

# Korean Geodetic Datum 2002(KGD2002) : Nationwide GPS Network Densification

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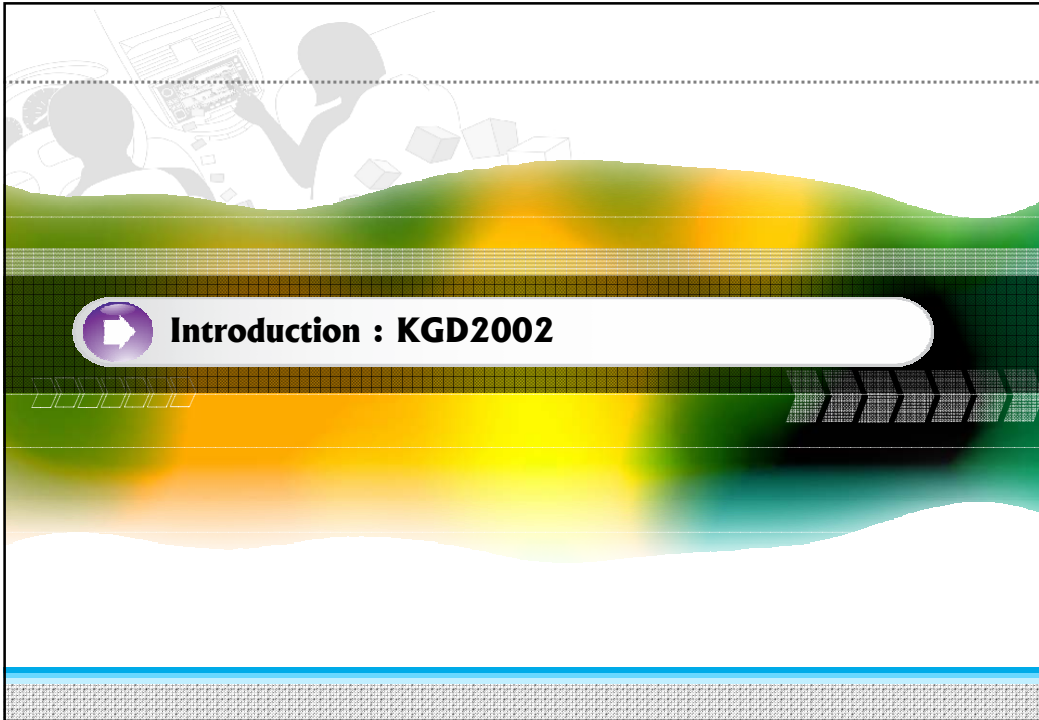
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- 2 GPS Observations and Processing
- 3 Network Adjustment for Densification
- 4 Concluding Remarks



## Korean Geodetic Datum 2002

New Korean horizontal geodetic datum was adopted on 1<sup>st</sup> January 2003

KGD 2002

Aligned to ITRF 2000 (Epoch 2002.0)

Reference Ellipsoid: GRS80

### ■ The Published Origin Coordinate of KGD2002

ECEF	X	Y	Z
	-3062002.7640	4055436.7512	3841860.8313
Geographical	Latitude	Longitude	Ellipsoidal height
	37-16-33.3659	127-03-14.8913	91.253m

This datum transition support modern satellite positioning techniques and ensure that spatial data is compatible with international standard!!!!

## Realization of KGD2002

The realization was achieved by determining the coordinates of its origin and the 1<sup>st</sup> order geodetic control points!!!

### VLBI Observation

- Joint Geodetic Project of Korean and Japan in 1995
- CALC & SOLVE S/W was used for data processing to estimate ITRF2000(epoch 1997.0) coordinate on **14 November 2000**.
- ITRF2000(epoch 2002.0) coordinate was determined by including the crustal motion vector

### GPS Observation

- Coordinate of the **origin point** was determined by GPS & TS observations in the end of 2002.
- Coordinates of 14 GPS CORS of NGII was estimated by processing GPS five days GPS observations
- **The CORSs are served as the 1<sup>st</sup> order control point in KGD2002.**

