3D Cadastre Modelling in Russia

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Key words: 3D Cadastre, Standards, cadastral modelling

SUMMARY

The paper presents the on-going project on 3D cadastre modelling in Russia. The aim of this project is to provide guidance in the development of a prototype and to create favourable legal and institutional conditions for the introduction of 3D cadastre modelling in Russia based on experience of the Netherlands and other countries. Among the planned results are:

1. 3D cadastral model for data generation, storage and distribution of information about 3D properties;
2. Prototype (and access portal)
3. Evaluation of the prototype for objects of a pilot region;
4. Strategy and action plan for proper institutional embedding. This includes the preparation of legal and organizational guidelines for the long-term development of 3D cadastre in Russia.

The project runs from May 2010 until May 2012. It is a Government to Government co-operation with Russian and Dutch partners: Federal Service for State Registration, Cadastre and Mapping (Rosreestr), Federal Cadastre Centre (FCC) "Zemlya" and the Netherlands' Cadastre, Land Registry and Mapping Agency (Kadaster) in consortium with Delft University of Technology (TUD), Grontmij Nederland B.V., and Royal Haskoning B.V. There is a strong vision and drive in the Russian Federation towards a 3D cadastre. This is a realistic vision insofar that 3D will be used where needed: complex buildings, or other types of constructions, and subsurface networks (e.g., cables and pipelines).

The cadastre law in the Russian Federation is quite generic concerning 3D situations: it neither explicitly mentions 3D, nor does it prohibit 3D volumetric parcels for registration.

Nizhegorodskaya Oblast has been selected as pilot region in this project. The territorial division of Rosreestr of Nizhegorodskaya Oblast is actively involved in the project, as well as the Nizhny Novgorod City Administration (with 1,9 million inhabitants). Specialists of Rosreestr and Land Cadastre Chamber in Nizhegorodskaya Oblast provide the local data needed for the pilot.

In this FIG WW paper the mid-term results are presented, including selected cases and initial 3D cadastral model that has been selected.

РЕЗЮМЕ

В данной работе представлены первые результаты текущего проекта по созданию модели трехмерного кадастра объектов недвижимости в России. Целью данного проекта является разработка прототипа и создание благоприятных (правовых и институциональных) условий для внедрения 3D- кадастра в России, с учетом опыта Нидерландов и других государств. Среди планируемых результатов:

1. Модель 3D-кадастра для создания, хранения и распространения информации об объектах недвижимости;
2. Прототип и портал для доступа к данным 3D кадастра;
3. Тестирование прототипа для объектов пилотного региона;
4. Стратегия и план действий по надлежащим институциональным изменениям. Это включает в себя подготовку рекомендаций по правовым и организационным аспектам в целях долгосрочного развития 3D кадастра в России.

Проект осуществляется с мая 2010 по май 2012 года, в рамках программы «Правительство для Правительства», российскими и нидерландскими партнерами. С российской стороны в проекте участвуют Федеральная служба государственной регистрации, кадастра и картографии (Росреестр) и Федеральный кадастровый центр (ФКЦ) "Земля", со стороны Нидерландов - Агентство кадастра, регистрации земель и картографии (Kadaster) в консорциуме с Технологическим университетом Делфта (TUD), Grontmij Nederland BV и Royal Haskoning BV. В России по отношению к 3D кадастру существует реалистичное видение и понимание того, что подход 3D будет использоваться в случае необходимости: для зданий сложной конфигурации или других типов конструкций, для подземных сетей (например, кабелей и трубопроводов).
Законодательные основы кадастра в России довольно благоприятны с точки зрения развития 3D кадастра: закон в явном виде не упоминает 3D, но и не запрещает регистрацию 3D участков.
В качестве пилотного региона в этом проекте была выбрана Нижегородская область, расположенная примерно в 450 км к востоку от Москвы.. Территориальный отдел Росреестра в Нижегородской области будет принимать активное участие в проекте, так же как и Администрация города Нижний Новгород (с населением 1,9 млн.). Специалисты Росреестра и Земельно-кадастровой палаты в Нижегородской области обеспечат получение данных по выбранным в пилотном регионе объектам.
В работе FIG WW будут представлены промежуточные результаты, в том числе выбранные пилотные объекты и начальная модель 3D кадастра.

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1. INTRODUCTION

There is a strong vision and drive in the Russian Federation towards a 3D cadastre. This applies in particular to the registration of complex buildings and structures like bridges, tunnels, metro lines and underground networks (cables and pipes). For Russia the question is not whether there should be a 3D cadastre, but how and when this should be realized. However before a 3D cadastre can be realized, many factors must be considered, especially the applicable laws and regulations, the organization of the workflow and procedures and the necessary technology.

