Integrated geodetic infrastructure as a support of national and international GNSS projects: case study of the Geodetic Observatory Pecný (CZE)

Pavel Novák
Research Institute of Geodesy, Topography and Cartography, Czech Republic

Chisinau, Moldava, May 17-21, 2010
Geodetic Observatory Pecný

- one component of the RIGTC
- observatory founded in 1957
- located in Ondřejov 35 km SE from Prague
Research activities

- development of the observation system and of analysis centres at GOP
- theory of detailed gravity field modelling
- improved ETRS national realization and NGC integration into European frames
- monitoring permanent GNSS array in the Czech Republic
- development of the GOP scientific database
- mandatory reference frames in the Czech Republic
Reference frames in CZ

- ETRS
- WGS-84 (Czech Armed Forces)
- S-JTSK (principal civil user system)
- old (Austrian-Hungarian) cadastral systems
- vertical reference system „Baltic“ (BVP)
- Gravity system 1995
- S-42 (former military system)
Horizontal geodetic points in CZ

- national permanent GNSS array (CZEPOS)
- scientific and research GNSS network (VESOG)
- GNSS reference network (DOPNUL)
- GNSS/triangulation stations (about 3,500) selected for periodical maintenance
- triangulation stations (1st – 5th order)
- GNSS/terrestrial densification points (about 35,000)
Permanent GNSS Stations in CZ
Stability of GNSS stations

<table>
<thead>
<tr>
<th>Category</th>
<th>CZEPOS</th>
<th>VESOG</th>
<th>GeoNAS</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable</td>
<td>8</td>
<td>-</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Outliers</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Unsure</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Periodicity</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Trend</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>
IGS permanent station GOPE

- located on the roof of the main observatory building
- beginning of measurements: September 1993, for IGS 1995, for EPN 1996
- now used receiver Ashtech Z18 and antenna Topcon CR3-GGD
- GNSS used: GPS NAVSTAR + GLONASS
- measurement interval: 1 sec decimated for IGS/EPN to 30 sec
- data:
  - files in RINEX format every 15min/1 hour/1 day
  - real-time data stream RTCM v.2 (DGPS, RTK)
- used Ashtech software GBSS with own software superstructure

Antenna Topcon CR3-GGD with conical radome

Receiver Ashtech Z18
VESOG – Research and Experimental Network for Observations of Satellites

MAP OF THE PERMANENT GNSS STATIONS IN THE CZECH REPUBLIC

- eight permanent stations of research, academic or military institutions (red on the picture)
- GO Pecny supplies to VESOG with 3 stations and operation center for data transfer and checking of station operations
VESOG stations

LYSH

VSBO

TUBO

KUNZ

POL1

PLZE
Improving the national reference system S-JTSK

Implementation of ETRS89 (R05) by CZEPOS network

New “GPS network”, measured 1997 – 2006 by Surveying Office
GNSS Data Centre Pecný

- observation files for more than 150 globally distributed stations
- GNSS RINEX data,
- IGS, EPN, IERS, CODE
- products, information about GNSS permanent stations etc.
Local Analysis Centre Pecný

- regular processing of 55 EPN stations
- regular processing of 39 GNSS permanent stations from the Czech Republic (CZEPOS, TOPNET, VESOG)
- regular processing of 79 GNSS stations within the projects of GPS meteorology – TOUGH, E-GVAP)
Absolute gravimeter

- absolute gravimeter FG5 No. 215 was purchased in August 2001 from Micro-g Solutions
- since March 2008 national standard of gravity (metrology)
- principe: free-fall gravity acceleration is determined from track of free-falling corner cube in vacuum (measurement of distance by interferometer using iodine stabilized He-Ne laser beam and measurement of time by rubidium atomic oscillator)
- overall accuracy about 2 µgal \((2.10^{-8} \text{m.s}^{-2})\)
- repeated at least one-day observations with one-month period
Relative gravimeters

- Relative gravimeters determine tidal and non-tidal gravity variations.
- Principle: Mass on spring – gravity variations cause the position change of mass on the spring (measurement of changed position or measurement of additional force used for keeping the mass in the same position).
- Spring relative gravimeters use usually metallic or quartz spring.
- Tidal station Pecny works from 1970 in basement of main building.
- Now two spring gravimeters are there: Askania Gs15 No. 228 and LaCoste-Romberg G No. 137.
Superconducting gravimeter

- the superconducting relative gravimeter was installed in tidal station in February 2007
- OSG No. 050 from GWR, USA
- principe is similar to relative gravimeters but the spring is defined by magnetic field of two superconducting coils – it is very stable and the gravimeter has very small drift (change of measurement in time due to changing of physical characteristic of measurement system)
- possibility to observe the long-period tidal waves and hydrological effects
Comparison of AG and SCG

- accurate detection of systematic error variations for absolute gravimeters
- drift determination for superconducting gravimeters
basic set of meteorological sensors (air temperature, relative humidity and atmospheric pressure) is installed on all VESOG permanent GNSS stations
- first measurements from 1996
- mobile climatologic station of Faculty of Nature of Charles University Prague was installed in 2002 on the top of hill Pecny
- climatologic station also measures the wind direction and velocity, sunshine, rain and surface and sub-surface temperatures.
Water in soil

- Rain gauge ANEMO S50 V measures rain fall automatically from 2002.
- Soil moisture sensors are installed in differential depths from 0.1 till 1.2 m since 2004.
- Six VIRRIB LP A sensors measure soil moisture every 10 min.
- Pressure sensor is used for measurement of groundwater level in the old unused well since 1998, from 1988 till 1998 the manual system was used.
Water vapour radiometer

- Water vapour radiometer TP/WVP No. 3025 was manufactured by Radiometrics, USA and it was installed in September 2006 at the rail on the roof of main building beside the GOPE permanent station.
- From brightness temperatures of molecule of oxygen, water and water vapour are derived the profiles of temperature, relative humidity and water content in the nearest atmosphere to height 10 km.
- Due to GPS options the water vapour and liquid water profiles are measured also in the directions to GPS satellites.

Radiometer without cover
Frequency standard

- main part of frequency system is a caesium atomic clock Symmetricom 5071A
- for connection of time and frequency to international time scale the GPS receiver for time-keeping applications will be used
- precise frequency is used for comparison of frequency of rubidium oscillator inside absolute gravimeter and for GNSS receiver at the GOPE permanent station
**Seismometer**

- very-broad band seismometer Guralp CMG-3TD with band between 360 s – 50 Hz will be installed in the new 60 m depth borehole on the top of hill
- build of surface object above borehole is near to finish
Conclusions

- improved ETRS national realization
- monitoring permanent GNSS arrays in CZ
- activities of the observatory important for many international projects and campaigns
- collocation between geometric and gravity field reference frames
- data collected / analyses performed by the observatory allow for integration of national geodetic controls into European and international reference frames
Thank you for your attention