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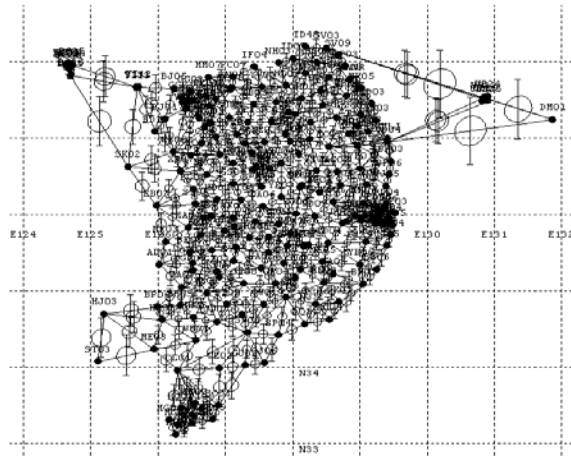
## The 2<sup>nd</sup> Order Geodetic Network

- ± 200 Points observed by GPS (1996-2000)
- ± Baseline length ranges from 10km to 100km (Mostly 40km)
- ± Network adjustment was completed in 2006
- ± Overall accuracy: 2cm (Horizontal) & 4cm (Vertical)
- ± Adjustment Summary

Fixed point (3D)	13 GPS CORSs
Number of points	214
Number of unknown parameters	603
Number of observations	2316
Degree of freedom	1719
Posterior Variance Factor	1.06
$\chi^2$ Test	Passed


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## The 2<sup>nd</sup> Order Geodetic Network



Adjusted Network with Absolute Confidence region (Lee et al., 2006 & 2007)

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 **GPS Observations & Processing**

## Objectives

- To examine the 3<sup>rd</sup> Order GPS observations (1997 -2007)
- To process them to estimate baseline vectors
- To determine KGD2002 coordinate of the 3<sup>rd</sup> Order Points by the baseline vector network

### Tools

#### GPS PROCESSING S/W

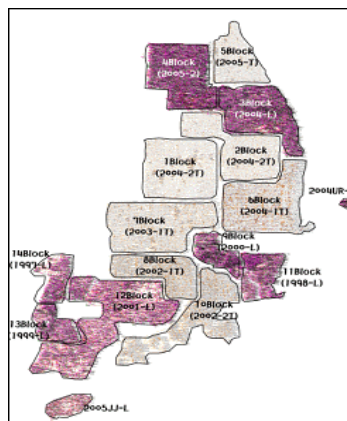
LGO & TGO GPS static processing module, BERNESE

#### NETWORK ADJUSTMENT S/W

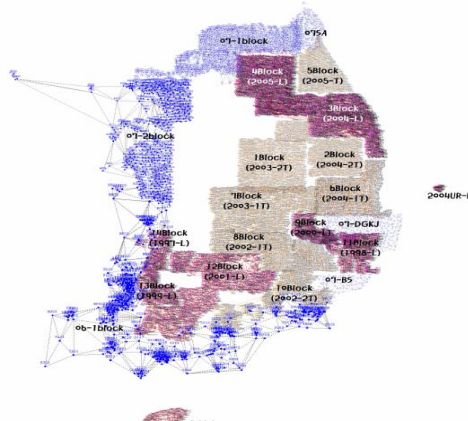
Geolab™, LGO & TGO network adjustment module

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## The 3<sup>rd</sup> Order Geodetic Network



The 3<sup>rd</sup> order GPS Network (2006)



The 3<sup>rd</sup> order GPS Network (2007)

Blank Area will be filled in 2008.

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## GPS Observation & Processing

### ■ GPS 3<sup>rd</sup> Order Observations

- NGII had held GPS campaigns over the 3<sup>rd</sup> order geodetic network, from 1997 to 2007
- About 11,000 points were observed
- The campaigns are ongoing to full cover whole country

### ■ Baseline Processing

- Processed by surveying contractors who made filed observations  
(Baseline Length: 2km - 5km)
- Software: Mostly TGO & LGO
- The solutions were used in subsequent network adjustment unless significant problems exist (e.g, incorrect antenna height and/or reference coordinates)

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## Composition of Block Networks

BLOCK	Num. of Camps.	Num. of Points	BLOCK	Num. of Camps.	Num. of Points
1997-L	241	3	2004-2T	5	1,057
1998-L	435	5	2004-L	3	824
1999-L	292	5	2004 UR-L	1	43
2000-L	430	6	2005-T	2	820
2001-L	1,117	7	2005-L	3	1,062
2002-1T	569	4	2005 JJ-L	1	194
2002-2T	792	5	06-1BBlock	2	400
2003-1T	702	5	07-1BBlock	6	1,074
2003-2T	1,192	5	07-2BBlock	4	469
2004-1T	1,004	5	07-SA	1	180

