Evaluation of the UTM GPS Reference Station in Relation to JUPEM's MASS Stations

Ng Yian Ching
Khairul Anuar Abdullah

Department of Geomatic Engineering, Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia (email: khairulabdullah@utm.my)

Abstract

Global Positioning System (GPS) is a technique of positioning using satellite-based radio-positioning and time transfer systems. Accuracy is the key issue in GPS surveying. Millimeter accuracies can be attained through relative positioning. In relative positioning, a reference station is needed to generate differential GPS corrections and maintenance of reference frames to improve the accuracy of GPS data collected by roving receivers. Hence, the accuracy of the coordinate of the reference station is important to provide high accuracy correction information. In this project, a reference station was established on the roof of the Faculty of Geoinformation Science and Engineering (FKSG), University Technology of Malaysia (UTM), Skudai, Johor Bahru. The objective of this paper is to evaluate the accuracy and reliability of the coordinate of the reference station in relation to MASS stations in Peninsular Malaysia. MASS data set were downloaded from the Department Of Survey and Mapping Malaysia (DSMM) website. Network adjustment was carried out using Trimble Geomatics Office Version 1.50 (TGO).

1.0 Introduction

Global Positioning System (GPS) is a technique of positioning using satellite-based radio-positioning and time transfer systems. Even though the satellite systems, more specifically the GPS, have revolutionized the art of positioning and navigation, there are still several setbacks to the accuracies that can be attained. Even though the accuracy of the unassisted GPS single point-positioning signal is adequate for most applications such as recreation, automobile navigation and fleet tracking; many other applications still require greater accuracy. In order to improve positional accuracies to the level of a few meters or better, a relative positioning technique is usually employed. Satellite positioning with accuracy better than 5m obviously requires the use of a reference station. Differential GPS operation (DGPS) uses a reference station at a known location to calculate and broadcast pseudorange correction to local user, resulting in improved user position accuracy (Farrell, Givargis, 1999). Clock errors, orbital errors, and transmission delays cause differences between the known position of the reference station and the autonomous position it calculates from GPS signals. These differences also apply to positions recorded at the same time by roving receivers within about 250km of the reference position. Data from a roving receiver can be corrected using the reference station's data if the rover is in range, uses some or all of the satellites the reference station uses, and collects data only when the reference station is operating (Trimble, 1999). Reference stations are supposed to provide high accuracy and reliable data. The difference between a conventional field reference station and a permanent reference station is that the latter requires an advanced, reliable and robust infrastructure so as to be able to run permanently providing data at certain epochs e.g. near real time daily or hourly (Ganeskumar, S.,1999).

2.0 UTM GPS Reference Station

A **UTM G**PS **R**eference **S**tation (UTM-GRS) has been established at the Faculty of Geoinformation Sciences and Engineering, University Technology of Malaysia (UTM), Skudai, Johor Bahru. The reference station automatically records and stored data from available satellites for accurate position determination on a 24 hours basis. The UTM-GRS will provide correction information to rover receivers around 250 km radius from the reference station in support of real time and post processing application.

The UTM-GRS uses the Trimble Reference Station (TRS) System for the data collection. Base data can be accessed directly from a hard disk, via a dialup BBS, or over the Internet. TRS system includes software, GPS receiver, antenna, 30 meter receiver to antenna cable, and a power supply connector. The GPS receiver, Trimble 4700 receiver tracks satellite in 5 seconds epoch, at 10^{o} elevation mask.

Presently, estimated coordinate is used for the reference station. Without knowing the reliability of the coordinate of the reference station, the reference station can not be used for relative positioning. This study is purposes in order to evaluate the accuracy and reliability of the coordinate of the reference station in relation with MASS stations.

3.0 Data Acquisition

The data used in this study consists of MASS and UTM-GRS data sets. The MASS stations raw data are directly obtained via DSMM or downloaded from DSMM website. Data of the month of October were obtained from 9 MASS stations in peninsular Malaysia. The stations are Arau, USM (Penang), Ipoh, Geting, Kuala Terengganu, Kuala Lumpur, Kuantan, Segamat, and UTM (Johor). Data sets for the month of October were obtained via FKSG website www.fksg.utm.my/base station. In this study, IGS precise orbit data is used in L3 processing style. The IGS precise orbit data were downloaded from http://ngs.noaa/gov/CORS-Proxy/UFCORS.

