Summary of the

Third International FIG Workshop on 3D Cadastres – Developments and practices

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Introduction

The third workshop did attract over 160 participants from 20 different countries. Of course, the host country China was well represented, most often at municipal level: Shenzhen, Hong Kong, Macao, Beijing, Shanghai, Guangzhou, Wuhan, Changchun, Chengdu, Xi'an, Ningbo, Nanjing, etc. Most of these are cities in the near or above 10 million inhabitants range. So, the high Chinese participation in the workshop was not only a matter of geographic closeness, but also illustrating the rapid 3D developments and urgent need for 3D Cadastre in many of these large Chinese cities, of which Shenzhen is a prime example. During the workshop there was a life demonstration of the operational 3D Cadastral system and during the technical tour various sites, registered with 3D cadastral objects, were visited.

Some background

The first workshop on 3D Cadastres was organized by Delft University of Technology in November 2001 and could be marked as the start of the international awareness of this topic. This was followed by 3D Cadastre presentations at every working week and congress of the International Federation of Surveyors (FIG). One decade after the first version, the second international workshop on 3D Cadastre was organized, again in Delft (as joint activity of the FIG, EuroSDR and Delft University of Technology). The fact that the third workshop was not one decade, but just one year later is a clear indication that the field is maturing and the global interest is rapidly growing. This is further supported by the fact that this time the workshop has been organized in another continent, China, in the beautiful (and very 3D) city of Shenzhen. A last indication of the maturing is the subtitle of the third workshop: 'Developments and Practices'. The aim of the third workshop was to consider current developments and practices in an international context. The third workshop has been organized as joint activity of Urban Planning, Land and

Resources Commission of Shenzhen Municipality, Wuhan University and the joint 3D Cadastres Working Group 2010-2014 of FIG commission 3 'Spatial Information Management' and 7 'Cadastre and Land Management'.

The increasing complexity of infrastructures and densely built-up areas requires a proper registration of the legal status (private and public). This can not in all situations be provided by the existing 2D cadastral registrations. After past research and prototype developments, we have now arrived in the new era where the first 3D Cadastral systems are in operation. Of course this brings new experience, which should be exchanged (registering of volumetric parcels in both the public registers and a 3D Cadastral map, the use of non 2-manifold geometries, a 3D user interface tailored to 3D Cadastre visualization and exploration, which specific types of situations are best represented with 3D Cadastre solutions; e.g. for buildings or infrastructure, etc.), investigated and further improved. Based on the common understanding of the involved concepts and terms as provided by ISO 19152 Land Administration Domain Model (LADM), the goal of this workshop was to provide an inventory of issues that have to be considered. For each issue raised, also the description should be given of alternative options in actual implementations covering legal, institutional and technical aspects.

It is important to realize that there is no single best solution for a 3D cadastre as this will always be dependent on the local situation and is based on the user needs, land market requirements, legal framework, and technical possibilities. Within the 3D cadastre working group, the concept of 3D cadastres with 3D parcels is intended in the broadest possible sense. 3D parcels include land and water spaces, both above and below surface. However, every country has to decide: which are the types of 3D cadastral objects that need to be registered? Are these related to real-world objects (buildings, utilities or other constructions) or not (airspace of arbitrary parts of the subsurface)? If related to real-world objects, how can then the relationship between the 3D cadastral registration (legal spaces) and the registration of the real-world objects be maintained within the context of the Geo-Information Infrastructure (GII).

Contributions to the workshop

The call for contributions to this third workshop consisted of a list of focus topics that included (but not per se limited to):

- Current developments and practices of 3D cadastres
- Overall situations on legal, technical and institutional aspects
- Legal issues and policies about 3D cadastre
- Data collection and modelling
- 3D topology
- 3D visualization
- 3D planning of urban space
- Investigation and detecting of underground space
- Qualifying and registration of the real estate
- 3D estimate of 3D land space
- Prediction and Monitoring of 3D land use

In total the call for contributions resulted in 27 abstract submissions, indeed covering most of the mentioned topics above. Note that 27 submissions is really a lot when taking into consideration that 3D Cadastre is quite a specific and that the second workshop was

organized less then a year ago. Each abstract was typically reviewed by 5 (or even more) programme committee (PC) members. The PC-members provided a lot of constructive feedback to the authors including aspects to be addressed in the final paper. On the average, the PC-members were quite satisfied with the quality of the abstracts. Based on the review scores, a selection was made and finally for 21 contributions, the corresponding authors did submit a full paper, which are all included in the proceedings. The proceedings are available both in hard copy (ISBN 978–87–92853–01–1, published by International Federation of Surveyors, FIG, Copenhagen, Denmark) and on-line at workshop website (http://www.cadastre2012.org).

