Using Wide Area Differential GPS in a Position Accuracy Audit

Annabel Scott

University of Newcastle

INTRODUCTION

This paper describes how wide area differential GPS was successfully used to complete a positioning accuracy audit during 1999. Positions were to be determined to a 2 metre or better accuracy, and it was decided that WADGPS was by far the most efficient means of producing results at the desired accuracy. The work involved locating a selection of power poles in the area that the client was working, and obtaining a position for the power poles. A comparison and analysis of the obtained positions and the clients positions was carried out to determine if the specifications were being met.

POSITIONING ACCURACY AUDIT

The client had been contracted to supply the coordinates of power poles in the south of NSW. To complete this large scale job, they were using a fixed wing aircraft mounted with an OmniSTAR system to collect their data. The relevant clause of their contract stated that *'The x and y coordinates of each asset are to be captured to an absolute accuracy of ± 1.0 metres in urban areas and ± 15.0 metres in a rural area to a 90% confidence interval. Data must be supplied in Australian Map Grid (AMG) to a precision of 0.001 metre'*. The role of the audit was to obtain independent positions on a selection of the power poles being located by the client in rural areas and to complete an analysis of the results to determine whether the specifications were being met.

It was decided that the most efficient way to complete the audit, both cost and time wise, was to use a WADGPS system to collect the position data. The system used was an OmniSTAR Virtual Base Station (VBS) system which was capable of collecting positions in real time at the required accuracy in a short time interval. The equipment allowed for positions to be determined from 30 second observation sessions, with virtually no set-up or pack-up time needed at the test point locations due to the DGPS antenna being mounted on the vehicle. The stationary position accuracy of the system can be seen in Figure 1. This position accuracy was determined during testing in March 1998 with sixteen different test points being observed with over 5453 observations being made. The same quality control checks and parameters were in place during the testing as was used for the audit.

The positions being collected were to be used as the control in the audit of the client's positions. In determining the actual accuracy specifications from the contract, the accuracy of the equipment was taken into consideration. The determination of the actual accuracy threshold can be seen in a following section.

