How to Utilize the Citizens to Gather VGI as a Support for 3D Cadastre Transition

Nikola VUČIĆ, Vlado CETL and Miodrag ROIĆ, Croatia

Key words: 3D cadastre, crowdsourcing, land administration, LADM, VGI

SUMMARY

Beside commercial purposes crowdsourcing is becoming more and more important for governmental institutions as well. Data acquisition is both time consuming and expensive. But required data can be accessed and utilized with free work force. Opposite to classic crowdsourcing where workers or volunteers are anonymous, in this project at the end contributors will be known since their names will be connected to the real property. Contributors for this project are an individual without a formal background in a subject, but who possesses time, and willingness to offer the data. It is important that the crowd perceives the initiative valuable and well intentioned. Therefore contributor's interest for participation will be calculation of utility rates or taxes based on construction volume and later for the use of the property. Initiative objective is to gather more precise three-dimension description of properties which will lead to quicker and easier 3D cadastre implementation. Because of a widespread use of smartphones and broadband Internet this initiative will be based on mobile infrastructure. Public institution should make a native application or a web page which will be used by contributors who will access application by their own smartphone over commercial network. Application will be linked to online database where contributors can upload required data. Control and validation of submitted data should be carried out to avoid vast quantities of incorrect data. In this paper we propose application design and required attributes from LADM (Land Administration Domain Model) Spatial Unit package collected and submitted by citizens. This paper shows case study for Croatian land administration system.

How to Utilize the Citizens to Gather VGI as a Support for 3D Cadastre Transition

Nikola VUČIĆ, Vlado CETL and Miodrag ROIĆ, Croatia

1. INTRODUCTION

Changes in society and technology increased diversity in the work organization and workforce. In 2006 Jeff Howe coined the term crowdsourcing of "crowd" and "outsourcing" and defined it as “the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call”. Crowdsourcing is a business model that use resources of individuals, which are in some cases networked. Beside commercial use, crowdsourcing is showing potential for government and the non-profit organization as well (Brabham, 2008).

Since crowdsourcing is relying on individual contribution an evaluation of participant is important. Participant can be an active contributor or a non-contributor. Quantity, usefulness and novelty are performance criteria of participant. Quantity as the number of provided contributions, usefulness as the value that a contribution has for the organizer of the initiative, and novelty as the newness of contribution. To create an effective initiative it is important to understand motivation of participants. Different motives have different effects. In general, there are two types of motivation: intrinsic and extrinsic. Intrinsic motivation implies that participant perform activity because it is interesting and gives satisfaction (Gagné and Deci, 2005).

Extrinsic motivation implies that participant perform activity for the reward (Frey and Oberholzer-Gee, 1997). Therefore participants have to be compensated because they are acting voluntarily. The use of voluntary resources provides benefits. A key benefit is cost savings since volunteers are not paid and contracted as employees. However, utilization of free or nearly workforce is not without flaws. Since volunteers are not part of closed-membership, control of the provided data have to be done. Volunteered geographic information (VGI) is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals (Goodchild, 2007). Some examples of this phenomenon are OpenStreetMap, WikiMapia, Google Map Maker, FourSquare, Geocaching etc.

Crowdsourcing usage examples can be found in various areas of human activity. The most common and very useful are those related to traffic and navigation. For instance, Waze smartphone application provides its users reporting on traffic conditions such as traffic jams, accidents, hazards, police presence, map errors as well as communication with other users. (Figure 1).

Figure 1. Smartphone application Waze (source: URL 1)

Bypassing demand bureaucracy could be a reason for encouragement participants to contribute to initiative. The initiative task must be understandable and contributors must be able to relate the goal of initiative to their living context.
In the last couple of decades, there has been an increasing demand for property development in urban areas, resulting in the division of property ownership so that different owners can own delimited space on, above or below ground surface. Under 3D cadastre, the 2D cadastre management of data cannot meet the real land management of the three dimension space aspect and property. It is essential to introduce the 3D cadastre (Choon and Seng, 2013).

This paper is organized as follows. Section 2 describes basic 2D to 3D cadastre transition terms. Section 3 describes how to VGI can be data acquisition support for 3D cadastre transition. Section 4 gives two case studies. The paper ends with conclusion.

