

# **APPLICATION OF SATELLITE NAVIGATION SYSTEMS IN GEODETIC AND GEODYNAMIC PROGRAMMES OF THE CEI (Central European Initiative)**

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## **1. INSTEAD OF INTRODUCTION**

Programme of action of the CEI (Central European Initiative) Working Group “Science and Technology” Section C “Geodesy” includes geodetic, geodynamic and gravimetric projects and activities of two Section’s Working Groups on University Education Standards and on Satellite Navigation Systems. Section C has close cooperation with two international organisations – European Geophysical Society (since 2003 European Geosciences Union) and International Association of Geodesy. At the moment there are seventeen CEI member countries (Albania, Austria, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Italy, Macedonia, Moldova, Poland, Romania, Serbia-Montenegro, Slovakia, Slovenia, Ukraine), however geodetic and geodynamic programme of the Section C is realised by 13 CEI countries. Belarus, Macedonia, Moldova and Serbia-Montenegro do not participate in CEI geodetic programmes. On the other hand two non-CEI countries - Germany and Finland cooperate with CEI countries in realisation of geodetic programme. In total about 150 scientists from 13 CEI countries are very active in Section C’s study groups.

Below you can find concise updated information on projects launched by the CEI WG S&T Section C “Geodesy” and activities of its working groups. Almost all actions of the Section C base on the application of the GPS system.

## **2. PROGRAMME OF ACTIVITIES OF THE CEI WG&ST SECTION C “GEODESY”**

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

- Geodetic and geodynamic programmes
  - 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/multi-lateral agreements of CEI countries, e.g. Czech-Polish-Slovak Cross-Border Studies of Regional Geodynamics (Sudetes, Beskydy, Tatra, Pieniny Mts);

- Working Group on University Education Standards;
- Working Group on Satellite Navigation Systems;
- Cooperation CEI Section C “Geodesy”– European Geophysical Society (EGS) / European Geosciences Union (EGU);
- Cooperation CEI Section C – International Association of Geodesy (IAG).

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

### **3. PROJECT CERGOP (Central Europe Regional Geodynamics Project). STATUS OF THE PROJECT CERGOP**

The status of the Project CERGOP could be characterised by the following statements:

The first phase of the Project was concluded in 1998 and now the second phase of the Project is being realised. The proposal of the second phase of the Project CERGOP-2 "A Multipurpose and Interdisciplinary Sensor Array for Environmental Research in Central Europe (CERGOP-2/Environment)" was accepted in March 2003 by the European Commission and now it will be financially supported during the next three years. The EU Coordinator of the Project is Austrian Academy of Sciences, personally Dr Peter Pesec from Graz, Austria.

The following 13 countries participate in the second phase of the Project: Austria, Bosnia-Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Italy, Romania, Poland, Slovakia, Slovenia and Ukraine.

Total number of stations of the CERGOP-2 is 63. About thirty CERGOP-2 points are permanent stations.

Seven monitoring GPS CEGRN campaigns were performed in 1994, 1995, 1996, 1997 (CERGOP-1) and in 1999, 2001 and 2003 (CERGOP-2). Next campaign is scheduled for June 2005.

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, Pécs, 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 and 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 Project CERGOP is the work of CERGOP Study Groups (CSG). At present – in the programme of CERGOP-2 there are seventeen study groups. They cover particular fields of activities supporting realisation of the Project and form the respective "workpackages" of the EU Project CERGOP-2/Environment (sub-projects of the CERGOP-2) 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),

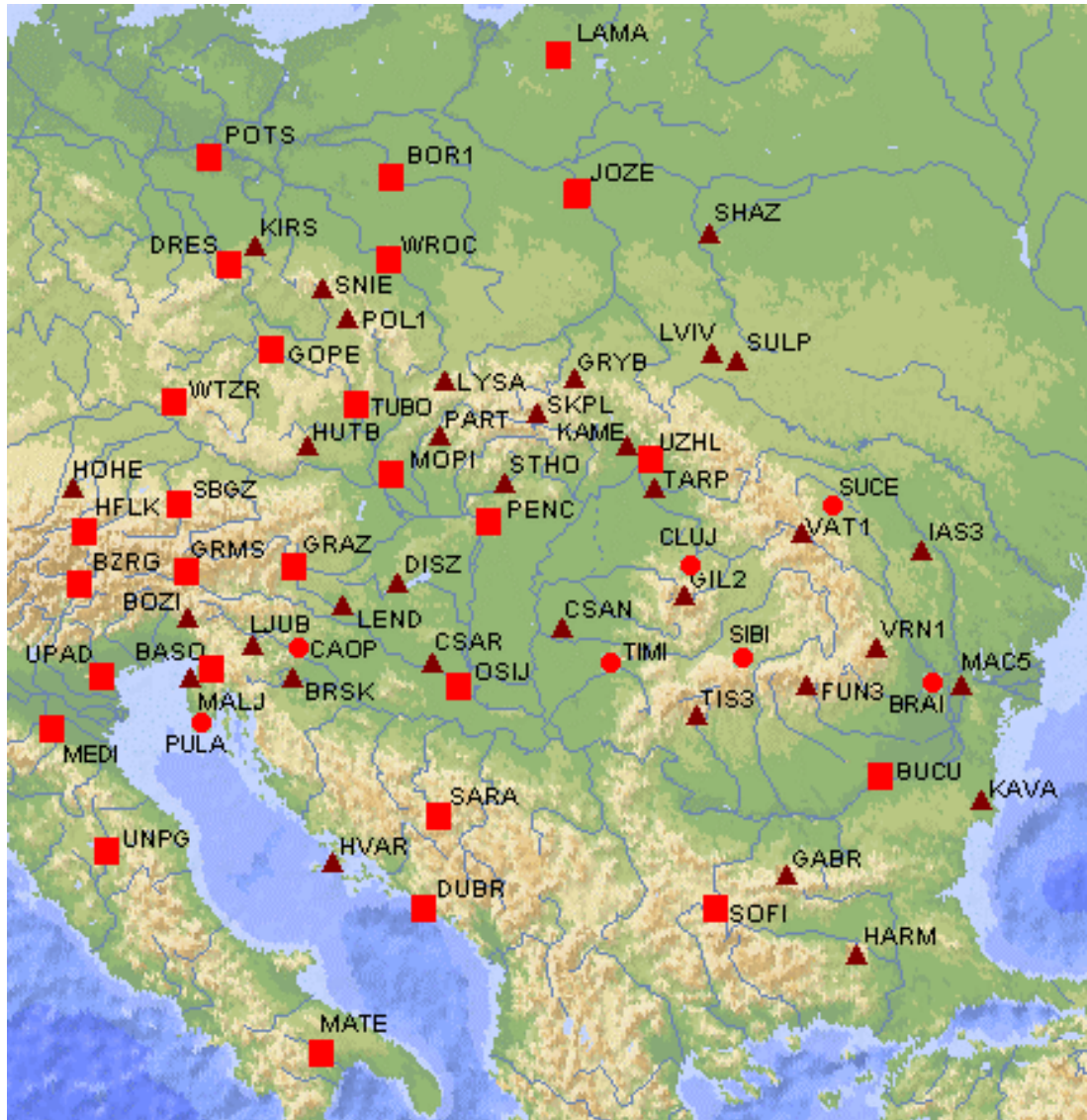
WP.10.6. Geodynamics of the Northern Carpathians (Ukraine),

WP.10.7. Geodynamics of the Balkan Peninsula (Bulgaria).

As main achievements of the CERGOP we can mention: (a) 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; (b) 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, (c) Publication of eight geotectonic monographs of the European regions: Bohemian Massif (editor P.Vyskočil), The Teisseyre-Tornquist Zone (J. Liszkowski), Pannonian Basin (G. Grenerczy),

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).



**Present and some proposed sites of the CEGRN**  
(rectangles – permanent sites,  
triangles – epoch sites,  
circles – proposed permanent sites)

(after: I. Fejes, P. Pešec. “CERGOP-2/Environment – a challenge for the next 3 years” presented at the G17 EGS-AGU-EUG Symposium “Geodetic and Geodynamic Programmes of the CEF”, Nice, France 2003)

The following conferences have been organised on CERGOP-2 since 1 April 2003, i.e. since signing the contract with European Commission:

- First CERGOP-2 kick-off Meeting Graz, Austria, 5-6 May 2003
- Second CERGOP-2/Environment Working Conference, Warsaw, Poland, 29-30 September 2003. Proceedings of this Conference was published in a separate issue of REPORTS ON GEODESY, No.3 (66), 2003 edited by the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology.
- Working CERGOP-2 splinter meeting, Nice, France, 27 April 2004.

#### **4. CONSORTIUM FOR CENTRAL EUROPEAN GPS GEODYNAMIC REFERENCE NETWORK (CEGRN)**

Project CERGOP was an impulse for establishment of the CEGRN Consortium of institutes involved in realisation of the Project. The Consortium is also a seedbed of new European projects and initiatives. The CEGRN Consortium, established in 2001, 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 "Memorandum of Agreement" of the Consortium was signed on 5 September 2001 in Budapest, Hungary. The representatives of the following institutions have signed the Memorandum of Agreement:

- Space Research Institute, Austrian Academy of Sciences, Graz, Austria;
- Geodesy Department of the Faculty of Engineering, Sarajevo, Bosnia and Herzegovina;
- Central Laboratory for Geodesy, Bulgarian Academy of Sciences, Sofia, Bulgaria;
- University of Zagreb, Faculty of Geodesy, Zagreb, Croatia;
- Research Institute of Geodesy, Topography and Cartography, Zdíby, Czech Republic;
- Faculty of Civil Engineering and Geodesy, University of Bundeswehr, Munich, Germany;
- Institute of Geodesy Cartography and Remote Sensing (FÖMI), 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 University of Technology, Warsaw, Poland;
- The Institute of Cadastre, Geodesy, Photogrammetry and Cartography, Bucharest, Romania;
- Dept. of Theoretical Geodesy, Slovak University of Technology, Bratislava, Slovakia;
- Faculty of Civil and Geodetic Engineering, University of Ljubljana, Slovenia;
- Chair of Geodesy and Astronomy, Lviv Polytechnic National University, Lviv, Ukraine;

Five following institutes have declared to maintain and operate CEGRN Processing Centres:

- 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.

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.

## **5. ACTIVITIES OF THE WORKING GROUP ON UNIVERSITY EDUCATION STANDARDS**

The Section C Working Group on University Education Standards is chaired by Profs. K. Czarnecki/Poland and F. Vodopivec/Slovenia. This Working Group organises every year one international educational seminar/workshop or symposium. The subjects of the events, that are now the most important from practical point of view, are satellite DGPS techniques and field training in application to different geodetic purposes.

### **Educational events organised by the Section's WG on University Education Standards**

- "International Symposium on Education in GPS Application to Geodesy and GIS", Ljubljana, Slovenia, September 18-21, 1996;
- "International Symposium on DGPS in Engineering and Cadastral Measurements, Education and Practice", Ljubljana, Slovenia, 25-27 August 1997;
- International Summer Seminar "Education in GPS Application to Geodesy and GIS/LIS", Grybow, Poland, 7-10 June 1998;
- International workshop on satellite DGPS techniques and field training, Sarajevo, Bosnia&Herzegovina, 11-14 September 2000;
- International workshop on satellite DGPS techniques and field training, Lvov, Ukraine, 24-26 September 2001;
- International workshop/seminar "Real time GNSS" Trieste, Italy, 9-10 September 2002 (joint event with WG on Satellite Navigation Systems);
- A Session on Education was held during the International Symposium on "Modern Technologies, Education and Professional Practice in the Globalising World", 6 November 2003, Sofia, Bulgaria.

Next session on Education will be organised also in Sofia, Bulgaria in November 2004. The Working Group management considers organising next workshops on satellite measurements and their different applications for participants coming from university non-geodetic faculties.

## **6. ACTIVITIES ON SATELLITE NAVIGATION SYSTEMS**

### **6.1 WORKING GROUP ON SATELLITE NAVIGATION SYSTEMS**

The Working Group is very active and is chaired by Profs. S. Oszczak from Poland and G. Manzoni from Italy. Several planned actions were carried out in the last years. The actions considerably contribute to exchange of information and to initiate the broad application of satellite positioning systems to land, marine and air navigation in CEI countries.

Last workshop/seminar on real time GNSS and the use of satellite navigation systems was organised on 9-10 September 2002 in Trieste, Italy.

The CEI Working Group on Satellite Navigation Systems is now engaged in developing navigation technologies for road transport using GPS and EGNOS systems.

### **6.2 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, so the Section C supports all actions related to EUPOS. 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 415 multifunctional satellite reference stations in Central and Eastern Europe. Fourteen countries (Bulgaria, 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 be compatible with the German network SAPOS and future European system Galileo. 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 Brussels. The participating countries decided to

form a Founding – Steering Committee. Four working conferences of the Founding (Steering) Committee were held up to now. The first one in Warsaw, Poland on 2-3 July 2002 (organised by the Institute of Geodesy and Geodetic Astronomy of the Warsaw University), the second one in Sofia, Bulgaria on 6-7 November 2002 (organised by the Union of Surveyors and Land Managers in Bulgaria), third conference in Riga, Latvia on 10-11 June 2003 (organised by the State Land Service of Latvia) and the fourth conference was held in Berlin on 23 November 2003 (organised by the Berlin Senate Department for Urban Development and the European Academy of the Urban Environment (EA.UE), Berlin). The conferences 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. Second Workshop on "EUPOS - Multifunctional GNSS Reference Station Systems for Europe" was held on 21-22 November 2003 in Berlin, Germany. Fifth meeting of the International EUPOS Steering Committee will be organised by Slovak colleagues in Bratislava on 18-19 June 2004.

In the meantime the project EUPOS was presented at many international conferences, e.g. to the "UN/USA Expert Meeting on the Use and Application of Global Navigation Systems", Vienna, Austria, 11-15 November 2002, to the "1<sup>st</sup> Conference 'Galileo' for an enlarged Europe" organised by the European Commission in Warsaw, Poland on 19-20 May 2003, to the "2<sup>nd</sup> Common Baltic Symposium on the Concept of Digital Height Reference Surface and Related GNSS Topics – GPS Heighting and Nation-wide Permanent GNSS Reference Systems" in Riga, Latvia on 12-13 June 2003, to the EGS/AGU/EUG Symposium G17 in Nice, France, 7-12 April 2003; and to International Symposium on Space Information Technologies, Acquisition, Processing and Effective Application, Sofia, Bulgaria, 7-8 November 2003 and others. The recommendations of all these conferences support the initiative of EUPOS as a common GNSS infrastructure for all kinds and accuracies of on-line and post-processing DGNSS applications based on the standards of multifunctional reference station networks.

On 12 November 2003 the representatives of the EUPOS International Steering Committee have held consultations in Brussels with Galileo Joint Undertaking and the European Commission EuropeAid Co-operate Office. The

objectives of consultations were to inform the EC about the Project EUPOS, its organisation, standards and services, links to the European Project Galileo and expected benefits for all participating countries. As positive aspects there were recognised short time (2,5-3 years) of realisation of the Project and the fact that the first organisational structures of the project are already available. was advised that the attempt could be made to request for financial support from different EU Programmes:

ERDF for EU member countries (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia),

ISPA – for EU candidate countries (Bulgaria, Romania),

CARDS – for West-Balkan countries (Macedonia, Serbia and Montenegro),

TACIS – for the Russian Federation,

INTERREG III C – for Germany (Coordinator of the Project).

The Project EUPOS is discussed by a separate paper presented at this symposium.

## **7. COOPERATION WITH INTERNATIONAL SCIENTIFIC ORGANISATIONS**

### **7.1 COOPERATION BETWEEN CEI SECTION C "GEODESY" AND THE EUROPEAN GEOPHYSICAL SOCIETY (EGS) / EUROPEAN GEOSCIENCES UNION (EGU)**

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 Kostecky (Prague, the Czech Republic). About 45-50 papers on GPS campaigns in CEI countries, on CERGOP and UNIGRACE, on activities of the study groups 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. In 2002 the European Geophysical Society EGS and the European Union of Geosciences EUG have

formed a new organisation “European Geosciences Union” EGU that will continue the activities of both preceding organisations, in particular it will organise the annual general assemblies. The CEI symposium “Geodetic and geodynamic programmes of the CEI” was accepted and will be organised in the frame of subsequent EGU general assemblies.

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

- 1997: EGS G14 Vienna, Austria,  
21-25 April 1997;
- 1998: EGS G16 Nice, France,  
20-24 April 1998;
- 1999: EGS G4 The Hague, The Netherlands,  
19-23 April 1999;
- 2000: EGS G12 Nice, France,  
24-29 April 2000;
- 2001: EGS G 9 Nice, France,  
26-30 March 2001;
- 2002: EGS G10 Nice, France, \  
21-26 April 2002;
- 2003: G17 Nice, France, 7-12 April 2003  
(joint event EGS-AGU-  
EUG);
- 2004: EGU G11 Nice, France,  
26-30 April 2004
- 2005: EGU G? scheduled for Vienna,  
Austria, 25-30 April 2005.

In total about 400 contributions were presented at oral and poster sessions of the symposia 1997-2004. They concerned different running CEI projects and actions of the CEI WG Science and Technology Section C “Geodesy” study and working groups

## **7.2 COOPERATION WITH INTERNATIONAL ASSOCIATION OF GEODESY (IAG)**

The cooperation with the International Association of Geodesy resulted in 1996 in creation of IAG Subcommission "Geodetic and Geodynamic Programmes of the CEI". Within 1996-2003 the Subcommission was acting in the frame of the IAG Commission XIV “Crustal Deformation” of the IAG Section V “Geodynamics”. After reorganisation of the working groups of the Association of Geodesy in 2003 the working group on CEI was incorporated as the permanent study group “Geodynamics of the Central Europe” to the Subcommission 3.2 Crustal Deformation” of the IAG Commission 3 “Earth Rotations and Geodynamics”.

The studies on recent crustal movements detected by satellite techniques and developing the global geotectonic model were recognised as most important and urgent action of the Subcommission. It was agreed that the working group on “Geodynamics of the Central Europe” would contribute to develop a global velocity field, so it declares to supply and release to the aims of the Subcommission the results of the GPS campaigns of the CERN (Central Europe GPS Reference network) realised in the frame of the Project CERGOP (Central Europe Regional Geodynamics Project), velocity vectors of about 60 sites in Central Europe calculated by CERGOP Processing Centres from the campaigns CERGOP, EXTENDED SAGET, EUREF; also information on local geodynamic projects realised by Central Europe CERGOP Study Groups and in CEI bilateral and multilateral cooperation.