Topographic Mapping Using KOMPSAT Imagery

Ho-Nam Lee*, Hyun-Duck Seo*, Hyung-Sup, Jung*

*Chung-Ang Aerosurvey, 18 Kyonam-dong, Jongro-ku, Seoul, Korea 110-100
Fax) +82-2-732-0999 / e-mail) yhnhan@chollian.net

ABSTRACT

Mapping systems using Satellite Imagery has not been well-established compare to conventional Arial Photograph mapping systems. In order for satellite imagery to produce a stable quality of maps, it requires to follow the standard mapping procedures. In this satellite imagery study, we proposed four methods of mapping procedures. Mapping methods were established by generating trial maps and analyzing types of input data and functions of DPW (Digital Photogrammetric Workstation).

On quantitative aspect, accuracy of each steps were measured by increasing 2 GCPs each time from the minimum of 6 GCPs. In DLT, with the minimum of 10 points, RMSE is 2 pixels at most.

Besides that, interpretation and stereoscopic plotting using KOMPSAT-1 imagery and other simulated imagery was performed. The tests resulted that, for KOMPSAT-1 (6.6m) stereoscopic images, the possibility of interpretation is 44.79% and possibility of stereoscopic plotting is 43.75%. In the other hand, for simulated imagery (1m), the possibility of interpretation is 60.92% and possibility of stereoscopic plotting is 55.18%.

key words : DPW, GCP, RMSE, interpretation, stereoscopic plotting, KOMPSAT-1, simulated imagery

I. INTRODUCTION

Conventional aerial photograph mapping technology has been well-established compared with satellite imagery mapping(NGI, 2001). There are only a few methods suggested for the utilization of satellite image. Until nowadays, standard mapping procedures using satellite image still have not verified yet. Many researches are mostly done on the things such as 3 dimensional modelling instead of interpreting and describing features from satellite image.

In case of mapping using KOMPSAT-1 imagery, there is still no standard on proper amount of GCPs to perform modelling. DPW used in this study doesn't provide function importing HDF information (LH Systems, 1997). So, DLT of non-Physical modelling method was used. It requires standard on that to guarantee stable accuracy of map.

KOMPSAT-1 has been observing data for mapping, but it's not obvious that mapping on any scale is possible using KOMPSAT-1 imagery(NGI, 2001). It is required to study the possibility of mapping using KOMPSAT-1 imagery. KOMPSAT-2 loading MSC is supposed to be launched by KARI in 2004. MSC is expected to provide panchromatic images at 1m resolution and to be useful in mapping. It is required to study the possibility of mapping using KOMPSAT-2 imagery before KOMPSAT-2 is launched.

For that reason, The purpose of this research is topographic mapping using KOMPSAT imagery. The specific objectives are : 1) to setup standard mapping procedures; 2) to propose suitable quantity of GCPs in DLT; 3) to analyze the possibility of mapping using KOMPSAT-1 imagery(6.6 m) & simulated image(1 m).

II. Methodology

A. Setup of Mapping Procedures

Parameters to affect mapping procedure are usable input data & function of DPW. If stereopair of image is usable, digital stereoscopic plotting or image matching procedure can remains a addition to mapping procedure. Existence of usable header information and DEM can affect mapping procedure. Table 1 shows 4 cases of usable input data.

Table 1 cases of usable input data

Case	Single image	Stereopair of image	Header	DEM
1	○	×	○	×
2	○	×	×	○
3		○	×	×
4		○	○	×

※ ○ : exist, × : non-exist

Functions of DPW affect mapping procedure. Modelling method can be determined by existence of function to import header information.

Decisively whole mapping procedure can be changed by function of 3-D plotting. Table 2 shows 3 cases of function that DPW provides.

Table 2 Cases of usable DPW function

Case	Modelling		Stereoscopic Plotting
	Non-Physical	Physical	
1	○	○	○
2	○	×	○
3	○	○	×
4	○	×	×

※ ○ : exist, × : non-exist

Parameters of Table 1 and Table 2 was analyzed. We produced a trial map referring to results of anlysis, and standard procedures on 4 mapping methods are proposed

B. Proper Amount of GCPs

In this study DPW provides with stereoscopic plotting was used, but doesn't do function of HDF import. So, DLT of non-Physical modelling method was used.

