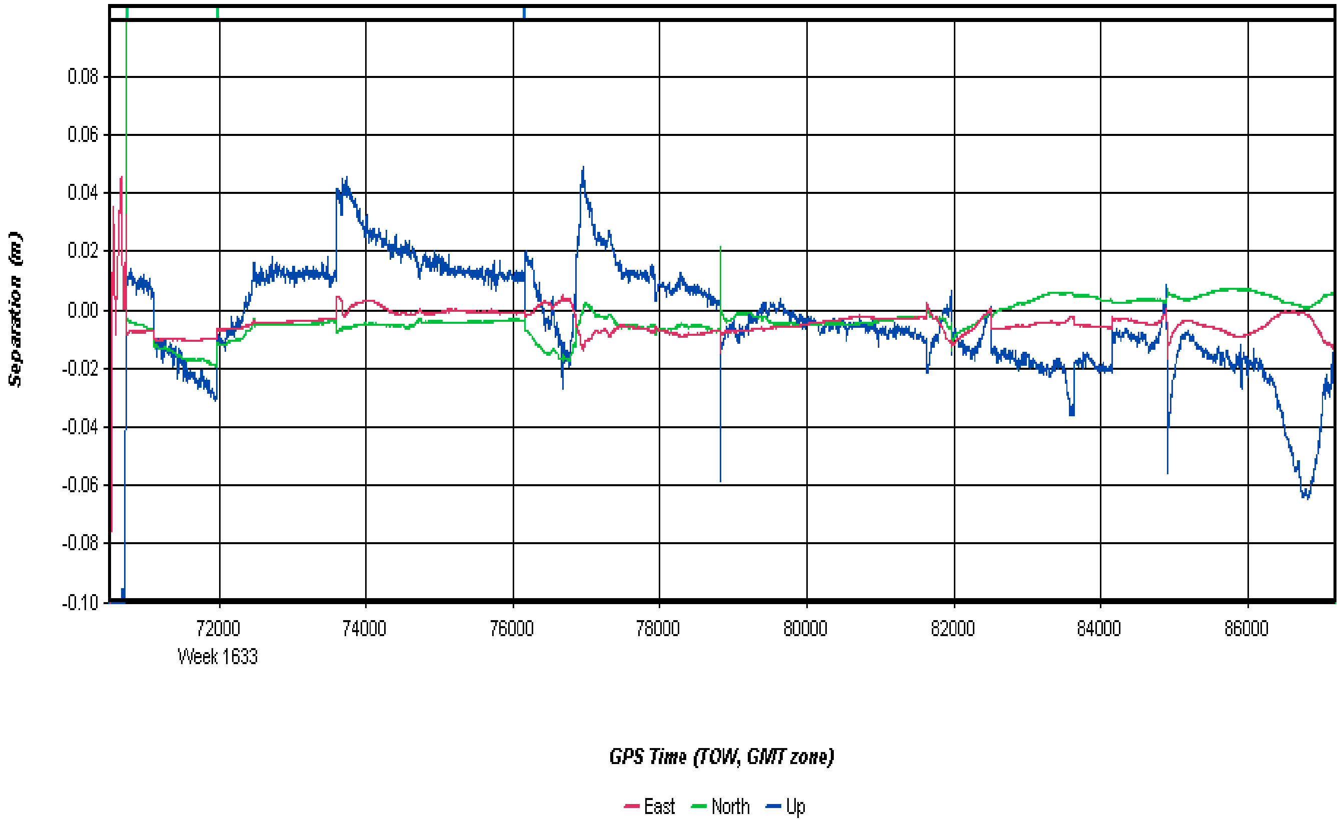
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 3: JD114F02 [Combined] - Height Profile Plot



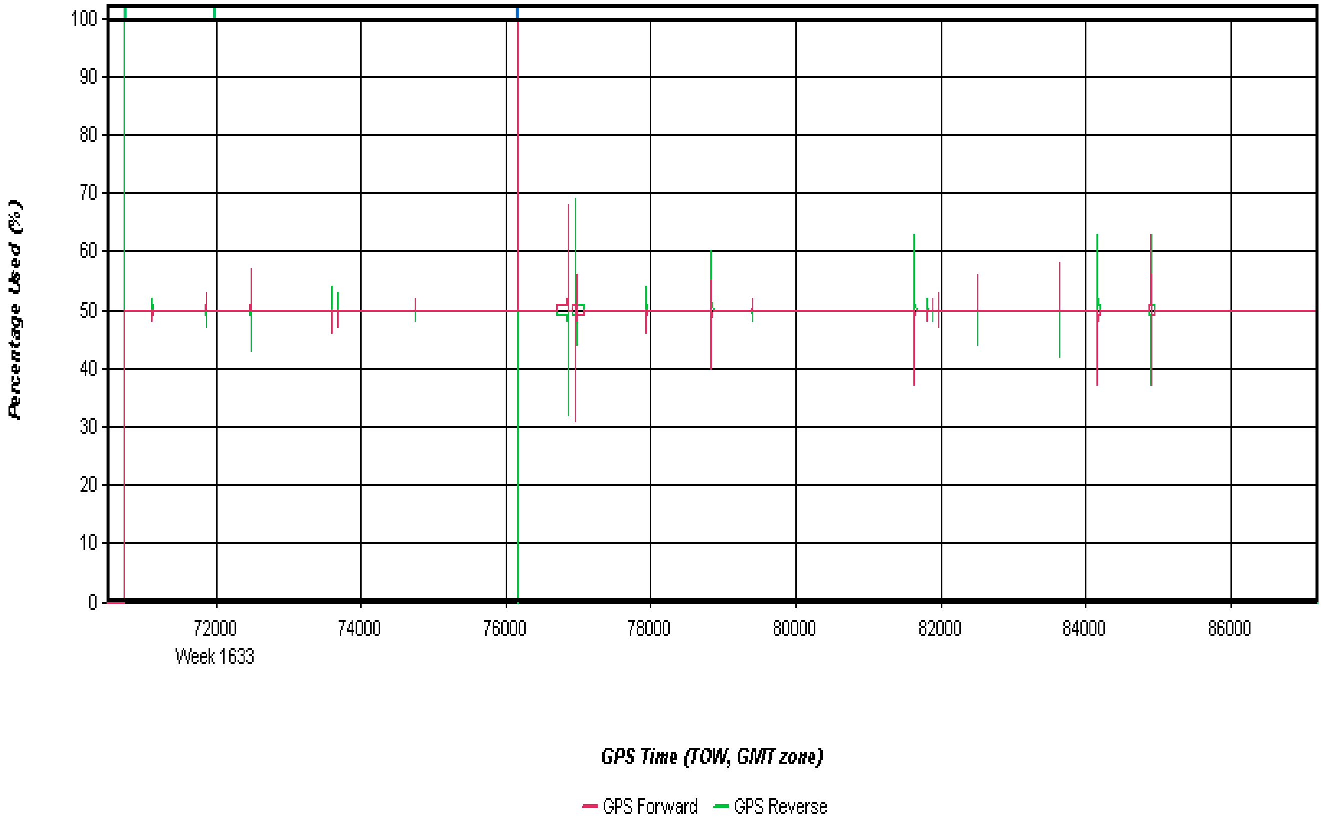
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 4: JD114F02 [Combined] - Forward/Reverse or Combined Separation Plot



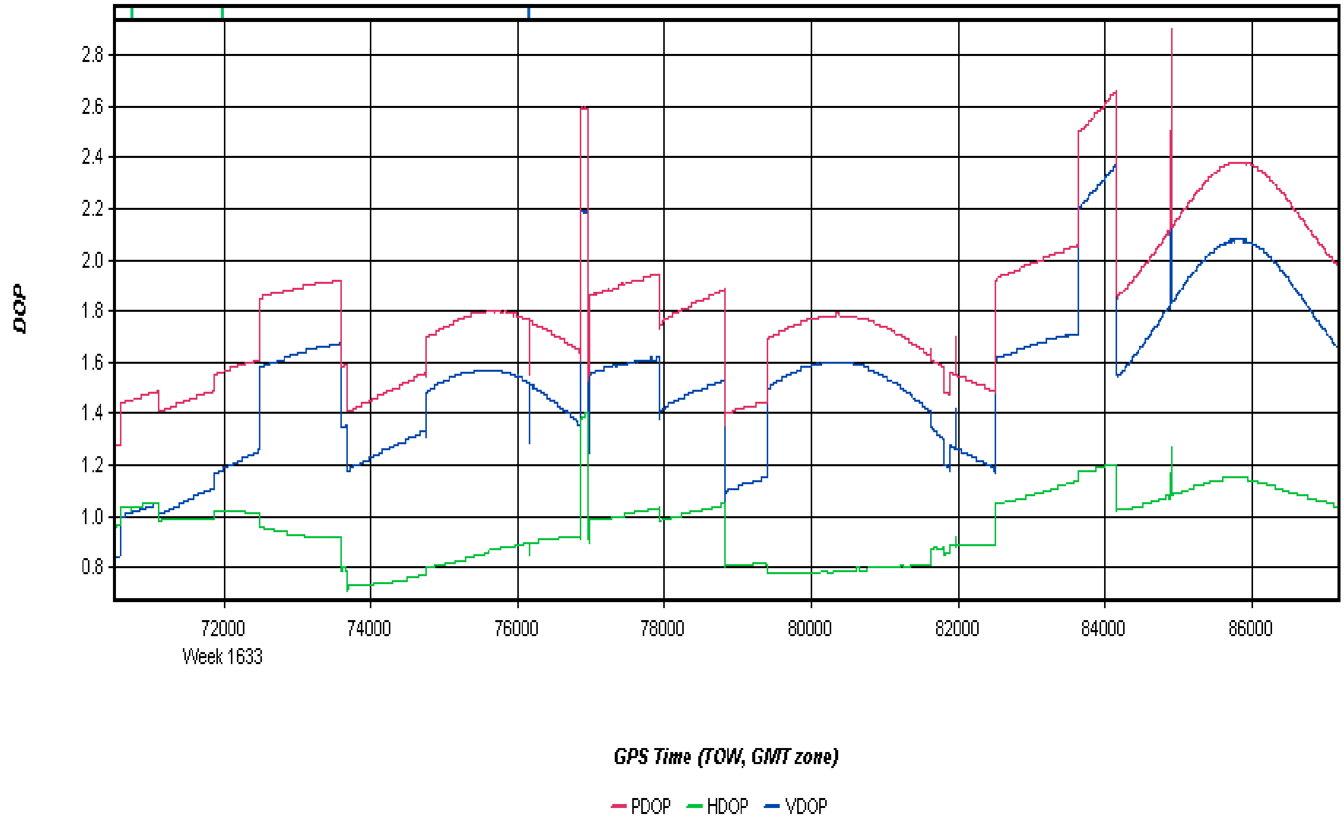
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 5: JD114F02 [Combined] - Forward/Reverse or Combined Weighting Plot



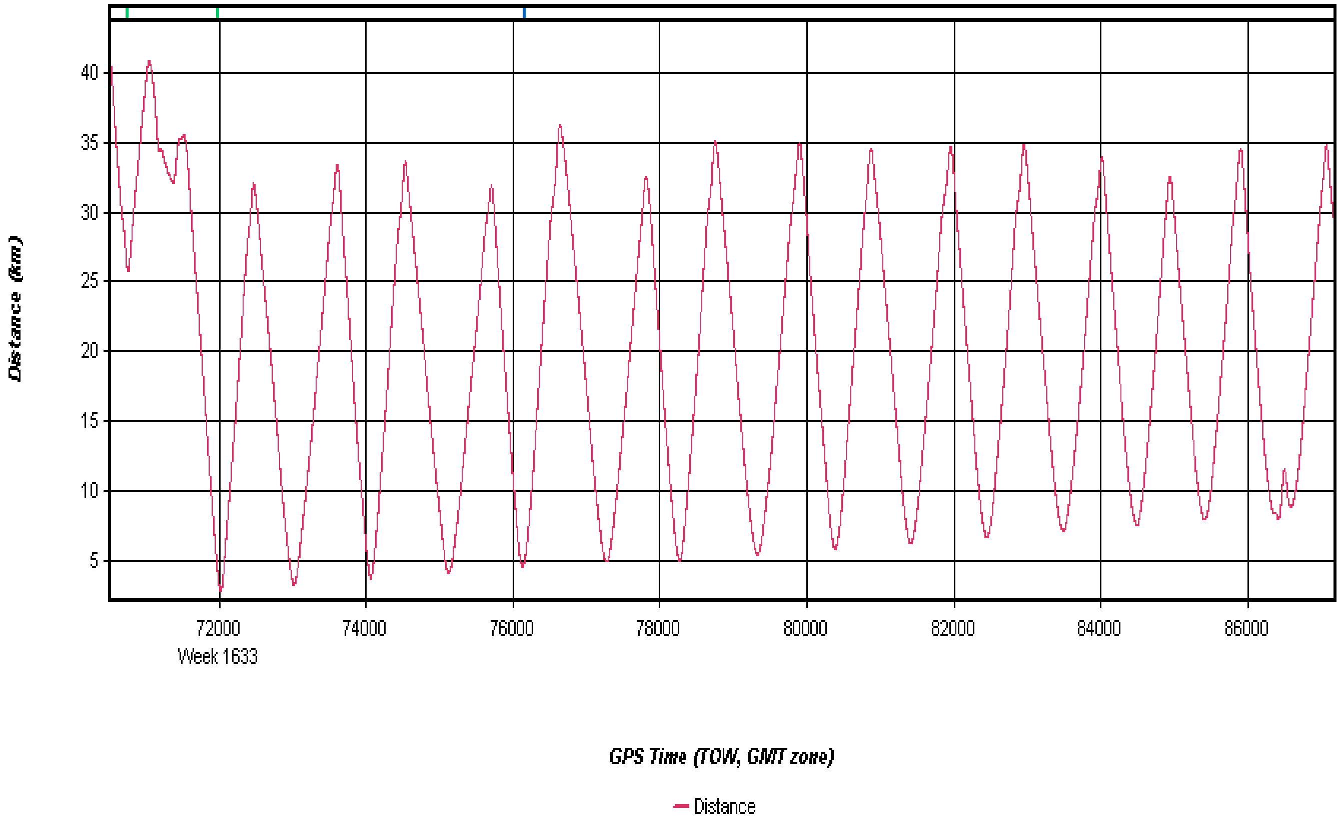
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 6: JD114F02 [Combined] - PDOP, HDOP, VDOP Plots



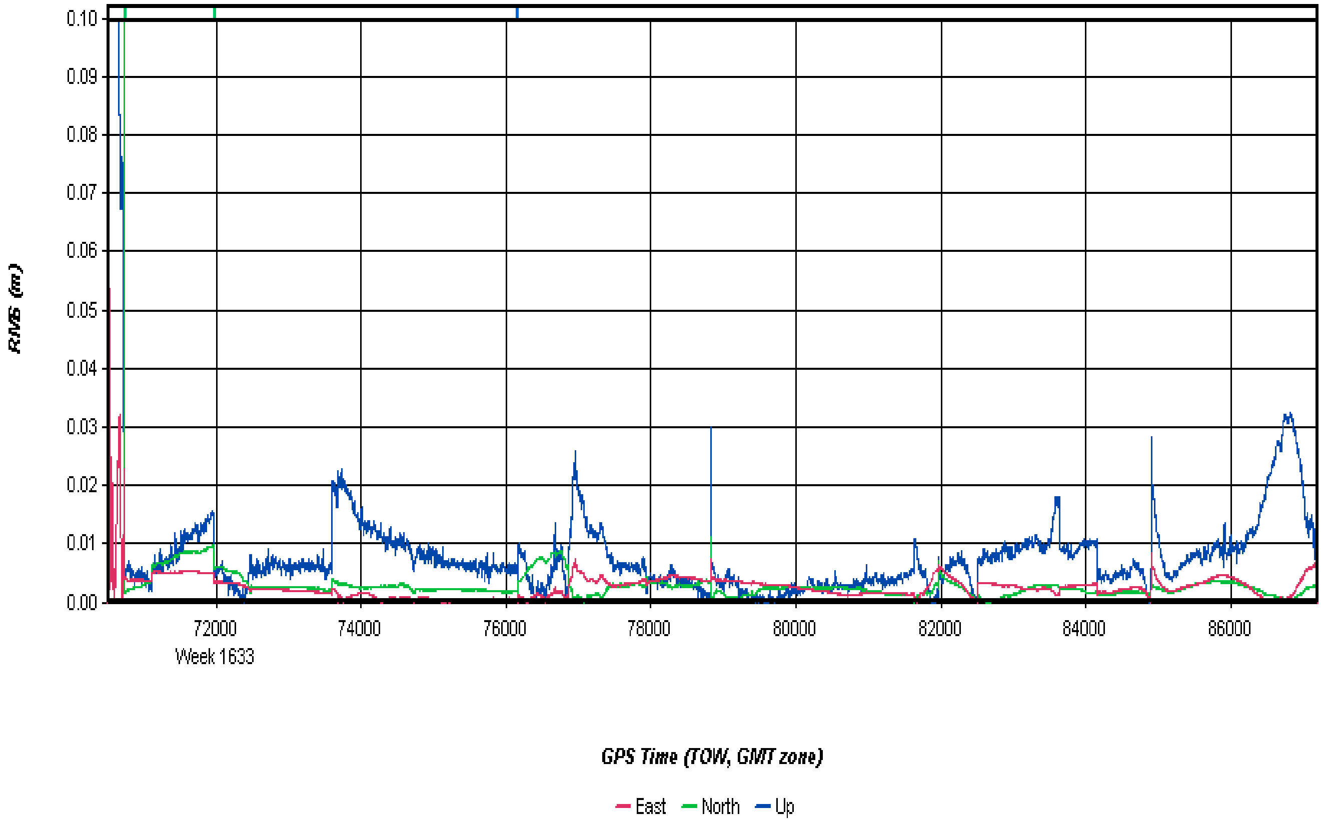
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 7: JD114F02 [Combined] - Horizontal Distance Separation (km)



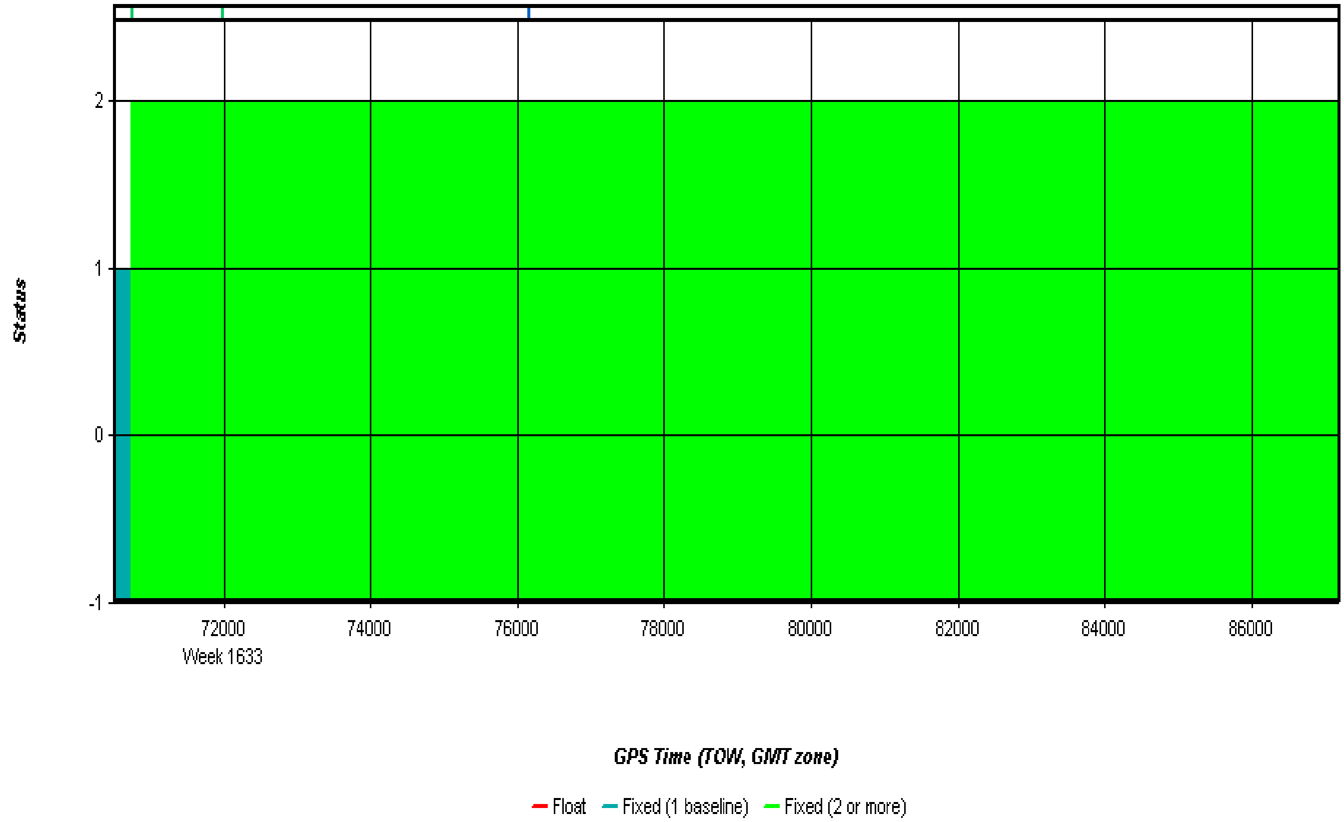
Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 8: JD114F02 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Figure 9: JD114F02 [Combined] - Float or Fixed Ambiguity

