CROPOS – CROatian POsitioning System

Željko BAČIĆ, Marijan MARJANOVIĆ and Marinko BOSILJEVAC, Croatia

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SUMMARY

During 2008, the State Geodetic Administration was building the **CRO**atian **PO**sitioning **S**ystem: **CROPOS**. The system is being built with the most advanced GNSS (**G**lobal **N**avigation **S**atellite **S**ystem) technological solutions and reflects the current technological state of affairs which makes it, therefore, one of the most advanced systems of this kind. **CROPOS** was launched on December 9, 2008, and has already been widely used by the professional geodetic circles and beyond. The system encompasses 30 permanent GNSS stations and 2 control GNSS stations covering the entire Croatian territory with a network offering three services and guaranteeing high accuracy and surveying reliability.

The establishment of **CROPOS** is of particular importance because the Government of the Republic of Croatia adopted a new referential system and a new referential framework in 2004. They have to be implemented by the end of 2010 in the State Geodetic Administration's (SGA) environment which is a pre-condition for the comprehensive implementation of the new referential system in Croatia and all the geo-subjects. In order to achieve the afore-mentioned, the establishment of **CROPOS** is one of the important pre-conditions and main tools so its importance is, thus, further emphasized.

This paper describes the system establishment and states its technical characteristics as well as the description of the services that the system offers to its users. In the context of the establishment of the new referential system, a special overview is offered on the pricing policy and the expectations of the State Geodetic Administration with regards to its cost-effectiveness or rather usefulness, as well as future use.

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1. INTRODUCTION

Satellite positioning and satellite navigation have today become part of the everyday habits of a great number of professionals and citizens. For the purpose of using the satellite positioning and navigation systems as efficiently as possible, networks of permanent stations are being developed worldwide, recording the observations of these satellites and, through mobile communications, putting the data at the disposal of users, thus doubling the efficiency of the system use and multiplying its reliability.

Not wanting to lag behind these advanced solutions, bearing in mind the growing needs of the Croatian society and especially anticipating the near future when every cell phone will be equipped with a GPS receiver and navigational charts, the State Geodetic Administration has established the **CROPOS** service. **CROPOS** is a State network of referential GNSS stations of the Republic of Croatia enabling its users to determine a position in the so-called real time with the accuracy of more than +/- 2 cm in the entire territory of the Republic of Croatia.

The **CROPOS** service is intended for all stakeholders of the geodetic and cadastral system of the Republic of Croatia, State administration bodies and local government units as well as public systems and economic subjects of the RoC but also to nautical enthusiasts, alpinists, hikers and others.

2. CROPOS

2.1. Referential Network Stations Concept

The GNSS has introduced significant changes in a number of commercial activities and systems and could not bypass the geodetic activity either. One of the main aspirations of the geodetic science and practice has always been to achieve greater accuracy and reliability in determining positions while incurring minimal material expenses.

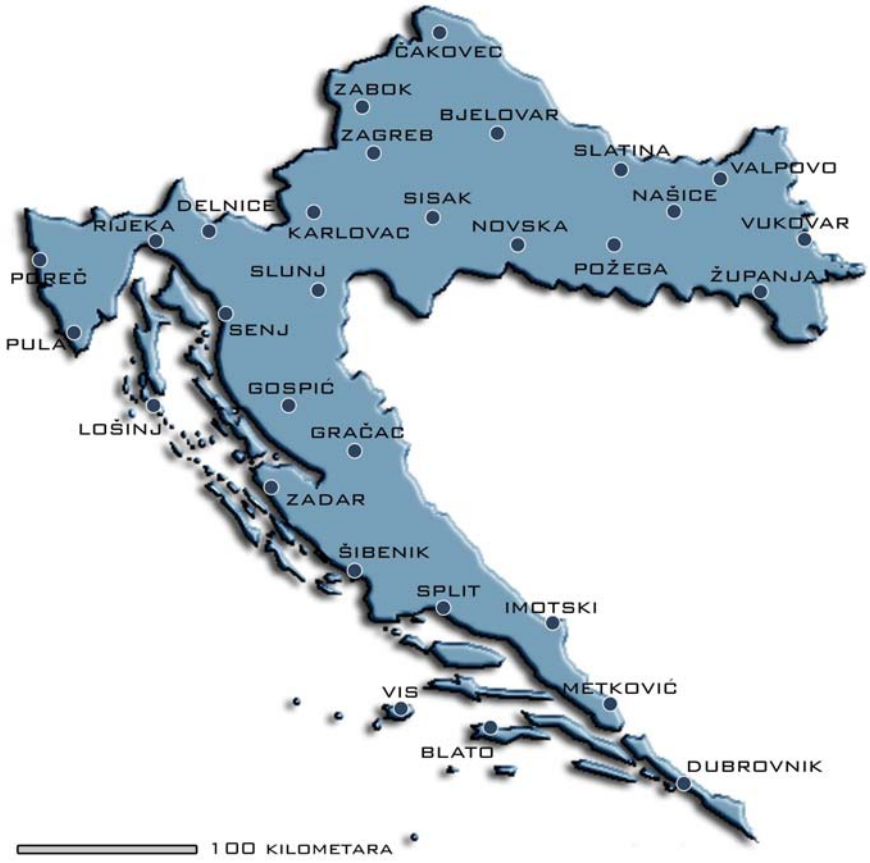

Figure 1. CROPOS - distribution of referential GNSS stations

Today, the answer to this is a concept of referential GNSS network stations. **CROPOS** consists of 30 referential GNSS stations dispersed in such a way as to cover the entire territory of the Republic of Croatia. The network system of referential GNSS stations enables a continuous GNSS surveying that is being computer processed at a control centre, and the obtained final results are being forwarded to the users in the field by wireless internet (GPRS/GSM). As compared to the present application of the GNSS surveying methods, the use of **CROPOS** will have the following advantages:

- reduction of investments in the required equipment (for approx. 50%)
- reduction in time (at least 50%) and human resources (at least 50%) – during the surveying
- while at the same time increasing the accuracy, reliability and homogeneity of the obtained surveying results
- service available 24/7/365

2.2. CROPOS System Technical Characteristics

CROPOS stations are positioned at a distance of approx. 70 km from each other and, due to safety reasons and easier communications and maintenance, they are located on the buildings of our regional and local cadastral offices (Figure 1).

The antennae of base stations are stabilized with the help of uniform support constructions made of high-quality materials such as steel (INOX) and differ only in terms of the length of the supporting tube. (see: figures 2 and 3).

Figure 2. GNSS PS Vukovar

Figure 3. GNSS PS Dubrovnik

The antennae - Trimble Zephyr Geodetic GNSS are fixed to the supporting construction with the help of special adapters enabling the horizontal adjustment and routing of antennae while other devices at the location of a specific permanent station, the GNSS receiver – Trimble NetR5 – and other ITC equipment are located in standardized communications racks (Figure 4).

Figure 4. GNSS and ITC equipment at the PS location

In order to ensure the accuracy enabled by today's technology, the most important thing is to ensure a continuous supply of data from the permanent stations to the control centre where the data is being verified, analyzed and processed by using models that reduce or completely eliminate the negative external influences and, through the process of adjustment, compute the correctional parameters that are available to the users in real time. The Trimble GPS Net software is used for this purpose.

The control centre is located at the Data Centre in the Head Office of the State Geodetic Administration and consists of the computer equipment for managing and maintaining the daily system functioning, data processing and network adjustment (Helwet Pachard), the communications equipment for linking specific system components (Cisco) and the computer and communications equipment for distributing the data to users (Helwet Pachard and Cisco). Figure 6 gives an overview of the computer and communications components at the control centre and their interconnection.

Figure 6. CROPOS Control Centre

2.3. CROPOS services

The users have at their disposal three types of services that differ between themselves according to the solution method, manner of data transfer, accuracy and data format. They are:

DSP – differential real time positioning service – 0.5 m accuracy intended for the implementation in geo-information systems, navigation, traffic regulation, environmental protection, agriculture and forestry.

VPSS – high-precision real time positioning service – accuracy in centimetres – intended for the implementation in State survey, cadastre, engineering geodesy, State border survey, aerial photogrammetry, hydrology.

GPPS – geodetic precision positioning service – of sub-centimetre accuracy, intended for the implementation of basic geodetic networks and for scientific and geodynamic research.

The basic characteristics of these services are given in the table 1.

Table 1: **CROPOS** services and their characteristics

CROPOS services	**METHOD SOLUTIONS**	**DATA TRANSFER**	**ACCURACY**	**DATA FORMAT**
DSP	network solution of coded surveys in real time	Wireless Internet (GPRS, UMTS) NTRIP protocol GSM	±0.3 do ±0.5 m	RTCM 2.3
VPPS	network solution of phase surveys in real time	Wireless Internet (GPRS, UMTS) NTRIP protocol GSM	±2 cm (2D) ±4 cm (3D)	RTCM 2.3 RTCM 3.1
GPPS	*post-processing*	Internet (FTP, e-mail)	±1 cm (2D, 3D)	RINEX RINEX VRS

2.3. Control of the System Functioning

The Department of the Basic Geodetic Works of the State Geodetic Administration is in charge of the system monitoring and control that are being undertaken at the Head Office. The Trimble GPS RTK software is used for continuous monitoring of referential stations.
Two control permanent stations simulating the work of users in the field (rover) and determining their position in real time by using corrective data several hundred times a day (approx. 600 initializations) have been set up for the system functioning control. Based on their results, the system functioning effectiveness and accuracy can be instantly accessed while the insight into the functioning and results of control stations is available to users at: www.cropos.hr .

3. CALCULATION OF THE PS COORDINATES AND SYSTEM TESTING

3.1. Calculation of the permanent station coordinates

The processing of survey data and the adjustment of the referential GNSS station coordinates of the **CROPOS** system have been performed by using the Bernese GPS Softwerom Ver. 5.0. The data used for calculations were the final IGS orbits and pole movements. The processing encompassed the 7-day surveying data taken during one 24-hour session for the GPS week 1503. The survey data processing was performed in the ITRF2005 referential framework, epoch 2008.83, and the coordinates were then transformed into the ETRF00 (R05). The median standard tolerances of the referential station coordinates, obtained on the basis of comparing the 7-day solutions and the common adjustment, are: σ_φ = 1.2 mm, σ_λ = 0.8 mm, σ_h = 3.4 mm.

3.2. System Testing

After having installed all the system components and calculated the referential station coordinates, the system testing was performed by measuring the points of the basic GNSS referential network of the first and second degree. The surveys were undertaken at the total of 372 points, evenly dispersed over the country in order to test the accuracy of the coordinate determination and system availability. During the testing, each point was measured by two independent sessions in a period of not less than 2 hours as follows: 3 x 5 seconds, 3 x 30 seconds and 3 x 60 seconds. The accuracy of determining the point coordinates based on odd measurements for determining the position is about ≈1 cm while the accuracy of the altitude component is: ≈2 cm.

4. TERMS OF USING THE CROPOS SERVICE

4.1. User Registration

The **CROPOS** services are available only to registered users. For that purpose, future users file a registration application to the State Geodetic Administration by using a prescribed form containing - apart from the personal details - the type of services as well as the number of the required licenses, and submitting a statement that they accept the general terms of using the service. After the completed registration, the users are given a user name and password for accessing a specific service. With one user name and password, the users may simultaneously access the system with only one device.

4.2. Service Pricelist

The **CROPOS** services are charged and the service pricelist is defined by the Rules and Regulations on Determination of the Categories of Actual Costs of Using the Date from the State Survey and Real Property Cadastre Documentation (Official Gazette 148/2008), see table 2.

Table 2: CROPOS Services Pricelist

Type of service	Accuracy	Data Format	Unit	Price	Registration Costs
CROPOS - DPS Differential positioning service	0.3 - 0.5 m	RTCM 2.3	1 year*	HRK 1.000	HRK 300*** (1€ = 7,4 HRK)
CROPOS - VPPS High-precision positioning service	0.02 - 0.04 m	RTCM 2.3 RTCM 3.1	1 minute 1 year	HRK 0,35 HRK 5.000	
CROPOS - GPPS Geodetic precision positioning service	*post-processing*	RINEX RINEX VRS	1 minute**	HRK 0,50	

* **CROPOS - DPS** service is charged on the annual basis only
** **CROPOS - GPPS** service is charged based on the selected time interval only
***Registration costs amount to HRK 300 and are being charged once when filing the application for registration regardless on the required number of services.
- for each additional user device of the same, already registered user, the fee will be calculated so as to multiply the fee for the previously registered user device by 0.9 without charging the costs of registration.

When forming the prices, the pricing models of several European countries were analyzed and the cost estimate for the annual system maintenance was carried out while we estimated the number of potential users at 300 registered users until the end of 2009, on the basis of the available data. Apart from covering the annual costs of the system maintenance, we geared the pricing model towards the prices that would, above all, be acceptable to the users and additionally stimulate them to use the system, or rather to use it mostly to apply for annual licenses. Furthermore, we also took care of having the pricing model as simple as possible and enable a simple monitoring of the costs incurred by the users. The fact that best indicates that we have estimated well all the elements is that in less than three months of the **CROPOS** functioning, 153 companies registered for the service(status as of 5 March 2009).

4.3. Customer Support

In order to provide the optimal and timely customer support, a web site, www.cropos.hr, has been established, containing all the basic information on the system, instructions and required forms for the registration process, promotional videos on the manner and benefits of using the **CROPOS** system as well as the latest information and warnings on the planned function disruptions.

5. SYSTEM ESTABLISHMENT

The establishment of the **CROPOS** service has mostly been financed by the EU pre-accession funds, within the PHARE 2005 program. The total value of the project is 1,720,000 € (75% EU funds and 25% RoC State Budget funds). Apart from this, funds from the State budget of the Republic of Croatia have been provided for the preparatory works (manufacturing and

placement of antennae constructions, establishment of the required installations and telecommunications lines) in the total amount of 120,000 €. Furthermore, it should be pointed out that the project preparation has been supported and assisted by the German GTZ as part of a long-standing bilateral cooperation. **CROPOS** was officially launched on December 9, 2008.

6. BENEFITS FOR CROATIA, ITS ECONOMY AND CITIZENS

By establishing the **CROPOS** system representing at present one of the most advanced systems of this type in Europe, the Republic of Croatia has become linked with the developed countries offering such services to their economies and citizens. Given the outstanding geodetic and construction activities, the transit nature of Croatia, its tourism and the generally pronounced commercial activities, the economy will directly benefit from the system because the use of the GNSS technology will become cheaper and the results more precise and reliable. Therefore, the **CROPOS** system represents the infrastructural background for the development of the entire range of economic activities in Croatia, i.e. it is a measure of our technological development.

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BIOGRAPHICAL NOTE

Prof. **Željko Bačić**, Ph.D., graduate geodetic engineer
Graduate on Faculty of Geodesy University of Zagreb in 1986 and took his Ph.D. at Institute for Applied Geodesy and Photogrammetry at Technical University in Graz in 1997. He started his professional career as teaching assistant at Faculty of Geodesy in Zagreb. In year 2002 was elected as Professor in Satellite Positioning and Navigation at the same Faculty. In year 1999 was appointed as Deputy Director and in year 2000 as Director General of State Geodetic Administration of Republic of Croatia. Since 2002 is member of EuroGeographics Management Boards and served as President in period 2005-2007. Since 2008 is member of Croatian National SDI Council and President of National SDI Board. Wrote alone, or with coauthors more than 50 papers in various fields of Geodesy and Geoinformatics.

Marijan Marjanović, Ph.D., graduate geodetic engineer
Academic experience: Graduate on Faculty of Geodesy University of Zagreb in 1992, Graduate on Post-Graduate Master of Technical Science Study on Faculty of Geodesy University of Zagreb in 2002 and Graduate on Post-Graduate Ph.D Study on Faculty of Geodesy University of Zagreb in 2008
Current position: Head of Department of the Basic Geodetic Works, Sector of State Survey, State Geodetic Administration
Practical experience: Geodesy, fundamental geodetic networks, GNSS, planning and development of CROPOS system
Member: Croatian Chamber of Architects and Civil Engineers

Marinko Bosiljevac, graduate geodetic engineer
Academic experience: graduate geodetic engineer, Faculty of Geodesy, University of Zagreb in 1985
Current position: Assistant Director, State Geodetic Administration, 2001-
Practical experience: Cadastre surveying, land registry, Geodesy, fundamental geodetic networks, GNSS, planning and development of CROPOS system
Member: Croatian Chamber of Architects and Civil Engineers, Croatian Geodetic Society

CONTACTS

Željko Bačić
State Geodetic Administration
Gruška 20
10 000 Zagreb
CROATIA
Phone + + 385 1 6165 444
Fax + 385 1 6157 389
Email: zeljko.bacic@dgu.hr
Web site: www.dgu.hr

Marijan Marjanović
State Geodetic Administration
Horvatova 82
10 000 Zagreb
CROATIA
Phone + 385 1 6165 415
Fax + 385 1 6165 430
Email: marijan.marjanovic@dgu.hr
Web site: www.dgu.hr

Marinko Bosiljevac
State Geodetic Administration
Horvatova 82
10 000 Zagreb
CROATIA
Phone + 385 1 6165 412
Fax + 385 1 6165 430
Email: marinko.bosiljevac@dgu.hr
Web site: www.dgu.hr