MAP REVISE TECHNIQUE BY USING COLLABORATION OF GPS AND GIS

M. Moriya[a,] *, S. Shimanoa[a] and M. Shikada[a]

[a] Kanazawa Institute of Technology (KIT) Nonoichi-machi Ishikawa 921-8501, JAPAN
[b] mitoshi@ venus.kanazawa-it.ac.jp, a6600183@venus.kanazawa-it.ac.jp
shikada@neptune.kanazawa-it.ac.jp

KEY WORDS: REAL TIME GIS, RTK-GPS, GIS, Remote Sensing, Base Map, Large scale digital map, Geoinfomatics

ABSTRACT:

Much local government has been utilizing the large scale digital map with Geographic Information System (GIS). GIS will be able to efficiently work and to reduce mapping costs. However, the maintenance and renewal of a map database need much labor and time. However, the updating method of a map is not established yet and, there is little successful example. The purpose of this study is establishment to update of the large scale map for local government by using a mobile GPS, REAL TIME GIS and its collaboration. REAL TIME GIS is one of the examples of mobile mapping technology.
REAL TIME GIS, which definition decided by our laboratory, is a technology that updates the digital map instantly by using RTK-GPS and the cellular phone. Map revise by using REAL TIME GIS is a major purpose of this study. RTK-GPS data use Japanese Geodetic Datum 2000 (JGD2000) of WGS-84, but most of the digital map of local government is still Tokyo Datum of old geodetic system. In order to correspond with two kinds of data which have different geodetic system, it is necessary to transform coordinates.
Geographic Survey Institute of Japan (GSI) opened a website for the conversion parameters and programs. GPS data is able to apply to digital map in small scale. However, Base Map and thematic map which has made by the large scale (1/500 or 1/1000) on the old geodetic system did not obtain sufficient accuracy. To solve these problems, our laboratory proposed High-Accuracy Regional Parameter (HARP) which changes from an old geodetic system to a new geodetic system.

1. INTRODUCTION

Much local government has been utilizing the Base Map (BM) by GIS in order to support urban planning and management of facilities. GIS will be able to work efficiently and to reduce mapping costs. Furthermore, by sharing the data with their position in local government, it is possible to improve the service to a citizen. However, the maintenance and renewal of a map database need much labour and time. The updating method of a map is not established yet, and there are very few successful examples. The purpose of this study is establishment to update of the large scale map for local government using a mobile GPS and REAL TIME GIS. These technologies have been called "Geoinfomatics" on new field of survey recently.
In this paper, Remote Sensing means high-resolution satellite imageries (HRSI). By overlapping HRSI and digital map with GIS, it is possible to find the changed houses at urban area in detail. The changed area is surveyed by using RTK-GPS. RTK-GPS is able to survey absolute position with high accuracy. Simultaneous update of digital map is possible using cellular phone and RTK-GPS. On the study, system was defined as the REAL TIME GIS as shown in Figure 1. And, collaboration of Remote Sensing, GPS and GIS is one of the examples of mobile mapping technology.
Japan adopted new general standard for a map geometry since April 1, 2002. Ellipsoid of new geodetic system in Japan is almost equal WGS-84 of GPS. However, most of the digital map of local government is still Tokyo Datum of old geodetic system. In order to correspond with two kinds of data which have different geodetic system, it has to transform coordinates.
In master thesis of Ms. Aki Okuno who finished master course, to solve the problem between old geodetic system and new one, she attempted to use Affine Transformation. Obtained result is shown below.

1. Better transformation type is the Affine Transformation.
2. The control point of transformation has to locate at four corners in the map as much as possible. Mark of control point is newly made when the exact point (national control point and public control point) did not find in field site of survey.
3. 1/500 scale map is desirable to convert.
4. The accuracy is more improved by using the adjustment of offset.

However, method of making control point was not complete because it is difficult to obtain the coordinates on a map, and it is difficult to find the point at the field. In this paper, town planning group data and cadastral data were used for coordinate transformation.
Previous researcher performed experiment at two places in the narrow area at Kanazawa district in Japan. It understood that error has some characteristics. Experimental results did not show specific data because the verification region is too few. Therefore, we increased the verification region by two fields in this study. As a result, changed old geodetic system will overlap to new map measured by RTK-GPS exactly.

