DATUM TRANSFORMATION BETWEEN NATIONAL GEODETIC DATUM AND ITRF

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INTRODUCTION

- COORDINATE TRANSFORMATION
  - Need of establishing dependence between two coordinate systems

- DATUM TRANSFORMATION
  - Need is result of disagreements in geodetic networks of different countries
  - Source of disagreements
    - Different ellipsoids
    - Different orientation (fundamental points)
    - Different coordinate systems
INTRODUCTION

DATUM TRANSFORMATION

- First steps tendency for integration of geodetic networks
  - NAD27 - North American Datum 1927 (Official geodetic datum used for geodetic and cartographic application on USA territory. Based on Clarke ellipsoid from 1866)
  - ED50 - Geodetic datum from period after Second World War and whom base aim was international connection of geodetic networks from European countries in one common system. Based on Hayford ellipsoid from 1924

- Second step
  - Development of measuring technique for more precisely defining Global Earth ellipsoid
    - GRS 80 - Global Reference System 1980
    - WGS 84 - World Geodetic System 1984
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NATIONAL GEODETIC DATUM

NAME: HERMANNSKOGEI

- CARACTERISTICS

  - ELLIPSOID: BESSEL 1841
    \[ a=6377397.155 \text{ m} \quad f^{-1}=299.152818859504 \]

  - TRANSFORMATION PARAMETERS TO WGS 84
    \[ \Delta \varphi=+1.5" \quad \Delta \lambda=-19.4" \]

  - Gauss-Kruger state cartographic projection
    - Transverse, cylindrical, conformal projection
    - 3° meridian zones
    - Central meridian \( \lambda = 21° \)

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NATIONAL GEODETIC DATUM

- State coordinate system
  - Definition of axis
    - Y-axis: projection of equator line
    - X-axis: projection of central meridian
  - Characteristics
    - \( m_0 = 0.9999 \)
    - False east: 500000m (Baumgarten's way)
    - False north: 0 m
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MATHEMATIC MODELS FOR DATUM TRANSFORMATIONS

- Helmert seven parameter transformation
- Standard Molodensky formula
- Formula for Multiple regression

\[
(y, x, H)_{LD} \Rightarrow (\phi, \lambda, h)_{LD} \Rightarrow (X, Y, Z)_{LD}
\]

\[
(y, x, H)_{ITRS} \Leftarrow (\phi, \lambda, h)_{ITRS} \Leftarrow (X, Y, Z)_{ITRS}
\]

\[
\begin{align*}
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix}
&= \begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix}_{GD}
+ 
\begin{bmatrix}
-\varepsilon_z & -\varepsilon_y & m \\
-\varepsilon_z & -\varepsilon_y & m \\
\varepsilon_y & -\varepsilon_x & m
\end{bmatrix}
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix}_{LD}
+ 
\begin{bmatrix}
\Delta X \\
\Delta Y \\
\Delta Z
\end{bmatrix}
\end{align*}
\]

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PROBLEM OF VERTICAL DATUM

- \( h = H + N \) or \( h = H^N + \xi \)

- In determination process of ellipsoidal height another problem is undefined Geoid

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BASIC GPS MEASUREMENTS MADE ON TERRYTORY OF REPUBLIC OF MACEDONIA

- First GPS measurements - EUREF MACEDONIA campaign
  - Put in to effect from 12th – 17th August 1996
  - Organization by RGD from Macedonia with collaboration with DGC from Republic of Slovenia and ADGC from Frankfurt

- GPS observations
  - 7 point for connection with ITRF 94
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BASIC GPS MEASUREMENTS MADE ON TERRITORY OF REPUBLIC OF MACEDONIA

- GPS observation
  - 5 sessions by 24 hours with 15 seconds registration
  - ITRF 94 epoch 1996.6 was established with 4 IGS stations: Wettzell, Matera, Graz and Zimmerwald
  - Controlling was established with free ITRF stations: Penc, Dionysos, Ilin Vrh and Ankara

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EUREF - MACEDONIA - 1996

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BASIC GPS MEASUREMENTS MADE ON TERRITORY OF REPUBLIC OF MACEDONIA

- GPS calculation
  - Association Department for Geodesy and Cartography from Frankfurt
    - Usage of Bernese software
    - IGS orbits for week 866

- Coordinate transformation from ITRF 94 epoch 1996.6 to ETRF 89 epoch 1989.0

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DETERMINATION OF DATUM TRANSFORMATION PARAMETERS BETWEEN $ITRF$ AND NATIONAL GEODETIC SYSTEM

- 11 displaced or destroyed points
  - Korab, Ramno, Visoka Cuka, Kajmakcalan, Titov Vrv, Krstec, Pelister, Kadiica, Borova Cuka, Keci Kaja and Galicica

- 2 points were without orthometric heights
  - Ruen and Livada

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## DETERMINATION OF DATUM TRANSFORMATION PARAMETERS BETWEEN ITRF AND NATIONAL GEODETIC SYSTEM

