



Evaluation of the Trimble ProXRS GPS Receiver Using Satellite Real-Time DGPS Corrections

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During 1998, the Missoula Technology and Development Center (MTDC) evaluated the real-time accuracy of the Trimble ProXRS GPS Receiver (Figure 1) using the OmniSTAR Satellite Differential Global Positioning System (DGPS). The evaluation was conducted under the forest canopy at the Lubrecht GPS Test Facility near Missoula, MT, on the B course, and in the open on the A course. This report compares the horizontal accuracy of data obtained using real-time differential satellite corrections, to that obtained by differential postprocessing of the data.

The B course consists of a 4.36-acre polygon with seven turning points (Stations B11 to B17). It is located on gentle terrain under a mixed canopy of ponderosa and lodgepole pine that is typical of the Intermountain Northwest. The trees are about 20 meters tall. The A course is a 4.75-acre polygon containing seven turning points (Stations A11 to A17) with no obstructions to the signal. The course is on gentle terrain.

The Trimble ProXRS is a 12-channel, real-time differential GPS receiver with an integrated antenna. The antenna receives the GPS signal and the real-time differential corrections broadcast by a satellite differential service, or by a radio beacon maintained by the U.S. Coast Guard or the U.S. Army Corps of Engineers. The operator can select which real-time broadcast to use. This



Figure 1—Trimble ProXRS GPS system: TDC1 data logger (left), GPS receiver (center), and integrated antenna (right). The antenna receives GPS signals and real-time DGPS corrections.

report documents OmniSTAR Satellite Service use.

The OmniSTAR system includes 10 permanent base stations that are located around the perimeter of the continental United States and one in Mexico. These base stations track all

GPS satellites more than 5° elevation above the horizon and compute corrections. The corrections are sent to the OmniSTAR's Network Control Center where the data are checked and reformatted. From there they are broadcast to a geosynchronous satellite and back down to the user. Correction messages



are broadcast about every 2½ seconds. This subscription service costs about \$800 per year (in early 1999).

The ProXRS receiver tested contains firmware Version 1.1. It is capable of outputting both the real-time differentially corrected position as well as the raw data for each position. Data were collected using the Trimble System Controller (TSC1) data logger with Asset Surveyor Software Version 4.01. The data collection interval was set at 1 second, with the PDOP and SNR masks set at 6, and the elevation mask set at 15°. Pathfinder Office Software Version 2.01 was used to differentially postprocess the raw-position data and display both the postprocessed and real-time-corrected position data. Base-station data for postprocessing were obtained from the Forest Service base station in Missoula (<http://www.fs.fed.us/database/gps/missoula.htm>). That station, just 30 miles from the test site, records data at 5-second intervals.

The B course (under canopy) was traversed three times with the ProXRS receiver. At each station a point file with about 150 position records was collected. Most of these records were satellite real-time-corrected positions. At some locations, the corrected signal was attenuated by the canopy. Position files from such locations contain both real-time-corrected and uncorrected positions. The captions of Figures 2 to 4 provide information on the stations with uncorrected positions. About 79% of the positions (2,519 of 3,173) were real-time corrected. This may indicate that the real-time signal was only 79% as efficient in penetrating the canopy under the test conditions and at the test latitude as the GPS signals. At lower latitudes, the percentage of real-time correction might increase because the geosynchronous satellites would be nearer the zenith where less of the canopy would attenuate the real-time correction signal.

Figures 2 to 4 also show the calculated average-horizontal-position error at each station on the B course for both the satellite real-time correction and the postprocessed correction. In general,

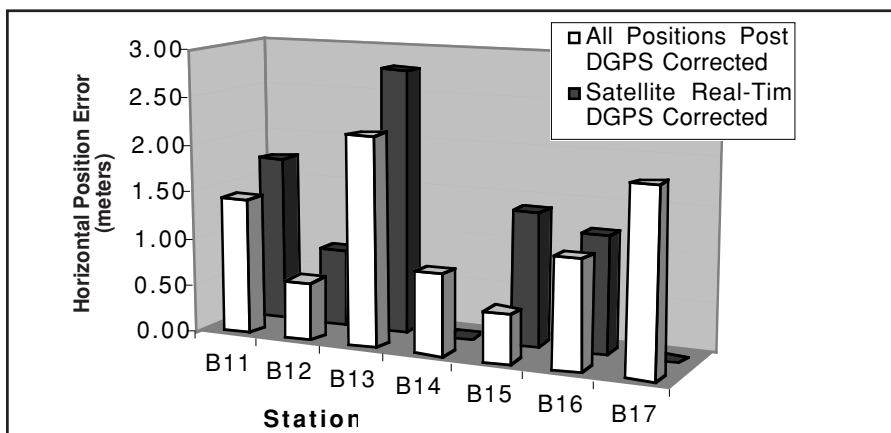


Figure 2—GPS accuracy using real-time DGPS corrections and postprocessed corrections for stations under the forest canopy on B course (first walk). All data were real-time corrected except Station B15 (56 of 152 positions real-time corrected), and Stations B14 and B17 (151 positions each) with no real-time corrections.