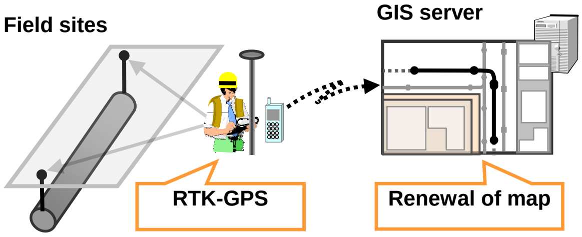


Figure 1. Concept of "REAL TIME GIS"

2. THE CONTROL POINTS FOR TRANSFORMATION

To transform the BM, the control point was made by using relative positioning GPS. In the research, control point means the point which shows both exact coordinates of Tokyo Datum and JGD2000. The verification area has the accurate data of Tokyo Datum (based on BESSEL ellipsoid and rectangular plane coordinate system), and it was generated by town planning group and cadastral data in Kanazawa City. Tested field of GPS measuring is shown in Figure 2. To obtain coordinates of JGD2000, static measuring of GPS was performed 15 minutes and over 2 hours at test field. Experiment areas are "Area A", "Area B", "Area C" and "Area D" (After this, it is marked A, B, C and D). GPS measurement of A and B was performed over 2 hours. The measurement place is limited, because measurement time of two hours is too long. Therefore, experiment of the accuracy verification was done for shortening the measurement time. The experiment method is an accuracy comparison between two hours and other shorter measurement time. As a result, all of measurement time in X and Y was less than 3cm as shown in Table 1. Therefore, the experiment adopted the shortest time of 15 minutes.

Time(minute)	X(m)	Y(m)
60	-0.0003	-0.0147
30	-0.0022	-0.0139
15	0.0094	-0.0167

Table 1 Comparison of measurement time

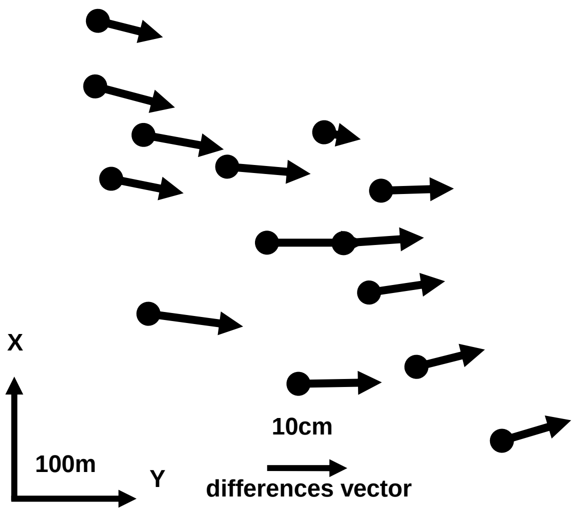
Figure 2. GPS measuring at the field point

Figure 3. Test field and control points (Area A)

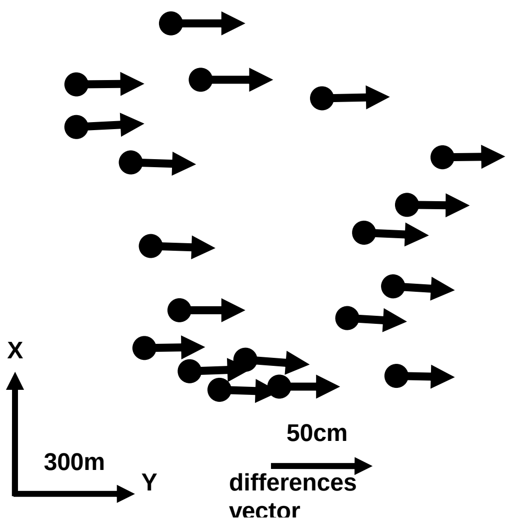
The control point of town planning group data and cadastral data was made by simple marking. Especially, the control point number was discerned on the road. So, everyone can easily confirm the control point at the field. However, in the future, marking ink of control point number will disappear. Better method to maintain and manage the control point for the coordinate transformation more efficiently is to adopt the control point of town block and IC tag.