Figure 1: MASS Stations location

Figure 2: FKSG Trimble Reference Station

4.0 Data Processing Strategies

The Trimble Geomatic Office (TGO) Version 1.50 were used in the processing. In this paper, there are 2 networks involved. Two processing strategies are applied in each network. The first strategy is to process the network by fixing a MASS station at one time. The second strategy is to process the network by increasing fixed station by one station at a time. All coordinates are adjusted to the WGS 84 datum.

4.1 Network 1

Network 1 consists of 9 MASS stations and UTM-GRS.

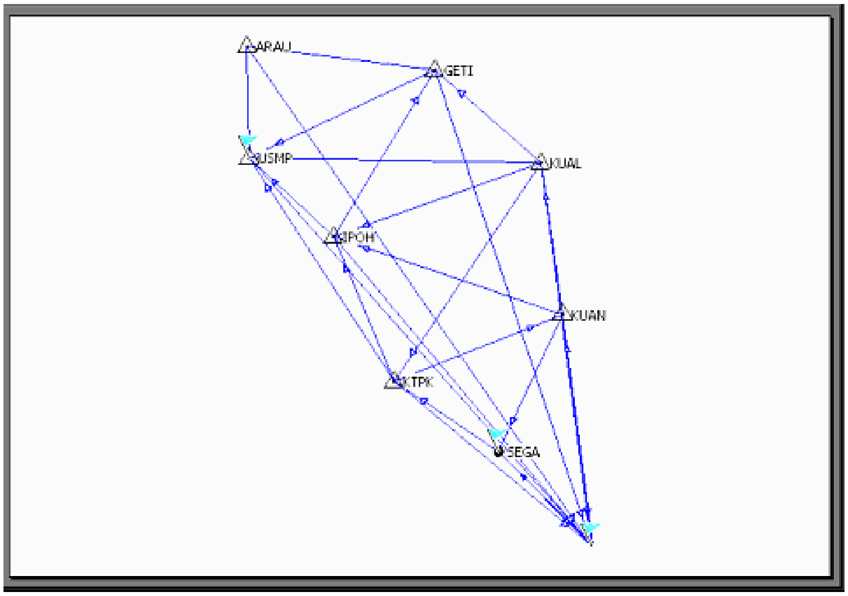


Figure 3: Network 1

4.2 Network 2

Network 2 consists of 2 MASS stations, SEGA and UTMJ, and UTM-GRS

.

