[AERO01] Availability and Effectiveness of Differential Navigation Satellite System (DGNSS) Radio Beacon for Hydrographic Positioning

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Introduction

Differential Global Navigation Satellite System (DGNSS) radio beacon has been recognized in most country as an aid to safety for marine navigation. The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has listed all DGNSS stations that have officially operated around the world. The authorized frequency for DGNSS radio beacon is between 283.5 kHz to 325 kHz. In this way, users are able to receive DGPS correction through Radio Technical Commission for Maritime Services Special Committee 104 (RTCM SC-104) format (IALA, 2001). Figure 1 shows a DGNSS radio beacon system. A typical DGNSS station will consist of the following components:

a) Reference Station
   Generate the DGPS correction.
b) Control Station
   Used for fault detection and correction.
c) Integrity Monitor
   Verify the correctness of the corrections generated by the Reference Station.
d) Transmitter
   Broadcast the DGPS corrections generated by the Reference Station to users.
e) Control Monitor
   Monitor the status of the DGNSS system.

Each DGNSS radio beacon system has its frequency and also an identification (ID) station number. This is to make sure that users know exactly which signal is been recording. To perform a hydrographic surveying using DGNSS radio beacon, user needs to have a Minimum Shift Keying (MSK) radio beacon receiver with antenna and a minimum of L1 C/A code GPS receiver with its antenna. Nowadays, most of the receiver manufacturers have developed a combined MSK radio beacon and GPS receiver with a combined MSK and GPS antenna. MSK receiver will demodulate the signal from DGNSS radio beacon to receive the differential correction. The differential correction will be applied to GPS position in order to get position in DGPS mode.

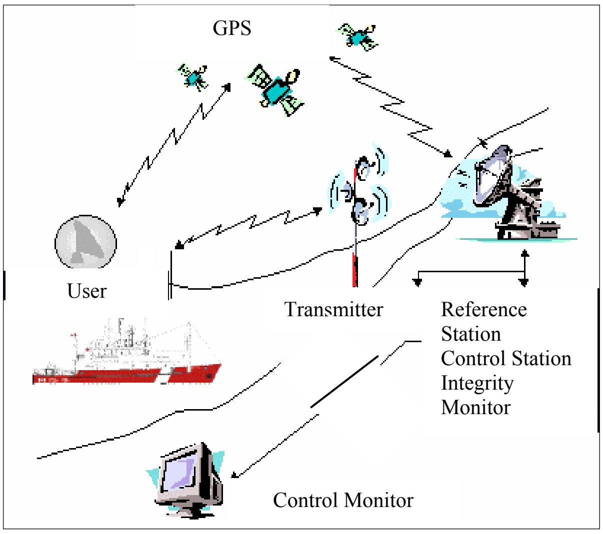

FIGURE 1 DGNSS radio beacon system

Materials and Methods

Static Test of DGNSS Radio Beacon

Essentially, an appropriate technique to determine the accuracy of real time DGPS system is to test the position solution compare to a known station. Two tests have been carried out using two difference distance from DGNSS radio beacon. Both of the tests were conducted using Trimble DSM212H receiver on a known point, which is BC10. Note that BC10 has been set up using a post-processing static GPS survey through the global International GPS Service (IGS) station and also the Malaysian Active GPS System (MASS) station run by the Department of Survey and Mapping Malaysia (DSMM). The observations were recorded from the Pulau Satumu, Singapore DGNSS station (46 kilometres) and from Kuantan DGNSS station (250 kilometres) for about 24 hours for each station (Figure 2). Note that both of the observations were recorded independently on two different days using BC10 as a known station. The observations were in National Marine Electronics Association 0183 (NMEA 0183) format.

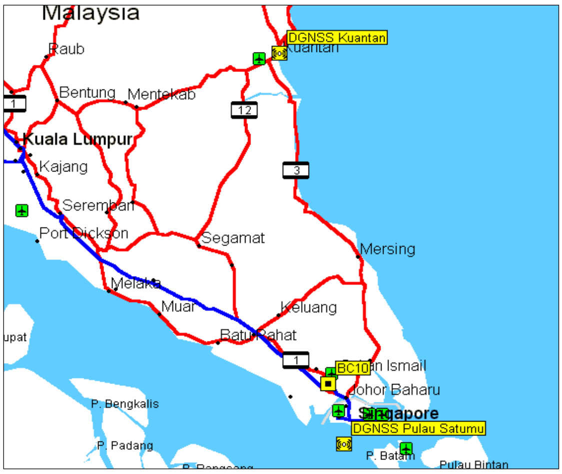

FIGURE 2 Map showing DGNSS radio beacon station of Kuantan and Pulau Satumu from BC10

Besides using difference distance, the tests will also evaluate some other factors such as the effect of the age of DGPS correction and the percentage of the DGPS fix recorded. The reason for the observations being recorded for 24 hours is to determine the best time for the DGNSS radio beacon for the transmission of the differential corrections. This is because the use of medium frequency (MF) radio signal by the station is easy to be affected by skywave and groundwave propagation. However the study of the skywave and groundwave propagation is not intended to be enlightened here since it is beyond the span of this research.