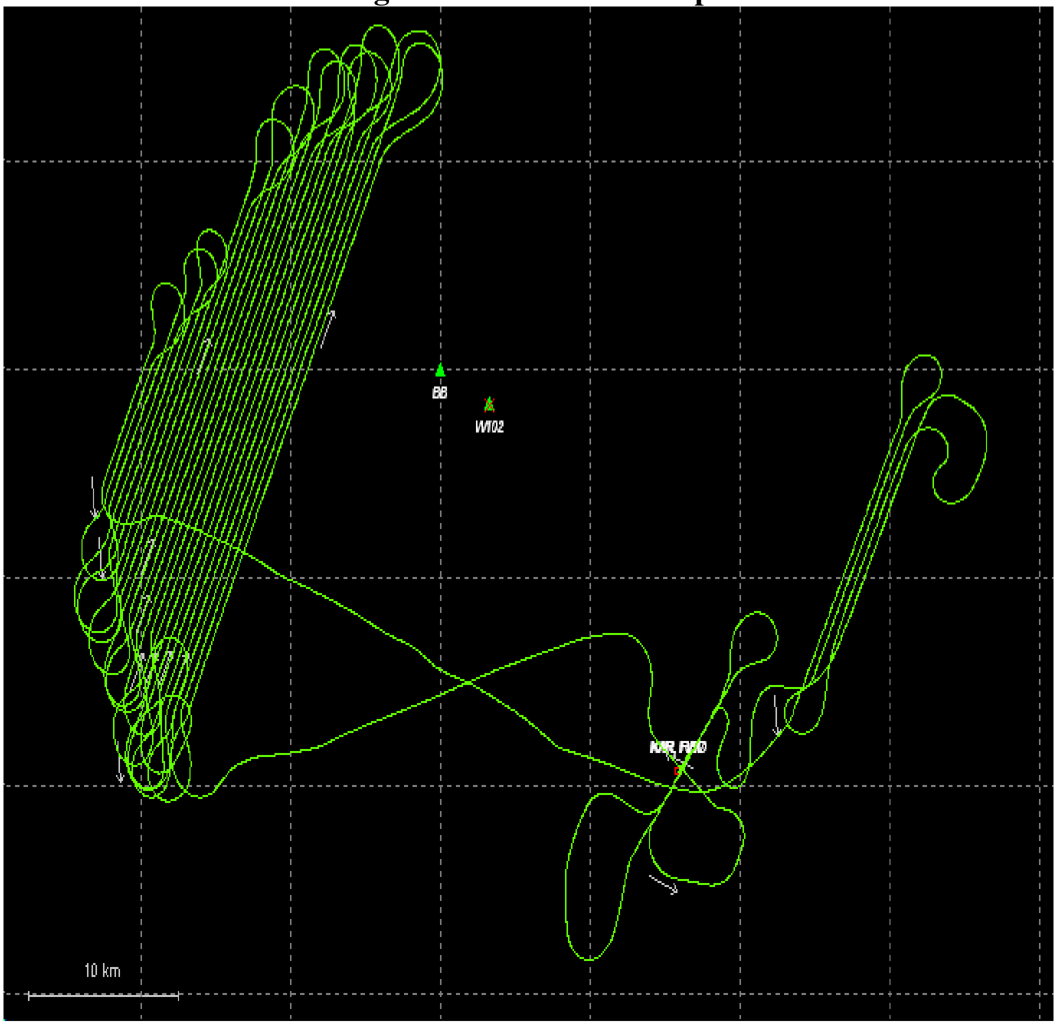


Process	Run (27)	by Unknown	on 06/16/2011	at 11:22:46

Output Results for JD115F01

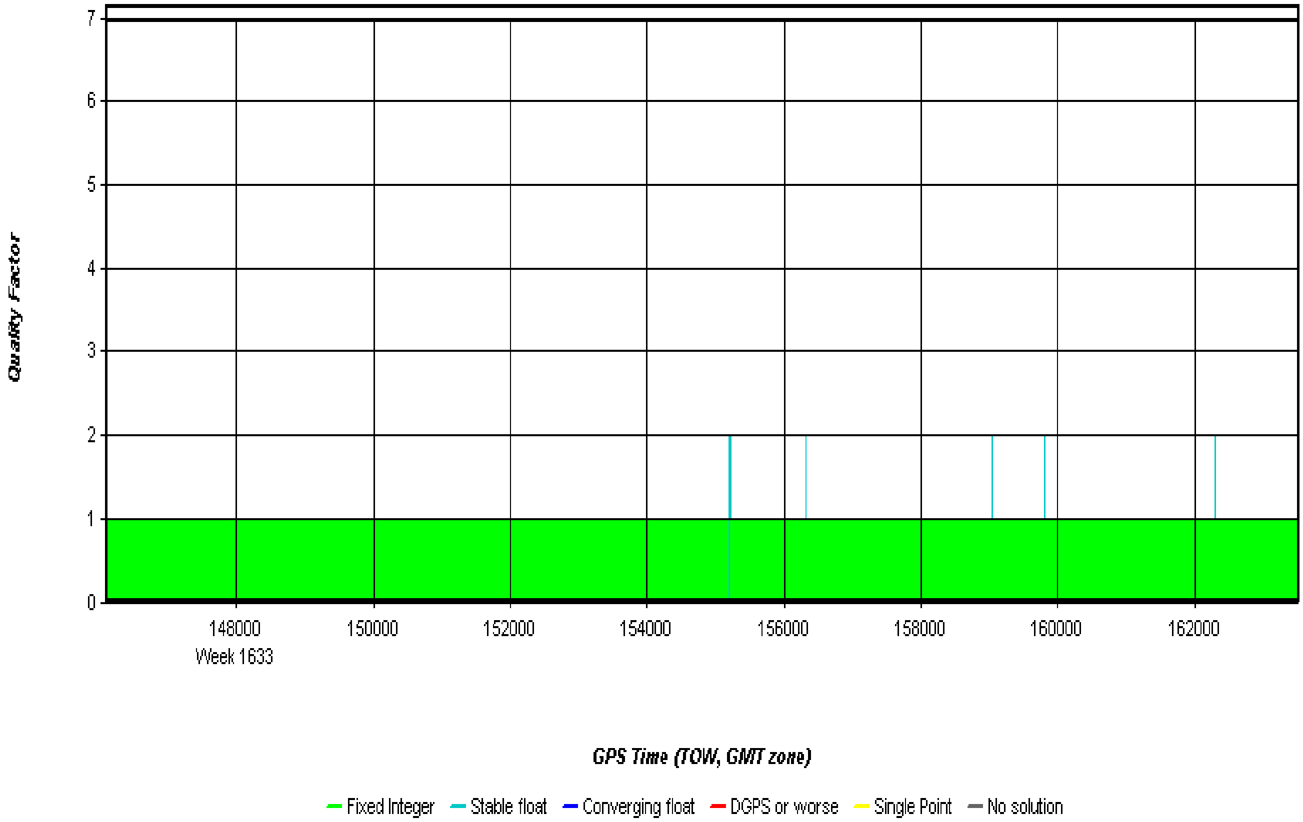
POSGNSS Version 5.20.1209
06/16/2011

Figure 1: Combined - Map



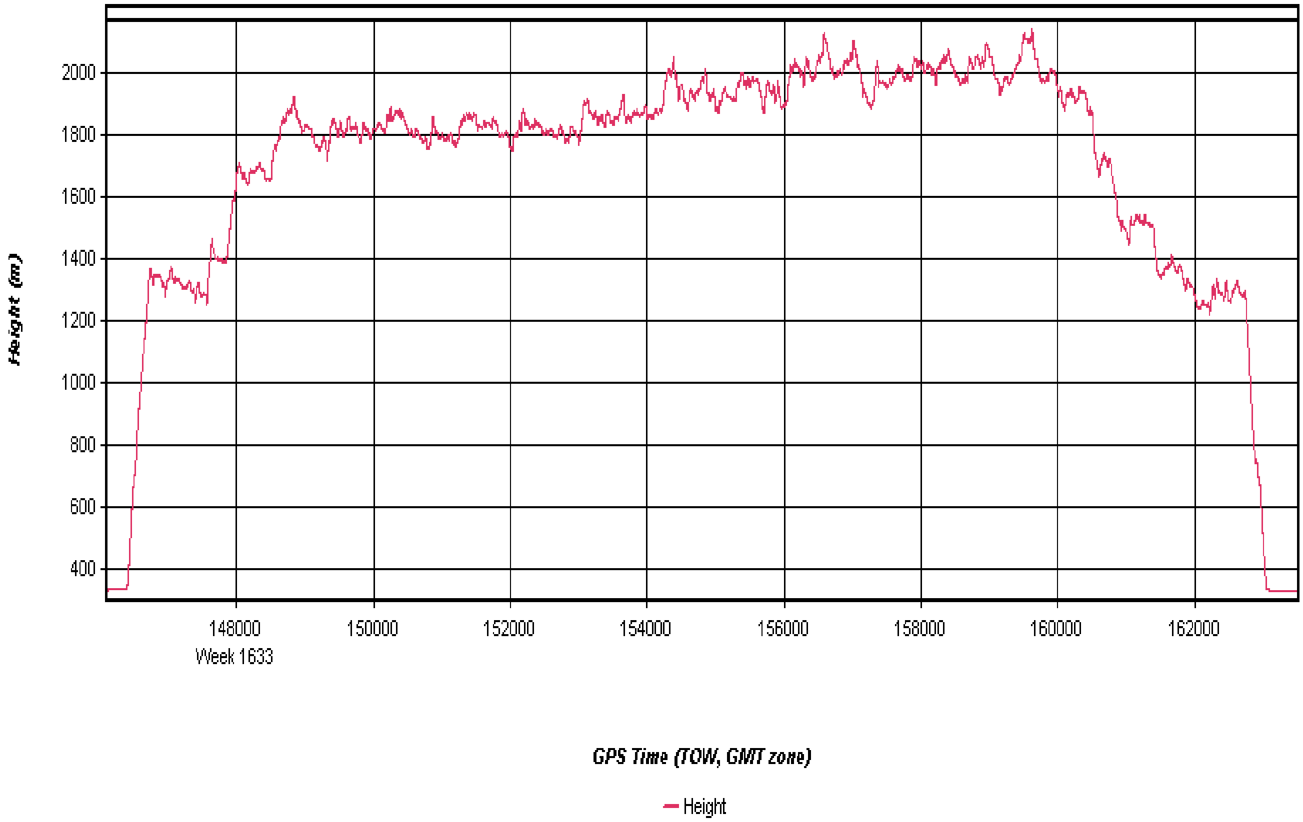
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 2: JD115F01 [Combined] - Quality Factor Plot



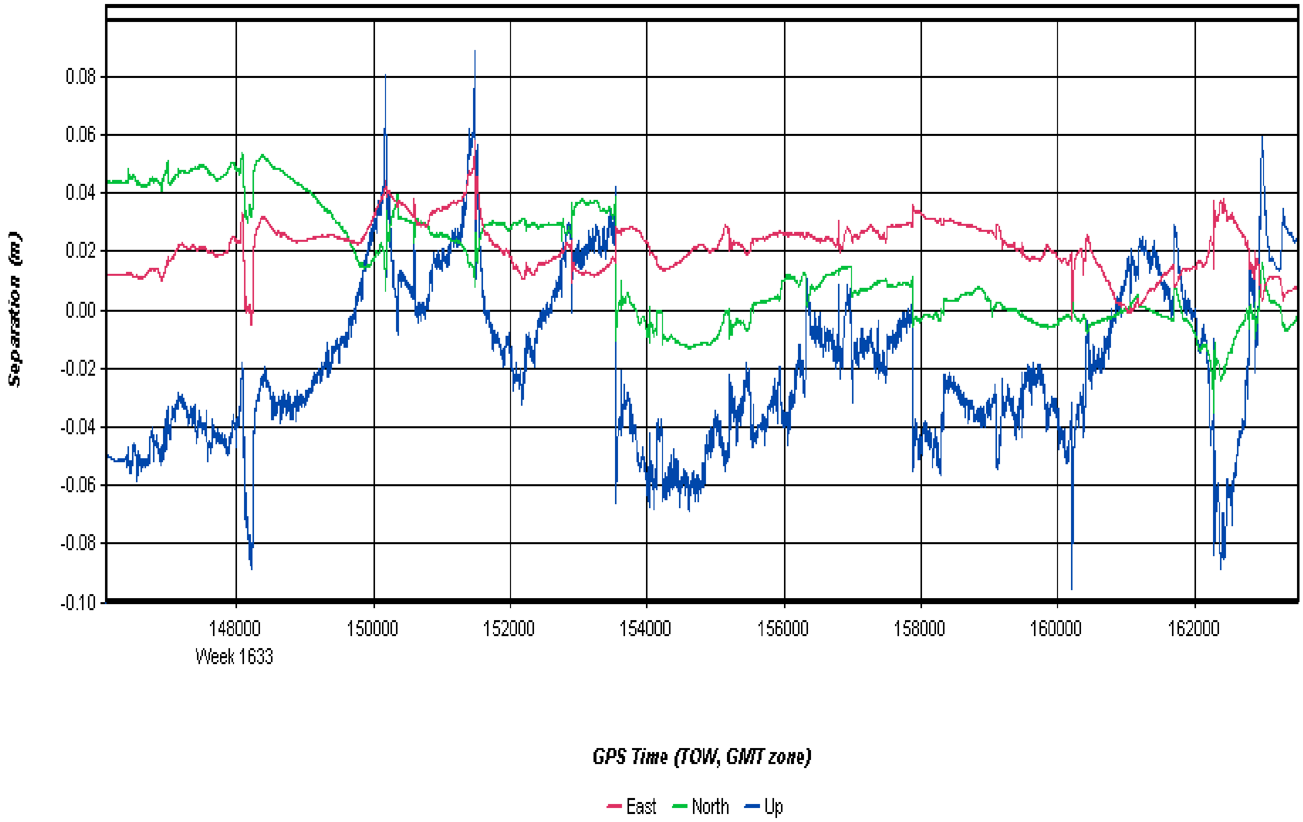
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 3: JD115F01 [Combined] - Height Profile Plot



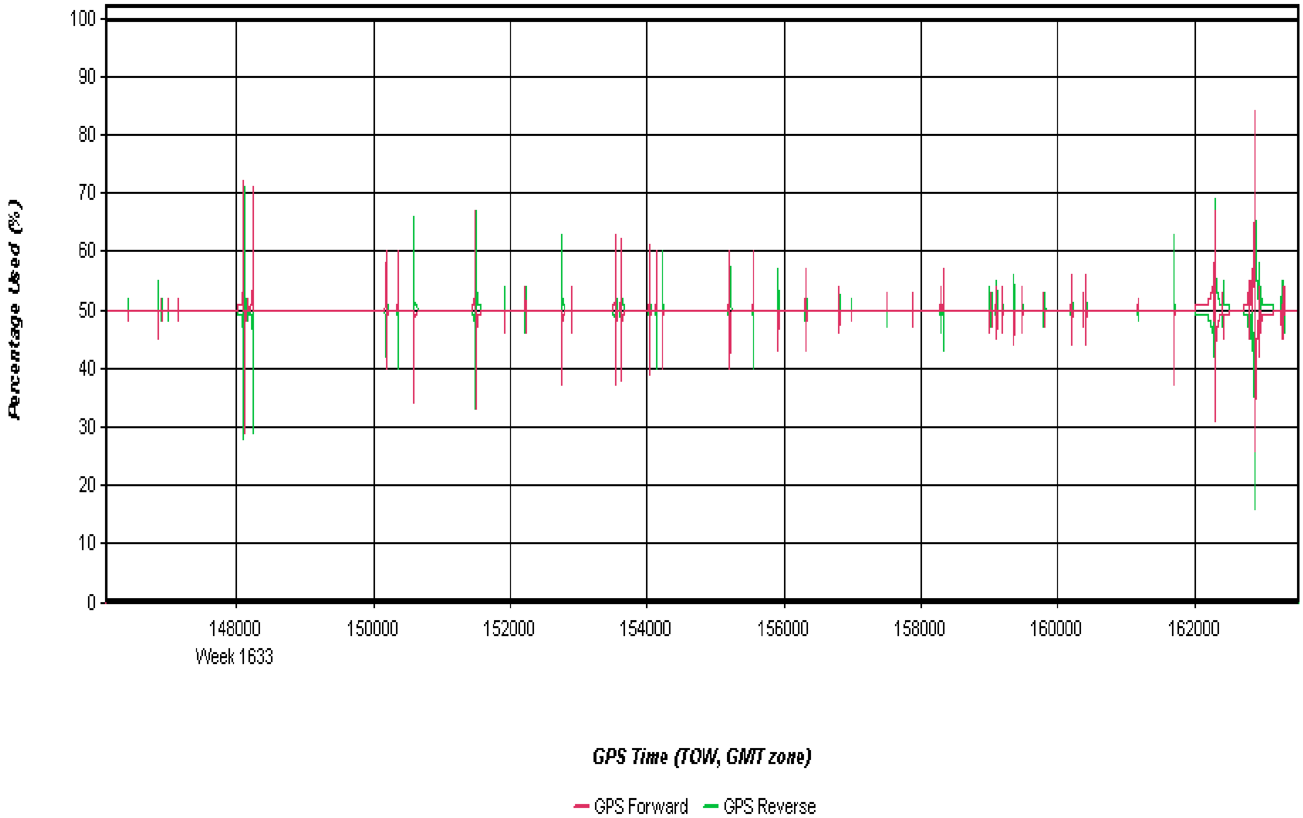
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 4: JD115F01 [Combined] - Forward/Reverse or Combined Separation Plot



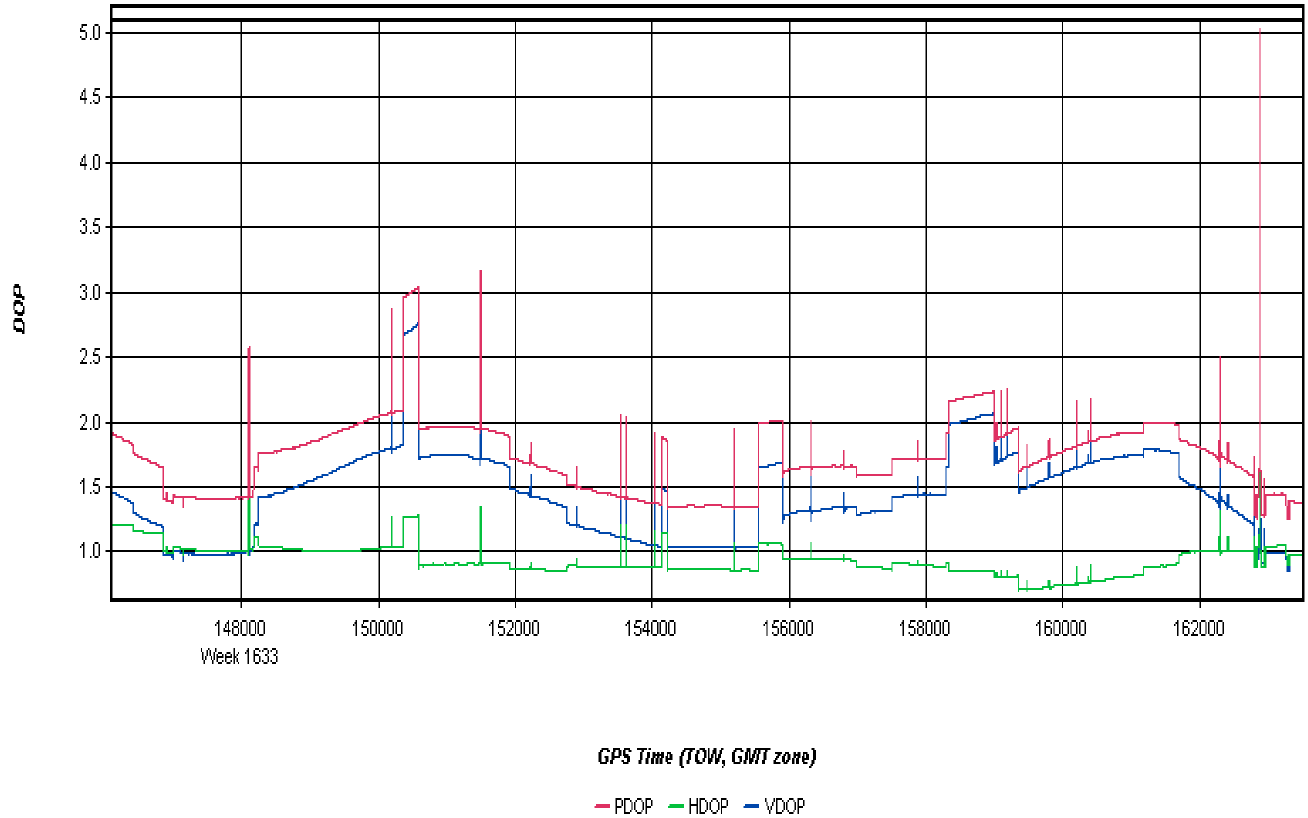
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 5: JD115F01 [Combined] - Forward/Reverse or Combined Weighting Plot



