Romanian Danube Geodetic Infrastructure

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1. Introduction;
2. Geodetic Concepts;
3. Geodetic Infrastructure;
4. Projects and Results;
5. Conclusions.
1. Introduction

- Geodesy as scientific discipline it is involved today in a lot of actual and modern applications as: navigation (terrestrial, water, air/space) >> autonomous navigation, (digital) cartography, geodynamics/earthquakes/tsunami >> disaster/hazards monitoring, climate change (ionosphere/troposphere parameters determination) et al.

- Smart city concept >> geodesy/geomatics (as GIS) concepts are transformed in tools for smart city implementation by using different types of electronic Internet of Things (IoT) sensors to collect data that is processed and analyzed to monitor and manage traffic and transportation systems, power plants, utilities, water supply networks, waste management, crime detection, information systems, schools, libraries, hospitals, and other community services.
2. Geodetic Concepts

- Geodetic real/virtual networks can be considered today as an important infrastructure similar to power/electricity or transportation infrastructure. **WHY?**

- Such networks provide data and information in order to establish 1D/2D/3D/4D positions expressed by coordinates in a well-defined reference system (datum); A reference system it is implemented by a reference frame consisting in a set of points established in the field.

- For example: ETRS (European Terrestrial Reference System) and ETRF (European Terrestrial Reference Frame); Similar EVRS (V – Vertical) and EVRF.
2. Geodetic Concepts

UNIFIED – CRS in EU

>> Including navigation!


- In Romania ETRS89 realization includes ETRF00 epoch 2000.0 coordinates adopted for the Romanian EPN stations and stations from Romanian GNSS Permanent network (ROMPOS)
- For the EVRS realization in Romania there are available levelling landmarks expressed as EVRF2007 or Black Sea 1975 (Constanta) normal heights.

- In Bulgaria ETRS89 realization it is based on BGS2005 including ETRF00 epoch 2005.0.
- For the EVRS realization in Bulgaria there are available levelling landmarks expressed as EVRF2007 and/or Baltic Sea – Kronstadt (1982) normal heights.
2. Geodetic Concepts

\[ n'_P = H^E_P - H^N_P \]

\[ H^N_P (EVRF07) = H^E_P - n'_P (EVRF07) \]
3. Infrastructure

**Geodetic infrastructure includes:**

- **Theoretical concepts** (CRS, observations and methods, numerical computation methods, statistic indicators et al.)
- **Practical “realizations”:** set of landmarks with known accurate coordinates = geodetic network >> triangulation (2D) / GNSS-satellite (3D) / Leveling (1D)

**Diagrams:**
- 2D networks
- 3D networks - GNSS
- 1D networks - Leveling
Geodetic network – landmarks / coordinates

<table>
<thead>
<tr>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Ell. Height (m)</th>
<th>X (m)</th>
<th>Y (m)</th>
<th>Z (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALXR</td>
<td>43°58'11,77238&quot;N</td>
<td>25°19'35,89839&quot;E</td>
<td>114,324</td>
<td>4155947,648</td>
<td>1966871,933</td>
<td>4405767,506</td>
</tr>
<tr>
<td>BAIS</td>
<td>44°01'20,39103&quot;N</td>
<td>23°20'25,90090&quot;E</td>
<td>115,529</td>
<td>4217905,209</td>
<td>1820054,940</td>
<td>4409956,413</td>
</tr>
<tr>
<td>BUCU</td>
<td>44°27'50,19198&quot;N</td>
<td>26°07'32,65012&quot;E</td>
<td>143,206</td>
<td>4093761,206</td>
<td>2007793,576</td>
<td>4445129,764</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H-MN75 [m]</th>
<th>H-EVRF07 [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>29,726</td>
<td>29,801</td>
</tr>
<tr>
<td>31,179</td>
<td>31,254</td>
</tr>
<tr>
<td>15,024</td>
<td>15,099</td>
</tr>
<tr>
<td>15,292</td>
<td>15,367</td>
</tr>
<tr>
<td>16,452</td>
<td>16,527</td>
</tr>
</tbody>
</table>