3. VERIFICATION OF "TKY2JGD" FOR JAPANESE STANDARD CONVERSION

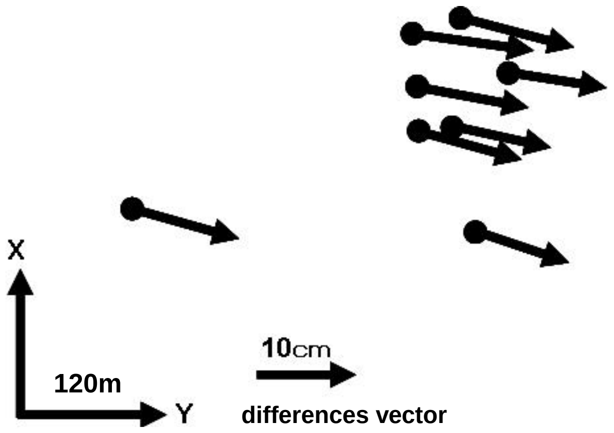
GSI opened the website for the conversion parameters and programs (TKY2JGD). First, coordinates of Tokyo Datum of old geodetic system was transformed to new one by using TKY2JGD. Differences of calculation results and GPS measuring data were verified. The results are shown in Figure4. Circle point means be transformed coordinates by using TKY2JGD. Top of arrow means GPS data. The difference on the average at A, B, C and D were about 11.3cm,31.9cm,11cm and 108cm respectively. In addition, A included rotation elements, and B was almost parallel shift. C's pattern was southeast, however D was irregular pattern.
Area of A, B, and C have regularity. But area D has not regularity. As the reason, many kinds of control points existed in area D (Figure 5).



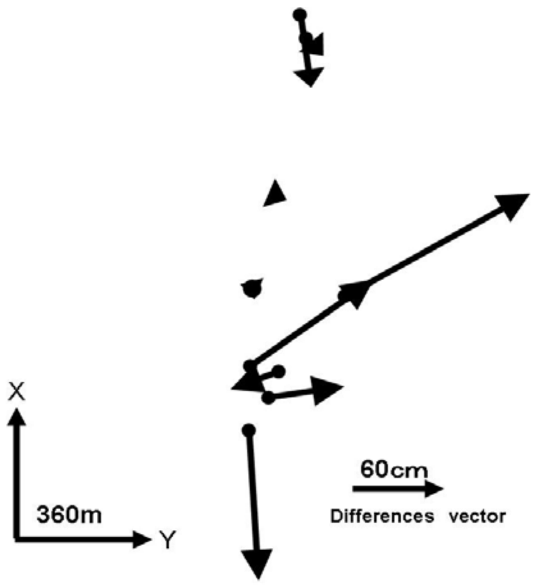
(a) Differences of vector at Field A



(b) Differences of vector at Field B
Figure 4. Differences of vector



(c) Differences of vector at Field C



(d) Differences of vector at Field D

Figure 4. Differences of vector

Figure 5. Many kind of control point in area D

Therefore the control point was not able to be measured accurately. It was suggested that maintenance of the reference point is very important to manage accurate GPS data.GPS data almost corresponded to digital BM data in small-scale map, however, the parameter could not adopt in large-scale map. Because of too large range which made parameter by TKY2JGD, it is necessary to make the parameter in narrow area.

4. VERIFICATION OF HIGH-ACCURACY REGIONAL PARAMETER USING AFFINE TRANSFORMATION IN NARROW AREA

Parameters obtained by Affine Transformation were called "High-Accuracy Regional Parameter (HARP)". HARP was calculated by the coordinates of town planning group and GPS data. In this paper, the data of A and B was used. To compare of accuracy, 11 points were chosen in B district. This limited area was named Area B' (Figure 6: After this, it is marked B'). In addition, calculated parameter by the coordinates of A and B' was named parameter A and parameter B' respectively. Individual method was calculated by two methods that are "4 control points were located at corner of map" and "4 control points were located at center of map".

