GNSS Radiobeacon Service Availability Study: The SISPELSAT

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SUMMARY

SIStem PELayaran SATelit (SISPELSAT), a National DGPS system was installed in January 2003. SISPELSAT is the primary navigational-aid for vessels navigating within the shore of Peninsular Malaysia, operated and managed by the Marine Department of Peninsular Malaysia. The system consisted of two beacon stations, located at Lumut and Kuantan, which are transmitting GPS differential corrections to area within 250 km radius. One Master Station set-up at the Marine Department Headquarters at Port Klang, functions as the main monitoring station for the system, while another station at Langkawi acted as the secondary monitoring station.

This paper presents results of a study conducted in August 2003 to evaluate on the service availability and coverage of SISPELSAT beacon at Kuantan for the service area around the South China Sea. Results have found that within the intended service coverage area of 250 km, signal strength varies erratically. Initial study has suggested that interferences to the radio wave propagation as the main factor.

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1. INTRODUCTION

The technique of Differential Global Positioning System (DGPS) has been fully developed and today it is accepted to be the most widely used terrestrial-based GPS augmentation systems for marine navigation worldwide. DGPS service providers need to ensure that the service continue transmitting reliable messages, hence providing safety of navigation to the users (Carroll, J.V., 2003). In doing so, any DGPS service must satisfy four requirements of service relibility. The four requirements are: *integrity*, that is the ability of the service to provide timely warning to users when it should not be used for navigation or other purposes; *accuracy*, that is the degree of conformance between the position provided by the service and the true position at a given time; *availability*, that is the ability of the service be used for navigation when and wherever it is needed by the users, and *continuity*, that is the probability that the service will perform its function within defined performance limits for a period of time given (Ochieng and Sauer, 2002). The detail concept of availability and continuity of marine beacon DGNSS/(DGPS) are discussed in (Grant et al, 2003; Grant et al, 2002).

Many parts of the world have already installed GNSS beacons to provide DGPS service for mariners. For instance, in the United States of America, the Coastal Guard has successfully established a Nationwide Differential Global Positioning System (NDGPS) for maritime and land navigations (Allen, L.W., 1997). A similar trend can be seen in Europe where 162 beacons has been setup to provide DGPS services in the whole of the European Maritime Area (EMA)(Last, et al, 2002). In Taiwan, medium range DGPS employing multi reference stations, similar to the concept of Wide Area DGPS has been suggested to replace the conventional single reference DGPS (Chang and Lin, 2003).

Malaysian Authority has embarked on a similar effort in providing DGPS service to all vessels navigating in Malaysian water. The Marine Department of Peninsular Malaysia has installed a DGPS system, called SIStem PELayaran SATelit (SISPELSAT) as the primary navigational-aid vessels navigating within the shore of Peninsular Malaysia in mid 2003 (Marine Department, 2004).

This paper presents partly results of a study conducted in August 2003 to evaluate on the service availability, coverage, and signal strength within the intended area of service of SISPELSAT.

2. THE SISPELSAT

SIStem PELayaran SATelit (SISPELSAT), a National DGPS system is the primary navigational-aid for vessels navigating within the shore of Peninsular Malaysia, operated and managed by the Marine Department of Peninsular Malaysia. This DGPS system is in operation since April 2003. As guaranteed by its service provider, the SISPELSAT provides differential corrections that yield the user's positional accuracy of 5 meter or better at 95% reliability level. The SISPELSAT system design was based on the International Association of Lighthouse Authorities (IALA) Guidelines for the Performance & Monitoring of a DGNSS Service in the band 283.5 – 325 kHz. (edition. March 1999) (ibid, 2004).

The system consisted of two beacon stations, the *Lumut Reference Station/ Integrity Monitoring (LRSIM)* Station, located at about 100 km north of Klang, and the *Kuantan Reference Station/ Integrity Monitoring (KRSIM) Station*, located at about 250 km east of Klang. These are the two beacon stations which are transmitting GPS differential corrections to the intended area service which is within 250 km radius on the Malacca Straits at the west coast and the South China Sea at the east coast. One Control Station was set-up at the Marine Department Headquarters at Port Klang, i.e. *Klang Control Station (KCS)***,** which functions as the main monitoring station for the system, while another station at Langkawi acted as the secondary monitoring station, i.e. *Langkawi Remote Integrity Monitor (LRIM)***,** located about 450 km north of Klang.

