Field research for Advanced GPS Network RTK Solution

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Abstract

In recent years there has been considerable interest in the network GPS RTK surveying. Single RTK has some limit in long distance and it has an accuracy problem depend on the baseline length. The significant improvement of GPS network technology, RTCM V3.0 correction format and telecommunication technology can eliminate the weakness of single GPS RTK. This paper is the practical field result of GPS network RTK.

Keywords: GPS, Network RTK, RTCM V3.0,

1. Introduction

Cadastral Surveyors have researched to improve the Cadastral survey for the fast, accurate and reliable result. It is possible to use signals from the satellite-based Global Positioning System (GPS) and SPIDERNet which GPS infrastructure that enables users to instantly improve the accuracy of their GPS positioning from around 10m to up to 1cm, anywhere in the network, even outside of network. GPS Network RTK enables Cadastral surveyors to capture the cadastral data faster and more flexibly. To enable pilot studies in the cadastral applications, Cadastral Research Institute made a partnership with Leica Korea.

Korea test GPS RTK Net consist of 6 geodetic GPS receivers around Seoul(KCSC Head office, Leica Korea office) and Gyeonggi-do(Kanghwa, Bucheon, KimPo, YongIn), Those receivers linked via internet(static IP) to SPIDER server and raw data is streaming out from receiver to the SPIDER server. The server generates RINEX, MAX & iMAX RTK corrections and they are streaming out via TCP/IP to a field. The corrections are based on standard RTCM V3.0 and all version of RTCM format.

Rover can fix ambiguity up to 40km distance from the nearest reference station. There are 21 control points across the network from inside to outside of network. The baseline range from the reference stations to rover is 1km - 35km.

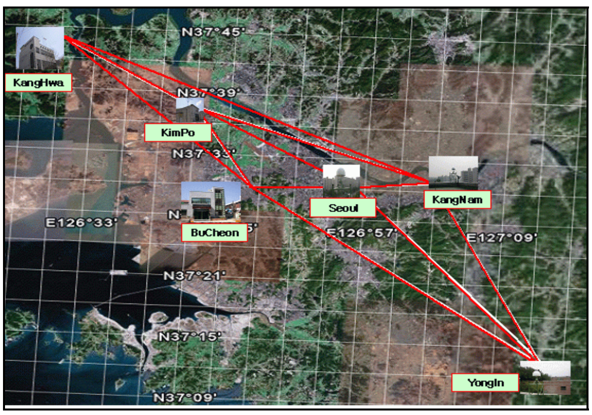

Figure 1. Network site MAP

2. Test GPS Reference Network Overview

2.1 Network Description.

Coordinate definition: Processing by AUSPOS online processing center.
Local Adjustment: BUCH & KCSC are control points; the final coordinates were defined by LGO local network adjustment.

Table 1. IGS Reference (GRS80 Ellipsoid, ITRF2000)

IGS	Latitude	Longitude	Height(m)
bjfs	39-36-30.9635	115-53-32.9486	87.446
daej	36-23-57.9423	127-22-28.1266	116.835
usud	36-07-59.1964	138-21-43.3569	1508.605
BUCH	37-29-45.3442	126-47-19.8573	51.554
KCSC	37-31-09.4650	126-55-37.6256	59.904
KHAC	37-44-40.7062	126-29-23.2055	48.022
KIMP	37-37-00.8794	126-42-54.6721	49.894
YOIN	37-13-17.2535	126-13-52.3770	161.988
	X	Y	Z
bjfs	-2148744.127	4426641.272	4044655.891
daej	-3120042.017	4084614.874	3764026.885
usud	-3855263.033	3427432.557	3741020.272
BUCH	-3034295.631	4057672.815	3861237.006
KCSC	-3043134.240	4049081.488	3863299.400
KHAC	-3003052.016	4059906.311	3883099.668
KIMP	-3024182.433	4055008.438	3871880.825
YOIN	-3076770.094	4048912.420	3837090.969

2.2 System description

The reference site and SPIDER server is connecting via TCP/IP (static IP, 10mb). NTRIP is the key communication between Rover user and SPIDER server in this test. CDMA modem(C-motech) is used for the communication device in rover side. User can connect the NTRIP server by specific User ID and Password (GPUID) for security.