Eqs (1) shows DLT equation. This equation was derived from unlinear equation of collinearity condition linear equation. So, there is simple solution. There is 2 eqs per one point, and 11 unknowns in 2 eqs. It requires at least 6 points to solve this equation(Gupta and Hartley, 1997). It requires more points to guarantee stable accuracy. Accuracy of each steps were measured by increasing 2 GCPs each time from the minimum of 6 GCPs.

$$x = \frac{L_1 X_A + L_2 Y_A + L_3 Z_A + L_4}{L_9 X_A + L_{10} Y_A + L_{11} Z_A + 1}$$

$$y = \frac{L_5 X_A + L_6 Y_A + L_7 Z_A + L_8}{L_9 X_A + L_{10} Y_A + L_{11} Z_A + 1} \quad (1)$$

where,

$L_1 \sim L_{11}$ = Unknown

X_A, Y_A, Z_A = GCP

x, y = image coordinate

C. Possibility of Mapping

To examine possibility of mapping, it is very important how much features interpreted and plotted from test imagery.

For analysis on qualitative attribute like interpreting and plotting, it requires quantitation on how to interpret features and how to descript. For quantitation on interpretability, we applied 4 level written in NIIRS(National Imagery Interpretability Rating Scales). Table 3 shows explanation on 4 level written in NIIRS(L.A.Maver, C.D.Erdman and K.Riehl, 1995).

Table 3 Classification of Image Interpretability

Classification	Status of Interpretation
I	Identify
B	Distinguish Between
D	Detect
N	Not Detect

For quantitation on possibility of stereoscopic plotting, we classified into 4 level on degree to describes features. Table 4 shows explanation on 4 level proposed.

For analysis on possibility of mapping using KOMPSAT imagery, we checked interpretability and possibility of stereoscopic plotting on KOMPSAT-1 imagery and simulated image.

We applied items included in 1/25,000 topographic map on KOMPSAT-1 at 6.6 m resolution, and items included in 1/5,000 topographic map on simulated imagery at 1 m resolution on test.

Table 4 Classification of 3-D Plotting

level	Status of 3-D Plotting
A	Absolutely Plot
B	Almost Plot
C	Temporally Plot
D	Not Plot

Ⅲ. TEST AREA and DATA SET

The solid circle in Figure 1 represents the test area, NONSAN and DAEJEON. Also stereopair of KOMPSAT-1 are shown in Figure 1.

For NONSAN, 1/25,000 topographic map was made as a example, and with this map the possibility of mapmaking at the scale of 1/25,000 was analyzed.

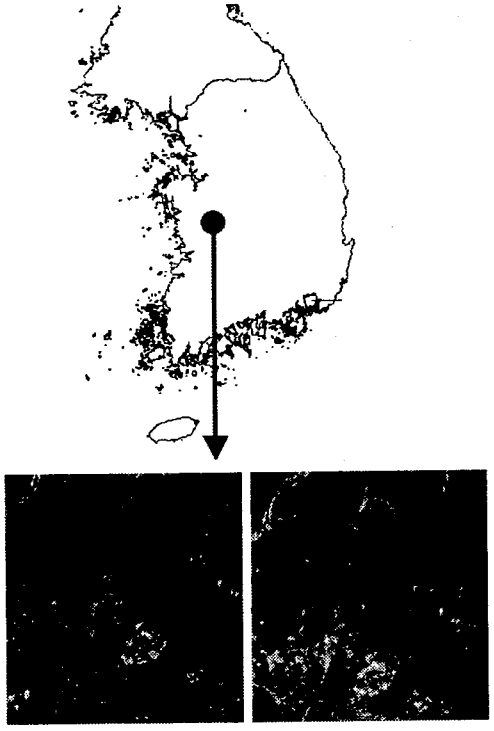

Figure.1 Test Area & Stereopair of KOMPSAT-1

Figure 2 shows stereopair of simulated image, which was generated from aerial photographs at the same resolution of KOMPSAT-2, 1m. With this image the possibility of mapping at the scale of 1/5,000 from KOMPSAT-2 imagery was analyzed.

