

Establishing Efficient Cadastral Surveying Plan in Accordance with Introducing World Geodetic Reference System in Korea

Sang Gu Kang

Spatial Information Research Institute, South Korea

Abstract: In Korea, cadastral records were made based on local coordinate system since 1910, from 2010 cadastral survey has been conducted by WGS in accordance with Act on the surveying & hydrographic and cadaster and special Act on the cadastral resurvey. There may occur some problems when considering distinct characteristics of cadastral surveying like a reinstatement using WGS (world geodetic system) if there are republished national control points related to ITRF version and tectonic deformation etc. Korea has accepted ITRF2000 at a reference epoch 1 January 2002 but ITRF version will be changed if made a precise model of new Earth's center of mass. ITRF2008 is a latest solution at present and ITRF2013 solution will release in the near future. After the 2011 Tohoku earthquake and tsunami, NGII (National Geographic Information Institute) analyzed effects of earthquake about national control points and then republished new coordinate for national control points on 27 January 2014. But there are no renewal methods for cadastral control points which was made by old national control so it is urgently needed for updating cadastral data. This study is how to manage cadastral data based on WGS, firstly analyzing influence of cadastral data due to republished control points and suggest how to revise old control data to the new national control points. And also made a suggestion for how to update when republishing national control points or releasing new ITRF version.

Key words: Cadastral Record, WGS (world geodetic system), ITRF2000, NGII (National Geographic Information Institute)

1. Introduction

In Korea, cadastral records were made based on local coordinate system since 1910, from 2010 cadastral survey has been conducted by WGS in accordance with Act on the surveying & hydrographic and cadaster and special Act on the cadastral resurvey. There may occur some problems when considering distinct characteristics of cadastral surveying like a reinstatement using WGS (world geodetic system) if there are republished national control points related to ITRF version and tectonic deformation etc.

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a precise model of new Earth's center of mass. ITRF2008 is a latest solution at present and ITRF2013 solution will release in next month(August). After the 2011 Tohoku earthquake and tsunami, NGII (National Geographic Information Institute) analyzed effects of earthquake about national control points and then republished new coordinate for national control points on 27 January 2014 But there are no renewal methods for cadastral control points which was made by old national control so it is urgently needed for updating cadastral data. This study is how to manage cadastral data based on WGS, firstly analyzing influence of cadastral data due to republished control points and suggest how to revise old control data to the new national control points. And also made a suggestion for how to update when republishing national control points or releasing new ITRF version.

Corresponding author: Sang Gu Kang, Ph.D., Department Head, research areas/interests: GNSS for cadastre, geospatial information etc. E-mail: sgukang@lx.or.kr.

2. Legal Basis of introducing WGS

At present legal basis of introducing WGS for cadastral surveying is Act on Land Survey, Waterway Survey and Cadastral Record (ALWCR) and Special Act on Cadastral Resurvey (SACR) have been enforced in 2009, 2012 respectively. According to the Article 6 (Standard of Surveys) of ALWCR, the location shall be indicated by the geographical latitude and longitude, and elevation (referring to the elevation from the mean sea level; hereafter the same shall apply in this paragraph) which are surveyed by world geodetic reference system: Provided, That if deemed necessary for producing maps, it may be indicated by the rectangular coordinate and the elevation, the polar coordinate and the elevation, geocentric orthogonal coordinate or other coordinates. In case of cadastral area, after 2010, Urban development projects, including the confirmation surveying for cadastral have been measured based on the WGS. Cadastral surveying data being measured by local datum before enforcement of ALWCR, is allowed cadastral surveyor to use local datum until 2020. 12. 30 with the interim

Rules. At present, according to the revised Enforcement Decree of ALWCR, railway construction in accordance with Act on the Rail Construction, Road construction projects by Act on the Road were included at land development project at the Article 83 of revised Enforcement Decree. As a result, confirmation survey for cadastral based on WGS was extended thus being expected the effect of decreasing the target project of cadastral resurvey. At present, the main scope of cadastral resurvey is 5,420,000 parcels excluding 120,000 (for cadastral confirmation survey) out of 5,440,000 which are cadastral mismatch. These parcels (5,420,000) are direct target to implement the resurvey project which will be surveyed cadastral boundaries in the real physical world where public and private right, restrictions and responsibilities in land applying.

The cadastral survey under special Act on cadastral resurvey is consist of fundamental and detail survey using GPS as a main survey method. If using GPS is impossible, Total Station may be used in survey especially, aerial photogrammetry can be used in case of detail survey.