2. TRANSITION FROM 2D TO 3D CADASTRE

A classical take of a cadastral parcel as a part of the land on which the rights are homogenous (in two-dimensional sense) in LADM (Land Administration Domain Model) is expanded by adding a third dimension which enables spatial representations of situations in which the interests over land overlap (Stoter et al. 2013). In addition, apart from using topologically structured cadastral parcels for the representation of person's interests over land, it enables some other approach based on textual descriptions, sketches, non-structured lines etc. in order to enable functioning of the system in situations when the data are not complete or when there is no possibility of establishing a more quality system.

Developed countries usually have well-developed 2D or 2.5D cadastre system. With the use of modern software solutions and the previous adjustment/change of regulations in the domain of civil law can create an effective 3D cadastre. For the transition from 2D to 3D cadastre system LADM is a useful tool because it is predicted and described numerous 3D real-life situations that need to be entered in the system of land administration.

Still, as the basic concept for the 2D representation of the spatial units LADM implies vertical boundary face strings, which spread infinitely, and are laid within the boundaries of spatial units (Figure 2), while for 3D representations of spatial units it implies boundary faces, but neither infinite, nor necessary vertical, but aligned so that they close a certain 3D space. Precisely because of that it is possible to interpret a 2D representation as a 3D prismatic volume without the upper and lower boundary. By interpreting 2D and 3D representations in such a way, they can be fitted into the same data model (Stoter 2004).

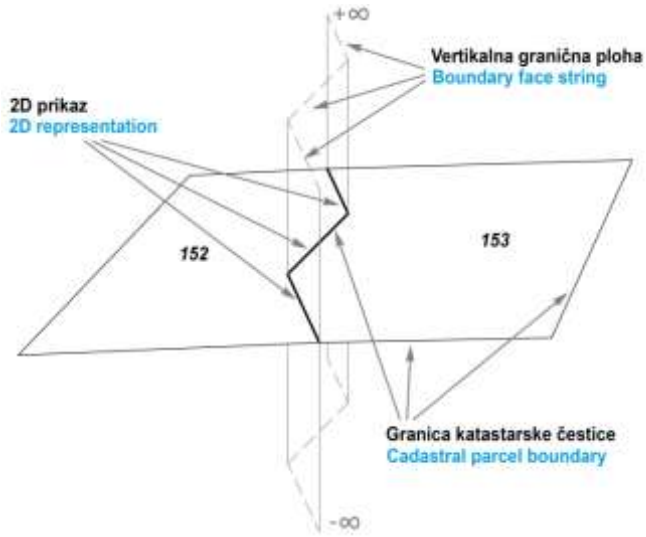

Figure 2. The concept of vertical boundary face strings

Liminal spatial units represent a special case in such a data model when 2D representation of one spatial unit is right next to 3D representation of its neighbouring spatial unit (Figure 3). On the contact points of 2D and 3D representations there is an overlap of infinite vertical face string which serves for a 2D representation and a vertical face which is used to model a side of 3D spatial unit. This kind of overlap is not permitted because it represents redundancy in the model. The existence of these two faces in a common model is conditioned by their merger in a common infinite vertical face string, split in a way that one of its parts matches the face by which is modelled the 3D side of a spatial unit, while as an entity, it meets the needs of 2D representation of a liminal spatial unit.

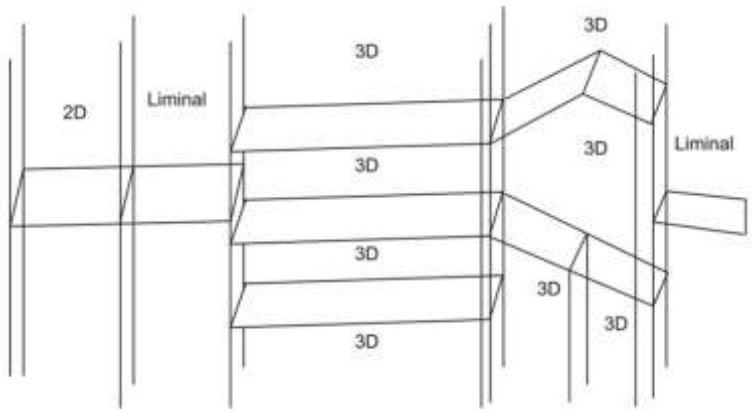

Figure 3. Mixed 2D/3D representation (ISO 2012)

Surveyors today in most cases use GNSS technology and determination of third (Z) coordinate is not particularly demanding anymore. Therefore official surveying data can be used in order to gather third coordinate for the 3D cadastre establishment. It is also possible to utilized required data with crowdsourcing initiative for the new geodetic datum, as Australia did. The currency and the resolution of datum and deformation model will depend directly on the resources available for data collection and processing. In regions where there is an economic or scientific incentive, there is no reason why private and public organisations cannot pool their geodetic information for the benefit of all. Practical experience in Australia (Queensland) has demonstrated the significant benefits in organizing and crowdsourcing geodetic measurement from multiple organisations (Haasdyk and Roberts 2013).

For the purposes of 3D cadastre beside official geodetic modes (measurements at the field by an authorized person) crowdsourcing can be used, especially for the delivery of height data for particular part of real property.

3. VGI AS A SUPPORT FOR 3D CADASTRE TRANSITION

For the purpose of create 3D cadastre from existing 2D cadastral data citizens (property owners) can be a useful target group for the data delivery to official registers such as cadastre and land book.

3.1 Infrastructure

Most of the crowdsourcing initiatives are either mobile or web based. Crowdsourcing requires abundant, reliable and cheap telephone or mobile access for its communication needs in order to ensure participation of the crowd (Donner, 2009). The ease of accessibility, reliability and quality of communication technologies (or technology infrastructure), internet is necessary for crowd participation (Heeks and Nicholson, 2004).

3.1.1 Methodology

Predetermined list of criteria for volunteers is simple. Only requirement is to have a

smartphone with an Internet access. Contributors for this project are an individual without a formal background in a subject, but who possesses the interest, time, and willingness to offer the data. To conduct successful initiative sufficient members of the crowd should participating in it. Initiative should have well-defined goals. The vision of the initiative is very important to the crowd. It is imperative that the crowd perceives the initiative as valuable and well intentioned

Motives of the crowd should be aligned to the objectives of the initiative. To promote the initiative and to stimulate the participation of the contributors public institution should defined benefits for participants. As a result public institution will have sufficient a data for a 3D cadastre, and as a reward contributor will have better definition of real property in public registers and other benefits provided by the public bodies (for motivation contributors). No special training was provided for the contributors. Therefore we strive to design easy and intuitive application.

3.1.2 Data delivery

Through mobile application contributors provide data on special part of the property height, reference point and data surface relation (Table 1). The property owner himself has to measure the height of the property. Property height is correlated with an attribute ParticularPartOfPropertyHeight from international ISO 19152 (LADM) extension, Croatian Country Profile of LADM. Other two attributes, referencePoint and surfaceRelation are in accordance with ISO 19152 (LADM). Combination of 2D report on partition of real property and data provided by contributors it is possible to establish part of the 3D cadastre. It is possible to visualize particular parts of the property (flats, apartments, office spaces) as well as volume.

Table 1. Attributes of Spatial Unit class - for delivery through crowdsourcing

Attributes	**Meaning attributes of Spatial Unit class**	**Native LADM attribute**	**Possibility of delivery through the mobile application**
referencePoint	the coordinates of a point inside the spatial unit	YES	YES
surfaceRelation	indicates whether a spatial unit is above or below the surface (above, below, mixed…)	YES	YES
ParticularPartOfPropertyHeight	height of Particular part of property	NO	YES

Attribute buildingRoofType is not specified in LADM original standard. This attribute already specified for LADM expansion - Croatia Country profile and is used for visualization of buildings and other structures, and for more complex approximations volume of buildings and their special parts (Table 2).

Table 2. Attributes of LegalSpaceBuildingUnit class – for delivery through crowdsourcing

Attributes	Meaning attributes of LegalSpaceBuildingUnit class	Native LADM attribute	Possibility of delivery through the mobile application
buildingRoofType	type of roof (flat, inclined, composite, etc.)	NO	YES

3.1.3 Data officiality

Owner has to be identified with personal identification number in order to provide more accurate data from previous chapter. There is a possibility that a representative of the co-owners submit all the information collectively via e-mail or regular mail, especially if building architectural drawings with the height of individual floors are preserved. For data officiality it is recommended that the bodies of land management system (cadastre and / or land book) carry out random control in the field.

3.2 CASE STUDIES

Following sub-chapters given two examples of the possibilities of using crowdsourcing in the preparation of 3D cadastre. The effort required for participation in the initiative is minimal.

3.2.1 Case study 1 – apartment in a residential – commercial building

This case study provides data of the property height, building reference point coordinates and surface relation. In this particular case flat is in a residential–commercial building with 65 apartments and 3 commercial units (Figure 4).

Figure 4. Case study 1 – building on Google street view service (URL 2)

First of all the area of territorial cadastral office jurisdiction and cadastral municipality has to be selected in mobile application (Figure 5).

Figure 5. General design of 3D cadastre crowdsourcing initiative mobile application

For final check of selected property object reference point coordinate must be submitted (best position is centre of the building). Coordinate is read from the State Geodetic Administration Geoportal (Figure 6) and entered in the required field in a mobile application. It is also possible to determine coordinate with smartphone using built in GPS receiver. In that case it is necessary to measure on the outer side of the window because the indoor GPS signal is weak, or no signal at all.

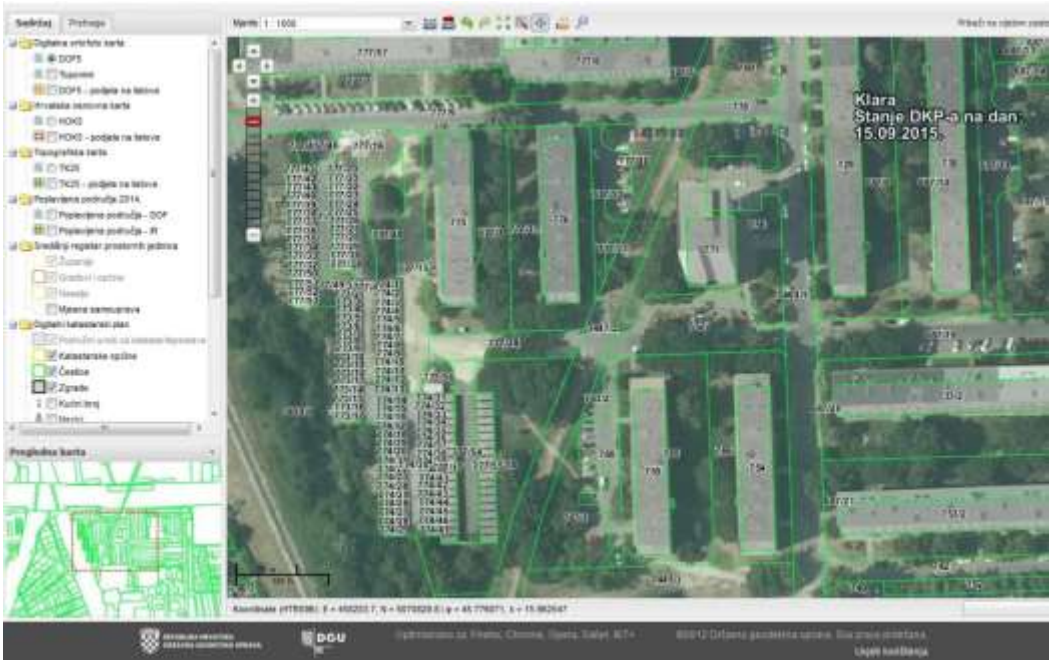

Figure 6. Case study 1 - building on Geoportal

For the data access on the real property it is necessary to know the basic information such as the name of the cadastral municipality, cadastral parcel number, number of land book file or number of land book sub-file. Because the 3D cadastre are not so significant on real property without buildings (agricultural land) application for crowdsourcing 3D cadastre warns that the selected cadastral parcel without buildings (Figure 7).

Figure 7. Mobile application design for 3D cadastre crowdsourcing initiative: selection of property

Requested data, described in Section 3.1.2. according LADM, could be submitted after property selection. Property owner should measure height with regular measuring tape which every household has. Property owner should also provide information on the property surface relation is it above, below ground or mixed. This information citizen participant could determine and deliver through application to the official authority. Participant must provide personal identification number as a proof that selected property is owned by him (Figure 8).

Figure 8. Mobile application design for 3D cadastre crowdsourcing initiative: data delivery

3.2.2 Case study – building after process of legalization

This case study provides data of the building volume. A case study is a house with finished process of the legalization. In the legalization process of illegally constructed buildings dimensions (length, width, height) and volume are determined (Figure 9).