The project "Modelling 3D Cadastre in Russia" started in 2010 and has a term of two years. It is a so-called Government-to-Government (G2G) project in which Russian and Dutch partners cooperate, and funded by the Dutch Ministry of Economy, Agriculture and Innovation. The partners in the project are the Federal Service for State Registration, Cadastre and Cartography (Rosreestr), the Federal Cadastre Center (FCC) 'Zemlya' and the Netherlands' Kadaster. Also participating are the Delft University of Technology, and Royal Haskoning BV and Grontmij Netherlands BV. The latter partners are responsible for scientific support and for building the prototype of a 3D cadastre for Russia and performing a pilot. The FCC Zemlya is a state unitary enterprise and is the main organisation in development of the State land cadastre automated system. FCC Zemlya realises scientific and technical maintenance of the implemented information technologies and software, and provides and supports its operation. FCC Zemlya is the Project Coordinator for the G2G project.

The long-term objective is: introduction of a 3D cadastre in Russia. The aim of the project "Modelling 3D Cadastre in Russia" is to make recommendations for optimal configuration of the legal and institutional framework for a 3D cadastre and for setting up a 3D registration. These recommendations include the definition of 3D objects and an explanation of the registration information both the administrative and geographic information. The recommendations will be based on a 3D model which is developed and implemented in a prototype for a number of cases in the pilot area Nizhny Novgorod.

This paper first gives a short introduction of the cadastre in the Russian Federation. The project is then presented: the selected cases (section 3), the pilot (including the prototype) (section 4) and the results and findings so far (section 5). The last section provides the conclusion.

2. CADASTRE IN THE RUSSIAN FEDERATION

The Federal Service for State Registration, Cadastre and Cartography (Rosreestr) was established by merging three government agencies: Rosregistratsia, Rosnedvizhimost and Roskartografia (Government Decree of 1 June 2009, No. 457). With this merger a single organisation responsible for all tasks related to the registration of rights, recording of parcels (cadastral map) and geodetic and (topographic) mapping was created. Rosreestr has about 6,500 offices and 60,000 staff members. Since the start of the Russian Federation approximately 80 million parcels have been registered together with associated rights and restrictions (responsibilities) and the involved parties (persons). Therefore Rostreestr maintains probably the world's largest cadastre. Both information on parcels and the legal and administrative information can be accessed online by the public (http://maps.rosreestr.ru/Portal/); see Figure 1. Rosreestr falls under the authority of the Ministry of Economic Development of the Russian Federation being the project counterpart.

The Russian cadastre registers five types of objects (see Figure 2):
1. Parcels
2. Buildings
3. Apartment Units
4. Other structures (bridges, pipelines etc.)
5. Unfinished objects, i.e. objects under construction (buildings, bridges, pipelines, etc.)

The current parcel system is 2D polygon based, implying that the boundary between two neighbouring parcels is repeated (redundancy). The database contains the full history of the polygon since its creation. There are regional differences in the contents of the cadastral map, for example in some areas government parcels are included, while in others these are not (yet) included. The coverage is not yet complete. The scale differs for pragmatic reasons from 1:2,000 in urban areas up to 1:10,000 in rural areas. Because of the size of the Russian Federation several coordinate reference systems are used for accurate coordinates on cadastral maps (3 degree zones). In each region, special local coordinate systems are used for cadastral purposes. There are rules to avoid overlap between parcels. The survey plans needed for the registration of new parcels are made by commercial companies.

Data maintenance is executed by the cadastre offices and data is managed in the databases of a number of regional offices (compared to the Netherlands this may mean that a region and sometimes also the number of inhabitants is larger). The software used countrywide comprises: Oracle 9, ArcGIS and some local software. Currently every three months data is copied to a central server for online web access to countrywide data (based on MapInfo's MapExtreme). From 2011 onwards it is foreseen that the updating will be executed on a daily basis resulting in real-time data.