Dynamic Test of DGNSS Radio Beacon

The focus of this test is to see the tracking methods of DGNSS radio beacon mostly used by DGPS receivers. Two types of tracking methods were tested, namely automatic and manual. The first is the automatic methods. Using this technique, DGPS receiver will automatically receive the strongest DGNSS radio beacon signal. Meanwhile, the latter technique will only select a signal from a specified DGNSS radio beacon station. Both of the position solution techniques were compared to a Wide Area DGPS (WADGPS) services to see the position differences. In the test, three receivers were used, which two receivers received the DGNSS radio beacon signal and one receiver received the WADGPS signal. The analysis will only take into account if the time from the three receivers is same. In this case, the Universal Time Coordinated (UTC) from the NMEA 0183 messages was used.

Results

DGNSS NMEA Analysis Program (DNAP), a computer program developed at Universiti Teknologi Malaysia, was used to analyze the static and dynamic test. This is because both of the tests used real time NMEA 0183 messages. Figure 2, 3, 4 and 5 shows the position differences from the static test using the 46 kilometres station. From the result, a 46 kilometres station can provide the horizontal accuracy between 1.0 metres to 1.6 metres (95% confidence level).

Meanwhile, Figure 7, 8, 9 and 10 shows the position differences from 250 kilometres station. The horizontal accuracy is between 3.7 metres to 5.3 metres (95% confidence level).

For the dynamic test, Figure 11 shows the antenna separation using the automatic tracking methods at different distance. The manual tracking method is shown by Figure 12. The mean value for antenna separation using automatic methods is 1.98 metres and 0.85 metres for the manual tracking methods.

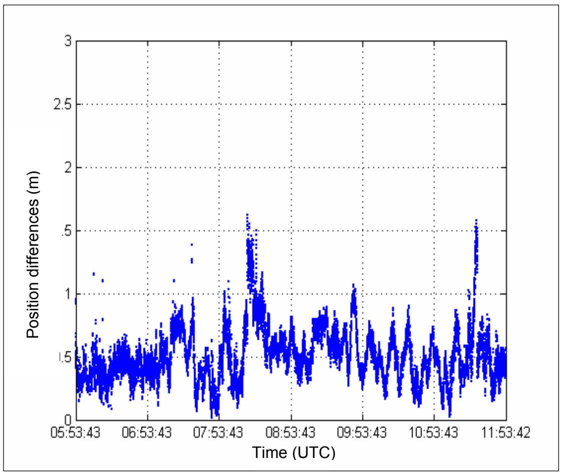

FIGURE 3 Position differences for the first six hours (46 kilometres)

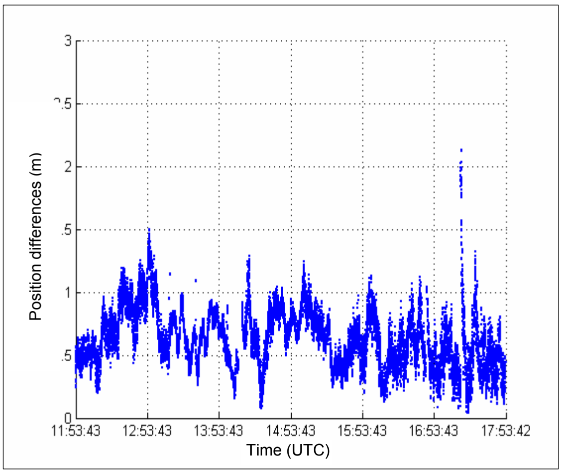

FIGURE 4 Position differences for the second six hours (46 kilometres)