Table 1 World Geodetic Reference System-Related Acts

World Geodetic Reference System-related Acts	Main Contents
Act on Land Survey, Waterway Survey and Cadastral Record (Enforcement Date 14. DEC, 2009)	After enforcement, confirmation survey for cadastral shall be surveyed by World Geodetic Reference System. ☞ Cadastral Record Before enforcement shall be surveyed by Local Geodetic System (Bessel1841) → allowed to use local datum until 2020. 12. 30 with the interim Rules according to Addenda
Special Act on Cadastral Resurvey (Enforcement Date 17. MAR, 2012)	Cadastral Resurvey shall be measured by World Geodetic Reference System. ☞ Confirmation survey for Cadastral(13%, 4.98 million parcels), Cadastral Mismatch survey(15%, 5.42 million parcels), Coordinate Transformation (72%, 27.13 million parcels)

The cadastral resurvey project is aim to cadastral mismatched group parcels which are more than 10 and regions excluding cadastral confirmation survey have to be changed into WGS by coordinate transformation. After checking whether it meets the real physical boundary or not through comparing results of coordinate transformation and aerial orthophoto and then extracting individual mismatched parcel.

3. Influence Analysis of Republished National Control Point

This study is how to manage cadastral data based on WGS, firstly analyzing influence of cadastral data due to republished national control point. There are two types of cadastral survey control point made by GNSS, one is static, another is RTK. The control points by static are easy to reprocess if there are GPS law data

(original measured data), because it is possible to recalculate law data based on new national control point But in case of RTK, being more complicated in recalculating.

Table 2 Main contents of Special Act on Cadastral Resurvey

1. Establishing survey plan	Making plan map for cadastral survey	
2. Installing temporary boundary point	<ul style="list-style-type: none"> · Landmark and structures in the original business district · Restoring boundary through previous cadastral records in case of being conflict · Agreed boundaries 	
3. One parcel boundary measurements	<ul style="list-style-type: none"> · Network- RTK(VRS) · Single-RTK: One or more times , one-second intervals, 30 seconds or more · Static(GPS): 2 hours -More than 10km, less than 1 hour · Total Station: Direction measurement 1 pair of observation, 2 repetition, 2 times measurement- horizontal distance 	
4. Calculating measurement and checking	RTK & Total Station	Static
	<ul style="list-style-type: none"> · Plane coordinates: 0.01 m · Angle: 1second · Distance: m 	<ul style="list-style-type: none"> · Longitude & Latitude: 0.0001 second · Distance: 0.001 m · Plane coordinates : 0.001 m · Elevation: 0.001 m
5. Determination of final results		
6. Determining Area	<ul style="list-style-type: none"> · Calculating unit : 0.01 square meter · Determining unit : 0.1 square meter 	

Table 3 Procedures of Cadastral Resurvey

Article 5 of Enforcement Ordinance(cadastral resurvey)	Resurvey Type ; fundamental and detail survey Fundamental SURVEY: GPS & Total Station (Using National and Cadastral control point) Detail survey ; GPS & Total Statio and Aerial photogrammetry etc)
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Article 6 of Enforcement Ordinance(Decision Making of cadastral resurvey)	Examination on Results - Cadastral control point: ± 0.03 m - Points of boundaries : ± 0.07 m
Regulation of Cadastral resurvey	- Network-RTK, Single-RTK - Static(GPS)
Article 6 of Enforcement Ordinance(Decision Making of cadastral resurvey)	Examination on Results - Cadastral control point : ± 0.03 m - Points of boundaries : ± 0.07 m
Regulation of Cadastral resurvey	- Network-RTK, Single-RTK - Static(GPS)

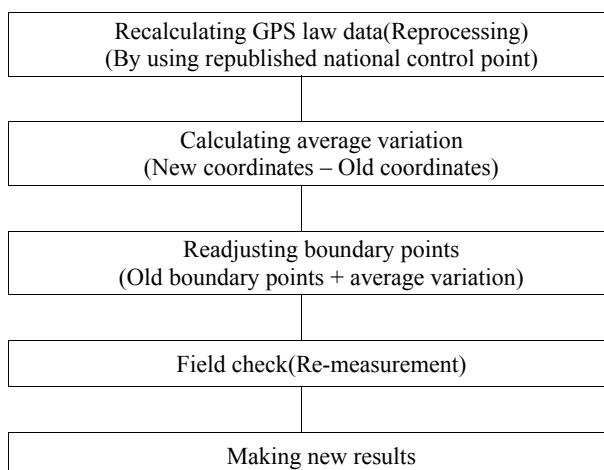


Fig. 1 Flow of validating republished NCP

Surveying data that is boundary point by RTK (VRS) is needed to analyze the coincidence between cadastral control point and supplementary control point and necessary to adjust numerical difference between parcel boundary and supplementary control point. In this study, we have performed field test on 5 cadastral resurvey area. For field test first we have reprocessed the GPS law data (RINEX) based on republished national control point and then compared coordinate difference and direction by using previous coordinate. After this we readjusted cadastral control point by applying average variation (X, Y differences of coordinate). Result of field test, readjusted control

points, supplementary control point and boundary points were same direction (variation vector) in accordance with republished national control point but depending on observation, ± 0.01 m difference occurred. Especially, Myeong-San area (region of Kun-san city) which was impossible to test by VRS, so that area was verified difference by GPS static survey.