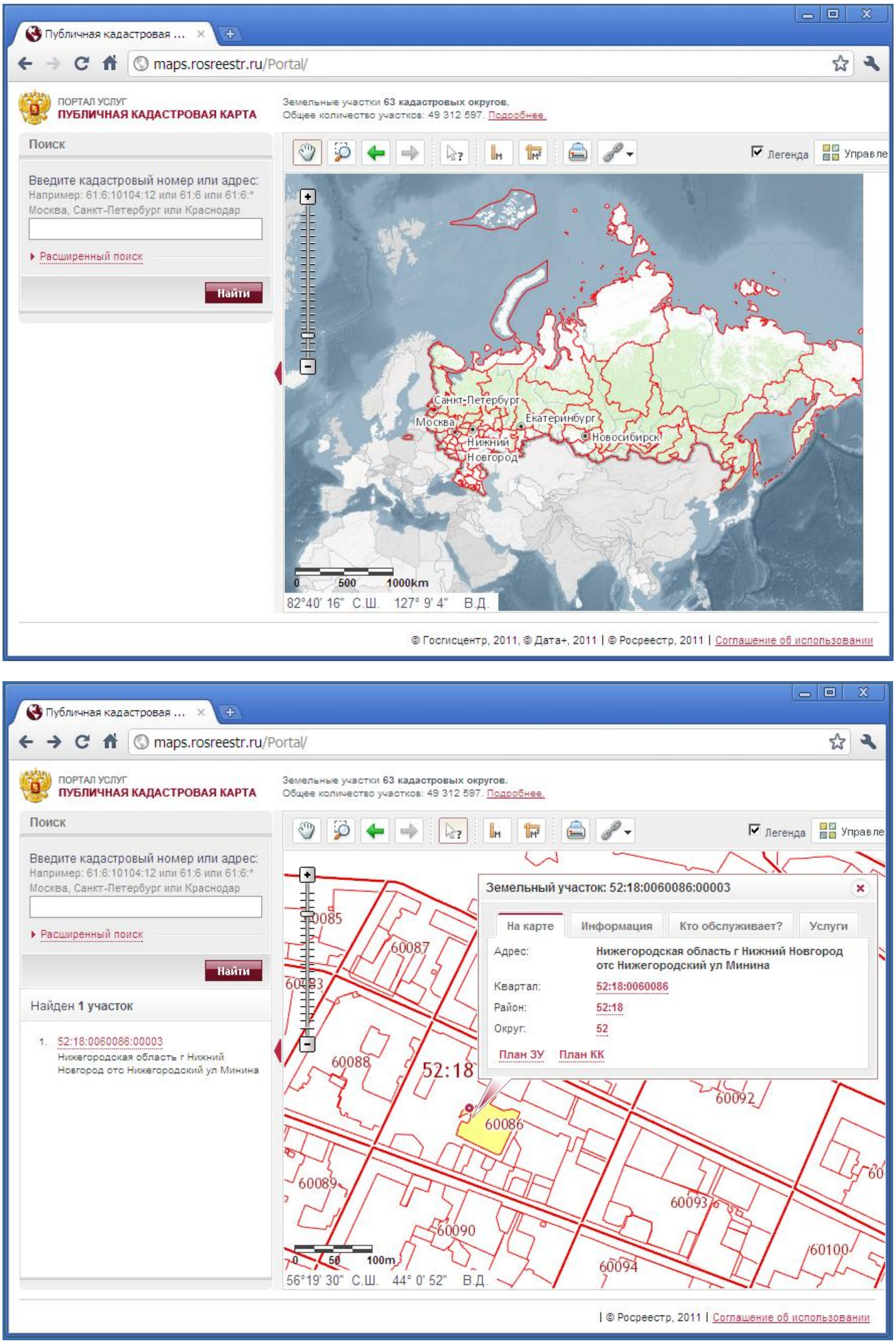

Figure 1: The on-line web portal and associated legal facts

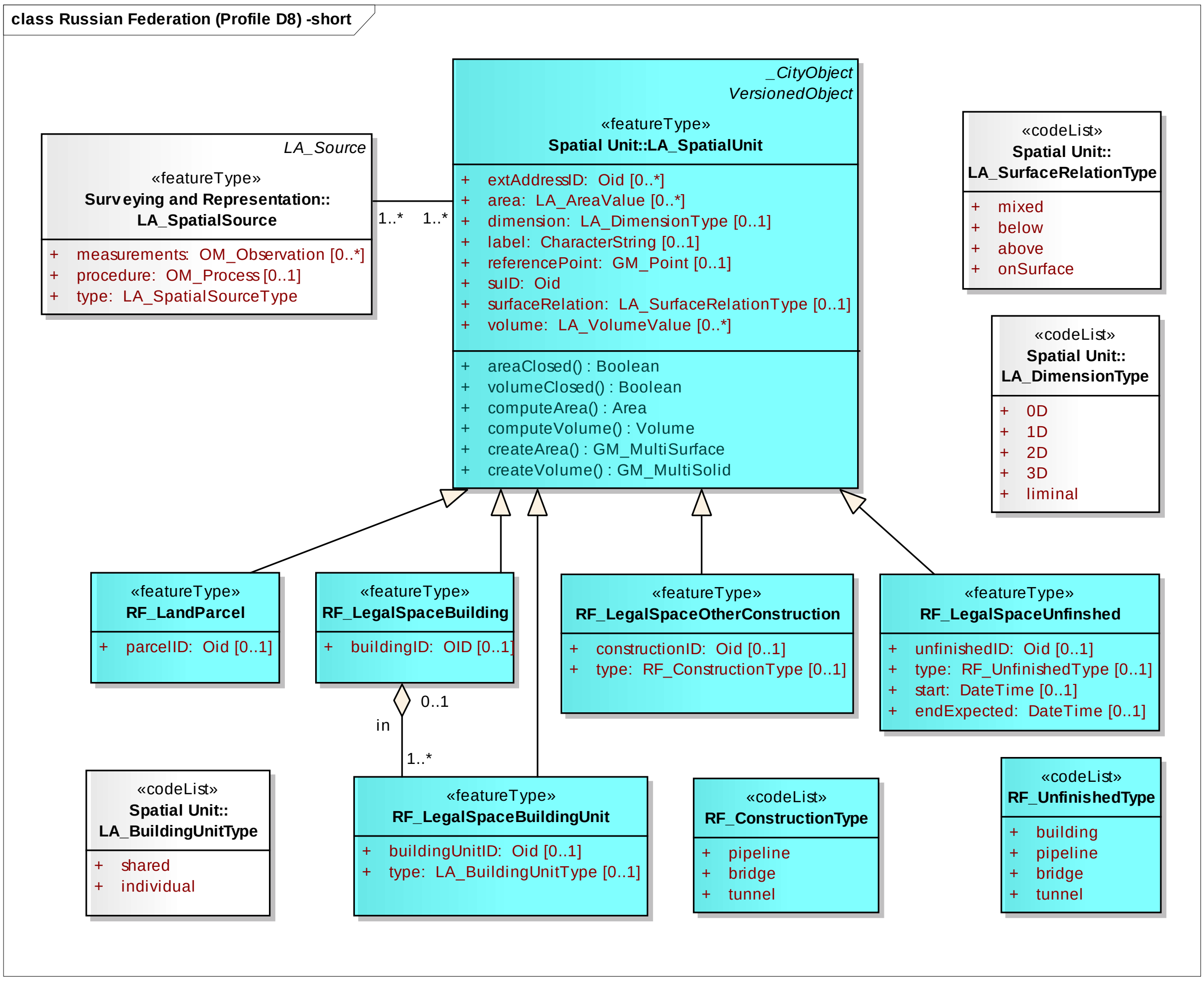

Figure 2: The initial Land Administration Domain Model (LADM) for the 3D cadastre pilot project in the Russian Federation, with five different types of cadastral objects (LA_SpatialUnits LADM in terminology)

Applicable laws and articles to 3D cadastre modelling are:

- Federal Law 'On State Cadastre for Real Estate', Article 1;
- Civil Code, Article 130;
- Land Code, Article 11.1; and
- Urban Development Code, Article 1.

The cadastre law in the Russian Federation is quite generic: it neither explicitly mentions 3D, nor does it prohibit 3D volumetric parcels for registration.

3. SELECTED CASES

For the project five representative cases were selected of “3D-like" situations in the pilot area Nizhny Novgorod. This area is located about 450 km east of Moscow. The territorial division of Rosreestr of Nizhegorodskaya Oblast (approximate size of 77,000 km2, with 3,5 million inhabitants) will be actively involved in the project, as well as Land Cadastre Chamber and the Nizhny Novgorod City Administration (with 1,9 million inhabitants in the capital).
During the first visit to Nizhny Novgorod, local authorities have shown much interest in the 3D project. The office of Rosreestr and Land Cadastre Chamber in Nizhegorodskaya Oblast has selected the necessary test cases and will provide the appropriate data.
The current 2D registration of the five cases is analyzed in order to:

- understand the current registration (2D).
- understand both the spatial and legal / administrative side of the registration.
- formulate specifications for future 3D registration.
- create initial guidelines for registration of 3D objects.

For the analysis of the cases text, photos, legal documents and maps are available. In addition, information will be collected in the field to get better understanding. There are roughly two types of cases selected: 1. complex 3D situations, which are uncommon, but much to gain from a real 3D registration, and 2. 3D normal situations, such as apartments, which are very common and also benefit from a 3D registration. A preliminary analysis of the five cases reveals the following details:

Case 1. Teledom building (near the television tower). This is an ‘older’ type of registration in technical building database including the floor plans. The rights of the various units are individually recorded in the rights register. The building has subsurface parts and above air overhangs. With the ‘older’ registration approach, the floors are either in DWG format or scanned images (roughly ‘geo-referenced’ by cadastral block or street address, not yet via parcel level). The basement (for underground parking) and first 2 floors are owned by a bank. The second owner has a multi-floor column (same part at every floor) on top of this and leases the different units (floors) to different users. If lease in Russia is longer than one year, then also the lease needs to be registered. In total 20 units are located in the building, with 10 different owners. The building has interesting overhangs (possible above neighbor parcel with shops and also possible above public road/ footpath). Because of the interesting 3D configuration of legal spaces, this is a very good case to be further used in the prototype (see Figure 3).