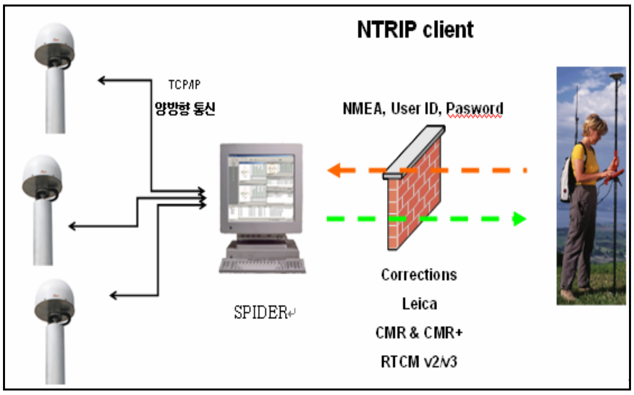

Figure 2. Communication Architecture

2.3 The basics of Network RTK (Master Auxiliary concept

The fundamental concept of the GPS network RTK (Leica MAC) approach was to transmit all relevant correction data from a reference network to the rover in a highly compact form by representing ambiguity levelled observation data as differences of dispersive and non-dispersive data. This approach was to become known as the Master-Auxiliary Concept (MAC) and is the basis for the RTCM 3.0 Network RTK messages.

To reduce the volume of data to be transmitted for a network, the Master-Auxiliary Concept sends full correction and coordinate information for a single reference station, referred to as the *master station*. For all other stations in the network (or sub-network), known as *auxiliary stations*, correction differences and coordinate differences are transmitted. This differenced information, which is calculated between the master and each auxiliary station, is numerically smaller and can thus be represented in the messages with a smaller number of bits. The rover simply to interpolate the error at the user's location or to reconstruct the full correction information from all reference stations may use the correction difference information.

The Master-Auxiliary Concept gives the rover the flexibility to perform a simple and efficient interpolation of the network corrections or a more rigorous calculation depending on its processing capabilities

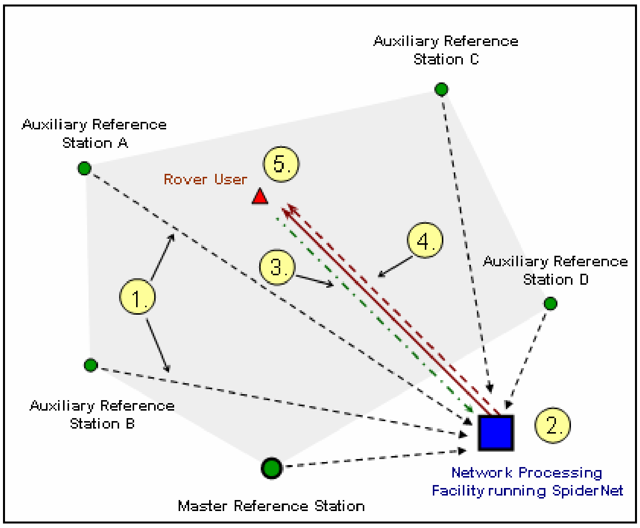

Figure 3. Generation of master-auxiliary corrections (MAX) for a Rover

1. Transmission of raw observation data from the reference stations to the network processing facility.
2. Network estimation process including **Ambiguity Resolution** to reduce the stations to the common ambiguity level.
3. (Optional) NMEA GGA position received from the rover at the network processing facility. The most appropriate reference stations are chosen for the rover based on its location.
4. Formation and transmission of RTCM 3.0 network message using **Corrections** for the Master station and **Correction Differences** for the auxiliary stations.
5. Computation of high accuracy rover position using the full information from the reference network.

