Accuracy Assessment of the CMC Electronics Superstar II GPS Receiver

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Background

Unlike many low cost single frequency receivers, the CMC Superstar II outputs carrier phase measurements. This report attempts to gauge the accuracy of this receiver in a rural environment in two separate surveys just outside of Calgary, Alberta, Canada. The receiver used in both tests was the Navistar with Superstar II board and built-in patch antenna. The Navistar is an "all in one" device containing antenna + receiver in a mouse-like form factor. Post processing was accomplished with Waypoint's GrafNav GPS post-processing package version 6.03.

Survey #1

Introduction

Despite the rural setting, some signal obstructions were encountered during this test that contributed to signal degradation. These obstructions included large treed sections, electrical transformers, and large trucks passing in the immediate vicinity of the survey.

Method

The following figure shows GrafNav's processed representation of the first survey.

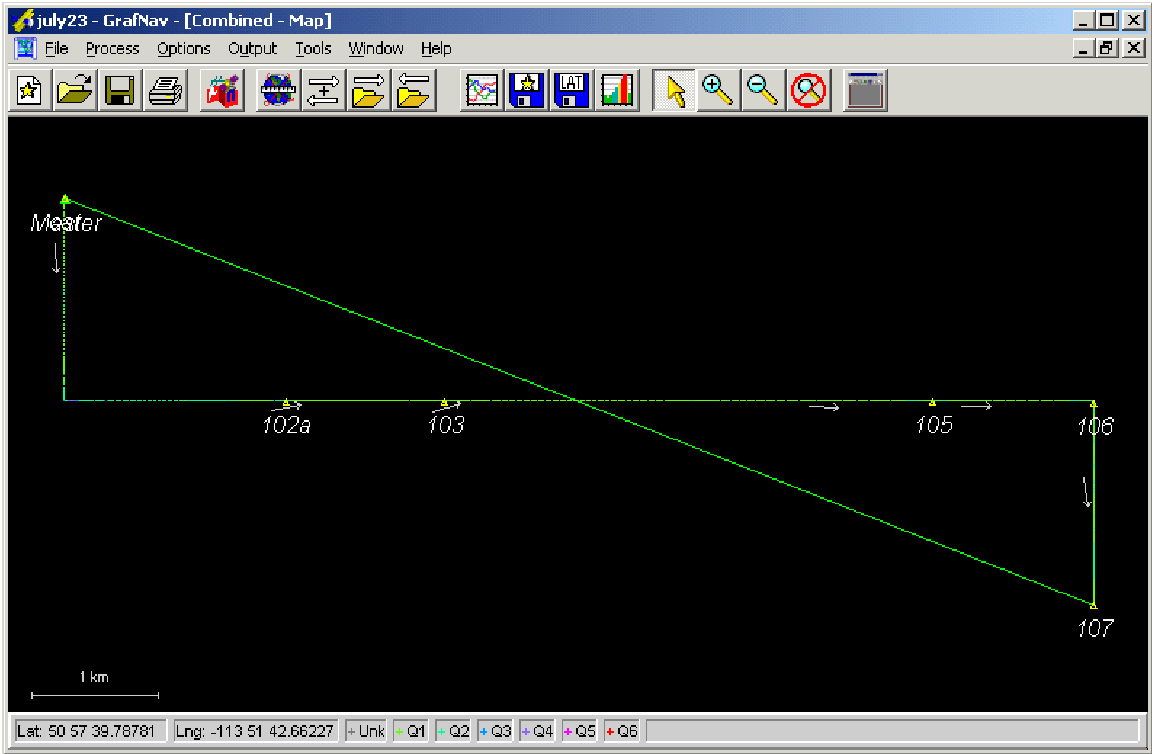

Figure 1: Survey Route #1

A base station was established by placing a NovAtel 3151 receiver on a known fence post along a rural road. The remote, a CMC Superstar II, was taped to the roof of a car that was then driven to five checkpoints. Before and after the kinematic survey, 20-minute static sessions were observed. Due to the small size of the receiver and the difficulty of re-taping it to the car without inducing a loss of lock, the car was simply driven as close as possible to the known point. A tape measure was then used to measure the distance from a point on the receiver to the checkpoint. To gauge the accuracy, the coordinates of the remote (at the time of measuring) were inversed with the checkpoint coordinates and this computed distance was compared to the taped distance. This procedure introduced error because the distance to the phase center of the CMC Superstar II was not measured, just a convenient place on the outside of the receiver.