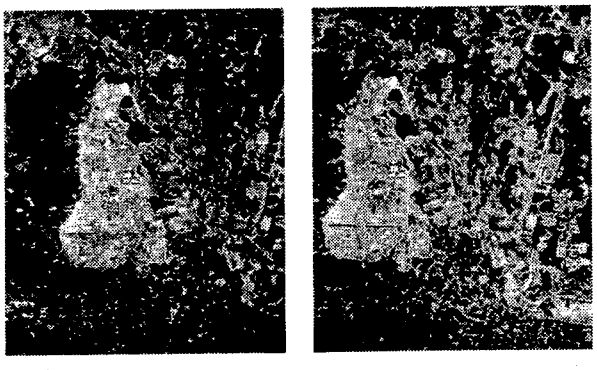

Figure.2 Simulated Stereoscopic Image(DAEJEON)

Figure 3 illustrates the plot plan of control points and check points. 25 points were used to analyze the proper amount of GCPs in case of modeling with the option of DLT. And these points were distributed equally for the geometrical stability.

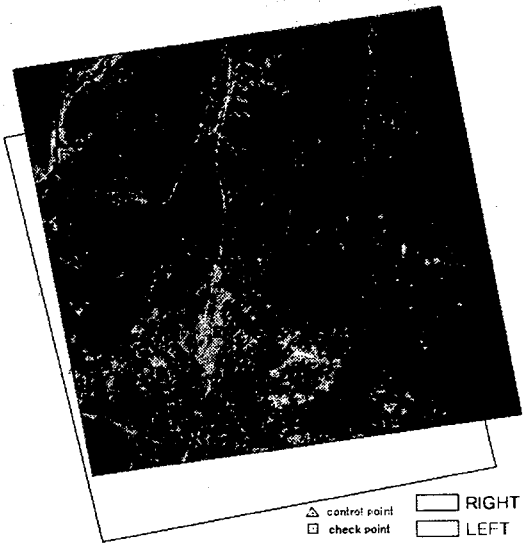

Figure.3 Control points & Check points location for NONSAN

Table 5 lists 25 GCP data which were used for this research. Accuracy of each steps were measured by increasing 2 GCPs each time from the minimum of 6 GCPs. The result are shown in Figure 3 and 4.

Table 5 GCPs for NONSAN

ID	X	Y	Z
CP01	333805.540	4025115.332	59.222
CP02	330270.531	4021184.504	44.0183
CP03	329780.071	4026843.666	47.8802
CP04	334843.625	4021729.143	62.1868
⋮	⋮	⋮	⋮
CP22	321908.559	4025738.594	25.3491
CP23	324611.905	4026090.406	98.0565
CP24	324692.061	4020869.618	72.2051
CP25	320987.981	4019917.346	40.711

Ⅳ. RESULTS AND DISCUSSION

A. Setup of Mapping Procedures

Mapping procedures were divided into two cases; with and without stereoscopic plotting.

- digital stereoscopic plotting on stereopair of image
- head-up digitizing on geometrically rectified image

Geometrical Rectification procedures were divided into three cases;

- using single image and GCPs
- using single image, DEM and GCPs

- using stereoscopic image and GCPs

4 types of mapping procedures were induced by making trial map in Figure 8.

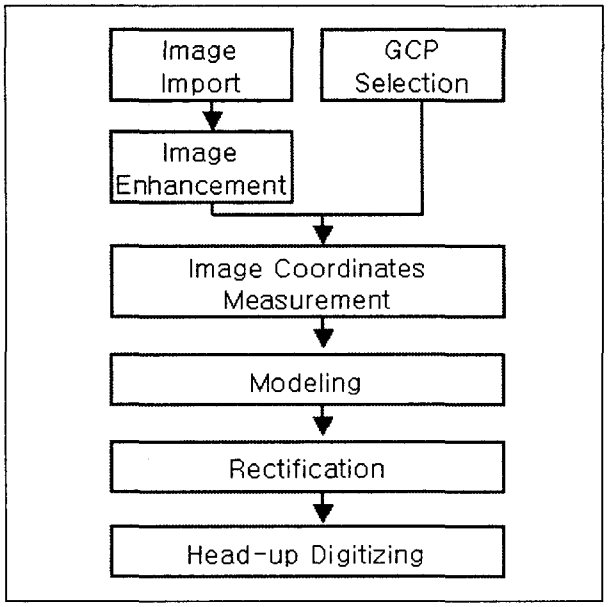

Figure 4 Mapping Procedure of case 1

So the method depicted in Figure 4 is less accurate, it is better not to be used in the field which requires good accuracy.

