

EUREF03: National Report on Austria

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1. Introduction

The department "Control Survey" of the Austrian Federal Office of Metrology and Surveying (BEV) is responsible for the realisation of reference frames for horizontal and vertical control as well as for the establishment and maintenance of the gravity base network and the determination of the local gravity field. There is a close co-operation with the Observatory Lustbühel-Graz (OLG), which belongs to the Austrian Academy of Sciences/Department of Satellite Geodesy. Further co-operations have been initiated with a number of departments of the universities of Graz and Vienna in the field of gravity (geoid determination, Bouguer-map of Austria,...).

The following projects are still in progress:

- Fundamental GPS-Networks
- Automated Real Time Kinematic Network for Positioning
- Transition to ETRS/UTM
- Vertical Control/new height system
- Gravity and Gravity Field Determination

2. Fundamental GPS-Networks and Permanent Stations

The Austrian fundamental GPS-Networks consist partially of traditional markers and partially of permanent stations. Traditional markers are observed occasionally

according to interest and financial facilities. The network AGREF (Austrian Geodynamic REFERENCE) started in 1990 and will be maintained also in the future. Out of these 60 or more markers the former EUREF markers were chosen. However, users preferred to use data of permanent stations, therefore a new Austrian EUREF network based on permanent stations is proposed. It should be pointed out that AGREF is observed with the same quality as a EUREF network. The repeated measurements of 2001/02 show no significant tectonic movements which means possible movements within Austria are at the level of 1mm/year or less.

2.1 Permanent Stations

The number of permanent stations increases each year reaching about 50 at the end of the decade. In 2003 19 stations are established, five of them (GRAZ, HFLK, LINZ, PFAN, SBGZ) having international status in IGS or EPN (Fig. 1). All stations follow the standards of the EPN and will be maintained in the future despite current problems of inactivity. A couple of them is proposed as the new EUREF network in Austria using observations of one week in 2002. As usual all permanent stations have multi-purpose functions, like maintenance of the reference, investigating tectonic movements, providing data for local surveying and future DGPS and RTK services.

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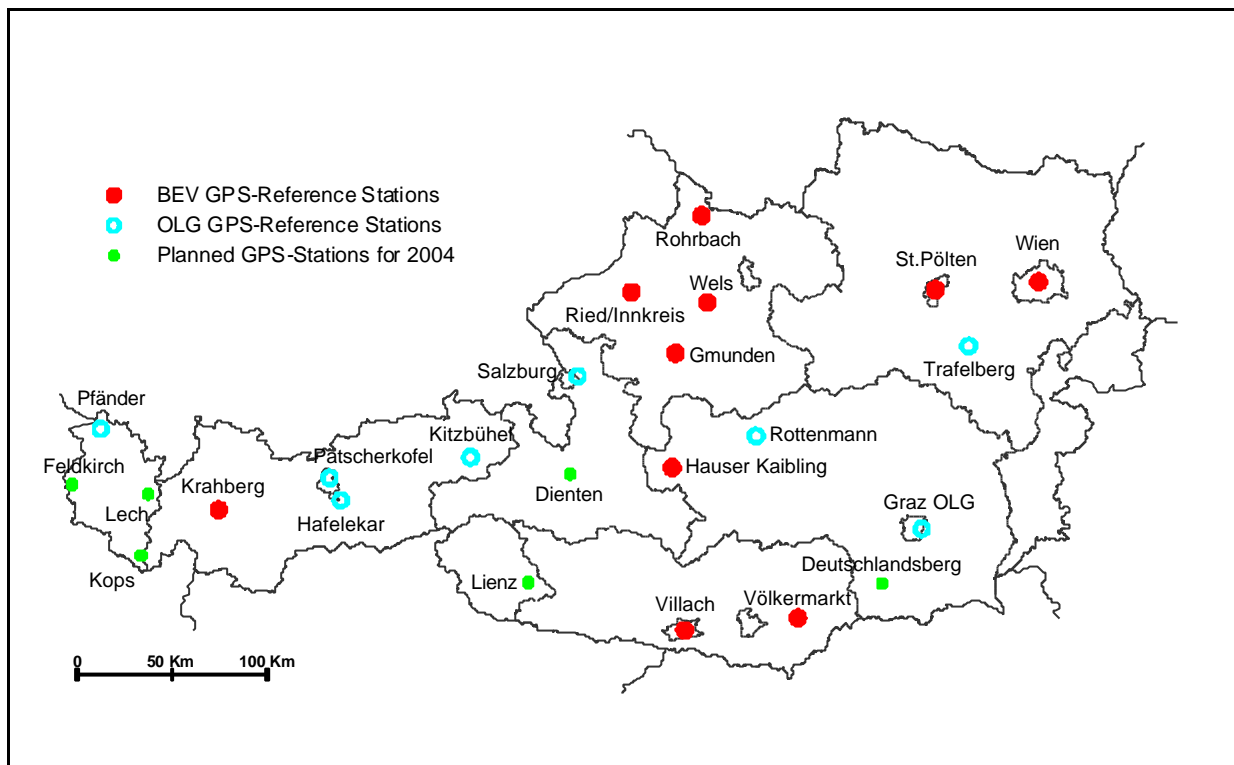