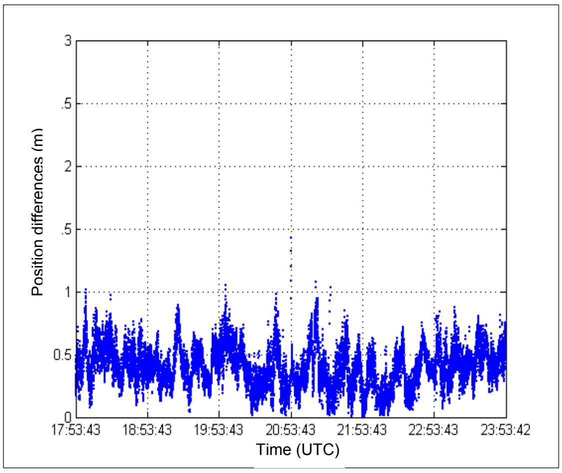

FIGURE 5 Position differences for the third six hours (46 kilometres)

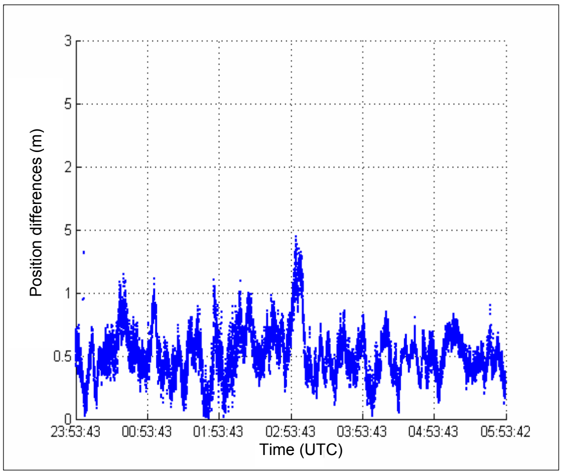

FIGURE 6 Position differences for the fourth six hours (46 kilometres)

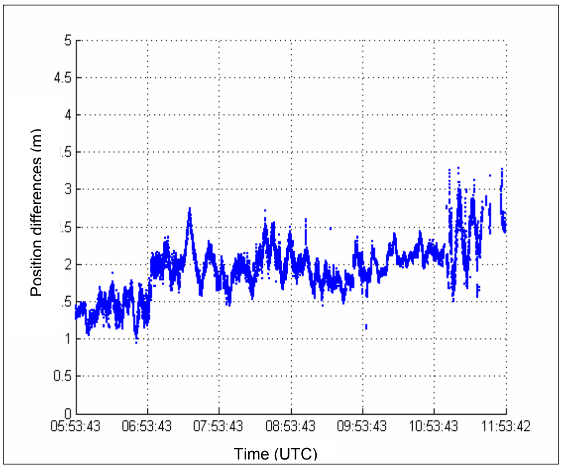

FIGURE 7 Position differences for the first six hours (250 kilometres)

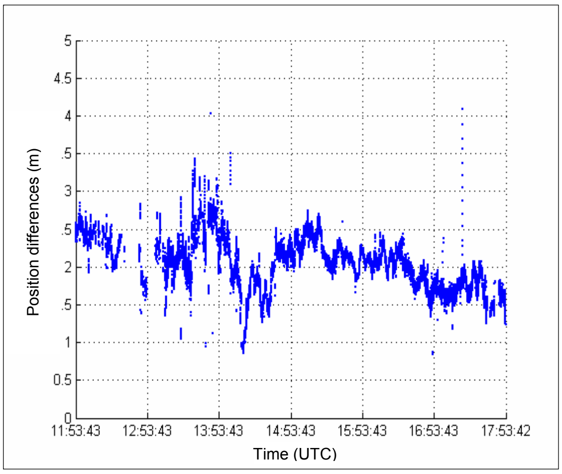

FIGURE 8 Position differences for the second six hours (250 kilometres)

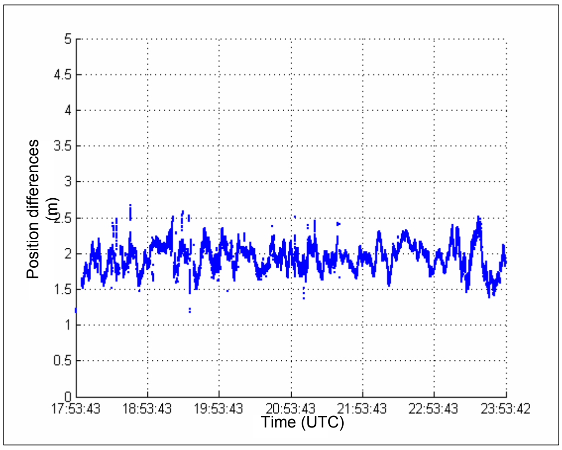

FIGURE 9 Position differences for the third six hours (250 kilometres)