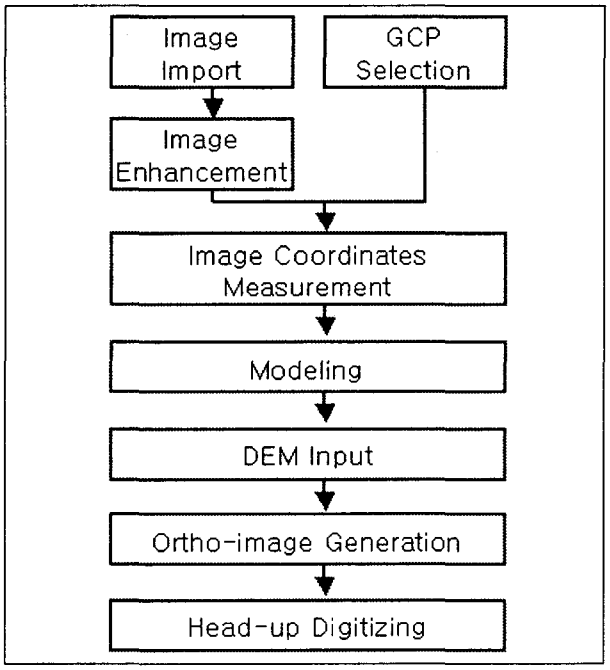

Figure 5 Mapping Procedure of case 2

The method depicted in Figure 5 can be used in cases that it is hard to obtain stereopair of image but DEM exists.

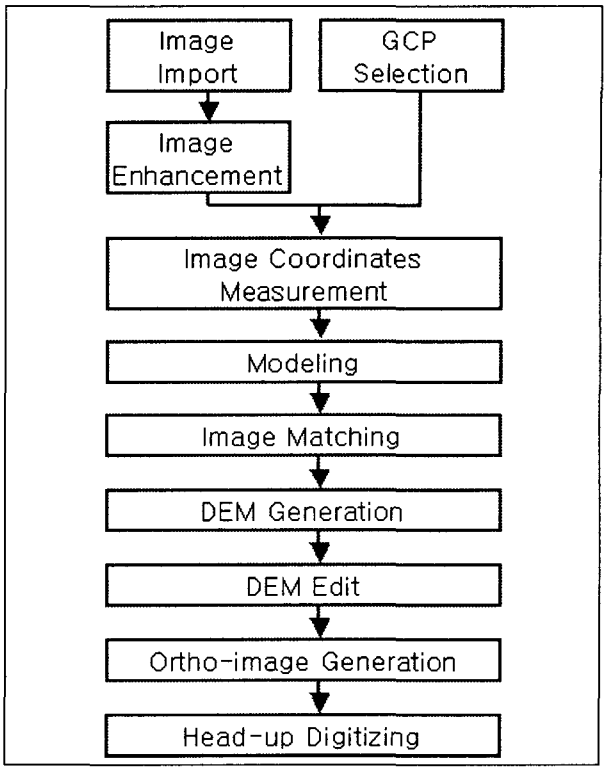

Figure 6 Mapping Procedure of case 3

If stereoscopic image is provided and digital stereo plotting cannot be used, image matching and orthoimage can be used to map as shown in Figure 6.