2D networks

3D networks - GNSS

1D networks - Leveling
4. Projects and Results

BORD / A.F.D.J. PROJECT (2012-2015)

“Realization of a support system for hydrographic works on the Danube for Minimum navigation levels” (POST)

Beneficiary: AFDJ RA GALATI
144 locations x 3 landmarks = 432 landmarks
~ 10 km between locations

Connected with neighbor countries (MD, UA, BG, SR)
4. Projects and Results
4. Projects and Results

FISA DE IDENTIFICARE A AMPLASAMENTULUI PUNCTULUI GEODEZIC

Data: 15.09.2014
Protecție: WATER DANUBE
Ordin punct: [Diagram and table containing detailed information about the project, including coordinates, descriptions, and measurements.]

Site description

SCHEMĂ OBSTRUȚIILOR GPS

NUMĂRUL LOCĂTIEI:

BORNĂ MARTOR (M)
Inălțimea aparatului: 1,5m.

BORNĂ REFERINȚĂ (R)
Inălțimea aparatului: 1m.

BORNĂ AZIMUTALĂ (A)
Inălțimea aparatului: 1m.

Site description

ACCESS LA PUNCT (descriere în cuvinte). Accesul la punct se face pe DN 54A, în locals. Urmăzează drumul Strada Carpaț, apoi Strada Portului, până la siloz. La siloz se ocolește prin incinta hotelui, spre hotelul Sudoaia. Se continuă drumul de pe malul drumului, prin spatele hotelului, pe lânga siloz, până la cca 15 m fata de mal, imediat după ce se termina gardul de delimitare silozului. Punctul este materializat prin borne triangululă din balon.
4. Projects and Results

DANUBE WATER - integrated water management project was financed under the Romania - Bulgaria Cross-border Cooperation Programme 2007-2013.

- The project goal was to establish a common management and control system of the quality of the Danube waters under extreme conditions, caused by natural and technological disasters.
- The project area included about 500 km on Romanian and Bulgarian common Danube border area.

11 Partners

Romania:
PP2 : National Administration “Romanian Waters” (ANAR)
PP3 : National Institute for Hydrology and Water Management (INHGA)
PP4: Technical University of Civil Engineering Bucharest (TUCEB)

Bulgaria:
PP9 : Ministry of Environment and Waters (MOEW)
PP11: Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR)
4. Projects and Results

Subactivities:

- Subactivity 6.1 - Establishment of a common geodetic system for measuring the levels of the Danube River between Romania and Bulgaria – harmonization of the data;
- Subactivity 6.2 - “Surveying of landmarks and development of conversion standards”

OBJECTIVES:

1. Adoption of a Common geodetic system & harmonization of data – INSPIRE:
   3D: ETRS89 – implemented by ETRF00 ; precision: +/- 3 cm >> GNSS measurements
   2D: UTM projection ; precision: +/- 2 cm >> GNSS measurements
   1D: EVRF2007 (heights) ; precision: +/- 1 cm >> leveling measurements

2. Implementation of common CRS by surveying and conversion/transf. standards

- Geodetic observations along the Danube water stages:
  satellite (GNSS) & terrestrial (leveling)

- Conversion & transformation standards: existing or new developed (parameters)
4. Projects and Results

**Water level stages on the project area**

*Red - Romanian*
*Blue – Bulgarian (cross-border bridges)*

**9 stations**

**ROMANIA**
- Gruia
- Calafat
- Bechet
- Corabia
- Turnu Mag.
- Zimnicea
- Giurgiu
- Oltenita
- Chiciu

**9 stations**

**BULGARIA**
- Novo Selo
- Vidin
- Lom
- Oryahovo
- Nikopol
- Svishtov
- Ruse
- Tutrakan
- Silistra
4. Projects and Results