At the KCS, its server records alarms and messages from LRSIM and KRSIM, and also from LRIM. The information can be used to monitor the sites remotely. Each site at LRSIM and KRSIM respectively plays two roles, as a Reference Station (RS) and as Integrity Monitoring (IM) station. The RS part generates DGPS corrections and outputs them on an MSK (Minimum Shift Keying) signal to the beacon transmitter. The IM part verifies that the broadcasted DGPS corrections can be used to calculate accurate positions. If they cannot, error messages are generated to warn the users and the KCS operator. The operator at KCS will identify the error(s) by changing the operational parameters of the system at the relevant RSIM beacon sites. This is done by means of a Medium Frequency (MF) radio and also by fixed-telephone line (Beacon Control Station, 2000).

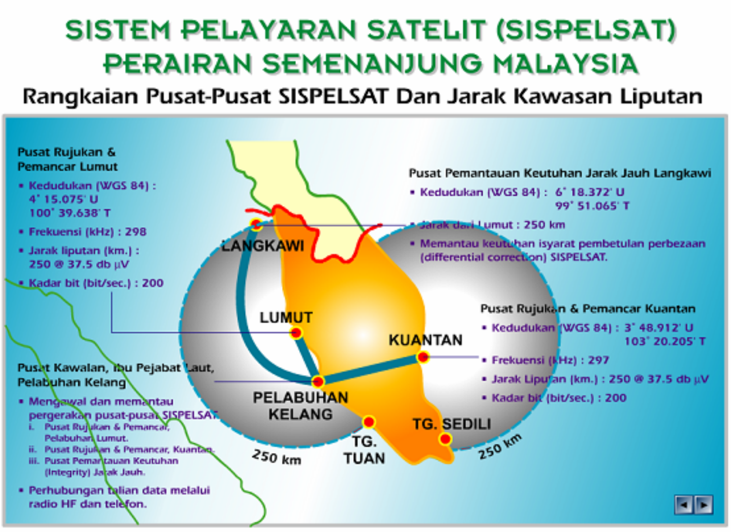

Figure 1: The Architecture of the SISPELSAT (source: Marine Department, 2004)

2.1 The Kuantan Reference Station/ Integrity Monitoring (KRSIM) Station

The Kuantan beacon station consists of two Reference Stations (RS) and two Integrity Monitoring (IM). Each of the assigned RS1 and RS2 is equipped with a set of Trimble 4000MSK DGPS receiver with antenna respectively. Meanwhile, each IM, assigned as IM1 and IM2 is equipped with a set of Trimble 4000IM MSK GPS receiver respectively.

Kuantan beacon is installed with a 74-foot coil loaded self supporting whip antenna Valcom model V-33070 type. Meanwhile the transmitter for the beacon is a Southern Avionics model SC-1000 DGPS AC/DC dual remote capable which produce 400 watt output power and transmits correction signals at the frequency ranged from 283.5 to 325 kHz. The transmitting frequency range compliances with the IALA Guideline (ibid, 2004).

Briefly, the site is situated on a flat area of about 10,000 meter square, about less than 1 km from the shoreline, and about 1.5 km from the city centre of Kuantan, Pahang, Malaysia. Geographically, to the east and south of the site, the area is quite flat with sporadic development of small factories and residential areas. To the west and the north, the ground is quite hilly with sporadic residential areas and orchards. Further to the north, there are mountainous and hilly areas, as part of the extension of Banjaran Timur (Eastern Ridge). The heights of the topography ranges from 250 feet (75 meters) to 3000 feet (914 meters) above sea level. Several hills can be spotted at the area such as Bukit Pelindung (less than 5 km from the site), Bukit Pengorak and others.

3. THE TEST

3.1 Objectives of the Test

The first objective of the test was to evaluate the availability and strength of the correction signal of the SISPELSAT in the intended area of service, that is at the South China Sea, for a radius of about 250 km from the Kuantan beacon. The second objective was to compare the accuracy of the Kuantan DGPS service with OmniSTAR. This paper only evaluate the first objective of this study.