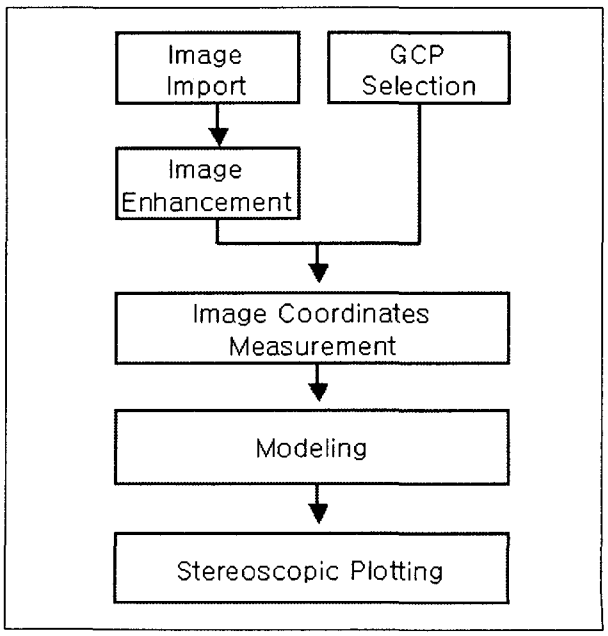

Figure 7 Mapping Procedure of case 4

If stereoscopic image is provided and stereoscopic plotting can be used, the method shown in Figure 7 can be applied. Up to date this is the most appropriate to extract features. Figure 8 shows 1/25,000 map which was made in this research.

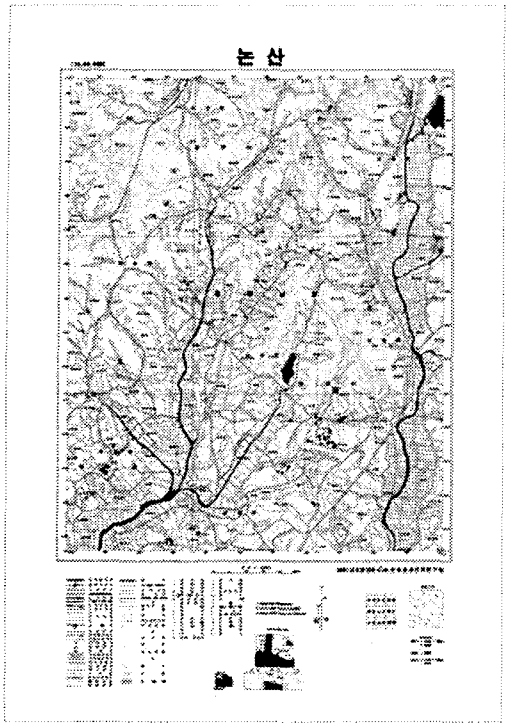

Figure.8 1/25,000 Trial Map(NONSAN)

B. Proper Amount of GCPs

For the experiment of deciding proper amount of GCPs, modeling with the option of DLT was used. Therefore, accuracies from left and right image would come out. Figure 9 shows accuracy of left image. Modeling using from 8 points had errors within 2 pixels constant.

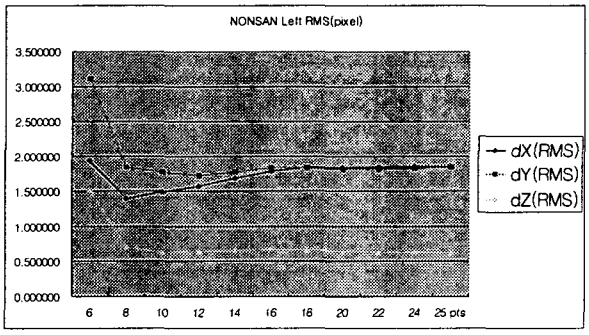

Figure 9 Modelling errors with GCPs used : NONSAN left

Figure 10 shows accuracy of right image. Modeling using from 10 points had errors within 2 pixels constant. Using more than 20 GCPs could not make accuracy better.

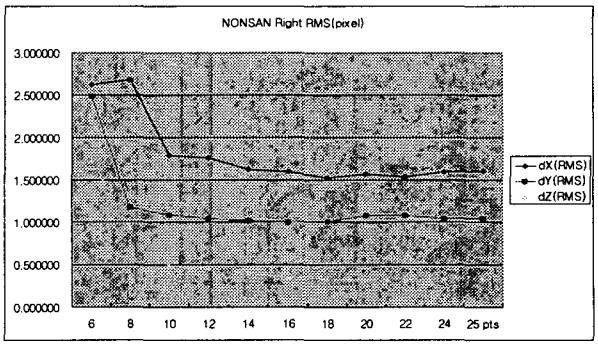

Figure 10 Modelling errors with GCPs used : NONSAN right

As a result, modeling KOMPSAT-1 imagery with the option of DLT using more than 10 points will generate accuracy within 2 pixels.

