APPLICATION OF MARINE GEOGRAPHIC INFORMATION SYSTEM USING ANALYSIS OF CONTROL POINTS IN POST PROCESSING DGPS SURVEYING

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ABSTRACT :

The GPS precise surveying which is prevailing in Korea now grasps the problem that the result of the GPS observed value is used without the analysis of the relationship between the geometric strength and the variance factor. And it was accomplished by the necessity of the unified projection of Digital Map and Digital Chart for the unified geographic information system construction on the land and the sea, respectively.

The purpose of this study is firstly presenting the method to improve the precision of the observed value in GPS, and secondly the direction for the unified management of Digital Map and Digital Chart by comparing and examining the boundary line error that is on these maps which used the GPS control point through the unified projection of them. For the former, it was done using the precision analysis method that was divided into two parts as the geometric strength and the change of the variance factor in the observed value of GPS. And all these are for 3 control points which is used in GPS network adjustment.

In this study, when we matched the Digital Map to the Digital Chart by using the coordinate of the boundary point through the EDM was carried out in using the result of GPS surveying, generally we could know that the errors were happened largely in the southeastern direction.

1. INTRODUCTION

Theoretically, GPS has the capacity for the mutual positioning to a few millimeter and also is possible to survey scores of kilometers in a short time without the mutual collimation. So, it can get the positioning value in the area which has the existing control point to be desired and the difficulty to survey.

Moreover, it's receiver is easy to be used when compared to a existing surveying instrument, and if it is connected with computer, the result value is acquired immediately. GPS is becoming a very effective surveying means for these reasons.

Also there are many kinds of GPS receivers to be developed, and the cost is lower and lower. These are caused by the advance of hardware and the combination the GPS positioning function with a computer technology.

GPS method is classified into the Static method, the Kinematic method and Dynamic method. The first is used in the precise static surveying, and the second, though this has a poor precision, is used in traverse point, boundary surveying, and the last is for tracing the real time position, connecting to the navigation instrument.

In the case of the Static surveying for GPS precise geodetic surveying, it must be carried out to proportion precise coordinates by the GPS network adjustment that use the control points as postprocessing. The GPS positioning involves not only 'natural' errors associated with the satellites position errors, refraction of EM wave in the ionosphere, etc., but also 'artificial' errors associated with the operation of S/A. Internally, Many of authors have studied on DGPS in order to improve the GPS Positioning Accuracy.(Kang, Lee, 1995; Kim, 1996; Park, 1997) For estimating the precision of GPS survey for the long baseline measurement, Yoo, H. performed the simultaneous GPS observations at two points in Korea and nine points in Japan, and analysed the precision of GPS survey by using broadcast ephemeris and precise ephemeris.(Yoo, Pio, 1997)

After GPS network adjustment carries out the base analysis, it does this adjustment by fixing 1 point, 2 point, or 3 point. Generally the method of 3 point fixing is used. (Kang, 1996)

Externally, they have used GPS for Hydro-Oceanographic Surveying(Abidin, 1994). Many of authors have studied and read paper about the GPS Networks, GPS Heighting, real time differential GPS surveying actively.(Brunner, 1994; Collier, Armstrong, Leahy, 1994; Doller, 1994)

Recently, they applied GPS surveying on wide area and studied on Error analysis(David, 2003), Fault Detection and Exclusion Using Normalized Solution Separation and Residual Monitoring Methods.(Ryan, 2003)

There are many kinds of domestic digital maps. Widely, these are divided into a digital map and a Digital Chart. At present, a digital map is turned out by the TM projection method and Digital Chart is by the UTM projection method.

Now, as the process of the united management for the national geographic information on land and at sea, the geographic information system is constructed on land, and the marine geographic information system, although this is in the beginning, is supposed to be constructed on the sea.

So, the management of the single projection method to digital map and Digital Chart will be accomplished for the final unified management of the national geographic information system and the marine geographic information system.