Results

As mentioned previously, given the many signal obstructions that were incurred during the survey and the sources of error inherent in the procedure of the survey, these accuracy values are considered pessimistic.

Station	Dist to Base (km)	Measured Distance from Receiver to Station (m)	Calculated Distance from Receiver to Station (m)	Accuracy (m)
102a	2.37	4.20	4.22	0.02
103	3.40	2.95	2.89	0.06

105	7.05	3.87	3.95	0.08
106	8.31	2.86	2.83	0.07
107	8.75	4.78	4.82	0.04
107	8.75	4.78	4.81	0.03

Analysis

The phase plot of the CMC Superstar II is shown below:

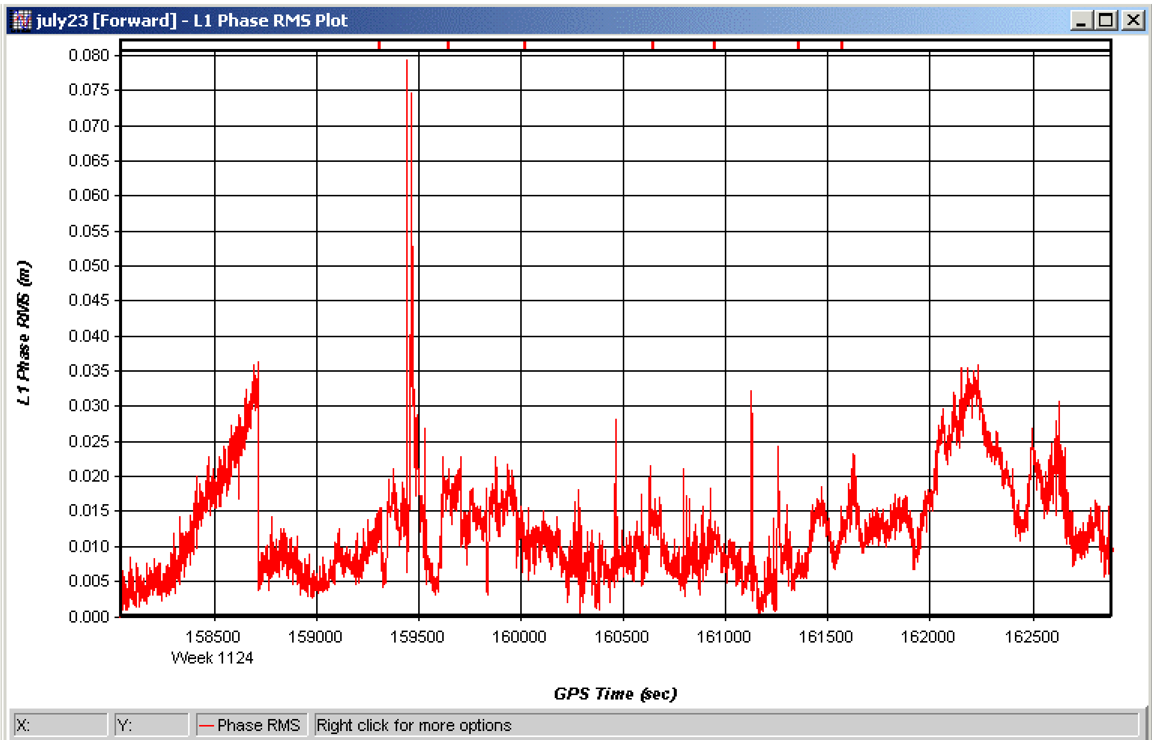

Figure 2: L1 Phase RMS Experiment #1

The small red lines at the top of the plot show when the stations were marked. It is easily observed from this plot that the second point (station 103), third point (station 105), and fourth point (station 106) were observed after about 3, 9 and 19 minutes respectively after a serious loss of lock (as seen from the large spike in the phase plot). This explains their relatively poor accuracies compared to the first and the last check points, as the solution took over 20 minutes to converge back to a couple of centimeters.

Survey #2

Introduction

The previous experiment was hindered by signal degradation problems as well as an awkward method of determining checkpoint accuracy. To avoid these difficulties in this survey, a new route was planned and a portable method of placing the remote receiver directly over the checkpoints was devised.