Leveling observations
4. Projects and Results

European Vertical Reference Network (EUVN)
Compound Coordinate Reference System

- European Terrestrial Reference System (ETRS89)
  - Geodetic Datum: ETRS89
  - Coordinate System: Ellipsoidal projected

- European Vertical Reference System (EVRS)
  - Vertical Datum: Normaal Amsterdams Peil (NAP)
  - Coordinate System: Gravity-related heights

1. (B, L) \( H_p^E \)
2. \( H_p^N \)
3. RO/BG National vertical reference system (Black Sea 1975/Baltic Sea)
4. Projects and Results

CASES FOR TRANSFORMATIONS IMPLEMENTATION

- Transformation (1) according to EUREF standards if ETRF solution it is implemented on both sides (countries); First this hypothesis needs to be verified >> Results indicated differences up to 5cm between RO-ETRF00 and BG-ETRF00;

- For transformation (1) a Helmert (7 parameter) transformation was computed as alternative for high accuracy transformation between RO-ETRF00 and BG-ETRF00;

- For transformation (2) a standardized plane (3 parameter) transformation was proposed according to EUREF recommendation; This was checked and works fine with official parameters and even for the landmarks from neighbor country (i.e. transf. from Baltic Sea for landmarks from RO to EVRF2007 with param. for BG);

- A similar transformation was implemented in addition for direct transformation from RO vertical reference system (MN75) to BG vertical reference system (Baltic Sea) >> DaWAT Software.
4. Projects and Results

**Helmert transformation parameters (5 common points)**

<table>
<thead>
<tr>
<th>Transformation param. (sec)</th>
<th>Transformation param. (rad)</th>
<th>Point residuals dX [m]</th>
<th>dY [m]</th>
<th>dZ [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000497 X vector [m]</td>
<td>0.000497 X vector [m]</td>
<td>1 1 0.0153 0.0048 0.0091</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.710724 Y vector [m]</td>
<td>2.710724 Y vector [m]</td>
<td>2 2 -0.0358 -0.0110 -0.0343</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1.064096 Z vector [m]</td>
<td>-1.064096 Z vector [m]</td>
<td>3 3 0.0241 0.0097 0.0191</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.07281956 X angle [sec]</td>
<td>0.3530392 X angle [μrad]</td>
<td>4 4 -0.0154 -0.0073 -0.0096</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.02233018 Y angle [sec]</td>
<td>-0.1082598 Y angle [μrad]</td>
<td>5 5 0.0118 0.0038 0.0158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05557777 Z angle [sec]</td>
<td>-0.2694486 Z angle [μrad]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.0130073 Scale [ppm]</td>
<td>-0.0130073 Scale [ppm]</td>
<td>0.0508 Max. spatial resid. [m]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0282 Average spatial resid. [m]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0178 Root Mean Square resid. (RMS) [m]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CRD differences for ETRS89 (RO/BG)**

<table>
<thead>
<tr>
<th>Site</th>
<th>dX</th>
<th>dY</th>
<th>dZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELE</td>
<td>-0.016</td>
<td>-0.016</td>
<td>-0.034</td>
</tr>
<tr>
<td>ORIA</td>
<td>0.060</td>
<td>-0.016</td>
<td>0.037</td>
</tr>
<tr>
<td>RUSE</td>
<td>-0.038</td>
<td>0.010</td>
<td>-0.058</td>
</tr>
<tr>
<td>SILI</td>
<td>-0.020</td>
<td>-0.026</td>
<td>-0.052</td>
</tr>
<tr>
<td>VIDI</td>
<td>0.039</td>
<td>0.006</td>
<td>0.017</td>
</tr>
<tr>
<td>SOFI</td>
<td>0.000</td>
<td>0.010</td>
<td>-0.031</td>
</tr>
</tbody>
</table>

**seven parameter (Helmert) transformation**
A comparison of Black Sea 1975 normal heights and EVRF2007 normal heights was performed. The results indicated a medium difference of 0.067 mm (EVRF2007-MN75). For BG a medium difference of 0.224 m (EVRF2007 – Baltic Sea).
4. Projects and Results

**FAIRway Danube project** (2015-2020) goal to provide current and harmonized information about shallow sections, water levels and water level forecasts. Available depths will be used optimally by adapting the location of the waterway to the current riverbed conditions. In parallel, FAIRway Danube is aiming at preparing the harmonized rehabilitation of the Danube and its navigable tributaries.