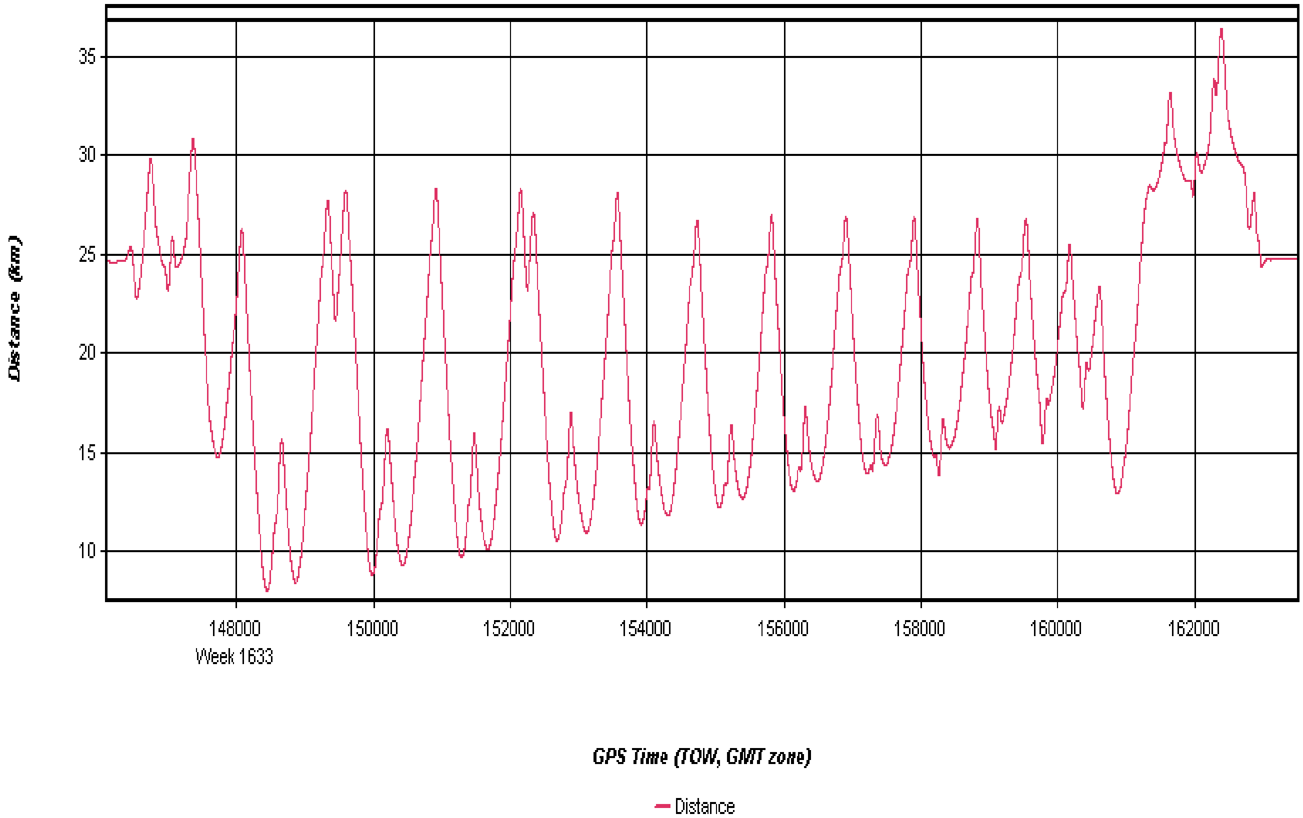
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 6: JD115F01 [Combined] - PDOP, HDOP, VDOP Plots



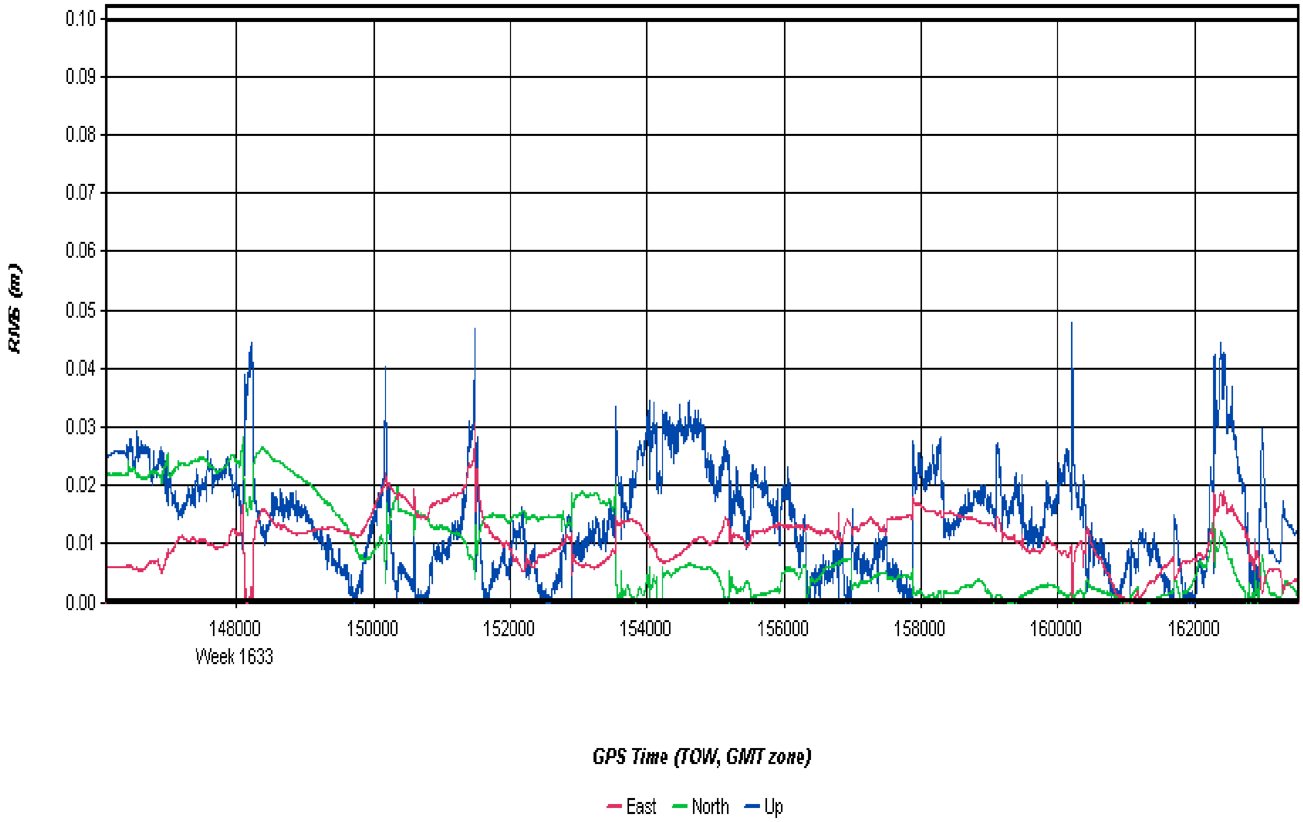
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 7: JD115F01 [Combined] - Horizontal Distance Separation (km)



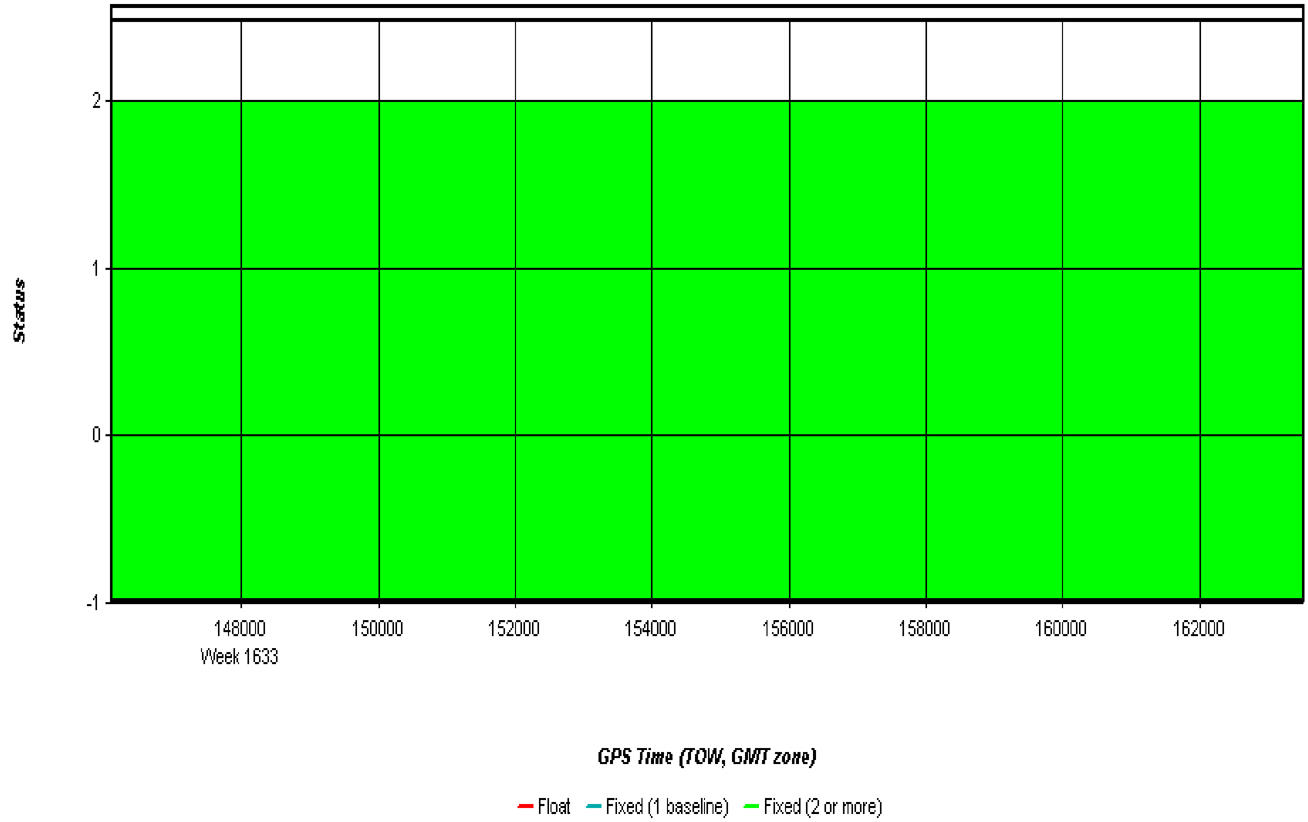
Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 8: JD115F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Figure 9: JD115F01 [Combined] - Float or Fixed Ambiguity

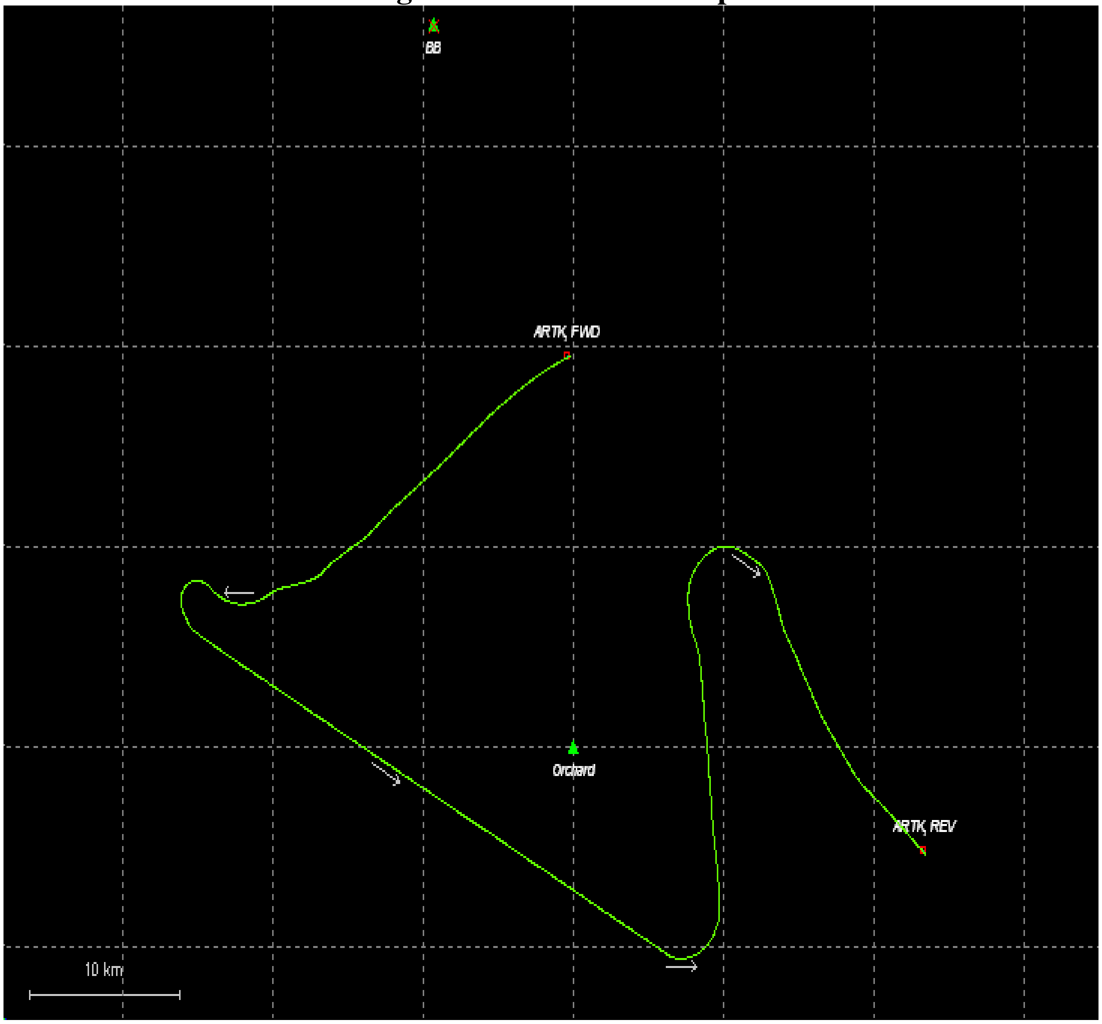


Process	Run (5)	by Unknown	on 06/16/2011	at 11:33:32

Output Results for JD116F01

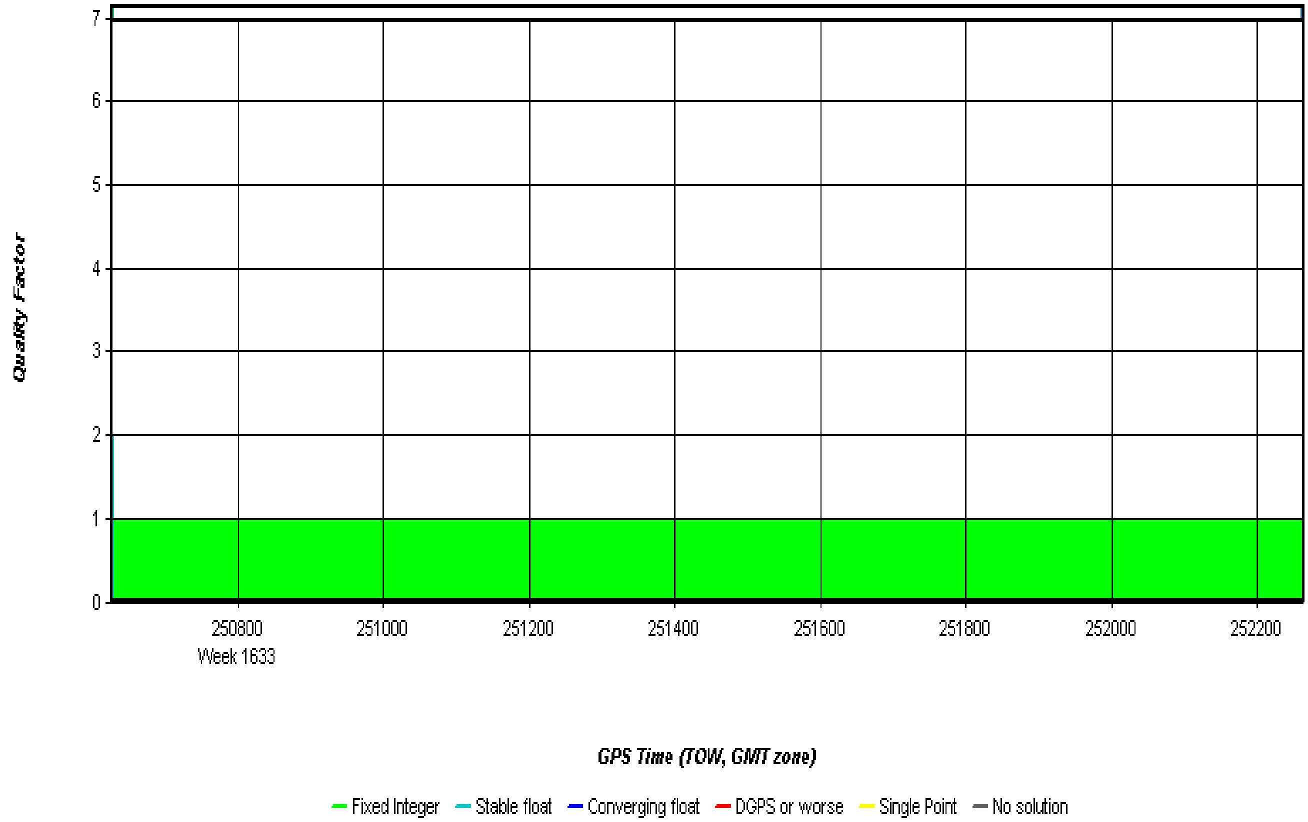
POSGNSS Version 5.20.1209
06/17/2011

Figure 1: Combined - Map



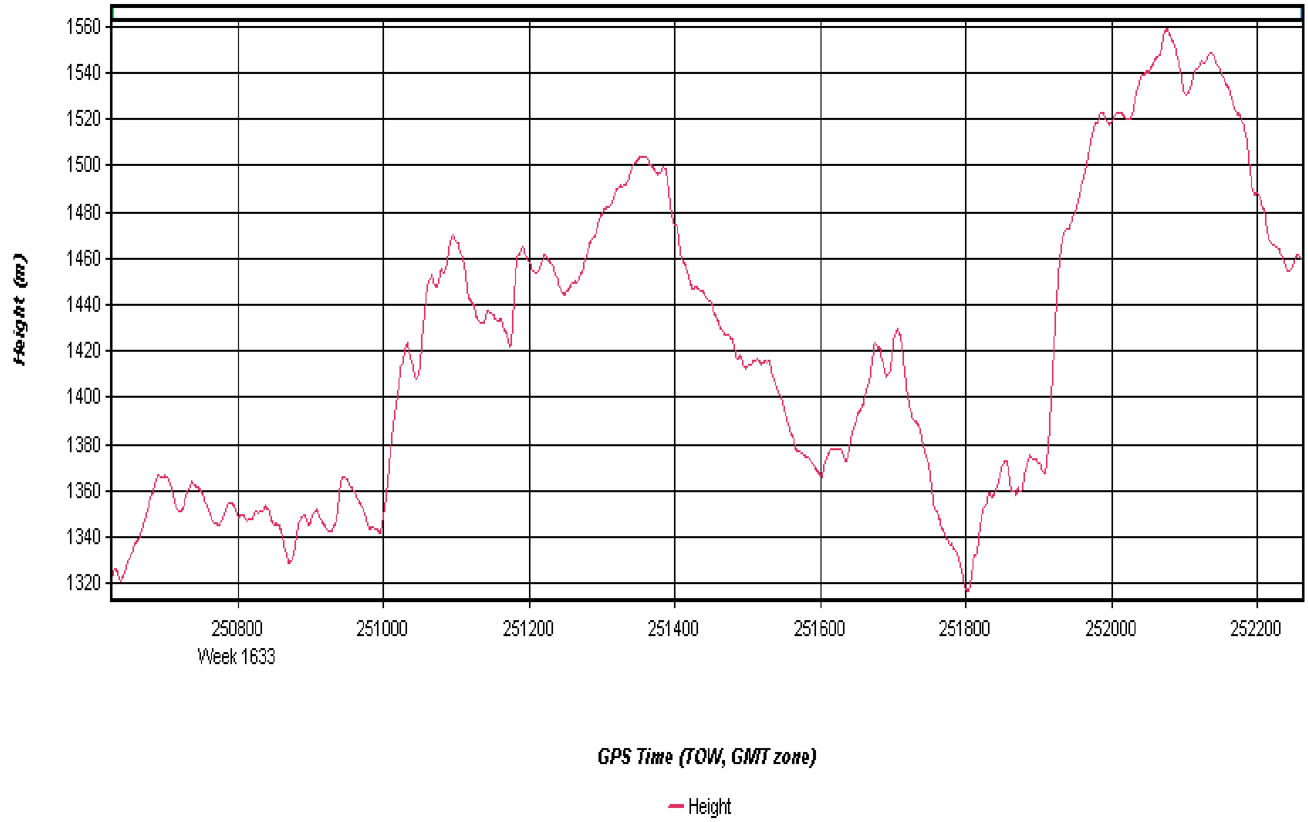
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 2: JD116F01 [Combined] - Quality Factor Plot



