GNSS antenna offset field test in Metsähovi

Ulla KALLIO, Hannu KOIVULA, Sonja NYBERG,
Pasi Häkli, Paavo Rouhiainen, Veikko Saaranen,
Finland

Zane Cirule, Didzis Dobelis, Vladimirs Golovka, Latvia

FINNISH GEODETIC INSTITUTE

Questions

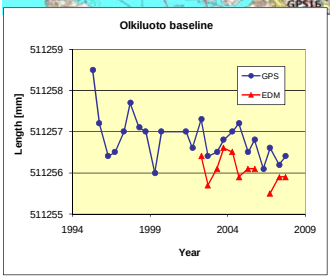
- How well the individual antenna calibration values are valid in the field ?
- What is the consistency between two sets (Ashtech Choke Ring ASH700936C_M and Leica AR25.R4 with radome) of GPS antennas ?

FINNISH GEODETIC INSTITUTE

FIG Rome 9.5.2012 TS07H Kallio Ulla et al 5580

GPS compared with EDM

- **Reference:** The electronic distance measurements with Mekometer ME 5000
  - traceable to the definition of the metre through the Nummela Standard Baseline, which has been measured with the Väisälä light interference method.
  - accuracy ±(0.2 mm +0.2 ppm)
- Baseline measurements in Olkiluoto deformation network in 2003-2012
  - investigation area, which was selected as a candidate for the final disposal sites of spent nuclear fuel



FINNISH GEODETIC INSTITUTE

Antenna calibration and test measurements in Kyviskes calibration baseline

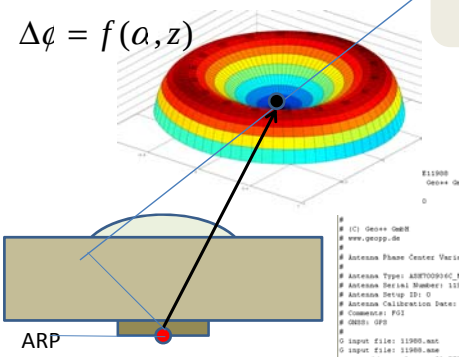
- **Individual absolute calibration** for the antennas in 2009 (Geo ++)
- **Measurements in Lithuania Kyviskes calibration baseline** and testfield in 2008 (Hannu Koivula and Pasi Häkli)
  - lengths 20...1320 m
  - Processing strategies:
    - **individual and type calibrated antenna tables**
    - a local and global ionosphere model
    - three different cut-off elevation angles
    - several linear combinations
    - several ambiguity resolution strategies