As the analysis scope of this study, it was done in the analysis of errors by 3 geometric strength points which are used as the control points in the analysis, and by the changes of the variance factor which is used in the Chi-Square goodness of fitness analysis of the observed value of GPS, respectively.

2. GPS SURVEYING

There are two types in the observation method of GPS, pseudoranges and carrier phases. The pseudoranges are often used in the navigation system. Although the carrier phases are usually used in the surveying to require the very high precision, the pseudoranges and the complex analysis methods are sometimes more prevailing comparing to the one. Since in the carrier phases, there are double difference and triple difference. (Kang, 2004)

3. APPLICATIONS.

3.1 Study area.

The sample areas of this study were selected as the first, second, third and forth points in the Pusan city. The existing triangular points were inspected to estimate the accuracy of the points.

The figure 3.1 shows the flow chart of this projects that are composed as three parts, planning, the field and the office works.

Planning
1. verifying triangular point and getting point record in 1:25,000 map. 2. Field investigation for verifying triangular point and if they are able to be used or not. 3. Determination of surveying session with considering GPS satellite positing and DOP

Field Work
1. GPS Static surveying. □ session 1 : GPS Static survering on five triangular points. □ session 2, 3 : GPS control point surveying for matching digital map with digital chart. 2. EDM surveying. □ EDM surveying boundary of digital map and digital chart using coordinates of points which were gotten by GPS surveying.

Office Work
1. Analysis for precision improvement of GPS surveying result. □ Analyzing error of control points with geometric intensity . □ Analyzing error of GPS surveying result with variation of Variance Factor in Chi-Square Verification. 2. Analyzing united error of digital map and digital chart. □ Analyzing error between digital map and digital chart through TM projection of digital chart.

Figure 3.1 Flow chart of this study

Table 3.1 The surveying implements used in this surveying

The name of Surveying equipment	specification
GPS Receiver	■ GRS 2600 GPS Receiver 1. GPS equipment of SOKKIA make : 3 Set 2. Accuracy(Static, Rapid Static) Horizontal : 0.5cm + 1ppm·D Vertical : 1cm + 1ppm·D ■ Radian IS GPS Receiver 1. GPS equipment of SOKKIA make : 2 Set 2. Accuracy (Static, Rapid Static) Horizontal : 0.5cm + 1ppm·D Vertical : 1cm + 1ppm·D
EDM	■ SET 530R 1. EDM equipment of SOKKIA make : 1set 2. Accuracy Horizontal : 0.2 cm + 2ppm·D Vertical : 0.2 cm + 1ppm·D

3.2 Field surveying

3.2.1 GPS static surveying.

GPS static surveying was processed, divided into plan, field work. And it was done in total 3 stages.

3.2.1.1 Check of the triangular points

The first work is the check of triangular points and of whether it is used or not. At this stage, the triangular point is selected and checked to carry out the GPS Static surveying.

For this study, it was intended to select the first and the second grade points, respectively. But those were to be few, so in study the following points was selected. The first grade triangular point(Bong-Lae Mt. triangular point)-1 point. The second grade triangular point(Um-Gaung Mt. triangular point)-1 point. The third(Jang-San Mt. triangular point)-1 point. The forth(Whang-Rung Mt., Keum-Ryun Mt. triangular points)-2 points.

The table 3.2 shows the name and the coordinate of the triangular point used in this study.

Table 3.2 The coordinate of triangular point

(unit : m)

Triangular Point	N	E	H
Bong-Lae Mt.	175,947.4206	204,971.4931	394.720
Um-Gaung Mt.	181,955.7937	201,906.9757	504.220
Jang-San Mt.	179,821.0950	211,051.9410	224.600
Whang-Lyung Mt.	184,236.8140	207,407.7780	427.630
Keum-Ryun Mt.	183,613.4990	209,158.8250	225.570

The picture 3.1 shows the triangular points of Um-gaung Mt. and Jang-San Mt. among points used.