Figure 3. Impression Teledom building

Case 2. Apartment complex. This case provides a more "normal" 3D configuration with property rights for 88 units for housing and 7 units for non-residential purposes. The underground car park is jointly owned. There are 6 registered mortgages on residential units. The land parcel is jointly owned and it is a so-called unfinished object (object under construction) under the registration. Figure 4 gives an impression of the situation.

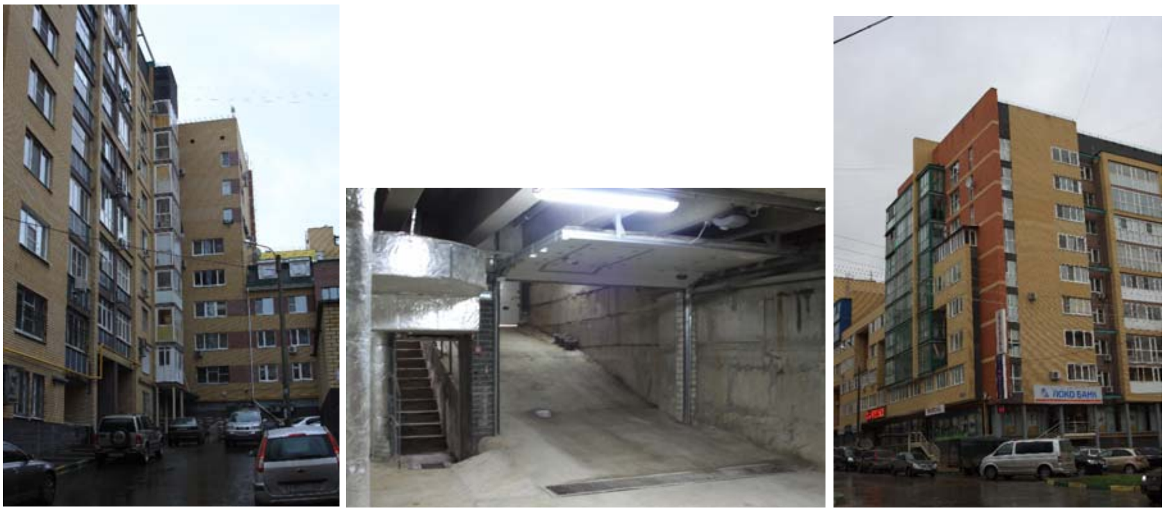

Figure 4. Impression Apartment complex

Case 3. Business complex "Nizhny stolitsa". This complex includes a building with 14 floors (and again an underground parking lot) containing non-residential property of five units, common shared ownership of 21 offices, 15 units are leased. There is one mortgage recorded. The land plot is leased by owners of premises. See Figure 5 for an impression.

Figure 5. Impression Business complex "Nizhny stolitsa"

Case 4. Short gas pipeline, partly above and partly below ground, from tie-in to boiler installation. The pipeline runs from junction to the heating installation at this address through a intermediate-pressure pipeline. It passes several parcels of land with several owners. The total length of this line is 285.7m, with 12.5m above ground and 273.2m below ground. See Figure 6 for an example of the cadastral map.

