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HSD-001 REAL DGPS OCEAN SURVEY LOCATION SYSTEM

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Abstract

The HSD-001 high precision Real DGPS Ocean Survey Location System, validated by the Departmental Level Assessment in August 1992, is the first system to be used in China which incorporates GPS for dynamic positioning at sea. Characterized by a coordinate differential deviation of ±4 m, and a pseudo-range deviation of ±2-3 m, the system has filled an existing gap in China in this respect. A wide range of application in fields such as Ocean Survey, Marine Engineering Prospecting, Ocean Oil and Mineral Exploration, can be expected from it.

In recent years, there have been great advances in the development of systems for ocean survey positioning. Positioning for coastal surveys is achieved by the HYS-103 Automatic Survey System, designed and produced in the Department of Ocean Hydrography, Dalian Naval Academy, and the Minima System, introduced from the United States, both having been identified in practice as ideal means of positioning. For intermediate ranges, the ARGO Radio Location System, produced in the United States, has been playing an important role in the field of continental shelf exploration. However, in the field of oceanic surveys, because of the undeveloped nature of operations carried out in China, the use of Loran C, and in recent years, also GPS single-point location, for this purpose, is limited, due to their apparently unsatisfactory precision. It is well-known that the South China Sea spreads over a large area, rich in mineral resources, as well as occupying an

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important strategic position. For a quicker exploitation of the South China Sea, there is a need to carry out surveys in the area as soon as possible. Unfortunately, the radio positioning system currently used in China will not suit this purpose, due to the special geographical conditions in this area. On the basis of the above consideration, the Dalian Academy earlier this year developed the GPS Ocean Dynamic Survey System, mark HSD-001, which is a modified version of the Global Positioning System (GPS).

The whole system is comprised of a GPS receiver combined with a differential reference station, some short-range and long-range radio transmission equipment, and the necessary software. By avoiding the restriction imposed by the internal software of the GPS receiver, this system has provided a real-time high-precision positioning method, which combines coordinate differentiation with pseudo-range differentiation. Standard interfaces are employed for the interconnection between system components, permitting easy integration and exchanges among units. One reference station will be sufficient for the differential location carried out by any number of ship stations, with the differential process fully automated.

The system has significantly improved the precision of the GPS dynamic positioning. Experimental data show that the precision of the positioning has been upgraded to 5-10 times the previous level achieved by the GPS single point positioning. What is more, the system has effectively reduced the deterioration in accuracy due to the selected availability introduced by the United States government. The GPS Differential Mapping Survey, carried out in July 1992, in the Pearl River estuary, and April 1992 in the Nansha Area, have demonstrated that the successful accomplishment of this project was of great significance for the off-shore and oceanic survey off China, and promises a wide range of application in the fields of Marine Engineering Prospecting, Oil Drilling, and Mineral Exploration.

At the Assessment Conference, sponsored by the Navigation Guarantee Department of the Chinese Navy Headquarters, in August 1992, the experts present unanimously confirmed that the system had achieved the following breakthroughs: 1) It was capable of reading from the receiver serial interface the original survey and navigation message which the manufacturer did not provide; 2) It was capable of long range radio message transmission; 3) It was capable of controlling various functions of GPS survey using an external computer. In addition, engineers of the Dalian Naval Academy have also compiled software for satellite coordinate differentiation and pseudo-range differentiation to facilitate the system usage. The experts also stated that this system was the first of its kind in China proving to have a technical quality level similar to other advanced international products of the same kind. Yet its cost was lower in comparison with other known systems.

The HSD-001 System consists of a shore station (reference station) and a shipboard station. The structure is shown in the following diagram:

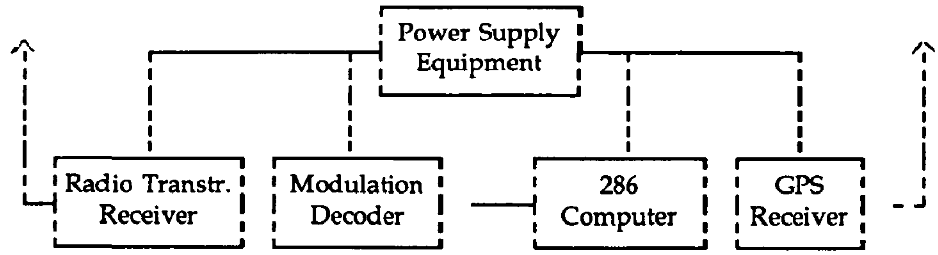

FIG. 1.- HSD-001 System.