Workshop sessions

The presentations were organized in six plenary sessions: 1. Legal Aspects, 2. Systems and Applications, 3. Modelling, 4. Organizational aspects, 5. Visualization, and 6. Technical aspects. In addition there were two demonstrations (one video demo and one life demo) of 3D cadastral systems and a technical visit was organized. The demonstrations showed the current 3D Cadastre practices in two Chinese cities: Changchun and Shenzhen. The technical tour included a visit to the multi-jurisdiction (Hong Kong-mainland China) 3D Cadastral object of the bridge and immigration terminal and a visit to a subsurface shopping complex in Shenzhen, which has also been registered using a 3D parcel.

In the first session on 'Legal Aspects' various countries were covered: China (3D title certificate by Yu et al.), Sweden (3D property by Paulsson), Greece and Cyprus (3D RRRs by Dimopoulou and Elia), and Austria (3D cadastre and public law by Navratil). Despite the fact that legislation is often national level matter, it was argued that it is important to also conduct international comparative legal research to discover similarities between countries, and perhaps even derive best legal practices. In the session 'Systems and Applications' a range of aspects of the 3D system development at different stages was presented and discussed. The use of 3D cadastral data for real estate mass valuation (including 3D view shed computations) was presented by Tomić et al. It was my personal privilege to present and demonstrate the 3D Cadastre prototype developed in the Russian Federation. Jiang et al. presented the reconstruction of administrative processes supporting the Chinese urban land management using the possibilities offered by a 3D cadastre approach.

Something considered the core of system development, 'Modelling', was the topic of the third session with first a presentation by Yu et al. on the Chinese 3D Cadastre data model. While the modelling approaches in respectively Taiwan, Korea and Malaysia were covered in the subsequent presentations by Chiang, Jeong et al., and Hassan et al. The 'Organizational aspects' were next discussed in the fourth session. First, Stoter et al. presented the phased 3D Cadastre implementation in the Netherlands. This was followed by the presentation of Ho (and Rajabifard) on the institutional challenges in the Australian setting. The Singapore ambition became clear in the presentation by Khoo on their "Smart Cadastre" approach supporting 3D Parcels, but in addition supporting more steps of the urban development than just the traditional functions of a Cadastre. This is nicely illustrated by Singapore Land Authority (SLA)'s new vision statement: 'Limited Land • Unlimited Space'.

The topic of the fifth session was 'Visualization', an extremely important aspect in order for humans to be able to comprehend and work with 3D cadastral data. The application of 3D GIS in order to realize a 3D Cadastre was discussed by Ying et al., while Shojaei et al. introduced the Australian 3D ePlanLandXML visualization system in Australia. Various 3D visual representations (even including 3D informal settlements) in Latin American countries, such as Colombia, Mexico, and Brazil, where shown by Erba (and Piumetto). A first assessment of the visual (or cartographic) variables applied to 3D cadastre was presented by Chen et al. and the question was raised: up to what extend is the visualization of 3D cadastral objects different compared to those for other 3D presentations?

The last session focused on various 'Technical aspects', which are as we all know crucial when actually realizing a system. The first presentation, by Thompson (and van Oosterom), discussed the formal validity of mixed 2D and 3D cadastral parcels, including parcels that are either unbounded at the top (sky) or at the bottom (earth) as specified in the LADM. Next Zhao et al. stressed the importance of the topological relationship, also in the case of 3D Cadastral objects and being able to discriminate between valid (e.g. touch) and invalid (e.g. overlap) topological relationships. The last presentation was by Soon and introduced a framework for representing the semantics in a more formal manner (than currently provided by the standards) by developing an OWL encoded ontology for 3D Cadastre, enabling among others validation, also of the non-spatial aspects, and where appropriate even support (machine) reasoning.

At the workshop website (http://www.cadastre2012.org) not only the full papers of the above mentioned contributions are available, but also the power-point slides as used during the presentations. Further, a photo impression of the workshop is available at the workshop website, including pictures from various sessions, the technical tours, and an impressive group photo in front of the Pavilion Hotel, the workshop venue in Futian District, Shenzhen.

Main conclusions

During the past year there has been a lot of developments w.r.t. 3D cadastre. One main trend is gradually moving from research and prototypes towards implementation and use of operational systems (backed by appropriate legislation). Despite the fact that this was now the third 3D cadastre workshop, it could still be noted that there was some confusion concerning terminology and key concepts. Terms such as 3D SDI and Ubiquitous Cadastre refer more or less to the same overarching concept of an information infrastructure in which both 3D legal space and 3D representations of physical real world objects (e.g. CityGML like) are included. It helps in communication to use existing standards when available (such as the LADM) and to further discuss terminology and concepts during the international events, such as this workshop series, the FIG working weeks, the FIG congress, etc.