Figure 1: GPS-Permanent Stations of BEV and OLG in Austria (2003-05)

2.2 EUREF Data and Analysis Centre OLG

OLG monitors three international and one national network at a weekly basis. All networks are processed using the standards of EPN. The local data centre OLG provides data of international and national stations including a complete mirror of the BKG data centre for EPN. The four networks are

- **EUREF** (EUREF sub-network OLG), the official sub-network for EPN, approximately 40 stations from the polar region to the Near East,
- **ARE** (Austrian Reference Extended), network for tectonic investigations of central and eastern Europe, including all permanent CEGRN stations,
- **MON** (Monitoring network of the Balkan, Anatolia and Near East region, EUREF region VI), the contribution to the EPN special project,
- **DGPS-A** (Differential GPS Austria), all public GPS permanent stations within Austria, about 20 stations.

2.3 ETRF-AUSTRIA2002

OLG and the Technical University of Vienna computed a new EUREF campaign using the permanent stations of EPN and IGS together with six new sites (Fig.2). HUTB (=AT01) was a former EUREF marker which was re-observed in 2002. The remaining five sites are permanent stations where data of one week have been used for this “campaign”. Austria is applying for exchange of the former EUREF network to this new one at the symposium 2003 [1].

2.4 CERGOP-2

EU supports a new project for investigating the region of Central Europe from the Baltic Sea to the Mediterranean concerning tectonics, natural hazards and permanent monitoring. The contractors are from 14 countries, mainly candidates for EU membership in 2004. Starting in 2003 the project lasts for three years. At the first meeting the contractors expressed their willingness to follow generally the standards of EUREF and the EPN.