The function of a shore station is to transmit a series of differential positioning corrective data. The GPS receiver used by the system may be chosen from the Trimble 4000 ST series provided it includes one RS-232 input port. Any computer (portable) IBM compatible can be used. For radio transmission and reception, a choice can be made between a VHF portable and a single-side band radio, depending on the distance. Power is supplied either by an alternating current source or by a battery.

Once power has been supplied, the GPS receiver will be switched to the position of satellite reception. The shore station operating software, stored in the computer, then commences to automatically preset the working status and various parameters of the GPS receiver, which will continuously collect a variety of survey data. These data are then processed to obtain the differential corrective data and their rate of change, which, in turn, will be transmitted in real-time through radio transmission equipment to the shipboard station, to perform differential positioning. During the whole process, the computer screen will display in time how the satellite is being tracked and how the signals are being transmitted. If necessary, artificial interference will be applied to alter the situation. At the same time, differential data are stored on the floppy disc for further use.

The shore station can work in two different modes: coordinate differential mode and pseudo-differential mode. The former will deliver such data as time beacon, satellite combination, longitude and latitude correction and rate of change; the latter will send out time beacon, number of all effective satellites, corresponding pseudo-range correction, and rate of change, etc.

The block diagram of the shipboard station is given below:

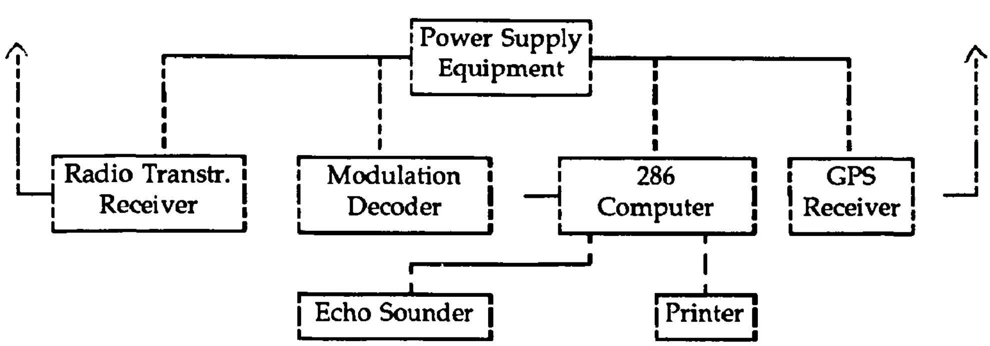

FIG. 2.- Shipboard station.

When the shipboard station software is initiated, the computer automatically pre-sets the working status of the GPS receiver, in accordance with the different working mode, continuously collects the survey data received by the GPS receiver, and, when differential data appear, automatically collects and renews these data.

Three kinds of working mode are designed for a shipboard station: 1) single point positioning, which will determine position with a fix obtained from Doppler smoothing, after the pseudo-range in the form of C/A code has been corrected by means of sidereal time, ionosphere, and troposphere; 2) coordinate differentiation, which will keep the shipboard satellite combination in constant coincidence with that of the reference station, and get a high-precision fix in real time by means of coordinate differentiation, interpreting the coordinates under control combination; 3) pseudo-range differentiation, which obtains a high-precision fix in real time through least square method based on the corrected differential data issued from the reference point.

This shipboard software is also capable of providing navigation along the scheduled route. For this purpose, a diagram window is opened to display graphical messages in the survey area such as unusual depth, shorelines, obstructions, etc, that are input manually or with a digitizer. During the survey process, the computer screen will serve as an electronic chart on which survey lines can also be tracked. This function is especially convenient for large scale hydrographic surveys.

This system has also post-processing capabilities and a plotting software component, capable of sifting and compiling depth and fix data, of applying instrument correction and tide correction, as well as plotting depths and isobaths.

From July to August 1991, at the Pearl River estuary, Guangdong Province, the HSD-001 Dynamic Ocean Survey Location System was first put into operation during its development stage. A 1:10,000 scale chart was obtained following the method of coordinate differentiation, with a sounding range covering an area of over 100 km^2. From March to April 1992, the system was used for the second time in the Nansha Islands to obtain a 1:25,000 scale chart covering a sounding range of 600 km also following the same method. In May of the same year, the pseudo-range mode of the system was applied to a survey range of 40 km, also in the Nansha Islands. Another application of the differentiation was carried out in the larger Nansha sea area, adopting a single-side band radio station for the transmission of differentiation data, over a distance of nearly 200 km. The transmission was reliable and accurate, and twice more efficient than a conventional one. Figure 3 and Figure 4 show the statistical data for the code error rate of a long distance data chain test.

Consecutive comparison tests were made at Guangzhou, Zhuhai, and Nansha to determine the precision of HSD-001 Dynamic Ocean Survey Location System. The test results are compared in Table 1.

