## **National Report of Bulgaria**

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## Abstract

The main activities on the EUREF have been outlined. The operation of the existing permanent IGS station near Sofia and the plans and development concerning the establishing of new permanent stations have been briefly presented. Information about the new national coordinate system BGS 2000 and about the prepared standards for its realisation, the improvement of the existing national geodetic network, national GPS network and development of DGNSS – analogous to SAPOS in Germany, has been given. Activities for the preparation of the national levelling network to be included in the data base of the European Vertical System for EVRS realisation, for finalising the work on the EUVN levelling and the connection to the tide gauges have been carried out. The work concerning projects UNI-GRACE, CERGOP-2, the national cadastre and other EUREF activities have been outlined.

## 1. General

The further realisation of EUREF on Bulgarian territory continues in accordance with the resolutions of the EUREF symposia, the adequate needs and possibilities of the country, the international cooperation, the available specialists and their orientation, etc. It is to be regretted that this realisation does not proceed at a better pace. This is due to a considerable degree to the economic transition in the country and the awareness on behalf of the government and the leading specialists for its realisation with an accelerated rate. Nevertheless, the realisation is in progress in the right direction. The main aspects of the EUREF realisation are focused on: standardisation, including the National Geodetic System 2000; the National GPS Network, the development of the permanent station system and the establishment of DGNSS, the integration of the National Levelling Network with the European one and the preparation for the EVRS implementation, the development of a National Gravity System and Geoid, the realisation of a Unified Geodetic Network of the country, problems related to the cadastre development, geodynamic studies, etc.

### 2. Permanent Stations

At the present moment there is one EUREF and IGS permanent station in Bulgaria – the Sofia Permanent Station (SOFI). The available information about it can be found in the National Report of Bulgaria at the EUREF Symposium held in Dubrovnik [MILEV et al. 2000] and in the website

#### of EUREF (file sofi0010.log).

The establishment of two other permanent stations is envisaged within the framework of the CERGOP-2 project with the financial support of the EC. At the same time other projects are developed for the realisation of the DGNSS systems in Bulgaria with a pilot project for the Sofia City and a network of 28 reference permanent stations in the country (see paragraph 5).

# 3. The New Coordinate System in Bulgaria and its Introducing as a Standard

The implementation of EUREF in Bulgaria is regulated by an Act of the Council of Ministers. For this purpose a special decree was enforced, which was coordinated with the ministries and institutions in the country (A decree of the Council of Ministers RB 140/4.06.2001 for defining of the Bulgarian Geodetic System 2000). The execution of this decree is assigned to the Ministry of Regional Development and Public Works and the civil National Geodetic Service (the Directorate of Geodesy and Cartography) is affiliated to it.

The geodetic system on the territory of Bulgaria, named Bulgarian Geodetic System 2000 (BGS 2000), includes:

- Fundamental geodetic parameters determined in the geodetic reference system 1980 (GRS 80);
- The geodetic coordinate system ETRF-89, realised by the European geodetic network EUREF;
- Vertical system realised by the levelling benchmarks of the State Levelling System, determined in connection with the European Unified Vertical Network (EUVN) by means of data about the gravity force in an unified gravimetric system;
- A system of plane map coordinates based on ETRF-89 and the conformable conic projection (Lambert projection) with two standard parallels and one central meridian, which is used for all civil applications;
- An international system for gridding and nomenclature of the map sheets up to scale 1:2000 including.

The Bulgarian Geodetic System 2000 is materialised by a network of geodetic points. The cadastre map of the country is created and maintained on the basis of the Bulgarian Geodetic System [MILEV et al. 2001].

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The following activities have been carried out with respect to the decree execution:

The optimal parameters for the Lambert conical projection have been determined.

An Instruction have been prepared for the implementation of BGS 2000. A preliminary project for the National GPS Network has been developed according to the instruction. The funding of this project is envisaged to be performed by the World Bank and by the national budget.

The corresponding software is being developed too.

All problems concerning the main parameters of the system and the map projection related with it, are given in the instruction as well as the basic formulas used for the calculations, the gridding and nomenclature of the large-scale topographic maps, the practical steps for introducing the system, the basic concepts for the National GPS System development on the territory of Bulgaria, the transformation of the coordinates of all points and maps from the system 1970 in BGS 2000.

- 1. General concepts
- 2. Parameters of the System 2000
- 3. Geodetic (map) projection of the Bulgarian Geodetic System 2000

- 4. Development of a national GPS network
- 5. Transformation of the GPS coordinates of the points of the National GPS Network in the new projection, calculation of the ellipsoid heights of the points
- 6. Introducing the European Vertical System
- 7. Transformation of the coordinates and elevations
- 8. Gridding and nomenclature of the maps
- 9. Transformation of the topographic and cadastre plans in the new system
- 10. Creation of a national geodetic, photogrammetric and cartographic archive
- 11. Protection and maintenance of the points of the national GPS network
- 12. Recording and checking the condition of the points
- 13. Annexes 25 items

Meanwhile the Law for the classified information was published in 2002, so eliminating the secrecy related with the data concerning coordinates, maps, gravity force, etc.

## 4. National GPS Network

The development of the preliminary project for the establishment of the National (State) GPS Network was started within the framework of the project for the cadastre development in Bulgaria supported by the World Bank [MILEV et al. 2001]. The preliminary project of the network was completed in 2002.





According to this project the network will comprise the 7, respectively 15 EUREF stations on the territory of the country (BULREF). Another 442 GPS points will be added to them,

113 being from the primary and 329 – from the secondary GPS network. It is envisaged that the points from the network will be determined in such a manner that they will be if

possible simultaneously (collocated) GPS points, points from the State Geodetic Network (SGN), from the State Levelling and Gravity Network. A scheme with the points of the preliminary project for the National GPS Network is presented in Fig. 1.

Points of the State GPS Network

The explanatory note of the project contains the requirements, reconnaissance, monumentation of the points, the equipment and data acquisition, the data processing and analysis, the necessary resources, the transformation of the point coordinates from the State Geodetic Network in the National GPS Network, etc.

GPS points [number]					Total
Class I and II from SGN	Class III and IV from SGN	Local GN	for construction		
			Gravimetric stations	Other	
134	249	9	47	4	442

## 5. DGNSS in Bulgaria – an Analogue of the German System SAPOS®

The multifunctional differential GPS systems (DNSS) have been introduced in many countries in the world and especially in Europe, as for instance the Satellite system for position determination in Germany (SAPOS). The multifunctionality and effectiveness of this system and especially its application in geodesy and cadastre have been generally acknowledged [4. SAPOS Symposium, 2002]. The necessity and expediency of realising the SAPOS analogue – DGNSS in Bulgaria has already been understood and active work is in progress for this realisation [MILEV, 2002].

Two projects have been suggested and developed on the basis of the already established cooperation between Bulgarian geodesists and the Berlin Senate – a pilot project for the Sofia City and a project for implementing an analogue of the SAPOS<sup>®</sup> system in Bulgaria.

The aim of the pilot project for developing an analogue of the SAPOS<sup>®</sup> system for the region of the Sofia City and for the reference station network in the whole country, is to ensure the determination of spatial position and orientation in a unified homogeneous reference system (ETRS89) for solving geodetic and cadastre problems. The projects will also contribute to the development of numerous other applications in management, legislation and economy.

The realisation of the project includes a DGNSS service for transferring the corrections to the users by means of different media (UKW/RDS, GSM/GPRS and the Internet).

## 6. European Vertical Reference System

#### 6.1. Preparations for Including the National Levelling Network in the Data Base of the European Vertical System

The realisation of the European Vertical Reference System (EVRS) on the Bulgarian territory is determined by the successful incorporation of the National Levelling Network together with the supplementary information in the UELN database. For this purpose the data from the first order levelling network of the country were prepared according to the requirements. The differences between the geopotential numbers of the levelling benchmarks, the latitude and longitude and the normal heights of the benchmarks in the Baltic Vertical System were determined. Special preparations are made for the connection of the levelling with the neighbouring countries and Romania in particular, since the connection with UELN will be realised through it. In general, the separate steps of this preparation are:

- Presenting the information from the State Levelling Network in a suitable form for further computer processing
- Calculating the differences between the geopotential numbers
- Determining the geographic coordinates of the benchmarks
- Preparing the network information in a suitable form for processing by means of the EXCEL software too
- Structuring the information in a suitable form for direct input in the UELN data base
- More precise determination of the connection between the levelling networks of Romania and Bulgaria.

#### 6.2. EUVN Levelling, Connection to the Tide Gauges

The territory of Bulgaria is included in the EUREF project European Vertical reference Frame (EUVN) by means of three stations. The points BG01 and BG04 are special pillars for GPS measurements, situated at the Black Sea coast in the vicinity of the tide gauges in the cities of Bourgas and Varna respectively. The point BG03 is the pillar, on which the antenna of the permanent GPS station near the Sofia City has been installed. The values of the gravity were measured for the three pillars during the development of the UNIGRACE project of the <sup>1</sup>/<sub>4</sub>OPERNICUS programme. Their normal heights were determined too. Vertical connection with the initial benchmarks of the tide gauges was realised with the pillars. The monthly values of the average sea level were determined for the period 1997-2000. They were submitted to the Centre, processing the EUVN data in France. The data for the tide gauges for the period 1928-1996 are available in PSMSL in the UK.

## 7. EUREF Related Activities

Bulgaria participates actively in the work carried out within the framework of IAG Section V "Geodynamics", the programme "Geodetic and Geodynamic programms of the Central European Initiative (CEI)" and the Central European Regional Geodynamic project, which was financially supported by the FP5 of the EU under the name CERGOP–2. Work groups were created in this project for the geotectonic analysis of the region of Central Europe. A special new group was created – Geodynamics of the Balkan Peninsula. The first contribution of this group will be the symposium "Geodynamics of the Balkan Region" within the framework of the 3<sup>rd</sup> Balkan Geophysical Congress, which will be held in Sofia, Bulgaria on June 24-28, 2002.

The complex measurements related with the project are made periodically every two years using the specially developed GPS network CEGRN (which is already a consortium). The participation of Bulgaria in this programme and these projects is based also on four points from the EUREF system. Two monographs dedicated on the geodynamics in Bulgaria were published in Report on Geodesy, Warsaw, in connection with the earthquakes in two of the most active seismic regions on the Balkan Peninsula and in Europe. Further GPS measurements are envisaged for the points from the Central European region and the Balkan Peninsula. Some of these points are EUREF ones too.

Three absolute stations were built as a result of the UNIGRACE project development within the framework of the COPERNICUS programme. The gravity in these points was determined as well as the geopotential numbers of the points in Bulgaria, included in EUVN.

The National Geodetic Network is being improved on the basis of GPS and EUREF in connection with the work on the project for the cadastre and real estate inventory in Bulgaria, financially supported by the World Bank.

Parallel to the above mentioned activities, some others works have proceeded in connection with land reform in Bulgaria, geodynmaic studies in some regions of the country, engineering GPS applications, etc. The 5<sup>th</sup> edition of the book "GPS, Theory and Practice" (B. Hofmann-Wellenhof, H. Lichtenegger and Collins, Springer Wien New York) has been translated and published in Bulgarian language.

## 8. Conclusions

The described activities in Bulgaria within the EUREF framework mainly after the Symposium in Dubrovnik, Croatia show that the Bulgarian geodesists continue their hard work in this respect. The emphasis is laid on the further efficient realisation of the programme and the reference system of EUREF. The work continues in accordance with the resolutions of the EUREF symposia, the respective needs and possibilities of the country, the international and bilateral cooperation, the specialists available and their orientation, etc. There are inevitable problems and the realising of some national projects proceeds at a lower pace. This is determined to a great extent by the economic transition in the country and the awareness on behalf of the government and the leading specialists that the realisation should be accomplished with accelerated rates. Regardless of the obstacles, the realisation is in good progress in the right direction.

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