Computations of re-measurement campaign of Estonian I-order National Geodetic Network

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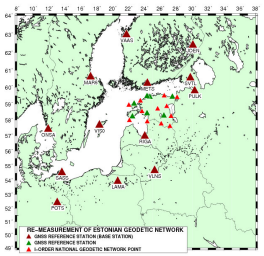

Fig.1. Schema for National Geodetic Network with fiducial points (Scenario A)

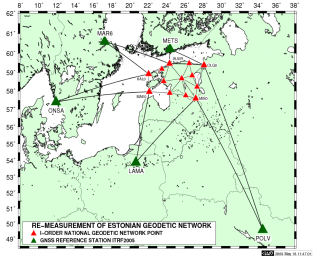

Fig.2. Vector schema for National Geodetic Network with fiducial points (Scenario B)

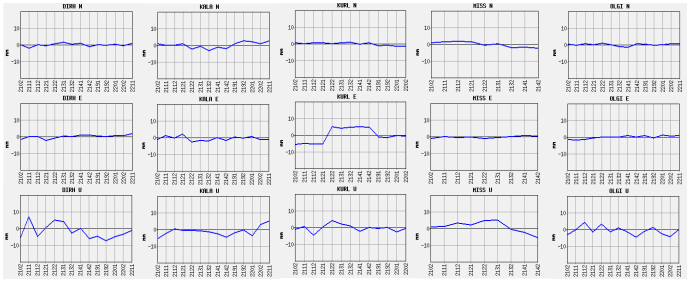

Fig. 3.Coordinate component change in Dirhami, Kalana, Kurla, Misso and Olgino stations (Scenario A)

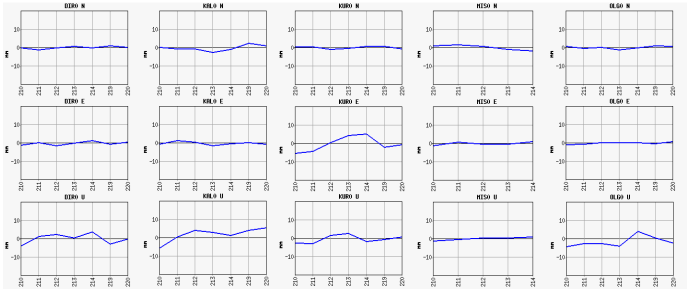

Fig. 4. Coordinate component change in Dirhami, Kalana, Kurla, Misso and Olgino stations (Scenario B)

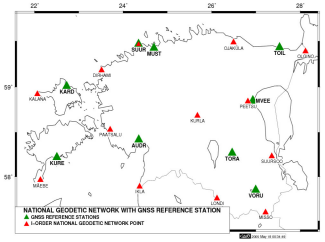

Fig.5. I order Estonian National Geodetic Network

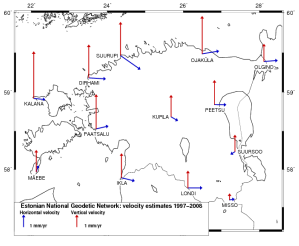

Fig. 6. Velocity vectors for National Geodetic Network I-order points from 1997 to 2008

Introduction

- In 2008, the Estonian Land Board carried out high-precision GPS measurements on the points of the I order National Geodetic Network
- Different structural units of the Land Board participated in the measurements
- GPS measurements were coordinated by Prof. Artu Ellmann from the Tallinn University of Technology

Management

- The final length of GPS field mission was from July 28 to August 08, 2008
- Altogether 7 days (GPS weeks 1490 and 1491)
- Measurement hours from 110 hours/point to 158 hours/point, exceptional was another unit in Suurupi, altogether 48 hours
- Altogether 12 units of Ashtech GPS receivers with GPS Choke Ring Antennas were used (8+1 sets were loaned from Finnish Geodetic Institute)
- Measurements were carried out simultaneously on all 12 points of I-order National Geodetic Netwiork

Computations

- In the data processing of RGP 2008 campaign, the principles of the RGP observation campaign of 1997 as well as the guidelines of EPN and NKG were followed
- In the computations Bernese GPS 5.0 software was used
- Computations were made by two different scenarious (simutaniously by two persons)
- Free network solution and constrained network solutions were performed
- Main points of computation strategy:
  - calculations were performed in IGS05 datum;
  - Precise IGS orbit products were used;
  - the coordinates of fiducial reference stations were taken from EPN weekly solutions (GPS weeks 1490 and 1491);
  - absolute calibration values of antennas were used;
  - L3 calculation algorithm and intersection angle of 10 degrees were used;
  - meteorological observations were not performed at stations, the used troposphere mapping functions were dry Saastamoinen and wet Niell accordingly;
  - for vector computations the vector schema from 1997 was used wherever possible;
  - In the adjustment *Minimal constraints solution with no translation* was used;
  - Ocean model FES2004;
  - Absolute calibration model for antennas (PHAS_COD.I05), satellite model (SATELLIT.I05)
- Differences in computation scenarious are listed in the following table:

Transformation to ETRS89

- The final coordinates were transformed into ETRS89 considering the principles
  and transformation parameters of Boucher and Altamini Memo (24.10.2008)
- Final coordinates are in ETRS89 at epoch 2008.59

Conclusions

- A posteriori RMS of unit weight (Scenario A): 1,11 mm
- A posteriori RMS of unit weight (Scenario B): 0,78 mm
- RMS of transformation (Scenario A): 4,5 mm
- RMS of transformation (Scenario B): 4,3 mm

Table 1. Repeatability for Scenario A

Station	#Days	Weekday 123456	Repeatability (mm) N	E	U
AUDR AUDR	14	XXXXXXX XXXXXXX	1.27	0.44	3.27
DIRH 6267	14	XXXXXXX XXXXXXX	0.87	1.00	4.36
IKLA 5312	9	XXXXXXX XX	1.49	0.98	3.82
JOEN 10512M001	11	XXX X XXXXXXX	0.70	0.74	4.32
KALA 6138	14	XXXXXXX XXXXXXX	1.71	1.20	2.78
KURE 10604S001	14	XXXXXXX XXXXXXX	0.59	0.71	3.58
KURL 6309	13	XXXXXXX XXXXXX	0.95	4.36	2.27
LAMA 12209M001	14	XXXXXXX XXXXXXX	1.02	0.76	3.29
LOND 5402	9	XXXXXXX XX	0.90	1.07	2.81
MAEB 5128	9	XXXXXXX XX	1.83	1.76	5.76
MAR6 10405M002	13	XXXX XX XXXXXXX	1.03	0.64	2.63
METS 10503S011	14	XXXXXXX XXXXXXX	1.00	0.66	2.25
MISS 4489	9	XXXXXXX XX	1.70	0.50	3.17
MUST MUST	12	XXXX XX XXXXXX	2.70	1.54	1.99
OJAK 6494	13	XX XXXX XXXXXXX	1.84	0.92	4.18
OLGI 6593	14	XXXXXXX XXXXXXX	0.67	0.76	2.51
ONSA 10402M004	11	XX XXXX XXXX	0.86	0.88	2.55
PAAT 5288	13	XXXXXXX XXXXX	1.19	1.01	3.63
PEET 6426	8	XXXXXXX X	0.97	0.81	2.06
POTS 14108M003	12	XXXXX XXXXX	0.96	0.82	4.96
PULK 12305M001	13	XXXXXX XXXXXX	1.20	1.54	4.28
RIGA 12302M002	13	XXXXXXX X XXXXX	0.79	0.78	3.52
SASS 14281M001	14	XXXXXXX XXXXXX	0.91	1.37	4.22
SURS 5459	9	XXXXXXX XX	2.02	1.73	3.79
SUUR 10601M001	9	XXXX XXXXX	0.62	0.82	3.94
SVTL 12350M001	14	XXXXXXX XXXXXX	1.19	0.70	2.99
TOIL 10605S001	14	XXXXXXX XXXXXX	0.82	0.45	2.78
TORA 10602S001	14	XXXXXXX XXXXXX	0.65	0.43	2.09
VAAS 10511M001	9	XXX XXXX X	1.16	0.74	5.02
VIS0 10423M001	14	XXXXXXX XXXXXX	0.77	0.78	2.19
VLNS 10801M001	14	XXXXXXX XXXXXX	1.49	0.80	2.85
		Total	1.19	1.15	3.45

Table 2. Repeatability for Scenario B

Station	#Days	0 1 2 3 4 5 6	Weekday Repeatability (mm) N	E	U
DIR0 6267	7	A A A A A A A	0.7	1.0	2.8
IKL0 5312	5	A A A A A	1.2	0.8	3.5
KAL0 6138	7	A A A A A A A	1.6	0.9	3.7
KUR0 6309	7	A A A A A A A	0.7	4.0	2.2
LAMA 12209M001	5	WWWWW	0.7	0.5	2.2
LON0 5402	5	A A A A A	0.8	1.3	2.5
MAE0 5128	5	A A A A A	1.8	2.3	4.1
MAR6 10405M002	7	WWWWWWW	1.2	0.5	2.7
METS 10503S011	7	WWWWWWW	1.0	0.4	2.5
MIS0 4489	5	A A A A A	1.5	0.9	1.0
OJA0 6494	7	A A A A A A A	2.1	0.9	3.2
OLG0 6593	7	A A A A A A A	0.8	0.5	3.0
ONSA 10402M004	7	WWWWWWW	0.9	0.8	2.4
PAA0 5288	7	A A A A A A A	0.9	0.8	2.4
PEE0 6426	5	A A A A A	1.0	1.0	4.0
POLV 12308M001	7	WWWWWWW	0.6	0.7	2.8
SUR0 8392	2	A A	0.4	0.4	1.9
SUU0 5459	5	A A A A A	1.8	1.4	1.3
SUUR 10601M001	5	A A A A A	1.0	0.9	2.6
		# Coordinate estimates: 112	1.1	1.3	2.6

