Evolution of Korean Maritime DGPS System to High Accuracy Nationwide DGPS Service

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Abstract

According to the recommendation of International Maritime Organization, the Ministry Of Maritime Affairs and Fisheries (MOMAF) of Korea provides the real time Differential Global Positioning System service using maritime radio beacon from 1999. Due to the benefit of DGPS service, the need of this system is increased from various user groups for acquiring the better accuracy and integrity. Therefore, MOMAF has extended their service to inland by installing the additional 6 DGPS stations. This nationwide DGPS service will be fully deployed at 2007.

In addition to the extension of service area, MOMAF has a plan to upgrade their nationwide DGPS to High Accuracy Nationwide DGPS (HANDGPS). The planned HANDGPS service of Korea will be a kind of long range RTK or Wide Area RTK techniques to provide under 1m accuracy and start their service from 2009 using the various broadcasting and communication media like as radio beacon, Wibro, Digital Multimedia Broadcasting, High Speed Packet Data Access.

The introduction of nationwide DGPS system of Korea and its evolution plan will be addressed in this paper. The research activities related with HANDGPS in Korea is also presented.

Keywords: DGPS, RTK, HADGPS. Data Link

1. Introduction

Radio navigation systems have been widely used in land, air, and marine during last two decades. The key role has been provided by Global Positioning System (GPS), the satellite based worldwide radio navigation system of United States. This system has the valuable characteristic than other navigation systems such as accessibility, reliability, better accuracy and etc. Due to its benefits, the International Maritime Organization (IMO) adopted this kind of World-Wide Radio Navigation System (WWRNS) as the one of maritime navigation systems.

Especially, IMO recommended the maritime Differential GPS (DGPS) to increase the accuracy and to provide integrity for safety navigation in maritime. According to this recommendation, the maritime DGPS systems have been installed in more than 40 countries and one of the most effective maritime DGPS systems had been installed in South Korea by the Ministry of Maritime and Fisheries (MOMAF) from 1999.

As the benefits of maritime DGPS had been acknowledged by the inland user groups, the need of extension of its coverage area to inland was strongly proposed. Therefore, MOMAF has extended their service to inland by installing the additional 6 DGPS stations. This nationwide DGPS service will be fully deployed at 2007.

In addition to the extension of service area, MOMAF has a plan to upgrade their nationwide DGPS to High Accuracy Nationwide DGPS (HANDGPS). The forthcoming HANDGPS service of Korea will be a kind of long range RTK or Wide Area RTK techniques to provide under 1m accuracy with single frequency GPS receiver and start their service from 2009 using the various broadcasting and communication media like as radio beacon, Wibro, Digital Multimedia Broadcasting, and High Speed Packet Data Access.

The introduction of nationwide DGPS system of Korea and its evolution plan will be addressed in this paper. The research activities related with HANDGPS in Korea is also presented.

2. Nationwide DGPS Service in Korea

The maritime DGPS service plan of Korea was established in 1997 by following to the recommendation of IMO. The first signals could be available on west coast in 1999 (Palmi-do and Echeong-do) and full operation capability of Korean maritime DGPS service could available from 2002. This system is consists of 11 DGPS broadcasting stations and 8 monitoring stations, and the coverage of DGPS service cover the 70 percents of South Korea with maritime radio beacon [1].

As the benefits of maritime DGPS had been acknowledged by the inland user groups, the need of extension of its coverage area to inland was strongly proposed. Therefore, MOMAF has extended their service to cover the whole country by installing the additional 6 inland DGPS stations (Fig. 1). This extension of maritime DGPS system to nationwide DGPS service in Korea was started from 2000 and the last inland station will start their service at 2007 (Chuncheon).

The Ministry of Maritime Affairs and Fisheries of Korea has the evolution plan of nationwide DGPS service for providing more reliable, more accurate, more flexible NDGPS service. This modernization plan includes the NDGPS System Reinforcement program for improving the utilization of DGPS infrastructure, High Accuracy NDGPS Service program for providing decimeter accuracy to maritime and inland users, and Next Generation DGNSS Service program for applying the forth coming GNSS service like as Galileo.

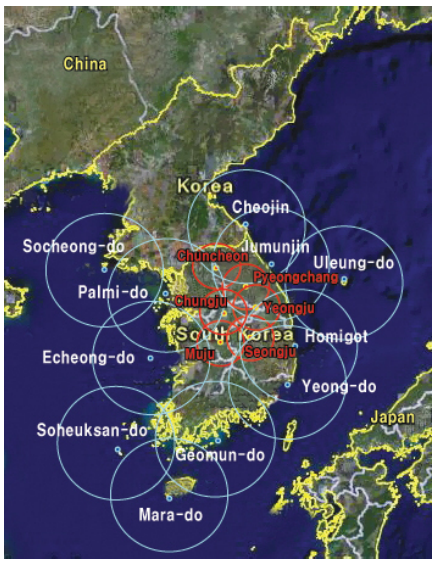

Figure 1. The coverage map of nationwide DGPS service by MOMAF, Korea.