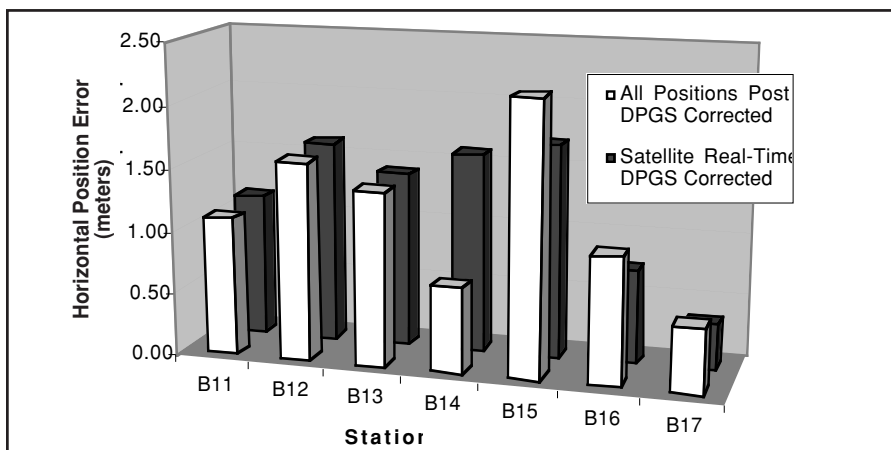


Figure 3—GPS accuracy using real-time DGPS corrections and postprocessed corrections for stations under the forest canopy on the B course (second walk). All data were real-time corrected, except Station B14 (109 of 152 positions real-time corrected), and Station B17 (125 of 151 positions real-time corrected).

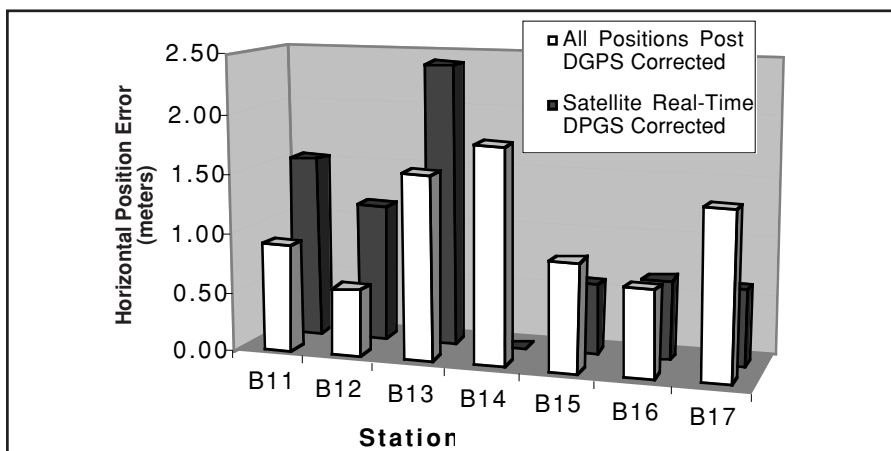


Figure 4—GPS accuracy using real-time DGPS corrections and postprocessed corrections for stations under the forest canopy on the B course (third walk). All data were real-time corrected, except Station B14 (none of the 111 positions real-time corrected), and Station B15 (78 of 154 positions real-time corrected).