Table 3. Coordinate residuals from Helmert transformation (Scenario A)

NUM	NAME	FLG	RESIDUALS IN MILLIMETERS		
14	KALA 6138	A A	4.0	0.1	-6.9
10	PAAT 5288	A A	-0.9	-1.2	-5.3
8	MISS 4489	A A	-4.0	5.0	-1.9
9	MAEB 5128	A A	-2.9	6.8	10.8
20	OLGI 6593	A A	-1.5	-1.2	5.7
15	DIRH 6267	A A	2.4	-4.9	4.1
11	IKLA 5312	A A	2.4	-3.2	-2.6
16	KURL 6309	A A	3.9	4.4	0.2
12	LOND 5402	A A	0.4	-2.4	-2.0
18	PEET 6426	A A	-1.2	0.3	3.1
19	OJAK 6494	A A	-2.5	-4.1	-5.2
	RMS / COMPONENT		2.8	3.9	5.4

Table 4. Coordinate residuals from Helmert transformation (Scenario B)

NUM	NAME	FLG	RESIDUALS IN MILLIMETERS		
14	KAL0 6138	A A	3.9	-0.4	-5.2
10	PAA0 5288	A A	-1.2	-1.2	-3.5
8	MIS0 4489	A A	-2.9	5.3	1.0
9	MAE0 5128	A A	-3.4	7.3	7.8
20	OLG0 6593	A A	-1.9	-0.6	6.2
15	DIR0 6267	A A	2.6	-5.0	4.5
11	IKL0 5312	A A	3.5	-2.9	-2.9
16	KUR0 6309	A A	3.4	4.6	2.9
12	LON0 5402	A A	-0.9	-3.7	-3.5
18	PEE0 6426	A A	-0.5	0.3	-1.5
19	OJA0 6494	A A	-2.5	-3.9	-5.9
	RMS / COMPONENT		2.8	4.1	4.8

Table 5. Coordinate comparison between Scenario A and B

NAME	RESIDUALS IN MILLIMETERS		
MIS0 4489	-1.4	-0.5	-2.9
MAE0 5128	0.8	-0.9	2.8
PAA0 5288	0.6	-0.1	-1.8
IKL0 5312	-1.0	-0.7	0.2
LON0 5402	1.2	1.1	1.4
SUU0 5459	-1.9	1.4	-1.5
KAL0 6138	0.7	0.2	-1.2
DIR0 6267	0.3	0.1	-0.1
KUR0 6309	0.6	-0.2	-2.6
SUUR 10601M001	0.1	-0.1	0.1
PEE0 6426	-0.5	0.0	4.8
OJA0 6494	0.0	0.0	0.9
OLG0 6593	0.4	-0.4	-0.2
RMS / COMPONENT	0.9	0.7	2.2

Table 6. Final coordinates of 2008 re-measurement campaign in ETRS89 at epoch 2008.59

STATION NAME	X (M)	Y (M)	Z (M)
MIS0 4489	3046876.0919	1567046.4974	5361954.0500
MAE0 5128	3141475.4038	1277731.0513	5383712.6421
PAA0 5288	3056335.4068	1342150.5236	5416702.6193
IKL0 5312	3095518.1759	1402529.1656	5379277.1008
LON0 5402	3062740.5041	1501881.3038	5371353.3911
SUU0 5459	2989696.2286	1546969.4131	5399408.0689
KAL0 6138	3058936.6663	1239946.5185	5439393.1457
DIR0 6267	3003712.9105	1306951.5983	5454358.9701
KUR0 6309	2995072.9666	1440090.6506	5425766.0376
SUUR 10601M001	2959056.3155	1341058.5791	5470427.3199
PEE0 6426	2952421.3591	1492709.5490	5434846.0366
OJA0 6494	2905638.7739	1448392.2753	5471665.8496
OLG0 6593	2871565.8490	1534668.7852	5466143.0753