Picture 3.1 stone landmark of Um-Gaung Mt.(left) and Jang-San Mt.(right)

3.2.1.2 GPS mission planning

In this stage, the present condition of GPS satellites arrangement and the work session is determined, which is accomplished before the field surveying. GPS positions the location by the satellites. So the arrangement of the satellites affects the accuracy of this surveying very much. In this reason GPS surveying should be carried out in the better arrangement of satellites. It is possible to check the arrangement of satellites by using the value of DOP. Generally if the value of DOP is less than 4, it's OK. And if it is required to do more accurate GPS surveying, it is good to do the surveying in the condition the value of DOP is less than 2.

In the GPS surveying of this study, the work session was determined in the condition the DOP value is 'below 2' which is set to the standard.

The figure 3.2 shows the present condition of the satellites arrangement to do the GPS Static surveying.

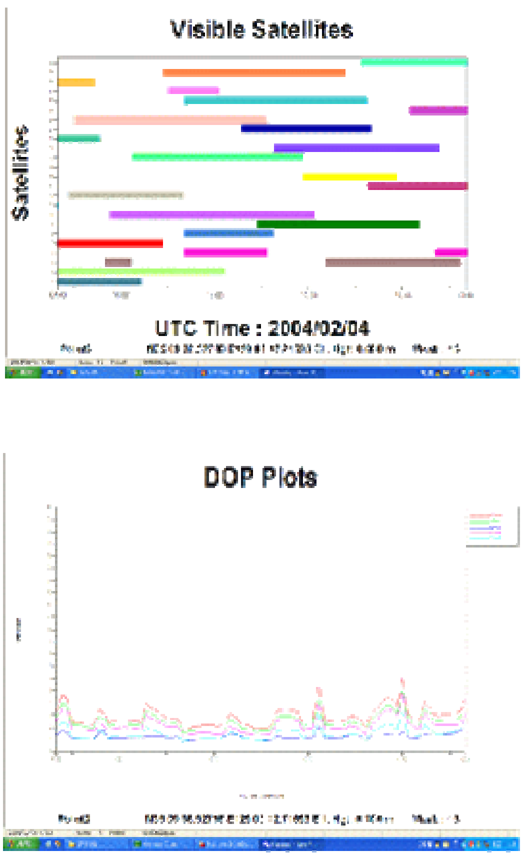

Figure 3.2 The situation of satellites arrangement

The table 3.3 is the work session to have accomplished the GPS Static surveying in this study.

Table 3.3 Session table

Session	Receiver 1	Receiver 2	Receiver 3	Receiver 4	Receiver 5
	Ant. Hight	Ant. Hight	Ant. Hight	Ant. Hight	Ant. Hight
Session 1	Um-Gaung Mt.	Bong-Lae Mt.	Whang-Lyung Mt.	Keum-Ryun Mt.	Jang-San Mt.
8:30~ 9:30	1.325	1.162	1.212	1.545	1.335
Session 2	Um-Gaung Mt.	Bong-Lae Mt.	Whang-Lyung Mt.	Gwang An Beach	Baek-Un port
12:30~13:30	1.340	1.096	1.163	1.542	1.566
Session 3	Da-Dae port	Nam Bu Min	Whang-Lyung Mt.	Wharf 1	Wharf 2
17:00~18:00	1.473	1.444	1.153	1.583	1.557

3.2.1.3 GPS surveying

The third stage is for carrying out the GPS Static surveying. GPS Static surveying has divided into total 3 sessions and accomplished. In the first session GPS Static surveying was done in the five triangular points. And in the second, third session, the GPS control point surveying was done to do the matching of Digital Map and Digital Chart.

The figure 3.3 is the GPS observed point to be carried out in this study.

