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Development of Ship Route Track System Based on Digital Sea Chart with the Capability of Precise Coordinate Analysis of GPS

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Abstract

For GIS to land and sea in Korea, GIS on land was almost completed with big cities by NGIS(National Geographic Information System) business. However, MGIS(Marine Geographic Information System) being constructed by the National Oceanographic Research Institute is still constructing geography information and definition of attribute information and real condition. We are being studied on research to get maximized the ripple effect linking GPS and Navigation techniques on GIS. GPS in accuracy is divided into navigation and precise surveying equipment. Now, GPS technology has been developed very much and low price GPS equipments are introducing. But expense on GPS equipment is high yet. Therefore, GPS equipment for navigation is used on cheap GPS equipment in a car or ship. In this paper, the author used algorithm to convert ellipsoid coordinate between WGS84 and Bessel ellipsoid and to analyze map projection between BESSEL ellipsoid and UTM plane coordinate system. And the author developed ship navigation system with cheap GPS equipment using algorithm of ellipsoid conversion and map projection. The author proposed the necessity on constructing MGIS to manage many ships.

Keywords : *Marine Geographic Information System, GPS, Navigation, Coordinate Convert*

1. Introduction

Recently, GPS in land is used on car navigation system and used positional Information system linked in PDA but it is not used yet in marine. In the early days, GPS was developed for ship navigation and used in near positional tracking method because positioning on sea was not affected on precision very well.

Precision of ship navigation on sea been imported since harbor was complex and ship were increased.

GPS coordinate system acquire datum on WGS84 ellipsoid. However, our country's topographical map or chart changes coordinate system from WGS84 coordinate system to Bessel ellipsoid and they use plane Cartesian coordinate system changed from Bessel ellipsoid to TM or UTM. That is to say, the chart is mapping by UTM projection and the topographical map is TM projection. 2 data of the same area is examined and managed by repetition to NGIS and MGIS. 2 data in identical spot was differently management because use other projection in position information.

Therefore, position information managed apart cause confusion about position information acquisition and provoke obstacle of correct navigation.

GPS was developed for military purpose and navigation by Department of Defense (DoD) in the 1970s and basis researches are studied steadily until present as being introduced first time in domestic in late 1980s. Previously, error had some hundred m to ten m, but recently could measure to error extent mm. It is utilized variously and extensively for vehicles automatic navigation, control survey, position information system that use PDA(Personal Digital Assistant), and leisure.

Initial ships or airplanes of navigation was possible that accuracy is inexact, at present the effectiveness overlook. However, as ships of large freight traffic that safe shipping service is the most important. To be fine

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necessary since Ships needed safely to sail due to large size ships in trend and the bottom of the sea by water level change of floating matter and surface of the water. The existing two-dimensional digital map only supplies position information in mean sea level, confirmation of data by water level change or accumulation of floating matter is difficult. It needed information of position and attribute as well as depth of sea hereupon.

Method of this study is divided by next 4 steps. first step acquired a voyage data by GPS absolute positioning method with real time. second step constructed geographic information and attribute information that based on sea digital chart for real time ship navigation cartography and geographic information construction of marine geographic information system. third step produced using 3-parameter coordinate conversion algorithm on GPS ellipsoid, and manufactured map projected algorithm that change WGS84 ellipsoid and longitude and latitude coordinate of Bessel ellipsoid to review sacking faith coordinate by UTM cast shadow. Finally, fourth step provided construction and practical use of GPS ship navigation system, and necessity of MGIS construction of wireless internet base for some ships management.

Additionally, Busan port created including 1:25,000 island in the sea to model area and established development of navigation system by absolute positioning method to research dimension in practical use side of low-cost equipment of GPS survey method. Therefore, it was not mentioned in this study, development of navigation system by companion positioning method may achieve continuously research, and will widen the study range to research about efficiency way including wireless communication area.

2. Marine Geographic Information System

2.1 Composition of MGIS

MGIS schematizes all phenomenons that happen in extent this space enemy by technology that handle space information and attribute information utilizing district along basic of the coast and sea, and expresses to database, and speak marine geographic information that become head of a family basis that is utilized to country dimension in sea field of country basis geographic information by system that can support various decision making because using GIS and the practical use uses in various field fishery marine products field and resources of the sea, physical distribution etc.