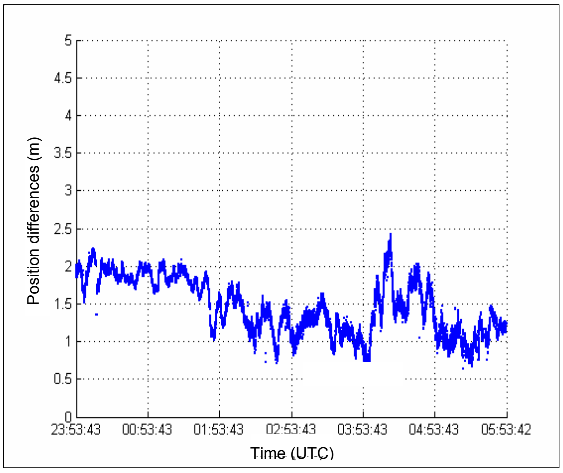

FIGURE 10 Position differences for the fourth six hours (250 kilometres)

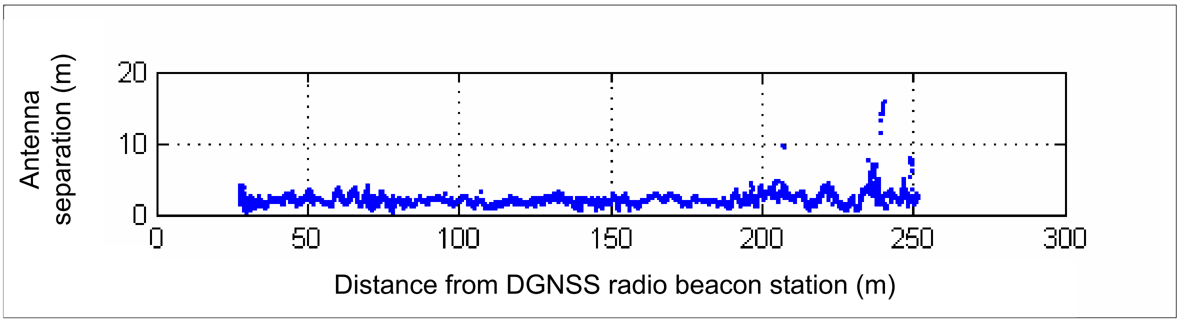

FIGURE 11 Automatic tracking methods (dynamic test)

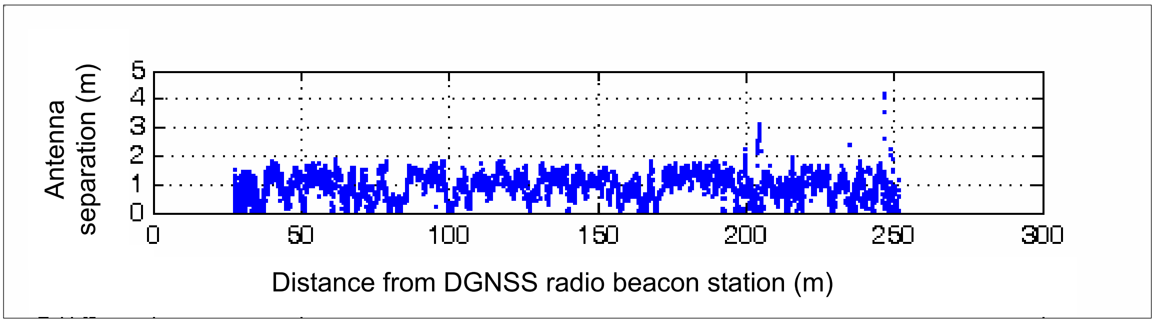

FIGURE 12 Manual tracking methods (dynamic test)

Discussion

From the static test carried out, a 46 kilometres station can meet the 95% horizontal accuracy for Special Order stated by International Hydrographic Organization (IHO). Meanwhile, the 250 kilometres station can only be used for First, Second and Third Order survey specifications. Distance separations between the reference station and user are the main factors, which degrades the accuracy. Because of increases of the distance, the reference station and user will not experienced the same error (ionosphere, ephemeris, satellite clock) anymore. This also will increase the age of the DGPS correction, which will lead to a latency issue. From the test also, the percentage of DGPS fix recorded at the second fix hours is the lowest from the other observations (12:00 UTC to 18:00 UTC).

For the dynamic test, the position solution from the manual tracking method is better than the automatic method. To use the manual tracking methods, user must recognize some information about the DGNSS radio beacon station. This including the frequency transmitted by the station, station identification number and also the status of the station (operate or not). This is to make sure that the right signal is been received from the right station.

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The specified format is available at www.marine.gov.my/service/index.html