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3D Land Administration for 3D Land Uses

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The increasing complexity of densely built-up areas and infrastructures (3D Land Uses) requires the proper registration of the legal status of built environment (private and public), which only can be provided to a limited extent by the existing 2D representations. This is the fourth themed issue on the topic of 3D Land Administration, showing the continuous progress in this field. The earlier issues on the topic are published as: 3D Cadastres (editors Lemmen, van Oosterom, 2003); 3D Cadastres II (editor van Oosterom, 2013); and Research and development progress in 3D cadastral systems (editors van Oosterom and Dimopoulou, 2019). In addition, the FIG (International Federation of Surveyors) published FIG Publication 72, Best Practices 3D Cadastres (editor van Oosterom, 2018).

Complete delivery of the 3D land administration theory, along with its practical implementation, is a multi-disciplinary problem. Each of the involved academic disciplines (i.e. legal foundations, 3D survey/initial registration, 3D information modelling, 3D spatial DBMS and Visualization) show that progress is being made, both within those certain disciplines, but also across disciplines. This is resulting in the development of prototype and operational systems supporting (a part of) 3D Land Administration. Moving forward, there is no single major bottleneck, but working towards 3D Land Administration will remain a multi-faceted challenge. Each paper in the special issue has its added value in that regard.

In this themed issue the term '3D Land Administration' is used instead of the more well-known term '3D Cadastres', as used by the FIG (Joint Commission 3 and 7 Working Group on 3D Cadastres, and the associated series of Workshops starting in 2001 all with name '3D Cadastres'). The main reason for this deviation is that the International Standards Organization (ISO) decided to use the term 'Land Administration' for this domain, including 3D representations (ISO, 2012), in the standard ISO 19152:2012, Geographic Information – Land Administration Domain Model (LADM). The definition used in ISO 19152 Edition I (and to be extended in Edition II (Lemmen et al., 2019)), is re-formulated from the definition of land administration as stated in the land administration guidelines by the UN ECE 1998 (UN ECE, 1996). The term 'Land Administration' is used in these Guidelines to refer to the processes of recording and disseminating information about the ownership, value and use of land and its associated resources. This is seen to include Land Registry and Cadastres. A second reason why the term 'Land Administration' is used is that it is less ambiguous than the term 'Cadastres', which in some parts of the world implies a focus only on the spatial aspects. However, with the term 'Land Administration' both the legal (administrative) and the spatial aspects are covered (in some countries indicated by the two terms: Land Registry and Cadastres). In short: 'Land Administration = Land Registry + Cadastres + Valuation + Land use (planning)' (c.f. Williamson et al., 2010). It should be noted that in many countries the term 'Cadastres' is also intended in a broader sense, as in the context of the FIG Working Group and their Workshops on 3D Cadastres. Concluding, to avoid any possible confusion with the term 3D Cadastres, this themed issue uses the term 3D Land Administration in line with ISO 19152:2012. It should be noted here that in the individual papers the term 3D Cadastres may still appear.

Taking a global and academic view, the topic is maturing, and there are more and more 3D Land Administration examples from diverse country contexts. Also, it is realized (again) that land administration is not an isolated activity, but one of the steps in the whole chain of activities needed to support spatial and societal development in a sustainable manner. The increasing attention for 3D representations in land administration can also be seen in other steps of the spatial development: planning, design, permitting, constructing, enforcement, and so on. In the information age, citizens and agencies do not accept isolated information silo's anymore: data sharing and reuse are topics of growing importance. The information infrastructure is a tool to realize data sharing by networked connectivity and improved interoperability. Standards play a crucial role in the information infrastructure, and specifically the earlier mentioned LADM (ISO 19152:2012). This standard has been in use for eight years by now, and the ISO TC211 members decided that the standard is up for revision and should address land administration with a wider scope, such as valuation, spatial planning (planned land use), marine spaces and with more detailed 3D representations. Several of the papers in this themed issue are in the

