Using Network-RTK for Cadastral Reform in Republic of Korea

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1. Korea Cadastral System

**Origin of Korea Cadastre**

- Established in 1918
  - Land Survey Project (1910–1918)
  - Forest Survey Project (1916–1924)
  - During Japanese Colonial Period
- Fiscal purpose
- Area-Oriented
- Paper-based map
- Low accuracy (depend on scales)

**Current Korea Cadastral System**

- Computerized Cadastral Map/Books
  - Digital Cadastral map (2000)
- Established Land Information System
  - Korea Land Information System (KLIS, 2003)
  - Integration of land data
- Position-Oriented
- Not improved positioning accuracy
  - ± 2 cm (numerical map region)
  - ± (12–90) cm (graphical map region)
2. General Plan of Reform

Goal of Cadastral Reform

- Convert to World Geodetic System
- Adopt Network-RTK Survey
- Correct map in troubled region
- Integrate land information in digital map
- Promote spatial information industry
- Establish 3D Cadastre
- Easy to access to land information

General Plan of digital Cadastre

<table>
<thead>
<tr>
<th>Category</th>
<th>2020 year</th>
<th>2030 year</th>
<th>Cost (million dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parcel Num.(million)</td>
<td>Ratio</td>
<td>Parcel Num.(million)</td>
</tr>
<tr>
<td>Change Numerical Map</td>
<td>300(6,000)</td>
<td>8 %</td>
<td>400(8,000)</td>
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<tr>
<td>Non-coincidence Resurvey</td>
<td>282(3,100)</td>
<td>7 %</td>
<td>550(6,130)</td>
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<tr>
<td>National Land Resolution</td>
<td>188(9,000)</td>
<td>5 %</td>
<td>564(25,000)</td>
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<tr>
<td>Coordinate Transformation</td>
<td>1,111(31,900)</td>
<td>30 %</td>
<td>2,295(61,907)</td>
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<tr>
<td>Total</td>
<td>1,881(50,000)</td>
<td>50 %</td>
<td>3,761(100,037)</td>
</tr>
</tbody>
</table>

3. Surveying Method

**Total Station Instrument**
- Combined theodolite with EDM
- Measure relative angles and distance
- Plane Surveys
- Calculating position using trigonometry

**GNSS**
- Satellites transmit signals
- Receivers measure travel time of signal or carrier phase
- Calculate absolute 3D positions
- Contain several error resources
  - Clock error (satellites, receivers)
  - Ionosphere/Troposphere Refraction
  - Multipath, satellite deployment
- Single receiver has ±15~20 m accuracy level
3. Surveying Method

Network-RTK

- One of the GNSS augmentation systems
- Needs permanent reference station
- Needs correction generating software
- Centimeter-level accuracy in real-time

Network-RTK in Korea

- NGII provided VRS Service (2007)
- 72 permanent Reference Stations
- Cover the whole country (South Korea)
- Free of charge
- Adopt world geodetic system
- Use only public surveys not cadastral surveys

*NGII : National Geographic Information Institute
3. Surveying Method

Instrument comparison

**Total Station**
- **Pros.**
  - Easy-to-use
  - Inexpensive instrument
  - Indirect measurement
- **Cons.**
  - Setting Coordinate System
  - Affect control pts. Accuracy
  - Need line-of-sight

**Network-RTK**
- **Pros.**
  - High precision
  - In real time
  - No need transformation
- **Cons.**
  - Difficult to accuracy control
  - High cost to building CORS
  - Affect site environment

Comparison of devices

**Current Survey Method**
1. 1st, 2nd order Control Pts. (GNSS)
2. Convert to Local Coordinate
3. 3rd order Control Pts. (T/S)
4. Check Control pts. with real boundary (T/S)
5. Measure real boundary (T/S)
6. Decide boundary based on field book

**Network-RTK Survey Method**
1. Measure real boundary (VRS)
2. Check measurement data and decide

- No need to 1~4 Steps
- No Accuracy degrade by converting coordinate
- Simplify survey process
4. Analysis of Experiments

Study Area

- Youngjong Island near Incheon International Airport
- Resurveyed in 2010 and numerical cadastral map
- Adopted world geodetic system

Environments

- Open sky
- No obstacle causing multipath
- Number of observed points
  - 3rd order control pts: 19
  - Parcel boundary: 21
- PDOP: 3~5
- Num. of satellite: 8~12
- Measured 2-session
4. Analysis of Experiments

### Analysis of control pts.

- **Observation interval**
  - 15 epoch, 2 session
- **Accuracy (std. deviation)**
  - X-axis : 0.9 cm, Y-axis : 0.9 cm
- **Efficiency**
  - 1~2 Surveyor
  - No need 2nd order control pts.

#### Accuracy less than allowable tolerance
- Save time, manpower
- Reduce work flow

#### Analysis of control pts.

<table>
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<tr>
<th>Control Points</th>
<th>Published value (A)</th>
<th>Average Network-RTK (B)</th>
<th>Error</th>
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#### Analysis of boundary pts.

- **Observation interval**
  - 10 epoch, 2 session
- **Accuracy (std. deviation)**
  - X-axis : 3.3 cm, Y-axis : 3.4 cm
- **Efficiency**
  - 1~2 Surveyor
  - No need 3rd order control pts.

#### This experiment is the part of

"A Study of Application Method with Latest Technology in Cadastral Reform"

<table>
<thead>
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<th>Boundary Points</th>
<th>Published value (A)</th>
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#### Within the tolerance
- Save time and manpower
- No additional works

#### Average Error
- 0.004 ± 0.002

#### Standard Deviation
- 0.003 ± 0.001
5. Conclusion

**Accuracy**
- Within tolerance range (2~5 cm)
- More accurate than current regulation (less than 10 cm)

**Improve efficiency**
- Network-RTK can improve resurvey efficiency (20%)
- Save manpower and simplify resurvey process.

**Pre-requisite**
- Amend regulation of cadastral survey

Thank you for your attention & Question?