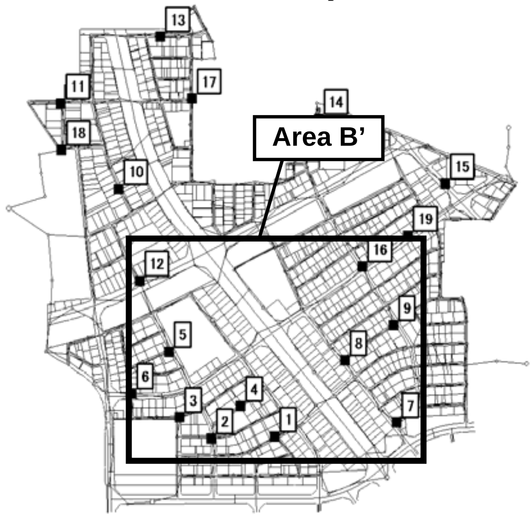


Figure 6. Limited Area B' in Area B

Transformed methods are as follows.

- A was transformed by using parameter A.
- B' was transformed by using parameter B'.
- B was transformed by using parameter B'.
- A was transformed by using parameter B'.
- B' and B were transformed by using parameter A.

Standard deviations of each area are shown in Table2, Table 3, Table 4 and Table 5. As a result of verification, obtained standard deviation obtained was less than 3cm in X and Y expects Table 5. In addition, the control points for the transformation have to place at the corner of unit.

control points	STD(m)	
	X	Y
4 points（corner）	0.0056	0.0199
4 points（center）	0.0100	0.0222

Table 2. Standard deviations of A

control points	STD(m)	
	X	Y
4 points（corner）	0.0084	0.0053
4 points（center）	0.0145	0.0075

Table 3. Standard deviations of B'

control points	STD(m)	
	X	Y
4 points（corner）	0.0120	0.0091
4 points（center）	0.0252	0.0081

Table 4. Standard deviations of B adopted B’

Parameter	STD(m)	
	X	Y
A (parameter B’)	0.0198	0.0133
B’ (parameter A)	0.0450	0.0424
B (parameter A)	0.0521	0.0584

Table 5. Standard deviations calculated by different parameter

Table 5 shows that result of adopting the parameter to a different area. Replacing the parameter, standard deviation of A and B increased four times than the standard method. So, it is possible to transform more large area by using the one parameter.
However, it need to overlay GPS data and transformed BM. Then, the accuracy of coordinate transformation will clear.

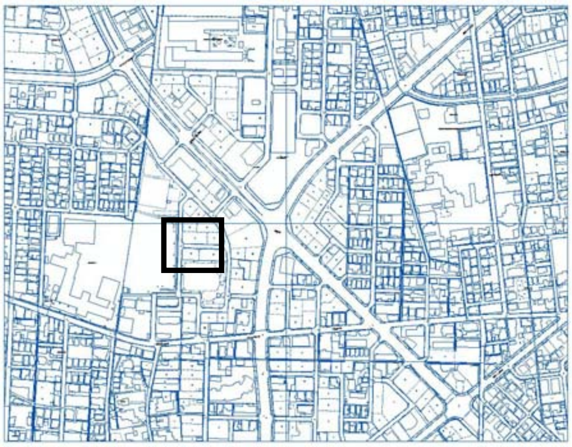
5. OVERLAY OF GPS DATA AND TRANSFORMED BM INTO JGD2000 SYSTEM

The large scale BMs used in local government was transformed by using the parameter. The parameter was calculated in Chapter 4. The transformed BM was overlapped with GPS data.

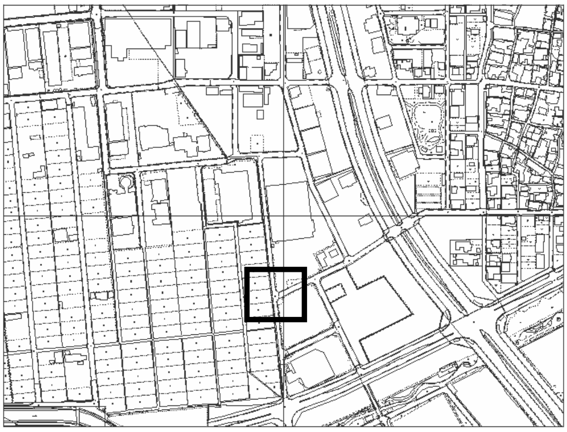
5.1 Experiment of RTK-GPS Using Original Reference Station