To construct MGIS is essential construction of basic geographic information. Basis data is observation and

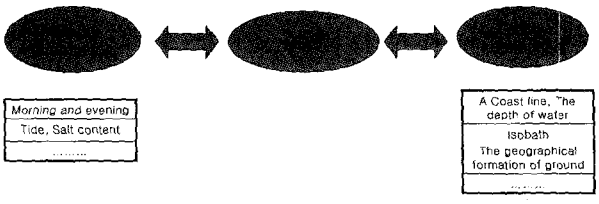


Fig. 1. Composition of Marine geography information system data.

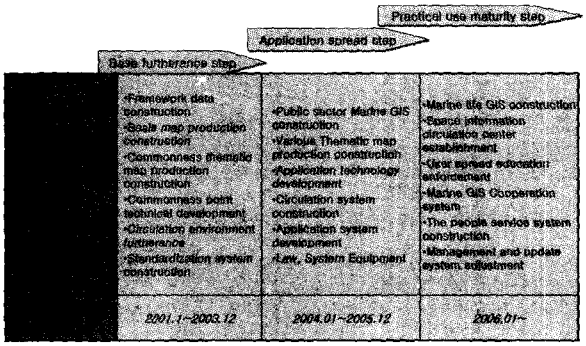


Fig. 2. Step propelling plan of Marine geography information system.

*source : a report of business plane of MGIS

control point of tide, coastline investigation survey, DB construction, offshore waters investigation survey, marine basis geographic information construction, harbor and bay underground facilities DB construction, seafloor information system. These basis data classifies to space information and attribute information, it gets into recent publication of MGIS construction.

Now, MGIS has based in the second country GIS drafted planning, since 2000 process of base step, now it is frame data construction, basis production construction, commonness subject work of production construction and standardization system construction. Step propulsion plan of MGIS was figure 3 .

2.2 Satellite Route Chase System Manufacture

This study consisted for automatic navigation system of ship with GIS and route chase system manufacture. Through this research, manufactured satellite route chase system consisted largely 3 module. The first module confirmed own position in character, voice, graphic in underway the ship present by real time route chase module and was manufactured so that can know distance and direction by accurate position relation analysis with surrounding topography. The second module was post processing route chase. That was manufactured for route of ship and statistics processing

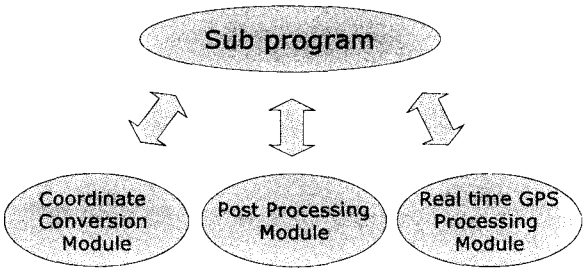


Fig. 3. Total structure of satellite route track system.

that is acquired by real time. That represent voyage data in AutoCad that auto conversion script file form of AutoCad. repeat voyage data is statistics processing and catch the standard deviation and error rate. The third module was manufactured to change longitude and latitude coordinate of WGS84 ellipsoid that was acquired from GPS satellite to data of form that user wants individual GPS received data because of accurate conversion by center of the earth coordinate, Bessel longitude and latitude coordinate, TM projecting, UTM projecting module. Structure of route chase system was developed in this research with figure 4.

Program that is developed in this research manufactured using Visual C++ version 6.0 Compiler that is developed in Microsoft company. Program manufactured by Single Document Interface(SDI), and each module manufactured by Dialog Box Based.

GPS received data is acquired to longitude and latitude coordinate of WGS84 ellipsoid. Our country's chart must convert coordinate system because of using geographic coordinate System of Bessel ellipsoid. 3-parameter that is offering in National Oceanographic Research Institute in this research proceeded coordinate conversion using parameters. Additionally, it executed map projecting to UTM plane cartesian coordinate to express GPS observation data on the chart and this research took advantage of the equation that is proposing in United States Defense Mapping Agency(DMA). Table 2 shows the 3-parameters that is the starting point elongation amount between ellipsoid is offering in national oceanic tide monastery.

