GNSS Reference stations network development in Moldova: Regional cooperation with Romania

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President of Moldavian Union of Surveyors
Subjects

- Milestones in the development of GNSS Network
- Development of the Geodetic Reference System
- Development of GPS Network
- Development of GNSS Permanent Network
- Development of MoldPos services
- Regional cooperation with Romania and Ukraine
- Geodetic data base development
- MoldPos applications
- Conclusions and recommendations
Development of the Geodetic Reference System

Vertical reference system:
Baltic Sea 1977 \(\rightarrow\) EVRS2000

Ellipsoids:
- SC 42
- WGS 84
- ETRS 89
- GRS 80

Map projections:
- Krasowsky
- WGS 84
- UTM
- Gauss Kruger

Scale:
- 1:500 - 1:10 000
- 6° zone
- 3° zone
- 6° zone
- 1:10 000 - 1:500 000
- 1:500 - 1:10 000
- 1:25 000 - 1:500 000
- MOLDREF99

U-Mark Group
EUREF99 Campaign

<table>
<thead>
<tr>
<th>Stations</th>
<th>RMS (mm)</th>
<th>Residuals (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>y</td>
</tr>
<tr>
<td>GIUR</td>
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<td>1.3</td>
</tr>
<tr>
<td>OTAC</td>
<td>2.2</td>
<td>1.4</td>
</tr>
<tr>
<td>PALA</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td>UNGH</td>
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<td>2.5</td>
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<tr>
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<tr>
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<tr>
<td>SIME</td>
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</tr>
<tr>
<td>UZHD</td>
<td>2.0</td>
<td>1.7</td>
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</tbody>
</table>
Development of GPS Network

GPS measurements

- 5 EUREF sites (120 hours), 5 mm plane, 20 mm vertical
- 78 first-order sites (4 hours), 20 mm plane, 40 mm vertical
- 400 second-order sites (1 hour), 30 mm plane, 60 mm vertical

EUREF sites

First/second order sites

UNGHENI
PALANCA
CHELTUITORUL
GIURGIULESTI
Starting from August 2006 CTIG station in Technical University of Moldova was installed in the frame of educational project JEP-24243-2003, TACIS-TEMPUS.

http://ctig.utm.md/?module=projects&action=1&project_id=6
Starting from August 2007 the Agency of Land Relations and Cadastre in collaboration with BKG installed and jointly operate a GNSS permanent tracking station IGEO (Chisinau) integrated into EPN and will be integrated in MOLDPOS (www.ingeocad/igeo).
Government decision to create National GNSS Network and MoldPos Service Nr. 307 from 28.04.2011 was adopted. On 1st November 2011 GNSS Permanent Network and MOLDPOS service were put on function with 10 permanent GNSS stations.

Real Time measurements:
- DGNSS with accuracy $\pm 50-70$ см
- RTK with accuracy $\pm 2-3$ см

Post processing with accuracy $\pm 1$ см
Development of GNSS Permanent Network

IGS RF stations used in the processing (11)

GNSS permanent stations network (10)

EUREF - 0 order National Geodetic Network sites (5) 24 hours data set

GNSS Observations campaign 16-30 August 2011

<table>
<thead>
<tr>
<th>Station</th>
<th>E RMS</th>
<th>N RMS</th>
<th>U RMS</th>
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<tr>
<td>CAHU (MoldPos)</td>
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<tr>
<td>CAUS (MoldPos)</td>
<td>2.3</td>
<td>1.7</td>
<td>2.5</td>
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<tr>
<td>CHEL (EUREF)</td>
<td>2.3</td>
<td>1.7</td>
<td>2.5</td>
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<td>CHIS (MoldPos)</td>
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<td>UNGH (EUREF)</td>
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<td>1.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>

- IGS RF stations used in the processing (11)
- GNSS permanent stations network (10)
- EUREF - 0 order National Geodetic Network sites (5) 24 hours data set
Conversion into ETRF97 epoch 1999.4:

- Application of Eurasia plate model to convert coordinates into epoch 1999.4

<table>
<thead>
<tr>
<th>City</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>E</th>
<th>N</th>
<th>H</th>
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<tbody>
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Development of GNSS Permanent Network

### Destination of the GNSS Permanent Network

- **EPN**
  - **Regional solutions**
    - Precise orbits
    - Atmospheric products
    - ETRF resolution
  - INGEOCAD

- **Land Relations and Cadastre Agency, INGEOCAD**
  - **MOLDPOS**
    - **Local solutions**
      - MOLDREF99 realisation
      - SC42/MOLDREF99 transformation parameters
      - Online automated positioning service

- **IGS**
  - **Global solutions**
    - Precise orbits
    - Atmospheric products
    - ITRF resolution

**End user**
Development of MOLDPOS services

RTCM-based Positioning GNSS-Services

MOLDPOS server

RTCM server

MOLDPOS data

RTCM message

NMEA String

Geodetic data base

Reference datum transformation parameters

B,L (ETRS89) -> B,L (SC 42) -> x,y (SC42)

x, y (SC42) -> B,L (SC42) -> B,L (ETRS89)
Development of MOLDPOS services

MOLDPOS architecture and communication configuration

CORS stations

- GPS
- NAVSTAR/GLONASS
- GALILEO

Control Center

- MOLDPOS Server
- RTCM Server
- Geodetic Data bases

Distribution

- Post processing data
  - FTP/WWW server
- Real time applications
  - GPRS/UMTS

Raw data

RTCM messages
Regional cooperation with Romania and Ukraine

• Early 2014 MoldPos started to receive data from 5 RomPos GNSS stations under agreement between Moldavian Agency for Land Relation and Cadastre and Romanian National Agency for Cadastre and Land Registration (ANCPI).

• At the moment we are working on data integration with Ukrainian GNSS stations

• Next step is data integration with EUPOS GNSS network
Development of MOLDPOS services

Orange cell phone coverage

Moldcell cell phone coverage
Development of MOLDPOS services

Ionospheric and tropospheric errors influence on GNSS measurements
Regional cooperation with Romania and Ukraine

Ionospheric and tropospheric errors influence on GNSS measurements

The estimated residual ionospheric error for RTK in metres

Network Online Visualisation of Accuracy (NOVA) Maps
Regional cooperation with Romania and Ukraine

Ionospheric and tropospheric errors influence on GNSS measurements

The estimated residual tropospheric and orbit error for RTK in metres

Network Online Visualisation of Accuracy (NOVA) Maps
Geodetic data base development

Transformation parameters databases development (Karlsruhe Solution)

COPAG = Continuously Patched Georeferencing

Continuity along the Mesh Borders!

Combined Old Classical Triangulation and ETRS89 Control Points from GNSS measurements

Meshes = “Patching“ for ETRS89 and Classical Datum-systems of Moldova

(1 – 4) cm accuracy transformation parameter Databases for Classical and ETRS89 Datum-systems
Geodetic data base development

Modelling of Quasigeoid for Moldova using EGG97 and GNSS/levelling measurements
Gridding for RTCM 3.1 Transformation Message

\[ B = B_{\text{TRANS}} - \delta B (\delta B_i) \]  
\[ L = L_{\text{TRANS}} - \delta L (\delta L_i) \]  
\[ h = h_{\text{TRANS}} - \delta h (\delta h_i) \]  

1. B, L, h \rightarrow x, y, H  
2. B, L \rightarrow x, y  
3. H
MoldPos applications

Geodetic surveying

Reconstruction of National Geodetic Network

National Geodetic Network Densification

Field Identification of control points
MoldPos applications

Cadastral surveying

Parcel boundary determination and field identification
MoldPos applications

Aero-photography and laser scanning

Orto-photo and mapping

Digital terrain modeling
MoldPos applications

Precise agriculture

RTK
Real-Time Kinematic
Dual Frequency L1/L2

Differential Correction
RTK Base Station
NTRIP
CORS/Cell

Typical Use
Strip Tillage
Bedding, Planting
Topographic Mapping
Landforming

AGI-4 or HiPer AG Mobile Base Station
Featuring multiple-constellation tracking
HiPer AG features Dual Constellation
GPS + GLONASS tracking
MoldPos applications

**On Board Equipment**
- Tablet PC
- L1GPS antenna
- Wi-Fi
- L1/L2 GNSS Receiver
- BlueTooth
- Trimble ACU Controller
- Trimble 5800

**On Ground Equipment**
- GMV magicSBAS
- SISNet Server

**Trail flights EEGS2**
MoldPos applications

SCADA - system of cleaning garbage containers

RFID-Sensor - Bluetooth

Mobile Administration

Dispatcher

Cloud services

Internet

3G Mobile

GNSS

MoldPos RTCM Server (DGNSS corrections)

WEB-Portal-Server

SCADA - Supervisory Control And Data Acquisition
RFID - Radio-frequency identification
• MoldPos provide real time horizontal coordinate determination with accuracy 2-3 cm on the border with Romania and 3-4 cm on the border with Ukraine. Normal height determination with accuracy 5-7 cm is possible using GNSS/levelling geoids model.

• To increase accuracy up to 2 cm regional cooperation is necessary to integrate GNSS data and to develop regional gravimetric geoid model.

• MolgPos is used by a large spectrum of users (geodetic works, cadastral surveying, GIS applications, precise agriculture, mapping and boundary marking, etc.)

• MoldPos could be a good support of scientific applications (landslide and floods monitoring, environmental research, geohazard prediction, geodynamic investigations etc.)
Thank for your attention