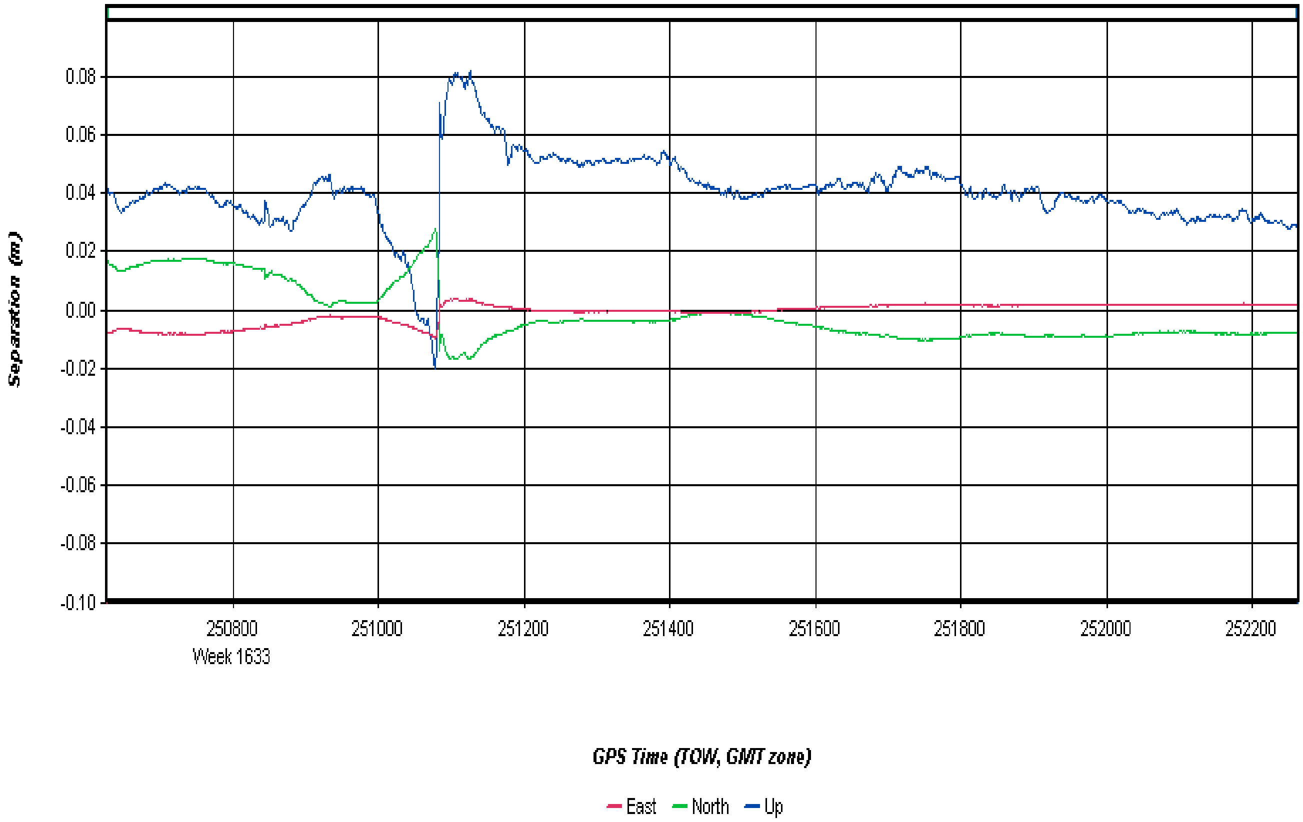
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 3: JD116F01 [Combined] - Height Profile Plot



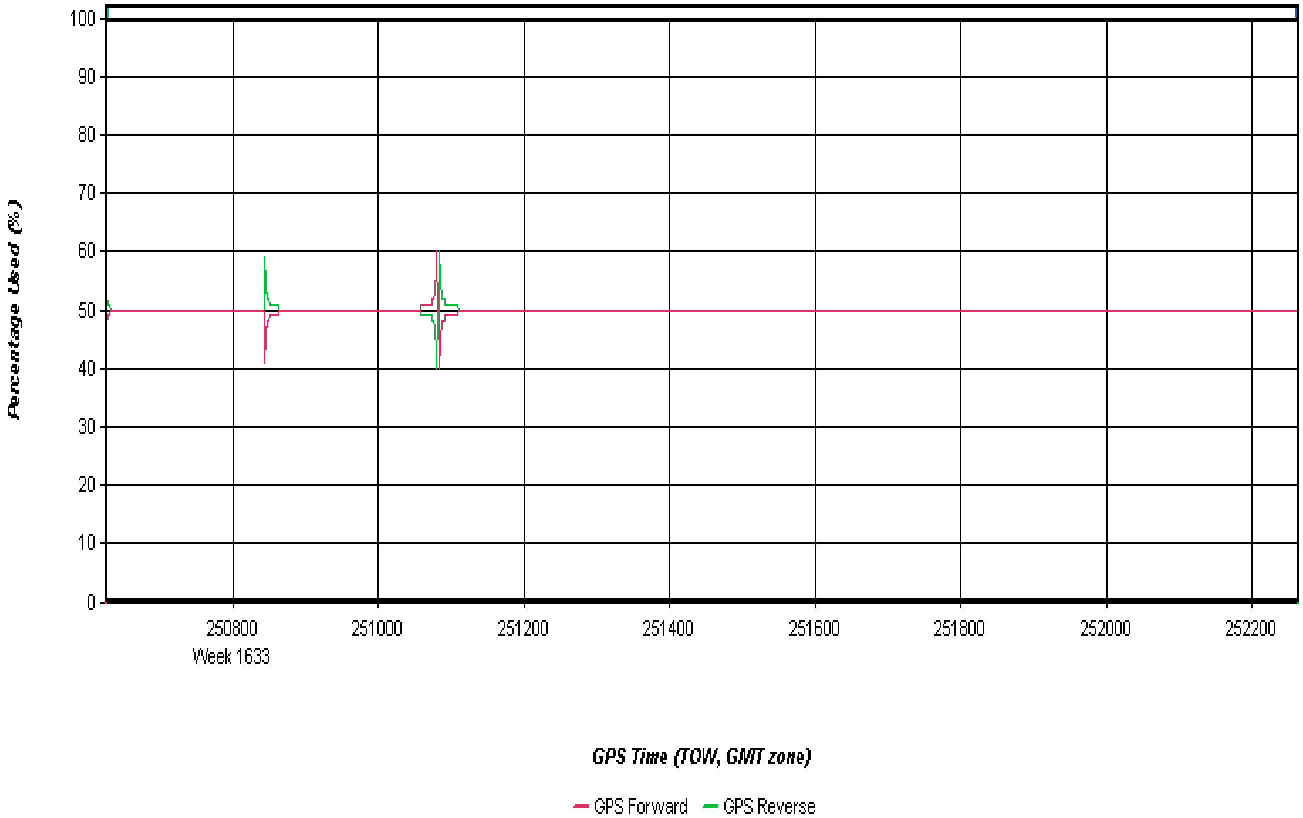
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 4: JD116F01 [Combined] - Forward/Reverse or Combined Separation Plot



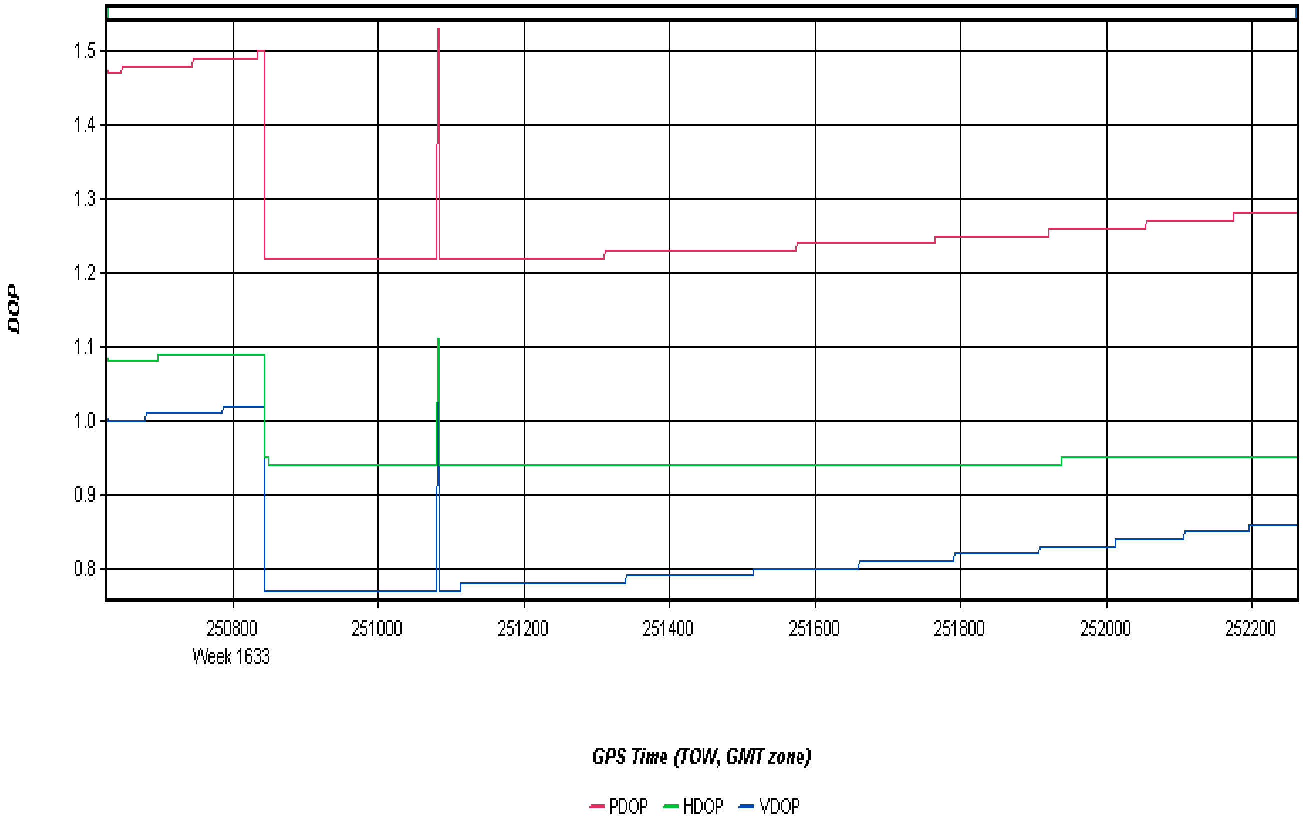
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 5: JD116F01 [Combined] - Forward/Reverse or Combined Weighting Plot



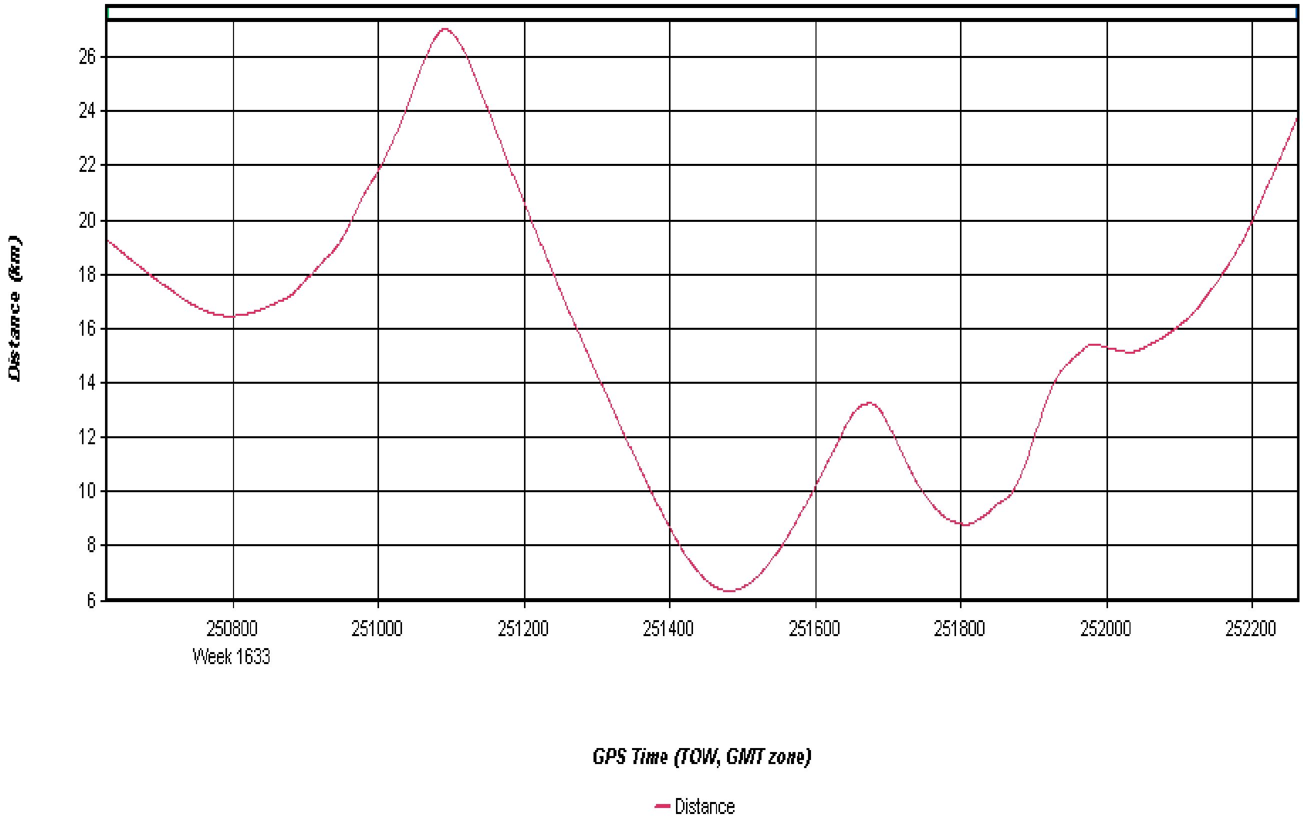
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 6: JD116F01 [Combined] - PDOP, HDOP, VDOP Plots



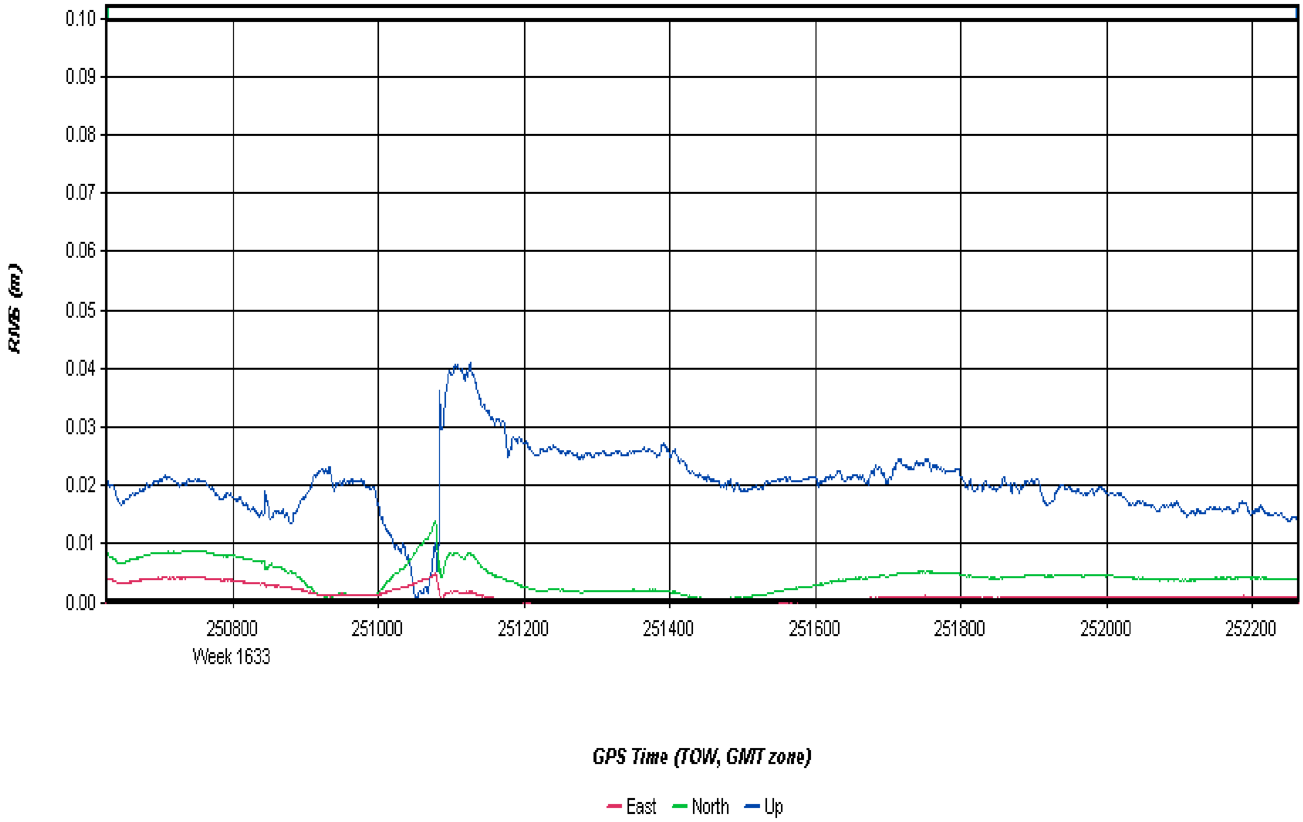
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 7: JD116F01 [Combined] - Horizontal Distance Separation (km)



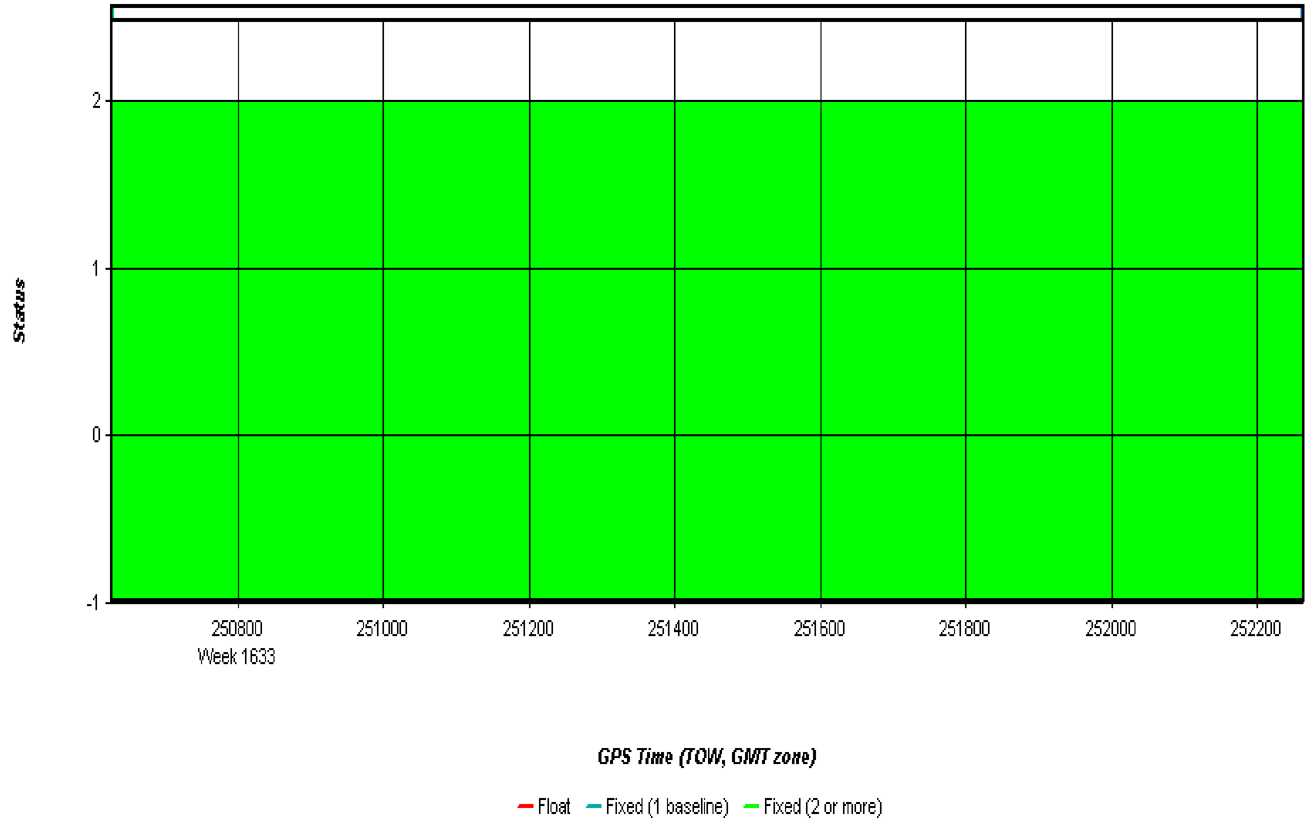
Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 8: JD116F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Figure 9: JD116F01 [Combined] - Float or Fixed Ambiguity