Total number of test data: 620
General rate of code error: 0.5%
Code error -- time distribution

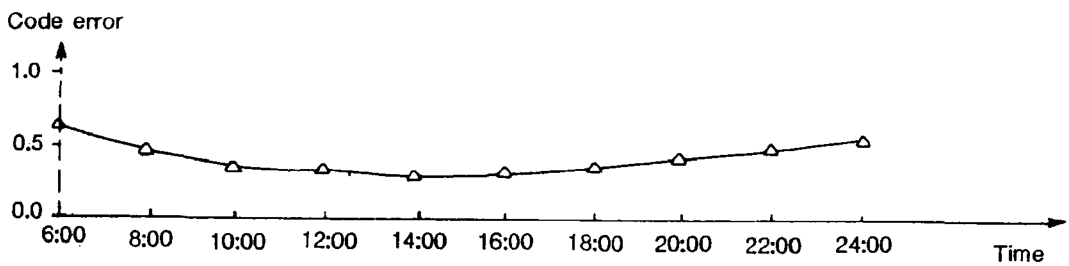

FIG. 3.- Statistical data for the code error of a long distance data chain test (a).

Distribution of code error -- distance
Rate of code error %

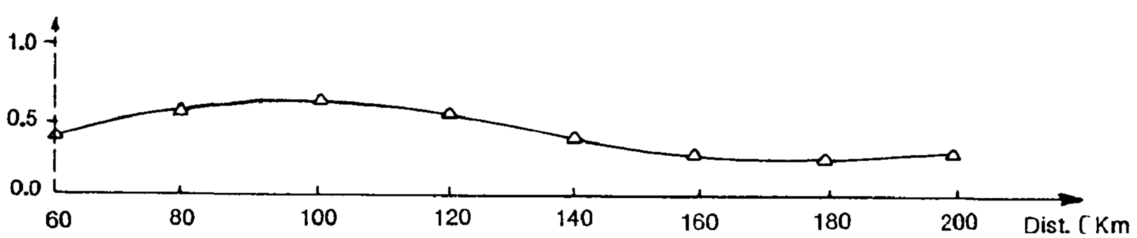

FIG. 4.- Statistical data for the code error of a long distance data chain test (b).

Table 1

Differentiation Md.	Coordinate differentiation		Pseudo-range differentiation	
Comparison Md.	Static	Dynamic	Static	Dynamic
Time	June, 1992	August, 1992	June, 1992	May, 1992
Place	Guangzhou	Zhuhai	Guangzhou	Nansha
Number of groups	41	22	214	30
Lat. average error	0.0	2.9	-1.2	0.8
Long. average error	-0.3	1.0	-0.3	-0.3
Lat. mean square error	2.7	2.0	2.4	0.9
Long. mean square error	3.3	3.3	1.2	2.7
Remark: Unit of error is in meters				

Table 2 shows the comparison of pseudo-range differentiations:

Table 2

Point Number	GPS Point	Polar coord. Pnt.	Error	Remark
1	9839.24 5444.03	9841.36 5443.64	-2.1 0.4	The higher order of the coordinates are omitted
2	9841.04 5461.09	9842.45 5459.26	-1.4 1.7	
3	9836.73 5463.82	9838.60 5461.53	-1.9 2.3	
4	9838.87 5467.48	9841.67 5466.26	-2.8 1.2	
5	9847.51 5455.02	9846.21 5466.26	1.3 -1.3	
6	9849.35 5455.93	9849.76 5458.06	-0.4 -2.1	
7	9863.17 5461.45	9866.22 5461.23	3.0 0.2	
8	9853.02 5463.56	9849.66 5464.61	3.3 -1.0	
9	9855.79 5462.65	9854.45 5462.33	1.3 0.3	
10	9803.08 5406.49	9803.55 5408.66	-0.5 -2.2	
11	0068.31 5392.27	0065.27 5393.36	3.0 -1.1	
12	300.02 5386.79	0298.85 5389.12	1.2 -2.3	
13	0445.38 5382.92	0445.10 5383.90	0.3 -1.0	
14	1023.08 5496.80	1019.45 5498.15	3.5 -1.3	
15	1032.56 5629.57	1031.98 5627.25	0.6 2.3	
16	1025.40 5781.48	1022.67 5778.07	2.7 3.4	

It is not difficult to infer from the table that the mean square error on the differential point of the system is $\sigma_1=\sqrt{\sigma_L^2+\sigma_B^2}=3.8\sim4.2m$; and the mean square error on the pseudo-range differential point is $\sigma_2=\sqrt{\sigma_L^2+\sigma_B^2}=2.7\sim2.8m$. Both of them will satisfy the requirement for ocean survey location.