

**IAG Commission 3 “Earth Rotations and Geodynamics”
Subcommission 3.2 “Crustal Deformation”**

PROGRESS REPORT

on

**ACTIVITIES OF THE IAG PERMANENT STUDY GROUP
“GEODYNAMICS OF THE CENTRAL EUROPE”**

Janusz Sledzinski

Chairman of the

of the Subcommission 3.2 “Crustal Deformation”

of the Commission 3 “Earth Rotations and Geodynamics”;

International Coordinator of the CEI WGST Section C “Geodesy”.

REPORT COMPILED FROM CONTRIBUTIONS

SUBMITTED BY FOLLOWING WG MEMBERS:

**A.Caporali, P.Dumitru, M.Fadur, I.Fejes, J.Hefty, G.Milev, M.Mojzes, T.Rus,
G.Schmitt, K.Vassileva, F.Zablotskij**

**Report presented at the General Assembly
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IAG Subcommittee 3.2 “Crustal Deformation” of the Commission 3 “Earth Rotations and Geodynamics”

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Abstract.

The Report includes concise information on recent geodetic and geodynamic projects that are realised by the members of the IAG WG “Geodynamics of the Central Europe” in the frame of different international projects. Most of the members of the Group cooperate with the CEI (Central European Initiative) WG Science and Technology Section C “Geodesy”. This is an organisation of 17 European countries that has a wide geodetic and geodynamic programme coinciding with what is listed in the charter duties of the IAG Permanent Working Group. Several international projects realised within the CEI Section C “Geodesy” were financially supported by the European Commission (CERGOP-1, CERGOP-2, UNIGRACE). In this Report there are outlined the main achievements of the international geodynamic project CERGOP (Central Europe Regional Geodynamics Project) realised within the time 1994 –2006. The establishment and maintenance of the Central European GPS Reference Network (CEGRN) consisting of about 100 sites on the territory of European 14 countries was performed with an accuracy of 2-4 mm in horizontal coordinates and 4-8 mm in vertical coordinates. Since 1994 nine epoch five-day monitoring satellite GPS CEGRN campaigns were carried out in 1994, 1995, 1996, 1997 (CERGOP-1) and 1999, 2001, 2003, 2005 and 2007 (CERGOP-2). Second phase of the project CERGOP was concluded in 2006.

Another CEI project UNIGRACE (Unification of gravity systems in Central and Eastern Europe) consisted in establishing seventeen absolute gravity stations covering the area from the Baltic Sea to Adriatic and the Black Sea forming the excellent frame for connection of all national gravimetric networks and providing the unified precise gravity frame in Central and Eastern Europe. The gravity observations were made by five absolute gravimeters from Austria, Finland, France, Germany and Poland. Two observation campaigns of the Project UNIGRACE have been successfully concluded (1998/1999 and 2000/2001).

The programme of activities of the Section C includes also the activities of the Working Group on Satellite Navigation Systems and actions realised by the Working Group on University Education Standards. The close cooperation links with EGS/EGU (European Geophysical Society/European Geosciences Union) existing since 1997 are outlined.

1. LIST OF THE MEMBERS OF THE IAG PERMANENT WORKING GROUP “GEODYNAMICS OF THE CENTRAL EUROPE”

Each member of the Permanent Working Group is involved in and is responsible for a definite area of the activities.

- Janusz Sledzinski (Poland) - Chairman of the Subcommission;
- Jozsef Adam (Hungary) - links between national geodetic/geodynamic networks and EUREF;
- Asim Bilajbegović (Bosnia and Herzegovina) – geodynamics of Dinarides and Adriatic Sea;
- Stefan Cacoń (Poland) - geodynamic research of the region of Sudetes;
- Alessandro Caporali (Italy) – geodynamics of the area covered by the CERGOP;
- Istvan Fejes (Hungary) - links between CERGOP and other geodynamic IAG projects;
- Dumitru Ghițău (Romania) - information on kinematics of the Romania regions;
- Jozef Glazek (Poland) – information on new studies on geologic structures in Central Europe;
- Gyula Grenerczy (Hungary) - geodynamic investigations in the Pannonian Basin;
- Jan Hefty (Slovakia) - problems of coordinate systems, EUREF, ITRF and ETRF;
- Dumitru Ioane (Romania) - joint research of geodesists, geologists and geophysicists in Romania;
- Claudio Marchesini (Italy) - information on research of Eastern Alps and the North and Eastern parts of Adriatic Sea;
- Iginio Marson (Italy) - interregional gravimetric connections, gravimetric projects of IAG/CEI;
- Damir Medak (Croatia) - information on the research in the geodynamic test area Plitvice Lakes;
- Georgi Milev (Bulgaria) - information on geodynamic research in Balkan Peninsula;
- Marcel Mojzeš (Slovakia) - geodynamics of the Tatra Mountains;
- Medzida Mulić (Bosnia and Herzegovina) – geodynamics of the region of Bosnia and Herzegovina;
- Vasile Nacu (Romania) – geodynamic research of the Romanian region;
- Peter Pešec (Austria) - geodynamic use of CEI permanent GPS stations within IGS programmes;
- Bosko Pribičević (Croatia) - information on the research in the geodynamic test area Plitvice Lakes;
- Jerzy Rogowski (Poland) - geodynamic use of CEI permanent GPS stations within IGS and other IAG programmes;
- Tiberiu Rus (Romania) – contribution of Romanian GPS permanent stations to the Balkan geodynamic investigations;
- Vladimir Schenk (Czech Republic)- information on geophysical and geological research in the region of Sudetes;
- Guenter Schmitt (Germany) - information on kinematics of the Romania regions;
- Jaroslav Šimek (Czech Republic) - problems of homogeneity and time changes of precise levelling networks and vertical datum in Central Europe.
- Guenter Stangl (Austria) - determination of velocity vectors for the area of Central Europe;
- Korneli Tretyak (Ukraine) – geodynamics of the region of the Pik Pop Ivan in Charnohora;
- Keranka Vassileva (Bulgaria), - information on geodynamic research in Balkan Peninsula;
- Francesco Vespe (Italy) – geodynamic research in Central and Eastern part of Mediterranean area, problems of coordinate and height systems;
- Florjan Vodopivec (Slovenia) – geodynamics of Northern Adriatic Sea and Eastern Alps region;
- Fedor Zablotkij (Ukraine) - geodynamics of the Northern Carpathians.