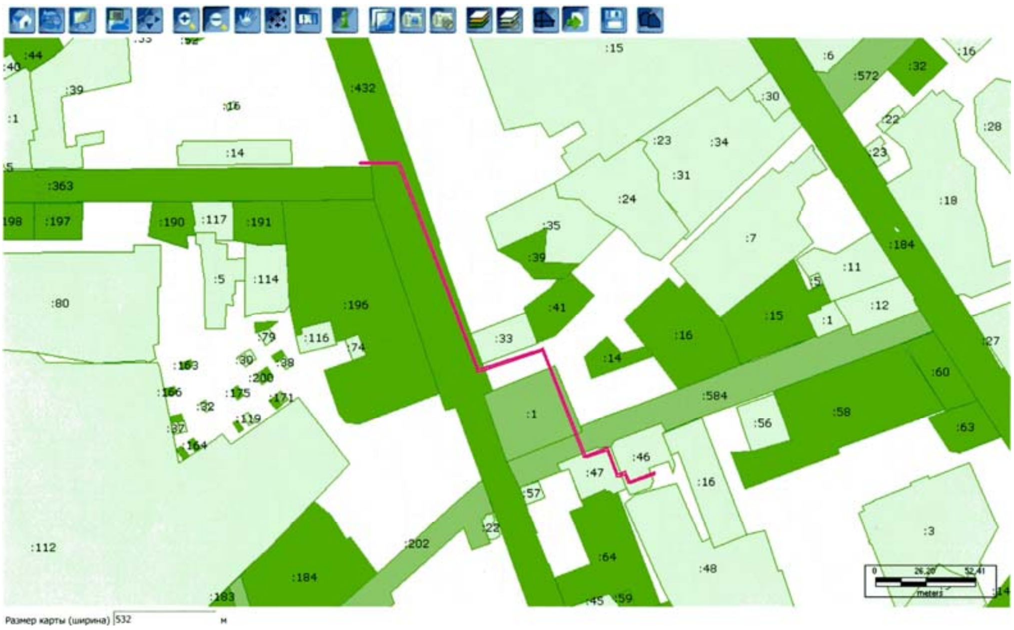

Figure 6. Cadastral map fragment with the intermediate-pressure pipeline

Case 5. Again a short gas pipeline, partly above and partly below ground, now from tie-in to input to a furnace. The low pressure pipeline passes several other land parcels with different owners. The total length of this line is 183.24m, of which two parts (8.7 m and 2.4 m) above the ground and the longest part underground (172.14m), see Figure 7.

Figure 7. Cadastral map fragment with the low pressure **pipeline**

4. THE PILOT AND PROTOTYPE

The name of the project, Modelling 3D Cadastre in Russia, emphasizes the aspect of modeling. This model is the basis for initial registration, for storing data, for dissemination and for exchange format for editing and querying data. In the pilot, the model is implemented in a prototype and applied to the selected cases so that the Russian project team acquire knowledge about the technical, organizational and legal implications of the 3D information. The registered data of the cases can be upgraded into suitable 3D data for the prototype. The application of the prototype to the cases will also show how the (Russian) users experience the prototype and the 3D data.

In order to enable easier incorporation by the Russian Cadastre, software architecture solutions are preferred in line with the current environment of the Russian Cadastre. Therefore the first technology options to be considered are Oracle 11 spatial (supporting polyhedrons) and ArcGIS. However, if during the lifetime of the project it becomes clear that this will give too many limitations for the prototype and pilot than other technology options will be explored. In this context cooperation with an ongoing 3D NL pilot in the Netherlands (Stoter et al, 2010), will be very beneficial (as many software vendors, government organizations, engineering firms and research organizations are participating in this pilot and bring in their knowledge). The goals of the pilot area activities are twofold:

- Testing of the prototype: does the prototype work, and is it possible to implement it within the client's setting, and does the prototype perform as anticipated?
- Obtaining experience: stakeholders (within and outside of Rosreestr and FCC Zemlya) know the implications of 3D cadastre through hands on experience.

Below the activities related to the pilot are described in more detail. The building of the prototype will entail two increments, or reiterations, in order to be able to test the functionality and component performance.

Increment 1: The first version of the prototype has very limited functionality and is particularly aimed at the technical testing of the selected technologies and components. To this end, the prototype will be installed on a computer in the office of Rosreestr in Nizhny Novgorod. Part of the testing is to load data into the prototype. After the installation of the prototype, the registration and retrieval of 3D objects will be tested. Some of the available 3D objects will be imported in the prototype and the objects will be stored in the database using the data model. The back office components of the prototype will perform these operations. The data is available in the portal, so the other parts of the processes (selecting and visualising 3D objects) can be tested. During testing, small changes to the software or implementation protocols may be made.
Increment 2: The second version of the prototype has more functionality and is more user-friendly than the first version. The new prototype will also be installed in Nizhny Novgorod. Again, the registration and retrieval of 3D objects will be tested. In this case, more objects will be used for loading into the prototype. After the loading of the objects, stakeholders will be involved in using the prototype in use cases, which mimic real life situations. This ensures

that possible future users of the system gain insight in possibilities of the loading, storing, selecting and visualising 3D cadastre objects. The outcome of this activity leads to recommendations for the next phases of the project.

5. RESULTS AND FINDINGS SO FAR

An initial analysis of the cases against the background of international 3D-Cadastre developments offers an indication about the scope of the proposed 3D cadastre in Russia. Important input for the analysis was the completed questionnaire on 3D Cadastres by the Russian. This questionnaire was executed in autumn 2010 by the FIG Working Group on 3D Cadastre (see Oosterom et al, 2011). The insights obtained so far (see also Hoogeveen et al, 2010; Oosterom et al, 2010) are described below and will be developed in the remainder part of the project.

5.1 Measuring the overlap of 2D plots with 3D object

3D cadastral objects in Russia normally have a relationship with a physical object (building, tunnel, pipeline, etc.). It is not meant that under-or aboveground (3D) cadastral objects (for a tunnel or pipeline) are split into several parts in case they traverse multiple land parcels.

5.2 Legal versus physical object

The model and its elaboration in the prototype will give explicit attention to legal vs. physical objects. The registration of legal items (cadastral parcels with rights) and their physical counterparts (buildings or tunnels) create two different but related databases. This is already the case in 2D, but is even more in 3D. The display of physical objects will provide the reference to understand the location and size of the legal objects. Figure 8 shows an integration of 3D and LADM CityGML (OGC standard for 3D spatial objects), with explicit links between 3D cadastral objects (as in LA_LegalSpaceBuildingUnit LADM) and its physical counterpart (part of building CityGML).