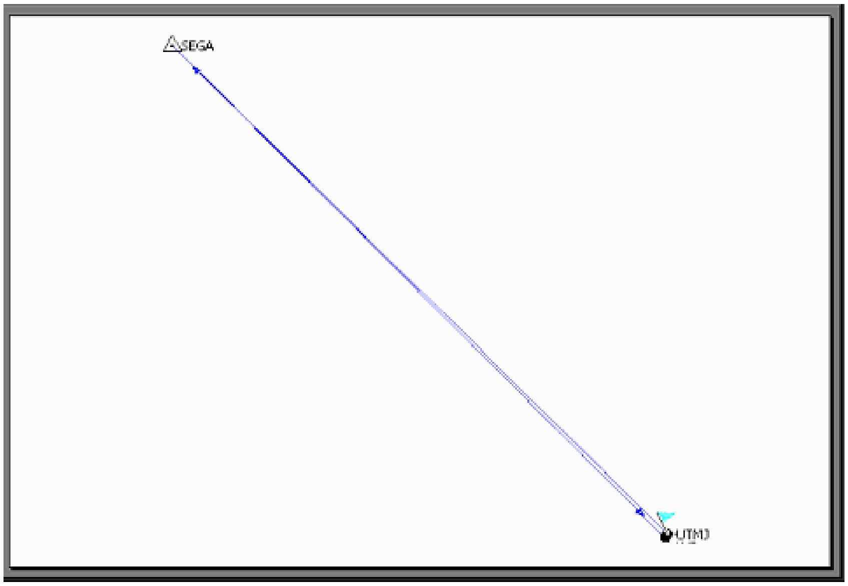


Figure 4: Network 2

5.0 Results and Analysis

5.1 Results for Network 1

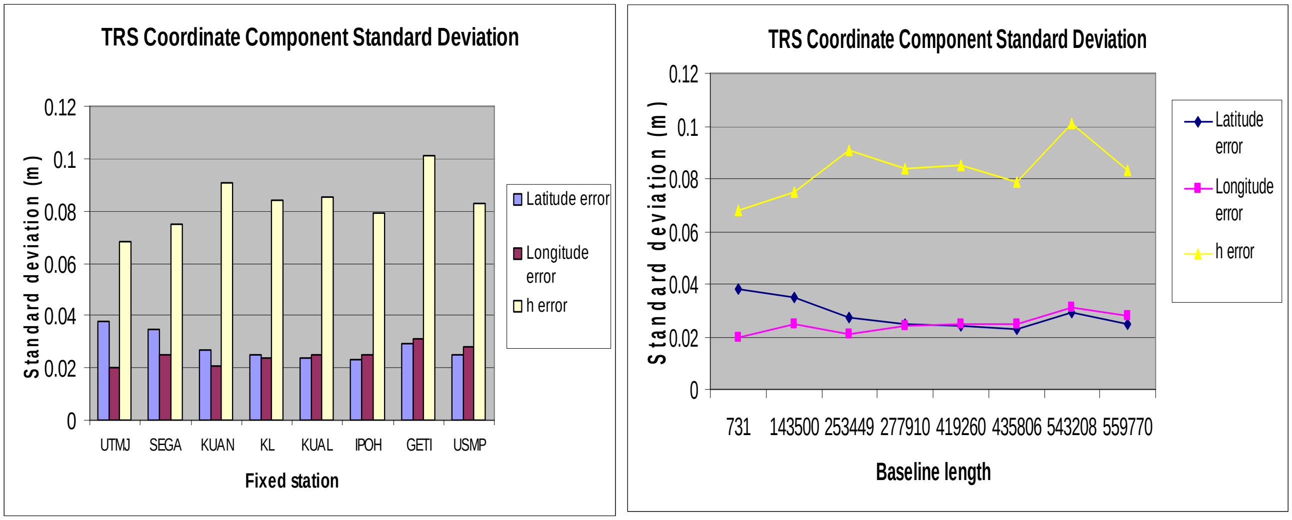


Figure 5: TRS coordinate component for first strategy in network 1

Table 1: Result of first processing strategy for network 1

Fixed stn	Baseline Length	TRS coordinate						
		Latitude	Latitude Standard deviation	Longitude	Longitude Standard deviation	Height	Height Standard deviation	Standard deviation
UTMJ	731.461m	1°33'37.35361"N	0.038m	103°38'08.98665"E	0.020m	57.997m	0.068m	0.042
SEGA	143500.856m	1°33'37.31215"N	0.035m	103°38'09.01966"E	0.025m	58.550m	0.075m	0.043
KUAN	253449.035m	1°33'37.35577"N	0.027m	103°38'08.98398"E	0.021m	58.554m	0.091m	0.034
KTPK	277910.675m	1°33'37.35496"N	0.025m	103°38'08.98284"E	0.024m	58.068m	0.084m	0.035
KUAL	419260.130m	1°33'37.35618"N	0.024m	103°38'08.98004"E	0.025m	58.004m	0.085m	0.035
IPOH	435806.639m	1°33'37.35534"N	0.023m	103°38'08.98198"E	0.025m	57.978m	0.079m	0.033
GETI	543208.419m	1°33'37.35570"N	0.029m	103°38'08.98036"E	0.031m	57.984m	0.101m	0.042
USMP	559770.209m	1°33'37.35560"N	0.025m	103°38'08.98136"E	0.028m	55.056m	0.083m	0.037

Table 5.2: Result of second strategy network adjustment for network 1

No of Fixed Station	Latitude	Latitude Standard deviation	Longitude	Longitude Standard deviation	Height	Height Standard deviation	Standard deviation
1	1°33'37.35361"N	0.038m	103°38'08.98665"E	0.020m	57.997m	0.068m	0.042
2	1°33'37.35349"N	0.039m	103°38'08.98674"E	0.021m	58.003m	0.067m	0.044
3	1°33'37.35449"N	0.029m	103°38'08.98627"E	0.018m	57.960m	0.059m	0.034
4	1°33'37.35475"N	0.030m	103°38'08.96855"E	0.018m	57.956m	0.061m	0.035
5	1°33'37.35527"N	0.031m	103°38'08.98592"E	0.020m	57.932m	0.065m	0.037
6	1°33'37.35516"N	0.030m	103°38'08.98586"E	0.020m	57.937m	0.065m	0.036