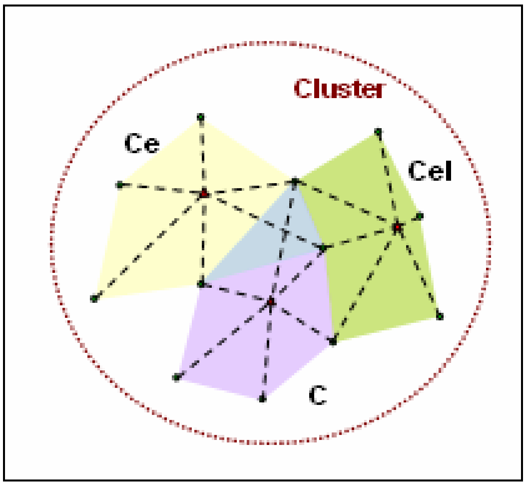

Figure 4. A cluster providing master-auxiliary corrections to several rovers, with each rover using an appropriate cell based on its location.

2.4 Reference station Installation

The reference stations are installed on 6 local offices. There are significant advantages in setting up reference station on buildings, as power and telephone connections are usually available and the equipment should relatively safe. The flat-roofed buildings of medium height with a relatively large base will normally be very stable and suitable for reference stations but towers and thin, tall skyscraper type buildings are often not suitable as they may sway in strong wind and in hot climate, may also deform, bend slightly due to expansion caused by the sun.

- Receivers at reference stations will usually be set to track satellites down to 10 degree above the horizon

- Flat-roofed buildings of medium height with a relatively large base is normally suitable for the building installation

- Reliable communication between site and control server.

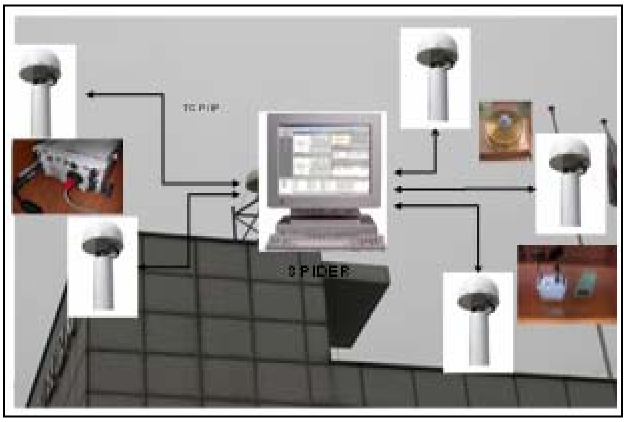

Figure 5. Reference station diagram

Analysis of 24 hr GPS observation using Leica GNSS QC software.

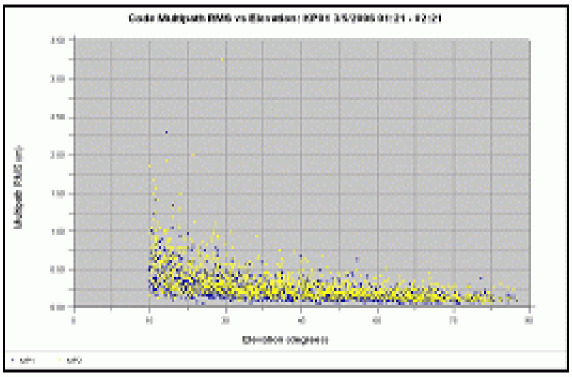

Figure 6. Quality Test

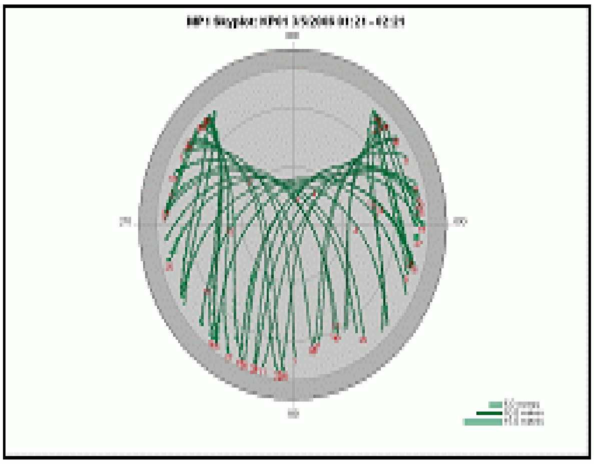

Figure 7. Code Multipath RMS (KIMPO)

2.5 Control Server

On receipt of the raw data, Leica Korea office server store s the raw data for post processing application, runs quality check and calculates the correction stream. This is providing MAX & iMAX and DGPS correction.