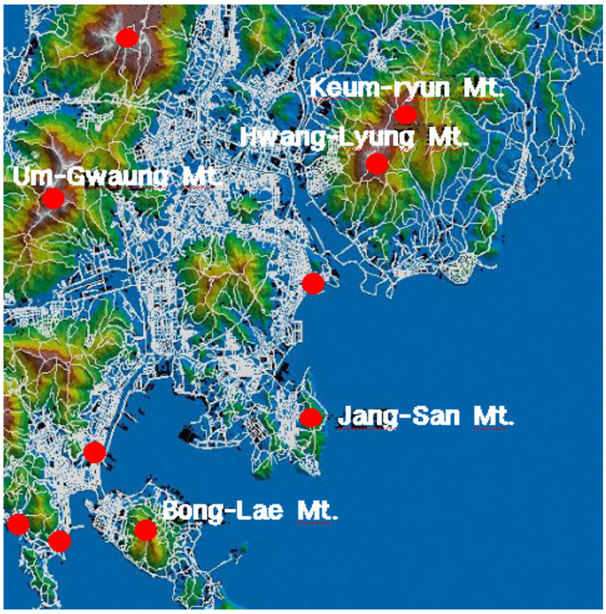

Figure 3.2 shows the part-look to carry out the GPS Static surveying among work sessions.

Picture 3.2 The picture of GPS Static Surveying is performed.

3.2.2 The boundary line surveying to match the Map and Chart

The EDM precise surveying was done to analyze the matching errors of the complex geography information which is the base in constructing the complex geography information of digital map and digital chart.

It was the EDM surveying that the boundary line surveying of digital map and digital chart used the GPS point acquired by the GPS control point surveying.

The EDM surveying was done by using the two points located in the wharf and output by the GPS Static surveying.

In this study, it took much time in office work. To do the surveying first, any coordinate was given to the two points of the wharf. And then, the EDM was done.

The figure 3.4 represents the coordinate of boundary lines output by the EDM surveying on CAD.

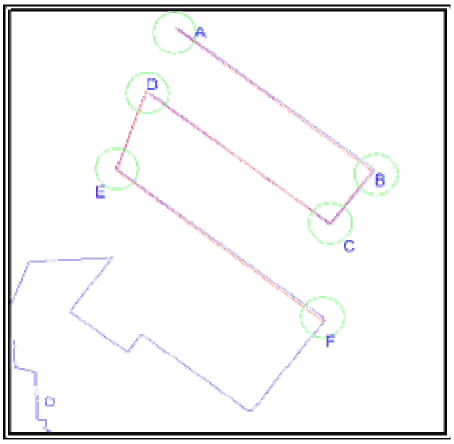

Figure 3.4 Digital Map and EDM Surveying.

(unit : m)

Node	dx	dy	$\sqrt{dx^2+dy^2}$
A	0.70	0.90	1.14
B	-0.96	-0.32	1.01
C	-0.99	-0.84	0.84
D	0.32	-0.60	0.68
E	0.78	0.28	0.83
F	0.30	-0.79	0.85
RMS	0.61	0.67	0.90

Table 3.4 Matching analysis between EDM surveying and digital map on wharf.

The matching with the digital map was attempted by setting up the points done EDM surveying at the wharf-side of the figure 3.4.

The table 3.4 is the arrangement of the elongation distance and the deviation of the x, y that is the outcome of the EDM, in each point on the digital map. When the EDM surveying point is the datum point, the points of the wharf-side on the digital map shows the mean +0.61m on x-axis, the mean -0.67m on y-axis in the value of RMS. And the mean elongation distance is 0.9m. This is less than the average drawing allowable error, that is, the one occurring on making allowance for 0.2mm of the drawing allowable error in 1/5,000 and 1/10,000 map, about 2.24m by 1.34m.

And the figure 3.5 is the matching with Digital Chart and Digital Map. This is done by using the coordinate of the boundary point the EDM was carried out.