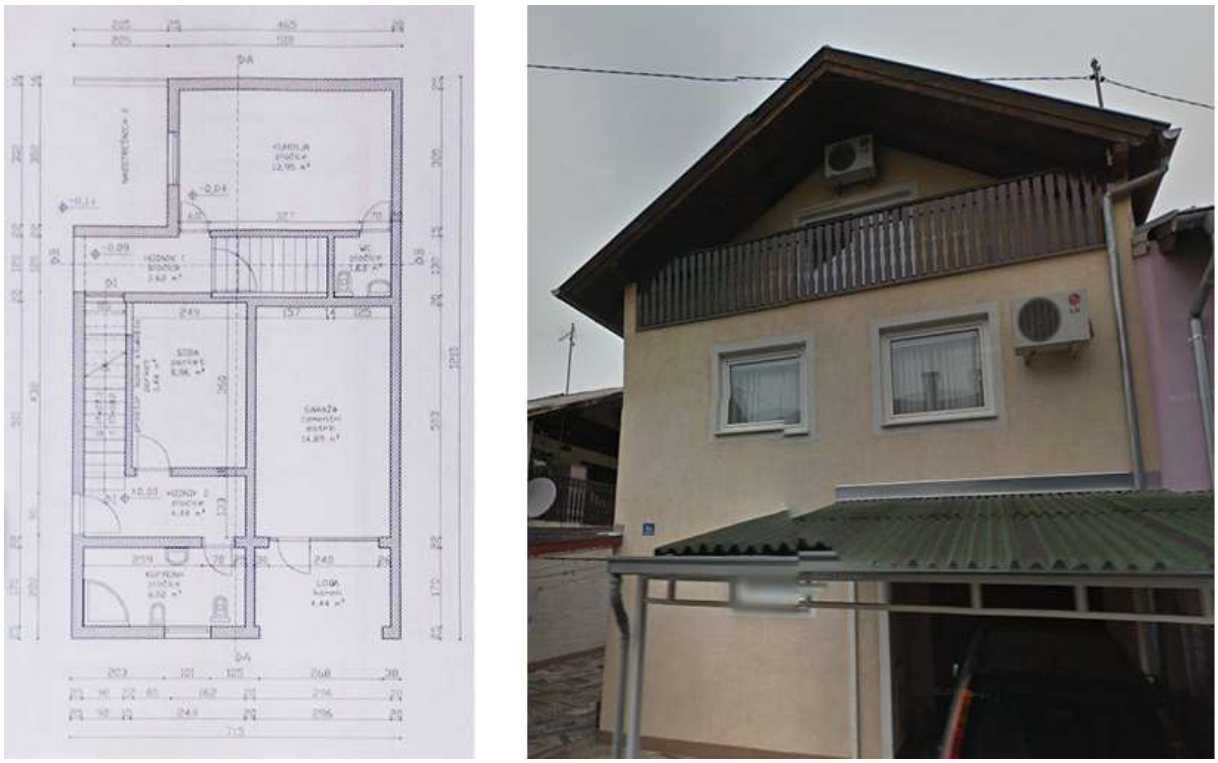

Figure 9. Case study 2 – family house

Volume is shown in the documentation provided by licensed architect (Table 3), and is kept by the owner and local office for construction. Final act of the derived condition which is the counterpart of the use permit shall be submitted to the land book office, but it does not contain volume data but only surface data of the building.

Table 3. Part of documentation provided by licensed architect

Volume of building	
Basement	V1 = 28,59 m^3
Ground floor	V2 = 221,93 m^3
I. floor	V3 = 208,12 m^3
Attic	V4 = 148,14 m^3
TOTAL	**V= 606,78 m^3**

However data on the volume that is in the process of legalization precisely calculated could be delivered through crowdsourcing – mobile application (Figure 10).

Figure 10. Mobile application design for 3D cadastre crowdsourcing initiative: volume data delivery

4. CONCLUSION

It is possible to create a mobile application that allows citizens and other interested parties submitted to the competent authority the information relevant for the formation one form of 3D cadastre (building cadastre).Initiative objective is to gather more precise three-dimension description of properties which will lead to quicker and easier 3D cadastre implementation. Because of a widespread use of smartphones and broadband Internet this initiative will be based on mobile infrastructure. Public institution should make a native application or a web page which will be used by contributors who will access application by their own smartphone over commercial network. Application will be linked to online database where contributors can upload required data. Control and validation of submitted data should be carried out to avoid vast quantities of incorrect data. In this paper we propose application design and required attributes from LADM (Land Administration Domain Model) Spatial Unit package collected and submitted by citizens. It is necessary to find a way to motivate people to participate and to give real and accurate information. There are ways, such as awarding a certain number of users, show the benefits for the citizens or similar.

ACKNOWLEDGEMENTS

Many thanks to Mrs. Sandra Kaić and Mr. Tomislav Kaić for provided data in case study 2. This paper is supported by the Croatian Science Foundation (HRZZ) under grant I-2485-2014

Development of Multipurpose Land Administration System – DEMLAS.