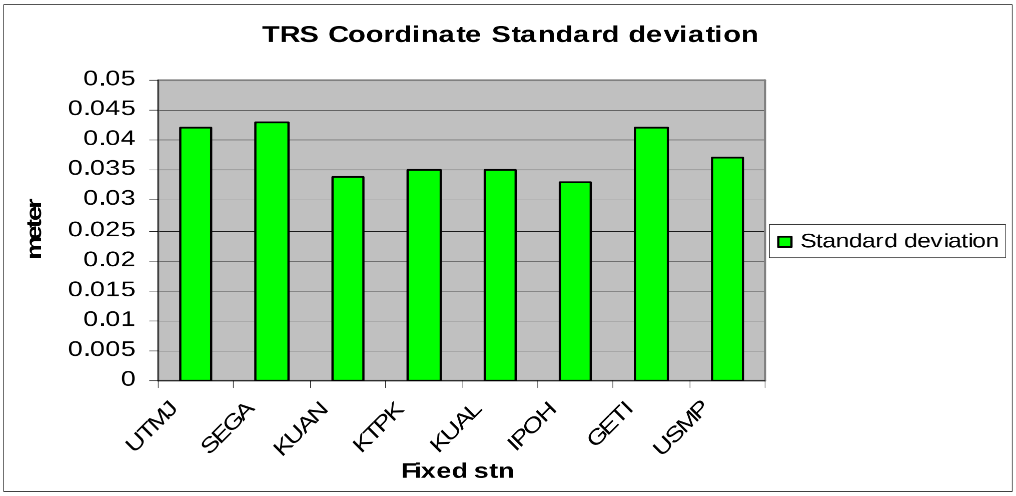
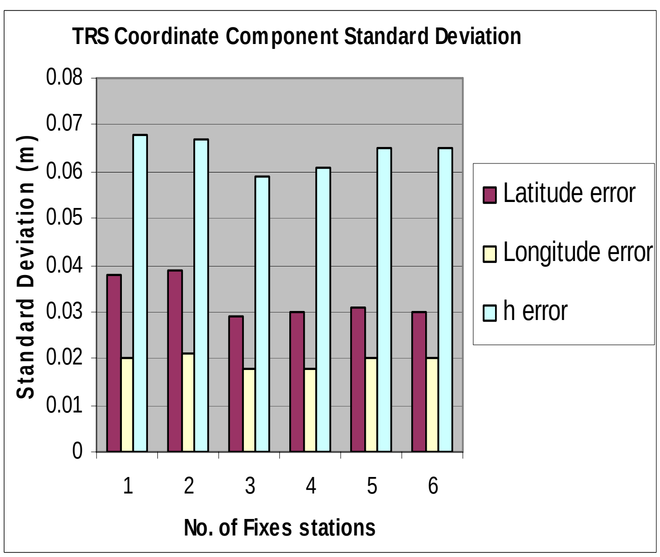


Figure 6: TRS coordinate standard deviation

Figure 6 shows UTM-GRS (a.k.a TRS) coordinate standard deviation in relative to fixed station. UTM-GRS coordinate standard deviation is the lowest when IPOH was fixed. The possible reason is that the position of IPOH is at the middle part of the network, distribution of error is more evenly compared to other fixed station located at the upper and lower part of the network.



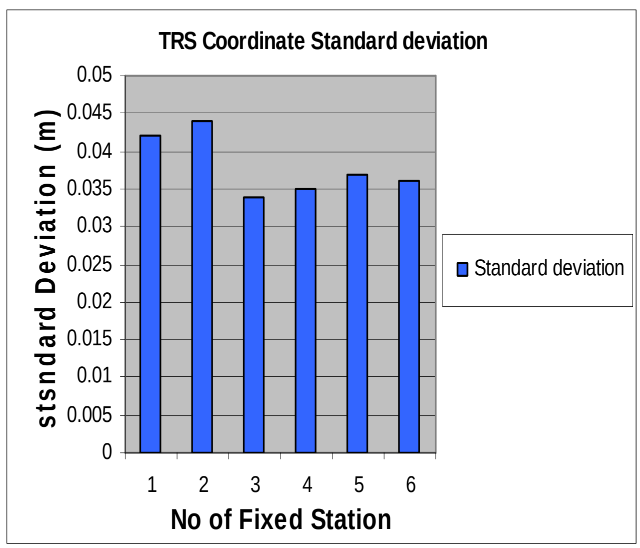
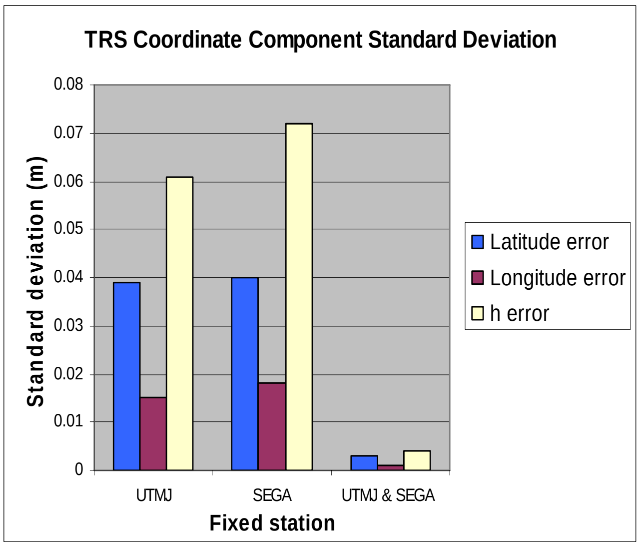