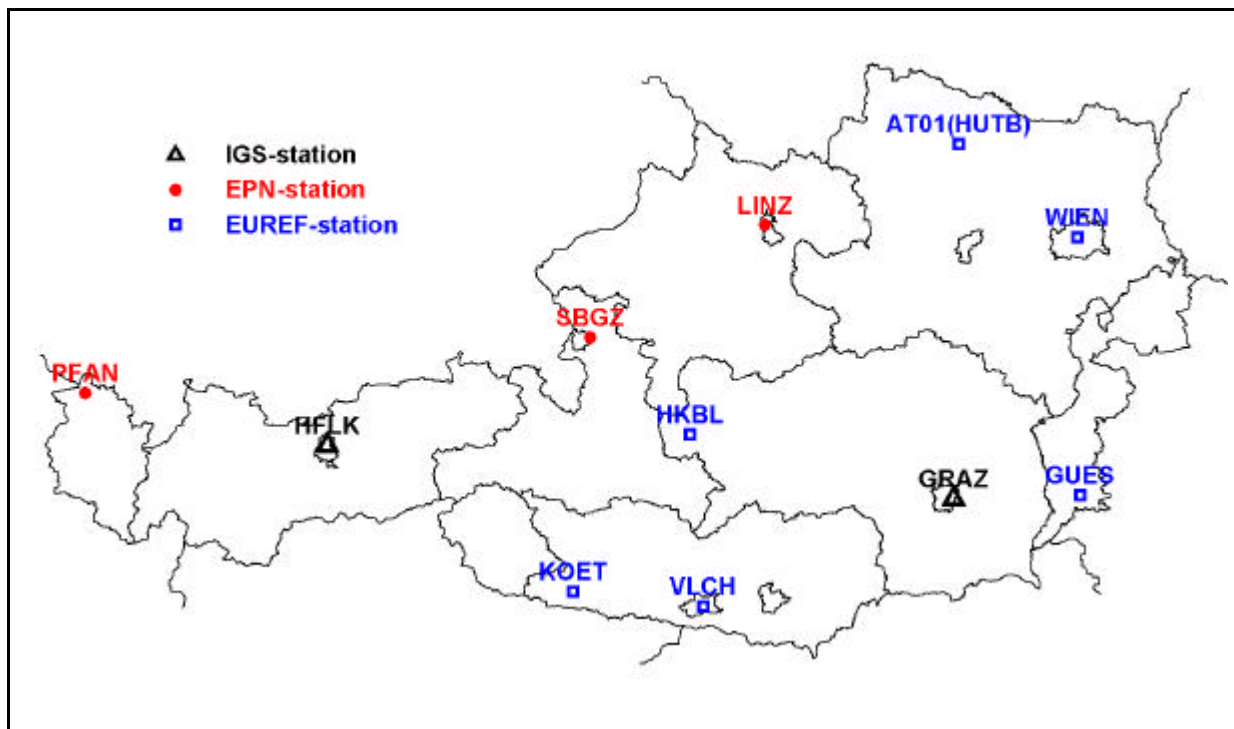


Figure 2: IGS, EPN and EUREF-Stations in AUSTRIA

3. Transition to ETRS/UTM - state of the work

The Austrian National Survey (BEV) is running a project aiming at the final introduction of the international reference system ITRS/ETRS as the national reference for all geodetic and mapping applications in Austria. In future the UTM projection will serve as a basis of the transition to 2-dimensional co-ordinates.

The realisation of the European System ETRS89 in Austria is based on the following national GPS densification campaigns:

- ETRF-Austria2002: (see chapter 2.3),
- AGREF (Austrian Geodynamic Reference Frame): finished in 1997; updated in 2001/2002,
- AREF (Austrian Reference Frame): This campaign was performed in 1996 by an alliance of private firms in co-operation with the BEV. 330 points with a mean distance of 25 km were measured in 24 hours' sessions. The Department of Advanced Geodesy of

the University of Technology, Vienna and the Department of Satellite Geodesy of the Institute for Space Research (OLG) performed the adjustment and the analysis of the campaign. The results are finally available and have been in the responsibility of the BEV since 2002,

- Remeasurement of selected 5th order points: to stabilise and strengthen the existing triangulation network of 1st to 5th orders (about 52.000 triangulation points = TP) it is necessary to remeasure a subset of about 20.000 of these triangulation points.

In the meantime the corresponding measurements in the Federal Provinces of Vorarlberg and the Tyrol have been finished. Homogeneous ETRF89 co-ordinates of all triangulation points are only available for Vorarlberg at the moment. The measurements in Carinthia and Burgenland will be finished by the end of this year. The presentation of a final set of ETRF89-coordinates for the whole area of Austria is planned for 2005/2006, combined and commonly adjusted to

existing trigonometric measurements. These final ETRF89 co-ordinates will supplement and probably substitute the inhomogeneous Gauß-Krüger co-ordinates now in use which have long wave length distortions of 1 m and more, and high frequency distortions in the 2-3 dm level.

4. Vertical Control

In order to be able to use modern surveying techniques such as GPS for height determination, it is necessary to use a well-defined height system. Therefore the existing normal orthometric height system will be improved by the introduction of a new orthometric height system. The improvement of the height system involves 3 different steps:

4.1 Precise Levelling Information

The UELN-95/98 (ver. 13) solution served as a basis for the computation of the C-values for all precise levelling points in Austria. The adjustment of the C-values was performed as a constraint one, with reference to the UELN reference points situated on the Austrian territory. To determine the mean gravity g^* value along the plumb line, intensive research was carried out.

The Kepler interpolation method has proved to give the best results and was therefore applied (valid for an altitude below 1400m). Consequently the gravity for 3 points that were placed at an equal distance along the plumb line were used to calculate the mean value. For the weights the relationship 1-4-1 was chosen; for points above 1400 m altitude the Simpson rule has to be applied, that means 5 points placed at an equal distance along the plumb line are used and the weights for the gravity values of these points are 1-4-2-4-1. The differences of the g^* values computed by means of the Kepler method or according to the Simpson rule in comparison with a g^* value computed by

use of 20 intermediate points along the plumb line are smaller than 1.1 mgal [2].