<table>
<thead>
<tr>
<th>Point</th>
<th>Geographic coordinates</th>
<th>Orthometric height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\varphi$</td>
<td>$\lambda$</td>
</tr>
<tr>
<td>Bogoslovec</td>
<td>41 45 52.3193</td>
<td>22 01 02.2531</td>
</tr>
<tr>
<td>Kozjak</td>
<td>42 18 34.8185</td>
<td>21 56 01.5411</td>
</tr>
<tr>
<td>Dobra voda</td>
<td>41 39 36.6028</td>
<td>21 03 26.6365</td>
</tr>
<tr>
<td>Slovenska glava</td>
<td>41 42 12.1546</td>
<td>21 24 33.7481</td>
</tr>
<tr>
<td>Golic</td>
<td>41 59 08.7874</td>
<td>21 48 12.9864</td>
</tr>
<tr>
<td>Crn vrv</td>
<td>42 01 56.4274</td>
<td>22 07 13.4738</td>
</tr>
<tr>
<td>Lisec</td>
<td>41 46 48.5456</td>
<td>22 30 44.6706</td>
</tr>
<tr>
<td>Ograzden</td>
<td>41 32 25.0780</td>
<td>22 52 49.1574</td>
</tr>
<tr>
<td>Bel kamen</td>
<td>41 30 32.9158</td>
<td>22 18 56.4142</td>
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<tr>
<td>Busava cesma</td>
<td>41 26 09.7483</td>
<td>21 12 46.5965</td>
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<tr>
<td>Babin srt</td>
<td>41 25 48.0954</td>
<td>20 41 12.5923</td>
</tr>
<tr>
<td>Plakenska planina</td>
<td>41 13 37.0322</td>
<td>21 02 17.1833</td>
</tr>
</tbody>
</table>

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DETERMINATION OF DATUM TRANSFORMATION PARAMETERS BETWEEN ITRF AND NATIONAL GEODE蒂C SYSTEM

\[ X = (N + h) \cos \varphi \cos \lambda \]

\[ Y = (N + h) \cos \varphi \sin \lambda \]

\[ Z = [N(1 - e^2) + h] \sin \varphi \]

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Parameters for Datum Transformation by MoIodensky-Badekas Model Between ITRF 94 and National Geodetic Datum

<table>
<thead>
<tr>
<th>parameter</th>
<th>value</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta X$</td>
<td>-703.6246 m</td>
<td>± 0.2450 m</td>
</tr>
<tr>
<td>$\Delta Y$</td>
<td>203.5943 m</td>
<td>± 0.2450 m</td>
</tr>
<tr>
<td>$\Delta Z$</td>
<td>-488.1939 m</td>
<td>± 0.2450 m</td>
</tr>
<tr>
<td>m</td>
<td>9.4811 ppm</td>
<td>± 3.9245 ppm</td>
</tr>
<tr>
<td>$\varepsilon_X$</td>
<td>3.93025 &quot;</td>
<td>± 1.18917 &quot;</td>
</tr>
<tr>
<td>$\varepsilon_Y$</td>
<td>5.03325 &quot;</td>
<td>± 1.51926 &quot;</td>
</tr>
<tr>
<td>$\varepsilon_Z$</td>
<td>-16.03012 &quot;</td>
<td>± 0.92878 &quot;</td>
</tr>
<tr>
<td>$X_0$</td>
<td>4430840.6627 m</td>
<td></td>
</tr>
<tr>
<td>$Y_0$</td>
<td>1767054.4086 m</td>
<td></td>
</tr>
<tr>
<td>$Z_0$</td>
<td>4221710.4885 m</td>
<td></td>
</tr>
</tbody>
</table>

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PARAMETERS FOR DATUM TRANSFORMATION BY
MOLODENSKY-BADEKAS MODEL BETWEEN ITRF 94 AND
NATIONAL GEODETIC DATUM

Control of quality

Obtained with original coordinates for control points

0.504 m (Lisec)
3.225 m (Crn Vrv)

Recommendation

1. Many local transformation parameters and
2. Astro-geodetic measurements for all territory of Macedonia

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The need for integration of our national geodetic datum in frame of world geodetic systems is because of tendency for adoption of international standards in area of geodesy and cartography.

The parameters for datum transformation between national geodetic datum and ITRF 94 for the first time are determined in frame of EUREF MACEDONIA 96 campaign. In this campaign were taken measurements on 25 points from first order trigonometric network and on 2 points at Macedonian airports.

13 points from those 25 were broken or moved from primary position. Obtained transformation parameters are from only 12 points identified in both systems.

From obtained analyses, calculated transforming parameters by Helmert seven parameters transformation and Molodensky-Badekas model are with ± 0.504 m position accuracy and ±3.225 m accuracy of heights.

Need is to perform astro-geodetic measurements on territory of Republic of Macedonia for getting high accuracy of transformation of heights. With last spoken is possible defining of local Geoid.
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THANK YOU FOR YOUR ATTENTION

BLGODARAM ZA VNIMANIE

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