Recent Steps Towards the Introduction of new European Reference Systems in Austria

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Hierarchic Schema for the Introduction of ETRS89 in Austria

- **APOS**: Austrian Positioning Service
- **AMON**: Austrian Monitoring Network
- **AGREF**: Austrian Geodynamic Reference Network
- **AREF**: Austrian Reference Network
- **TIREF**: Tyrolean Reference Network
- **REVUE**: Revision and remeasurement of 6th order control points

**European Terrestrial Reference System (EUREF, EPN)**

1. **TP**: 1st-5th orders: 57,000
2. **EP**: 6th order: 270,000
3. **Boundary points**: 12,000,000

**International Accepted Solution ETRS89 Austria 2002**

- **IGS**: Accepted Solution by the EUREF Symposium 2003 in Toledo
- **ETRS89 Austria 2002, ETRF2000 Epoch 2002.45**

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**ETRS89**

- **Epoch Measurements**
- **Network Adjustment**
- **Remaining 6. O.Points Polygon Points Boundary Points by: Interpolation**

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**Revue APOS-RTK**

- **TP**: 1st-5th orders: 57,000
- **EP**: 6th order: 270,000
- **Boundary points**: 12,000,000
APOS – Austrian Positioning Service

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<td>CZEPOS</td>
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</table>

Σ = 73 used in APOS

APOS-Trafo GRID by RTCM 3.1:

\[ m_{\text{Pos}} < 0.15 \text{ m}, m_{\text{Height}} < 0.15 \text{ m (3σ)} \]
(for the RTK solution)

AGREF/AREF/TIREF – GPS Epoch Measurements

- IGS Station (= ITRS)
- EPN Station
- EUREF Station: Solution ETRS89 Austria 2002
- GPS Permanent Station APOS
- GPS - Basic Network AGREF/AREF
**Vector Measurements (static) from 1989 - 2009**

- 36,764 control points
  - 28,427 TP (50% 1st to 5th orders)
  - 8,337 EP (4% 6th order)
- 121,897 Vectors (3.3 / Punkt)
- +30,000 EP phot. 2000-2007 (13% of the EP)

**Terr. Measurements from 1910 - 1997**

- 65,431 control points
- 912,371 directions -> 13.9 / point
- 82,412 distances -> 1.3 / point
- 517,091 vertical angles -> 7.9 / point
MGI<->ETRS89 Transformation by use of GRID Models

**NTv2** (National Transformation version 2 - Canada)

- **MGI**: Militär Geographisches Institut, Vienna
- **GK**: Gauß-Krüger Coordinate System
- **GIS grid available as download from the BEV portal free of charge**

**GRID**: ellipsoidal Coordinate System \( \varphi, \lambda \),

**GRID Distance**: 30’x45’ (≈ 1x1 km)

2 Products: GIS GRID NTv2 (only horizontal position)
GIS GRID APOS (3-D)

**GRID values** \( d\varphi, d\lambda, (dh) \) depending on the product

- **Accuracy** < 0.15 m (3σ)

**Base**: 28,120 control points
European Reference Systems in Austria

Precise Levelling Network of Austria

Base: Precise levelling Network
~30,000 points with C-values referring to UELN 95/98

C-Values:
Basic information to derive
H_orth: orthom. heights
H_norm: normal heights

BKG Formula for Height Transformation

H(2000) = H(95) + \alpha_3 - \beta_3 M_0 (LAT - LAT_0) - \beta_2 R_0 (LON - LON_0) - \cos(LAT) \cdot \cos(LAT_0) \\
with:
H(95): height in the reference system [m]
H(2000): height in the target system [m]
M_0: meridian radius of curvature of GRSS80 [m]
R_0: normal radius of curvature of GRSS80 [m]
LAT: latitude in ETRS89 [radian]
LAT_0: longitude in ETRS89 [radian]
LON_0: reference point of the transformation
\alpha_3: translation in the vertical direction [m]
\beta_3: inclination in the latitude [radian]
\beta_2: inclination in the longitude [radian]

BKG: Bundesamt für Kartographie und Geodäsie/Germany
BKG Formula for transformation of national heights into EVRS2000
Source: http://www.crs-geo.eu/en_124226/crseu/EN/CRS_Description/crs-national_node.html?__nnn=true
Transformation of National Heights into Normal Heights of EVRS

Differences \( d = h_n^A - h_n^{BKG} \) minus Height from BKG-formula

National heights: Normal orthometric heights
Precise Normal heights: \( h_n^A = C_{U,E,L,N} / g_n \)
Transformed Normal Heights by use of BKG formula \( h_n^{BKG} \)
30,000 \( d \)-values available

Austrian Gravity Base-Network

Absolutestationen: \( \Delta 40 \)
Absolutestationen: \( \Delta 700 \)
Punkte 1. Ordnung
Punkte 2. Ordnung
Punkte 3. Ordnung
Database for gravity:
54,400 g-values: 1 point/1.5 km²
50% of levelling points with g-values

Interpolation results:
1 rms<±0.2 mgal for reproduction of the basic points
1 rms<±1.0 mgal for interpolated points

The Austrian Geoid 2008

- Global Gravity model: GRACE EIGEN-GL04S
- Terrestrial data:
  - DHM: BEV, Swisstopo, SRTM: 1.4"x2.3"
  - Gravity-values: grid 4x4 km -> 14,001 points
  - Deflection of Vertical: 672
  - Collocation points: GPS/levelling -> 161 points
- Comparison with European Quasi-Geoid solution

Differences: European - Austrian Quasigeoid
Legal Foundations (1)


• Definition of reference system for control points and cadastre (MGI/Gauß-Krüger coordinates)

• Connection between cadastral measurements and the nearest control points is binding (independent of measuring technique)

• GK-coordinates are legally fixed (Grenzkataster) – holds true for about 10% of all parcels in Austria

Legal Foundations (2)

2004: Proclamation of ETRS89 as the official 3-D Coordinate System provided by APOS (Austrian Positioning Service)

2008: Amendment to the legal Act:

• APOS (Austrian Positioning Service) defined as an instrument to realize ETRS89 in Austria

2010: By-law to the legal act (Vermessungsverordnung):

• Use of APOS in combination with ETRS89 coordinates
  Use of another positioning service forces the user to include control points in the field to get the transformation parameters
Thank you for your attention!