Figure 7(left): Standard deviation of UTM-GRS (a.k.a TRS) coordinate component in relative to number of fixed station for Network 1

Figure 8(right): Standard deviation of UTM-GRS (a.k.a TRS) coordinates in relative to number of fixed station for Network 1

When 3 stations were fixed, UTM-GRS achieved lowest standard deviation. Three fixed stations in processing provide more redundancy for processing compared to 2 fixed stations.

5.2 Results for network 2



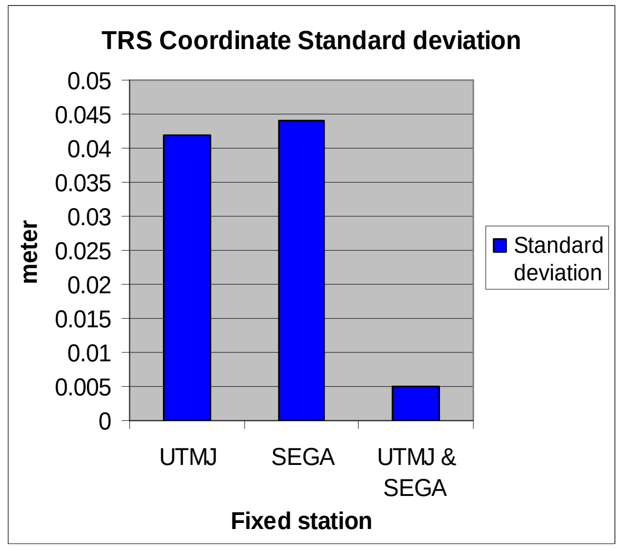


Figure 9(left): Standard deviation of UTM-GRS (a.k.a TRS) coordinate component in relative to number of fixed station for Network 2

Figure 10(right): Standard deviation of UTM-GRS (a.k.a TRS) coordinates in relative to number of fixed station for Network 2

When both stations were fixed, UTM-GRS achieved lowest standard deviation because when both stations were fixed, it provides redundancy for network adjustment.

6.0 Conclusions

Table 1: Summary of result of TRS adjusted coordinate

		Latitude	Longitude	Height	Standard deviation
Network 1	1st strategy (IPOH)	1°33'37.35534"	103°38'08.98198"	57.978m	0.033
	2nd strategy (3 fixed station)	1°33'37.35449“	103°38'08.98627“	57.960m	0.034
Network 2	1st strategy	1°33'37.35353"	103°38‘08.98690"	58.002m	0.042
	2nd strategy	1°33'37.35347“	103°38'08.98707"	58.009m	0.005

UTM-GRS achieved the best standard deviation in compartment style of processing because this processing style reduces atmospheric error due to its short baseline. Processed coordinate with the best standard deviation will be used as the coordinate of UTM-GRS and this refers to the adjusted coordinate from second strategy in network 2, giving the latitude as N01° 33' 37.35322“, the longitude as E103° 38 '08.98690" and finally, the height as 58.009m in the WGS 84 datum.

References

Farrell J., Givargis T. (1999). Experimental Differential GPS Reference station Evaluation. *Proceeding of the American Control Conference*, San Diego, California. http://www.ics.uci.edu/~givargis/docs/acc-99a.pdf

Ganeshkumar, S. (1999). Global Positioning System Aided Straight-Road Centerline Surveys - An Assessment with Different Real Time GPS Settings**.** Thesis Asian Institute of Technology, Space Technology Applications and Research Program. http://www.romdas.com/romdascd/info/other/gps/gps-ait.pdf