3.2 The Data Collection

The collection of data for the test was carried out on a buoy-servicing vessel (MV Pemancar) owned by the Marine Department of Peninsular Malaysia. The ship cruised along the shore of east coast of Peninsular Malaysia and up to about 300 km offshore to the South China Sea. The duration of the test was from July 28th to August 2nd, 2003. Fortunately, the sea condition and the weather during the test were fair and sunny. Data was collected at a 10 second interval, through the NMEA format, into a dedicated Notebook computer for each receiver using the Hypertext terminal. The extent of the route in this test was as depicted in Figure 1, spanning an area of about 300 km south and 400 km north of Kuantan respectively, and about 150 to200 km offshore of Peninsular Malaysia on to the South China Sea.

3.3 Equipment Used

Three units of DGPS receivers were used for the different set up. A unit of Trimble DSM212H DGPS receiver was locked to AUTO POWER MODE to receive strongest DGPS signal transmission, another unit was locked to MANUAL MODE to station ID=629 (which is the Kuantan beacon). Another receiver used in the test was a Omnistar 3200LR DGPS receive. Each of these receivers are having their respective antenna placed close to each other on the upper deck of the vessel.

4. TEST RESULTS

Availability defines the percentage of time for which a signal at a location is usable, while ‘usable’ mean that the system meets minimum criteria for coverage set out by the International Telecommunication Union (ITU) as in the case of Malaysia, the ITU-R M823-2 (ibid2004). In Europe, these criteria are that the field strength must be not less than 20 dBμV/m and the signal-to-noise ratio (SNR) not less than 7 dB.(Grant, et al., 2003),

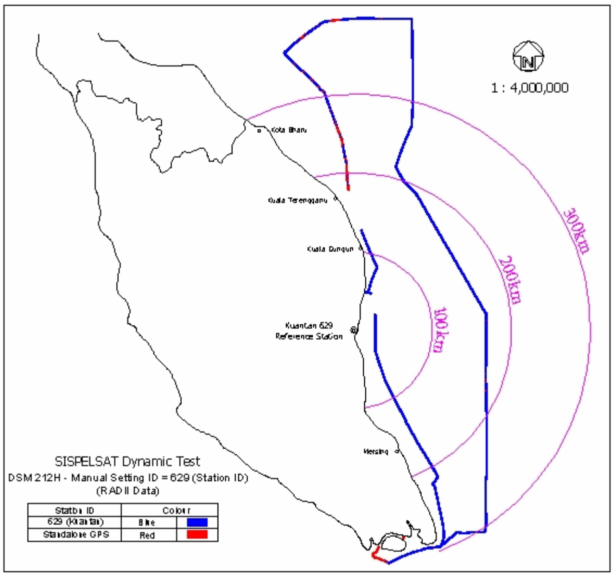

Figure 2: Availability of Signal – Manual Mode (Radii data)

Figure 2 shows the availability of signal from the Kuantan beacon, recorded by the Manual Mode receiver. Through out the test route which spans to more than 300 km south and 400 km north of Kuantan, signal transmission was recorded stronger than the 20 dB minimum requirement. Clearly the setup is fulfilling the intended 250 km radius of area of service. The two gaps on the northern part of the route indicated that no data was collected in that period due to technical problems of the receiver. On the northern part, surprisingly closer to the shore, there are many instances where stand-alone GPS were recorded. We assumed that this could due to the DGPS signal blockages caused by the mountain range blocking the transmission from reaching the intended area of service.

Figure 2a looks into more detail on the signal strength. Within slightly less than 100 km radius, signal strength of more than 60 dB was recorded. While up to more than 200 km, 40 dB was recorded, especially within the southeast region. As for the northern region however, lower signal strength was recorded, some down to 34 dB level. For area between the 200-300 km, signal strength of 39 dB down to 31 dB was recorded. Signal strength of more than 20 dB was still recorded beyond the 300 km range. Overall, for area closer to the shore recorded better signal strength as compared to area further out.