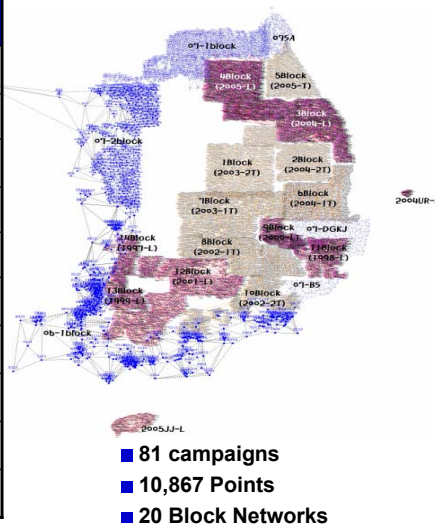
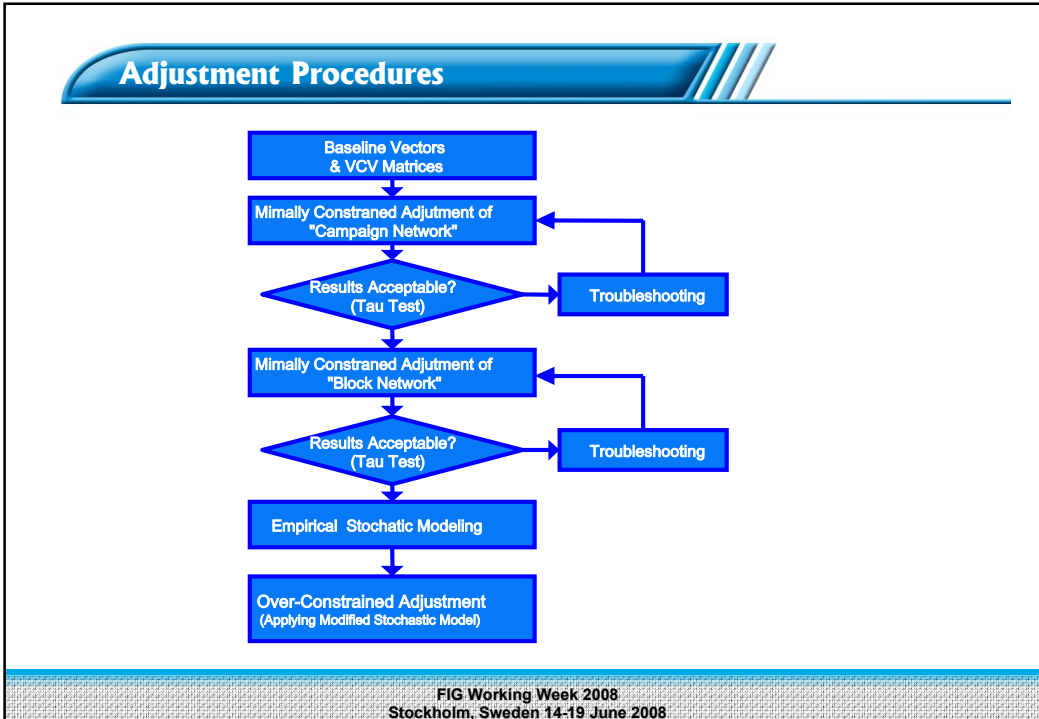
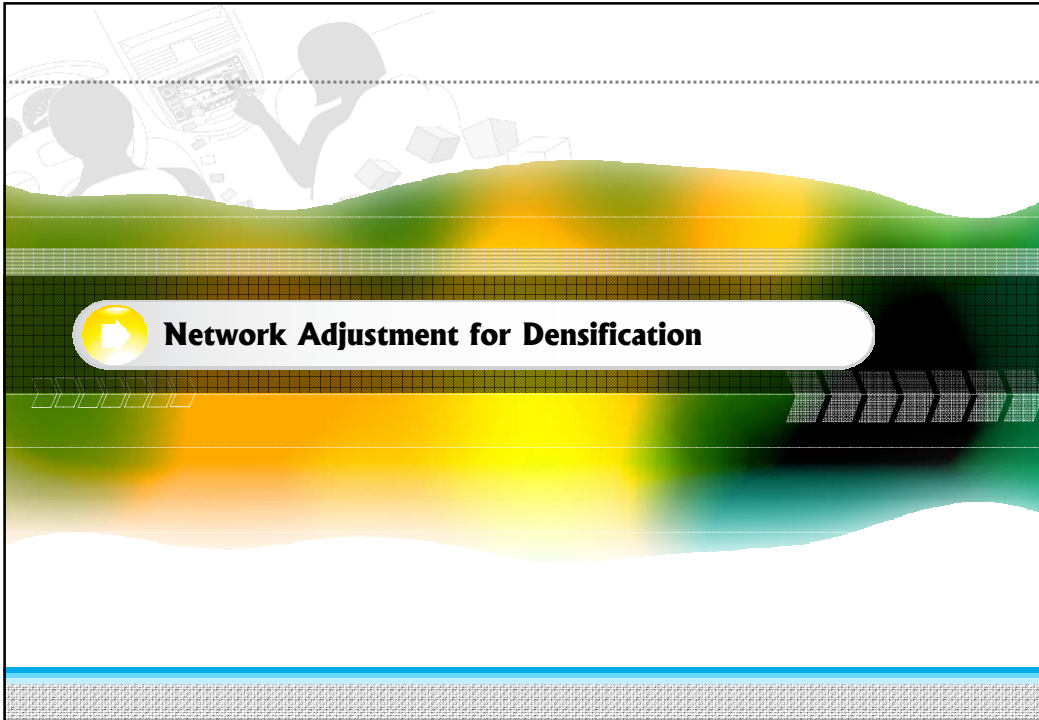