Table 1 is a table that introduces work each module of satellite route chase system in detail. A method (1), (2), (3) is United States Defense Mapping Agency (DMA).

$$\begin{aligned}\Delta\phi'' = {} & 11.42838 + 0.38110U + 0.66055V - 2.85156U^2 - 7.9092U^3 \\ & + 2.66005U^2V - 1.44720UV^2 - 0.55880V^3 + 17.02465U^4 \\ & + 13.83455U^3V + 2.24425UV^3 + 4.26478U^5 + 10.19286U^4V \\ & - 12.27058U^3V^2 + 1.72169UV^4 - 10.70332U^6 + 9.42547U^4V^2 \\ & - 0.04957U^3V^3 - 1.63710U^7 - 3.31782U^4V^3 + 5.58416U^3V^4 \\ & + 2.14642U^8 - 3.44749U^4V^4 - 0.18249V^8 - 0.40958U^2V^7 \\ & - 0.08997V^9 + 0.75251U^3V^7 - 0.14797U^2V^8 - 0.00866U^8V^5\end{aligned} \tag{1}$$

$$\begin{aligned}\Delta\lambda'' = {} & -9.41485 - 4.14394V - 0.20672UV - 1.387944V^2 - 1.23235U^3 \\ & - 0.83040U^2V + 5.62308V^3 + 1.80638V^4 - 4.51075V^5 + 0.09944U^6 \\ & - 0.91183U^7 + 0.90813U^70.28770U^{2V^6} + 1.48962V^7 + 0.16266V^8 \\ & - 0.27918U^8 - 0.16036V^9 - 0.03918U^5V^8 + 0.01027U^7V^8\end{aligned} \tag{2}$$

$$\begin{aligned}\Delta H_m'' = {} & 17.498 - 5.767U - 30.032V - 93.585U^2 - 23.478UV + 20.307U^2V \\ & + 11.444UV^2 + 12.581V^3 - 235.503U^4 + 48.615U^3V + 76.860U^5 \\ & - 2.569V^5 + 170.295U^6 - 39.287U^5V - 73.837U^7 - 11.695U^3V^4 \\ & - 38.249U^8 + 9.382U^7V + 18.230U^9 + 3.445U^4V^5 + 0.329UV^9 \\ & - 0.147U^3V^7\end{aligned} \tag{3}$$

Table 1. Work that each modules of route track system

Main Module	Sub Module	Management Work
Realtime Processing Module	Text Moudule	Topology offer with real time coordinate and surroundings facilities
	Voice Module	Moving information by voice support
	Graphic Module	Real time of roue to drawing indication
Post Processing Module	CAD Converting Module	Moving path in CAD indication
	Statistics Module	Statistic calculation of static surveying
WGS84 Converting Module	GeoCenter Coordinate Calulation Module	WGS84 coordinate to geocentric coordinate system conversion
	Bessel Converting Module	WGS84 to Bessel coordinate conversion
	TM Converting Module	WGS84 to TM coordinate conversion
	UTM Converting Module	WGS84 to UTM coordinate conversion

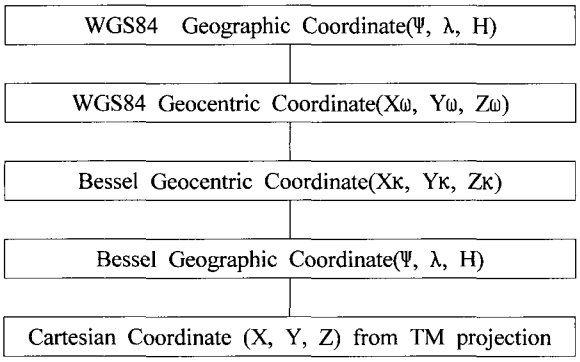


Fig. 4. Map projection of Coordinate conversion.

$\because U = K(\phi - 35)\ V = K(\lambda - 135)\ K = 0.15707963$

ϕ : local coordinate system of latitude

λ : local coordinate system of longitude

Table 2. 3-parameters of Tokyo Datum that offer in National oceanographic research institute (unit: m)

WGS84 ⇔ BESSEL	ΔX	ΔY	ΔZ
	-147±2	506±2	687±2

Fig. 4 is process map projection of coordinate conversion.

Figure 5, Figure 6 and Figure 7 are pictures that show the execution state and some of original source of real time processing module, after processing module and coordinate conversion module.

