Zero-order network of Armenia connected to ITRF 2000 and ETRS 89

presented by

Lotti Jivall / Dan Norin

on behalf of

the State Committee of the Real Property Cadastre of the Government of the Republic of Armenia, SCC
Background

• Swedesurvey engaged in the project “The development of the cadastral system in Armenia”

• A first GPS campaign on the zero order network carried out in the autumn 2000 (not successful)

• A second GPS-campaign on the zero order network carried out in the autumn 2002
The campaign

4 new Armenian stations
8 EPN/IGS stations
5 x 24 hours sessions starting November 26th 2002 02:00

SCC observed all Armenian stations (including the IGS/EPN station NSSP)
Stations and Equipment

All Armenian stations observed by SCC with: Leica SR 520 and LEIAT502
Data used

- Co-ordinates: IERS ITRF 2000 epoch 2002.9
- Final IGS-orbits and corresponding EOPs
- Relative antenna models from PHAS_IGS.01 except for LEIAT502 which was taken from NGS
- Ocean tide loading from Onsala (H-G S)
- RINEX data from EPN/IGS and SCC
Processing strategy - session

- Bernese Software ver 4.2
- 10 ° cut-off, elevation dep weighting, dry Niell
- baselines formed as a star from NSSP
- pre-processing, trippel-differences
- first float-solution
- screening of residuals
- second float solution
- regional ionosphere model using L4
- ambiguity resolution using QIF
- final network solution, EPN station ZECK constrained
- alternative final solution 15 ° cut-off
- test solution with 25 ° cut-off
Processing Strategy - combination

• Session solutions combined with ADDNEQ
• minimum constrained solution with just ZECK constrained
• Helmert-fit to IERS ITRF 2000 epoch 2002.9
• Constrained solution with all EPN/IGS constrained that fit well in the previous step constrained
# Quality of daily solutions

<table>
<thead>
<tr>
<th>Session</th>
<th>Res amb</th>
<th>RMS flt</th>
<th>RMS fix</th>
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Float - Fixed solution

Unit = mm
Daily repeatability

Baseline repeatability length (mm)

Residual length (mm)

Baseline length (km)

Unit = mm
Comparison with ITRF

Minimum constrained solution compared to IERS ITRF 2000 epoch 20

3-parameter, $\text{rms} = 16.3 \text{ mm}$

<table>
<thead>
<tr>
<th>Station</th>
<th>N(mm)</th>
<th>E(mm)</th>
<th>U(mm)</th>
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</table>

6-parameter, $\text{rms} = 17.5 \text{ mm}$

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<td>RMS / COMPONENT</td>
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<td>26.8</td>
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Minimum constrained solution compared to EPN-solution of GPS week 119

3-parameter, $\text{rms} = 2.7 \text{ mm}$

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<td>RMS / COMPONENT</td>
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Comparison with ITRF

Outliers TRAB and ANKR excluded

3-parameter, rms = 5.8 mm

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6-parameter, rms = 5.9 mm

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No significant rotations
Minimum constrained - constrained

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<tr>
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<tr>
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Unit = mm

Outliers TRAB and ANKR excluded/not constrained
Comparison to 15° solution

Comparison of constrained solutions, old standard solution 15° minus new 10°

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<th>dN (mm)</th>
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<th>dU (mm)</th>
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Any elevation dependency?

25° solution minus 15° solution, daily differences

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<td>6</td>
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</table>
Conversion to ETRS 89

According to guidelines in “Specification of reference frame fixing in the analysis of a EUREF GPS campaign” ver 5.0

\[
X_E(2002.9) = X_0(2002.9) + \begin{bmatrix}
T_{100} \\
T_{200} \\
T_{300}
\end{bmatrix} + \begin{bmatrix}
0 & -R_{300} & R_{200} \\
R_{300} & 0 & -R_{100} \\
-R_{200} & R_{100} & 0
\end{bmatrix} \cdot X_0(2002.9) \cdot (2002.9 - 1989.0)
\]

\[X_E(2002.9) = \text{Coordinates in ETRS 89 at epoch 2002.9}\]
\[X_0(2002.9) = \text{Coordinates in ITRF 2000 at epoch 2002.9}\]
\[T_{100} = 5.4 \text{ cm}\]
\[T_{200} = 5.1 \text{ cm}\]
\[T_{300} = -4.8 \text{ cm}\]
\[R_{100} = 0.000081" /Y\]
\[R_{200} = 0.000490" /Y\]
\[R_{300} = -0.000792" /Y\]
Final co-ordinates

- The final co-ordinates in ETRS 89 epoch 2002.9 are based on ITRF 2000
- ARMREF 02 is the proposed name for the Armenian ETRS 89 realization
- Estimated accuracy: 1 cm (95%) for the horizontal co-ordinates and 2-3 cm (95%) for the vertical at the epoch of the observation.
- ARMREF 02 has been densified in a first order network (2002) and a second order densification is on-going
- SCC asks EUREF to adopt this solution as an ETRS 89 realization and to accept the selected points AMAS, KAPA and NSSP as national EUREF-points
Comparison to campaign 2000

Comparison made in ITRF 2000 epoch 2002.9

<table>
<thead>
<tr>
<th>Station</th>
<th>Strategy 1 for alignment to ITRF2000 epoch 2002.9</th>
<th>Strategy 2 for alignment to ITRF2000 epoch 2002.9</th>
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