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## Minimally Constrained Adjustment

### ✦ The number of the outliers identified from the MC adjustments

Block Name	Num. of Points	Num. of outlier identified			Block Name	Num. of Points	Num. of outlier identified		
		Campaign	Block	Total			Campaign	Block	Total
1997-L	241	5	1	6	2004-2T	1057	0	0	0
1998-L	435	4	2	6	2004-L	824	4	6	10
1999-L	292	1	1	3	2004U-L	43	0	0	0
2000-L	430	12	0	12	2005-T	820	0	1	1
2001-L	1117	5	10	15	2005-L	1062	5	6	11
2002-1T	569	0	0	0	2005J-L	194	0	0	0
2002-2T	792	3	0	3	06-1B	400	6	3	9
2003-1T	702	1	2	3	07-1B	1,074	13	2	15
2003-2T	1192	1	0	1	07-2B	469	4	2	6
2004-1T	1004	3	5	8	07-SA	180	4	0	0

✘ In both of campaign & block network adjustment, a second order point was held fixed.

✘ A total of **108 baselines** were identified as outliers

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## Minimally Constrained Adjustment

### ■ Stochastic Modeling (2-5 km)

- Empirical stochastic modeling scheme was applied (Rizos, 1996)
- Several iterative processing was carried out until the variance factor test ( $\chi^2$ ) was passed.
- Derived magnitude of absolute and relative error

Absolute error (a)		Relative error (b)	
Horizontal	Vertical	Horizontal	Vertical
5 mm	10 mm	0.5 ppm	1.0 ppm

After modifying the original VCV matrices, all of the block networks were readjusted by fixing a single second order control point

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## Minimally Constrained Adjustment

- Summary of coordinate differences of the overlapped points between two adjacent block networks (total 601 points)

Component	Average	RMS
Horizontal(2D)	0.031m	0.034m
Vertical(1D)	0.046m	0.052m

- Summary of differences between the adjusted and predetermined 2<sup>nd</sup> order control points within the block networks (total 67 points)

Component	Average	RMS
Horizontal(2D)	0.036m	0.044m
Vertical(1D)	0.038m	0.048m

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## Minimally Constrained Adjustment

- Statistical summary of relative confidence regions with 95% probability (unit: m)

Block	Component	Mean	Std.	Block	Component	Mean	Std.
1997-L	Horizontal	0.006	0.001	2004U-L	Horizontal	0.006	0.001
	Vertical	0.014	0.003		Vertical	0.014	0.002
1998-L	Horizontal	0.006	0.001	2005-T	Horizontal	0.006	0.001
	Vertical	0.013	0.002		Vertical	0.014	0.002
1999-L	Horizontal	0.006	0.001	2005-L	Horizontal	0.006	0.001
	Vertical	0.013	0.002		Vertical	0.013	0.002
2000-L	Horizontal	0.006	0.002	2005-L	Horizontal	0.006	0.001
	Vertical	0.014	0.004		Vertical	0.013	0.002
2001-L	Horizontal	0.006	0.002	2005-L	Horizontal	0.006	0.001
	Vertical	0.014	0.003		Vertical	0.013	0.002
2002-1T	Horizontal	0.006	0.001	2005J-L	Horizontal	0.006	0.001
	Vertical	0.014	0.002		Vertical	0.015	0.002
2002-2T	Horizontal	0.006	0.001	06-1block	Horizontal	0.009	0.002
	Vertical	0.014	0.003		Vertical	0.021	0.013
2003-1T	Horizontal	0.006	0.001	07-1block	Horizontal	0.006	0.003
	Vertical	0.013	0.002		Vertical	0.014	0.006
2004-2T	Horizontal	0.006	0.001	07-2block	Horizontal	0.004	0.001
	Vertical	0.013	0.002		Vertical	0.009	0.002
2004-L	Horizontal	0.006	0.001	07-SA	Horizontal	0.009	0.002
	Vertical	0.014	0.002		Vertical	0.019	0.010