3. Application

3.1 Model area

Model area of this research took advantage of

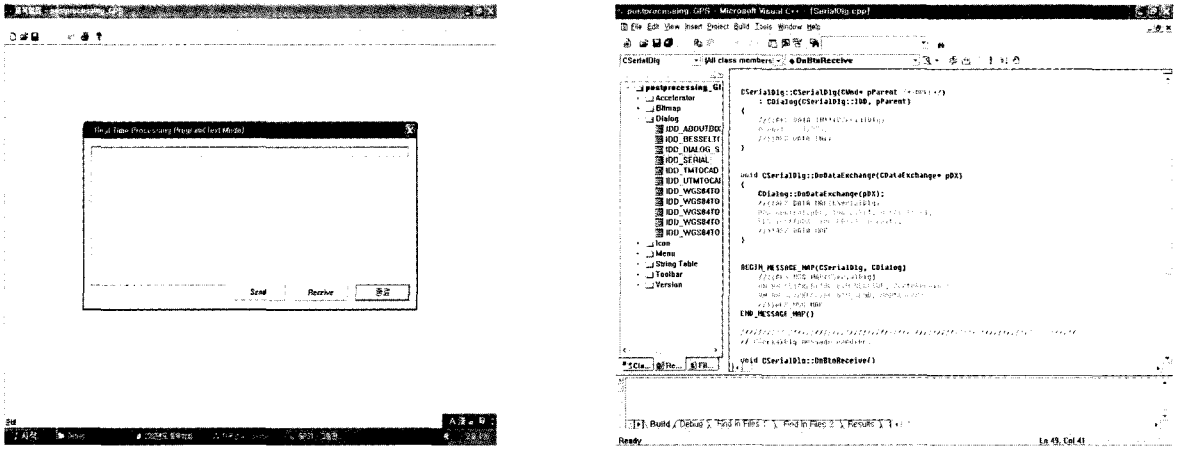
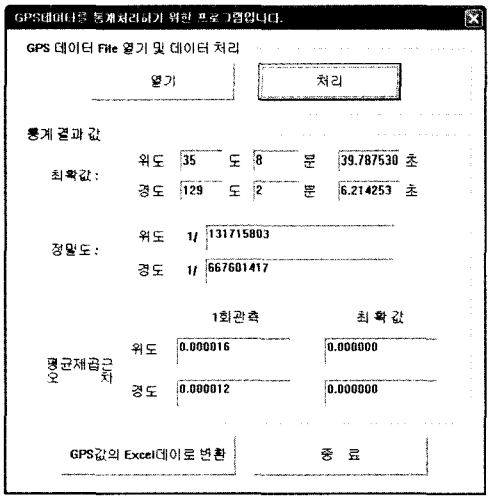
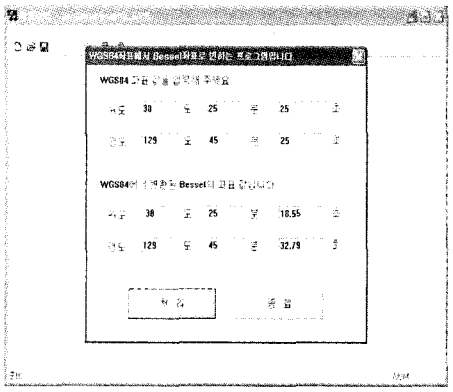


Fig. 5. Execution state and some of original source of real time computing module.




```
for(i=0;i<nCount;i++)
{
    wgs84_wido_degree[i] = lat_deg[i] + lat_min[i] / 60.0;
    wgs84_kyungdo_degree[i] = lon_deg[i] + lon_min[i] / 60.0;
}

for(j=0;j<nCount;j++)
{
    sum_wido += wgs84_wido_degree[j];
    sum_kyungdo += wgs84_kyungdo_degree[j];
}
ave_wido = sum_wido / nCount;
ave_kyungdo = sum_kyungdo /nCount;

wido_deg = int(ave_wido);
wido_min = int((ave_wido - wido_deg) * 60.0);
wido_sec = ((ave_wido - wido_deg) * 60.0 - wido_min) * 60.0;

for(k=0;k<nCount;k++)
{
    v_wido[k] = wgs84_wido_degree[k] - ave_wido;
    vv_wido[k] = pow(v_wido[k],2);
    sum_vv_wido += vv_wido[k];
}

rmse_wido_1 = sqrt(sum_vv_wido/(nCount-1));
rmse_wido_n = rmse_wido_1 / sqrt(nCount);

presion_wido = int(ave_wido / rmse_wido_n);
```

