Seismic Surveying under Tree Canopy Using Ashtech GG-24 GPS/Glonass Receivers and Waypoint's GrafNav Post-Processing Software

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Introduction

Current seismic exploration in forested areas is increasingly subject to environmental regulations aimed at decreasing the impact of seismic cut lines on forest regions. In many cases, these cut lines have decreased in width to a 1-m hand cut with virtually no view of the sky. Seismic surveying has started to rely on GPS as its principal surveying tool. Unfortunately, GPS may have serious deficiencies under the forest canopy.

This report describes an experimental seismic survey performed in post-processing mode by Paladin Positioning Inc. of Calgary, Alberta using Ashtech GG-24 receivers provided by Gemini Positioning Systems. The purpose of the survey was to show that in combination with proper field procedures, GPS/Glonass receivers are capable of providing sufficient accuracy for seismic purposes. As well as, production comparable to or better than that achievable with conventional survey equipment. Waypoint's GrafNav post-mission package, incorporating its new GPS/Glonass capability, was used to process the data.

Figure 1: GPS\Glonass in the Forest

The Survey

This survey took place on a typical existing seismic hand-cut line of 1.5-m width in the Water Valley area 50-km northwest of Calgary. This is a sensitive foothill area where the conventional 8-m wide bulldozed seismic lines are no longer acceptable; a situation more and more prevalent in the oil and gas industry. Modern geophysical surveys place large emphasis on minimum environmental impact. Unfortunately, the problem with conventional survey techniques is that they are difficult to perform without reasonable line of sight. This means cutting valuable timber in order to satisfy accuracy and production requirements for survey crews. With GPS, the difficulty from the surveyor's point of view is that tree cover on a narrow hand-cut line degrades the GPS signal to the point where typical kinematic GPS surveys are unacceptable. Indications are that kinematic GPS under heavy tree canopy may produce coordinate errors up to 10 m or more, especially when the GPS antenna is in motion.

On the other hand, it has been observed that static GPS antennae produce a signal that is considerably more well-behaved under forest cover. This led the authors of this report to independently arrive at the conclusion that short static sessions interspersed with kinematic data might provide accuracies and production levels adequate for seismic survey specifications.

Precision requirements in geophysical surveys are generally in the order of several metres horizontally and one metre vertically. Production levels are quantified by measuring the number of kilometres of seismic line surveyed per day. This amount varies according to the terrain and type of geophysical work being performed. On a narrow hand-cut line in moderate terrain, 6 - 8 km would be a very reasonable day's work.

Figure 2: Minimum Environmental Impact

Figure 3: Typical Seismic Hand-Cut Line

Seismic surveys are essentially topographic surveys performed on lines cut through terrain overlaying possible oil and gas formations. At intervals varying between 50 m and 100 m, a flag is placed on the ground indicating that an energy source (typically dynamite or vibrators), called a "shot point", is to be situated at that location. Using the static/kinematic scheme proposed above, it would seem reasonable to occupy each of the shot points for some given static interval. While moving from point to point, the receiver data would be tagged as kinematic. The key issue is to determine the optimal static time to be allotted to each point of interest. This interval must be sufficiently long to enable the GPS solution to converge to at least one metre vertically, while still allowing the surveyor to visit enough stations to satisfy production requirements.

In the survey described in this report, only eight points were occupied over a typical 800-m portion of an existing seismic cut line. True coordinates for these points were established to an accuracy of approximately 10-cm with a total station survey. The Paladin crews determined that each shot point should be occupied for two consecutive minutes of static with a minimum of six satellites in view. It should be noted that several points under heavier canopy were actually give up to three minutes of static to insure that the minimum number of satellites were continuously observed.

Post-Processed Results

Tables 1 and 2 below depict the coordinate differences between the total station and the post-processed GPS/Glonass surveys. The results in Table 1 were obtained by only using 2 minutes of static data at each station, while the results in Table 2 were obtained by using all of the static data available. In both cases metre level coordinate accuracies were generated by the GPS/Glonass combination, with maximums at the 2-metre level.

Table 1: GPS/Glonass Coordinate Errors using Strictly 2 Minutes of Static with GrafNav Post-Processing Software

Station	Error in Easting	Error in Northing	Error in Height
340	-0.484	0.855	0.260
336	0.721	2.077	1.121
331	0.531	0.922	2.536
328	-0.241	1.581	-0.306
325	0.027	1.715	1.324
317	-1.447	0.924	-0.109
312	0.006	1.009	0.398
304	0.258	0.838	-0.097
311	-1.876	1.063	0.523

RMS	0.868	1.293	1.057

Table 2: GPS/Glonass Coordinate Errors using 2 to 3 Minutes of Static with GrafNav Post-Processing Software

Station	Error in Easting	Error in Northing	Error in Height
340	-0.418	0.820	0.369
336	1.000	2.148	1.346
331	0.399	1.135	1.299
328	-0.221	1.634	-0.031
325	0.090	1.903	0.852
317	-1.242	0.792	0.359
312	0.006	1.042	0.409
304	0.255	0.884	-0.048
311	-1.904	1.073	0.565
RMS	0.858	1.354	0.744

Production-wise, the 800 metres surveyed above took about one hour. Given that this was not a true job-related situation, it is very likely that the survey was not performed with the urgency that would normally be associated with a real-life scenario. Even given the relatively conservative benchmark of 800 m/hr, this still extrapolates to about 6 - 8 km in an average 10-hour day. Considering the number of horizontal angles that would be turned on a line of this type with total stations, this level of production compares very favorably to conventional-style work.

Conclusions

A test on an existing seismic hand-cut line by Paladin Positioning Inc. suggests that under forest canopy, in combination with strict field procedures, GPS/Glonass may be capable of providing coordinate accuracies and production levels sufficient to satisfy seismic requirements. Two guidelines need to be followed to produce results similar to those shown in this report. At each point under foliage, a minimum of 2 minutes of static data should be collected, and during this time, at least 6 satellites must be continuously tracked. It should also be noted that these results were obtained in a post-mission, not RTK, environment.

Further field trials are required to validate the conclusions presented here. It may very well be that ultimately some small relaxation may have to be made in the specification for the vertical component of a seismic survey in order to utilize satellite surveys in a comprehensive manner under tree cover. The trade-off in minimized environmental damage and increased reliability in the overall survey may make this an attractive transaction.