The computation procedure of C- and g^* -values for all precise levelling points in Austria (about 30.000) has now been finished. That means orthometric as well as normal heights are now available for each precise levelling point in Austria.

First internal use of the orthometric heights was made for the computation of the Austrian geoid surface and for the improvement of the height information of the triangulation points. External use was made for the planning of the "Brenner Basis Tunnel" situated between Austria and Italy.

Before the new orthometric height system can be introduced in Austria it is necessary to improve the height information of the triangulation points as well as the geoid.

4.2 Triangulation network 1st to 5th orders

The recalculation of the triangulation network also includes the height component. The use of GPS-, vertical angle-, distance measurements and vertical deflections in a combined adjustment will lead to improved ellipsoidal heights for all triangulation points 1st to 5th orders in Austria.

4.3 The Austrian Geoid

A refined version of the Austrian geoid with the working title "GEOID 2000" will be released after the IAG General Assembly in Sapporo [3]. The project was worked out in a co-operation of the Federal Office of Metrology and Surveying (BEV) in Vienna and the Technical University of Graz, Institute of Geodesy.

The first high resolution geoid determination in Austria was performed in 1987 using a set of more than 650 deflections of the vertical. In 1998 a reasonable amount of gravity data was available, too, so that a gravimetric geoid could be computed. A combination of both data sets, supported by GPS and levelling

was presented during the meeting of the Gravity and Geoid Commission (IGGC 2002) of IAG section III in Thessaloniki, Greece in August 2002. This investigation showed a remarkable increase of the accuracy.

Nevertheless, certain differences between the two solutions (gravity, astro) were not at all satisfactory and consequently a special GPS-campaign was initiated in October 2002. This fact also led to some new levelling connections and an examination of the stability and identity of the observed points. The result of the GPS campaign is a set of 102 points, located with high precision in the frame of AGREF/AREF (the Austrian GPS reference frame), which represents the Austrian densification of EUREF/ETRS89. All points were measured in at least 24 hours' sessions over the past decade. 50% of the points were occupied in two independent sessions. Therefore the corresponding ellipsoidal heights could be estimated with an rms of $\pm 1-2$ cm.

By combining the astrogeodetic and gravimetric data sets, using remove-restore

and least squares collocation, and the comprehensive new GPS/levelling information a refined calculation of a new version of the Austrian geoid was possible. The high accuracy of the available GPS-derived ellipsoidal heights as well as the high quality of orthometric heights recalculated within the new Austrian height system served as a basis for this calculation. Therefore the new Austrian geoid is a combined astro-gravimetric solution, transformed into a best fitting position to the "real" GPS-derived ETRF89-values. For all GPS/levelling points the remaining undulation residuals have been modelled by use of Surfer 32 (Kriging,) in a regular grid of 10km x 10km. The "final" geoidal undulations result in the combination of the undulations of the transformed astro-gravimetric solution with the interpolated residuals. The remaining residuals decrease to a mean value of $\pm 1,4$ cm and mirror the high accuracy of the solution (Fig. 3).

