FIVE YEARS OF EUREF-PERMANENT GPS-STATIONS IN CROATIA

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ABSTRACT

In October 2000, the Faculty of Geodesy, University of Zagreb, with the support of German Federal Agency for Cartography and Geodesy (BKG) and Croatian State Geodetic Administration, established two permanent GPS-stations: one in Dubrovnik and another one in Osijek. The stations became the part of large global network International GPS Service for Geodynamics (IGS), ie. the part of EUREF/Permanent project. This paper describes the background for the choice of locations, stabilization and precise measurements of local GPS-networks that connected the stations with EUREF/CROREF points nearby. The problems in the maintenance of the stations have been described as well. A view on the perspective of permanent GPS-services in Croatia is given, too.

INTRODUCTION

Since 1960, the movement of the Earth's litospheric plates has been explained by the analysis of global ocean floor spreading rates, transform fault systems and earthquake slip vectors. According to this theory, the Earth's crust consists of 14 to 16 major litospheric plates, floating on the fluid astenosphere.

At the mid-oceanic ridge hot magmatic material emerges, spreading the ocean floor apart. By this spreading the plates are shifted on their boundaries and begin to move. The horizontal motions of the litospheric plates generally range from a few to more than 150 mm/yr.

The NUVEL-1 model describes motions of 14 major plates relative to the fixed Pacific Plate (DeMets et al., 1990). The NNR-NUVEL1 model (no net rotation) gives absolute angular velocities of the plates (Argus and Gordon, 1991). Tectonic development of the Adriatic Sea area was and still is a very interesting puzzle for scientists. Some of them believe that the Adriatic Microplate is a promontory of the African Plate (Mantovani et al., 1995), asserting that this promontory moves in the northwest direction with the velocity of cca. 5 mm/yr.

On the other hand, other scientists explain the earthquakes that are frequently occurring in this area as an internal deformation of the Adriatic microplate (Anderson and Jackson, 1987). The measurement of such small movements between points that are far away from each other has been made possible by the development of the space techniques like Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR) and recently with GPS. In order to enable precise ground control for GPS

measurements, a multi-purpose international network has been established: International GPS-Service for Geodynamics (IGS). Beside the controlling of measurement accuracy for the whole system (orbit determination and correction), the role of such a network is substantial in the determination of the movement of the Earth's crust. Croatian geodesy joined to this world project in 2000 through establishing of two permanent GPS-stations (Dubrovnik and Osijek) within the EUREF Permanent subproject of IGS Network. Activity of these stations shall contribute to our knowledge of motions of the Adriatic Microplate as an important successor of the CRODYN project (Altiner, 1999; Altiner et al. 2001).

This paper describes the efforts of the mentioned projects and ends with future plans of a multi-purpose Croatian GPS-Permanent Network, which can be improved by adding a new permanent station in the area of Plitvice Lakes.

IGS AND EUREF-PERMANENT PROJECTS

Since the late 1980s, the U.S. Global Positioning System (GPS) constellation of satellites has come to play a major role in regional and global studies of Earth. In the face of continued growth and diversification of GPS applications, the worldwide scientific community has made an effort to promote international standards for GPS data acquisition and analysis, and to deploy and operate a common, comprehensive global tracking system.

As a part of this effort, the IGS was formally recognized in 1993 by the International Association of Geodesy (IAG), and began routine operations on January 1, 1994, providing GPS orbits, tracking data, and other data products in support of geodetic and geophysical research (Beutler et al., 1994; 1996). There are 288 IGS-stations as of January 2002.

Within the IAG Commission X, EUREF is the sub-commission, which is responsible for the maintenance of the European Reference System ETRS89. Members of the group are mainly federal survey authorities, universities and research institutes interested in the realization of a unified horizontal and vertical reference frame. Since 1995, the epoch-wise EUREF GPS campaigns were replaced to a great extent by the installation of the EPN, the EUREF Permanent GPS Network (EPN), (Bruyninx et al., 1996). This was done in close collaboration with the IGS seeking for regional densifications. In 1996 the EPN was accepted as a regional Network Associate Analysis Center (RNAAC) of the IGS for Europe. The number of stations was 118. From these, 47% of them belong to the IGS network as well.

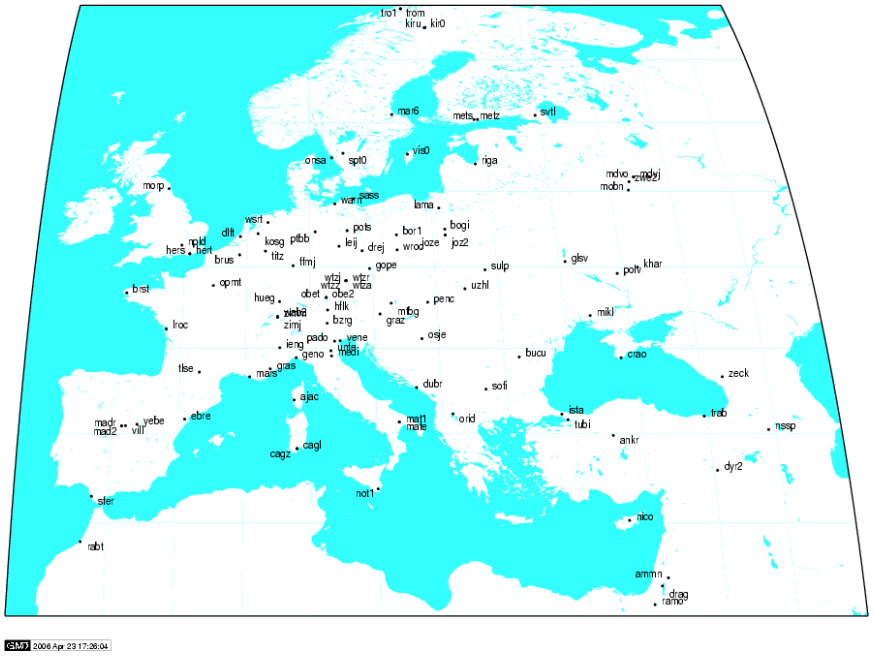

Figure 1. IGS stations in EUREF permanent tracking network

Figure 1 shows the IGS stations in EUREF permanent tracking network as in April 2006. To encourage the installation of EPN stations in less dense regions, the EUREF Technical working group has adopted a new guideline concerning the station location: a minimal distance of 300 km to already existing EPN stations is required, accepting the interest of each nation to have at least one EPN station. Exceptions to this rule are possible for stations submitting hourly data or contributing to EPN Special Projects. Thanks to this new guideline, 45% of the EPN stations are now submitting hourly data. The quality of daily data flow has been improved: at the EUREF Data Centre (BKG), the proportion of bad files (unreadable or wrong contents) fell from 1% to 0.05%. A part of this improvement was achieved by introduction of checking routines at the EPN Data Centres. The observations of the European Permanent Network are currently analysed by 13 Local Analysis Centers, which submit weekly solutions of their subnets to the EUREF Data Center at BKG.

There are two special projects within the EPN: Time Series Project and Troposphere Parameter Estimation. In 2000, the Time Series Project has been established in order to improve the EPN performance with a careful analysis and overview of each station encompassing the coordinate time series, the stability of the monumentation and the environmental effects. The SP is a joint effort of 6 different groups, where each group is responsible for a specific sub-region of the whole EPN. The groups are also encouraged to involve additional, non-official EPN sites into the analysis in order to derive a more detailed kinematic pattern of Europe. Within the routine analysis of a network of ground-based GPS receivers, tropospheric parameters are part of the estimation. Longer series of the zenith path delays, for example, support climate research. Therefore EUREF decided to create a Special Project Troposphere Parameter Estimation (Bruyninx et al., 2000).

PERMANENT STATIONS IN CROATIA

In 1998, several reconnaissance campaigns were undertaken in order to determine which sites suit the needs of potential GPS Permanent sites. Figure 2 shows the vicinity of Croatian territory with locations of existing IGS permanent stations.

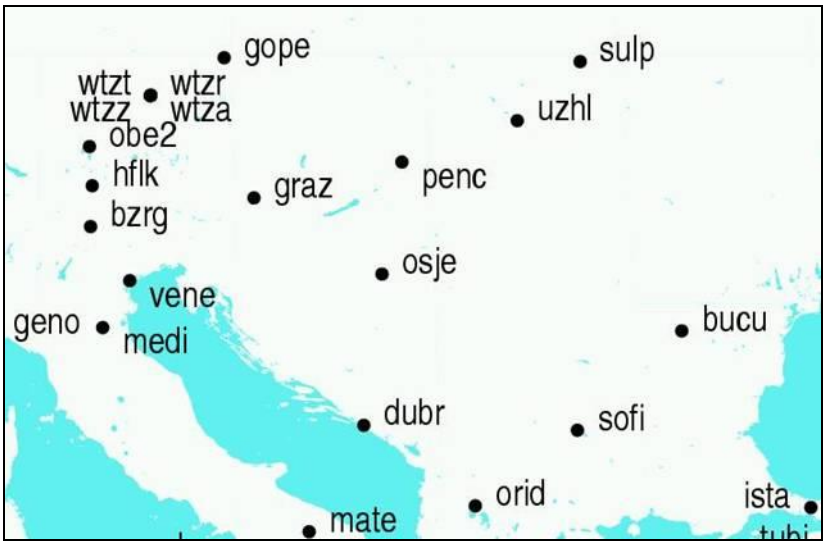

Figure 2. IGS stations in Adriatic Sea area

The shape of the Croatian territory dictated the choice: one point in the north-east and one point in the south-east. Finally, the experts from BKG agreed with Croatian colleagues to set up the stations in Osijek and Dubrovnik. According to the guidelines for European Permanent Network that were valid at that time (Gurtner, 1992), the area in north-east Croatia was not particularly suitable since it was not possible to set up the marker onto a bedrock foundation. Therefore, the building of the Geodetski zavod Osijek was chosen for stabilization of the marker. In Dubrovnik, the station was placed in an ancient fortress named Imperial, located at the Mount Srdj, the hill dominating the area. Special construction for antenna support was erected to achieve better angle for low-elevation satellites. Both stations are equipped with an Ashtech Z-12 GPS-receiver and an Ashtech Choke Ring antenna with Radome. Personal computers running the program GPS-Base are used for the control of receivers and data transfer. Observation interval has been set to 1 second, but these datasets are available only directly from the station within 14 days. The data that are hourly sent to the Data Center in BKG are rendered to 30 seconds intervals. Special GPS-campaigns were performed to determine the coordinates of the stations in the official Croatian reference frame CROREF96. It is important to stress that the Dubrovnik station was directly linked with the Dubrovnik tide gauge, yielding the important information of sea level rise in the long run.

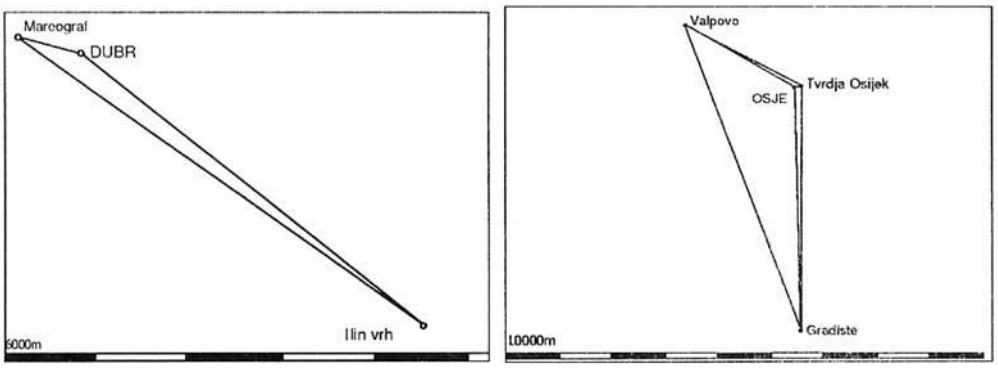

Figure 3. Networks of IGS points in Croatia: Dubrovnik (left) and Osijek (right)

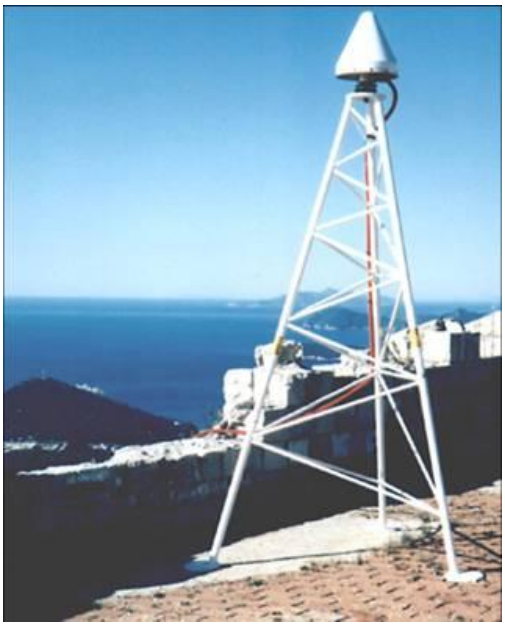

Figure 4. The monument at DUBR station

The stations are operating since October 2000. Although the obtained performance and stability of the stations is very good, it would be very useful to establish the ground control micro-network. High-precise terrestrial measurements should be used for long-term monitoring of monument stability, especially in Osijek.

Two another permanent stations, in Zagreb and Pula, are operating for even longer time, but these stations were not included into international projects so far. Because of their location and good stabilization, their inclusion in international projects has been recently considered. The station in Zagreb is operated by the City Cadastre and located on an independent part of the building of the City Computing Centre. This station had an important role in both geodynamical GPS-campaigns within the project Geodynamic GPS-Network of the City of Zagreb (Medak and Pribicevic 2001).

CONCLUSION

Croatian participation in the International GPS-Service for Geodynamics network is of great importance for more accurate explanations of recent tectonic and seismic patterns in the Adriatic Sea area. Good performance and inclusion of both stations in both

EUREF Permanent Network and the IGS network guarantee for continuous independent processing of all observations collected by the stations. Coordinates of both stations are determined in CROREF96 ensuring the connection to the local network. In this way, geodetic measurements shall contribute not only to better understanding of geodynamic activities of the region and a more accurate determination of satellite orbits, but shall give a better insight in tropospheric modelling related to the climate change. Continuous operation of the stations opens the possibility of real-time navigation by means of emitting the RTCM correction: precise differential GPS. Croatia has a chance to build up a modern service, interesting both for scientific purposes and for practical real-time navigation on the land, at the sea and in the air. Putting the permanent stations in Dubrovnik and Osijek in operation was just the first step in this direction. Unfortunately, the time allowed by customs to have imported equipment on Croatian soil was overstepped on 31st December 2005. Due to the fact that the Faculty of Geodesy has been restructured, another partner institution is sought by the BKG in order to continue with this important mission.

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