

## Development of RTK-GPS Field Quality Checking Module for Korean Cadastral Resurvey Project

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### I. INTRODUCTION

#### 1. Background

- Real-Time Kinematic Surveying(RTK-GPS) provides the surveying results in the field,
- Difficult for a beginner to check the quality of RTK surveying results
- Cadastral surveyors can not make best use of RTK-GPS in cadastral surveying

#### 2. Purpose

- To develop a method to check the quality of RTK surveying results
- ➡ Our cadastral surveyors can use RTK with ease, the module could be applied to field surveying

3. Method

- Quality checking module development
- Performance Evaluation
- Surveying results verification

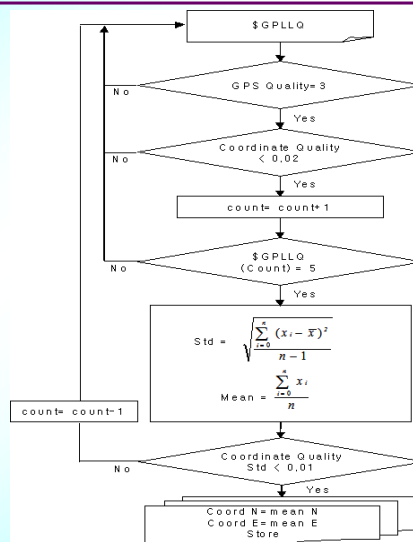
- Development of NMEA Signal, \$GPLLQ Data, PDA
- Performance Evaluation on Field Quality Checking Module
- Yeouido Ecology Park
- Surveying Results Verification by TS
- Surveying Results Verification by STATIC
- Analysis of Surveying Results

■ Data Format : \$GPGGA, \$GPGLL, \$GPGSA, \$GPGSV, \$GPRMC, \$GPMSS, \$GPVTG, \$GPLLQ

\$GPLLQ,020520.00,043008,193122.623,M,446277.260,M,3,07,0.021,-777.952,M \* 1D

1. Developing Field Quality Checking Module

- Acquire \$GPLLQ data selectively from GPS receiver among NMEA data
- Select RTK Fix data for which GPS quality is 3
- Select \$GPLLQ data for which Coordinate Quality falls within user-specified accuracy range
- Repeat data acquisition until specified quantity of data is selected consecutively
- Calculate standard deviation and mean of location coordinates
- Save final results as determined coordinates



<Figure 1> Program Process Flow

### 2. Performance Evaluation On Field Quality Checking Module

- Pilot test area
- Yeouido Ecology Park
- Confirmed 4 control points (do1~do4)
- Marked 11 survey points (p1~p11)
- Consideration of site conditions (visibility for TS, static and RTK surveying)



### ■ Location Of control points

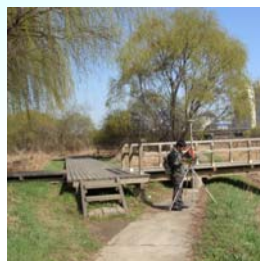


d1

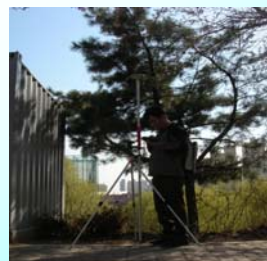


d2

### ■ Location Of Survey points



p5



p11

## II. QUALITY CHECKING MODULE DEVELOPMENT

- For conversion of area coordinates, cadastral control points of the pilot test area

<Table 1> Published coordinates of cadastral control points(Supplementary) in the pilot test area

Control Name	X coordinate(m)	Y coordinate(m)
d1	446113.24	193406.64
d2	446195.88	193229.10
d3	446285.59	193050.44
d4	446470.46	192728.41

- Survey equipment : Leica System 500, with SR530 receiver, AT502 antenna, RF wireless modem and tripod to check accuracy
- The module was developed and installed in a connected PDA in place of Rover Controller

## II. QUALITY CHECKING MODULE DEVELOPMENT

- GPS data was received for around 30 seconds more or less per each of the all observation point
- GPS data of all observation points was saved when I confirmed a message on the PDA display that surveying was performed as intended by field quality checking module



<Figure 2> Correction data not transmitted

- Initial surveying state
- PDA display shows 6 satellites but GPS quality is 1, indicating GPS Nav Fix status.