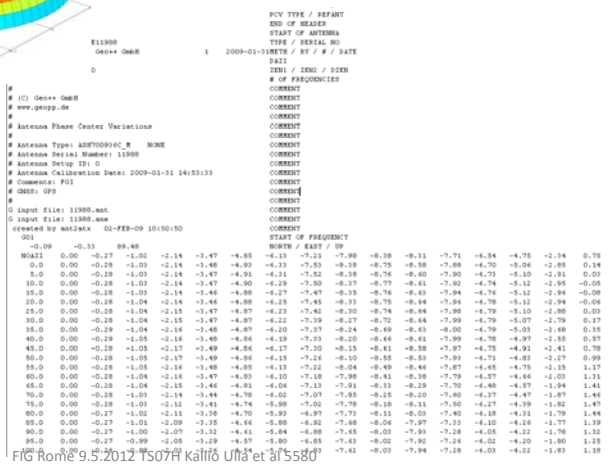
FINNISH GEODETIC INSTITUTE

FINNISH GEODETIC INSTITUTE

Offset and phase center variation

$\Delta\phi = f(\alpha, z)$



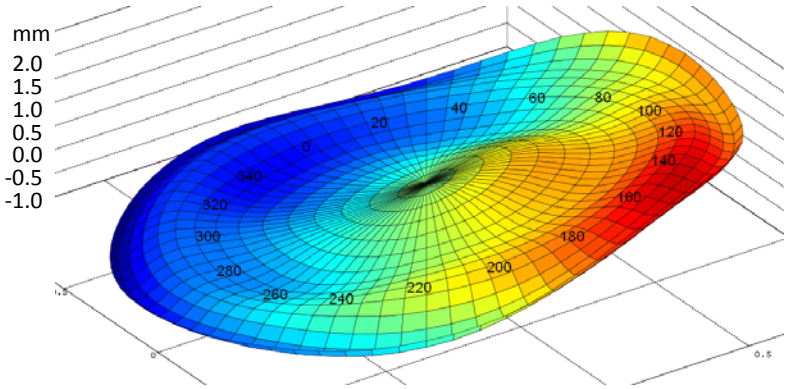


FINNISH GEODETIC INSTITUTE

One antenna, two calibrations

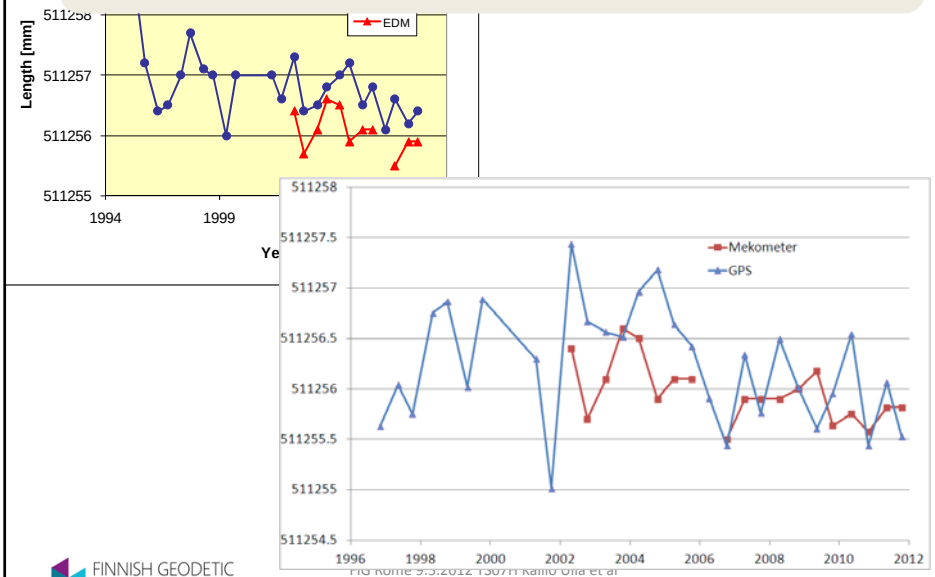
Differences of antenna calibration corrections in L1

We need a simple test to verify the calibration results!



FINNISH GEODETIC INSTITUTE

Olkiluoto baseline, the latest results



FINNISH GEODETIC INSTITUTE

FIG Rome 9.5.2012 TS07H Kallio Ulla et al 5580

Technique spesific offsets in local tie measurements

- Difference in local tie vector between terrestrial and GPS determination

FINNISH GEODETIC INSTITUTE

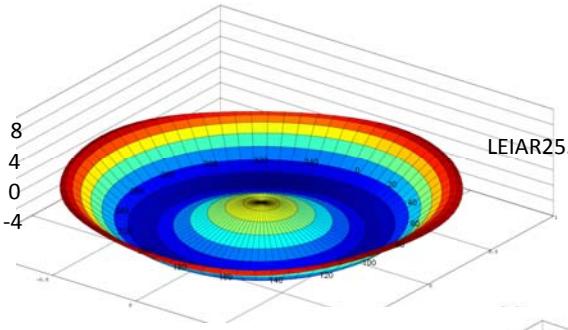
FIG Rome 9.5.2012 TS07H Kallio Ulla et al 5580

Antennas used in our field test

- 8 Leica AR25.R4 antennas with radome
- 9 Ashtech Choke Ring antennas without radome