Fig. 6. Execution state and some of original source of after processing module.



```
// TODO: Add your control notification handler code here
UpdateData(TRUE);

double wgs84_wido_deg, wgs84_wido_min, wgs84_wido_sec;
double wgs84_kyungdo_deg, wgs84_kyungdo_min, wgs84_kyungdo_sec;
int bessel_wido_deg, bessel_wido_min, bessel_kyungdo_deg, bessel_kyungdo_min;
double bessel_wido_sec, bessel_kyungdo_sec;

CString temp1, temp2, temp3, temp4, temp5, temp6;

wgs84_wido_deg = atof(m_WGS84_Wido_Deg);
wgs84_wido_min = atof(m_WGS84_Wido_Min);
wgs84_wido_sec = atof(m_WGS84_Wido_Sec);
wgs84_kyungdo_deg = atof(m_WGS84_Kyungdo_Deg);
wgs84_kyungdo_min = atof(m_WGS84_Kyungdo_Min);
wgs84_kyungdo_sec = atof(m_WGS84_Kyungdo_Sec);

wgs84_wido_degree = wgs84_wido_deg + wgs84_wido_min / 60.0 + wgs84_wido_sec / 3600.0;
wgs84_kyungdo_degree = wgs84_kyungdo_deg + wgs84_kyungdo_min / 60.0 + wgs84_kyungdo_sec / 3

bessel_wido_degree=wgs84_to_bessel_wido(wgs84_wido_degree,wgs84_kyungdo_degree);
bessel_kyungdo_degree=wgs84_to_bessel_kyungdo(wgs84_wido_degree,wgs84_kyungdo_degree);

bessel_wido_deg = int(bessel_wido_degree);
bessel_wido_min = int((bessel_wido_degree - bessel_wido_deg)*60.0);
bessel_wido_sec = ((bessel_wido_degree - bessel_wido_deg)*60.0 - bessel_wido_min)*60.0;
bessel_kyungdo_deg = int(bessel_kyungdo_degree);
bessel_kyungdo_min = int((bessel_kyungdo_degree - bessel_kyungdo_deg)*60.0);
bessel_kyungdo_sec = ((bessel_kyungdo_degree - bessel_kyungdo_deg)*60.0 - bessel_kyungdo_mi
```

Fig. 7. Execution state and some of original source of coordinate conversion module.

1:25,000 digital map of Busan port around. Figure 8 shows 1:25,000 digital map that is model area of this research.

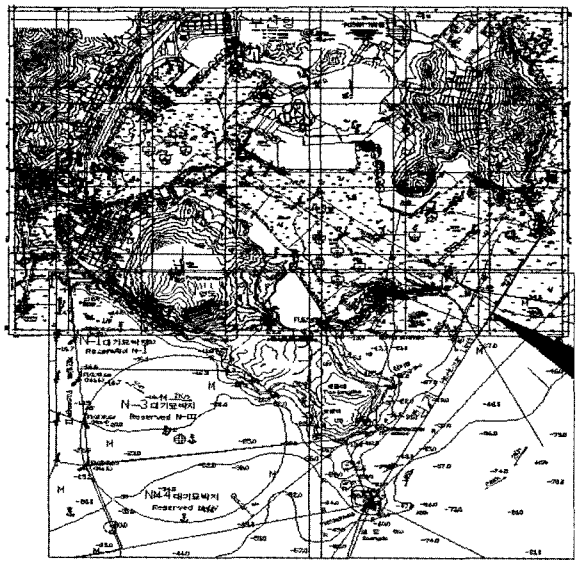


Fig. 8. Model area of Busan port

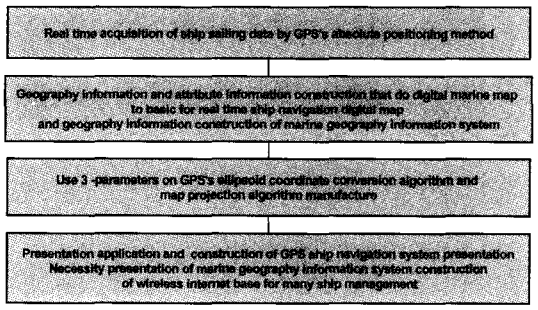


Fig. 9. shows flowchart of research that achieve this study.

3.2 Geographic information and construction of attribute information

In this research, construction of geographic information constructed geographic information of MGIS that the present MOMAF Affairs Ministry is achieving managed by standard. Basis geographic information constructed and based on the digital chart which has the drawing layers. Table 3 is a table that shows part of geographic information that construct in this research.