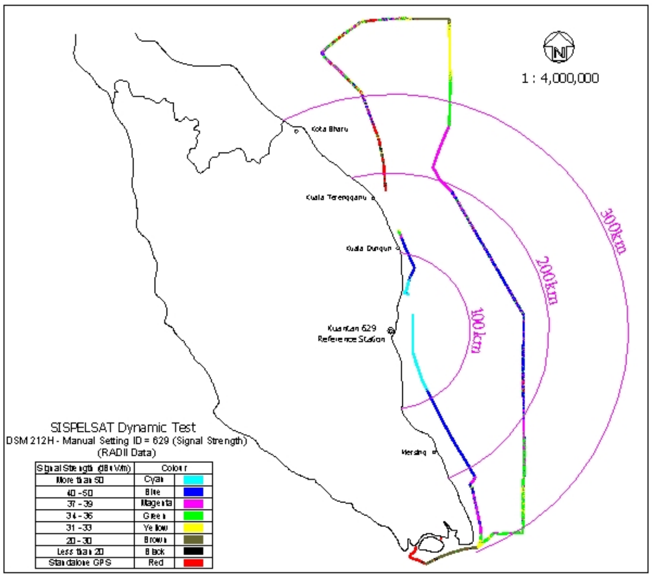

Figure 2a: The Signal Strength – Manual Mode (Radii data)

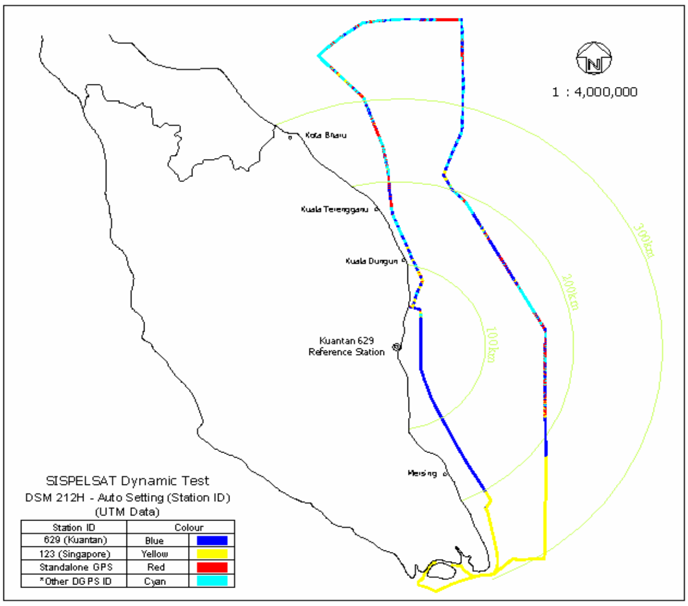

Figure 3: Availability of Signal – Auto Mode (UTM data)

Figure 3 shows signal availability recorded via the receiver operating in the auto mode. In this observations, strongest signal reception was recorded regardless of the beacon transmitter. Signal transmission from Kuantan beacon (ID=629) was recorded along the southward route closer to the shore up to about 200 km, after which transmission from the Singapore beacon (ID=123) was obtained. On other area of the route, signal from Kuantan beacon was only intermittent. On the northward route, signal reception was not good, even for area closer to the shore just over 50 km from Kuantan beacon. Many unknown sources of transmission was recorded in this area and the rest of the route.

5. CONCLUSIONS

SISPELSAT is the first GNSS augmentation public infrastructure installed in the country for the marine users where other applications such as Marine Electronic Highway (MEH) System will be built on. (Marine Department, 2004). It was designed to follow the requirement as stated by the IALA Guide for Marine radio beacon. From the initial test that was carried out in August 2003, it was found that in terms of service availability, SISPELSAT was found to be adequately following the related guideline.

Several unknown sources of signal transmissions which causes interference to the service was found to be in existence, especially in the northern part of the Kuantan beacon. This needs to be identified through the Malaysian Communications and Multimedia Commission (MCMC), and further negotiations should be carried out. In particular, with those signal owner affecting SISPELSAT service availability in the northern part of the Kuantan beacon, for area closer to shore which include several medium and small servicing ports.

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BIOGRAPHICAL NOTES

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Dr. Subari is currently Associate Professor and Head, Department of Geomatic Engineering, Universiti Teknologi Malaysia. He obtained his Bachelor degree in Land Surveying from Universiti Teknologi Malaysia in 1983, Master in Science (Geodetic Sciences) from the Ohio State University in 1987 and PhD in GPS Surveying from the University of New South Wales in 1996. His current research includes GPS/GNSS applications, system integration and development. He also produces the Malaysian Almanac for Surveyors.

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