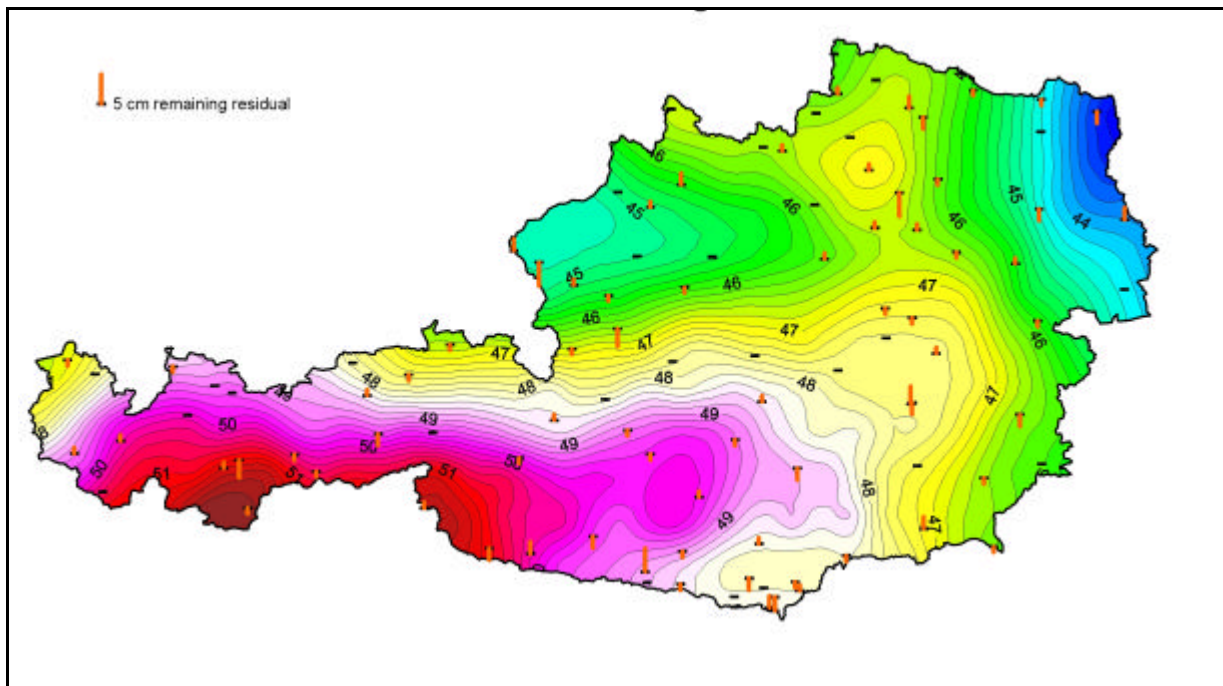


Figure 3: Refined Geoid after Modelling the Residuals

5. Gravity

Austria participates in the new adjustment of the European Gravity network UEGN2002 (Unified European Gravity Network). A lot of new absolute gravity stations which were not included in the solution of UEGN1994 will now strengthen the network.

All available gravity data of Austria will be homogenised by recalculating the reductions with the newest DTM. The mean plumb line gravity values of all levelling points of the orthometric height system are calculated by a more precise algorithms. Within this programme the surface gravity can be predicted for each point with an accuracy better than 1 mGal ($\text{stdv} < 0,19 \text{ mGal}$).

References

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EUREF Stations in AUSTRIA: 2003-05

| EUREF No | CODE | RESPONSIBLE INSTITUTE | NETWORK | PERM./SINCE | GROUND MARKERS | LEVEL. | REMARK |
|----------|-----------|-----------------------|--------------|-------------|----------------|--------|--|
| 61 | GRAZ | OLG | IGS | yes/1992 | 8 | yes | |
| | HFLK | OLG | IGS | yes/1994 | 4 | no | |
| 60 | PFAN | OLG | EPN | yes/1997 | 9 | yes | |
| | (SBGZ) | OLG | EPN | yes/1998 | 2003 | no | suspended at the moment |
| | (LINZ) | MAGL | EPN | yes/2001 | no | no | suspended at the moment |
| | WIEN | BEV | EUREF A2002 | yes/1996 | 1 | yes | EUREF candidate 2003 |
| | HKBL | BEV | EUREF A2002 | yes/2000 | 3 | no | EUREF candidate 2003 |
| | VLCH | BEV | EUREF A2002 | yes/1998 | 2 | 2003 | EUREF candidate 2003 |
| | GUES | BEWAG | EUREF_A2002 | yes/1997 | 2004 | no | EUREF candidate 2003 |
| | KOET | KELAG | EUREF_A2002 | yes/2001 | 2003 | no | EUREF candidate 2003 |
| 93 | HUTB/AT01 | BEV | EUREF89/EUVN | no | 9 | yes | every 2 nd year remeasured in CEGRN |
| 59 | Haid | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| | GERL | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| 735 | GRMS | OLG | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| | GSST | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| | HOPY | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| | MAYB | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |
| | OSWA | BEV | EUREF_A94/95 | no | | | to be withdrawn in 2003 |

OLG: Academy of Sciences /Graz Lustbühel

BEV: Federal Office of Metrology and Surveying/Vienna

BEWAG: Burgenländische Elektrizitätswirtschafts AG/Eisenstadt

KELAG: Kärntner Elektrizitäts AG/Klagenfurt

MAGL: Magistrat Linz