2.6 Reference GPS receiver

Hardware: Leica GRX1200Pro Receiver. AT504 ChokeRing Antenna
Software : Leica GPS SPIDERNet V2.0

2.7 Rover

GX1230 geodetic receiver AX1202 geodetic antenna

2.8 Rover GPS Receiver

Surveyors dial into the NTRIP using CDMA modem, sending in their approximate position. The server software creates and sends back MAX and iMAX correction via internet on RTCM V3.0 format. The user's rover then interprets this information to correct their position.

3. GPS Network RTK accuracy testing

The test was performed during July and August 2006, 21 test points across Seoul and Gyeonggi-do were taken. Those points are calculated using 6 reference stations network adjusted data.

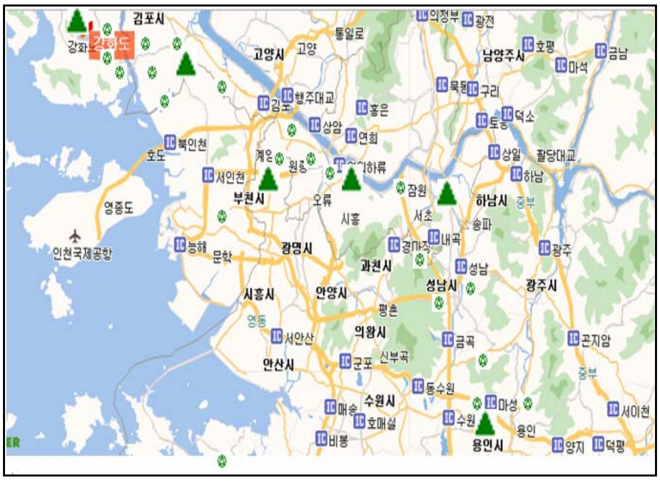

Figure 8. Reference stations (▲) & 21 Test Point (Δ)

4. Summary of GPS Net quality test

4.1 Initialization times

Also of interest from the tests was an analysis of initialization times of all of the test points. This remained steady at around 25-30 seconds, see graph right. The average time to track satellites was 15 seconds. The average time to fix ambiguity was 10 seconds there will be some dependency on the rover equipment – in this trial Leica GX1230 receiver and AX1202 antenna were used. There would probably be some change if a different GPS receiver was used.