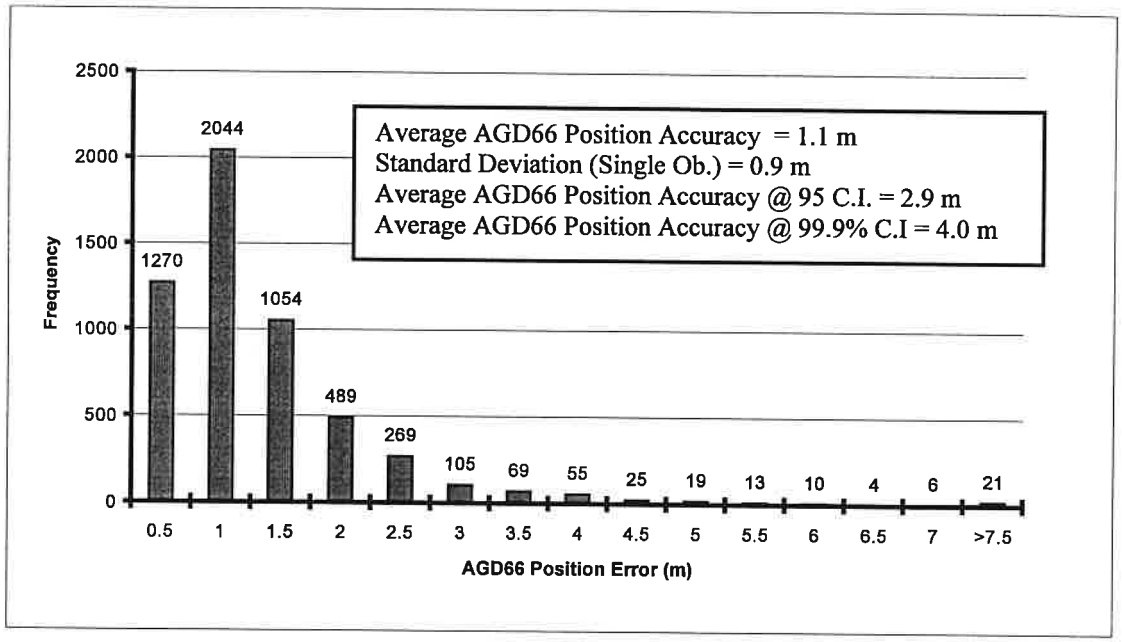

Figure 1 - "Ashtech G12 + OmniSTAR 3000LRE" Stationary Position Accuracy

WIDE AREA DIFFERENTIAL GPS

Wide area differential GPS (WADGPS) is a differential GPS (DGPS) technique that uses a network of reference stations. It is similar to DGPS in that it provides GPS corrections to the users, but the coverage area that the corrections can be used over is much larger and the distance between reference station and user has little or no impact on the accuracy of the system. It also has the benefit over standard DGPS in that if one reference station fails, the network is still able to function at its specified accuracy. One definition of WADGPS is 'a sparse network of GPS reference stations that can provide real-time network DGPS corrections to users over a large region'.

The WADGPS system used to complete this job was an OmniSTAR Virtual Base Station (VBS) system. This system uses corrections from nine base stations around Australia which are continually collecting GPS position data. The corrections from the base stations are sent to the user via the network control centre (NCC) in Perth. All correction data is checked at the NCC to ensure the integrity of the data.

To receive the corrections, the user must have an omnidirectional antenna and an OmniSTAR demodulator, either connected to an external GPS unit or with an inbuilt GPS unit. The antenna receives the corrections, which along with the GPS position, are used to calculate a set of corrections valid at the user position which have been corrected for atmospheric effects at the current location. The correction can then be applied to the user GPS position, either externally or internally to give the final corrected position.

OVERALL ACCURACY THRESHOLD

When a survey is being carried out by an independent organisation for checking purposes, then ideally all survey equipment, field practices and processing methods should produce zero random error. Unfortunately, this is not physically possible therefore a new threshold of accuracy needs to be calculated which makes allowances for the accuracy limitations of the survey. The new threshold can be calculated using the sum of the variances (σ^2) of the error sources.

To work out the standard deviation of the specifications (σ_{spec}) the required accuracy must be divided by a 2D multiplying factor. For a 90% confidence level the multiplying factor is 2.15.

$$\sigma_{spec} = \pm 15.0 / 2.15$$
$$= 6.977$$

The standard deviation for the audit equipment (σ_{equip}) was 0.9 metres (see Figure 1) and the standard deviation of the control positions (σ_{pos}) was 1 metre.

The total variance was calculated as follows:

$$\sigma_{threshold}^2 = \sigma_{spec}^2 + \sigma_{equip}^2 + \sigma_{pos}^2$$
$$= (6.977)^2 + (0.9)^2 + (1)^2$$
$$= 50.489$$
$$\sigma_{threshold} = 7.106$$

$$\therefore \text{Threshold} = 7.106 * 2.15$$
$$= \pm 15.3 \text{ metres}$$

For analysis of the client's positions, a threshold of **±15.5** metres was used.

FIELD WORK

The Positioning Accuracy Audit was carried out over three days with data being collected at two hundred and fifty seven test points, in six test areas close to Griffith, involving over 1000 kilometres of travel. Table 1 shows the area locations and the number of poles located in each test area.

	Location	Number of Poles
1	Carrathool	29
2	Corbie hill	61
3	Goolgowi	17
4	Maude	99
5	Toms Point	28
6	Yarmawl	23
Total		**257**

Table 1- Test Locations

Equipment

The equipment used for the position collection was an OmniSTAR LR12 Workabout system. The equipment required for this system consists of a dual frequency DGPS antenna capable of receiving both GPS signals and WADGPS corrections, a Psion data logger for the data collection, an OmniSTAR VBS unit with an inbuilt 12 channel Ashtech GPS receiver as well as battery power to run the system.

The dual purpose single DGPS antenna was attached to the front roof rack of the four-wheel drive vehicle with all other equipment located inside the vehicle, thus allowing the majority of positions to be collected without having to leave the vehicle. This setup maximised the number of test points that could be visited each day with ease of movement between test points being increased by the use of the four-wheel drive vehicle.