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## Over Constrained Adjustment

- The final stage of the 3<sup>rd</sup> order network adjustment
- Over constrained adjustments were successively performed with respect to the 20 block networks.
- To be held fixed by;
  - all available 2<sup>nd</sup> order control points within the block network
  - the 3<sup>rd</sup> order control points, overlapped with adjacent networks whose coordinates had been estimated from a proceeding block network adjustment.
- This approach avoids the repetitious estimation of the overlapped points between two adjacent block networks

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## Over Constrained Adjustment

### ■ Summary of Over Constrained Adjustments

Adjustment Sequence	Block Network	Num. of Points	Num. of Baselines	Adjustment Sequence	Block Network	Num. of Points	Num. of Baselines
1	2003-2T	1,292	3,540	11	1998-L	435	1,233
2	2004-2T	1,057	3,057	12	2001-L	1,116	3,189
3	2004-L	824	2,238	13	1999-L	291	795
4	2005-L	1,062	3,082	14	1997-L	240	621
5	2005-T	820	2,175	15	2004U-L	32	87
6	2004-1T	1,004	2,697	16	2005J-L	188	540
7	2003-1T	902	2,469	17	2007-1	1,074	3,806
8	2002-1T	567	1,617	18	2007-2	469	1,475
9	2000-L	430	1,209	19	2006-1	400	1,284
10	2002-2T	794	2,223	20	2007-SA	180	447

A total of **37,684** baselines were adjusted to determine the KGD2002 coordinate sets at **10,867** control points

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## Over Constrained Adjustment

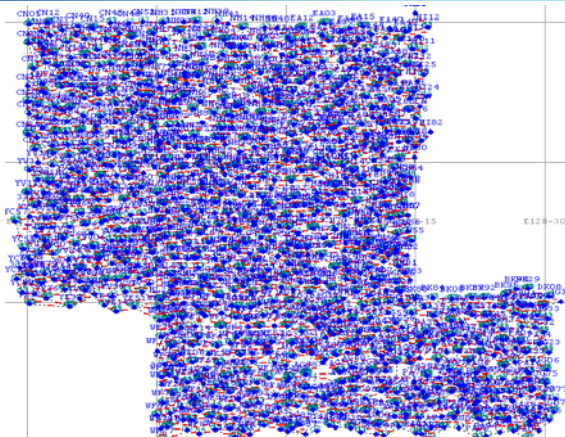
Statistical summary of absolute confidence regions with 95% probability (unit: m)

Block	Component	Mean	Std.	Block	Component	Mean	Std.
1997-L	Horizontal	0.006	0.001	2004-2T	Horizontal	0.007	0.001
	Vertical	0.023	0.003		Vertical	0.015	0.003
1998-L	Horizontal	0.007	0.002	2004-L	Horizontal	0.007	0.001
	Vertical	0.016	0.004		Vertical	0.015	0.003
1999-L	Horizontal	0.007	0.002	2004U-L	Horizontal	0.006	0.001
	Vertical	0.015	0.004		Vertical	0.015	0.003
2000-L	Horizontal	0.008	0.003	2005-T	Horizontal	0.006	0.001
	Vertical	0.017	0.007		Vertical	0.014	0.002
2001-L	Horizontal	0.007	0.002	2005-L	Horizontal	0.006	0.001
	Vertical	0.017	0.005		Vertical	0.015	0.003
2002-1T	Horizontal	0.006	0.001	2005J-L	Horizontal	0.007	0.004
	Vertical	0.015	0.003		Vertical	0.016	0.009
2002-2T	Horizontal	0.007	0.002	06-1block	Horizontal	0.009	0.002
	Vertical	0.016	0.004		Vertical	0.021	0.005
2003-1T	Horizontal	0.006	0.001	07-1block	Horizontal	0.006	0.002
	Vertical	0.014	0.003		Vertical	0.014	0.005
2003-2T	Horizontal	0.006	0.001	07-2block	Horizontal	0.004	0.001
	Vertical	0.014	0.003		Vertical	0.009	0.002
2004-1T	Horizontal	0.006	0.001	07-SA	Horizontal	0.008	0.002
	Vertical	0.014	0.003		Vertical	0.019	0.005

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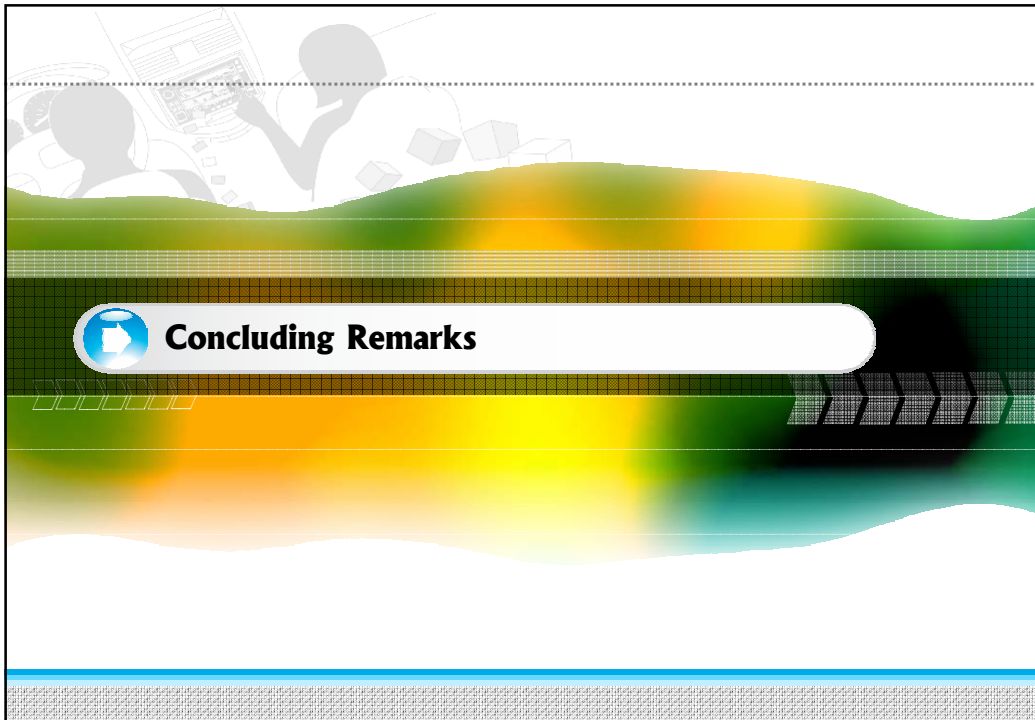
## Over Constrained Adjustment

An example of adjusted network with absolute confidence region (95%)



2005-L

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## Summaries

- This presentation has described issues related with nationwide GPS network adjustment for the densification of KGD2002.
- Details of the 3<sup>rd</sup> order GPS network adjustment has been discussed with an emphasis of the network adjustment procedure.
- Results of the 3<sup>rd</sup> order network adjustment showed that overall accuracy of the derived coordinate was evaluated to be about 1cm and 2cm in horizontal and vertical component.
- GPS campaigns are ongoing to cover whole country, simultaneous adjustment is planned to derive final version of KGD2002 coordinate sets.

## Conclusion

### ■ Further Works

1. New GPS Observations in year 2008
2. One-step Adjustment by Integrated network
3. One-step Updating of Coordinates
4. Datum Transition Modelling

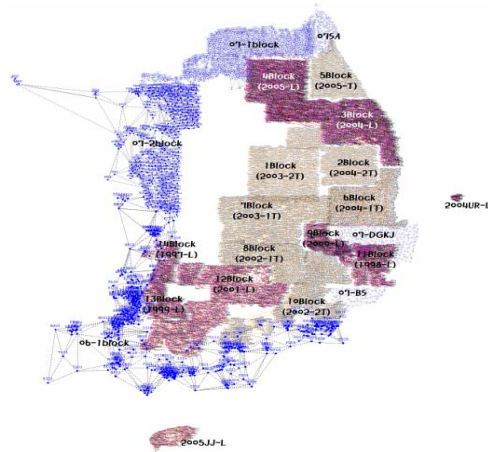


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Thank You ..