Method

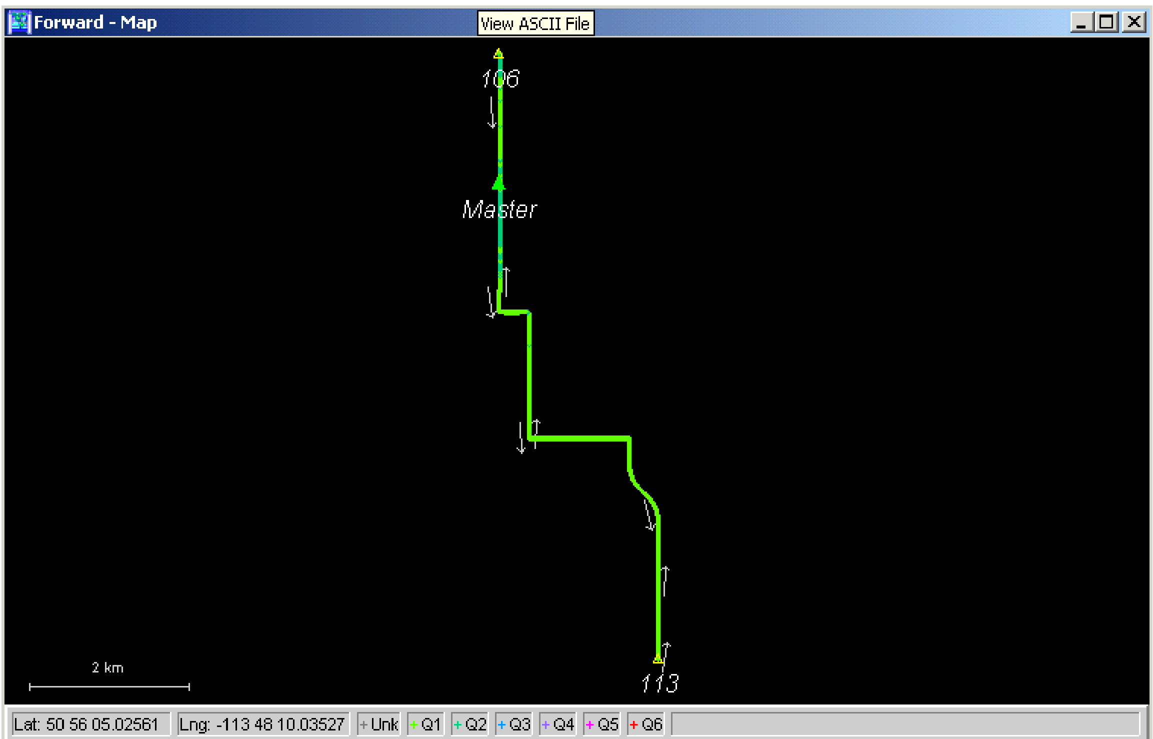

Figure 3: Survey Route #2

As in the first experiment, a NovAtel 3151 acted as the base station. The CMC Superstar II was taped to a portable ground plane that was magnetically attracted to the roof of the car. This made it possible to place the Superstar II directly over the checkpoints. Generally, conditions were much better than the first experiment as lock was maintained on seven satellites at all times. A twenty-minute static session was performed only at the beginning of the survey, which covered roughly 15 km in length.

Results

The remote static initialization was performed over point 106. Point 113 was then used as a checkpoint, and then point 106 was revisited to form a tie. These coordinates were obtained from the forward solution, in which a fixed solution was obtained.

Station	Dist to Base	Horizontal Error (m)	Vertical Error (m)	Comment
106	1.60 km	0.0438 N, 0.0213 E	0.018	Static Initialization
113	6.26 km	0.0246 N, 0.0417 E	0.019	Kinematic Check
106	1.60 km	0.0459 N, 0.0153 E	0.013	Kinematic Check

Generally, accuracies seemed to be good to within 5 centimeters in the horizontal and, surprisingly, within 2 cm in the vertical.

Analysis

Due to GrafNav's extensive plotting capabilities, data can be thoroughly analyzed. What follows is a brief look into the quality of the observed measurements in this survey.