2. GENERAL CHARTER DUTIES OF THE WORKING GROUP

The general charter duties of the Working Group are the following:

- to integrate the geodynamic research in the region of Central and Southern Europe based on high accuracy space geodetic surveys and to provide a precise geodetic reference frame for studies on geodynamics of Central Europe, in particular on areas Pannonian Basin, Bohemian Massif, Teisseyre-Tornquist Zone, Carpathian Orogenic Belt, Subalpine Region and Balkanides;

- to provide a reliable three-dimensional tectonic velocity field covering the Central Europe region and integrate it into hierarchically higher level (i.e. global) tectonic models as well as to prepare and publish geotectonic monographs highlighting and summarizing the latest research and studies on regions under study;
- to contribute to other geodynamic programmes organised and coordinated by International Association of Geodesy related to the region of Central Europe, such as EUREF, WEGENER.
- to support local area geodynamic research, environmental studies, seismic hazard assessment, meteorology etc. in Central Europe region based upon the high accuracy space geodetic measurements carried out on an integrated geodynamic network of permanent GPS stations in CEI countries;
- to coordinate and to integrate the international geodetic and geodynamic programmes supported by IAG and CEI;
- to create close links between running projects of IAG and those of CEI, e.g. CEI CERGOP - Central Europe Regional Geodynamics Project and IGS (International GPS Service) and EUREF (European Reference Frame), use of CEI permanent GPS stations within IGS and other programmes for maintenance of the ETRF and ITRF, etc.;
- to initiate common geodetic and geodynamic projects for the region of Central and Eastern Europe;
- to foster the cooperation among universities and research centres from Central Europe and Western countries in the field of geodesy and geodynamics, promoting actions contributing to the development of innovative technologies and participation of CEI scientists in international IAG research programmes;
- to organise scientific symposia, working conferences and workshops on geodetic, gravimetric, geodynamic programmes and satellite techniques to discuss results and future planned actions (e.g. Working Conferences of the programmes of CERGOP - Central Europe Regional Geodynamics Project, UNIGRACE - Unification of Gravity Systems in Central and Eastern Europe, Symposia "GPS in Central Europe, etc.).

3. CONCISE INFORMATION ON CENTRAL EUROPEAN INITIATIVE

In November 1989 the Foreign Ministers of Austria, Hungary, Italy and Yugoslavia at the conference in Budapest founded an organisation named QUADRAGONALE. A few months later, in April 1990 (Vienna) former Czechoslovakia joined this organisation forming the PENTAGONALE and in July 1991 at the conference of Prime Ministers in Dubrovnik Poland was admitted creating the HEXAGONALE. In July 1992 the HEXAGONALE was renamed as Central European Initiative. Violent political development in Europe, break-up and civil war in Yugoslavia, disintegration of Czechoslovakia, formation of new countries in the region of Eastern and Southern Europe, all these events caused considerable changes in organisation and international cooperation within the Central European Initiative. The current (as on 1.06.2007) status of the CEI membership is the following: Albania, Austria, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Hungary, Italy, Macedonia, Moldova, Poland, Romania, Serbia and Montenegro, Slovakia, Slovenia and Ukraine.

