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NATIONAL COMMITTEE FOR GEODESY AND GEOPHYSICS**

**Reports on the activities in the period
1995–1998**

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Reports of the Croatian National Committee of Geodesy and Geophysics on activities in the period 1995–1998

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Geodesy in Croatia, 1995 – 1998

Report to the International Association of Geodesy of the International Union of Geodesy and Geophysics

Croatian geodesists and geophysicists have continuously participated in a small number as members of former Yugoslav delegations in the most of General Assemblies of the International Union of Geodesy and Geophysics (IUGG). However, our geodetic researchers have got the opportunity to participate actively as the representatives of the sovereign Republic of Croatia in Vienna in 1991. Several prominent geodetic scientists from Croatia were then or later selected into some Special Study Groups of Special Commissions and Commissions within the framework of International Association of Geodesy (IAG).

In January 1992 our independent state became a member of the United Nations and in December 1992 the member of IUGG which was confirmed by the Council at the XXI General Assembly of IUGG in Boulder 1995. Croatia was the first there to report on the activities in the period from 1991 – 1994, and also had the report for IAG (Čolić 1995, 1996a). The Croatian National Committee for Geodesy and Geophysics was established before that, in 1992, with the great support by Professor Helmut Moritz, the president of IUGG at that time, and the Croatian Academy of Sciences and Arts had founded the Adhering Body.

This report gives the presentation of the published articles and some articles just being printed by Croatian researchers, mostly from the Faculty of Geodesy at the University of Zagreb, as well as the papers about these works realised in collaboration with the colleagues from abroad. In the work on the papers about the researches that are of interest to IAG in the time from 1995 – 1998, Croatia participated with altogether 45 researchers, and many researches and works were made in collaboration with more than 30 colleagues from abroad in spite of the fact that only a smaller number of Croatian authors is active in geodesy as a geoscientific discipline, but they work mostly in engineering and technical fields.

In **Geodetski list**, the only Croatian periodical with the international reputation, a certain number of papers have been published in Croatian language (mostly with an abstract in English). The third congress of the Croatian Geodetic Society was the occasion at which the 50th Anniversary of the periodical's continuous issuing in Split from 12. – 14. April. Up to that moment, **Geodetski list** had been published with some interruptions and changes of its name for 73 years, and hence it is the 5th oldest geodetic magazine in Europe according to (Frančula, Lapaine 1996). It is of great significance that the editorial staff was enriched by international members as well, during 1996. This report mentions some characteristic articles from this scientific and professional periodical: (Benčić 1996, 1998), (Benčić, Dusman 1996), (Breznikar 1995), (Čolić et al 1996), (Frančula, Lapaine 1996), (Lapaine 1996b, 1996c), (Lapaine et al 1996), (Lichtenegger 1996), (Rožić 1996), (Solarić, M. et al 1995, 1996), (Viher, Lapaine 1998), and the paper (Rožić, Kanajet 1996) was published in the only geodetic magazine in the neighbouring Slovenia. At the Faculty

of Geodesy, University of Zagreb, the work on Croatian Geodetic Dictionary was initiated (Lapaine et al. 1996). On the other hand, Croatian geodetic scientists have published their articles even earlier in famous magazines abroad, and in the last period the following authors have done so: (Klak et al. 1996), (Solarić, M. 1997), (Šimičić 1998). They also took part at a number of geophysical and other types of symposiums other than geodetic (Bašić et al. 1999), (Feil, Fučkan Držić 1998), (Kapović 1996), (Solarić N. et al. 1995), (Tunjić, Lapaine 1999), etc.

Among them there are 10 doctoral dissertations: (Bačić 1997) at the University of Technology Graz, (Roić 1996) at the University of Technology Vienna, and others at the University of Zagreb – Faculty of Geodesy (Rožić 1995), (Cigrovski-Detelić 1998), (Džapo 1998), (Frangeš 1998), (Ivković 1997), (Lapaine 1996), (Lasić 1997), (Novaković 1996). Four Master's thesis should be added here: (Barković 1997), (Špoljarić 1997), and (Vučetić 1996) at the University of Zagreb, Faculty of Geodesy and (Pribičević 1999) at the University of Ljubljana, Faculty for Civil and Geodetic Engineering (Slovenia).

The most of the activity was realised in the field of **Section I: Positioning**, mainly GPS observations for the improvement of the State geodetic survey in the Republic of Croatia, geodynamic establishment of the zero order 3D-Network with altogether 22 GPS points including 3 IGS stations, and all that for the purpose of connecting the Republic of Croatia and the Republic Slovenia into the unique European co-ordinate system EUREF (Altiner et al. 1995). Following immediately the EUREF 1994 Croatia and Slovenia GPS Campaign, the first phase of CRODYN'94 of the project CRODYN, initiated and conducted in Croatia (see later), was performed by the academician Krešimir Čolić (Čolić et al. 1996).

In 1995 the German partner, Institut für Angewandte Geodäsie – IfAG – (now BKG) was delayed for some objective reasons at the territory of the neighbouring country where a large GPS campaign was carried out under the title SLOVENIA 95. At that time, GPS measurements were made in Croatia along the border at 12 first order trig points, and on some other GPS points as well. Fortunately, as early as in the summer 1996, the State Geodetic Administration realised in collaboration with the Faculty of Geodesy at the University of Zagreb and the above mentioned German partner the great GPS campaign CROREF'96-CRODYN'96 in four blocks with about 80 carefully selected GPS points. Thus, the fundamental GPS network of Croatia, titled as well the First Order GPS Network, was created, and the last block belongs also to the second phase of already mentioned project CRODYN. The numerical processing of GPS observation in those two for Croatian geodesy very significant projects were made in the German institution in Frankfurt/Main by our two geodetic experts (Rašić, Marjanović 1997).

The third important step in applying modern GPS technology is the participation of the Republic of Croatia in the biggest European scientific and research project European Vertical Network EUVN. In the first phase of EUVN'97 we participated with our own GPS receivers and with experienced team of experts in GPS measurements at altogether 12 selected points. Eight of them were officially enlisted into EUVN'97, and those were 2 EUREF points, 4 tide gauges in the Croatian part of the eastern Adriatic Sea coast (the next are in Kopar/Slovenia and Trieste/Italy) and one nodal point in Zagreb. The remaining 4 points have been registered as the supplementary and indispensable for connecting the second order precise levelling

at our territory with the new European levelling network, as well as for the absolute orientation of the geoid surface at the Croatian territory (Čolić et al. 1997). The acknowledgement was given to our country and Croatian geodesists by establishing the EUVN computer centre in the State Geodetic Administration (Marjanović, Rašić 1998a, c).

It should also be pointed out that single works deal with the investigations of precise kinematic GPS survey (Bačić et al. 1995), (Bačić 1997), (Bačić, Lichtenegger 1997), (Kalafut et al. 1995), (Lichtenegger et al. 1997), and in the paper (Cheng et al. 1997) some problems of DGPS in practice are dealt with. Let us mention also the first GPS measurements in the last period (Solaric M. et al. 1995), and the review of the achieved results (Solaric M. et al. 1996). Furthermore, a fundamental GPS network was established under the scientific surveillance of the academician Krešimir Čolić, the homogeneous field of geodetic points for the Plitvice Lakes, declared a National Park 50 years ago and celebrating the 20th anniversary of entering the UNESCO World Heritage List, is leaning on. The UNESCO list has also world famous Dubrovnik among its other items, and it must get its precise GPS network as soon as possible, not only for the cadastral needs, but above all for the purpose of geodynamic researches, because this old town and its wider area are seismotectonically very active and have experienced the appearance of strong earthquakes through many centuries. There was also the GPS network of Split and its surroundings established on the occasion of celebrating its 1700 years long existence, and the Croatian capital Zagreb gets about 4000 points of the homogeneous field at the entire area of the city leaned on the Fundamental GPS Network.

Comission X: Global and Regional Geodetic Networks, several regional or local GPS networks were established by the State Geodetic Administration, Faculty of Geodesy at the University of Zagreb and some leading Croatian geodetic firms (Čolić et al. 1998a), and the most important is the II order GPS Network of Croatia with the distance between the GPS points of 10 km (50% finished). At the same time there were also GPS homogeneous fields of geodetic points established at the territory of the towns Varaždin, Karlovac, Sisak and Prelog, which was followed later on by the towns Osijek, Ivanovac, Đakovo, Krapina, Čakovec etc.

Another subject was treated in the doctoral dissertation (Rožić 1995) within the frame of testing the scale of levelling rods with respect to the Second Precise Levelling for Croatia. This area includes also the paper (Klak et al. 1996), (Feil et al. 1998) about the connection of height systems of Hungary and Croatia. The same task is connected with the second of the two works (Klak et al. 1997, 1998) submitted to Bundesamt für Kartographie und Geodäsie, Frankfurt/Main, Germany, and the first one brings the Precise levelling data of the Republic of Croatia for the purpose of supplementing the Untied European Levelling Network – UELN.

The paper (Čolić, Seeger 1997) is especially significant because of its presenting new state surveys at the territory of the Republic of Croatia and presenting a complete review of made and planned enterprises, as well as the obtained results (establishment of the new state positioning system with GPS with the basic zero, first and second order GPS network, of the height network and the participation in the project EUVN'97, the creation of the new gravimetric network and the methods of geoid determination).

Special Commission 4: Applications of Geodesy to Engineering, encompasses the works (Kapović 1996) and (Kapović, Roić 1998), as well as (Solaric N. et al. 1995, 1996, 1997, 1998). We have also a paper on the joint use of GIS, GPS and Aerial Photogrammetry (Štefanović et al. 1998), etc.

In the interest area of the **Section II: Advanced Space Technology** we have achieved no significant contributions. Though, it should be pointed out that the project WEGENER-MEDLAS by means of GPS measurements has been extended to the Adriatic microplate following earlier expressed international wishes, because it is a part of the Mediterranean area with really very vivid seismotectonic movements and no rare appearance of earthquakes.

Important activities have been made within the scope of **Section III: Determination of the Gravity Field**, and that is in the **Commission III: International Gravity Commission**, but primarily in the **Commission XII: International Geoid Commission**. Two methods for testing the gravity field, especially for the determination of geoid, have been applied: the usage of gravity field anomalies for the geoid in the entire Croatia (Bašić et al. 1998), and that is, in the combination of satellite altimetry for the Adriatic Sea, GPS levelling data and global geopotential model EGM 96. The major aim was the improved new usage of astrogeodetic vertical deviations with the combination of GPS levelling data in the entire central part of the region Alps-Adria (Kühtreiber et al. 1998). However, the local researches of the geoid have also been carried out, for the area of the Plitvice Lakes National Park (Čolić et al. 1998d) and cm-geoid for the territory of the City of Zagreb (Čolić et al. 1998e). Apart from astrogeodetic geoid for four countries of Central Europe (Austria, Slovenia, Croatia and Hungary), its precise determination in combination with GPS levelling data for land, and satellite altimetry data for the belonging territorial waters of the Adriatic Sea, is planned to be prepared for Birmingham.

Within **Commission III** the first absolute Gravity Measurements in Croatia with the instruments and experts from IfAG at three stations /Zagreb, Pula, Makarska) should by all means be mentioned and they were described in (Richter et al. 1998), as well as their extension to be performed very soon by two more stations (Dubrovnik and Osijek) within the scope of the international project UNIGRACE (Čolić, Pribičević 1998).

In **Section IV: General Theory and Methodology** one should mention the review paper on isostatics in connection with the problem of geoid/Moho (Čolić 1998). The idea of measuring the total gravity vector for the research of carbon hydrogen resources (oil and gas) has been developed further on, now in the combination with GPS levelling and the application on the third of the inner plate in the central region of the Dinaric Alps.

Into the **Special Commission 1: Mathematical and Physical Foundations of Geodesy** one could enlist earlier mentioned papers the authors of which are Benčić and Lapaine themselves or with co-authors, but also some other above mentioned papers and doctoral thesis.

The major geodetic work in the period from 1995 – 1998 belongs to the field of the **Section V: Geodynamics**. The main reason for it is the geological structure in Croatia and the neighbouring countries as Slovenia, Austria and Italy: Adriatic microplate causes in all these countries the main seismotectonic changes, and espe-

cially in the coastal part of the Croatian territory. It also provoked a very strong earthquake with the magnitude of 6.3 by Richter's scale and with the centre in the vicinity of Zagreb damaging it pretty badly on 9. November 1880. Among other earthquakes, a very important one occurred on 8. October 1909 southeast of Zagreb and Andrija Mohorovičić discovered the limit crust/mantle on the basis of this earthquake. This limit was named after its discoverer "Mohorovičić's discontinuity or abbreviated Moho. On the occasion of the 140th birth anniversary of this most famous Croatian scientist, of course together with the even more prominent Ruder Bošković, the symposium was held in Zagreb at which our geodetic scientist participated with their papers: (Čolić 1998), (Čolić et al. 1998b), (Solarić M. 1998), (Solarić M. et al. 1998b).

Because of everything mentioned above, the efforts for realising geodetic contribution to geodynamic researches in the Republic of Croatia have been intensified in the last five years, and especially along the Adriatic coast and island and at the territory of the capital Zagreb. Only two campaigns CRODYN'94-CRODYN'96 have yielded in the period of two years already very interesting results in the performed geodynamic analysis (Altiner et al. 1998a) very well in accordance with the geotectonic and seismic data (Cigrovski-Detelić 1998). At the end of the summer 1998 the GPS campaign CRODYN'98 was completed as the third phase of the Croatian geodynamic project – CRODYN. With the same aim, but also for the purpose of introducing co-ordinate cadastre of our metropolis, the Fundamental GPS network of the city of Zagreb was established in the autumn 1997 with 43 precisely determined GPS points, mostly by means of extraordinary well founded pillars (Čolić 1996b). The next campaign is foreseen to be carried out in 3 – 5 years.

Some of these works have been performed within the scope of the Central European Initiative and they all contain a common project: Central European Regional Geodynamics Project – CERGOP with altogether 11 countries participating in it (Feješ et al. 1998), (Reinhart et al. 1996). GPS measurements have been executed continuously through the period of one week from 1994 – 1997, in Croatia first only at the point Brusnik, and later on, the Observatory Hvar was included (Solarić M. 1998), (Solarić et al. 1998a). CERGOP computer center has been established in the State Geodetic Administration of the Republic of Croatia, and the first results were presented in (Marjanović, Rašić 1998b).

The most of stated papers and the obtained results have been the main reason for the organisation of the Second International Symposium: Geodynamics of the Alps-Adria Area by means of Terrestrial and Satellite methods, September 28th – October 2nd 1998, Dubrovnik, Croatia (proceedings in print). The Croatian organiser was the academician Krešimir Čolić, IAG national correspondent, and the co-organiser from abroad was H. Moritz, honorary president of IAG. The following papers made in collaboration with the scientists from abroad have were presented at the symposium: (Altiner et al. 1998a, 1998b), (Čolić, Moritz 1998), (Kühtreiber et al. 1998), (Richter et al. 1998). The following authors from Croatia presented their papers: (Čolić et al. 1998c), (Prelogović et al. 1998), (Solarić, Podunavac 1998), (Marjanović, Rašić 1998d), The success of the symposium – held after the first IAG symposium in Dubrovnik only nine years later because of the war consequences imposed upon us – has been very much contributed to by foreign participants among who only one really significant contribution is mentioned above (Moritz 1998).

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