- 2017 - AFDJ Galati requested TUCEB-GEOS Research Centre to achieve the best possible link (transformation) between the height systems used in the area of interest of the project: Black Sea 1975 (RO), Baltic Sea 1982 (BG) and EVRF. This link is necessary for the specific works to be carried out on the Danube for regularization, such as: water level determinations in different sections, constrain of Digital Terrain Models (DTM) in the area, vertically setting out works for rehabilitation of the Danube and its navigable tributaries, dredging et al.

- TUCEB-GEOS proposed a methodology for determining conversion / transformation parameters between altitude reference systems used in the Danube joint sector between Romania and Bulgaria, supplying the calculation algorithm and transformation parameters.
4. Projects and Results

- For transformation (3) from ellipsoidal ETRS89 heights to normal EVRF07 heights and improved transformation accuracy, a polynomial transformation was proposed.
4. Projects and Results

- On the Romanian part of the Danube as in other similar countries in the last 10 years the geodetic networks along the Danube were modernized by new landmarks, new observations including satellite (GNSS) observations and data processing, new/updated coordinates in modern reference systems;

- A unified CRS should be implemented along the Danube, including navigation purposes > especially the height component can be critical if different/less known/old ref. systems are used;

- ETRS89/ETRF00 and EVRS/EVRF2007 are available on this area;

- Transformation algorithms and software are available from/to European reference systems to national reference systems (S42 – Krasovski ellipsoid / Stereographic 1970 projection / Black Sea 1975 normal heights);

- Refined quasigeoid model (+/-3cm) was provided by TUCEB along the RO/BG Danube banks in order to be able to use “GPS leveling”
Geodetic network area

(Gruià loc.109 / VRAV loc.7711 – OSTROV loc.50 / Silistra loc.890)
4. Projects and Results

**Observations:**
33 GNSS epoch stations on Romanian Danube bank
26 GNSS epoch stations on Bulgarian Danube bank

**Known:**
- Normal heights in national reference system (Black Sea 1975 - RO / Baltic Sea 1982 - BG)
- Normal heights in EVRF07

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**Geodetic network with epoch stations positions**

(GRUIA loc.109 / VRAV loc.7711 – OSTROV loc.50 / Silistra loc.890)
4. Projects and Results

**Observations:**
9 GNSS permanent stations on Romanian Danube bank
9 GNSS permanent stations on Bulgarian Danube bank

**Known:**
ETRS89 coordinates for all perm. stations
(ETRF00 realizations in RO and BG)

**GNSS permanent stations in the project area** / **EPN stations:** BUCU, COST, SOFI
TRANSFORMATION 1 – Horizontal CRS. For the transformation from National realization of ETRS89 to ETRS89 (ETRF00), a set of seven parameter (Helmert) transformation for each country can be provided based on GNSS data processing from a common set of GNSS permanent stations from RO and BG. From Romania EPN stations Bucharest (BUCU), Constanta (COST) and Sofia (SOFI) are also included. A third set of transformation parameters could be computed for direct transformation between National realization of ETRS89 to ETRS89 (ETRF00 epoch 2005.0). (EPN – European Permanent Network)
4. Projects and Results

TRANSFORMATION 2 – Vertical CRS. For the transformation 2 from National vertical reference system (Black Sea 1975 – MN75 for Romania and Baltic Sea 1982 for Bulgaria) to/from EVRF2007 a set of transformation parameters adopted by EUREF for each country it is available. The transformation equation it is presented below:

\[ H_{\text{EVRF2007}} = H_{\text{national}} + a1 + a2 \cdot Mo \cdot (LAT - LAT_0) + a3 \cdot No \cdot (LON - LON_0) \cdot \cos(LAT) \quad (1) \]

\(a1, a2\) and \(a3\) coefficients are known; \(LAT, LON\) – ellipsoidal coordinates; \(LAT_0, LON_0\) – reference point coordinates.

