CROPOS – Current Status and Implementation of T7D Transformation Model

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Introductory remarks

This lecture builds on:


- “CROPOS – positioning easier than ever” (M. Marjanović & T. Bašić), INF-0002, Trimble Dimensions 2010 conference “Converge, Connect and Collaborate” (5th), 8-10, November 2010, Las Vegas, USA.
CROPOS – launched on 9th of Dec. 2008

- CROPOS is a reference GNSS network of permanent stations of the Republic of Croatia enabling its users to determine a location with the GNSS technology in the real time with an accuracy of 2 cm for position and 4 cm in height on the entire Croatian territory.

**Importance:**

- Introduction and application of new geodetic reference systems (datums) of the Republic of Croatia
- Homogenization of coordinate system
- Same accuracy of measurement and coordinate determination at the entire territory
- Utilization of the unique measurement methods - standardization in performing of geodetic works
- Faster and more efficient performing of geodetic works
CROPOS – Basics

- Collecting the data from the reference stations that are placed at 30 locations at the territory of the Republic of Croatia
- Reference station real-time GNSS data exchange with the neighbouring countries
- Networking and computing the real-time correction parameters
- Distribution of measuring data and real-time correction parameters to the users
- Monitoring of the system operation and users support
- 24/7/365 service availability
CROPOS – Current Status

- Hardware upgrade: data storage (+ 2 TB), tape backup (1 GB)
- Software update: Trimble GPSNet Ver. 2.730, GNSS receiver firmware Ver. 4.03
- Implementation of system for remote administration and system control of servers
- New application for user administration and charging, additional system usage statistics
- Processing of RINEX data in order to monitor and analyse stability of CROPOS reference frame – GPS week solutions
CROPOS – Current Status (43 stations)

www.cropos.hr
Number of registered companies - in total 302
CROPOS Statistics ...

Number of service users - in total 773

Payment models - VPPS service

Average of 40 users connected at the same time during working hours (max. 79)
CROPOS Statistics ...

System usage - VPPS service - in total 7 278 708 min.

Month, year
Average use of VPPS service (RTK)
> 325 000 minutes/month

24.11.2010.
CROPOS Statistics ...

System usage - GPPS service - in total 1 091 180 min.
HRG2009 – New Geoid Solution

- Data:
  - Earth’s gravity field - free air gravity anomalies (~ 30000)
  - Satellite altimetry in the Adriatic Sea (400)
  - Global geopotential model EGM2008
  - High frequencies field structures modeled with the help of 3" x 3" Shuttle Radar DEM's
  - Discrete geoid undulations obtained by GNSS/leveling on the mainland (495)

- Least squares collocation calculation technique
- Geoid surface point raster 30" x 45"
- Internal accuracy $\sigma = 2 – 3$ cm
- Absolute accuracy based on comparison with GNSS/Leveling values (59 points – not included in model); $\sigma = \pm 3.5$ cm
GNSS/Leveling and transformation points

CROPOS

N=2000

CROPOS

N=5500

N = h - H

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EESRSinSLO
Gravity data and DTM (3"x3" i 1’x1’ SRTM)
T7D – new transformation model

- Unique transformation model HTRS96<>HKDS - uniform, reliable and simple transformation system, available to all users

- GRID transformation for the whole Croatian territory, consisting of 7-parameter transformation and a proper raster predicted values of distortion, both in plane coordinates and height

Transformation Problems:

- ETRF00 (R05), 1989.0 (ETRS89)
  - GRS80
  - \( \varphi, \lambda, h \) (X, Y, Z)
  - Ellipsoidal height: \( h \)

- HTRS96/TM
  - GRS80
  - N, E, H (Transverse-Mercator projection)
  - Orthometric height: \( H = h - N \) (HVRS71)

- HDKS
  - Bessel
  - \( y, x, H \) (Gauss-Krüger projection)
  - Orthometric height: \( H = h - N \) (Trieste)
**T7**

<table>
<thead>
<tr>
<th>N = 5200</th>
<th>Transformation parameters</th>
<th>Accuray estimation (m₀=0.804 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx</td>
<td>-546.62 m</td>
<td>±0.59 m</td>
</tr>
<tr>
<td>Ty</td>
<td>-162.38 m</td>
<td>±0.66 m</td>
</tr>
<tr>
<td>Tz</td>
<td>-469.48 m</td>
<td>±0.59 m</td>
</tr>
<tr>
<td>Rx</td>
<td>5.905 &quot;</td>
<td>±0.019 &quot;</td>
</tr>
<tr>
<td>Ry</td>
<td>2.074 &quot;</td>
<td>±0.022 &quot;</td>
</tr>
<tr>
<td>Rz</td>
<td>-11.510 &quot;</td>
<td>±0.019 &quot;</td>
</tr>
<tr>
<td>μ</td>
<td>4.439 ppm</td>
<td>±0.075 ppm</td>
</tr>
</tbody>
</table>

|            |                           | ±0.53 m                         |
|            | σφ                        | ±0.53 m                         |
|            | σλ                        | ±0.59 m                         |
|            | σh                        | ±0.13 m                         |
|            | 2D                        | ±0.79 m                         |
|            | 3D                        | ±0.80 m                         |

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200 cm
Positional and height distortion

\[ \varphi (m) \]
\[ \lambda (m) \]
\[ H (m) \]

rms = ±53.3 cm
rms = ±58.7 cm
rms = ±12.9 cm

Trieste – HVRS71 (m)

Mean  21.0 cm  
Stdev  6.6 cm  
Min    5.0 cm  
Max    41.1 cm  

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T7D

7P + (δφ, δλ)

(bi-linear interp.)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>σφ</td>
<td>±0.041 m</td>
</tr>
<tr>
<td>σλ</td>
<td>±0.041 m</td>
</tr>
<tr>
<td>σh</td>
<td>±0.001 m</td>
</tr>
<tr>
<td>2D</td>
<td>±0.058 m</td>
</tr>
<tr>
<td>3D</td>
<td>±0.058 m</td>
</tr>
</tbody>
</table>

24.11.2010.
Control of height transformation using T7D model

HVRS71

Trieste

average: -0.012
stdev: 0.035
min: -0.076
max: 0.059

average: -0.012
stdev: 0.036
min: -0.084
max: 0.059
Upgrading CROPOS

- Implementation of T7D model in CROPOS in order to facilitate on-line transformation of coordinates in real time (on site)

- Trimble Transformation Generator (TTG): standalone application, installed on a separate server, which allows the preparation RTCM 3.1 transformation messages 1021 and 1023 for users (it is possible to select multiple types of transformation depending on user choice – source table)
Implementation of T7D in CROPOS

TTG new services > update CROPOS source table

- CROPOS_VRS_HTRS96
  HTRS96/TM – on-line geoid model

- CROPOS_VRS_HDKS
  HDKS – datum transformation & on-line geoid model

- RTCM 3.1
  - Message 1021
    - 7 parameter transformation
      (Tx, Ty, Tz, dM, Rx, Ry, Rz)
  - Message 1023
    - Transformation corrections
      (δφ, δλ or δN)
Transformation Data Flow

Global Geocentric Datum

Step 1: Message 1021 (Transformation parameters)

Local Geodetic Datum

Step 2: Message 1023 (Corrections - Grid)

Local Geodetic Datum (Final coordinates)
Testing of on-line geoid model

- 1000 points (September/November 2010)
- Comparison of heights: on-line geoid model vs post-processing geoid model

![Map of the area with marked points and coordinates](image)

### First results

<table>
<thead>
<tr>
<th>ID</th>
<th>H (m) CROPOS</th>
<th>H (m) T7D</th>
<th>ΔH (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1011719</td>
<td>400.124</td>
<td>400.125</td>
<td>-1</td>
</tr>
<tr>
<td>1010883</td>
<td>387.532</td>
<td>387.532</td>
<td>0</td>
</tr>
<tr>
<td>1011777</td>
<td>211.111</td>
<td>211.111</td>
<td>0</td>
</tr>
<tr>
<td>1018843</td>
<td>90.913</td>
<td>90.912</td>
<td>+1</td>
</tr>
<tr>
<td>1018868</td>
<td>151.783</td>
<td>151.784</td>
<td>-1</td>
</tr>
<tr>
<td>1005817</td>
<td>94.426</td>
<td>94.425</td>
<td>+1</td>
</tr>
<tr>
<td>1021685</td>
<td>35.003</td>
<td>35.003</td>
<td>0</td>
</tr>
<tr>
<td>1021683</td>
<td>57.500</td>
<td>57.499</td>
<td>+1</td>
</tr>
<tr>
<td>1021830</td>
<td>221.837</td>
<td>221.838</td>
<td>-1</td>
</tr>
</tbody>
</table>
Future Activities

• Official use of on-line geoid model – January 1st, 2011
• Preparing of grid files for positional datum transformation and their testing in on-line mode (Spring 2011)
• Processing of RINEX data in order to monitor and analysis stability of CROPOS reference frame – GPS week solutions
• Use of CROPOS data and processing results in geodynamic research
• Organization of “2nd CROPOS User Conference”
Conclusion

- CROPOS project – successfull story
- User trust – reliable and accepted system
- “With CROPOS positioning easier than ever”

HVALA – THANKS!