3. High Accuracy Nationwide DGPS System

The key issues to enhance the GPS capability are accuracy and reliability. Differential GPS technique and integrity monitoring system using the GPS network have been developed to resolve these problems. For these issues, various DGPS techniques were introduced, for examples, post-processing, Real-Time Kinematic (RTK), and Wide Area Augmentation System.

In the case of data link for the real time correction data, DGPS users currently use the maritime radio beacon, dedicated radio modem and the packet data streaming using mobile phone. In addition to these, we can consider new candidates for data link like as DMB (Digital Multimedia Broadcasting) and WiBro (Wireless Broadband) systems. And many kind of data protocol can be used for transferring the correction data like as RTCM, RTCA, NTRIP and etc.

Through the proper combination of these components, GPS users could get the wide spectrum of accuracy from meter level to centimeter level.

Various DGPS techniques, protocol and data link methods to enhance the GPS capability are shown in figure 2.

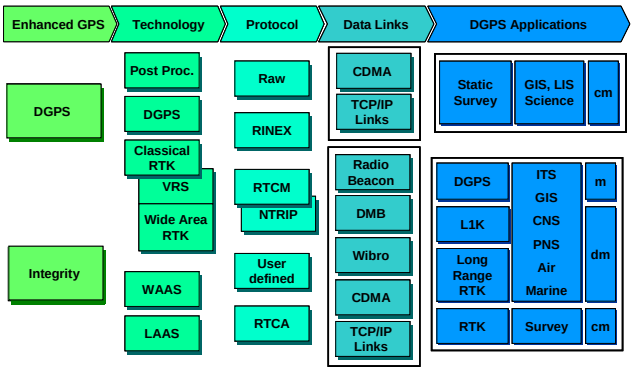

Figure 2. Technical components to enhance GPS capability.

3.1 High Accuracy Differential GPS

There are two main approaches to make high accuracy DGPS except the classical RTK.

One of them is virtual reference system to estimate DGPS and RTK correction for virtual position using GPS network. Several manufactures release their products like as VRS of Trimble, MultiRef of Univ. of Calgary and WaSoft/Virtuell of WaSoft Ltd.

Another approach is wide area or long range RTK. The key characteristic of this technique is to provide additional correction data like as precise ionospheric error to extend the RTK coverage up to 200 nautical miles. HADGPS of XYZ Company [2] and long baseline RTK of University of New Brunswick are belonging to this category.

Although the classical RTK can give decimeter accuracy under 30 kilometer baseline, the goal of high accuracy nationwide DGPS of Korea is to extend their coverage to 200km with decimeter accuracy using long range RTK concept.

3.2 Data Link for HANDGPS

To get the decimeter accuracy, we have to deal the carrier phase data of GPS signals. Because of characteristics of RTCM data architecture, data capacity is rapidly increased when we use the RTK technique. Approximately, 3 kbps is needed for L1 & L2 RTK correction data.

Because of restriction of maritime radio beacon (200 bps), we need to 14.2 seconds to send RTK correction data with RTCM 2.3 format (Table 1). If we can use 1kbps, the broadcasting time can be reduced to 2.84 seconds. Even though new RTCM 3.0 version is applied, the transferring time is more than 1 seconds. To resolve this aging problem, XYZ Company developed her own format, XCOR. This format has been designed to provide all the required data for RTK in a 1k bps based on the data compressed techniques.

Table 1. Data requirement for RTK and data transfer time at 200bps and 1000bps for several protocols

Data Requirements (bit)

	RTCM 2.3	RTCM 3.0	CMR	XCOR
DGPS	660	808/1000	864	1000
RTK (L1)	1420	808/1000	864	
RTK (L1/L2)	2840	1324/1936	1536	

Data Transfer Time at 200bps (sec)

	RTCM 2.3	RTCM 3.0	CMR	XCOR
DGPS	3.3	4.0/5.0	4.3	5.0
RTK (L1)	7.1	4.0/5.0	4.3	
RTK (L1/L2)	14.2	6.6/9.7	7.68	

Data Transfer Time at 1000bps (sec)

	RTCM 2.3	RTCM 3.0	CMR	XCOR
DGPS	0.66	0.81/1.0	0.86	1.0
RTK (L1)	1.42	0.81/1.0	0.86	
RTK (L1/L2)	2.84	1.32/1.94	1.54	

There are several data link candidates for high accuracy DGPS in Korea. First one is modified radio beacon tested in US DOT and it can give 1 kbps using raised cosine MSK modulation. Second one is terrestrial DMB which was started their service from last year in Korea. Third one is satellite DMB and forth one is WiBro. The last one is High Speed Downlink Packet Access (HSDPA) system using third generation wireless system

The characteristics of brand new broadcasting and communication system are shown in Table 2. DMB has just been started their service from last year and WiBro and HSDPA is ready to service from this year in Korea. These brand new services can provide more than 1 Mbps and cover the whole country including the seashore. Therefore, these systems are considered as the strong candidates of data transferring media for high accuracy DGPS in Korea.