Test Procedure

At each test point, the four-wheel drive vehicle was parked with the DGPS antenna within one metre of the power pole. If the vehicle could not park within one metre of the pole, the DGPS receiver was removed from the roof rack and held adjacent to the power pole. Thirty DGPS position readings were then logged at a rate of one per second and averaged by the Psion before being stored.

At each test point, the four wheel drive vehicle was parked so that the antenna was within one metre of the power pole. Where it was not possible for the vehicle to be parked within one metre of the power pole, then the antenna was removed from the vehicle and held adjacent to the power pole.

Once the antenna was in place at each test point, the Psion was started to begin data collection. Thirty corrected position readings were then logged, at a rate of one per second. During the data logging process, each positions data is shown on the Psion's screen. This allows a comparison between the positions being collected and those supplied by the client. After collecting the thirty positions for each test point the Psion calculates an average position as the final corrected position. This final position is shown on the screen along with an average standard deviation for the results. This screen provides a check on the quality of the position, allowing the test point to be re-surveyed if required. The requirements that needed to be met for a position to be accepted can be seen in Table 2. These measures are used to ensure that the data being collected is of an acceptable standard. Most of the settings can be entered into the Psion, which will then not accept positions with characteristics that do not meet the quality control settings.

Quality Control Settings	Value
HDOP (Satellite Geometry)	<2.5
DGPS	Differentially corrected position only
Age of DGPS corrections	<15 seconds
Number of satellites	4 or more
Average Standard Deviation (horizontal)	<1.0 metre

Table 2 - Quality Control Settings

At the end of each day, all data was downloaded both to the field laptops and to a floppy disc as backup. Some initial processing was done each day, but the majority of data processing and analysis was completed in the office.

RESULTS

The results downloaded from the Psion were read into an Excel spreadsheet where the data was collated with the clients positions and a comparison made. For each test point data was prepared in the following sections.

- Location
- LIC coordinates
- The clients coordinates
- Position error in Easting, Northing and overall 2D position

For each of the six test areas a table was prepared showing the following items for position error in easting, northing and overall 2D position.

- Average
- Standard deviation
- Number of observations in each test area.
- Maximum and minimum error values.
- Number of observations less then the accuracy threshold.
- Percentage under the accuracy threshold.
- Whether the test area complied with the contract.

For each of the six test locations three individual graphs were prepared. These included a position accuracy histogram showing the spread of the position errors, a graph showing the position error separated into its easting and northing components as well as a plot of the collected positions to see the shape and orientation of the test areas. Figures 2, 3 and 4 are examples of the above mentioned graphs.