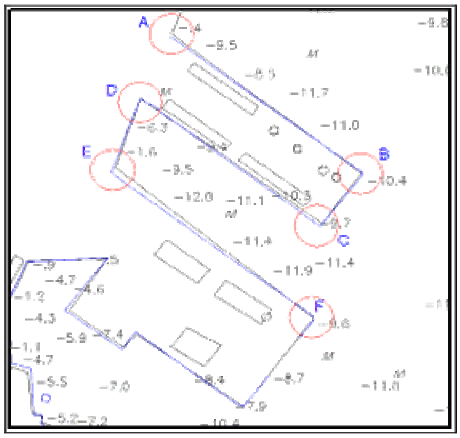

Figure 3.4 The matching of digital map and digital chart.

(unit : m)

Node	dx	dy	$\sqrt{dx^2+dy^2}$
A	-1.73	-5.44	5.71
B	-0.78	-1.29	1.51
C	-3.70	-4.52	5.84
D	0.32	-0.60	0.68
E	-7.24	-11.02	13.19
F	-0.09	-4.20	4.20
RMS	3.41	5.64	6.59

Table 3.5 Matching analysis between digital chart and digital map.

On the whole it is known that the errors were happened largely in the southeastern direction. In the northern direction the error was about 3.41m, in the eastern about 5.64m.

3.3 Analysis of the GPS observed value.

3.3.1 The accuracy analysis according to the geometric strength of the GPS network.

The 3 points of Bong-Lae Mt., Jang-San Mt. and Um-Gaung Mt. were selected as the control points in adjusting the given GPS network. The figure 3.6 is the geometric arrangement of these points and shows about 49°50' 14.64" , 45°38' 21.20" , and 84°31' 24.16".

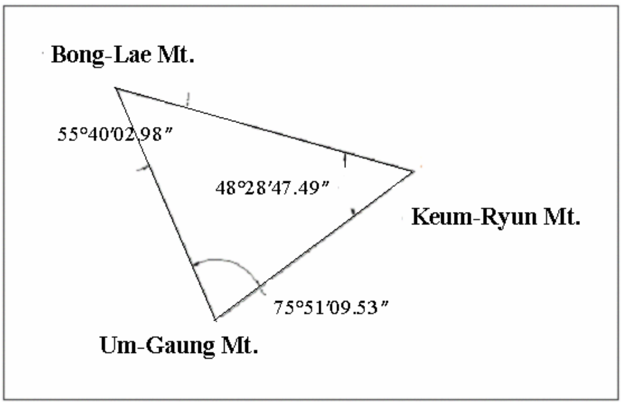

Figure 3.6 The geometric arrangement plan which is gotten from GPS network adjustment.

The table 3.6 shows the errors that were achieved by the network adjustment and the actual coordinate of the triangular point. This shows the deviation between the coordinate of point record and the coordinate output by the network adjustment, which was adjusted to Bong-Lae Mt. - Keum-Ryun Mt - Um-Gaung Mt. That is the stablest in the geometric arrangement.

Node	dx	dy	$\sqrt{dx^2+dy^2}$
Jang-San Mt.	0.000000	0.000000	0.000000
Whang-Lyung Mt.	0.000625	0.000001	0.000625
Keum-Ryun Mt.	0.000529	0.000016	0.000529
Bong-Lae Mt.	0.000000	0.000000	0.000000
Um-Gaung Mt.	0.000000	0.000000	0.000000
RMS	0.015194	0.001849	0.015306

Table 3.6 The difference between real coordinate and coordinate in geometric arrangement.

3.3.2 Analysis of the accuracy according to the change of the variance factor.

The variance factor(VF) used in the Chi-Square test of goodness of fitness when the GPS network adjustment would be done was divided into the value of 'out the effective range', the value of 'within the effective range' and 'the more precise value within the effective range'. In this condition the precision of GPS observed value was made a comparative analysis.