The main objectives of the CEI cooperation are to encourage dialogue and cooperation in the region, to strengthen the stabilisation within the region of Central Europe, to promote all-European integration processes, to bring its non-EU members closer to the European Union and to avoid the creation of new divisions among advanced and less advanced countries as well as to help the Central and Eastern European countries in entering the integrated world by adjusting their multi-lateral relations to Western European standards.

The CEI is an intergovernmental organisation of 17 European member countries operating through the annual meetings (usually in November every year) of the Heads of Government and the Ministers of Foreign Affairs. The annually rotating CEI presidency is assisted by the CEI Executive Secretariat in

Trieste, Italy. It has the legal status of an international organisation and is responsible for the administrative and conceptual support in the preparation and follow-up activities. The CEI Secretariat for CEI Projects is located in the CEI-ES Headquarters in Trieste and maintains a permanent office at the EBRD, London, with the task of assisting the CEI with economic, strategies, investment projects, international events and programmes, including the organisation of the CEI Summit Economic Forum.

Working Groups constitute the basic structural component of the CEI. They plan and approve initiatives, agreements and projects which they promote and complete in cases requiring financing, or which they pass to the National Coordinators or Foreign Ministries for approval and financing. At the moment there are 17 CEI Working Groups organising the international cooperation of all 17 CEI member countries in different fields: Geodesy and other geosciences are represented in the Working Group “Science and Technology”. There are three sections: Section A – Geology, Section B – Geophysics and Section C – Geodesy”. In this paper we report programmes and achievements just this Section C.

In the international cooperation in geodesy and geodynamics take part almost all CEI member countries. At the moment (as on 1 August 2005) the scientists from thirteen CEI countries are very active and participate for years in many actions initiated and organised by the Section. Up to now four CEI member countries do not participate in realisation of Section C programmes. They are Albania, Belarus, Macedonia and Moldova. We do hope that also these countries would be able to undertake the cooperation in the near future. On the other hand two other non-CEI countries, Germany and Finland, closely cooperate in realisation of CEI geodetic and geodynamic programmes.

4. PROGRAMME OF ACTIVITIES OF THE WORKING GROUP

Very active international cooperation of the WG teams is noted in the following areas:

➤ **Geodetic and geodynamic programmes**

• **Regional European programmes:**

- CERGOP = Central Europe Regional Geodynamics Project;
- CEGRN = (Central European GPS Reference Network) Consortium,
- Post-UNIGRACE action (Unification of gravity system in Central and Eastern Europe).

• **Local geodynamic projects**

- projects realised by the subgroups of the CERGOP Study Group CSG.5 “Geotectonic Analysis of the Region of Central Europe”; they concern the following regions:
 - Eastern Alps and the North and Eastern Adriatic Sea,
 - Romania Plate,
 - Pannonian Basin;
 - Plitvice Lakes, Croatia;
 - Tatra Mountains;
 - Northern Carpathians;
 - Balkan Peninsula;
- projects realised in bilateral/multilateral agreements of CEI countries, e.g. Czech-Polish-Slovak Cross-Border Studies of Regional Geodynamics (Sudetes, Beskydy, Tatra, Pieniny Mts);

➤ **Activities of the Working Groups on University Education Standards and on Satellite Navigation Systems**

➤ **Cooperation with other scientific organisations - European Geophysical Society (EGS)/European Geosciences Union (EGU).**

Below there is given a concise information on the status of realisation of some selected projects and some gained achievements.

5, PROJECT CERGOP (Central Europe Regional Geodynamics Project)

Project CERGOP (Central Europe Regional Geodynamics Project) was initiated in 1993 by the scientists from FÖMI Satellite Geodetic Observatory Penc (Hungary), the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology and the Space Research Centre of the Polish Academy of Sciences. It was approved for realisation by the CEI member countries in May 1993 in Książ Castle, Poland. Eleven countries participated in the first phase of the Project: Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Romania, Slovakia, Slovenia, Ukraine. In the years 1995-98 the European Commission supported CERGOP in the frame of the COPERNICUS programme.

The first phase of the Project was concluded in 1998 and the second phase of the Project CERGOP-2 "A Multipurpose and Interdisciplinary Sensor Array for Environmental Research in Central Europe (CERGOP-2/Environment)" was concluded in 2006. The Project was financially supported by the European Commission.

The general objectives of the Project were the following:

- to integrate the geodynamic research in the region of Central Europe based on high accuracy space geodetic surveys and an integrated geodynamic network;
- to provide a precise geodetic frame - so called Central European GPS Reference Network (CEGRN) – for geodynamic research in the region of Central, Eastern and Southern Europe;
- to provide the velocity (displacement) vectors of the area under study;
- to initiate studies on local geodynamics of some areas of Central Europe,
- to collect satellite observations for studies and interpretation of geodynamic interactions in Central Europe;
- to foster the international cooperation among research groups of participating countries;

The programme and scope of work of the second phase of the Project has been considerably enlarged.

As main achievements of the CERGOP we can mention:

- Establishment of the Central European GPS Reference Network (CEGRN) of the highest accuracy standard - 2-4 mm in horizontal coordinates and 4-8 mm in vertical coordinates; it consisted of 35 European stations in the first phase of the Project and about 100 stations in the second phase. The CEGRN covers the area of the following countries: Austria, Bosnia&Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Italy, Romania, Poland, Slovakia, Slovenia and Ukraine (about 15% of the territory of Europe). About 50 % of the CEGRN stations will receive permanent status.
- Calculation of velocity vectors for Central European stations; the monitoring campaigns of CEGRN provided already significant kinematic results about intraplate tectonic motions in Central Europe,
- At the end of the first phase of the project there were published eight geotectonic monographs of the European regions:
 - Bohemian Massif (editor P.Vyskočil),
 - The Teisseyre-Tornquist Zone (J. Liszkowski),
 - Pannonian Basin (G. Grenczy),
 - Northern Carpathians (F. Zablotskij),
 - Southern Carpathians (D. Ioane),
 - Central Europe - summary and proposals for future investigations (P. Vyskočil, J. Sledzinski),
 - Bulgarian Krupnik-Kresna region (G. Milev),
 - Bulgarian Chirplan-Plovdiv region (G. Milev).

At the end of the second phase of the Projects there were published the following geotectonic monographs:

“Geodynamic studies in Romania-Vrancea Zone” (editor: T. Rus). REPORTS ON GEODESY, IGGA WUT, Warsaw, No.6 (81),2006.

“Report on Geodynamics of Central Europe”. Work package WP.10. “(editor: J. Sledzinski), REPORTS ON GEODESY, IGGA WUT, Warsaw, No.4 (79). 2006.

“Geodynamics of the Balkan Peninsula” (editor G. Milev). REPORTS ON GEODESY, IGGA WUT, Warsaw, No.5 (80). 2006.



Stations of the Project CERGOP (Network CEGRN)

Nine monitoring GPS CEGRN campaigns were performed up to now. Four campaigns were organised in the frame of the first phase and five campaigns during the second phase of the Project. They are listed below.

CEGRN Monitoring GPS Campaigns

Campaign	Date	
CERGOP-1:		
CEGRN'94	2 May – 6 May	1994
CEGRN'95	29 May – 3 June	1995
CEGRN'96	10 June – 15 June	1996
CEGRN'97	4 June – 10 June	1997
CERGOP-2:		
CEGRN'99	14 June – 19 June	1999
CEGRN'01	18 June – 23 June	2001
CEGRN'03	16 June – 21 June	2003
CEGRN'05	20 June – 25 June	2005
CEGRN'07	17 June – 22 June	2007

CERGOP Data Centre is hosted by Graz Lustbühel Observatory. At the moment five institutes have declared to maintain and operate CEGRN Processing Centres in the second phase of the Project:

- FÖMI, Satellite Geodetic Observatory, Penc, Hungary;
- Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology, Warsaw, Poland;
- Agenzia Spaziale Italiana Centro di Geodesia Spaziale, Matera, Italy;
- Space Research Institute of the Austrian Academy of Sciences, Austria
- Department of Theoretical Geodesy of the Faculty of Civil Engineering of the Slovak University of Technology, Bratislava, Slovakia.

One of the main important parts of the international activities within the EU Project CERGOP is the work of CERGOP Study Groups. They cover particular fields of activities supporting realisation of the Project and form the respective "work packages" (somehow sub-projects) of the EU Project CERGOP-2/Environment (CSG). At present – in the programme of CERGOP-2 there are seventeen work packages listed below.

- WP.1. Internet based seamless database for environmental studies (chaired by Austria),
- WP.2. Station quality assessment and upgrade (Hungary),
- WP.3. Periodic determination of the reference frame CEGRN (Hungary),
- WP.4. Creation of new permanent observation facilities in CEI countries (Germany),
- WP.5. GPS data analysis and the definition of reference frames (Slovakia),
- WP.6. Analysis of the long-term coordinate time series (Italy, Padova),
- WP.7. Geokinematical modelling and strain analysis (Slovakia),
- WP.8. Impact of atmospheric effects on GPS height determination (Czech Republic),
- WP.9. GPS based rapid service for meteorology and hazard assessment (Italy ASI),

WP.10. Geodynamics of Central Europe (Poland),

- WP.10.1. Crustal movements in the Eastern Alps and Northern Mediterranean (Slovenia),
- WP.10.2. Three dimensional plate kinematics in Romania (Romania),
- WP.10.3. Integration of present geodynamic investigations in the Pannonian Basin (Hungary),
- WP.10.4. International geodynamic test area Plitvice Lakes (Croatia),
- WP.10.5. Geodynamics of the Tatra Mts. (Poland, Slovakia),
- WP.10.6. Geodynamics of the Northern Carpathians (Ukraine),
- WP.10.7. Geodynamics of the Balkan Peninsula (Bulgaria).

6. CONSORTIUM FOR CENTRAL EUROPEAN GPS GEODYNAMIC REFERENCE NETWORK (CEGRN)

Long-term experience gained from the realisation of the Project CERGOP has proved the importance of international collaboration in the field of space geodesy, geodynamics and Earth sciences and the need for a coherent, high accuracy and high quality reference network in Central Europe for geodynamic investigations. It became evident that only a coordinated programme of measurements, scientific and technical development of methods and international access to wide amount of monitoring results gathered in a long period of time can give the proper background for any further geodynamic interpretations.

The CEGRN Consortium is a non-profit organisation of institutes that supports and promotes, coordinated establishment, maintenance and upgrade of CEGRN sites, monitoring the CEGRN by permanent and epoch type measurements and the establishment, maintenance and development of CEGRN Data Centre and Processing Centres.

The member institutes contribute to the CEGRN with their own established and accepted sites, with site maintenance and with coordinated observations on these sites. They are committed for the highest quality standards and a minimum of 5*24 hours observations every second year. They supply observational data to the common Data Centre. Additional contribution of designated institutes consists of operation the Data Centre and/or Processing Centres. The Consortium shall agree on a programme for the development of scientific potential of the CEGRN and shall formulate and submit proposals for new scientific and technological developments. These proposals may specify the member institutes in which such developments should be carried out. The Consortium may submit proposals either to national or international entities.

The "Memorandum of Agreement" of the Consortium was signed on 5 September 2001 in Budapest, Hungary. The representatives of the following institutions are now member of the Consortium (see: www.fomi.hu/cegrn).

- Space Research Institute, Austrian Academy of Sciences, Graz, Austria
- Geodesy Department of the Faculty of Engineering, Sarajevo, Bosnia and Hercegovina
- Institute for Water Problems, Bulgarian Academy of Sciences, Sofia, Bulgaria
- University of Zagreb, Faculty of Geodesy, Zagreb, Croatia
- Research Institute of Geodesy, Topography and Cartography, Zdiby, Czech Republic
- Institute für Physikalische Geodäsie, Technische Universität Darmstadt, Germany
- FÖMI Satellite Geodetic Observatory, Budapest, Hungary
- Centro di Geodesia, Agenzia Spaziale Italiana, Matera, Italy
- Department of Geology, Paleontology and Geophysics, University of Padova, Italy
- Institute of Geodesy and Geodetic Astronomy, Warsaw Univ. of Technology, Warsaw, Poland
- The Institute of Cadastre, Geodesy, Photogrammetry and Cartography, Bucharest, Romania
- The Geodetic Authority, Republic of Serbia
- Dept. of Theoretical Geodesy, Slovak University of Technology, Bratislava, Slovakia
- Faculty of Civil and Geodetic Engineering, University of Ljubjana, Slovenia
- Chair of Geodesy and Astronomy, Lviv Polytechnic National University, Lviv, Ukraine

The CEGRN can be considered as a well-established research infrastructure in Central Europe for Earth sciences. Therefore this infrastructure can be used as a prominent research and educational tool in the region. Most of participating institutions are university institutes with educational experience in Earth science disciplines. Therefore the Consortium can also be a forum for a wide educational activities. Some training programmes initiated and organising by the Section C Working Group on University Education Standards can be realised in cooperation with the Consortium. The Consortium provides an open discussion forum also for other institutes from all European countries, it forms a broad platform for European international cooperation in the field of Earth sciences, in particular in space geodesy and geodynamics. We expect that the number of member-institutes will increase in the near future.

7. EUPOS (European Position Determination System)

This is a new European initiative of establishment of the multifunctional reference station system in Central and Eastern countries. Formally it is not a CEI Section C Project but nine CEI countries are engaged in the Project.. The Project EUPOS was initiated by the Berlin Senate Department for Urban Development and European Academy of the Urban Development Berlin. The project consists in establishment of about 900 multifunctional satellite reference stations in Central and Eastern Europe. Fourteen countries: Bosnia&Herzegovina, Bulgaria, the Czech Republic, Estonia, Germany, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Russian Federation, Serbia & Montenegro, Slovakia and Slovenia) intend to participate in the project. One common project standard set will be observed by all countries, however the project will include the existing or developed infrastructure in participating countries. The system will use as standard the future European system Galileo as soon as this signal is available. Experiences of establishing and operating satellite systems gained by other countries will also be used. The network of reference stations will provide signal for both positioning of the geodetic control points and for land, air and marine navigation. Several levels of positioning accuracy will be offered. The project was consulted with the representatives of European Commission in Brussel and is financially supported by European Union. The participating countries decided to form a Founding – Steering Committee. The conferences of this Committee were devoted to discussions on practical aspects of realisation of establishment of a multi-functional network of GNSS reference stations in Central and Eastern European countries.

8. COOPERATION WITH INTERNATIONAL SCIENTIFIC ORGANISATION

COOPERATION WITH THE EUROPEAN GEOPHYSICAL SOCIETY (EGS) / EUROPEAN GEOSCIENCES UNION (EGS).

Since 1997 there have been organised every year by the CEI Section C “Geodesy” special symposia on geodetic and geodynamic programmes realised in the frame of the international cooperation of CEI countries. They are included to the programme of annual General Assemblies of the European Geophysical Society. The Convener of these symposia is Prof. Dr. Janusz Sledzinski (Warsaw, Poland) and the Co-Convener Prof. Dr. Jan Kostelecký (Prague, the Czech Republic). About 45 papers on GPS campaigns in CEI countries, on CERGOP and UNIGRACE, on activities of the CSGs and contribution of permanent GPS stations in CEI countries to international programmes, etc. are usually presented at the oral and poster sessions of the EGS-CEI symposia. Within 1997-2005 there were presented 450 papers highlighting activities of the Section C’s study and working groups.

EGS-CEI Symposia “Geodetic and Geodynamic Programmes of the CEI (Central European Initiative)”

1997:	G14 Vienna (A),	21-25.04.1997;	66 pres.
1998:	G16 Nice (F),	20-24.04.1998;	36
1999:	G4 Haag (NL),	19-23.04.1999;	45
2000:	G12 Nice (F),	24-29.04.2000;	49
2001:	G9 Nice (F),	26-30.03.2001;	46
2002:	G10 Nice (F),	21-26.04.2002;	51
2003:	G18 Nice (F),	7-12.04.2003;	46
2004:	G11 Nice (F),	25-30.04.2004;	55
2005:	G9 Vienna (A),	25-29.04.2005;	56
2006:	G6 Vienna (A),	2 - 7.04.2006;	44
2007:	G11 Vienna (A),	15–20.04.2007;	30
	T o t a l	1997 - 2007	524 presentations

9. OTHER WORKS PERFORMED BY THE WG MEMBERS IN DIFFERENT COUNTRIES.

9.1. STUDIES RELATED TO GEODYNAMICS IN CENTRAL EUROPE PERFORMED BY THE SLOVAK UNIVERSITY OF TECHNOLOGY, BRATISLAVA, SLOVAKIA

REFERENCE FRAMES (J. Hefty)

The reference frames issues are studied in Slovak Republic at various levels – continental, regional and national. Slovak University of Technology act as the EUREF Local Analysis Center (LAC SUT). The sub-network analysed consists of 40 stations distributed mainly in Central Europe and partially in other regions of Europe (West Europe, North-East Europe and Mediterranean). The standard products of LAC SUT as well as some other specific products like coordinate series with subdaily resolution are summarized in (Hefty & Igondová, 2004, Hefty, 2002 and Hřčka & Hefty, 2006). The denser network of about 40 permanent GPS stations concentrated in Central Europe is analysed at SUT in framework of the CERGOP-2/Environment EU project. Analysis method, coordinate time series and evaluation of stability of network stations is described in (Hefty, Kartikova & Kováč, 2003, Hefty, Gerhátová, Igondová & Kováč, 2004, Hefty, 2005a). The history of GPS epoch observations in Central Europe starts from 1994 when first campaign of Central Europe Geodynamic Reference Network (CEGRN) was performed. The analysis of all CEGRN campaigns until 2006 resulting to coordinates and velocities for more than 50 stations is in (Hefty & Gerhátová, 2006, Hefty et al., 2005, Hefty, 2005b, Hefty, 2005c). Problems of effective combination of permanent and epoch-wise GPS observations are investigated in (Hefty, 2004, Hefty, Kováč & Igondová, 2004). The Slovak national GPS networks and levelling networks of 1st order are analysed in (Hefty & Vanko, 2005).

EARTH ROTATION & GEODYNAMICS (J. Hefty)

Geokinematics of Central European region was investigated on the basis of long-term GPS observations in several projects. The site velocities from permanent stations are evaluated and analysed in (Hefty, Gerhátová, Igondová & Kováč, 2004, Hefty, Igondová & Hřčka, 2005), kinematics from epoch stations is subject of papers (Hefty et al., 2005, Hefty & Gerhátová, 2006). The relatively stable Central Carpathians, northward oriented drifts of Adriatic part and Dinarides and southward oriented motion of East Balkan are outputs of CEGRN monitoring (Hefty, 2005b, Hefty et al., 2005). The homogenized velocity field and subsequent deformation analyses based on horizontal velocities in Central Europe are subject of papers (Hefty & Duraciova, 2003, Hefty, 2005b, Hefty, 2005c).

Periodic site coordinate variations in diurnal and sub-diurnal bands are evaluated and analysed on the basis of permanent GPS networks. The results summarized in (Hefty, 2002, Hefty et al., 2004, Hřčka & Hefty, 2006) proves the existence of slight high-frequency variations in majority of GPS stations and points on some deficiencies in modelling of reference frames, ocean loading and locally induced site variations.

POSITIONING & APPLICATIONS (J. Hefty)

The astronomical positioning at more than 30 points using the portable Circumzenithal 50/500 instrument was applied for geoid determination in Poland. Observations and their analysis were performed within the Polish – Slovak cooperation (Bogusz et al., 2005).

Methods of integration of terrestrial and satellite geodetic observations are analyzed in (Gerhátová & Hefty, 2003) yielding the complex 3D network with gravity field parameters determined. The

integration of heterogeneous GPS networks in unique model is studied in (Hefty, 2004, Hefty, Kováč & Igondová, 2004).

Determination of relative GPS antenna phase centres and the resulting coordinate drifts and variations are investigated in (Hefty & Plánovský, 2002, Hefty, 2004). The influence of extreme catastrophic environmental phenomena on permanent GPS observations is investigated in (Igondová & Hefty, 2005).

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AREA OF ACTIVITIES: GEODYNAMICS OF THE TATRA MOUNTAINS (M. Mojzes)

Tatra Mnt. are part of the West Carpathian arc and part of the border between Carpathian system and Polish platform. The geodynamic investigation of Tatra Mnt. started from 1998. The crust movement investigation in Tatra Mnt. region was a local sub project of the CERGOP-2/Environment supported by the European Union. In order to study this important area and especially its dynamical properties, the special test network of GPS points has been established by Polish and Slovak cooperation (Warsaw University of Technology and Slovak University of Technology in Bratislava). The GPS network consists of 11 sites, 7 in Slovak Republic and 4 in Poland. The size of the investigated area is approximately 40 km by 60 km. The GPS epoch measurements lasted from 3 to 5 days every year from 1998 to 2006. The data was processed by Bernese software with standard procedures. After analysis of GPS data, the mean horizontal relative velocity to Eurasian platform was 1.1 mm/year in azimuth 318 degrees and the mean vertical relative velocity was -1.2 mm/year determined from the period 1998 to 2006. Information about the movements of Tatra Mnt. has been presented in EGU General Assembly in 2006. For testing of relative vertical movements the repeated absolute gravity measurements at the chosen points have been used. The absolute gravity test has a good agree with GPS measurements. The results of the test have been presented at the EGU General Assembly in Vienna in 2007.

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9.2 UNIVERSITY OF KARLSRUHE, GERMANY (G. Schmitt, Nuckelt) Collaborative Research Center 461 „Strong Earthquakes – A Challenge for Geosciences and Civil Engineering” - Subproject B1 “Three- dimensional Plate Kinematics in Romania”

Activities in the last two-three years:

- 2006: GPS-campaign in Romania, cooperation of CRC 461 (Germany), ISES (The Netherland), University of Bucharest and University of Civil Engineering Bucharest (Romania)
- Reprocessing of all GPS observation using Bernese GPS Software 5.0, the available data were collected in GPS campaigns between 1995 and 2006
- Detailed analyses on GPS data concerning multipath effects and influences of antenna phase centre variations
- Time series analyses of GPS permanent station Bucharest (Romania)
- Development of a new approach for velocity field interpolation using multilevel B-spline techniques, including error propagation
- Strain analyses based on B-spline approximation surfaces

Recent results:

- Time series analyses of GPS permanent station Bucharest:
 - Seasonal effects were detected for the height coordinate of station BUCU
 - Possible correlation with changes of ground water level
- Three dimensional velocity field for Romania:
 - Based on reprocessed GPS data,
 - Velocities of GPS stations are estimated using the kinematic model of deformation analyses
 - Velocity field interpolation using multilevel B-splines
 - Areas of significant movement can be distinguished
 - Principal strains and shear strains were derived from the velocity field
 - Quality information for velocity field and strains

The Romanian scientists will organise in Bucharest an international symposium “On Strong Vrancea Earthquakes and Risk Mitigation” 4-6 October 2007.

9.3 STATE UNIVERSITY “Lviv, Polytechnic” UKRAINE (F. Zablotkij).

The scientists from the Lviv University were carrying out investigations of the vertical and horizontal movements of the Earth surface in the Carpathians region. The repeated levelling data were also used. There were obtained the new results of the horizontal displacements of the points of the Carpathian geodynamic test field. They are represented in the form of the deformation velocity vectors. Further works at the Pip Ivan test field were performed. The precise coordinates of the station Pip-Ivan Mountain (the second highest top of the Ukrainian Carpathians) were determined basing on the data obtained from the campaigns of 2002, 2003 and CEGRN’2005. A new permanent satellite station SHAC was established. Ukrainian stations took part in all last CEGRN campaigns. The Ukrainian scientists prepared a monograph “Investigations of recent geodynamics of the Ukrainian Carpathians”. The manuscript of this monograph was submitted to the European Commission at the end of the CERGOP Project.

9.4 STATUS OF GEODETIC ACTIVITIES IN ROMANIA (T. Rus, P. Dumitru, M. Fadur)

The Romanian colleagues submitted an exhaustive report on activities in different kinds of geodetic works. In the report there are outlined the most important aspects concerning the new GPS permanent

network (evolution, extension, services). New levelling data were used jointly with GPS for determination of the new model of the Romanian quasi-geoid.

9.5 GEODYNAMIC RESEARCH IN BALKAN PENINSULA (G. Milev, K. Vassileva)

The territory of the Balkan Peninsula is the most active region in Central and Eastern Europe in geodynamical respect. A number of hazardous geodynamic processes of endogenic (earthquakes, contemporary movements of the Earth's crust, mud volcanoes) and exogenic origin (natural and technogenic), including landslides, abrasion, erosion, subsidence, collapse, rockfalls, mud-stone flows, deformations caused by mine workings, karsts, etc., are observed in the area.

The single processes and cases are superposed or interact with each other in many respects. Their combined display, range of manifestation and multilateral, in many cases destructive effect is especially typical for the Balkan Peninsula territory.

At present the space of the Balkan Peninsula falls within the zone of collision between three large plates - Euroasian, African and Arabian, which are themselves divided in smaller ones.

Related geodynamic investigations accomplished concern:

- Systematisation and analysis of the existing investigations for the region.
- Accomplishment of complex measurements, investigations and generalizations with respect to:
 - seismological conditions and processes,
 - geophysical fields interpretations related to the geodynamical processes,
 - see bottom geology and processes,
 - seismotectonics,
 - geology and geomorphology,
 - geodesy,
 - complex analysis and interpretation.

The investigations are mainly based on the results of the Central European Regional Geodynamics Project (CERGOP) of the 5-th Framework Programme of EC.

Existing permanent stations and some new established ones (permanent and epoch) on the territory of the Balkan Peninsula are involved in the study. Two new CERGOP permanent stations (VARN, ROZH) were established in Bulgaria early in 2005. VARN and ROZH stations are collocated with absolute gravity stations and connected to the National Levelling Network and they are included as an element of the EUREF project – ECGN (European Combined Geodetic Network).

Several GPS CEGRN campaigns have been carried out and data from stations covered the territory of the Balkan Peninsula have been collected, processed and analyzed.

In the CEGRN'03 all 15 BULREF points on the territory of Bulgaria were involved.

The velocity vectors estimated from combine campaign solution show undisturbed behaviour for all BULREF stations for the period of 10 years, period between two campaigns. The values of station velocities are very similar and differences vary with an amount of maximum up to 2 mm in north component and in east component. Also the deviations to the NUVEL model velocities are in a reasonable size. This indicates that no unexpected jumps or outliers occurred in the behaviour of stations during that time.

Respective station velocity vectors estimated for the territory of the Balkans are compatible with the NNR-NUVEL1A velocity model and results from other studies.

The generalized results from the investigations of the Balkan Peninsula and Bulgaria show that:

- Orientation of the global velocity vectors is generally north-east and south-east direction,
- Horizontal movements are of amount of 2 mm/yr,
- Results achieved are reliable as they have been obtained by different approaches and by independent researchers,
- Comparison of the particular solutions within the CERGOP-2 project shows an agreement.
- Without doubt the Balkan Peninsula exhibits a pronounced and active geodynamics with respect to other regions in Central and Eastern Europe.

As a generalized result of the efforts of the Bulgarian and Balkan countries partners is the Monograph "Geodynamics of the Balkan Peninsula", published in Reports on Geodesy, Poland, end of 2006, 648 pp. Many scientists (about 100 authors) from different Earth sciences - geodesy, geophysics, geology and other branches from all Balkan countries and some other European countries contributed to it. The Monograph presents general data and prerequisites for the part of global geodynamics comprising BP. Different aspects of studies are accomplished by the particular countries. Assessments and relevant generalized conclusions, analysis and generalization of the results obtained from the GNSS - geodetic investigations, complex interpretation of the velocity and deformation vector field, generalized geodynamics of BP have been done. The investigation results outline possibly most representative picture of the geodynamic phenomena occurred in the Balkan Peninsula and their interpretation on the background of the Mediterranean geodynamics. It is oriented to a large range of specialists from the Earth sciences, disaster protection – more particularly earthquakes, monitoring and prevention of environment, planning and urbanization, and many others.

10. CONCLUSION

CEI WGST Section C "Geodesy" declares further close cooperation with the International Association of Geodesy in any form that would be considered as the most effective. The research and interpretation of recent crustal movements detected by satellite techniques are recognised as most important and urgent action within the mentioned workpackages of the CERGOP-2. The Section C "Geodesy" will provide the velocity vectors (displacement vectors) from the regions of Central Europe covering the area of CEI countries. The results of the CERGOP and other CEI projects will be release for the IAG scientific groups dealing with geodynamic investigations.

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