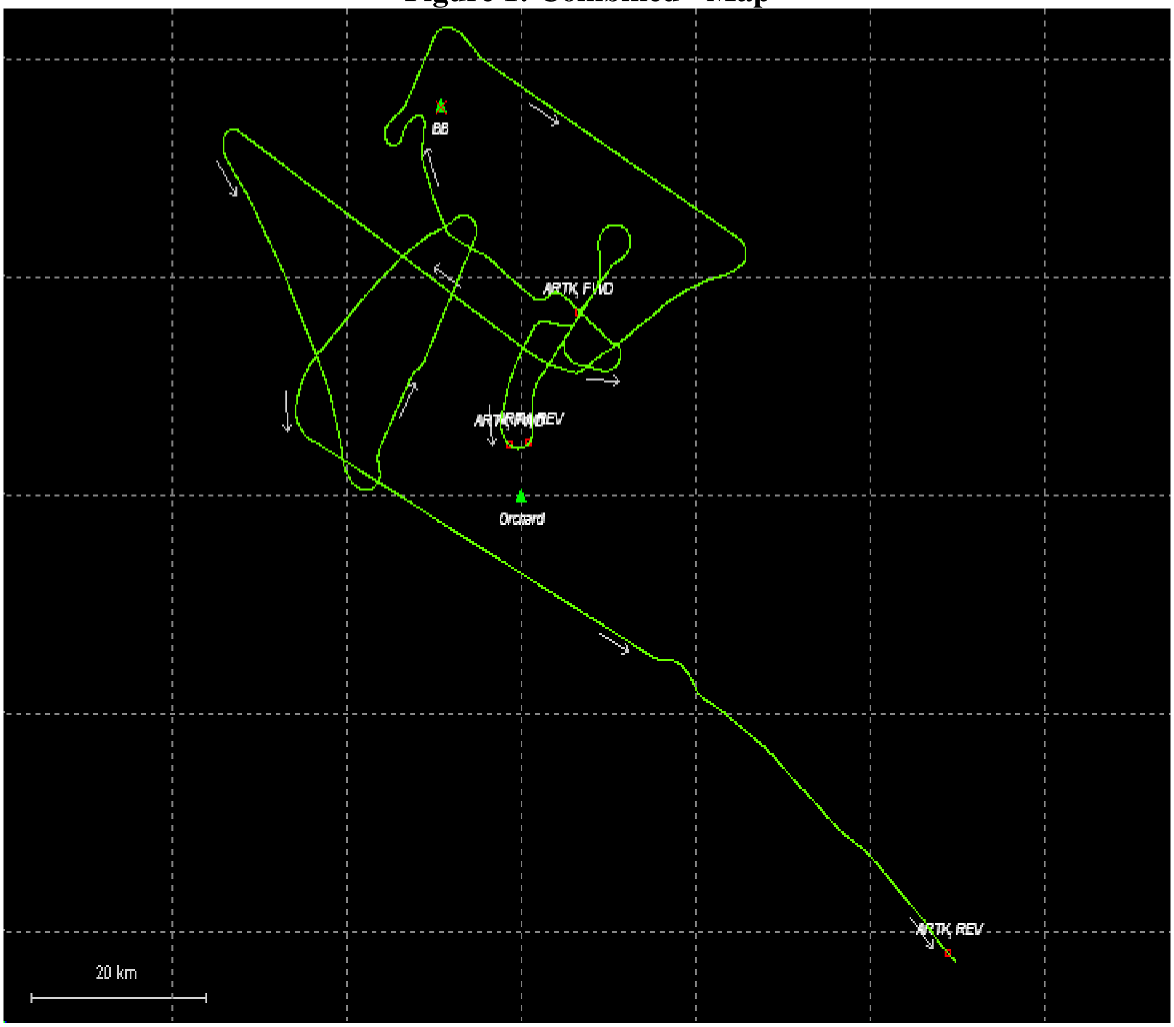


Process	Run (12)	by Unknown	on 06/17/2011	at 11:45:23

Output Results for JD119F01

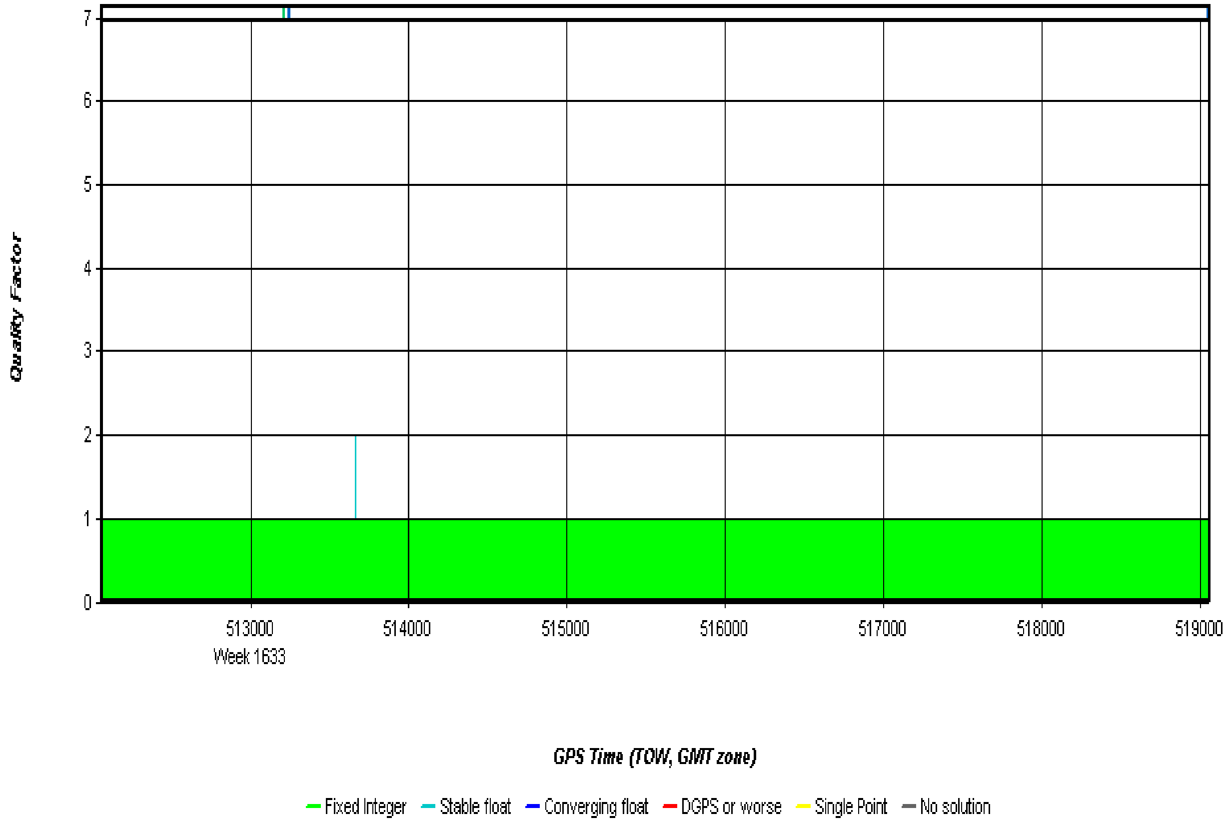
POSGNSS Version 5.20.1209
06/17/2011

Figure 1: Combined - Map



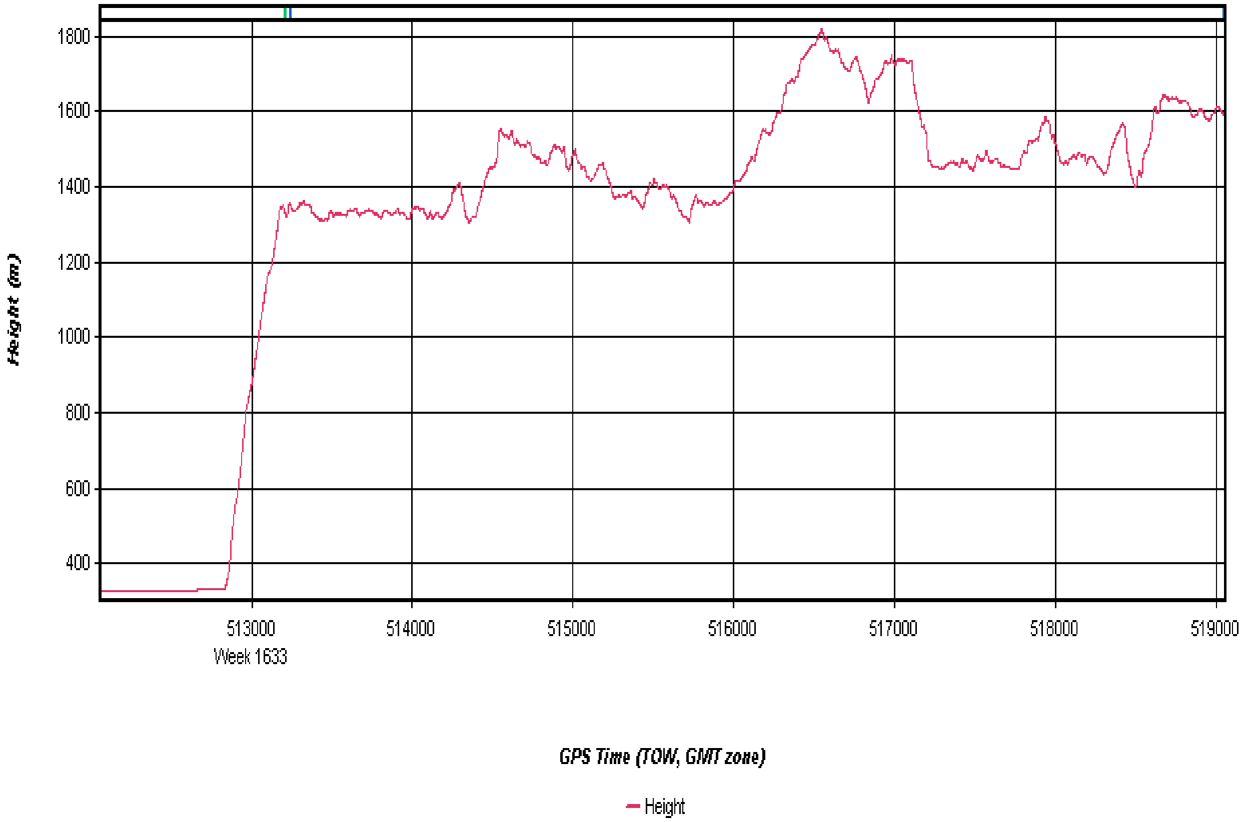
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 2: JD119F01 [Combined] - Quality Factor Plot



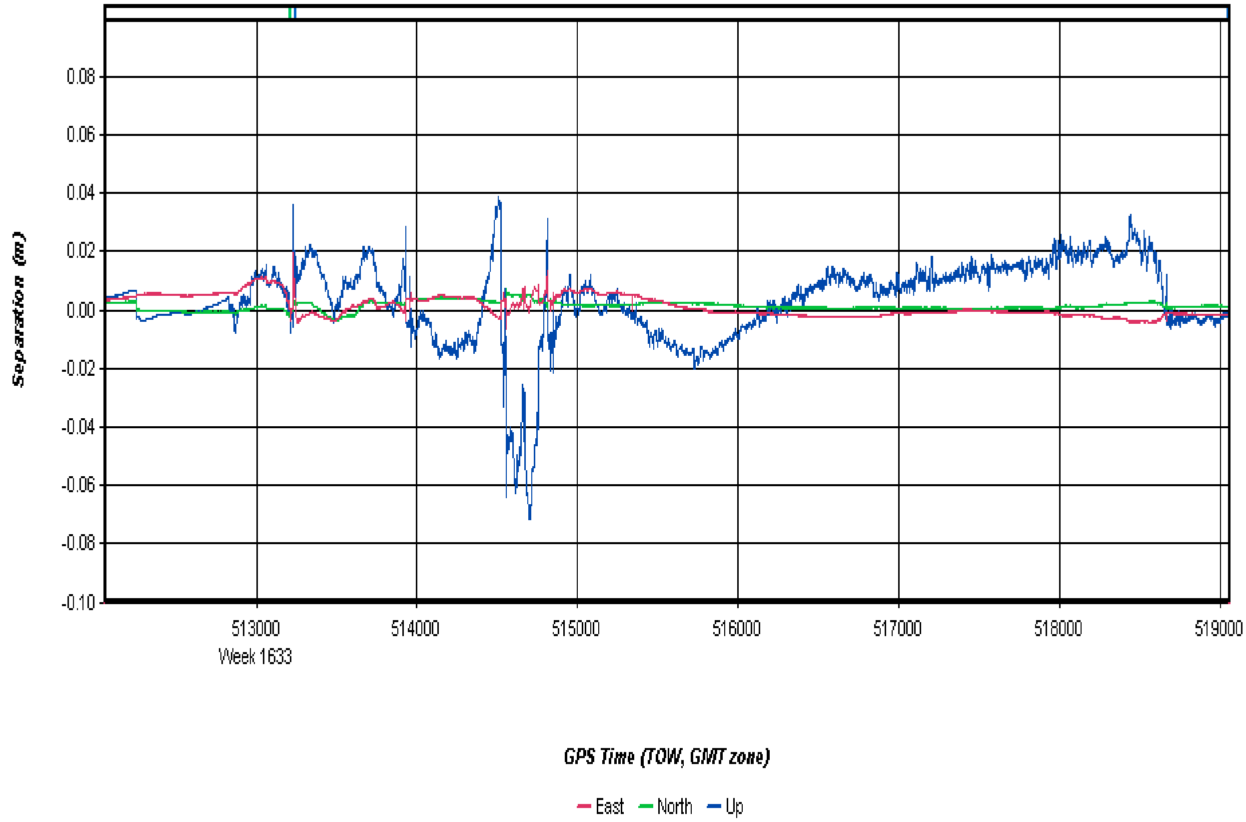
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 3: JD119F01 [Combined] - Height Profile Plot



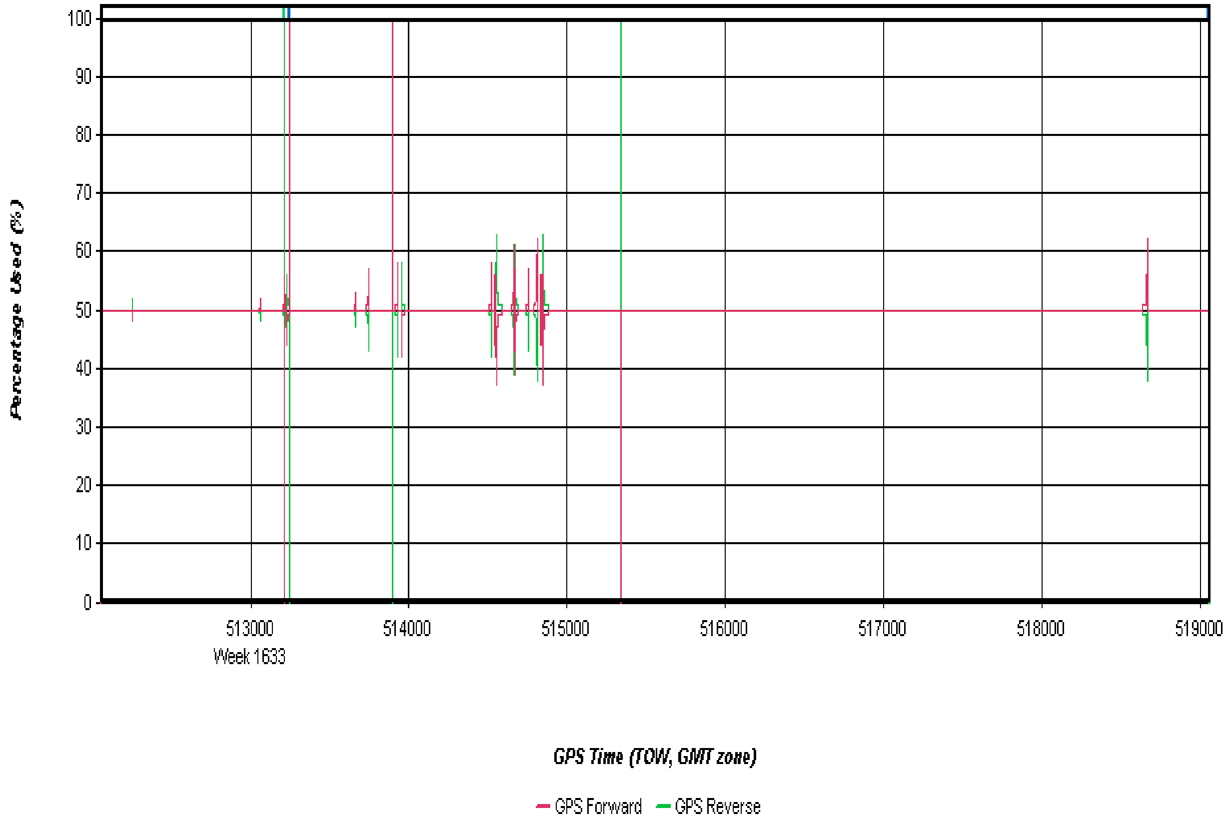
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 4: JD119F01 [Combined] - Forward/Reverse or Combined Separation Plot



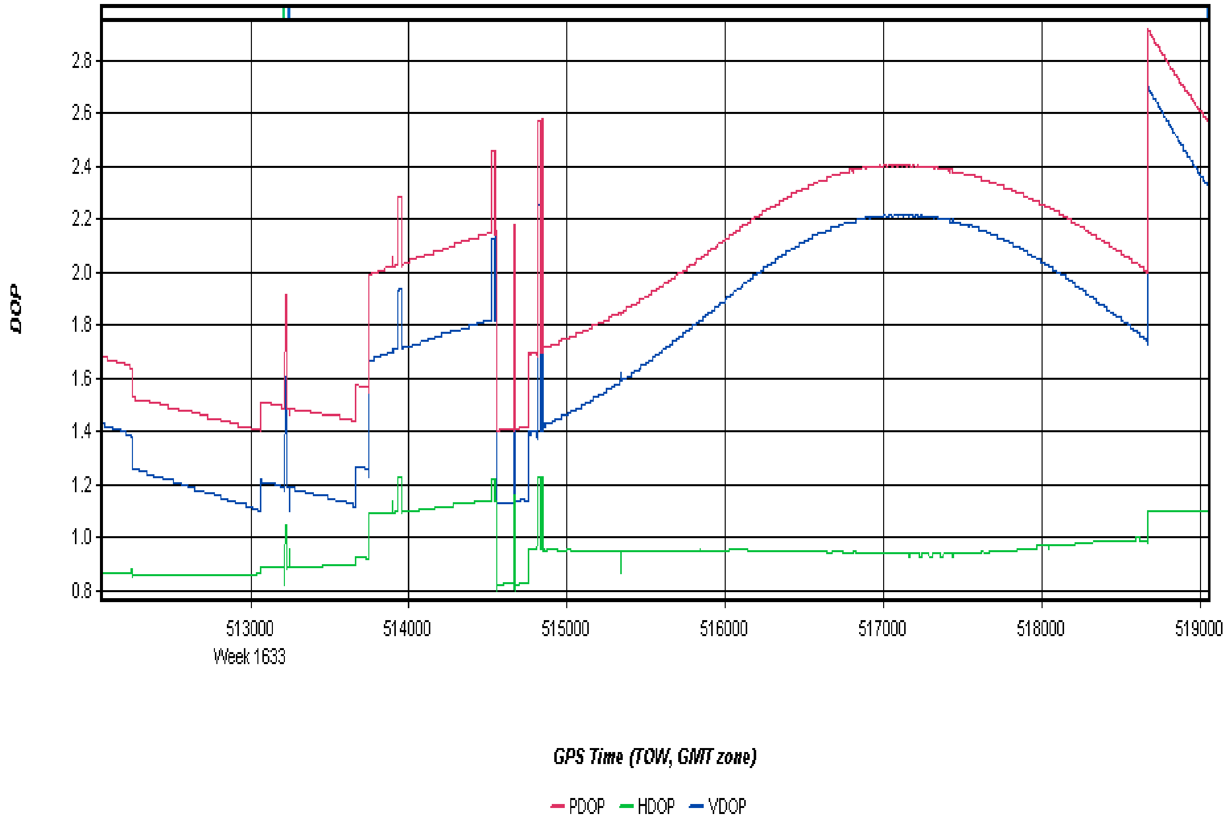
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 5: JD119F01 [Combined] - Forward/Reverse or Combined Weighting Plot