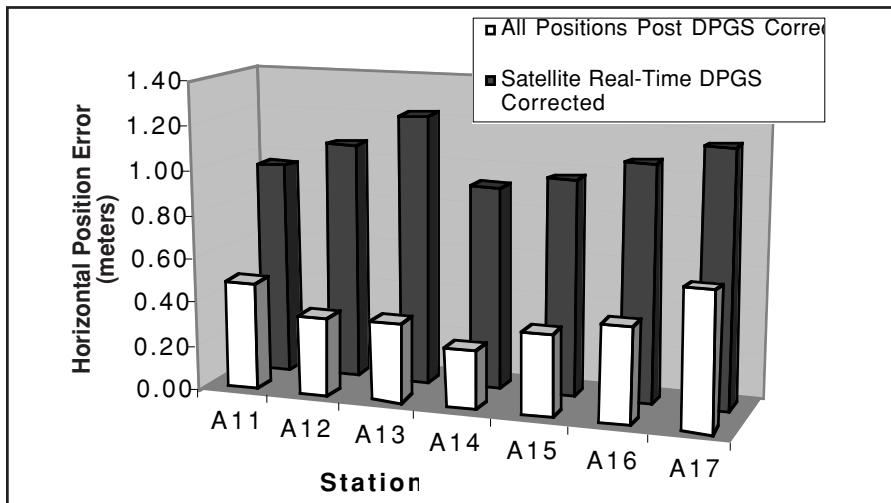


Figure 5—GPS accuracy using real-time DGPS corrections and postprocessed corrections for stations in the open (no canopy) on A course (first walk).

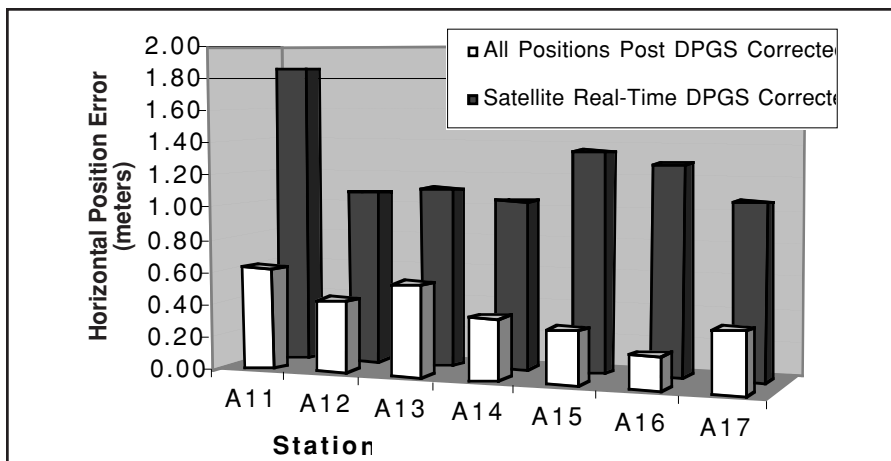


Figure 6—GPS accuracy using real-time DGPS corrections and postprocessed corrections for stations in the open (no canopy) on A course (second walk).

the postprocessed correction produced more accurate results. The exceptions were Stations B15 to B17 (Figures 3 and 4). Postprocessed corrections at this site would be expected to be accurate because the base station is just 30 miles from the test site. Real-time corrections are generated by base stations scattered around the perimeter of the United States. Because these stations may be hundreds of miles from the interior of the United States, a real-time correction will have a longer latency before it is received. Latency is the time it takes for the real-time-correction message to be generated, broadcast, and received. The longer the latency, the less accurate the cor-

rections, and the less accurate the real-time-corrected positions. We do not have a good explanation of why the real-time-corrected positions of Stations B15 to B17 were more accurate than the postprocessed positions. If the 1-second receiver recording interval had been synchronized with the 5-second base-station interval, the postprocessed positions would have been more accurate. This may account for the discrepancy.

The Trimble ProXRS receiver was used to traverse the A course (no canopy) twice—once with the TSC1 data logger and once using a Fujitsu pen-based computer as the data logger. Both were

set to collect data at a 1-second interval. A point file of about 150 position records was recorded at each station. With no canopy attenuating the signal, all positions were real-time corrected. Postprocessed corrections produced considerably more accurate positions than the real-time corrections (Figures 5 and 6). This is because the base station was much closer to the test site than the stations generating real-time satellite corrections.

Figure 7 shows the horizontal-position error for each station by correction method and canopy condition. Only those stations where all the positions were real-time corrected are shown. The largest position error occurred under the canopy. The real-time-corrections error was 2.79 m (9.15 ft), and postprocessing-corrections error was 2.19 m (7.19 ft). The average horizontal error for these stations was 1.40 m (4.60 ft) for real-time corrections, and 1.28 m (4.19 ft) for postprocessed corrections. The difference between the two methods is only 0.12 m (0.41 ft) for operation under the canopy when using unsynchronized data for postprocessing. Had the ProXRS logging interval (1 second) been set to the 5-second interval used by the Missoula base station, the accuracy of the postprocessed data would have increased, possibly increasing the difference in accuracy between the two correction methods.