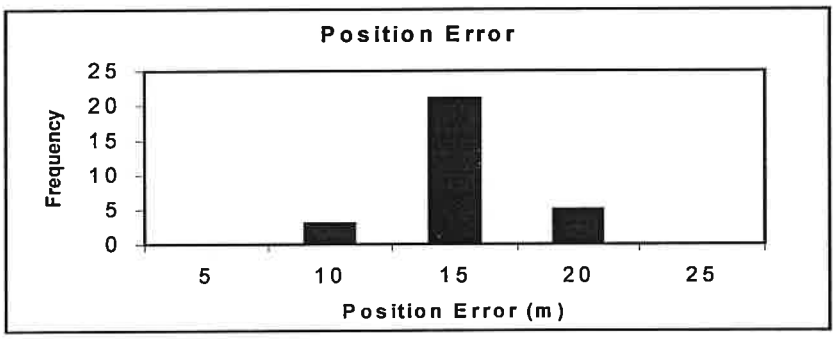

Figure 2 Position Accuracy Histogram

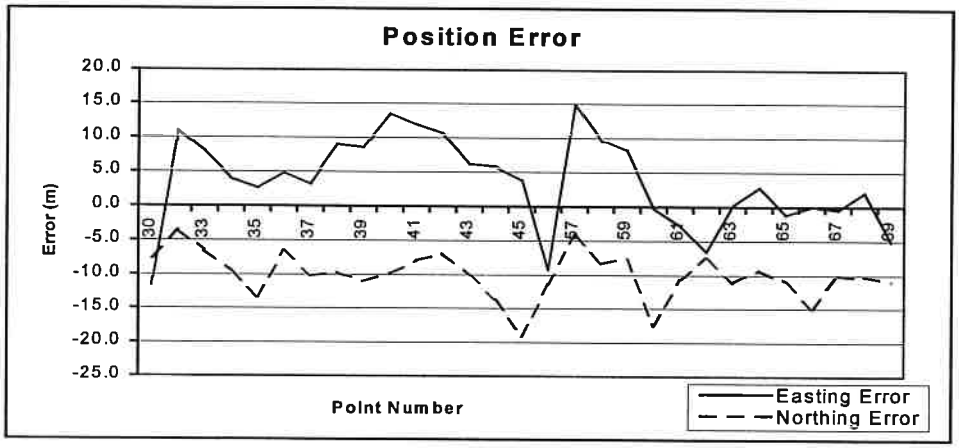

Figure 3- Easting /Northing Position Error

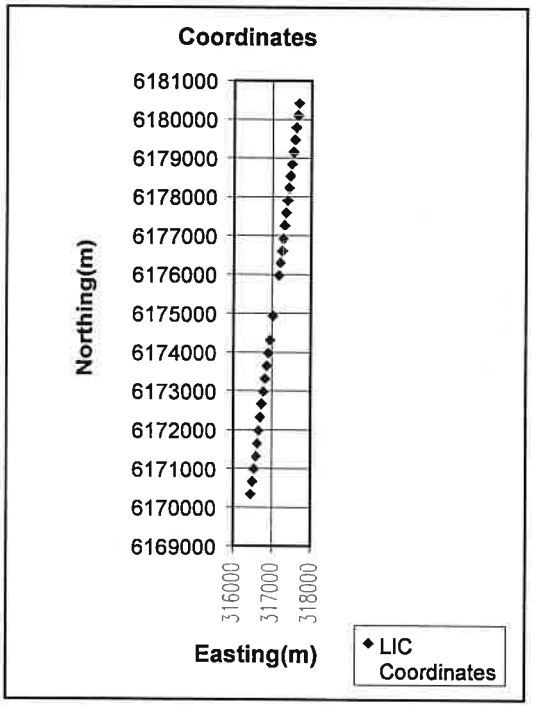

Figure 4 –Coordinates

In the final analysis each test area was looked at as a separate area to comply with the specifications, as well as an analysis being done of the results as a whole. Looking at the graphs and the analysis of the results showed the quality of the clients positions, highlighted any problems and showed whether the specifications were being met. The results were presented to the client in a report which showed for each area the above graphs and a table which summarised the findings from the analysis as well an explanation of all results and findings. A sample summary table can be seen in Table 3.

12.7 metres	Average Position Error
± 2.6 metres	Standard Deviation
29	Total Number of Observations
19.7 metres	Maximum Position Error
8.2 metres	Minimum Position Error
15.5 metres	Required accuracy
26	Number under C.I
90%	% under C.I
Yes	Comply with Contract

Table 3 - Position Accuracy Summary

CONCLUSION

It can be seen that for this positioning accuracy audit, wide area differential GPS was a successful means of collecting the position data. It provided the required accuracy and could produce a position from 30 seconds of data. Having the antenna attached to the car and the equipment being operated from inside the vehicle proved to be a simple and effective equipment setup which allowed for a quick transition between test points. Being able to see the results on the screen of the Psion meant that the positions could be checked in real time, as the survey was taking place, giving the advantage of re-observation of any points that did not meet the quality control settings.

Once downloaded, the results obtained in the field were easy to work with. The comparison of the results with the clients positions was reasonably straightforward using a spreadsheet and the production of graphs and tables for each test area made the explanation of the findings easier. Any problems were easily identified, and could be explained to the client using the graphs and tables.

In conclusion, it seems that wide area differential GPS can be a very useful surveying tool, as long as the accuracy specifications of the system being used and the specifications of the job are comparable. If this is then case then using WADGPS becomes an easy to use and efficient means of completing the fieldwork.