Attribute information adds field and record field in attribute table and added position coordinate and information of main topography. Table 4 is a table that show part of attribute information that construct in this research. Table 4 decided topography title, position coordinate and information in the name of field as a lighthouse, a sea university, a wharf and main topography elements constructed the name of the record.

In this research constructed basic geographic information and construct in the MOMAF to relate geographic information for connection to constructed drawing the construction of relation data base. Therefore, geographic information and integration that wish to construct in the MOMAF are thought to be possible. Figure 10 shows that construct geographic information and attribute information to ArcView GIS S/W. Figure 11 shows ship navigation using map object.

3.3 Satellite Route Track System developments

This research developed route of ship chase system possibility for using GPS navigation. Through this research, manufactured satellite route chase system developed hardware and software. First, hardware portion achieved real time route chase and GPS data moral training using Notebook computer. Figure 12 is picture that shows hardware that uses to satellite route chase system.

Table 3. Geography information that construct in this study

The Name of Geographic information	The name of database field	Symbol	The Name of Geographic information	The name of database field	Symbol
Index Contour Line	LNDELV_TC	line	Intermediate Contour Line	LNDELV_TN	line
Road	ROADWY	line	Railway road	RAILWY_HV	line
Shoreline	COALNE_FL	line	The same depth line	DEPCNT	line
Jetty	SLCONS_ISL	line	Wharf	SLCONS_SW	line
Pier	SLCONS_WH	line	The route of a ship	FAIRWY_M	line
Church	BUISGL_CH	✢	Buddhist temple	BUISGL_TP	┆

Table 4. Attribute information that construct in this research

The name of geographic information	Location coordinate		Information
	X	Y	
lighthouse	508553.71	3877941.55	Excursion The Vicinity of Ferry
Korea Maritime University	508144.32	3880423.82	End of A breakwater
The Vicinity of Ferry	507821.93	3880251.69	The Vicinity of Ferry
End of Taejongdae	508980.35	3878967.60	Taejongdae bluuff

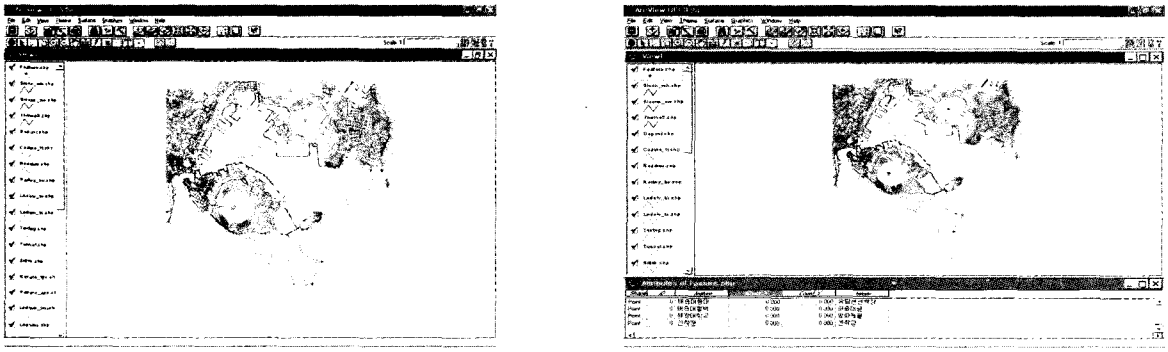


Fig. 10. Sea geographic information constructs to electron island in the sea and GIS S/W.

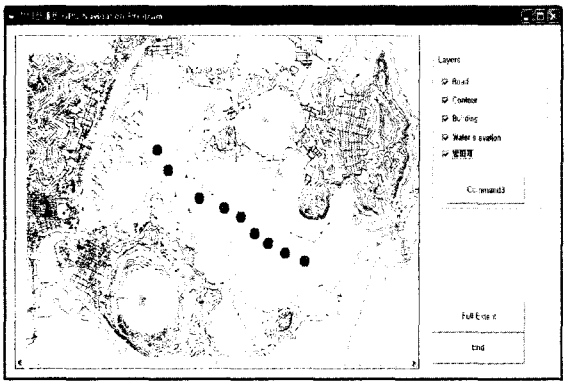


Fig. 11. Ship Navigation Using Map Object.

Software portion first of all number of GPS data acquired and analysis, and developed program that can supply ship sailing information by real time. Additionally, the possible GPS data verification module with an affair state processing developed to examine accuracy of GPS received data that was acquired by real time. Moreover, developed coordinate conversion module that can change mutually for domestic coordinate system.