For operation with no canopy to attenuate the signals, the largest real-time correction error was 1.87 m (6.12 ft), and 0.63 m (2.07 ft) for postprocessed corrections. The overall average horizontal error in the open for the real-time corrections was 1.16 m (3.79 ft) and 0.42 m (1.36 ft) for postprocessed corrections. The difference between the two methods is 0.74 m (2.4 feet). These data indicate that the Trimble ProXRS GPS receiver can produce accuracy to less than a meter when used in the open and corrected with postprocessed corrections. Operations under the canopy resulted in less-accurate data, because the canopy attenuates the signals, producing less-accurate positions.

UNDER CANOPY								OPEN CANOPY							
Postprocessed DGPS Corrected								Postprocessed DGPS Corrected							
Station	B11	B12	B13	B14	B15	B16	B17	Station	A11	A12	A13	A14	A15	A16	A17
	1.44	0.61	2.19	x	x	1.14	x		0.49	0.36	0.36	0.27	0.37	0.44	0.62
	1.11	1.59	1.40	x	2.19	1.02	x		0.63	0.44	0.56	0.38	0.33	0.20	0.37
Totals	3.46	2.76	5.15	x	2.19	2.89	1.41	Totals	1.12	0.80	0.92	0.65	0.70	0.64	0.99
Average error = 1.28 m (4.19 ft)								Average error = 0.42 m (1.36 ft)							
Satellite Real-Time DGPS Corrected								Satellite Real-Time DGPS Corrected							
	1.76	0.80	2.79	x	x	1.22	x		0.97	1.08	1.23	0.93	0.98	1.07	1.16
	1.15	1.62	1.41	x	1.71	0.75	x		1.87	1.08	1.11	1.05	1.36	1.29	1.07
Totals	4.46	3.59	6.60	x	1.71	2.64	0.64	Totals	2.84	2.16	2.34	1.98	2.34	2.36	2.23
Average error = 1.40 m (4.60 ft)								Average error = 1.16 m (3.79 ft)							
<i>X = Because all positions were not real-time corrected for these stations, the errors are not included.</i>															

Figure 7—Horizontal-position error for all stations (including real-time DGPS corrections and postprocessed corrections), September 1 and 2, 1998.

Conclusions

This test indicated that the forest canopy could attenuate satellite real-time DGPS correction signals, preventing them from being picked up by the receiver. No real-time corrections at all were received for Stations B14 and B17 (Figure 2) or for Station B14 (Figure 4). In some cases only a portion of the positions were real-time corrected: Station B15 (Figure 2), Stations B14 and B17 (Figure 3), and Station B15 (Figure 4). The percentage of positions with real-time corrections might in-

crease at lower latitudes because the geosynchronous satellite broadcasting the real-time signal would be nearer the zenith. The signal would potentially have less canopy to penetrate, but a heavy canopy could still attenuate the signal. Topography could block the satellite signal on north-facing slopes, especially at the higher latitudes. If you are planning a satellite real-time operation under the canopy, allow extra time to get the data.

This test indicated that when the Trimble ProXRS GPS receiver was used in the

open and corrected with OmniSTAR satellite DGPS, it provided nearly 1-meter (1.16 m, 3.79 ft) average horizontal-position accuracy. If the data are postprocessed, the ProXRS will produce better than 1-meter (0.42 m, 1.36 ft) average horizontal accuracy. For operations under the canopy, the average horizontal accuracy was 1.28 m (4.19 ft) with postprocessed corrections, and 1.40 m (4.60 ft) with the real-time corrections. The maximum errors were 2.19 m (7.19 ft) and 2.79 m (9.15 ft) with real-time corrections. ☞

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Library Card

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Describes evaluation of the real-time accuracy of the Trimble ProXRS GPS receiver using the OmniSTAR satellite differential global positioning system (DGPS). The evaluation was conducted at the Lubrecht GPS test facility near Missoula, MT. The Trimble ProXRS is a 12-channel receiver that can integrate GPS signals with real-time differential corrections broadcast by a satellite differential service or by a radio beacon. The OmniSTAR Satellite Service was used during this evaluation. When the Trimble ProXRS was used in the open and corrected with the satellite data, it provided nearly 1-meter horizontal-position accuracy. When the GPS unit was operated under the canopy, the average horizontal accuracy was 1.4 meters with the real-time corrections.

Keywords: accuracy, DGPS, differential corrections

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