REFERENCES

Brabham, D. (2008) Crowdsourcing as a model for problem solving. An introduction and cases, Convergence: The International Journal of Research into New Media Technologies. 14 (1), pp. 75 – 90

Choon, L. T, Seng, L. K, (2013), Towards a Malaysian Multipurpose 3D Cadastre based on the Land Administration Domain Model (LADM) - An Empirical Study, Proceedings of the 5th Land Administration Domain Model Workshop, Kuala Lumpur, Malaysia, FIG, Copenhagen, Denmark

Donner, J. (2009) Mobile based livelihood services in Africa: pilots and early deployments, Communication technologies in Latin America and Africa: A multidisciplinary perspective, pp. 37–58

Frey, B.S, Oberholzer-Gee, F. (1997) The cost of price incentives: An empirical analysis of motivation crowding-out. The American economic review, 87(4), pp. 746 – 755.

Gagné, M., Deci, L. (2005) Self-determination theory and work motivation, Journal of Organizational Behavior, 26, pp. 331 – 362

Goodchild, M.F. (2007) Citizens as sensors: the world of volunteered geography, GeoJournal 69 (4): pp. 211–221

Haasdyk, J, Roberts, C. (2013) Monitoring Station Movement using a State-Wide Simultaneous, International Global Navigation Satellite Systems Society IGNSS Symposium 2013, Outrigger Gold Coast, Queensland, Australia

Heeks, R., Nicholson, B. (2004) Software Export Success Factors and Strategies in Developing and Transitional Economies. Competition and Change, pp. 267-302

ISO (2012): Geographic information - Land Administration Domain Model (LADM) - ISO 19152, International Organization for Standardization, Switzerland

Stoter, J. (2004): 3D Cadastre. PhD Thesis, Netherlands Geodetic Commission, Publications on Geodesy, 57, Netherlands

Stoter, J., Ploeger, H., Oosterom, P. van (2013): 3D Cadastre in the Netherlands: Developments and international applicability, Computers, Environment and Urban Systems, 40, pp. 56-67

URL 1: www.waze.com, 1 September 2015

URL 2: maps.google.hr, 1 October 2015

BIOGRAPHICAL NOTES

Nikola Vučić graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. He is the Head of the Department for Administrative and Professional Supervision at the State Geodetic Administration of the Republic of Croatia. He is a PhD student in Geodesy and Geoinformation at University of Zagreb, Faculty of Geodesy. The topics that he specializes in are land administration systems, cadastres and geoinformation. He is a member of the Croatian Geodetic Society.

Vlado Cetl is an associate professor at the Faculty of geodesy, University of Zagreb. The main fields of his research interest are Cadastre, Land Management, Geoinformation Systems, Spatial Data Infrastructure, Volunteered Geographic Information and Risk management. He authored or co-authored more than 60 papers in various fields of geodesy and geoinformatics.

Miodrag Roić graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. In 1994, he received a PhD from the Technical University Vienna for the thesis "Surveying of Natural 3D-Structures with Video-theodolites". Since 1996, he is a professor at the University of Zagreb, Faculty of Geodesy. He was Vice Dean of the Faculty, Head of the Chair of Spatial Information Management and the Institute of Engineering Geodesy, and he is appointed as Dean for 2011-2015. The topics that he specializes in are land administration systems, engineering geodesy, cadastres and geoinformatics. He was an editor-in-chief of "Geodetski list", an internationally recognized Croatian scientific geodetic journal. He is a corresponding member of the German Geodetic Commission (DGK) and many other national and international scientific and professional institutions.

CONTACTS

Nikola Vučić
University of Zagreb – Faculty of Geodesy
Kačićeva 26
Zagreb
Croatia
Phone: + 385 98 622 034
Fax: + +385 1 4828 081
E-mail: nvucic@geof.hr
Website: http://www.geof.unizg.hr

Vlado Cetl
University of Zagreb – Faculty of Geodesy
Kačićeva 26
Zagreb

Croatia
Phone: + 385 1 4639 191
Fax: + +385 1 4828 081
E-mail: vcetl@geof.hr
Website: http://www.geof.unizg.hr

Miodrag Roić
University of Zagreb – Faculty of Geodesy
Kačićeva 26
Zagreb
Croatia
Phone: + 385 1 4639 229
Fax: + +385 1 4828 081
E-mail: mroic@geof.hr
Website: http://www.geof.unizg.hr