1. Jang-San Mt.

0.4795<VF<1.7085	dx	dy	$\sqrt{dx^2+dy^2}$
VF=6.1733	0.000000	0.000000	0.000000
VF=3.2522	0.000000	0.000000	0.000000
VF=1.6216	-0.022000	0.005000	0.022561
VF=0.9364	0.000000	0.000000	0.000000

2. Whang-Lyung Mt.

0.4795<VF<1.7085	dx	dy	$\sqrt{dx^2+dy^2}$
VF=6.1733	-0.024000	0.005000	0.024515
VF=3.2522	-0.018000	0.004000	0.018439
VF=1.6216	-0.019000	0.013000	0.023022
VF=0.9364	-0.024000	0.003000	0.024187

3. Keum-Ryun Mt.

0.4795<VF<1.7085	dx	dy	$\sqrt{dx^2+dy^2}$
VF=6.1733	-0.023000	0.000000	0.023000
VF=3.2522	-0.017000	0.001000	0.017029
VF=1.6216	-0.025000	0.008000	0.026249
VF=0.9364	-0.022000	0.002000	0.022091

4. Bong-Lae Mt.

0.4795<VF<1.7085	dx	dy	$\sqrt{dx^2+dy^2}$
VF=6.1733	-0.000400	0.000100	0.000412
VF=3.2522	-0.000400	0.000100	0.000412
VF=1.6216	0.000600	0.006100	0.006129
VF=0.9364	-0.000400	0.000100	0.000412

5. Um-Gaung Mt.

0.4795<VF<1.7085	dx	dy	$\sqrt{dx^2+dy^2}$
VF=6.1733	-0.000300	-0.000300	0.000424
VF=3.2522	-0.000300	-0.000300	0.000424
VF=1.6216	-0.141300	0.222700	0.263744
VF=0.9364	-0.000300	-0.000300	0.000424

Table 3.7 The error of coordinate with VF variation.

The next is the investigation of the happened error followed by the change of the VF which is the factor of the network adjustment in the geometric network structure of Bong-Lae Mt. - Jang-San Mt. - Um-Gaung Mt. The case of being included 'within the effective range' has the less error than the opposite case. In the case of being included 'within the effective range' the more precise output of the coordinates was not possible if the less value of VF was given.

4. CONCLUSION

For the results of this paper, 'Application of marine geographic information system using analysis of control points in postprocessing DGPS points surveying', it is concluded as following,

First, the variance factor(VF) used in the Chi-Square test of goodness of fitness when the GPS network adjustment would be done was divided into the value of 'out the effective range', the value of 'within the effective range' and 'the more precise value within the effective range'. In this condition the precision of GPS observed value was made a comparative analysis. Here, the case of being included 'within the effective range' has the less error than the opposite case. In the case of being included 'within the effective range' the more precise output of the coordinates was not possible if the less value of VF was given.

Second, when the Digital Map was matched with the Digital Chart by using the coordinate of the boundary point through the EDM was carried out in using the result of GPS surveying, totally it is known that the errors were happened largely in the southeastern direction. In the northern direction the error was about 3.41m, in the eastern about 5.64m. So in the case of the matching the Digital Map and Digital Chart, it is thought that the closer examination and matching would be carried out.

Third, in this study, the 3 points selected as the control points in adjusting the GPS network, the case of 'Bong-Lae Mt.','Keum-Ryun Mt.',' Um-Gaung Mt.' has the least error. The geometric arrangement on 3 points selected as the control points was about 55°40' 02.98" , 48°28' 47.49" , and 75°51' 09.53". So the more geometric strength approaches 60°, the more precise coordinate result is output.

And the GPS and the EDM surveying done in this study was carried out in the limited range. So it need the surveying and analysis of the more observed points to get the more practical result. Also, for the analysis of the statistical result of GPS network adjustment and the performance of the study for the matching the Digital Map and Digital Chart, the study of the geographic information management for the unified geographic information system construction could be activated and the database structure, contents, and the integrated management system must be researched more systematically.

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