In this paper, RTK-GPS means that reference station and rover station were required for RTK-GPS measuring. The experiment was performed at district A and B. Experiment fields were shown in figure 6. Reference station was made just on the control point. Communication from reference station to rover station for the RTK-GPS depended on radio broadcasts. Measurement of RTK-GPS carried out on the road line of BM (Figure 7).

Figure 7. RTK-GPS on road line



(a) Experiment area at A



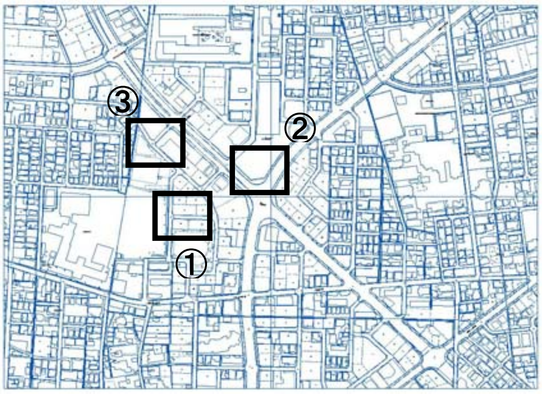
(b) Experiment area at B

Figure 6. Experiment area for RTK-GPS

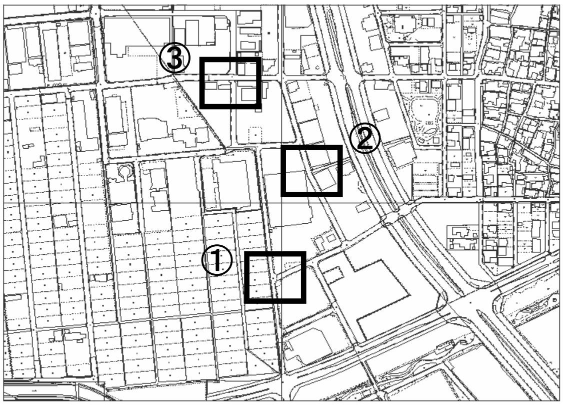
5.2 Experiment of RTK-GPS Using Virtual Reference Station (VRS)

Second actual experiment was performed by using RTK-GPS of VRS. Virtual Reference Station - GPS does not need to set the reference station. VRS was made virtually around the measuring point. Distance of virtual point to the point is about 3m to 5m. Revision information of rover station was sent to mobile phone by using wireless system. This system is possible to measure by only one person with light a baggage (Figure 8). Experiment fields were shown in figure 9.

Figure 8. VRS-GPS on the road line



(a) Experiment area at A

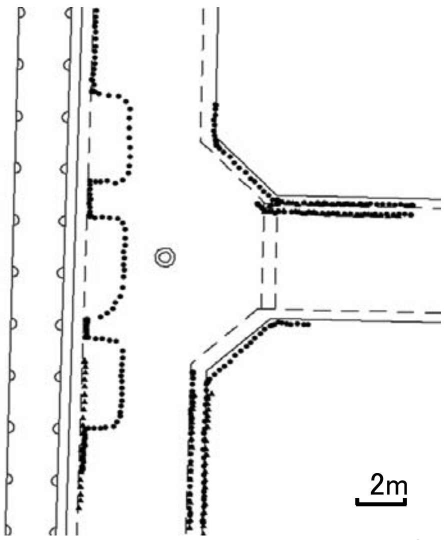


(b) Experiment area at B

Figure 9. Experiment area for VRS-GPS

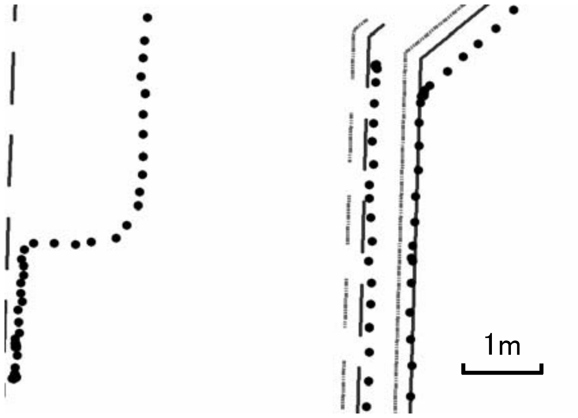
5.3 Overlay of Large Scale Map and GPS Data