Table 2. The characteristics of data link candidates for HANDGPS in Korea

Data Link Candidates for HANDGPS in Korea

	Upgrade Beacon	T-DMB	S-DMB	WiBro	HSDPA
Frequency	435-495KHz	204-210MHz 180-186MHz	2.630-2.655GHz	2.3GHz	1.8-2GHz
Data Capacity	1Kbps	1.152Mbps	7.68Mbps	1~30Mbps	7.2Mbps (MSM6280)
Channel Layout	Data	Video(1) Audio(3) Data(1)	Video(13) Audio(27) Data(5)	Packet Data	Packet Data
Modulation	RCMSK	OFDM	OFDM	OFDM	QPSK
Service (Provider)	Planning (MOMAF)	2005.12 (6 broadcasting companies)	2005.05 (Tu Media)	2006.07 (KT)	2006.07 (3 Carriers)

- RCMSK = Raised Cosine Minimum Shift Keying
- OFDM = Orthogonal Frequency Division Multiplexing

The coverage area of satellite DMB in Korea is shown in figure 3, which cover the many part of ocean around Korean peninsula.

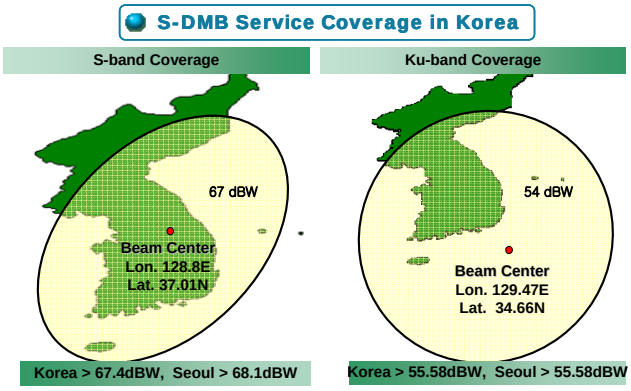

Figure 3. The coverage map of satellite DMB service in Korea

3.3 R&D Activities for HANDGPS in Korea

Related with the high accuracy nationwide DGPS, MOMAF of Korea has performing and planning some R&D projects.

One of them is the reinforcement of reference system and another is the preliminary study on data link methods and accuracy test for high accuracy DGPS service from 2004 to 2006 [3][4].

A new project will start from next year and main objective of this planned project is the development and implementation of high accuracy DGPS service system including data processing, data format, data links using the advanced broadcasting/ communication systems, dedicated Rx module and field test.

Following to the internal policy of MOMAF of Korea, the high accuracy nationwide DGPS service in Korea will be started from 2009. Two technical approaches of HANDGPS will be used in simultaneously with the support of advanced IT and broadcasting/communication system like as DMB, WiBro, HSDPA and upgraded maritime beacon

Most important feature of high accuracy nationwide DGPS will be to give the decimeter accuracy over the whole country. The proposed applications in maritime include the precise docking, container tracking, accurate dredging, canal cruise, ocean mapping. High accuracy DGPS can provide more benefits to precise inland applications like as GIS, surveying, ITS, etc.

4. Conclusion

The requirements of high accuracy, decimeter accuracy, are rapidly increasing in maritime and inland applications. The Ministry Of Maritime Affairs and Fisheries of Korea has the plan to develop the nationwide High Accuracy DGPS service system to provide decimeter accuracy for various applications.

HANDGPS service will broadcast correction data with compact format for maritime radio beacon users. Simultaneously, RTCM messages and other correction data will be provided via advanced broadcasting/communication media like as terrestrial DMB, satellite DMB, WiBro, HSPDA. HANDGPS service will be available from 2009 in Korea

To make valuable HANDGPS system, more research on proper data format for the maritime radio beacon is needed. On the other hand, to get the advantages of the brand new broadcasting and communication systems, the capability and reliability on data link characteristics of these systems are carefully tested for high accuracy DGPS service. Additional researches on maritime applications using high accuracy DGPS has to be performed for verifying the benefits of HADGPS service.

International collaboration program for R&D on the maritime applications, specification and new resolution for this edge technology are also needed

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