## II. QUALITY CHECKING MODULE DEVELOPMENT



<Figure 3> GPS surveying data received accurately on PDA

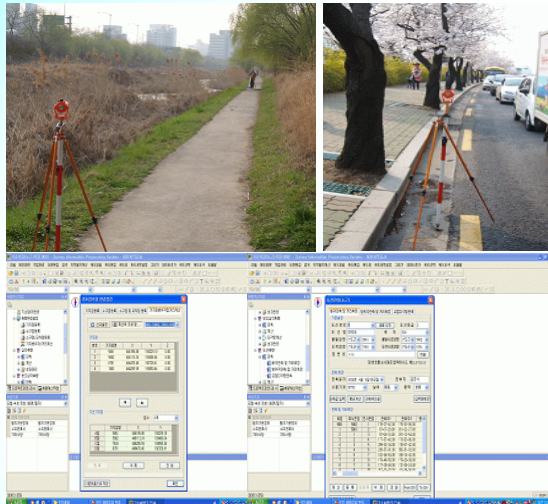
- RTK-GPS surveying is in progress as usual
- 7 satellites are used for calculation and GPS quality is 3, indicating RTK Fix status

- 'OK' sign is shown at the bottom left of the PDA display, indicating that location coordinates are within specified tolerance range and surveying product quality is acceptable
- 'Good' message shown at the bottom right indicates that wireless communication quality is good
- If measured coordinates are out of user-specified accuracy range and communication quality is poor, "moved" and "bad" will be displayed instead of "OK" and "good"

## II. QUALITY CHECKING MODULE DEVELOPMENT

### 2.1 Surveying Results Verification by TS

- TS surveying was performed to verify the results produced by the module
- Surveying equipment : Sokkia SET230R
- Observation and calculation : 3 repetition method and SIP system
- Calculation Results : connection error was 0.05m tolerance range was  $\pm 0.23m$ .



(SIP: Survey Information Processing System)

## II. QUALITY CHECKING MODULE DEVELOPMENT

- Azimuth angle of given points and distance calculation results
- Azimuth angle of arrival calculated for given point d3→d4 : 299-51-32.9
- Azimuth angle of arrival calculated for observed value : 299-52-15
- 42.1 seconds out of tolerance =±108 seconds are assigned to the observation angle of each survey point.

<Table 2> Azimuth and distance calculation

Name	X(m)	Y(m)	Direction	Azimuth	Distance(m)
d1	446113.24	193406.64	d2→d1	114-57-38.5	195.83
d2	446195.88	193229.10			
d3	446285.59	193050.44	d3→d4	299-51-32.9	371.32
d4	446470.46	192728.41			

## II. QUALITY CHECKING MODULE DEVELOPMENT

<Table 3> RTK surveying results verification with TS surveying results (unit: m)

Survey Points	RTK		TS		RTK-TS		Misclose Vector
	X(N)	Y(E)	X(N)	Y(E)	□X	□Y	
p1	446221.594	193169.666	446221.63	193169.67	-0.036	-0.004	0.036
p2	446200.144	193161.621	446200.15	193161.62	-0.006	0.001	0.006
p3	446145.506	193266.098	446145.49	193266.11	0.016	-0.012	0.020
p4	446093.081	193375.668	446093.04	193375.71	0.041	-0.042	0.059
p5	446024.346	193277.093	446024.31	193277.13	0.036	-0.037	0.052
p6	446063.832	193188.695	446063.80	193188.71	0.032	-0.015	0.035
p7	446090.102	193136.700	446090.08	193136.71	0.022	-0.01	0.024
p8	446148.376	193020.555	446148.37	193020.52	0.006	0.035	0.036
p9	446180.508	192948.816	446180.50	192948.77	0.008	0.046	0.047
p10	446283.624	192989.763	446283.62	192989.76	0.004	0.003	0.005
p11	446305.592	193000.372	446305.61	193000.35	-0.018	0.022	0.028
RMSE					0.0224	0.0260	0.0166

- Standard deviations of ΔX : 2.24cm, ΔY : 2.6cm and misclose vector : 1.66cm
- Surveying results had no problems and the field quality checking module was effective