Because a large amount of data was stored in BM, original program for transformation was made by us. Transform parameter were input to the program, and result of overlapped map shows figure 10. In figure 10, triangle symbol means RTK-GPS and circle symbol means VRS-GPS respectively. Figure (b) and (e) indicates extended Figure (a) and (d) respectively. Dot-line of ash colour in Figure (b) and (e) showed the transformed result of exchange parameter.



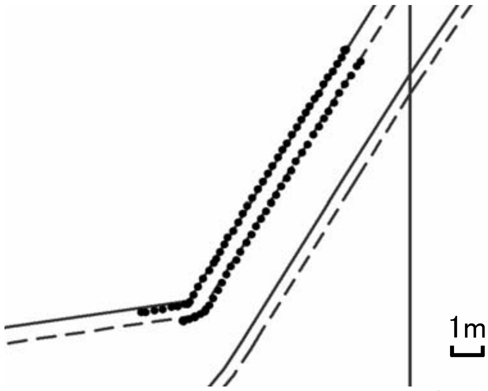
(a) Overlapped map at A ①

Figure 10. Overlapped BM and GPS data

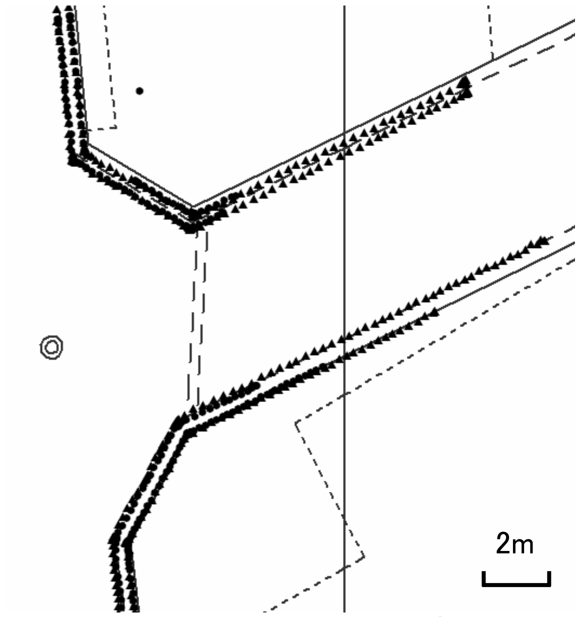


(b) Extended figure of (a)

(Dot-line of ash color shows the result of exchange parameter)

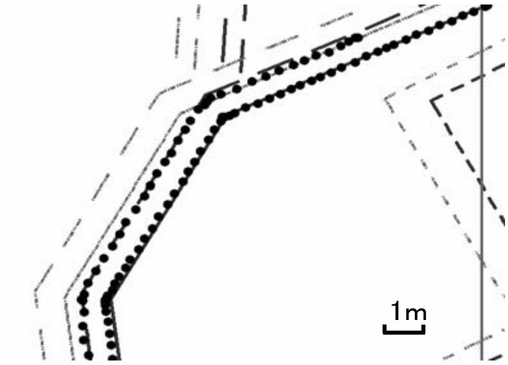


(c) Overlapped map at A ②

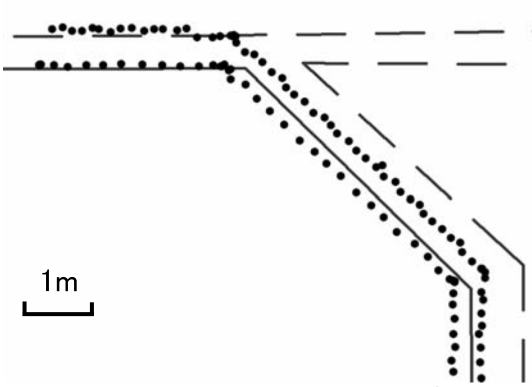


(d) Overlapped map at B ①

Figure 10. Overlapped BM and GPS data



(e)Extended figure of (d)
(Dot-line of ash color shows the result of exchange parameter)