As no static data was collected at the end of the survey, reverse processing suffered in float mode, as the following forward/reverse plot shows:

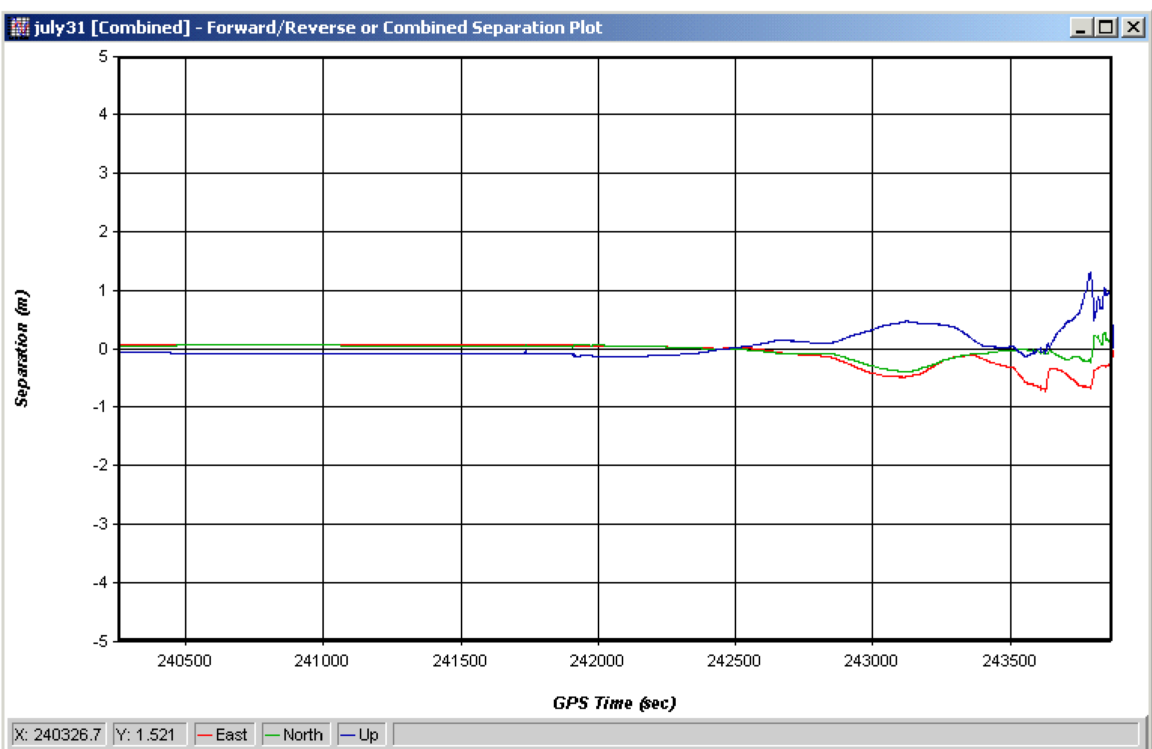

Figure 4: Combined Difference of forward/reverse float solutions

As seen from the graph, the reverse solution took about 20 minutes to converge to a near identical solution as the forward solution. Despite this, sub-50 cm agreement between the two solutions was available almost instantly. This gives some indication of the expected float accuracy of the CMC Electronics Superstar II if no static initialization or kinematic ambiguity resolution techniques are performed. It is important to note that combining the forward and reverse solutions does not degrade the solution accuracy, as GrafNav weights the two solutions internally.

The quality of the phase measurements can be seen by the following graph:

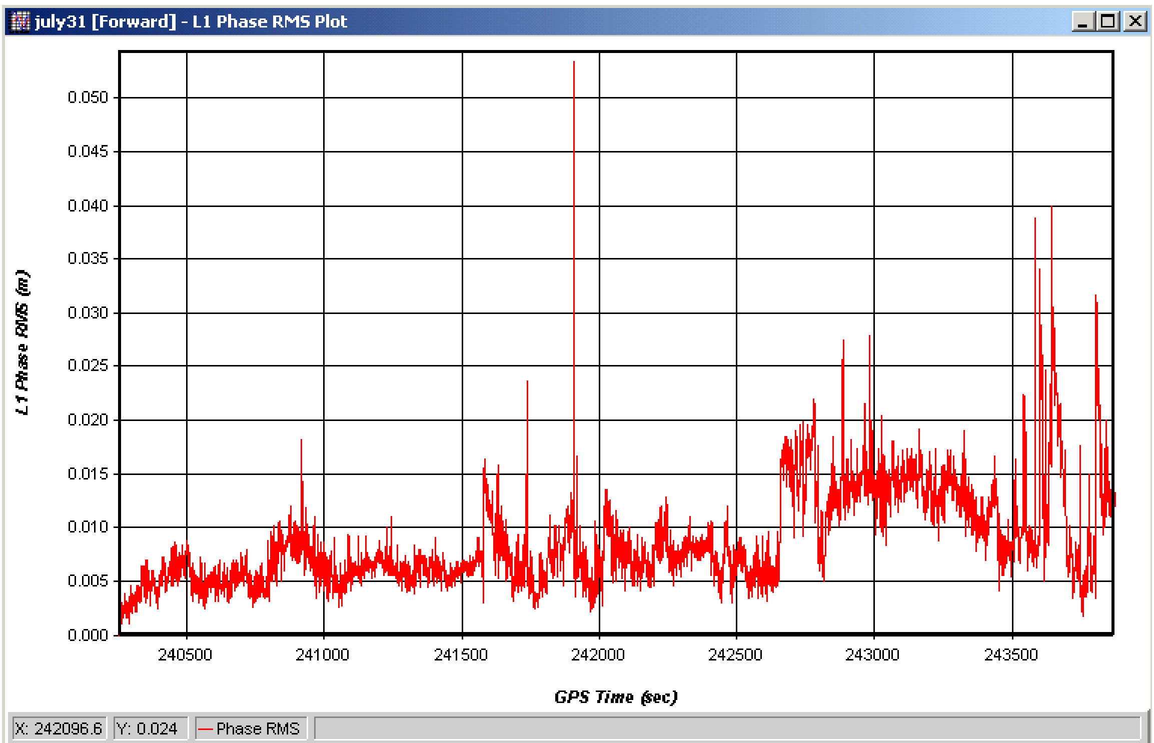

Figure 6: Phase plot of survey #2

Upon further analysis, it can be shown that the spikes in the phase plot coincide exactly with spikes in the observed DOP values:

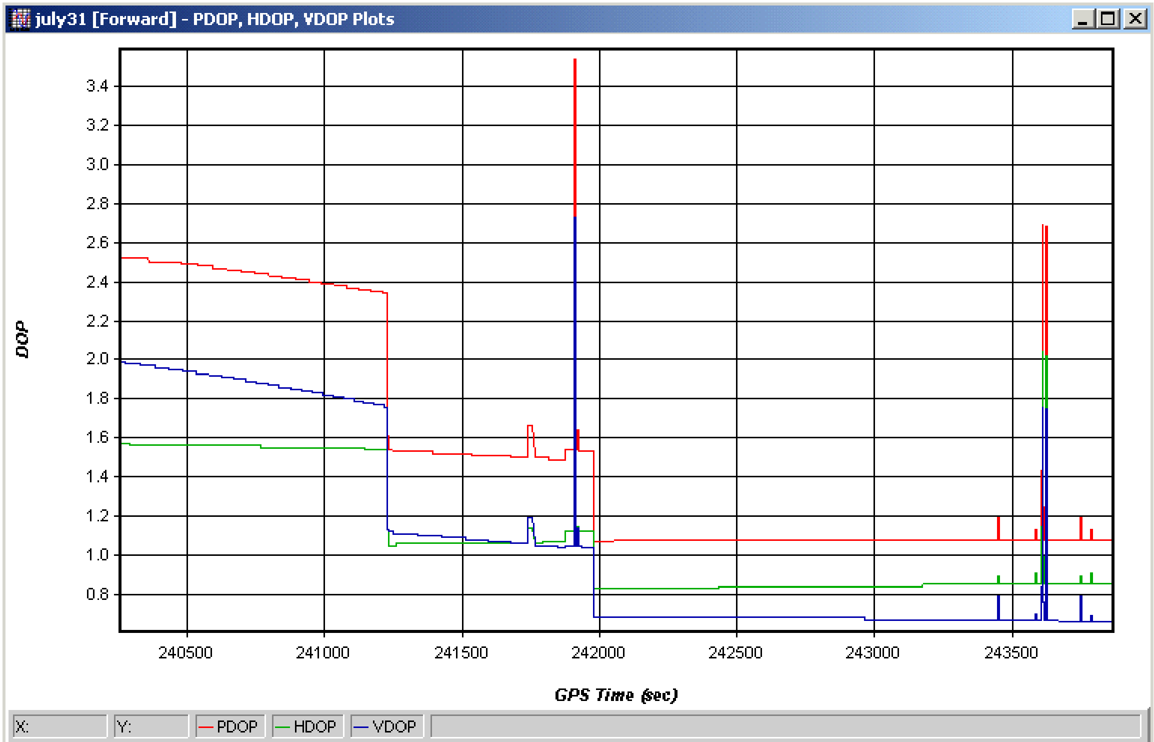

Figure 5: Observed DOP of experiment #2

Passing obstructions such as treed areas, which temporarily blocked satellites from view, likely caused the spikes in the DOP plot.