C. Possibility of Mapping

To analyze the possibility of mapping, interpreting and plotting were performed on stereopair of KOMPSAT-1 imagery and stereopair of simulated image. The result were listed in Table 6 to Table 9. Table 6 shows the result of analysis of interpretabilities on KOMPSAT-1 imagery. 43 of 96 (44.79%) features in the 1/25,000 mapping standard could be interpreted.

Table 7 shows the result of analysis of possibility of 3-D plotting on KOMPSAT-1 imagery. 42 of 96 (43.75%) features in the 1/25,000 mapping standard could be plotted.

The result of analysis of interpretabilities on simulated stereoscopic image is shown in Table 8. 69 of 87 (79.31%) features in the 1/5,000 mapping standard could be interpreted. Table 9 shows the result of analysis of possibility of 3-D plotting on simulated stereoscopic image. 48 of 87 (55.17%) features in the 1/5,000 mapping standard could be plotted.

Table 6 Analysis of Interpretabilities(KOMPSAT-1)

level	I	B	D	N	Non-exist	합계
Number	20	15	8	33	20	96
(%)	20.83	15.63	8.33	34.38	20.83	100

I : Identify, B : Distinguish Between,
D : Detect, N : Not Detect

Taking interpretability/possibility of plotting using aerial photograph for mapping into consideration, the amount of external work will be increased considerably compared with that of internal work to make 1/25,000 topographic map using KOMPSAT-1 imagery.

Table 7 Analysis of Possibility of Stereoscopic Plotting (KOMPSAT-1)

level	◎	○	△	×	Non-exist	합계
Number	25	9	8	34	20	96
(%)	26.04	9.38	8.33	35.41	20.83	100

◎ : Absolutely Plot, ○ : Almost Plot
△ : Temporally Plot, × : Not Plot

Table 8 Analysis of Interpretabilities(KOMPSAT-2)

level	I	B	D	N	Non-exist	합계
Number	51	2	16	12	6	87
(%)	58.62	2.30	18.39	13.79	6.90	100

Table 9 Analysis of Possibility of Stereoscopic Plotting (KOMPSAT-2)

level	A	B	C	D	Non-exist	합계
Number	41	7	10	23	6	87
(%)	47.13	8.05	11.49	26.44	6.90	100

V. CONCLUSIONS

There are four proposed mapping methods using KOMPSAT imagery. The four methods can be applied for mapping when accuracy is not a big concern to the user. If the user were to generate an accurate topographic map, stereoscopic plotting method must be applied.

If the header information of satellite data is not provided, DLT modeling method can be used. In DLT, with the minimum of 10 points, RMSE is 2 pixels at most. But it is recommended to use more then 15 points to have a better result.

From interpretation and stereoscopic plotting tests about stereopair of KOMPSAT-1, interpretability was 44.79%, and possibility of stereoscopic plotting was 43.75%. At the same tests about simulated images, interpretability was 60.92%, and possibility of stereoscopic plotting was 55.18%. Considering interpretability and stereoscopic plotting about aerial photograph, a quantity of external work should extend in order to generate topographic map.

ACKNOWLEDGMENTS

The authors would like to thank Mr. Kyoung-Jong, Kim and Mr. Doo-Youl, Park of my co-officer and Dr. Yong-Seong, Kim of KARI for useful helping concerning this study.

REFERENCE

NGI, 2001, Study on Mapping using Satellite image, CH1 : 1-2

LH Systems, Socet Set User's manual, 1997, CH7 : 1-18

Gupta, R and Hartley, R, 1997, Linear Pushbroom Cameras, IEEE Transaction on pattern analysis and machine intelligence, 19(9): 963-975

Yoo, B. M. and Anton F. Schenk, 1999, Modern digital photogrammetry, MoonunDang: 139-214

L.A.Maver, C.D.Erdman and K.Riehl, 1995, Imagery Interpretability Rating Scales, SDI: 117-200.