All the landmarks observed by precise levelling can be determined in the national vertical system and after, by transformation eq.(1), in the EVRF2007. As examples there are results in Tab.1 (landmarks from Romania) for EUVN stations situated in five areas (Calafat, Turnu Magurele, Giurgiu, Calarasi and Negru Voda). Three of these areas were directly connected by precise levelling (Calafat, Giurgiu and Ostrov).
As examples there are results in Tab.1 (landmarks from Romania) for EUVN stations situated in five areas (Calafat, Turnu Magurele, Giurgiu, Calarasi and Negru Voda). Three of these areas were directly connected by precise levelling (Calafat, Giurgiu and Ostrov).

**Table 1 – EUVN results**

<table>
<thead>
<tr>
<th>Country</th>
<th>Point ID</th>
<th>Point name</th>
<th>ETRS89-RO B (deg)</th>
<th>ETRS89-RO L(deg)</th>
<th>H-MN75 [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO</td>
<td>RO102</td>
<td>Bailesti</td>
<td>44,032732</td>
<td>23,352459</td>
<td>61,222</td>
</tr>
<tr>
<td>RO</td>
<td>RO107</td>
<td>Calarasi</td>
<td>44,187677</td>
<td>27,335867</td>
<td>15,593</td>
</tr>
<tr>
<td>RO</td>
<td>RO118</td>
<td>Hodivoaia</td>
<td>43,917877</td>
<td>25,779621</td>
<td>95,494</td>
</tr>
<tr>
<td>RO</td>
<td>RO142</td>
<td>Turnu Magurele</td>
<td>43,768856</td>
<td>24,881293</td>
<td>36,216</td>
</tr>
<tr>
<td>RO</td>
<td>RO143</td>
<td>Vinju Mare</td>
<td>44,432561</td>
<td>22,864746</td>
<td>94,044</td>
</tr>
<tr>
<td>RO</td>
<td>9</td>
<td>Negru Voda (RO-BG)</td>
<td>43,788889</td>
<td>28,156944</td>
<td>161,821</td>
</tr>
<tr>
<td>RO</td>
<td>23</td>
<td>Calafat</td>
<td>43,996667</td>
<td>22,932500</td>
<td>69,919</td>
</tr>
<tr>
<td>RO</td>
<td>19</td>
<td>Giurgiu</td>
<td>43,895278</td>
<td>25,959444</td>
<td>20,634</td>
</tr>
<tr>
<td>RO</td>
<td>20</td>
<td>Turnu Magurele</td>
<td>43,751111</td>
<td>24,876944</td>
<td>29,931</td>
</tr>
<tr>
<td>RO</td>
<td>22</td>
<td>Calarasi</td>
<td>44,197778</td>
<td>27,354722</td>
<td>18,750</td>
</tr>
</tbody>
</table>
4. Projects and Results

Based on "TransDatRo" software official implemented by National Agency for Cadastre and Land Registration, conversion of (B,L) coordinates to UTM plane coordinates was performed in the same time with transformation of Black Sea 1975 heights to EVRF 2007.

A numerical test for the height transformation was performed also with online transformation software [http://crs-geo.eu] and the results were identical.
4. Projects and Results

A comparison of Black Sea 1975 normal heights and EVRF2007 normal heights was performed in Tab.3. The results indicated a medium difference of 67 mm (EVRF2007-MN75).

A similar comparison indicate a difference of 225 mm for Bulgaria (EVRF2007 - Baltic Sea 1982).