OTF processing in reverse direction

As no static data was collected at the end of the survey, OTF techniques must be used if centimeter accuracies are desirable quickly in reverse processing. The following graph shows the difference between the forward fixed solution and the reverse OTF solution.

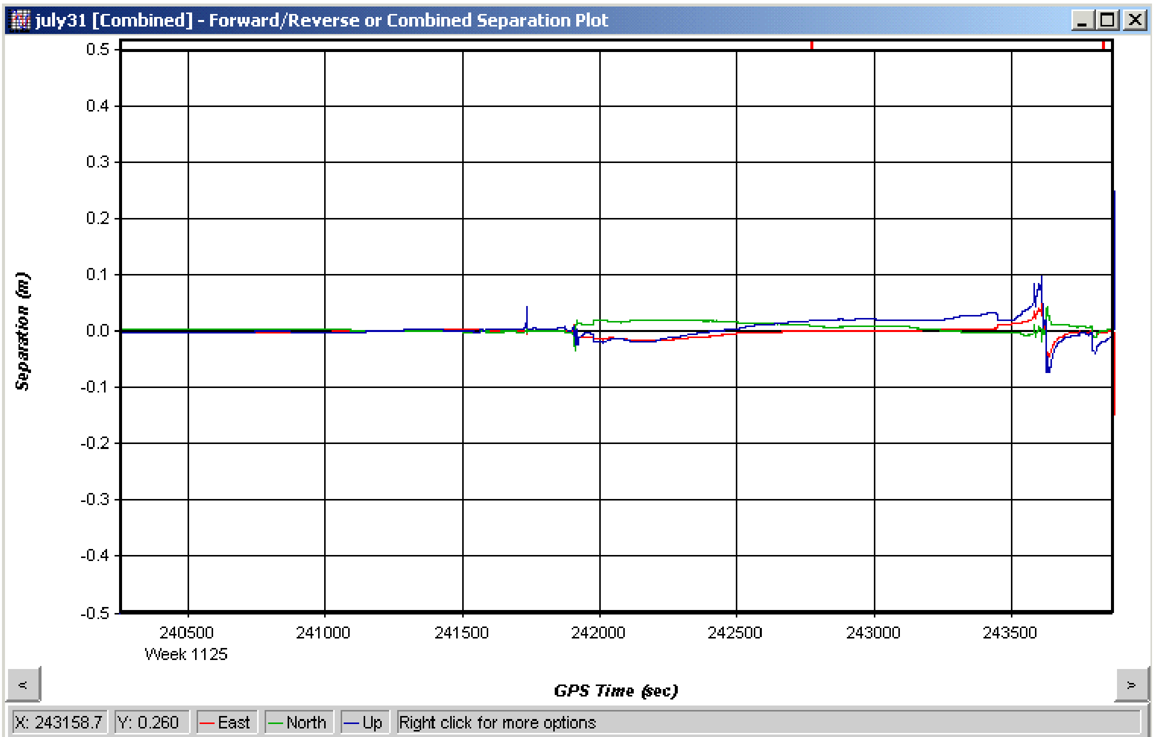

Figure 4: Combined difference between forward fixed solution and the OTF solution

The OTF solution was at worst only briefly 10 cm different than the forward solution. Otherwise, the two solutions agreed to very closely (within 2 cm).

Conclusion

It is clear from the two surveys that this receiver should be seriously considered for sub-10 centimeter surveys, and could possibly even be used in high accuracy applications. Given its very low cost and the surprisingly accurate results, this is a receiver that could soon be widely used.

The first survey shows that this receiver can maintain sub-10 centimeter accuracies despite briefly passing large signal obstructions such as treed sections, electrical transformers and large trucks. The second survey shows how effective single frequency OTF techniques can be used given open conditions with many satellites in view. Additionally, this survey produced float results that were again well below the decimeter level.

It is important to realize that during both surveys, a high quality receiver was used as the base station (NovAtel 3151), and there were generally seven satellites in view with a reasonably good view to the sky. More testing should be performed to validate the results presented here. Users attempting to reproduce these results should keep the above conditions in mind as GPS performance degrades significantly in urban canyon or tree cover.