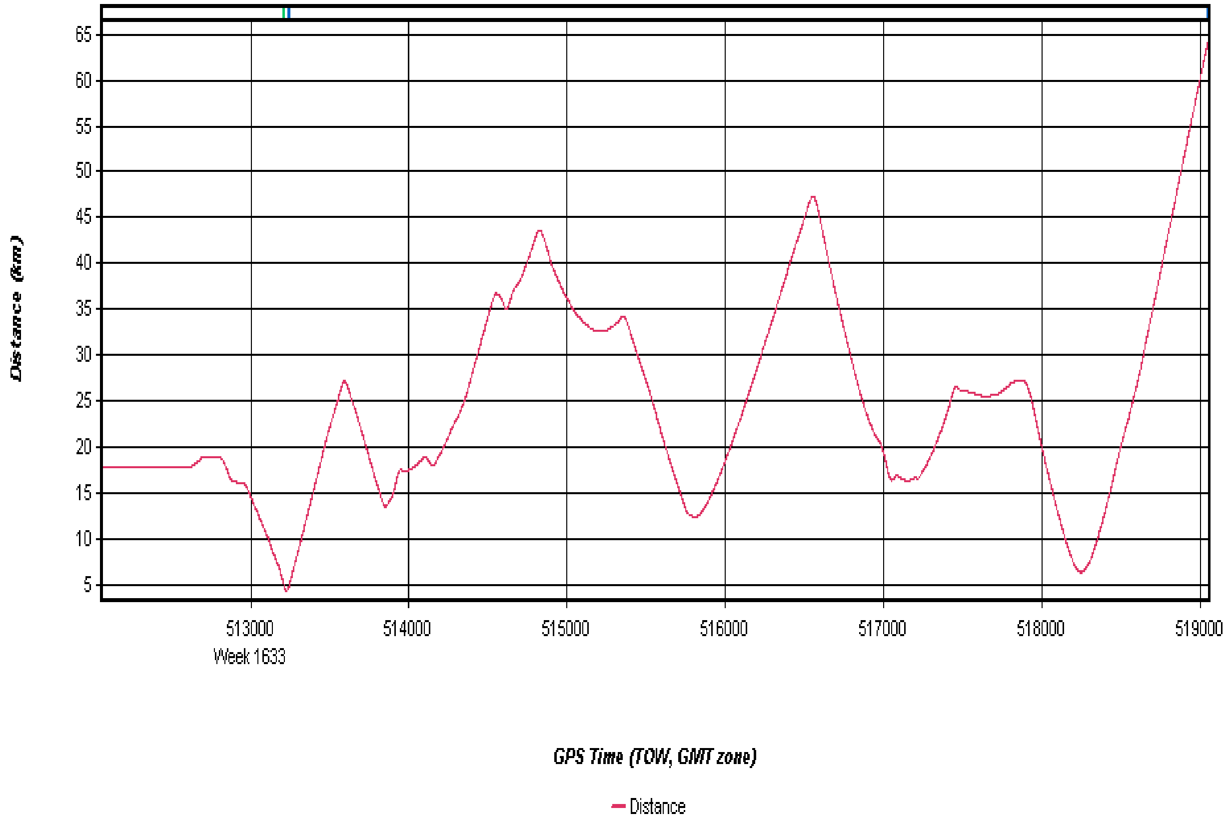
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 6: JD119F01 [Combined] - PDOP, HDOP, VDOP Plots



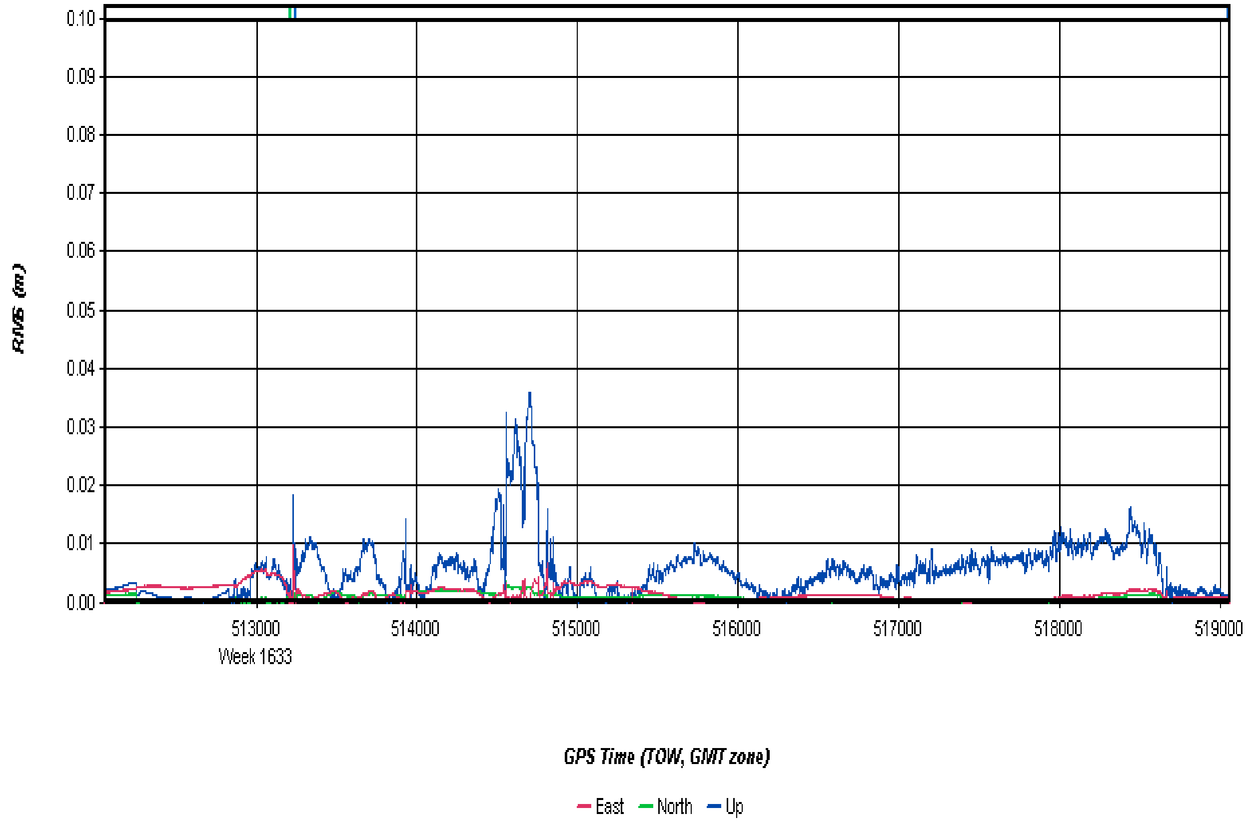
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 7: JD119F01 [Combined] - Horizontal Distance Separation (km)



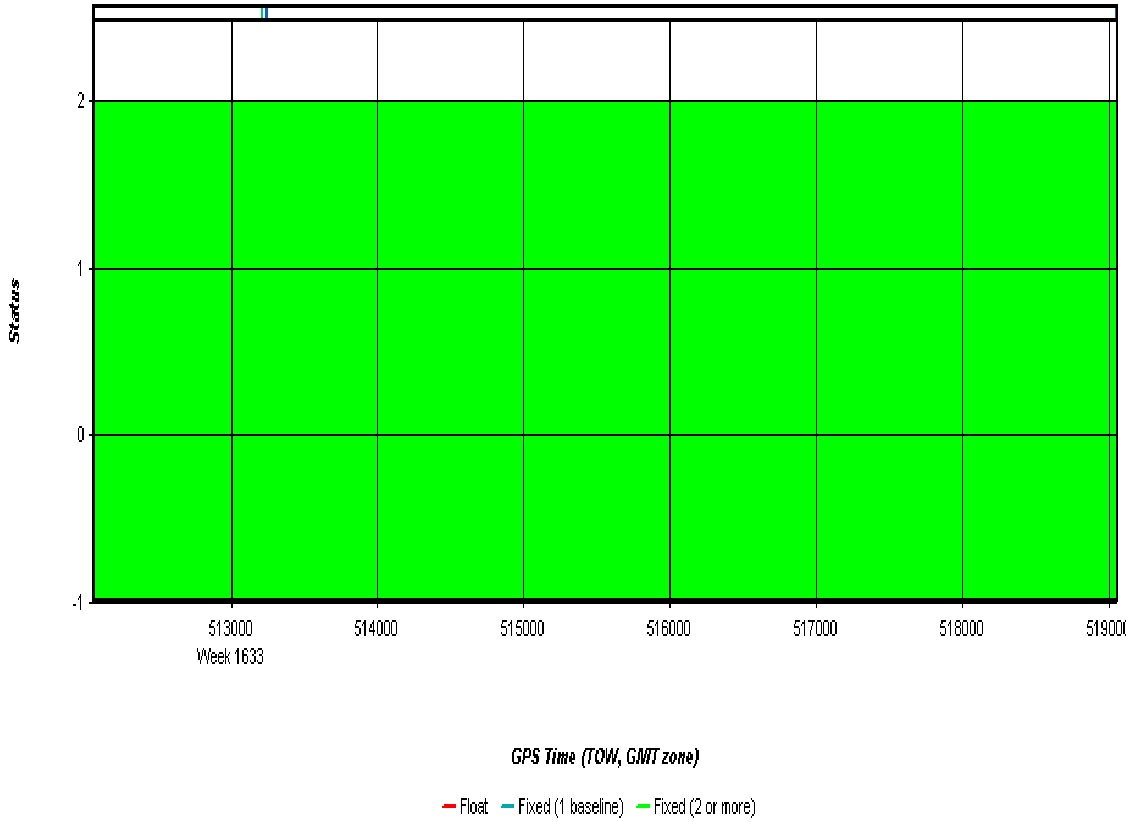
Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 8: JD119F01 [Combined] - Forward/Reverse or Combined RMS Plot



Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

Figure 9: JD119F01 [Combined] - Float or Fixed Ambiguity



Process	Run (18)	by Unknown	on 06/17/2011	at 08:47:34

3 LiDAR Processing & Qualitative Assessment

3.1 Data Classification and Editing

LiDAR mass points were produced to LAS 1.2 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, 10, or 11, including vegetation, buildings, etc.
- Class 2 = Ground, includes accurate LiDAR points in overlapping flight lines
- Class 7 = Noise, low and high points
- Class 9 = Water, points located within collected breaklines
- Class 10 = Ignored Ground due to breakline proximity.
- Class 11 = Withheld, Points with scan angles exceeding +/- 20 degrees.

The data was processed using GeoCue and TerraScan software. The initial step is the setup of the GeoCue project, which is done by importing a project defined tile boundary index encompassing the entire project area. The acquired 3D laser point clouds, in LAS binary format, were imported into the GeoCue project and tiled according to the project tile grid. Once tiled, the laser points were classified using a proprietary routine in TerraScan. This routine classifies any obvious outliers in the dataset to class 7 and points with scan angles exceeding +/- 20 degrees to class 11. After points that could negatively affect the ground are removed from class 1, the ground layer is extracted from this remaining point cloud. The ground extraction process encompassed in this routine takes place by building an iterative surface model.

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

The following fields within the LAS files are populated to the following precision: GPS Time (0.000001 second precision), Easting (0.01 foot precision), Northing (0.01 foot precision), Elevation (0.01 foot precision), Intensity (integer value - 12 bit dynamic range), Number of Returns (integer - range of 1-4), Return number (integer range of 1-4), Scan Direction Flag (integer - range 0-1), Classification (integer), Scan Angle Rank (integer), Edge of flight line (integer, range 0-1), User bit field (integer - flight line information encoded). The LAS file also contains a Variable length record in the file header that defines the projection, datums, and units.

Once the initial ground routine has been performed on the data, Dewberry creates Delta Z (DZ) orthos to check the relative accuracy of the LiDAR data. These orthos compare the elevations of LiDAR points from overlapping flight lines on a 1 meter pixel cell size basis. If the elevations of points within each pixel are within 10 cm of each other, the pixel is colored green. If the elevations of points within each pixel are between 10 cm and 20 cm of each other, the pixel is colored yellow, and if the elevations of points within each pixel are greater than 20 cm in difference, the pixel is colored red. Pixels that do not contain points from overlapping flight lines are colored according to their intensity values. DZ orthos can be created using the full point cloud or ground only points and are used to review and verify the calibration of the data is acceptable. Some areas are expected to show sections or portions of red, including terrain variations, slope changes, and vegetated areas or buildings if the full point cloud is used. However, large or continuous sections of yellow or red pixels can indicate the data was not calibrated correctly or that there were issues during acquisition that could affect the usability of the data. The DZ orthos for NRCS Virginia showed that the data was calibrated correctly with no issues that would affect its usability. The figure below shows an example of the DZ orthos.

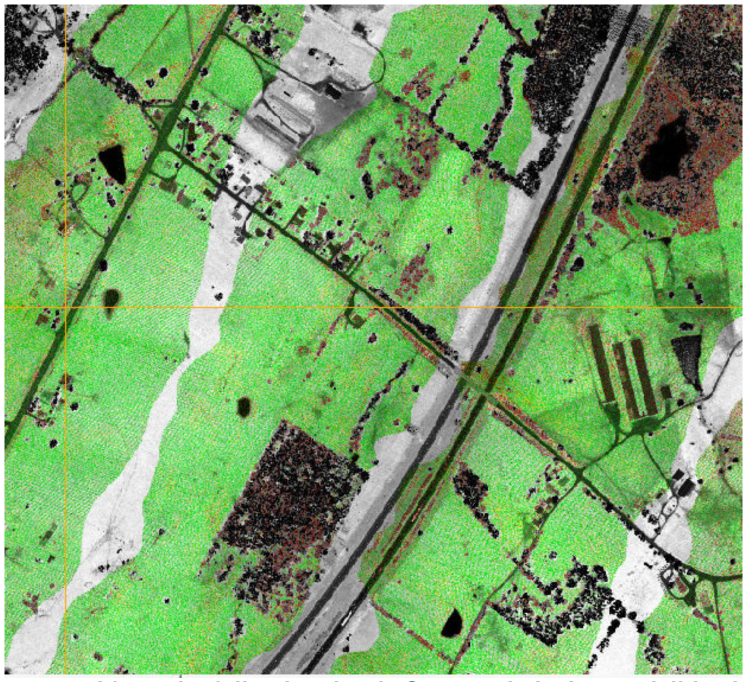


Figure 2: DZ orthos created from the full point cloud. Some red pixels are visible along embankments, sloped terrain, and in vegetated land cover, as expected. Open, flat areas are green indicating the calibration and relative accuracy of the data is acceptable.

BAE utilized a variety of software suites for data processing. The LAS dataset was received and imported into GeoCue task management software for processing in Terrascan. Each tile was imported into Terrascan and a surface model was created to examine the ground classification. BAE analysts visually reviewed the ground surface model and corrected errors in the ground classification such as vegetation, buildings, and bridges that were present following the initial processing conducted by Dewberry. BAE analysts employ 3D visualization techniques to view the point cloud at multiple angles and in profile to ensure that non-ground points are removed from the ground classification. After the ground classification corrections were completed, the dataset was processed through a water classification routine that utilizes breaklines compiled by BAE to automatically classify hydro features. The water classification routine selects ground points within the breakline polygons and automatically classifies them as class 9, water. The final classification routine applied to the dataset selects ground points within a specified distance of the water breaklines and classifies them as class 10, ignored ground due to breakline proximity.

3.2 *Qualitative Assessment*

Dewberry 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.

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 photogrammetrically-derived DEMs where point spacing can be eight meters or more, LiDAR nominal point spacing for this project is 1 point per 0.7 square meters. The end result is that millions of elevation points are measured to a level of accuracy previously unseen for traditional elevation mapping 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 dataset is statistically bound to have some errors both in the measurement process and in the artifact 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, and is verified with DZ orthos. 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 artifact removal process was performed correctly. To reiterate the quantitative approach, if the LiDAR sensor operated correctly over open terrain areas, then it most likely operated correctly over the vegetated areas. This does not mean that the entire bare-earth was measured; only 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 (or removal of above-ground artifacts) is paramount. Since there are currently no effective automated testing procedures to measure cleanliness, Dewberry 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 Dewberry 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.

3.3 *Analysis*

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

Following the completion of LiDAR point classification, the Dewberry qualitative assessment process flow for the USGS NRCS Virginia LiDAR project incorporated the following reviews:

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

- Format, Echos, Intensity
    - LAS format 1.2, point data record format 1
    - Point data record format 1
    - Multiple returns (echos) per pulse
    - Intensity values populated for each point
- ASPRS classification scheme
    - Class 1 – unclassified
    - Class 2 – ground
    - Class 7 – Noise
    - Class 9 – Water
    - Class 10 – Ignored Ground due to breakline proximity
    - Class 11 – Withheld due to scan angles exceeding +/- 20 degrees
- Projection
    - Datum – North American Datum 1983, HARN adjustment
    - Projected Coordinate System – State Plane Virginia North (4501)
    - Units – U.S. Survey Feet
    - Vertical Datum – North American Vertical Datum 1988, Geoid 09
    - Vertical Units - Feet
- LAS header information:
    - Class (Integer)
    - GPS Week Time (0.0001 seconds)
    - Easting (0.01 foot)
    - Northing (0.01 foot)
    - Elevation (0.01 foot)
    - Echo Number (Integer 1 to 4)
    - Echo (Integer 1 to 4)
    - Intensity (8 bit integer)
    - Flight Line (Integer)
    - Scan Angle (Integer degree)

2. *Data density, data voids:* The LAS files are used to produce Digital Elevation Models using the commercial software package "QT Modeler" which creates a 3-dimensional data model derived from Class 2 (ground points) in the LAS files. Grid spacing is based on the project density deliverable requirement for un-obscured areas. For the USGS NRCS Virginia LiDAR project it is stipulated that the minimum post spacing in un-obscured areas should be 1 point per 0.7 square meters.

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

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

    a. *Artifacts:* Dewberry identified the presence of a very limited number of artifacts in the dataset. Artifacts are caused by the misclassification of ground points and usually represent vegetation and/or man-made structures. The artifacts identified are usually low lying structures, such as porches or decks. These low lying features are extremely difficult for the automated algorithms to detect as non-ground and must be removed manually. The vast majority of these features have been removed from, as shown in Figure 3, but a small number of these features are still in the ground classification. The limited numbers of features remaining in the ground are also small features, usually 1 foot or less above the actual ground surface, and should not negatively impact the usability of the dataset.

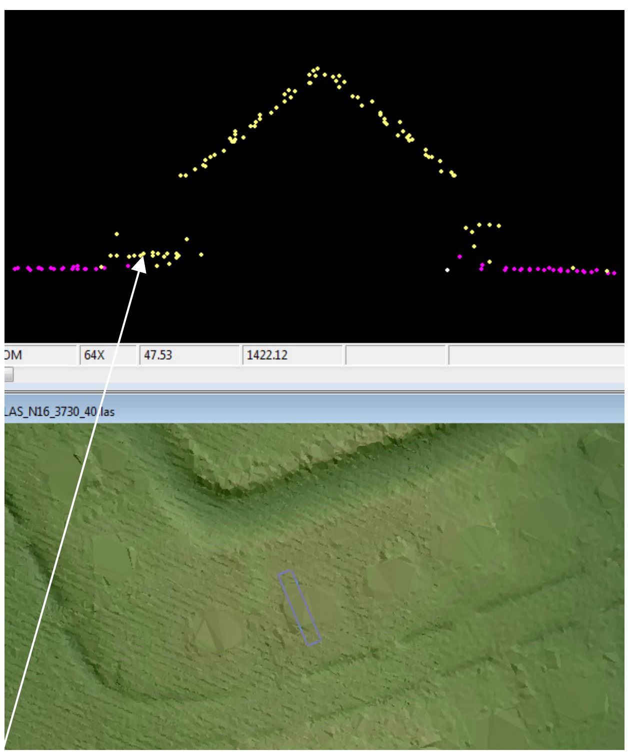


Figure 3 – Tile number LAS_N16_3730_40. Profile with points colored by class (class 1=yellow, class 2=pink) is shown in the top view and a TIN of the surface is shown in the bottom view. The arrow identifies a porch

structure that has correctly been removed from the ground classification. A limited number of these small features are still classified as ground.

b. *Misclassification:* A very limited number of areas with misclassification were identified. The majority of these areas were corrected. Only very small areas of misclassification may remain in the dataset. The areas that that are misclassified are in flat terrain that will not impact the usability of the dataset.

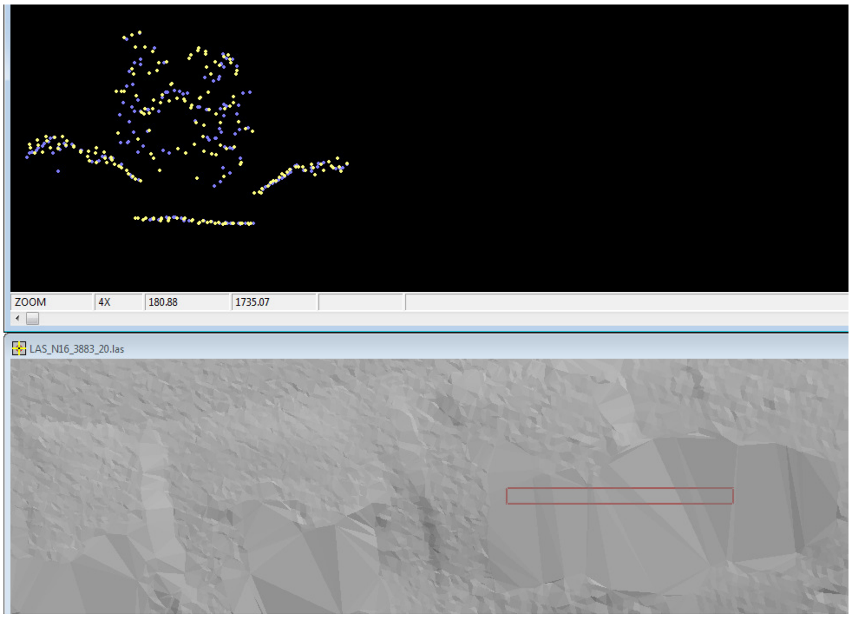


Figure 4 – Tile number LAS_N16_3883_20. Profile with points colored by class (class 1=yellow, class 11=blue) is shown in the top view and a TIN of the surface is shown in the bottom view. A very small portion of ground between two houses is not classified as ground, but as class 1.

c. *Culverts and Bridges:* Bridges have been removed from the bare earth surface while culverts remain in the bare earth surface. In instances where it is difficult to determine if the feature is a culvert or bridge, such as with some large box culverts or small bridges, Dewberry erred on assuming smaller features, especially if they are on secondary or tertiary roads, would be culverts. Below is an example of a culvert that has been left in the ground surface.