<table>
<thead>
<tr>
<th>Point ID</th>
<th>ETRS89-RO</th>
<th>MN75 [m]</th>
<th>EVRF 2007 [m]</th>
<th>Diff. [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B [deg]</td>
<td>L[deg]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RO102</td>
<td>44,03273248</td>
<td>23,352458</td>
<td>61,222</td>
<td>61,285</td>
</tr>
<tr>
<td>RO107</td>
<td>44,18767743</td>
<td>27,335867</td>
<td>15,593</td>
<td>15,668</td>
</tr>
<tr>
<td>RO118</td>
<td>43,91787669</td>
<td>25,779621</td>
<td>95,494</td>
<td>95,565</td>
</tr>
<tr>
<td>RO142</td>
<td>43,76885594</td>
<td>24,881292</td>
<td>36,216</td>
<td>36,284</td>
</tr>
<tr>
<td>RO143</td>
<td>44,43256133</td>
<td>22,864746</td>
<td>94,044</td>
<td>94,104</td>
</tr>
<tr>
<td>9</td>
<td>43,78889</td>
<td>28,156944</td>
<td>161,821</td>
<td>161,899</td>
</tr>
<tr>
<td>23</td>
<td>43,996667</td>
<td>22,932500</td>
<td>69,919</td>
<td>69,981</td>
</tr>
<tr>
<td>19</td>
<td>43,895278</td>
<td>25,959444</td>
<td>20,634</td>
<td>20,705</td>
</tr>
<tr>
<td>20</td>
<td>43,751111</td>
<td>24,876944</td>
<td>29,931</td>
<td>29,999</td>
</tr>
<tr>
<td>22</td>
<td>44,197778</td>
<td>27,354722</td>
<td>18,750</td>
<td>18,825</td>
</tr>
</tbody>
</table>
Main problem: to be able to obtain (normal) heights with +/- (1...3) cm accuracy for the project area where classical precise leveling observations are impossible or difficult to be realized.

Solution: to use GNSS observations (ellipsoidal) heights combined with a local accurate (quasi)geoid model.

Algorithm:

1. to compute (quasi)geoid undulations $n'_p$ for the geodetic network points

$$n'_p = H_p^E - H_p^N$$

$p$ - points with known ellipsoidal and normal heights

2. to establish a local model of these quantities for the project area

$$n'_p = f(x,y)$$

$(x,y)$ - horizontal coordinates

3. to use the local (quasi)geoid model for (normal) height determinations from GNSS ellipsoidal heights

$$H_i^N = H_i^E - n'_i$$

$i$ – points observed by GNSS

TRANSFORMATION 3 – Ellipsoidal to normal height

$$H_p^E = H_p^N + n'_p$$

Height systems

(ellipsoidal - $H_p^E$, normal - $H_p^N$, ortometric - $H_p^{OR}$)
4. Projects and Results

**FOR TRANSFORMATION 1:**

A set of 7 parameter (Helmert) transformation
- In order to be able to pass from RO ETRS89 realization to BG ETRS89 realization or opposite (if necessary)

**FOR TRANSFORMATION 2:**

A set of 3 parameter transformation
- In order to convert from national vertical reference systems to EVRF07

\[ H(\text{EVRF}2007) = H(\text{MN75}) + a_1 + a_2 \cdot M_0 \cdot (B - B_0) + a_3 \cdot N_0 \cdot (L - L_0) \cdot \cos(B) \]

**FOR TRANSFORMATION 3:**

A set of 10 parameters for a polynomial transformation
- In order to transform from ETRS89 ellipsoidal heights to EVRF07 normal heights

\[ n'_i(x, y) = p_1 + p_2 x + p_3 y + p_4 x^2 + p_5 xy + p_6 y^2 + p_7 x^3 + p_8 x^2 y + p_9 xy^2 + p_{10} y^3 \]

\[ H_i^N = H_i^E - n'_i \]

*Obs. Transformation 3* it is the most important if we know that the access by (precise) geometric leveling to the project area it is very difficult and now an alternative of GNSS leveling was implemented for accuracies of 3 cm.
4. Projects and Results

Quasigeoid undulations model
(ETRS89 / EVRF07)
Danube area (Km375 - Km 863)
4. Projects and Results