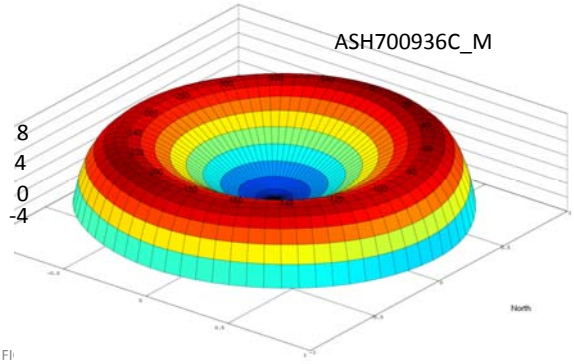
- Geo++ individual calibration tables for all antennas

Cut off angle 15 degrees



LEIAR25.R4 LEIT

ASH700936C_M



Simple test procedures

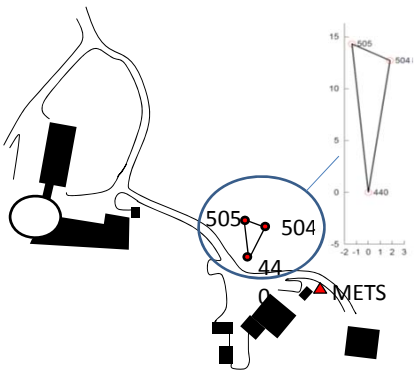
- Rotating the antennas without tilting (absolut N and E)
- Antenna swapping (relative)
- Comparing with ground truth (distances, height differences)

- Permutation method (relative)
  - Antenna circulation (on three or more points)
  - Full roving method (Bányai)

Observation schedule

	440	504	505
1	988	22	40
2	40	988	22
3	22	40	988
4	988	3	5
5	5	988	3
6	3	5	988
7	988	6	7
8	7	988	6
9	6	7	988
10	988	11	12
11	12	988	11
12	11	12	988
13	988	194	754
14	754	988	194
15	194	754	988
16	988	761	770
17	770	988	761
18	761	770	988
19	988	772	959
20	959	988	772
21	772	959	988
22	988	963	995
23	995	988	963
24	963	995	988

48 h sessions
cut of angle: 5 degrees



FINNISH GEODETIC INSTITUTE
FIG Rome 9.5.2012 TS07H Kallio Ulla et al
5580

Field work

Zane Cirule, Didzis Dobelis and Vladimirs Golovka from Riga Technical University visited Finnish Geodetic Institute in summer 2011 in ERASMUS program.

During three months in summer 2011 antennas were changed twice a week

FINNISH GEODETIC INSTITUTE

Bernese processing

- separately L1 and L2 solutions
- Geo++ individual absolute calibration tables using the offsets in tables (and with zero phase center offsets using only phase center variations)
- IGS rapid orbits and earth orientation parameters
  - available soon after the measurements
- Ambiguites were solved using the sigma strategy
- The troposphere was modelled using Saastamoinen apriori model mapped with Dry Niell mapping function. Zenith path delay paremeteres were estimated using Wet Niell mapping function at 2-hour intervals.
- The observation cut-off angle was set to 10 degrees.

FINNISH GEODETIC INSTITUTE

Mathematical model in least squares adjustment

Functional model

$$X_{pB} - X_{pA} + O_{a2} - O_{a1} = \Delta X_{AB}$$
$$X_{pC} - X_{pA} + O_{a3} - O_{a1} = \Delta X_{AC}$$

1. session

$$X_{pB} - X_{pA} + O_{a1} - O_{a3} = \Delta X_{AB}$$
$$X_{pC} - X_{pA} + O_{a2} - O_{a3} = \Delta X_{AC}$$

2. session

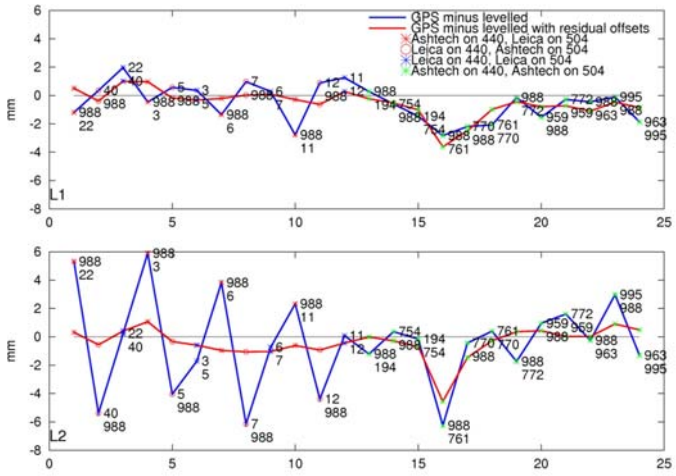
$$X_{pB} - X_{pA} + O_{a3} - O_{a2} = \Delta X_{AB}$$
$$X_{pC} - X_{pA} + O_{a1} - O_{a2} = \Delta X_{AC}$$

3. session

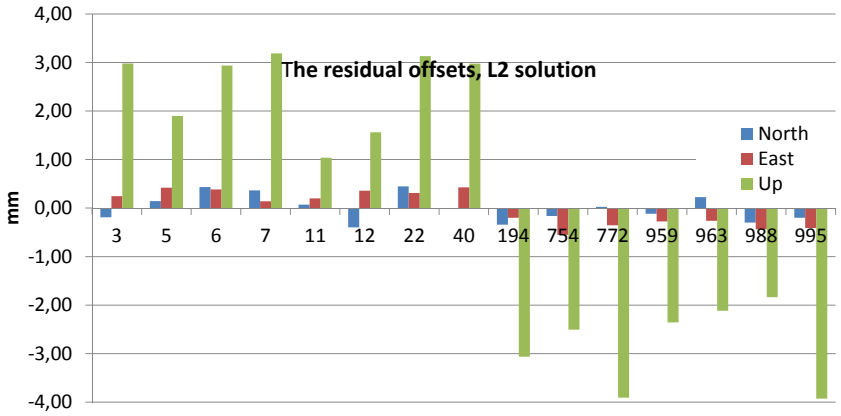
Stochastic model

Full covariance matrix from SINEX files

Height difference compared with levelled height difference

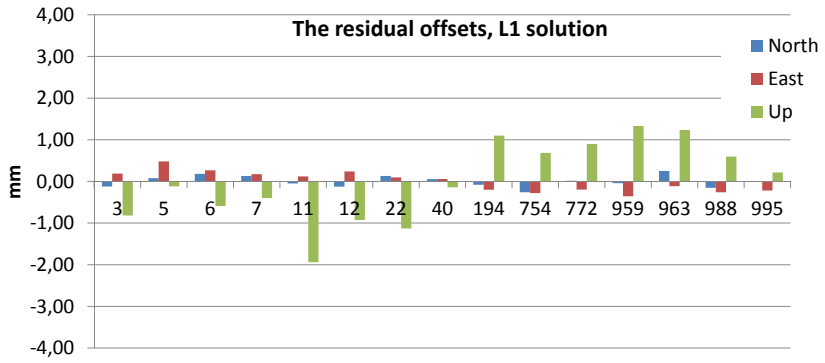


Results L2



FINNISH GEODETIC INSTITUTE

Results L1



FINNISH GEODETIC INSTITUTE

FIG Rome 9.5.2012 TS07H Kallio Ulla et al 5580

Conclusion

- Did we get answers to our questions?
  - We may ecpect a small jump to time series of coordinates when we replace the antenna and antenna type
  - The offset values of the individual absolute calibration were not consistent between the two antenna types tested in Metsähovi. There seems to be biases which propagate to the coordinate results.
- New questions
  - What is the role of the near field effect ?
  - Can we isolate the near field effect from our results?
- What to do next ?
  - We will reprocess the data with several different strategies
  - We will process the extra measurements we made in autumn 2011
  - We will continue our tests using different mountings in different location and environment.

Thank you for your attention!

FINNISH GEODETIC INSTITUTE
FIG Rome 9.5.2012 TS07H Kallio Ulla et al 5580