(f) Overlapped map at B ③
Figure 10. Overlapped BM and GPS data

RTK-GPS data and VRS-GPS data were almost same as shown in Figure 10 (a) and (d). The distance between the GPS data and the BM was different according to the field site. Result of VRS-GPS was shown in Figure 10. It was measured around parked cars along the road side as shown in the left side of the map in Figure (a).

In case of field A ((a) ~ (c) in Figure 10), the center area of the transformed map was just corresponded with GPS data. However, in the corner of map, GPS data and the map was not overlaid at latitude. Reason of the distance of two data was caused by parameter included rotation element.

In case of B ((d) ~ (f) in Figure 10), some part area was just corresponded GPS data with transformed BM. The accuracy of coordinate transformation was not influenced in the measurement area. In addition, the accuracy will more improve by using the adjustment of offset.On the other hand, the method of exchanging parameter was not correct for coordinate transformation of large scale map.

6. CONCLUSION

If the local government introduces HRSI as a background of BM, government and general user can easily recognize the urban conditions. We recommend that local government introduce the system of "REAL TIME GIS" and Remote Sensing imageries for their work. The simplification of mapping process, reduction of mapping and updating cost, and understanding of accurate urban conditions are connected with the improvement of the service to the citizens. On the experiment, coordinate transformation of large scale map for local government was established at a part of test site area. And, measurement of VRS-GPS was carried out without trouble. However, all BMs were not transformed to new geodetic system on high accuracy.

It is suggested alternatives to use the town block control point for geometrical transform. The town block control point has making by "Basic Survey of Town Block for Renewal of Urban Areas" from GSI (Figure 11). The town blocks control points maintain high accuracy data, and it was set up in short distance (every 200m). The town block control point is managed at the nation. Therefore, accurate reference point data can be acquired. If the town block control point is used for geometrical transform, characteristic between old geodetic system and new one will easily understand. And, planning for coordinate transformation will be more efficiently performed. In addition, IC tag will become useful tool for maintenance and management of wide variety of control point.

Collaboration of Remote Sensing, GPS and GIS (equal to one of the examples of mobile mapping technology) will help local government to renew large scale map.

figure 11. Town block control point

ACKNOWLEDGEMENTS

The authors wish to special thank to Ms.Aki Okuno of KOKUSAI KOUGYO Co.,LTD. We wish to express our gratitude to Kanazawa Water and Energy Center , the town planning group of Kanazawa City , Hitachi, Ltd., CENTRAL Aero.Survey,KokudoKaihatu Center, Ltd., and Nihonkai consultant, Ltd, that offered data. Moreover, we would like to express our heartfelt gratitude to the cooperation of Leica Geosystems, Ltd. for VRS-GPS experiment.

References

Masaaki, S, Okuno, A et al, 2004, Coordinate Transformation of Large-scale Map Data for Real-time Update of Maps using RTK-GPS, The Journal of Survey,Vol.54,No.8,pp.10-13.

Masaaki, S, Okuno, A et al. Coordinate Transformation of Large-scale Map Data for Real-time Update of Maps using RTK-GPS, The Journal of Applied Survey Technology, Vol.15, pp.51-56, 2004

M. Tobita, 2002. Japanese Geodetic Datum 2000 and coordinates transformation, pp.42-64, pp.136-156

A. Okuno and M. Shikada, "Application of REAL TIME GIS using RTK-GPS for Local Government, XX International Society of Photogrammetry and Remote Sensing Symposium,pp.1-6,2004.

Chieko, A., Naoko, M., Masaaki, S., H. Tomita, K. Iwamura, 2002 "Management of Mapping in Local Government using Remote Sensing and the REAL TIME GIS", IEEE 2002, International Geoscience and Remote Sensing Symposium, 0-7803-7537-8/02