**Software implementing the coordinate transformations for the project area**

DaRAT software was realized by Research Centre in Space Geodesy, Photogrammetry, Remote Sensing and GIS (GEOS) from T.U. of Civil Engineering Bucharest within the FAIRway Danube project coordinated by AFDJ RA Galati and with the EAEMDR (Executive Agency for the Exploration and Maintenance of the Danube River) Ruse support.
4. Projects and Results

Software implementing the coordinate transformations for the project area

Software window with transformation from RO national to EVRF07 normal height
4. Projects and Results

Software implementing the coordinate transformations for the project area

Software window with transformation from ellipsoidal ETRS89 to EVRF07 normal height
4. Projects and Results

Software implementing the coordinate transformations for the project area

Software window with transformation from geodetic (ellipsoidal) coordinates to UTM plane coordinates
5. Conclusions

- On the Romanian part of the Danube as in other similar countries in the last 10 years the geodetic networks along the Danube were modernized by new landmarks, new observations including satellite (GNSS) observations and data processing, new/updated coordinates in modern reference systems;

- A unified CRS should be implemented along the Danube, including navigation purposes > especially the height component can be critical if different/less known/old ref. systems are used;

- ETRS89/ETRF00 and EVRS/EVRF2007 are available on this area;

- Transformation algorithms and software are available from/to European reference systems to national reference systems (S42 – Krasovski ellipsoid / Stereographic 1970 projection / Black Sea 1975 normal heights);

- Refined quasigeoid model (+/-3cm) was provided by TUCEB along the RO/BG Danube banks in order to be able to use “GPS leveling”
The Applications area of the DanubeGeodetic infrastructure includes:

- Danube navigation improvement >> more accurate positioning based on geodetic network;
- Water level measurements in a unified reference system;
- “Zero” level new (re)established at hydrometric stations;
- Possibility to perform “GPS leveling” in areas with difficult access;
- Navigation maps/charts to be upgraded more easy;
- Maintenance works along the Danube aided by new geodetic network: new DTM’s, profiles, bathymetry;
- More accurate risk/hazard maps;
- Other applications: cadaster, railway/highway transport closed to the Danube.
5. Proposals

✓ 1. Based on a theoretical and practical RO/BG experience concerning old/new CRS’s along the common part of the Danube, as a good practice, similar studies should be performed in other Danube sectors if are not yet done!

➢ RO/SR sector and RO/UA sector …?

✓ 2. As a consequence, EVRS/EVRF(2007) can be implemented and transformation to/from other CRS’s can be available;

✓ 3. If RELATIVE values for the water levels are a common practice in NAVIGATION > we propose as in parallel, ABSOLUTE values for the water levels to be implemented!

Advantages: i.e. more straight connection of Danube water level with DTM including dams/bridges around the area >>> faster floods modelling and scenarios
5. Proposals

Possibility to introduce **ABSOLUTE** values for “0” stage \ water level in EVRF2007 (MN75 and MB) and terrain model (profile) in parallel

Actual “reading” on water stage (REL.)

“0” reading on water stage (ABS.)

“0” water stage (ABS.)

“0” EVRF2007

“0” MN75 (Black Sea 1975)
5. Proposals

**Possibility to introduce AND ABSOLUTE values for “0” stage in EVRF2007 et al. ref. systems, MN75 and MB**

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<th>GIURGIU</th>
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<th>RO</th>
<th>BG</th>
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[http://gis.danube-water.ro/](http://gis.danube-water.ro/)
References

[3] Implementation Plan of the Activity 6 – on WATER project (MIS 161) funded under Romania-Bulgaria cross border Cooperation Programme 2007-2013
[4] Technical Specifications for the implementation of the Activity 6 – on WATER project (MIS 161) funded under Romania-Bulgaria cross border Cooperation Programme 2007-2013
[12] ISO/DIS 19111 (Geographic Information – Spatial Referencing by Coordinates) - ICS 35.240.70
Web: