Control networks and R2016

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Bratislava, 21.11.2017
Outlines

1. Control networks
2. SAPOS® - An overview
3. SAPOS® - Monitoring
4. Realisierung 2016 (R2016)
5. Test field for GNSS
Control networks

- The 1st order points for height (HFP) form the German main height network (DHHN),
- the 1st order gravity points (SFP) form the German main gravity network (DHSN),
- the reference stations (RSP) form the reference station network (RSN – ground marked stations only),
- the geodetic control stations (GGP) form the geodetic main network (GGN).
Networks of the R2016

### Levelling (2006-2012)
- 7 Leveling main points
- 65 GNSS + RSP
- Wallenhorst (Datum DHHN92)

### Gravity (2009-2010)
- Gravity acceleration (GGN):
  - 100 stations: by absolute gravimetry,
  - 150 stations by relative gravimetry.

### GNSS (2008)
- GGN (250 stations)
SAPOS® - An overview

• SAPOS® is a positioning service and operated by the AdV (Surveying Authorities of the States of the Federal Republic of Germany),

• SAPOS® provides the current official spatial reference for everyone with state-of-the-art technique (ETRS89),

• SAPOS® is the legal task of the state land surveying in Germany (real-estate cadaster, infrastructure).
SAPOS® - A short history

<table>
<thead>
<tr>
<th>Developing</th>
<th>Installation</th>
<th>Production</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network test</td>
<td>Cadastral surveying</td>
<td>Quality management</td>
<td>Galileo, PPP</td>
</tr>
</tbody>
</table>

Decision by the AdV in 1995 (96. plenum) for the setting up the SAPOS®

Certificate of the German Patent and Trademark Office from 20.01.1997
SAPOS® - Positioning Services

- ~270 reference stations
- Cross border networking
- Interoperability
  (International standard definition – RTCM, RINEX, NMEA, NTRIP)
- Standardized fees (AdV-catalogue)
- Standardized quality management
- GPS, GLONASS ➔ Galileo ➔ Beidou

EPS (Real-time)
HEPS (High precision real-time)
GPPS (Geodetic postprocessing)

http://www.sapos.de
# SAPOS® - Service characteristics

<table>
<thead>
<tr>
<th>SAPOS®</th>
<th>EPS</th>
<th>HEPS</th>
<th>GPPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td>Real-time</td>
<td>Real-time</td>
<td>Post-processing</td>
</tr>
<tr>
<td>Accuracy-position</td>
<td>3 - 8 cm</td>
<td>1 - 2 cm</td>
<td>≤ 1 cm</td>
</tr>
<tr>
<td>Accuracy-height</td>
<td>50 - 150 cm</td>
<td>2-3 cm</td>
<td>1-2 cm</td>
</tr>
<tr>
<td>Transmission technique</td>
<td>Ntrip over Internet (GPRS, UMTS, LTE)</td>
<td>Ntrip over Internet (GPRS, UMTS, LTE), GSM</td>
<td>Internet (Web Server)</td>
</tr>
<tr>
<td>Clocking unit</td>
<td>1 second</td>
<td>1 second</td>
<td>1 second</td>
</tr>
<tr>
<td>Unit</td>
<td>Inapplicable</td>
<td>1 minute</td>
<td>1 minute</td>
</tr>
<tr>
<td>Fee per unit</td>
<td>150 € p. a.</td>
<td>0,10 €</td>
<td>0,20 €</td>
</tr>
<tr>
<td>Standard, format</td>
<td>RTCM 2.3</td>
<td>RTCM 2.3, RTCM 3</td>
<td>RINEX 2.1</td>
</tr>
</tbody>
</table>

[http://www.sapos.de](http://www.sapos.de)
SAPOS® - Quarterly monitoring

Precursor of the DREF-Online

From the GPS-Week 0991 (03.01.1999) to 2005
Variation of differences

GPS-Week 1175 (14.7.2002)

Limits: 2D-Position 10 mm, Height 15 mm

GPS-Week 1175: Difference in ETRS89/DREF91

![Histograms showing variation of differences in 2D position and height](chart.png)
DREF-Online for monitoring the SAPOS<sup>®</sup> reference stations

DREF-Online (as of 20.09.2017): 61 stations from the GREF, SAPOS<sup>®</sup>, IGS and EUREF permanent networks.

As of March 2016

Zero-Epoch

ITRF2005
Epoke: 2008,459

ETRF2000
Epoke: 2000

ETRS89 / DREF91
Epoke: 2000

DREF-Online for monitoring the SAPOS<sup>®</sup> reference stations

DREF-Online (as of 20.09.2017): 61 stations from the GREF, SAPOS<sup>®</sup>, IGS and EUREF permanent networks.

As of March 2016

Zero-Epoch

ITRF2005
Epoke: 2008,459

ETRF2000
Epoke: 2000

ETRS89 / DREF91
Epoke: 2000
Realisations of the geodetic spatial reference frames in Germany

<table>
<thead>
<tr>
<th>Campaign</th>
<th>Coordinates at IGS/ITRF Reference</th>
<th>Reference frame Realisation</th>
</tr>
</thead>
</table>
R2016: GGN

Trimble

Leica
## Equipments

**Adapter for measurement of the antenna height** FG-ANA 100B (Source: FPM 2008).

**Calibration of antennas in Garbsen und Berlin**

<table>
<thead>
<tr>
<th>Company</th>
<th>Receiver (Quantity)</th>
<th>Firmware</th>
<th>Antenna (Quantity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leica Geosystems</td>
<td>GX1230GG (16) GRX1200GGPRO (2)</td>
<td>5,62</td>
<td>LEIAT504GG (17)</td>
</tr>
<tr>
<td>Trimble Navigation</td>
<td>Net R5 (15) R7 GNSS (4)</td>
<td>3,5</td>
<td>TRM29659.00 (18)</td>
</tr>
</tbody>
</table>
### R2016: Network extended

<table>
<thead>
<tr>
<th>Network</th>
<th>Sta.</th>
<th>Network</th>
<th>Sta.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGN</td>
<td>250</td>
<td>EXAGONE (FR)</td>
<td>6</td>
</tr>
<tr>
<td>GREF</td>
<td>29</td>
<td>GPSnet.dk (DK)</td>
<td>3</td>
</tr>
<tr>
<td>IGS</td>
<td>8</td>
<td>GUGIK (PL)</td>
<td>8</td>
</tr>
<tr>
<td>SAPOS (D)</td>
<td>264</td>
<td>SPSLUX (L)</td>
<td>4</td>
</tr>
<tr>
<td>06GPS (NL)</td>
<td>5</td>
<td>SWIPOS (CH)</td>
<td>5</td>
</tr>
<tr>
<td>APOS (A)</td>
<td>10</td>
<td>WALCORS (B)</td>
<td>2</td>
</tr>
<tr>
<td>CZEPOS (CZ)</td>
<td>7</td>
<td>Total</td>
<td>601</td>
</tr>
</tbody>
</table>

*MATE at BKG only*
NRW: Test field for GNSS

North Rhine Westphalia

GNSS:
Max. horizontal difference = 1.5 cm

Control point

Tachymeter:
Max. horizontal difference = 1.0 cm

Connection point

50 m
Determination of GNSS control points

• Calibration of antenna in the calibration chamber,
• Each point must be measured at least twice,
• Session length ≥ 90 min. with an observation interval of 15 s,
• Coordinates at UTM derived from ETRS89.
Thank you very much for your attention!

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