Information of construction in this research was geographic information, attribute information, voice information, character information. Among this, voice information and character information constructed topography of a excursion ship surrounding to indicate the practical use possibility to voice information.

This research developed the ship route track system that used Notebook computer. Now, just-in-time of PDA that development is accelerated, is going to

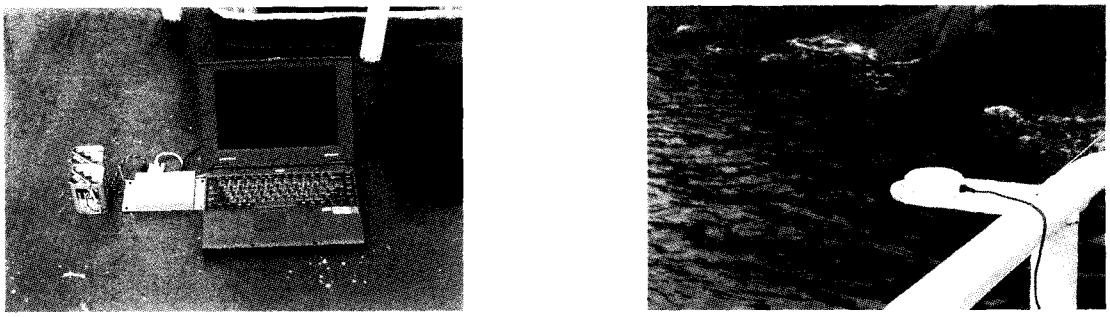


Fig. 12. Hardware that uses to satellite route chase system.

develop route track system of PDA through subsequentness research with necessity of optimization of route track system using PDA. Furthermore, geographic information and attribute information are more specific for link anger of MGIS and practical use anger which is constructing present because constructed using basic data and practical use anger will develop possible system while construct reunified information.

3.4 The comparison consideration

This research has many difficulties from first and achieved. First of all, it was not supported at the time that support of hardware for research achievement wants. Additionally, in this achieved research occurred among problems and difficulties.

A lot of problems were happened in extraction of data that was acquired by binary mode that geographic coordinate of WGS84 ellipsoid that was acquired by real time in GPS Sensor was not acquired by text mode. Therefore, it may be desirable that data that was acquired in GPS Sensor in case for development navigation system inflecting GPS Sensor that was introduced in domestic and bought GPS Sensor of text mode. Moreover, a problem happened in selection of ship that pass fixed path at process that acquire GPS data of ship route. This problem could solve by practical use of ship that patrol sightseeing path.

Difficulty in research achievement was the most difficult as development of software. All figures and navigation system were performed in this research and developed using Visual C++ and Visual Basic. However, it had difficulty that must spend in much time to achieve basic study about Visual C++ language seeing many difference programing methods that were numerical analysis which a general college student knows and program technique ability that manufactured to achieve this research. Additionally, there were many difficulties in program construction by comprehension insufficiency for Packet at serial com port program manufacture for real time of GPS data.

Furthermore, more reasonable matching should be performed between sea portion and land portion but it happened some problems as there was not correct basis data. Geography information of construction had many difficulties when there was not correct standard about MGIS.

Many difficulties and problems happened as achieving this research but many practical use degrees through integration ship navigation system construction are expected. Navigation system that construct in this research constructed own position by system that can know own. Therefore, it will be feeling necessity of algorithm development about companion positioning method that can express position of ship minutely more with administrable majority ship managerial system in the ship Management and Maintenance Bureau and is going to improve navigation system that develop through continuous research through this research.

4. Conclusions

In this study, finding following conclusion about construction of ship navigation system development of accurate GPS coordinate analysis base.

First, it could decide our country's UTM accurate plane cartesian coordinate by 3-parameter coordinate conversion and UTM projection that use parameters on WGS84 ellipsoid and Bessel ellipsoid by real time GPS data.

Second, it could construct attribute information of main topography, and could display precisely character information and voice information using constructed attribute information during sailing.

Third, base basis geography information data of marine geography information system that is promoting at present and geography information abstraction of the

digital chart is possible.

Additionally, in this research developed ship navigation system that used geography information of sea geography information system and attribute information in elementary grade. Therefore, it will construct more general navigation system through continuous geography information and addition of attribute information. Moreover, it may be land and sea of topographical chart to be wider through integration and study research for geographic information system construction, land and sea of the chart connection is reunified continuously.

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