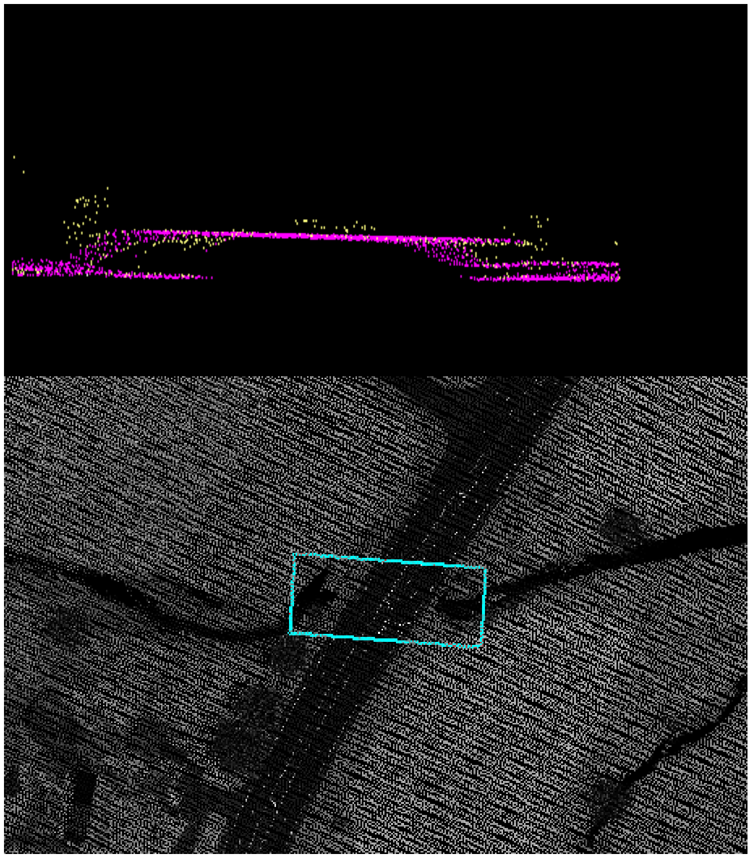


Figure 5– Tile number LAS_N16_3876_30. Profile with points colored by class (class 1=yellow, class 2=pink) is shown in the top view and the intensity is shown in the bottom view. This culvert remains in the bare earth surface. Bridges have been removed from the bare earth surface and classified to class 1.

3.4 *Conclusion*

The dataset conforms to project specifications for format and header values. The spatial projection information and classification of points is correct. Minor artifacts and small areas of misclassification are isolated and have minimal impact on the usability of the dataset.

4 Survey Vertical Accuracy Checkpoints

PT. #	NORTHING	EASTING	ELEVS.
	US STATE PLANE VA NORTH		
POINT ID	**NORTHING (FT)**	**EASTING (FT)**	**ELEVATION (FT)**
OT-1	6943946.13	11401372.15	1365.47
OT-2	6927979.32	11434294.59	958.66
OT-3	6907669.99	11411942.05	1099.45
OT-4	6889401.62	11376387.52	1417.62
OT-5	6865311.14	11414634.46	1243.05
OT-6	6864125.76	11371393.26	1285.26
OT-7	6855129.40	11333822.17	1459.09
OT-8	6831556.13	11314774.20	1416.53
OT-9	6828375.39	11359113.46	1302.74
OT-9A	6826969.50	11358613.63	1290.87
OT-10	6841410.76	11382953.80	1406.96
OT-11	6818347.92	11407007.17	1201.47
OT-12	6795554.60	11385649.27	1147.46
OT-13	6803946.63	11343075.53	1284.43
OT-14	6789972.96	11294774.81	1585.75
OT-15	6754311.03	11306651.26	1446.64
OT-16	6759428.60	11338657.49	1211.69
OT-17	6747302.77	11368632.10	1241.12
OT-18	6742225.86	11343276.75	1355.13
OT-19	6720932.09	11302724.54	1564.35
OT-20	6720939.67	11335072.08	1417.45
OT-21	6691539.62	11341872.83	1390.93
OT-22	6693591.05	11316957.61	1458.66
OT-23	6680704.18	11280197.89	1763.19
OT-24	6654792.57	11342071.24	1717.76
GWC-1	6942056.08	11420950.20	1074.68
GWC-2	6918481.77	11412755.66	972.25
GWC-3	6899051.85	11422256.70	1103.94
GWC-4	6892376.74	11397045.12	1223.33
GWC-5	6879007.68	11385900.10	1172.51
GWC-6	6852023.59	11405689.50	1496.06
GWC-7	6848358.48	11371449.45	1395.19
GWC-8	6861735.78	11351842.01	1374.41
GWC-9	6839122.95	11327326.57	1391.03
GWC-10	6823757.12	11340023.06	1286.07
GWC-11	6810377.81	11389233.25	1214.03
GWC-12	6794902.48	11365029.15	1134.24

GWC-13	6785598.51	11340243.57	1334.45
GWC-14	6797023.86	11310487.33	1472.86
GWC-15	6779740.98	11302653.22	1476.38
GWC-16	6768607.20	11323034.23	1426.86
GWC-17	6755579.06	11353684.81	1263.45
GWC-18	6734242.61	11357911.84	1216.81
GWC-19	6724783.35	11380439.11	1257.20
GWC-20	6694139.40	11358999.73	1348.15
GWC-21	6726714.44	11322663.54	1513.64
GWC-22	6709575.98	11316179.28	1456.64
GWC-23	6694964.35	11293214.17	1667.62
FO-1	6939020.27	11449766.57	1021.31
FO-2	6926210.61	11397232.11	1284.27
FO-3	6908601.25	11435623.49	1028.52
FO-4	6904651.02	11387823.65	1185.08
FO-5	6882580.92	11427054.24	1207.36
FO-6	6866320.93	11392868.28	1319.34
FO-7	6875520.71	11342546.83	1628.76
FO-8	6855588.46	11298849.69	2047.82
FO-9	6842898.98	11343576.72	1320.92
FO-10	6824860.34	11398806.03	1402.31
FO-11	6813138.45	11372345.23	1346.79
FO-12	6812049.28	11314400.53	1354.44
FO-13	6826781.23	11293667.06	1783.29
FO-14	6810108.71	11266970.75	2155.57
FO-15	6783672.04	11319722.34	1501.54
FO-16	6774097.54	11368855.14	1183.14
FO-18	6717248.81	11368191.19	1374.34
FO-19	6735364.26	11312350.30	1552.21
FO-20	6704602.91	11295924.40	1963.95
FO-21	6678785.23	11332719.42	1639.25
FO-22	6672190.49	11301838.75	1880.08
FO-23	6672492.58	11353349.45	1507.85

Table 1: USGS NRCS Virginia LiDAR surveyed accuracy checkpoints

4.1 Survey Checkpoints not used in vertical accuracy testing.

Three (3) checkpoints were surveyed in non-ideal locations for testing LiDAR data. Some of these checkpoints were located on sloped terrain. Due to the horizontal spread of the sensor laser, survey checkpoints should be located on flat terrain to ensure LiDAR returns will be measuring a uniform surface and not a sloped surface which could introduce error into the vertical accuracy calculations. Additionally, some of these checkpoints were not used because they are located in land cover, such as impenetrable brush, or next to obstructions, such as trees or buildings, that do that do not give the LiDAR sensor an adequate chance to measure the ground surface.

Additional checkpoints are normally surveyed in case some of the checkpoints are deemed unusable. Even after removing these three checkpoints from the dataset, there were still 67 checkpoints remaining for the vertical accuracy testing, meeting project requirements of 60 total checkpoints comprised of 20 checkpoints in each land cover category. Table 2, below, identifies checkpoints not used in the vertical accuracy testing.

Point ID	Easting	Northing	Elevation
OT-14	11294774.81	6789972.96	1585.75
FO-4	11387823.65	6904651.02	1185.08
FO-12	11314400.53	6812049.28	1354.44

Table 2: Checkpoints not used in vertical accuracy testing.

Below are examples of two checkpoints that were not used in vertical accuracy testing.

Figure 6: Survey Checkpoint OT-14. This checkpoint is located on sloped terrain, better shown in the profile below.

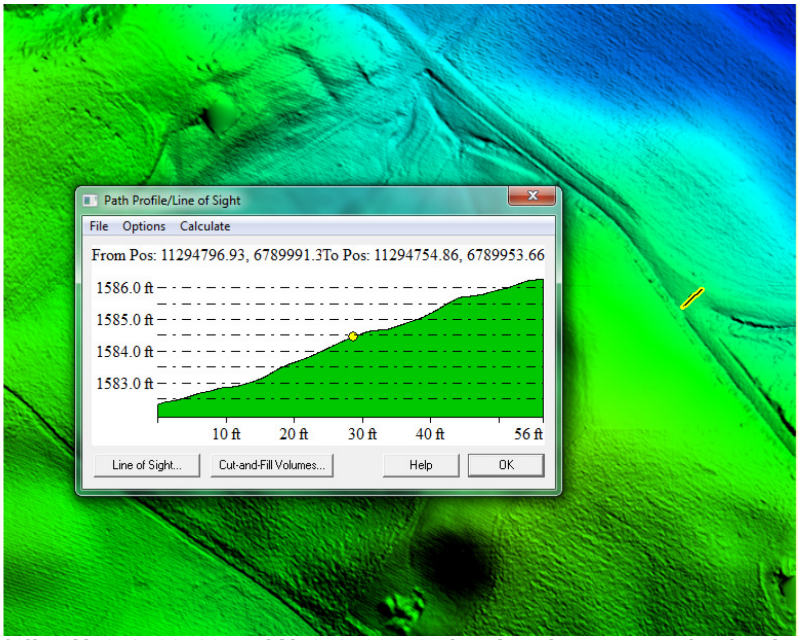


Figure 7: DEM of tiles N16_2798_20 and N16_2799_10 showing that survey checkpoint OT-14 is poorly placed, located on sloped terrain, and therefore was not used in vertical accuracy testing.

Figure 8: Survey Checkpoint FO-12. This checkpoint is located right next to a large tree. Checkpoints must not be located next to obstructions as this can prevent the LiDAR sensor from reaching its target. Due to the poor placement of this checkpoint, it was not used during vertical accuracy testing.

5 LiDAR Vertical Accuracy Statistics & Analysis

5.1 Background

Dewberry tests and reviews project data both quantitatively (for accuracy) and qualitatively (for usability).

For qualitative assessment (i.e. vertical accuracy assessment), sixty-seven (67) check points were surveyed for the project and are located within open terrain, forest, or grass, weeds, and crops land cover categories. The checkpoints were surveyed for the project using RTK survey methods. A survey report was produced which details and validates how the survey was completed for this project.

Checkpoints were evenly distributed throughout the project area so as to cover as many flight lines as possible using the "dispersed method" of placement.

5.2 Vertical Accuracy Test Procedures

FVA (Fundamental Vertical Accuracy) is determined with check points located only in the open terrain (grass, dirt, sand, and/or rocks) land cover category, 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 (RMSEz) of the checkpoints x 1.9600. For the USGS NRCS Virginia LiDAR project, vertical accuracy must be 0.61 ft (18.3 cm) or less based on an RMSEz of 0.31 ft (9.25 cm) x 1.9600.

CVA (Consolidated Vertical Accuracy) 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. The USGS NRCS Virginia LiDAR Project CVA standard is 1.21 ft (36.3 cm) 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 (Supplemental Vertical Accuracy) is determined for each land cover category other than open terrain. SVA at the 95% confidence level equals the 95^{th} percentile error for all checkpoints in each land cover category. The USGS NRCS Virginia LiDAR Project SVA target is 1.21 ft (36.3 cm) at the 95% confidence level. Target specifications are given for SVA's as one individual land cover category may exceed this target value as long as the overall CVA is within specified tolerances. Again, $Accuracy_z$ differs from SVA because $Accuracy_z$ assumes elevation errors follow a normal error distribution where RMSE procedures are valid, whereas SVA assumes LiDAR errors may not follow a normal error distribution in vegetated categories, making the RMSE process invalid.

The relevant testing criteria are summarized in Table 3.

Table 3 — Acceptance Criteria

Quantitative Criteria	Measure of Acceptability
Fundamental Vertical Accuracy (FVA) in open terrain only using RMSEz *1.9600	0.61 ft (based on RMSEz (0.31 ft) * 1.9600)
Consolidated Vertical Accuracy (CVA) in all land cover categories combined at the 95% confidence level	1.21 ft (based on combined 95th percentile)
Supplemental Vertical Accuracy (SVA) in each land cover category separately at the 95% confidence level	1.21 ft (based on 95th percentile for each land cover category)

5.3 Vertical Accuracy Testing Steps

The primary QA/QC vertical accuracy testing steps used by Dewberry are summarized as follows:

1. Dewberry's team surveyed QA/QC vertical checkpoints in accordance with the project's specifications. Figure 6 shows the location of the checkpoints.
2. Next, Dewberry interpolated the bare-earth LiDAR DTM to provide the z-value for each of the 67 checkpoints.
3. Dewberry then computed the associated z-value differences between the interpolated z-value from the LiDAR data and the ground truth survey checkpoints and computed FVA, CVA, and SVA values.
4. The data were analyzed by Dewberry to assess the accuracy of the data. The review process examined the various accuracy parameters as defined by the scope of work. The overall descriptive statistics of each dataset were computed to assess any trends or anomalies. This report provides tables, graphs and figures to summarize and illustrate data quality.

Figure 9 shows the location of the QA/QC checkpoints within the project area.

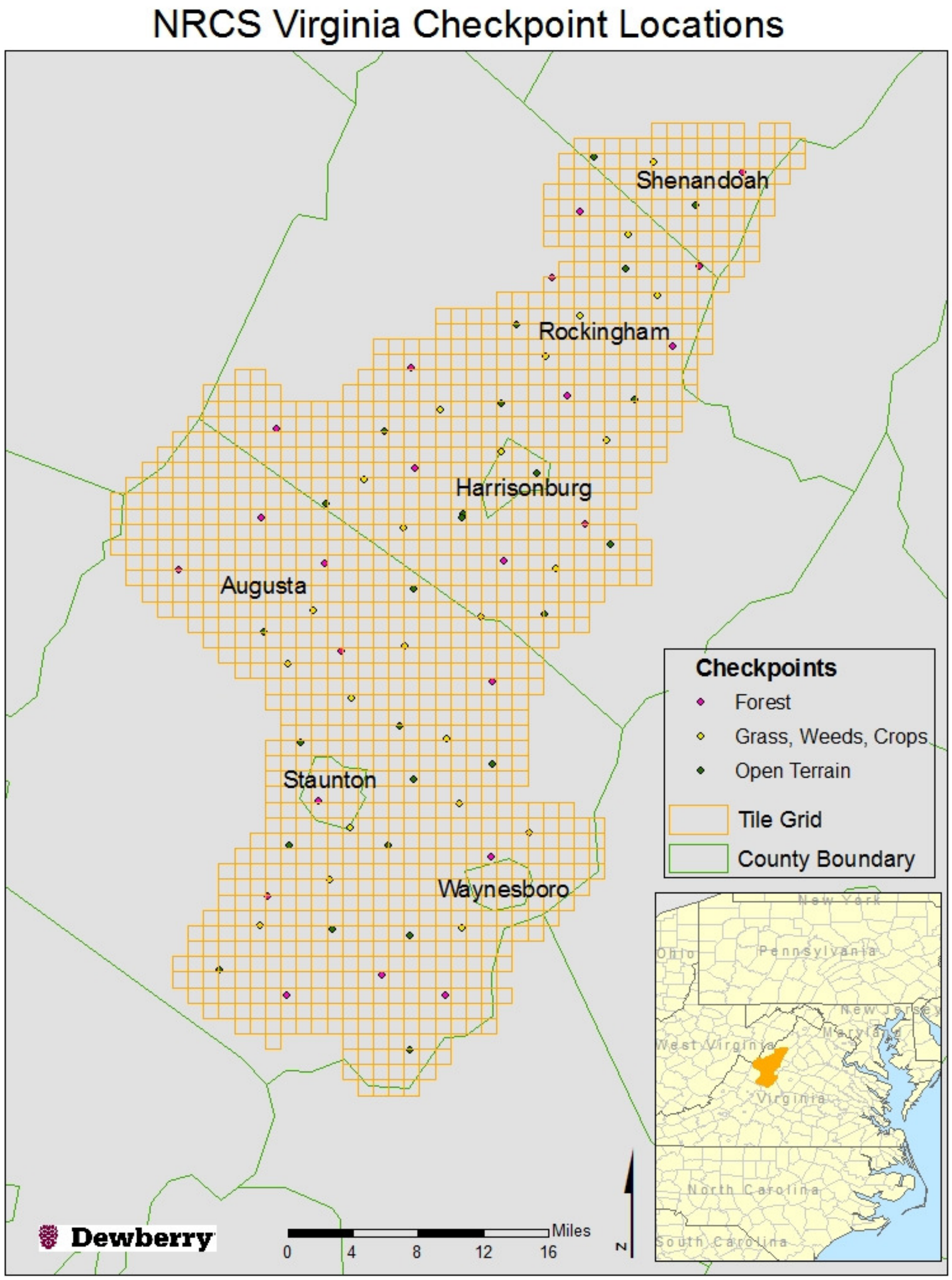


Figure 9 – Location of QA/QC Checkpoints

5.4 Vertical Accuracy Results

Table 4 summarizes the tested vertical accuracy resulting from a comparison of the surveyed checkpoints to the elevation values present within the LiDAR LAS files.

Table 4 — FVA, CVA, and SVA Vertical Accuracy at 95% Confidence Level

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=0.61 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.21 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.21 ft
Consolidated	67		0.95	
Open Terrain	24	0.47		
Grass/Weeds/Crop	23			0.95
Forest	20			0.99

The $RMSE_z$ for checkpoints in open terrain only tested 0.24 ft, within the target criteria of 0.31 ft. Compared with the 0.61 ft specification, the FVA tested 0.47 ft at the 95% confidence level based on $RMSE_z$ x 1.9600.

Compared with the 1.21 ft specification, CVA for all checkpoints in all land cover categories combined tested 0.95 ft at the 95% confidence level based on the 95^{th} percentile.

Compared with target 1.21 ft specification, SVA for checkpoints in the grass, weeds, and crops land cover category tested 0.95 ft and checkpoints in the forest land cover category tested 0.99 ft at the 95% confidence level based on the 95^{th} percentiles.

Figure 10 illustrates the magnitude of the differences between the QA/QC checkpoints and LiDAR data. This shows that the majority of LiDAR elevations were within +/- 0.50 ft of the checkpoints elevations, but there were some outliers where LiDAR and checkpoint elevations differed by up to +/- 1.40 ft.