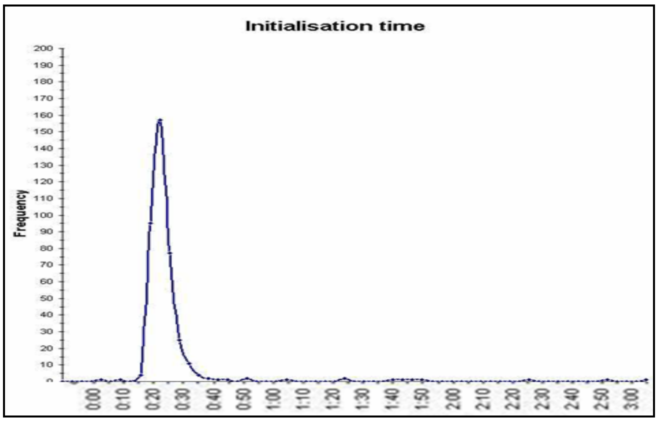

Figure 9. Initialization times

4.2 Precision Test result (field data)

The minimum difference on the X axis was 0.001 :
PtId, WarehouseRT05, 06

The minimum difference on the Y axis was -0.001 :
PtId, EVERLANDRT02, 03

The minimum difference on the Z axis was 0.001:
HwaSungRT04, 14

Table 2. Points Difference

	dx	dy	dz
Min diff	0.001	-0.001	0.001
Max diff	0.034	0.065	0.042

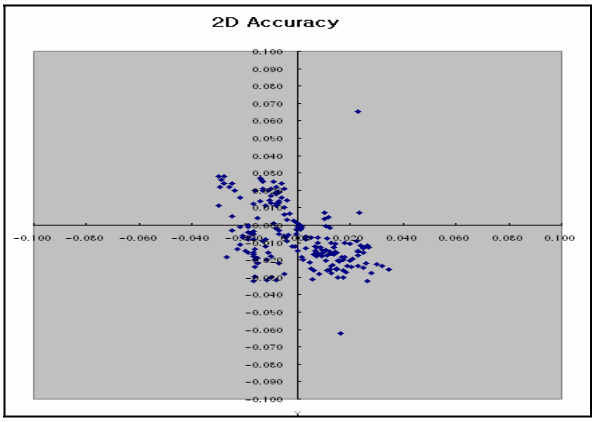

Figure 10. All RTK Points Distribution Graph (2D)

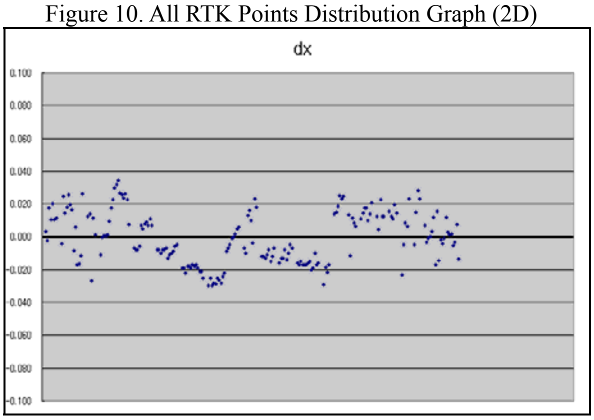

Figure 11. All RTK Points Distribution Graph (dx)

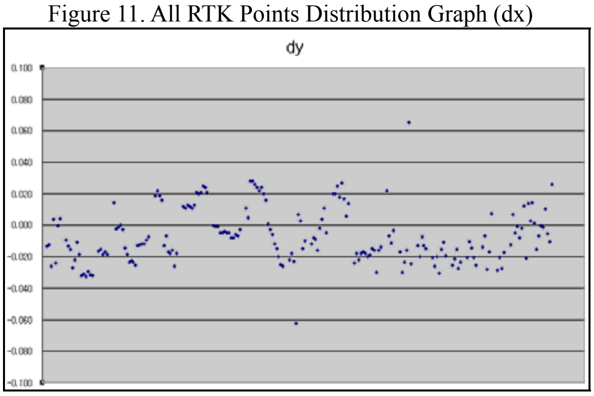

Figure 12. All RTK Points Distribution Graph (dy)

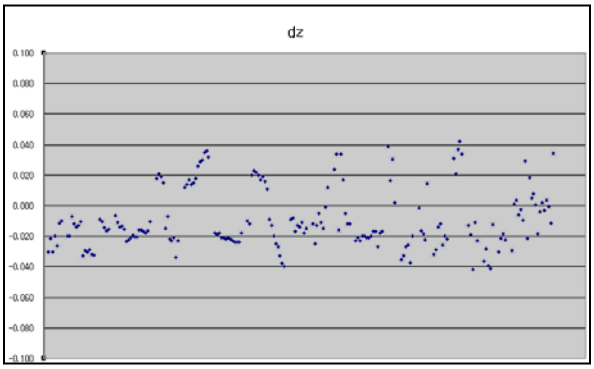

Figure 13. All RTK Points Distribution Graph (dz)