When taking the complete development life cycle of rural but especially urban areas into account there are many related activities, which should all support 3D representations (and not just the cadastral registration of the 3D spatial units associated with the correct RRRs and Parties). The exact naming of these activities may differ from country to country and also the order of execution may differ. However is some form or

another the following steps performed by various public and private actors, which all somehow are related to 3D cadastral registration, can be recognized:

- develop and register zoning plans in 3D
- register (public law) restrictions in 3D
- design new spatial units/objects in 3D
- acquire appropriate land/space in 3D
- request and provide (after check) permits in 3D
- obtain and register financing (mortgage) for future object in 3D
- survey and measure spatial units/objects (after construction) in 3D
- submit associated rights(RR)/parties and their spatial units in 3D
- validate and check submitted data (and register if accept) in 3D
- store and analyze the spatial units in 3D
- disseminate, visualize and use the spatial units in 3D

Several of the activities and their information flows need to be structurally upgraded from 2D to 3D representations. As this chain of activities requires good information flows between the various actors, it is crucial that the meaning of this information is well defined. Here is an important role for standardization. Very relevant are ISO 19152 (LADM) & ISO 19156 (Observations & Measurements), but also much related and partially overlapping is the scope of the new OGC's Land Development - Standards Working Group (LD-SWG), with more focus on civil engineering information; e.g. the planned revision of LandXML (to be aligned with LADM). This is especially true in case of 3D Cadastre registrations as now in more and more countries is tested and becoming practiced. For example in the case of buildings (above/below/on surface or constructions such as tunnels, bridges), and (utility) networks this overlap is clear. LADM is focusing on spatial/legal side and this could be complemented by civil engineering physical (model) extensions. It is important to reuse existing standards as basis and continue from that point (ensuring interoperability in this important domain in our developing environment)!

Main topics for future 3D cadastre research raised and (partly) covered during the workshop were: 1. legal framework, 2. creation&submission of initial 3D spatial units, 3. 3D cadastral visualization, and 4. more formal semantics. It was argued that more *international comparative legal research* should be conducted, despite the fact that this may be very hard due to differences in national legislation and terminology. Starting or reference points in international legal research could be the current informative Annexes F 'Legal Profiles' and J 'Code lists' of the LADM (especially add more content and 'structure' to the code lists for the for Administrative Package) and the Legal Cadastral Domain Model (LCDM) as developed by Jesper Paasch in the context of his recently completed PhD-thesis at KTH Stockholm, Sweden.

In many countries the actual surveying work is conducted outside the cadastral organization and it is important to clearly define what are acceptable (valid) *3D cadastral object representations* and how these should be formatted before submission. Difficult aspects include the fact that the involved geometries may be: 1. non two-manifold (self-touching in edge or node), 2. partially open (up into the sky or down into the earth), and/or 3. consist of non-linear (curved) primitives in some legislations. This is not well supported by current GIS, CAD, DBMS software and generic ISO standards such as ISO 19107 (spatial schema).

The *visualization and/or interaction with 3D cadastral parcels* need more attention and may be quite different from the more well know visualization of 3D City models. Some specific attention points are: 1. how to visualize dense 3D volumetric partitions such as in a complex building as the first visible outside layer of 3D spatial units would block the view on the others (solutions could be based on selections and the use wireframes, semi-transparent objects, showing cross sections/slices, or apply slide-out layer techniques as developed in the Russian prototype, etc.), 2. how to display the open or unbounded parcels, 3. how to include the earth surface and/or other reference objects (e.g. CityGML like) for the 3D cadastral parcels, 4. how to provide the proper depth cues for subsurface legal spaces related to utilities (e.g. use stereo, perspective, movement/ rotation, or connecting vertical sticks from a subsurface object to earth surface).

Finally, more *formal semantics* is asked for within the domain of 3D Cadastre. For example, an ontology should be further developed in OWL (or RDF) for 3D Land Administration (based on the foundation of ISO 19152). Not only for 3D cadastre in the narrow sense, but in the sense of the whole chain of activities of 3D (rural or urban) development. Further formalization of the involved information, will better support the various steps and enable as much automation as possible (based on formal knowledge and reasoning).

The 4th FIG workshop on 3D cadastres

When will the 4th FIG 3D cadastre workshop be organized, taking to account that in 2014 the FIG congress will be organized in Kuala Lumpur, Malaysia? During the FIG 2014 congress it is planned to have significant attention to the topic of 3D Cadastre, so not a good year to also organize a separate workshop. Then the question is: should there be a workshop in 2013 or would this be too soon after workshops in 2011 (Delft) and 2012 (Shenzhen)? At the moment this is still an open question.

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