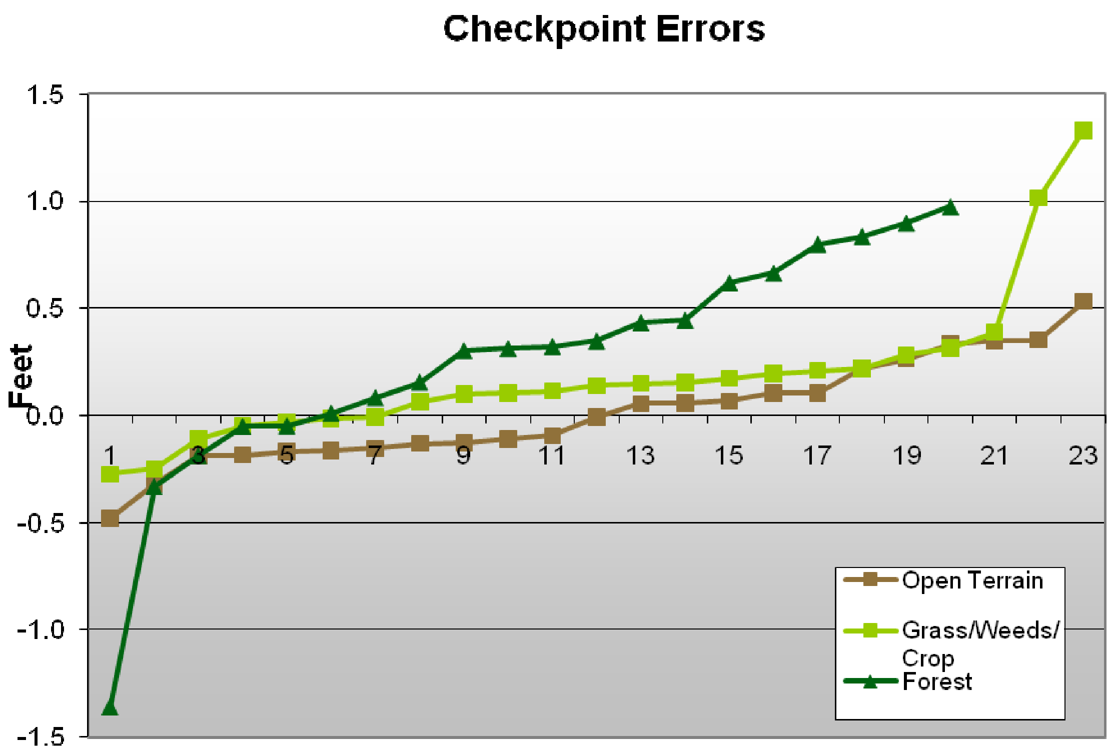


Figure 10 – Magnitude of Elevation Discrepancies

Table 5 lists the 5% outliers that are larger than the 95th percentile, or 0.95 feet.

pointNo	NAD_1983_NSRS2007 Virginia State Plane Coordinate System, North Zone		NAVD88	LiDAR - Z (feet)	Delta Z
	Easting - X (feet)	Northing - Y (feet)	Survey -Z (feet)		
FO-6	11392868.28	6866320.93	1319.34	1317.98	-1.36
GWC-15	11302653.22	6779740.98	1476.38	1477.71	1.33
GWC-3	11422256.70	6899051.85	1103.94	1104.95	1.01
FO-20	11295924.40	6704602.91	1963.95	1964.92	0.97

Table 5 — 5% Outliers

Table 6 provides overall descriptive statistics.

100 % of Totals	RMSE (ft) Open Terrain Spec=0.31ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated		0.29	0.10	0.01	0.39	67	-1.36	1.33
Open Terrain	0.24	0.20	-0.05	0.34	0.24	24	-0.48	0.53
Grass/Weeds/Crop		0.25	0.14	2.06	0.35	23	-0.27	1.33
Forest		0.46	0.32	-1.38	0.53	20	-1.36	0.97

Table 6 — Overall Descriptive Statistics

Figure 11 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 -1.3 ft and a high of +1.45 ft, the histogram shows that the majority of the discrepancies are skewed on the positive side. The vast majority of points are within the ranges of -0.05 ft to +0.45 ft.

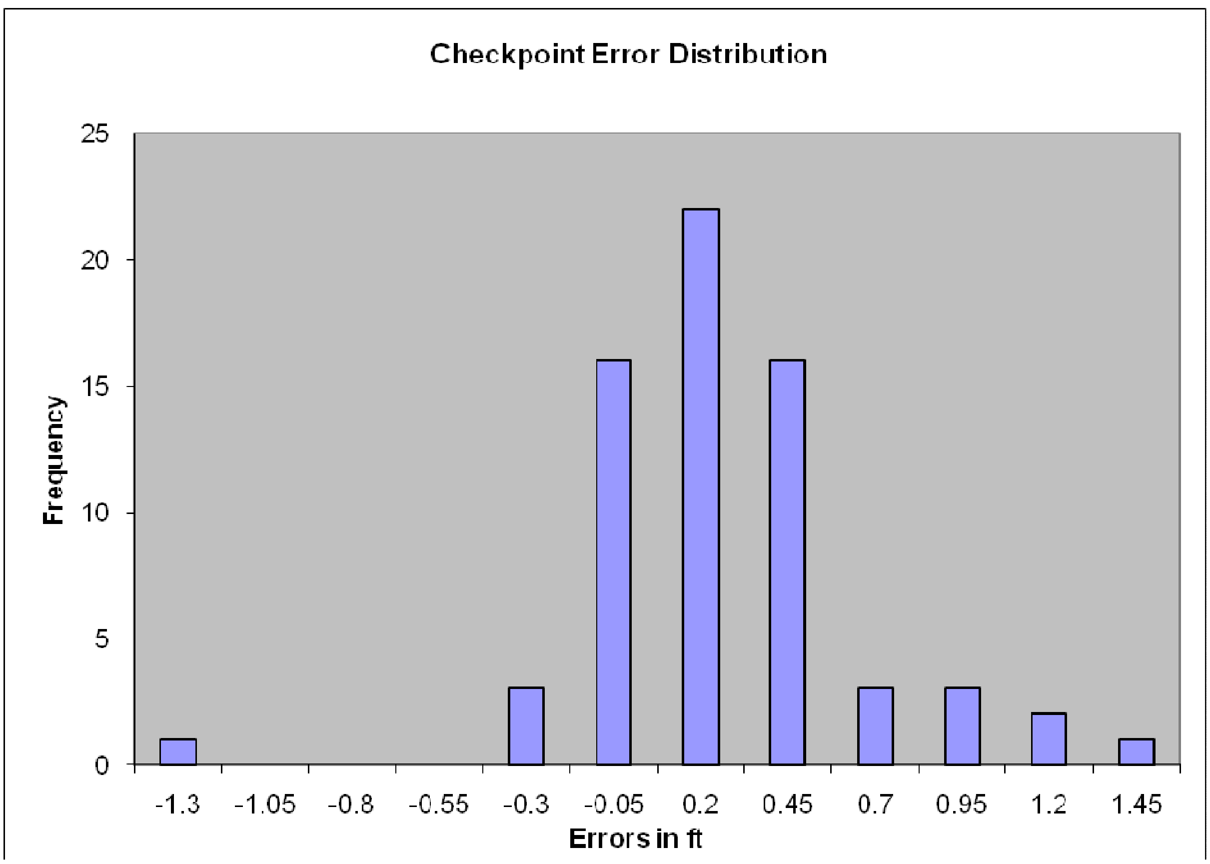


Figure 11 — Histogram of Elevation Discrepancies within errors in feet

5.5 *Conclusion*

Based on the vertical accuracy testing conducted by Dewberry, the LiDAR dataset for the USGS NRCS Virginia LiDAR Project satisfies the project's pre-defined vertical accuracy criteria.

6 Breakline Production & Qualitative Assessment Report

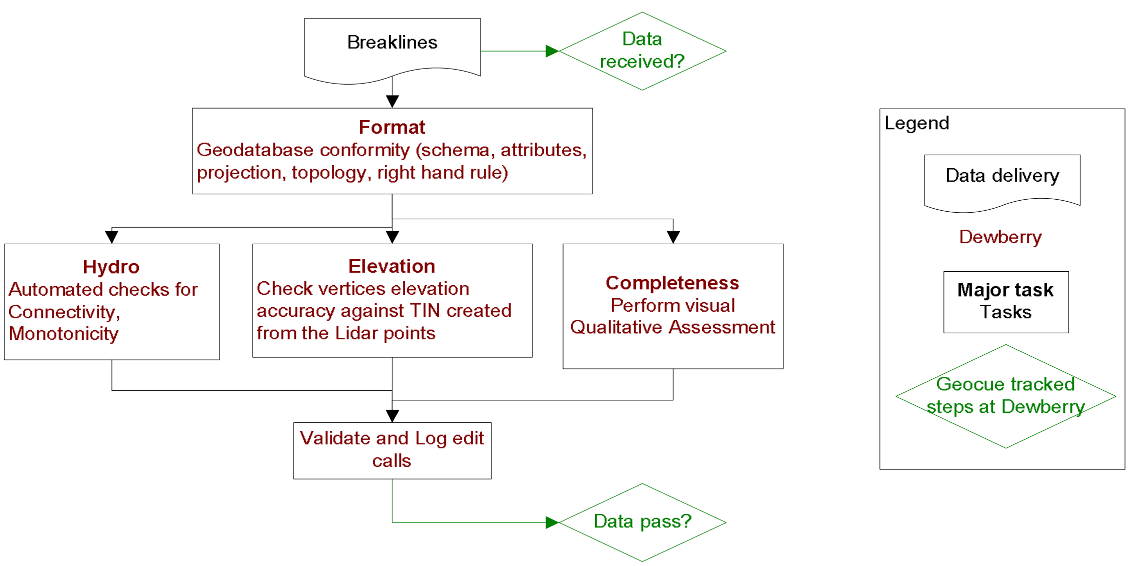
6.1 *Breakline Production Methodology*

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

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

6.2 *Breakline Qualitative Assessment*

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



6.3 *Breakline Topology Rules*

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

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

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

6.4 Breakline QA/QC Checklist

Project Number/Description: TO G11PD00336 USGS NRCS Virginia LiDAR

Date:______02/17/2012____

Overview

☒ All Feature Classes are present in GDB

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

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

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

Perform Completeness check on breaklines using either intensity or ortho imagery

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

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

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

Compare Breakline Z elevations to LiDAR elevations

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

Perform automated data checks using PLTS

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

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

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

☒ Perform "duplicate geometry check" on (inland streams to inland streams), (inland ponds to inland ponds), (inland ponds to inland streams). Attributes do not need to be checked during this tool. This tool is found under "Duplicate Geometry Checks."

☒ Perform "geometry on geometry check" on (inland ponds to inland streams). Spatial relationship is contains, attributes do not need to be checked. This tool is found under "Feature on Feature Checks."

☒ Perform "polygon overlap/gap is sliver check" (inland streams to inland streams), (inland ponds to inland ponds), (inland ponds to inland streams). Maximum Polygon Area is not required. This tool is found under "Feature on Feature Checks."

Perform Dewberry Proprietary Tool Checks

☒ Perform monotonicity check on inland streams features using "A3_checkMonotonicityStreamLines." This tool looks at line direction as well as elevation. Features in the output shapefile attributed with a "d" are correct monotonically, but were compiled from low elevation to high elevation. These errors can be ignored. Features in the output shapefile attributed with an "m" are not correct monotonically and need elevations to be corrected. Input features for this tool need to be in a geodatabase. Z tolerance is .01 feet. Polygons need to be exported as lines for the monotonicity tool.

☒ Perform connectivity check between (inland ponds to inland streams) using the tool "07_CheckConnectivityForHydro." The input for this tool needs to be in a geodatabase. The output is a shapefile showing the location of overlapping vertices from the polygon features and polyline features that are at different Z-elevation. The unnecessary polygon boundary check must be run and all errors fixed prior to performing connectivity check. If there are exceptions to the polygon boundary rule then that feature class must be checked against itself, i.e. inland streams to inland streams.

Metadata

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

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

Completion Comments: Complete – Approved

6.5 Data Dictionary

Dewberry®

LiDARgrammetry Data Dictionary & Stereo Compilation Rules

For the USGS NRCS Virginia LiDAR Project

March, 2011

Table of Contents

HORIZONTAL AND VERTICAL DATUM

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

Coordinate System and Projection

All data shall be projected to Virginia State Plane North, Horizontal Units in Feet and Vertical Units in Feet.

Inland Streams and Rivers

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

Feature Class: STREAMS_AND_RIVERS
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 linear hydrographic features with a width greater than 100 feet.

Table Definition

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

Feature Definition

Description	Definition	Capture Rules
Streams and Rivers	Linear hydrographic features such as streams, rivers, canals, etc. with an average width greater than 100 feet in length. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other natural or manmade embankments will not qualify for this project.	Capture features showing dual line (one on each side of the feature). Average width shall be great than 100 feet to show as a double line. Each vertex placed should maintain vertical integrity and data is required to show "closed polygon". Generally both banks shall be collected to show consistent downhill flow. There are exceptions to this rule where a small branch or offshoot of the stream or river is present. The banks of the stream must be captured at the same elevation to ensure flatness of the water feature. If the elevation of the banks appears to be different see the task manager or PM for further guidance. Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually. 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. Every effort should be made to avoid breaking a stream or river into segments. Dual line features shall break at road crossings (culverts). In areas where a bridge is present the dual line feature shall continue through the bridge. Islands: The double line stream shall be captured around an island if the features on either side of the island meet the criteria for capture. In this case a segmented polygon shall be used around the island in order to allow for the island feature to remain as a "hole" in the feature.

Inland Ponds and Lakes

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

Feature Class: PONDS_AND_LAKES
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 that are at a constant elevation.

Table Definition

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

Feature Definition

Description	Definition	Capture Rules
Ponds and Lakes	Land/Water boundaries of constant elevation water bodies such as lakes, reservoirs, ponds, etc. Features shall be defined as closed polygons and contain an elevation value that reflects the best estimate of the water elevation at the time of data capture. Water body features will be captured for features 2 acres in size or greater. “Donuts” will exist where there are islands within a closed water body feature greater than ½ acre in size.	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> Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually. An Island within a Closed Water Body Feature will also have a “donut polygon” compiled. 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.

Contact Information

Any questions regarding this document should be addressed to:

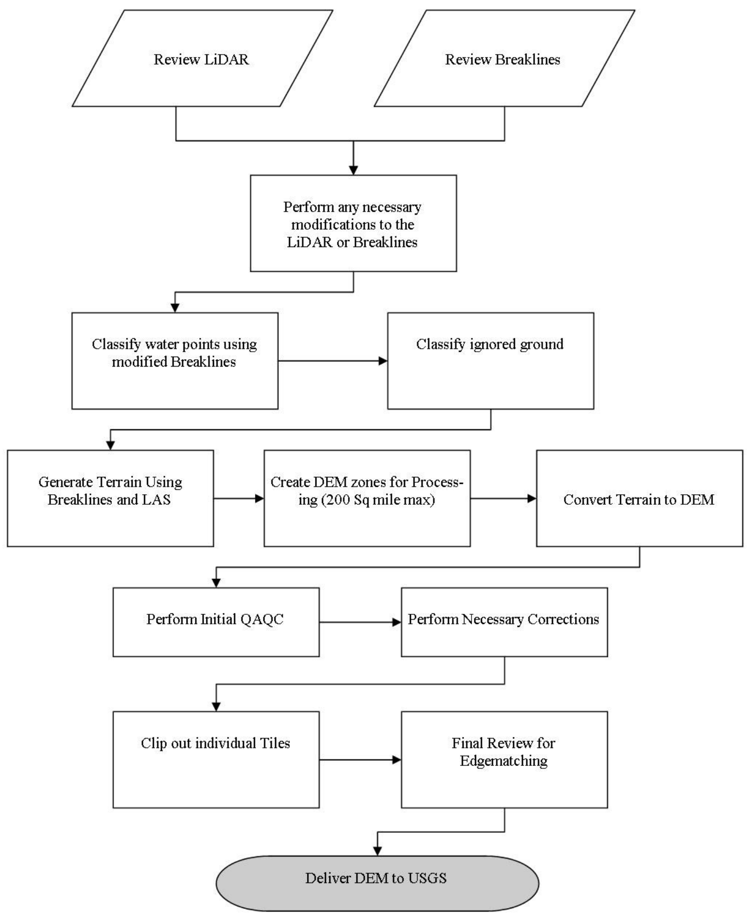
Brian Mayfield, C.P., GISP, G.L.S.
Director of Remote Sensing Services
Dewberry
1000 N. Ashley Dr., Suite 801
Tampa, FL 33602
(813) 421-8628 – voice
(703) 340-4141 – cell
bmayfield@dewberry.com

7 DEM Production & Qualitative Assessment

7.1 DEM Production Methodology

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

Dewberry Hydro-Flattening Workflow



1. Classify Water Points: LAS point falling within hydrographic breaklines shall be classified to ASPRS class 9 using TerraScan. Breaklines must be prepared correctly prior to performing this task.
2. Classify Ignored Ground Points: Classify points in close proximity to the breaklines from Ground to class 10 (Ignored Ground). Close proximity will be defined as no more than 1x the nominal point spacing on the landward side of the breakline. Breaklines will be buffered using this specification and the subsequent file will need to be prepared in the same manner as the water breaklines for classification. This process will be performed after the water points have been classified and only run on remaining ground points.

3. Terrain Processing: A Terrain will be generated using the Breaklines and LAS data that has been imported into Arc as a Multipoint File. If the final DEMs are to be clipped to a project boundary that boundary will be used during the generation of the Terrain.
4. Create DEM Zones for Processing: Create DEM Zones that are buffered around the edges. Zones should be created in a logical manner to minimize the number of zones without creating zones too large for processing. BAE will make zones no larger than 200 square miles (taking into account that a DEM will fill in the entire extent not just where LiDAR is present). Once the first zone is created it must be verified against the tile grid to ensure that the cells line up perfectly with the tile grid edge.
5. Convert Terrain to Raster: Convert Terrain to raster using the DEM Zones created in step 6. In the environmental properties set the extents of the raster to the buffered Zone. For each subsequent zone, the first DEM will be utilized as the snap raster to ensure that zones consistently snap to one another.
6. Perform Initial QAQC on Zones: During the initial QA process anomalies will be identified and corrective polygons will be created.
7. Correct Issues on Zones: BAE will perform corrections on zones following Dewberry's correction process.
8. Extract Individual Tiles: BAE will extract individual tiles from the zones utilizing the Dewberry created tool.
9. Final QA: Final QA will be performed on the dataset to ensure that tile boundaries are seamless.

7.2 DEM Qualitative Assessment

Dewberry performed a comprehensive qualitative assessment of the DEM deliverables to ensure that all tiled DEM products were delivered with the proper extents, were free of processing artifacts, and contained the proper referencing information. This process was performed in ArcGIS software with the use of a tool set Dewberry has developed to verify that the raster extents match those of the tile grid and contain the correct projection information. The DEM data was reviewed at a scale of 1:5000 to review for artifacts caused by the DEM generation process and to review the hydro-flattened features. To perform this review Dewberry creates HillShade models and overlays a partially transparent colorized elevation model to review for these issues. Upon completion of this review the DEM data is loaded into Global Mapper to ensure that all files are readable and that no artifacts exist between tiles.

7.3 DEM Vertical Accuracy Results

The same 67 checkpoints that were used to test the vertical accuracy of the LiDAR were used to validate the vertical accuracy of the final DEM products as well. Accuracy results may vary between the source LiDAR and final DEM deliverable. DEMs are created by averaging several LiDAR points within each pixel which may result in slightly different elevation values at each survey checkpoint when compared to the source LAS, which does not average several LiDAR points together but may interpolate (linearly) between two or three points to derive an elevation value.

Table 7 summarizes the tested vertical accuracy results from a comparison of the surveyed checkpoints to the elevation values present within the final DEM dataset.

Table 7 — FVA, CVA, and SVA Vertical Accuracy at 95% Confidence Level

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=0.61 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.21 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.21 ft
Consolidated	67		0.90	
Open Terrain	24	0.44		
Grass/Weeds/Crop	23			0.87
Forest	20			1.00

The $RMSE_z$ for checkpoints in open terrain only tested 0.22 ft, within the target criteria of 0.31 ft. Compared with the 0.61 ft specification, the FVA tested 0.44 ft at the 95% confidence level based on $RMSE_z$ x 1.9600.

Compared with the 1.21 ft specification, CVA for all checkpoints in all land cover categories combined tested 0.90 ft at the 95% confidence level based on the 95th percentile.

Compared with target 1.21 ft specification, SVA for checkpoints in the grass, weeds, and crops land cover category tested 0.87 ft and checkpoints in the forest land cover category tested 1.00 ft at the 95% confidence level based on the 95th percentiles.

Table 8 lists the 5% outliers that are larger than the 95th percentile, or 0.95 feet.

pointNo	NAD_1983_NSRS2007 Virginia State Plane Coordinate System, North Zone		NAVD88	DEM - Z (feet)	Delta Z
	Easting - X (feet)	Northing - Y (feet)	Survey -Z (feet)		
GWC-15	11302653.22	6779740.98	1476.38	1477.72	1.34
GWC-3	11422256.70	6899051.85	1103.94	1104.86	0.92
FO-20	11295924.40	6704602.91	1963.95	1964.93	0.98
FO-6	11392868.28	6866320.93	1319.34	1317.98	-1.36

Table 8 — 5% Outliers

Table 9 provides overall descriptive statistics.

100 % of Totals	RMSE (ft) Open Terrain Spec=0.31ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated		0.29	0.13	-0.06	0.38	67	-1.36	1.34
Open Terrain	0.22	0.18	-0.03	0.44	0.23	24	-0.43	0.55
Grass/Weeds/Crop		0.25	0.16	2.08	0.34	23	-0.28	1.34
Forest		0.45	0.32	-1.58	0.52	20	-1.36	0.98

Table 9 — Overall Descriptive Statistics

7.3 DEM QA/QC Checklist

Project Number/Description: TO G11PD00336 USGS NRCS Virginia LiDAR
Date:______02/17/2012_____
Overview

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

Review

☒ Manually review bare-earth DEMs with a hillshade to check for issues with hydro-enforcement process or any general anomalies that may be present. Specifically, water should be flowing downhill, water features should NOT be floating above surrounding terrain and bridges should NOT be present in bare-earth DEM. Hydrologic breaklines should be overlaid during review of DEMs.
☒ Overlap points (in the event they are supplied to fill in gaps between adjacent flightlines) are not to be used to create the bare-earth DEMs
☒ DEM cell size is 2.5 feet
☒ Perform final overview in Global Mapper to ensure seamless product.

Metadata

☒ Project level DEM metadata XML file is error free as determined by the USGS MP tool

☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc.

Completion Comments: Complete - Approved