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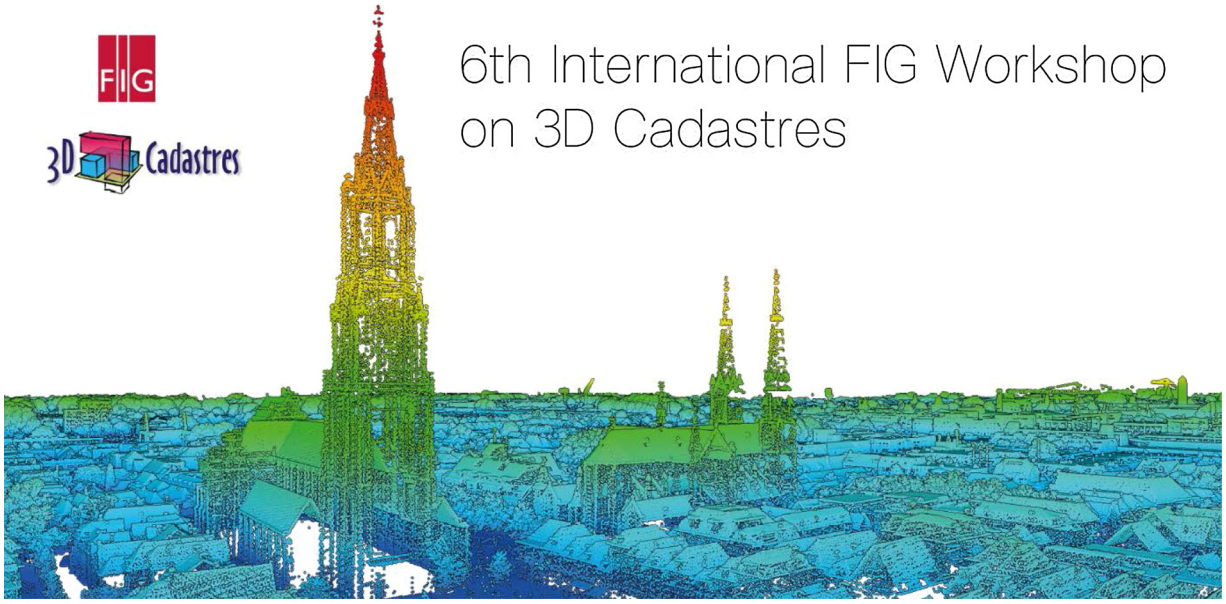

Fig. 1. The 6th International FIG Workshop on 3D Cadastres.

shadow cast ahead by this LADM revision.

The content of this themed issue has its origin at the "6th International FIG Workshop on 3D Cadastres", conducted on 2-4 October 2018, Delft, the Netherlands; see Fig. 1. The Workshop was organized by the FIG joint commission 3 and 7 Working Group on 3D Cadastres to offer a platform for exchanging ideas and solutions between scientists from academia, industry, and government. The workshop proceedings (van Oosterom and Dubbeling, 2018) contain the full text of the various accepted contributions. After the workshop, authors of selected papers were invited to publish a significantly different or extended paper to a themed issue within the international scientific journal 'Land Use Policy' (LUP). The 16 papers published in this themed issue are the end result of the authors' hard work and an independent and rigorous journal's peer review process. The aim is to provide the most contemporary view of the developing field of 3D Land Administration, in terms of tools, methods, and theories – and the country contexts where exploratory work is underway, or even implementation is commencing. We, the Editors, hope you enjoy the collection of works and the challenges and opportunities they collectively present to the domain of Land Administration.

Maria Gkeli, Chryssy Potsiou and Charalabos Ioannidis present a technical solution under development, aiming to provide initial acquisition, registration and representation of 3D crowdsourced cadastral data. The proposed solution consists of a server-side Database Management System (DBMS) where the collected data are stored, and a client-side open-source mobile application for the acquisition of 3D crowdsourced cadastral data. The solution enables 3D modelling and visualization of 3D property units as block models (LoD1) on a mobile's phone screen in real-time.

Dubravka Sladić, Aleksandra Radulović and Miro Govedarica write in support of efficient, automatic management, and storage of cadastral information. The paper presents a developed process model for the Serbian cadastre. It is based on the hierarchical decomposition of two basic groups of processes: processes for changing cadastral data and processes for displaying cadastral data. The model, which is an abstract model, meaning it is independent of the implementation, aims to extend the current 2D process model upgrading it with 3D data, in the move towards a 3D cadastre.

Nikola Vučić, Mario Mađer, Saša Vranić and Miodrag Roić present a historical background of cadastral data acquisition in Croatia resulting in a variety of cadastral data qualities. To improve the current Land Administration System and commence upgrading it to a 3D cadastre, the paper proposes a model based on the ISO 19152 standard, including its static components, and improvements for cadastral resurvey related processes. Critical points and recommendations for the Real Property Cadastre upgrade are discussed.

Karolina Larsson, Jesper Paasch and Jenny Paulsson discuss the problems and challenges concerning the conversion of 2D analogue cadastral boundary plans into 3D digital information, focusing on the legal issues in Sweden. The study shows that current legislation has to be re-investigated and re-interpreted in in order to support the 3D system. Analysis on the current cadastral process and suggestions for further development are provided.

Anka Lisec, Dimitrios Kitsakis, Gerhard Navratil and Marcin Karabin focus on approaches to the registration of real property rights in the case of underground or subway tunnels in different EU countries: Austria, Bulgaria, Czech Republic, Croatia, Greece, Poland, Slovenia, and Sweden. The authors conducted analysis on the registration of rights to subway tunnels in the chosen countries, including its effectiveness in ensuring appropriate property rights to construct and exploit tunnels. Benefits which might be achieved by the introduction of a 3D real property subdivision are pointed out. The analysis of the available data concerning the geometry of subway tunnels in particular countries was presented.