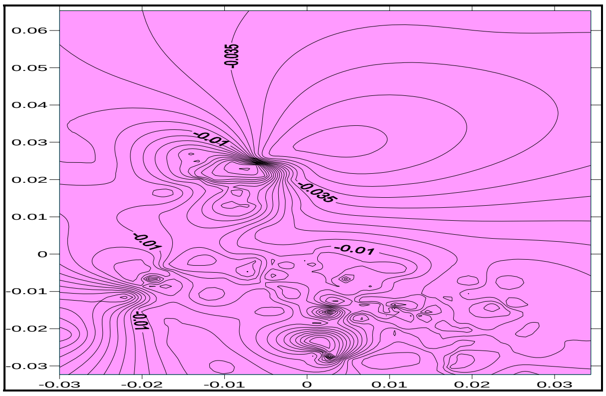

Figure 14. Points Difference (2D) Modeling

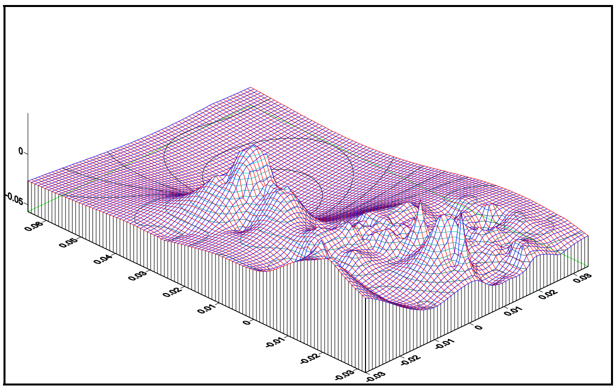

Figure 15. Points Difference 3D Modeling

4.3 Repeatability (Individual point) Test

Test point: HwaSung
Baseline: 35.830km from the nearest site.
Test duration: 7days, 10 measurements per day.

Table 3. Repeatability Points Difference (m)

	dx	dy	dz
Average diff	0.006	0.009	0.011
Max. diff	0.016	0.026	0.035
Mini. diff	- 0.017	- 0.021	- 0.030

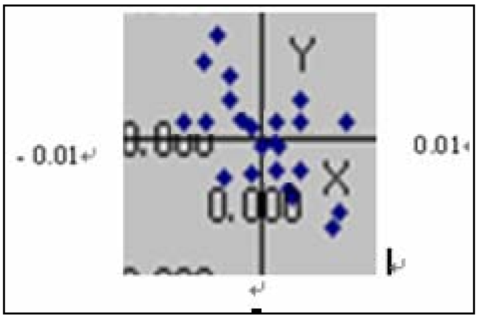

Figure 16. Repeatability Difference Distribution (X & Y)

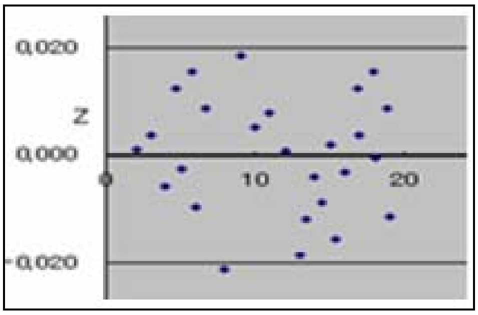

Figure 17. Repeatability Difference Distribution (Z)

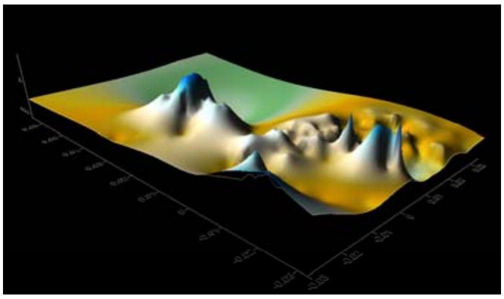

Figure 18. Repeatability Difference Distribution

5. Conclusion & Future work

The test results in the GPS network RTK. Mainly inside of network was that the coordinates differences are 1-2cm average in 2D, 1-3cm in the height. The factor which can give big differences was fixed L1/L2 in the reference station and the number of satellites. Using the more satellites the better result came out and it is expected to get better result when the equipment uses GPS, GLONASS and Galileo system in the future. Further GPS RTK project is going to be launched on the end of September. To compare between existing cadastral result and new GPS RTK result on the local coordinate system, SPIDERNet and different kind of GPS will be used. The accuracy, the working time, position repeatability and the other practical advantages will be discussed. Also the coordinates will be analyzed in the different distance and discuss the coordinate accuracy in different condition, inside and outside of the network. The next step of the research is going to be developed new application based on GPS RTK network.

Reference

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