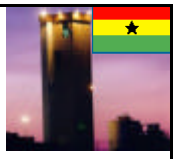
The use of RTK GPS in Open Pit Survey – A Case study at Gold Fields Ghana Limited, Tarkwa, Ghana.



by

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Introduction

- GPS is being used for Planimetric controls, detailing as well as a wide variety of engineering applications.
- Goldfields Ghana Limited (GGL) currently operates 10 active mine pits with pit locations being at a maximum distance of 6km apart. GGL management took the bold decision of purchasing some GPS equipment to help facilitate the surveying process and enhancing the map-making process of the company.

History of the Mine

- Mining in the Tarkwa area started as far back as 1800. Around 1877, Skarchley visited Tarkwa and there were about 600 natives engaged in gold production by digging pits to depth of about 24 m or more.
- The Tarkwa mines started around 1878 by a French company under the management of Bonnet until the mine closed down in early 19 century.
- In line with the Ghana Government economic recovery programme, a memorandum of agreement of incorporating the project development was signed on the 26th May 1993, in which GGL acquired 85% shares and took over the operations of the mine on 1st July 1993.

Location, Climate and Topography

- The project area falls within the equatorial climatic zone.
- The topography of the lease area comprises ragged ridges with peaks of 335 m above mean sea level in some areas, interspersed by undulating valley bottoms.

GPS Survey at Gold Fields Ghana Limited

- RTK survey was introduced to GGL in December 2004 to augment the fleet of Sokkia Total Stations being used on the mine.
- The RTK survey system at GGL comprises of 1 R5700 Trimble unit as the main base, 1 R 5800 mobile base, and 5 R 5800 Trimble receivers.

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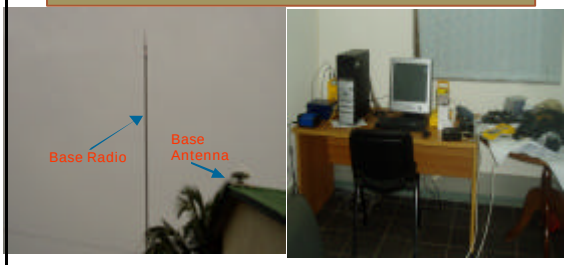
- Figure 2 shows the main base station set up at the survey office with the antenna on the roof of the survey office. A calibration survey was performed on 8 known coordinates to establish the known point for the base.

RTK Base station and Radio Link antenna set up at GGL



Office Accessories

Calibration Results

Calibration Survey

From-To	Min. no of satellites	RMS(m)	Slope distance(m)	Horizontal precision(m)	Vertical precision(m)	PDOP(m)
Thaw-PT6M	7	0.005	3681.582	0.010	0.016	1.305
Thaw-PT9M	7	0.004	2418.006	0.010	0.017	1.652
Thaw-PS3M	6	0.004	1835.020	0.007	0.017	2.096
Thaw-TEH1M	7	0.003	2927.499	0.006	0.012	1.888
Thaw-GFID13M	10	0.006	5196.384	0.010	0.017	1.524
Thaw-AKE5M	7	0.003	1468.594	0.006	0.011	2.395
Thaw-AKE3AM	10	0.005	1957.357	0.007	0.012	1.124
Thaw-KOT3M	10	0.006	4612.562	0.007	0.012	1.135

Calibration Results

- Weighted Ambiguity Vector Estimate (WAVE) provided statistics to evaluate the quality of a baseline solution. The statistics in table 2 are the default values indicating good baselines.

Table 2 Default values for good Baselines

Parameters	Default Values
Reference variance	=1
Ratio	>1.5
Root Mean Square (RMS)	<15mm
PDOP	<7
Residual Plots	±15mm

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- From the results above, the RMS values were all within the acceptable limit of <15mm, the PDOP were within acceptable limits of 3 as used in the Trimble Survey Controller. A horizontal precision of 8mm and vertical precision of 14mm were achieved.
- The known coordinate of the main base station on WGS-84, Ghana National Grid and GGL Grid was generated and tabulated in table 3.

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Table 3 Base Station ground Coordinates in 3 grid systems

Base Station	Latitude	Longitude	Ellipsoidal height	Remarks
WGS-84	5-19-34.0907N	2-01-26.2801W	125.069m	Universal
Ghana Grid	72686.740	160812.173	125.069m	National
GGL grid	11059.882	8674.491	125.069m	Local

Comparison of RTK survey and Total Station survey

- In other to ascertain the accuracy of the RTK operations, a comparison between conventional survey using Total Station measurement and RTK GPS measurement was performed and the outcome of the survey were as follows:

Table 4: RTK and Total station Survey Analysis

RTK GPS SURVEY			TOTAL STATION SURVEY			
EASTING	NORTHING	ELEVATION	EASTING	NORTHING	ELEVATION	CODE
9045.774	10031.035	112.311	9045.767	10030.997	112.374	RP1
9469.867	9587.151	183.872	9469.851	9587.178	183.842	AKE2
9964.974	9612.569	187.154	9964.949	9612.621	187.127	AKE3
10799.493	10742.998	98.704	10799.493	10742.936	98.688	MTS1
10549.179	8139.019	146.986	10549.131	8139.065	147.028	GT6
10516.895	8340.638	154.842	10516.871	8340.826	154.100	GT5
10467.634	8746.716	159.240	10467.640	8746.684	159.273	TE01
10484.956	8572.403	160.184	10484.925	8572.400	160.192	GT4
10466.752	8721.964	160.958	10466.734	8721.971	160.016	GT3
10472.040	8851.035	147.501	10472.048	8851.008	147.468	GT2
10466.591	8956.116	134.948	10466.577	8956.091	134.916	GT1

DEVIATION					
dE	dN	dZ	CODE	MISCLOSE VECTOR(m)	
0.007	0.035	-0.063	RP1	0.039	0.000
0.016	-0.027	0.010	AKE2	0.031	0.000
0.021	-0.033	0.027	AKE3	0.039	0.000
0.000	0.008	0.016	MTS1	0.008	0.001
0.048	0.014	-0.042	GT6	0.050	0.000
0.024	0.002	-0.018	GT5	0.027	0.000
0.016	0.030	-0.025	TE01	0.035	0.000
0.025	0.053	-0.005	GT4	0.059	0.001
0.018	-0.005	0.042	GT3	0.019	0.000
-0.009	0.027	0.033	GT2	0.026	0.000
0.014	0.025	0.036	GT1	0.029	0.000
			MEAN	0.033	SD 0.001

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- The results between the two techniques compared very well with the distance closures ranging from 8mm to 59mm, with an average closure of 33mm and a standard deviation of 1mm.

The Usage

- **Currently, RTK GPS is being used at GGL for the following surveys:**
- **Road survey**
- **Topographical survey (Pit floor pick ups,)**
- **Stakeout survey (grade control, mine design pegs, blast pattern layout)**
- **Stockpile survey**

RTK GPS Usage

Bench Mark

Grade control pegs demarcation

RTK GPS Survey

Road Survey Plot

Grade Conrol markout

Grade control pegs demarcation

Problems associated with RTK usage.

- The basic problem currently been experienced is the erratic radio link in some areas of the mine due to the topography of the operational area as enumerated under topography and drainage in the relevant information about the mine and high PDOP in some pits with high walls thereby restraining surveyors from achieving higher productivity as compared to others.
- It was also observed in the course of the year that when satellite availability exceeds 8 radio data link becomes difficult due to the volume of data that needs to be broadcast through the repeater stations.

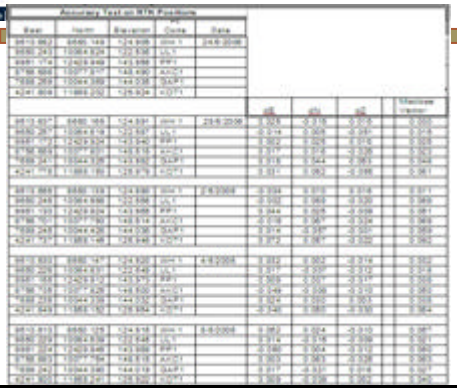
Advantages

- RTK survey at GGL have reduced man hours by approximately 40 - 50%, a surveyor is able to demarcate 100 grade control pegs within an hour and half with RTK which other wise could have been achieved at the fastest period of 3 hours by means of Total Station method. There is no need for a surveyor to wait for fog to clear before starting a survey, bad weather is now a thing of the past.

Efficiency

- In other to ascertain the efficiency of the system, control points were installed in 6 out of the 10 Pits currently in operations and monitored over a one week period which yielded the results in table 5.

Accuracy test on RTK positions



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- From the data above, it could be observed that the partial differences are all less than 10 cm even though the presence of human error due to improper leveling could not be over ruled. This test proved that the RTK GPS is accurate and efficient.

Conclusions and recommendations

- The introduction of RTK GPS has generally enhanced mapping operations at GGL thereby reducing the mapping process by 30%.
- Responses for mapping services by other departments are being met on time and with utmost efficiency. The use of RTK in setting out blast patterns has also improved floor conditions due to accurate drilling depth especially on design ramps.
- For mining purposes the accuracies obtained using GPS were very reliable and of high quality.
- We wish to recommend to Trimble to improve upon the memory battery life of the TSCe which for now does not last for the eight hours guarantee to last.
- To other Mining companies who have not yet tried the technology, we will encourage them to put their money in it for they will never regret they did.

- THANK YOU

- Question Time