Eftychia Kalogianni, Efi Dimopoulou, Rod Thompson, Christiaan Lemmen, Shen Ying and Peter van Oosterom discuss dense urbanisation and the growing need for creating usable space, which has led to increasing pressure for land development. Interoperability, data sharing and data integration are required for an efficient spatial development lifecycle of (3D) objects. The paper underlines the role of spatial profiles that can efficiently support a holistic lifecycle thinking and enhance the interoperability between the different phases and disciplines. The spatial profiles of LADM Edition I are described, and the new 3D spatial profiles that are proposed to be included in the new edition are discussed.

Jernej Tekavec and Anka Lisec note there is currently no solution that enables large-scale indoor spatial data acquisition. Their work looks at the appropriateness of existing cadastral data for 3D indoor modelling. A framework for 3D indoor modelling is then developed, starting from the initial cadastral data and ending with an OGC IndoorGML compliant document. The Slovenian Building Cadastre data represents the basis for the framework design and data assessment. The

IndoorGML standard is used for final outputs.

Abdullah Alattas, Peter van Oosterom, Sisi Zlatanova, Dick Hoeneveld and Edward Verbree consider the issue that during indoor emergencies an efficient evacuation plan is required to help users move to safe areas. A complication is that users of indoor environments have different rights to access the indoor spaces. In response, the authors extend the conceptual model of LADM-IndoorGML to define the access rights for users of the indoor environments. The development of a database for the conceptual model is proposed based on PostgreSQL/PostGIS and QGIS. The approach enables movement analyses of individual and groups of users in 3D and supports decision-making in critical situations.

Dimitrios Kitsakis and Efi Dimopoulou address the incorporation of Public Law Restrictions (PLRs) into cadastral systems, which is seen as a step towards the development of integrated land administration systems. This paper focuses on identifying PLRs that have explicit or implicit 3D characteristics, using the Trans Adriatic Pipeline (TAP) project as a case. The aim is to identify the nature of 3D PLRs, based on the legal requirements defined in Environmental Impact Assessment (ESIA) studies, and to investigate the possibility of compiling 3D environmental models from recorded ESIA data. Economic implications are also considered.

Tarun Ghawana, Jason Sargent, Rohan Bennett, Jaap Zevenbergen, Pradeep Khandelwal and Subu Rahman focus on Delhi, where the increasingly complex 3D infrastructure environment presents a challenge for land agencies. This paper explores both the current and potential future application of 3D representation in Delhi, with respect to land use planning, development and management. The legal framework is shown to already consider the third dimension, however, administrative practices relating to 3D representation are considered immature. Engagement with international developments and a standards-based approach is proposed.

Agung Indrajit, Bastian van Loenen, Hendrik Ploeger and Peter van Oosterom discuss how to construct interoperable information between spatial planning and land administration. The standardization of spatial planning information and land administration are considered interoperable subsets of land-related information. The paper proposes the development of a spatial planning package within the existing LADM standard.

Charisse Griffith-Charles and Michael Sutherland initially posit the need for 3D cadastres in low-income but densely structured urban areas of informal tenure and informal development. The paper then tests the ability of an existing LiDAR dataset together with orthoimagery, derived to be low cost, so therefore having limited specifications, in a densely structured case study area of Laventille, Trinidad and Tobago. The difficulties of manually or automatically discriminating between close and overlapping structures and boundaries are highlighted, and it is found that there is still a need for verification on the ground.

Ali Asghari, Mohsen Kalantari and Abbas Rajabifard examine a structured framework for 3D cadastral data validation in Victoria, Australia. As part of the process of transition from the 2D representation of cadastre towards 3D digital cadastre, not only will 2D representations be replaced with 3D models, but the examination workflow and its principles also need to be able to deal with 3D models. The paper's methodology utilises a case study approach where plan examination process in Victoria, Australia has been analysed to investigate the principles of examining cadastral plans and expanding them for validating 3D digital plans.

Barbara Cemellini, Peter van Oosterom, Rod Thompson and Marian de Vries describe the visualization requirements, the database schema, and the provision of LADM-compatible views of the data for the purpose of developing a 3D Cadastral prototype. A number of 3D building units and volumetric parcels are added to the 2D Cadastral data in the case study area, located in Brisbane, Australia. The mixed 2D and 3D content is available on the web for visualization and interaction in the form of KML, through Cesium JS. The paper presents the results of the usability tests.

Abdullah Kara, Peter van Oosterom, Volkan Çağdaş, Ümit Işıkdağ and Christiaan Lemmen present how 3D datasets and spatial analyses (such as viewshed analyses) could be used to support property valuation activities and to investigate to what extent it is possible and meaningful to include derived 3D characteristics of property units in valuation registries. Further, a 3D profile of the recently proposed Valuation Information Model LADM extension is described. A case study with open data from the Netherlands is conducted.

Ramiro Alberdi and Diego Erba present the development of a conceptual model of 3D water bodies as Legal Land Objects (LLOs) with dynamic limits based on the legal definitions of riparian boundaries of Argentine Law, to be registered in a future 4D cadastre system. The paper shows that it is possible to automatize and describe the movement and the deformation of the dynamic boundaries with free and basic information and tools. Marine Cadastre and the Fluvial Cadastre renew the opportunities to consolidate the international standard LADM in Latin-America.

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