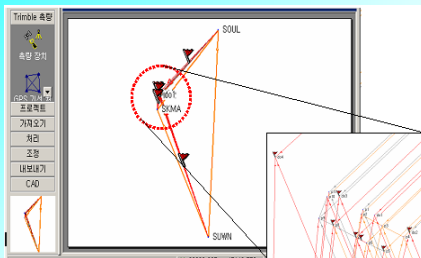
2.2 Surveying Results Verification by STATIC

- Observation time was 30 minutes for each survey point
- Trimble Geomatics Office was used to process observed values
- Korean coordinate system for conversion with GPS(WGS84) coordinate system :  
System of Korea Cadastral Survey Corporation 1998/10/30 VERSION 2.1

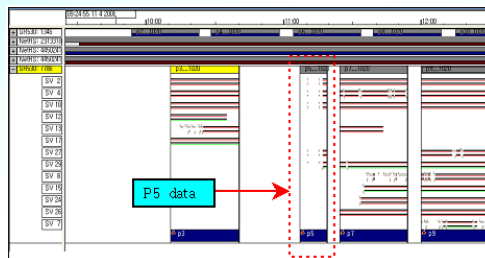
<Table 4> Published surveying results at the GPS observation stations used herein

Station Name	GRS80				Owner
	Latitude	Longitude	H	Origin	
SUWN (Suwon)	37-16-31.8529	127-03-15.2638	83.816m	Middle	NGII
SOUL (Seoul)	37-37-46.8973	127-04-47.0067	59.109m	•	•
SKMA (Seoul)	37-29-36.70257	126-55-04.79368	61.697m	•	KASSI

- Data processed by TGO program with 3 GPS observation stations fixed.



<Figure 4> data processed by TGO program with 3 GPS observation stations fixed



<Figure 5> Analysis result of data received at P5 in the field

- Excessive error occurred at survey point P5 among surveying products calculated by 3D network adjustment
- P5 was not received for the first 20 minutes before being received for around 10 minutes later

## II. QUALITY CHECKING MODULE DEVELOPMENT

<Table 5> RTK surveying results verification by STATIC (unit: m)

Survey point	RTK		STATIC		RTK-STATIC		Misclose vector
	X(N)	Y(E)	X(N)	Y(E)	$\Delta X$	$\Delta Y$	
p1	446221.594	193169.666	446221.619	193169.609	-0.025	0.057	0.062
p2	446200.144	193161.621	446200.144	193161.586	0.000	0.035	0.035
p3	446145.506	193266.098	446145.507	193266.052	-0.001	0.046	0.046
p4	446093.081	193375.668	446093.074	193375.612	0.057	0.056	0.080
p5	446024.346	193277.093	446025.406	193277.071	-1.060	0.022	1.060
p6	446063.832	193188.695	446063.847	193188.649	-0.015	0.046	0.048
p7	446090.102	193136.700	446090.091	193136.703	0.011	-0.003	0.011
p8	446148.376	193020.555	446148.363	193020.538	0.013	0.017	0.021
p9	446180.508	192948.816	446180.536	192948.765	-0.028	0.051	0.058
p10	446283.624	192989.763	446283.640	192989.761	-0.016	0.002	0.016
p11	446305.592	193000.372	446305.607	193000.329	-0.015	0.043	0.046
RMSE	All				0.3030	0.0202	0.2932
	p5 exception				0.0141	0.0208	0.0207

- Except for p5 where excessive error occurred, standard deviations of  $\Delta X$  : 1.41cm,  $\Delta Y$  : 2.08cm and Misclose vector : 2.07cm
- Except for  $\Delta X$  at P5 surveying results determined by static surveying and RTK-GPS surveying did not show significant differences

## III. ISSUES IN THE NEAR FUTURE

### III. ISSUES IN THE NEAR FUTURE

- RTK-GPS is not actively used in cadastral surveying of the Korea
  - Designed to enable even a beginner to use RTK-GPS surveying, developed to check surveying data in the field
  - It is illustrated that the field quality checking module could be applied to cadastral surveying very usefully
- 
- GPS data was received varyingly, depending on the time of day, even if surveying was conducted at the same location and for the same period of time
  - The module proposed herein will be developed further in consideration of the time of day, DOP and number of satellite signals received, etc.
  - In addition, the module will be applied to cadastral resurvey model projects to identify further user requirements and incorporate such requirements in subsequent studies



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**Thank You**

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