Results of Myeong-San area showed a same variation between new and old coordinate. The different deviations occurred at cadastral resurvey area because of structural limit ($\pm 0.01 \sim 0.02$ m) of VRS. However, judging by the overall result of the field test, we can know that recalculating method is available to modify old data made by cadastral resurvey project.

Table 4 Results of Field Test

Region	Type	Average variation NCP republished		Average variation CCP recalculated		Average variation CCP resurveyed		Average variation BP resurveyed	
		dn	de	dn	de	dn	de	dn	de
Sejong	VRS	-	-	-	-	0.01	0.02	0.00 (-0.01)	0.02
Boryeong	VRS	0.00	0.02	0.00	0.02	0.01 (+0.01)	0.03 (+0.01)	0.00	0.02
	TS	-	-	-	-	-	-	0.00	0.02
Kunsan	Static	0.00	0.02	0.00	0.02	0.00	0.02	-	-
	TS	-	-	-	-	-	-	0.00	0.02
Busan-jingu	VRS	0.01	0.03	0.00 (-0.01)	0.03	0.01	0.03	0.01	0.03
Ulju	VRS	0.01	0.03	0.01	0.03	0.00 (-0.01)	0.03	0.01	0.02 (-0.01)
Donghae	VRS	0.00	0.04	0.01 (+0.01)	0.03 (-0.01)	0.00	0.03 (-0.01)	0.00	0.05 (+0.01)
	TS	-	-	-	-	-	-	0.01 (+0.01)	0.03 (-0.01)

4. Managing Cadastral Record

In the past, Korea had two system of survey, one was a cadastral survey another was a geodetic survey (including general and public survey) but all survey control point was combined by introducing world geodetic reference system and integration of survey related Acts in 2009. Therefore it is strongly needed how to manage and utilize cadastral data based on WGS. For this, it is necessary to review introducing dynamic cadastral system (tentatively) as a new concept in order to effectively deal with crustal deformation and earthquake, ITRF version update, republishing national control point. In case of RTK (VRS) it can be considered for separating the server operated by NGII into main server for new performance and backup server for past performance. Another method is to install mathematical model that can be calibrated automatically differences between

new and old coordinates into the GPS receiver Firmware.

4.1 Managing Cadastral Record Related to Republishing National Control Point

For managing cadastral record according to republishing national control point, there are two major steps: first is recalculating cadastral control points, second is update the old points through campaign. Recalculation is consisting of 3 steps such as obtaining GPS data, reprocessing data, adjusting network. Through recalculation method, we can determine average variation between new and old control points and then applying it to boundary points, due to these procedure old cadastral data can be updated. Updated cadastral data must be validated through field test. In order for this method to expand nationwide, classifying cadastral data based on WGS as completed and ongoing region through nationwide investigation then

proceeds to the following order : Prepare regional data for recalculating, recalculating cadastral control points, analyzing direction and average variation, determining new result, validating through field test. RTK survey areas are applied by the same method and analyze recalculated data. Through these processing, we have to analyze regional specificity and come up with an effective counter plan (definition of cause etc.) for solving the problems.

4.2 Managing Cadastral Record (ITRF Version)

Because World Geodetic System is tend to convert new version by seismic shift and modeling technique for the center of the earth, in order to maintain the consistency of the cadastral data it is necessary to develop new cadastral model such as a dynamic cadastral system (Tentatively) for effective registration and application. For instance, if ITRF2000 is changed to ITRF2005 it can be registered new cadastral record based on ITRF2005 automatically and it allows surveyor to cadastral survey using new record. The new model is to be capable of transformation between physical and record boundary through nationwide mathematical model and updated with the new version of ITRF automatically. To do this, detailed study is needed for unifying cadastral records such as control points, boundary point depending on the ITRF version by simultaneously or stepwise.

4.3 Managing Cadastral Record Related to RTK

In order to use RTK (VRS) for cadastral survey, first, separating the server operated by NGII into main server and backup server, increasing the capacity of a server, and then service the correction data by ITRF

version to cadastral surveyor. To do this, it is needed to consult with NGII. Second, using the LX infrastructure, at present LX is operating 30 GNSS sites similar to the national CORS to realize 3th generation cadastral survey. This is very simple technically, it can be implemented just through data sharing between NGII server and SIRI (Spatial Information Research Institute) server. Third, developing nationwide mathematical model that can be calibrated differences between new and old coordinates automatically and installing it into the GPS receiver Firmware. For this, prior consultation is required with receivers distributor.

5. Conclusion

This study is how to manage cadastral data based on WGS, firstly analyzing influence of cadastral data due to republished control points and suggest how to revise old control data to the new national control points. And also made a suggestion for how to update when republishing national control points or releasing new ITRF version. In order to realize the proposed methods in this study, it is needed for detailed and in-depth research in the near future.

References

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