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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. Close co-operation was established especially concerning projects related to satellite geodesy.

Further co-operations have been initiated with a number of departments of the universities Graz and Vienna in the field of gravity (geoid determination, Bouguer-map of Austria,...).

The following projects are still in progress:

- Fundamental GPS-Networks and Permanent Stations
- Transition to ETRS/UTM
- Vertical Control/new height system
- Gravity and Gravity Field Determination

2. Fundamental GPS-Networks and Permanent Stations

CERGOP-2

The results of the 1994, 1995, 1996, 1997, 1999 and 2001 campaigns were recalculated using the EUREF permanent stations available in that region. The recalculation followed the guidelines presently recommended for the EPN. Although the time span for 50% of the about 70 stations is quite short (1-2 years), most of the velocities estimated seem to be reliable compared to NUVEL-1. In 2001 the number of permanent stations outweighed the number of epoch markers for the first time.

Permanent Stations

Three new permanent stations, namely KRBG-Krahberg, WELS-Wels, GRAY-Graz (which is located on the top of the new building of the institute of the Academy of Sciences in Graz) were added to the Austrian GPS permanent network. The GPS sensor in GRAY is collocated with a WVR (water vapour radiometer) of the University of Armed Forces, Munich, Germany, on loan from December 2001 until June 2002. A fourth new permanent station (KITZ-Kitzbuehel) will operate as of July 2002. Some more stations are being planned. All stations record data with a sample rate of 1 second (1 hour packages) and are put at the users' disposal at the Data Centre Graz.

An overview of the stations is given in Figure 1 and Table 1.

EUREF Data and Analysis Centre OLG

Unfortunately the EUREF LDC OLG was hit by several servere crashes, almost all of them related to the public ftpserver. Therefore two public ftp servers (olggps.oeaw.ac.at and geols01.iwf.oeaw.ac.at) are kept in the DMZ (demilitarized zone) to give users the chance to switch from one to the other in case of a breakdown of the system.

The OLG analysis centre computes its four networks according to EPN guidelines each week.

a) ARE (Austrian Reference Extended) -CERGOP from the Baltic Sea to Bulgaria, including all CERGOP permanent stations and some Austrian national stations; two ambiguity fixing strategies (L5/L3 and QIF), about 40 stations

b) EUREF (EUREF subnetwork OLG) from Norway to Israel, L5/L3 ambiguity fixing, about 40 stations

c) MON (Monitoring network of the Balkan, Anatolia and Middle East region, EUREF region VI) from Romania to the Middle East, about 15 stations

d) DGPS-A (Differential GPS Austria), all public GPS permanent stations within Austria, about 15 stations.

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Figure 1: GPS-Permanent Stations in Austria (2002-06)

Table 1: GFS-Fermanent Station Description (numbers in columne NO referes to Figure 1	Table 1:	GPS-Permanent	Station De	escription (numbers in	columne l	NO referes to	Figure .	1)
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NAME	NO	CODE	OPERATED BY	NETWORK	DOMES NR
Pfänder		PFAN	ÖAW	EPN	11005S002
Hafelekar		HFLK	ÖAW	IGS	11006S003
Villach		VLCH	BEV	proposed EUREF	11036S001
Graz (Lustbühel)		GRAZ	ÖAW	IGS	11001M002
Mattersburg	2	MTBG	BEWAG/TU Wien	IGS/IGLOS	11030M001
Wien (BEV)		WIEN	BEV	proposed EUREF	11035S001
Linz	12	LINZ	Mag.Linz/TU Wien	EPN	11033S001
Salzburg		SBGZ	ÖAW	EPN	11031S001
Hauser Kaibling		HKBL	BEV	proposed EUREF	110398001
Kötschach	5	KOET	KELAG/TU Wien	proposed EUREF	
Krahberg		KRBG	BEV		11043S001
Güssing	4	GUES	BEWAG/TU Wien	proposed EUREF	
Patscherkofel		PATK	ÖAW		11029S001
Kitzbühel		KITZ	ÖAW		
Völkermarkt		VLKM	BEV		11040S001
Wels		WELS	BEV		
St.Pölten		STPO	BEV		11041S001
Rottenmann		RTMN	ÖAW	IGS/IGLOS	

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

The Austrian National Survey is running a project aiming at the final introduction of the international reference system ITRS/ETRS as the national reference frame for all geodetic and mapping applications in Austria. The UTM projection will serve as a basis of the transition to 2-dimensional coordinates. Until now the following steps towards the above mentioned objectives have been taken:

GPS-base-network AGREF and additional GPS-measurements

In 1997 the Austrian Geodynamic Reference Frame (AGREF) was finished. This GPS network consists of about 100 reference points. To stabilize and strengthen the existing

triangulation network of 1^{st} to 5^{th} orders (about 52.000 triangulation points = TP) it is necessary to remeasure a subset of about 20.000 of these triangulation points. Until the end of 2001 15.631 TPs have been remeasured by GPS, with reference to the GPS base network (75% of the whole set of about 20.000 TPs). Within a common adjustment of AGREF and the additional GPS-measured TPs, adjusted 3-d co-ordinates will be derived. By the end of 2001 about 10% of the remeasured TPs were computed in that way (the whole Federal Province of Vorarlberg).

Recomputation of existing trigonometric measurements

The existing reference points of 1st to 5th orders, determined by trigonometric measurements, will be included in the frame of AGREF and the remeasured triangulation points. In order to do this computational work, it is necessary to digitize the old measurement data (62% of this work has already been done). The adjustment procedure has been done for the above mentioned region of the western-most part of Austria - the Federal Province of Vorarlberg.

4. Vertical Control

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:

Precise Levelling Information

Every reference point for height, measured by the BEV by precise levelling, will get a geopotential value C by a strong calculation procedure (reference UELN95/98). These C-values serve as a basis for the computation of orthometric heights, but on demand the normal height values are available,

too. During the computation procedure not only C-values for the precise levelling points are computed, but the trigonometric reference points along the levelling line are included as well. 90% of the computation work has been done until 2002-05.

Triangulation network 1st to 5th orders

As mentioned in 3) the recalculation of the triangulation network includes the height component, too. 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. 5% of this work has been done until 2002-05.

Geoid Information

Since 1987 a geoid solution has been available for Austria. This geoid solution has been computed by the use of about 700 deflections of vertical, the accuracy of this first geoid being about \pm (5-10) cm/100km.

The recalculation of the Austrian geoid is now under way and uses the above mentioned deflections of vertical, additional gravity anomalies (6x6km) and modern computation algorithms (least squares collocation). The combination of the results of the new geoid solution with a set of 60 GPS/ levelling control points will be the next step towards the final solution. To find a proper weighting fuction for the different observation sets, is a serious problem and needs further investigation.

5. Gravity

In Obergurgl (1930m) / Tyrol twice a year absolute gravity measurements have been carried out since 1987. The results show increasing gravity values and seasonal differences (see Figure 2).



Figure 2: Gravity changes at Obergurgl (Tyrol)

APPENDIX to the National Report on Austria

Reference Points with 3-d coordinates by GPS and height information derived by levelling

1) GPS

Table 2: GPS measurement and computation information for the collocation points in Austria

Category	No	period	session	software	elev	zenit delav	Ref.	height
Category	110.	period	lengui	sonware	elev.	ueray	System	acc.(IIIII)
			6x24h to				ITRF96	
EUVN	5	1997	7x24h	Bernese 4.0	5/	2h	epoch97.4	± 5
			2x24h to				ITRF94	
AGREF	53	1990-97	3x24h	Bernese 4.0	10/	2h	epoch93.0	±(10-20)*
ADDE	17	1000	10.41	D	10/	21	ITRF94	(10.15)
AKEF	17	1996	1x24n	Bernese 4.0	107	∠h	ep.96.45	±(10-15)
local trig.	about	1990 to		LEICA: SKI				
Points	1500	2001	1x1h	Trimble 4000	15/		ETRF89	±(20-30)

EUVN: European Vertical Reference Network

AGREF: Austrian Geodynamic Reference Frame, published coordinates

* for 1990 measured points: ±(20-40) mm

AREF: Austrian Reference Frame: established by private company, restricted coordinates

2) C-values and orthometric heights

2.1) Availability

C-values: available for 80% of precise levelling pointssystem UELN95/98 (including levelled triangulation points)

Orthometric heights: for each point with a C-value orthometric height can be computed

2.2) Accuracy

) C-values: 0.8 kgal mm/km (UELN95/98 computation Final Report)

C-values: 10-12 kgal mm (reference Amsterdam)

Orthometric height:

$$\begin{split} H_{orth} &= C/g^* \ a \ dH = -C/g^{*2} \ dg^2 \ appr. \ dH = 42,8.h2 \ dD \\ Test \ computations: \ dD &= 5\% \ dH = 5 \ mm \ (H = 1000 \ m \), \\ dH &= 20 \ mm \ (H = 2000 \ m). \end{split}$$

Use of different weights, depending on the elevation of the point, can solve the problem of the height-dependent accuracy of orthometric heights.



Figure 3: Existing collocation points in Austria (measured by GPS and levelling)