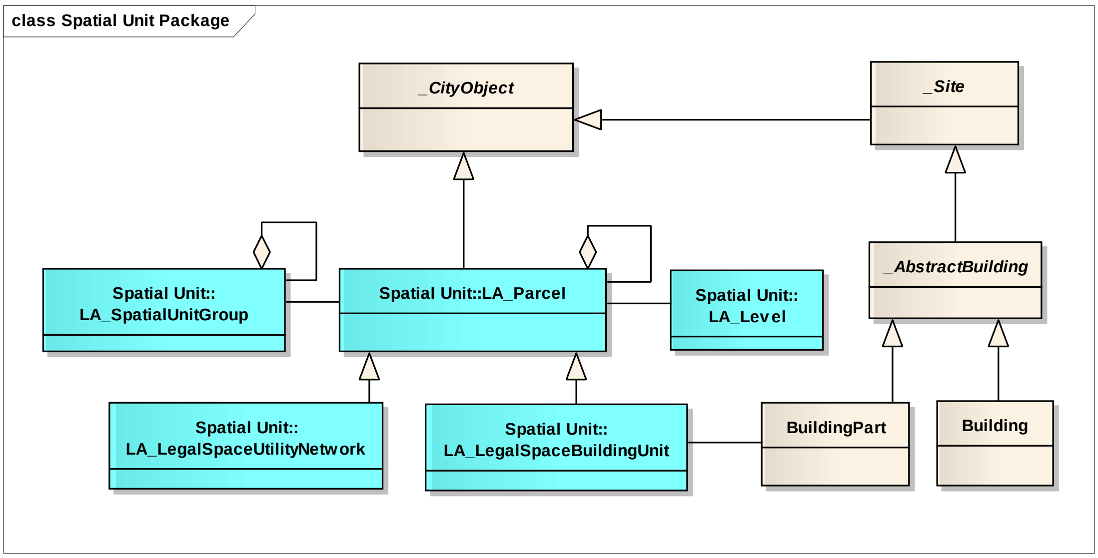

Figure 8: integration of LADM-3D and CityGML

5.3 Validity of the 3D-legal object

When a new 3D-legal object is registered on the basis of all necessary legal and spatial source documents, the 3D-legal object can be visualized and checked for accuracy (e.g. is it closed? No overlaps not another registered 3D-legal objects?). This check is important for consistency and quality. But it also means that there must exist a database with Geo-referenced 3D representations of the earlier recorded 3D right objects. The 3D cadastre thus includes more than just a record of source documents.

5.4 Selection of best option for the 3D-cadaster

The basis of the Russian 3D Cadastre model could be formed by the ISO 19152 Land Administration Domain Model (LADM) (ISO, 2011). However, LADM is still allowing many options and these should be investigated. Below a range of options for a 3D cadastre model as identified by the FIG working group on 3D Cadastres (http://www.gdmc.nl/3DCadastres):

1. *Minimalistic 3D cadastre:* do not consider cables, pipelines and (rail)roads as real estate objects (and do not register them in the cadastre), this eliminates the majority of subsurface objects. For apartment buildings: make them available via layers (by clicking on a symbol on 2D map/floor plans as in Spain), this takes care for the majority of above surface objects. For all other 3D objects add a symbol to the 2D map and refer the spatial source document (and other tricks to make the situation 'clear'). Advantage: easy to implement. Drawback: the minority of 3D exception cases (non layered apartments or pipelines and cables) may give the majority of problems.
2. *Topographic 3D cadastre:* do not create own geometry for the legal objects, but define the legal objects by referring to (boundaries) of physical objects (topography, including pipelines and cables). Advantage: when a reliable 3D topographic data set is available, this can also form the basis of the 3D Cadastre. Drawbacks: This implies that a legal object can only exist if there is a topographic counterpart to refer to. The topographic 3D cadastre is non-consistent with the design principle of the current 2D cadastre (based on legal parcel boundaries).
3. *Polyhedral Legal 3D cadastre:* 3D volume parcels have their own geometry, similar as in the current 2D database (via polygons). However, this time the geometry is represented by a polyhedron (volume bound by flat faces). Advantages: relatively easy implementable with current technology (database, GIS/CAD), and similar to polygon approach in 2D. Drawbacks: no topology structure (for better quality guarantees) and no curved faces.
4. *Non-polyhedral Legal 3D cadastre:* similar to the previous model alternative, but now allowing curved faces, such as cylinder and spherical patches (which can be the result of buffers) of even more complicated curved surfaces, including NURBS. Advantage: more type of 3D shapes can be registered (as needed in Queensland, because the law and regulations do not enforce restrictions on the geometry types). Drawbacks: no so easily implemented with current technology and also still no topology structure.
5. *Topological Legal 3D cadastre:* 3D volume parcels are described by a topological structure based on nodes, edges, faces and volume primitives. It is assumed that, and most useful when, the 3D objects are to be considered a partition of space. That is, the 3D objects have touching neighbours on all sides: Advantages: no redundancy in storing the boundaries,

good quality control (no overlap and gaps). Drawbacks: less well supported by current technology and also not consistent with the current polygon parcel approach in the 2D Russian cadastre.

Of these five options, option 3 (legally 3D Land Registry based on polyhedron volume objects, flat planes) seems to be the most obvious. Perhaps with a mix of option 4 for volumes with curved surfaces such as around pipes or buffers around objects. Option 1, the minimalist approach to 3D Land Registry does not solve the sometimes complex 3D situations. Option 2, topographical 3D cadastre (3D plots define referrals of 3D physical objects), is not conform to the current 2D Land Registry which is based on properties with own geometry. And Option 5, a topologically structured 3D Cadastre, is not conform to the current 2D Russian Land Registry, which has no topology.

5.5 Guidelines for registration of 3D Parcels

It is desirable to develop guidelines (possibly in the legislation on cadastre) to prescribe how the future in Russia 3D parcels can be recorded. This could be in the way such as the Queensland 'Directions for the Preparation of Plans' (Queensland Government, 2008). Chapter 10 of these directions describes exactly how a volumetric parcel should be described so it can be registered. Based on this example and after analyzing the Cadastre in the Russian Federation, the following guidelines are proposed for the registration of new 3D parcels (cadastral objects):

- 3D plot narrative as well as PDF (for easy visualization) and 3D data (according to LADM / CityGML model for supporting the cadastral registration process) should be supplied;
- For normal parcels a 3D polyhedron is a sufficient description;
- For 3D linear plots (including pipeline) an additional option would be the following: an attached (multi-) polyline diameter or height and width;
- New 3D plot that crosses multiple land parcels is a transfer of ownership (or other right of these plots at a single new 3D plot);
- A 3D plot gets a (temporary) ID, volume (m3), and surface water system board (m2);
- For reference, the following topographic objects are required: 3D buildings (rooms), roads, pipelines and cables and relevant surface with height;
- Accuracy of a 3D object is equal to 2D object (15 cm). One side face must be within 15 cm of a flat plane.
- For horizontal and vertical reference the standard of Oblast Nizhny will be used
- Height (z) coordinate: absolute (vertical reference) required and relatively (compared to Earth's surface) is optional;
- Curved surfaces will be approached by multiple flat edges (this model is relatively easy to implement);

These proposals should be discussed by Russian experts, beneficiaries and counter partners. Final recommendations will be prepared on the basis of the results of this discussion taking into account the results of the pilot project.

6. CONCLUSIONS

The aim of the "3D Cadastre Modelling in Russia" project, a cooperation by Russian and Dutch partners, is to provide guidance in the development of a prototype and to create favourable (legal and institutional) conditions for the introduction of 3D cadastre in Russia. More specifically, a prototype will be developed for the registration and retrieval of 3D cadastral objects from the pilot area Nizhegorodskaya Oblast.

The project provides a unique opportunity to bring insights gained in various studies (such as Stoter, 2004; Stoter and van Oosterom, 2006) into practice and to achieve the optimal implementation of a 3D cadastre for a specific national context. Two results of the pilot are equally important. The first is the gained knowledge within the project team of the technical, organisational and legal implications of an information system as it is implemented in the pilot area. The second result is the experiences of the stakeholders with the prototype and the 3D data. This will be the basis for further activities in the next project phases.

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BIOGRAPHICAL NOTES

Natalia Vandysheva holds a PhD in Physics and Mathematics from S.-Petersburg University, Russia. About 30 years experience in spatial data processing, digital mapping, GIS applications for land monitoring and cadastre. Since 2000 works as the head of the Spatial Data department in the Federal Cadastral Centre "Zemlya"("Land") being responsible for digital cartography and creation of cadastre information systems on the basis of GIS-technologies. Now is also involved in creation of SDI of the Russian Federation that are implemented under the direction of the Rosreestr (Federal Service for State Registration, Cadastre and Mapping). Project leader or expert in many international projects (USA, UNEP, EU countries).

Vladimir Tikhonov holds a degree in Technical Computer Science from Moscow Physical Engineering Institute, Russia. Since 1996 worked at the Federal Cadastral Centre "Zemlya" (Moscow) as the head of International Project division, responsible for the realization of different international projects in Russia. Now is the International Projects Director at the "Meridian+" company.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, The Netherlands. In 1990 he received a PhD from Leiden University for this thesis 'Reactive Data Structures for GIS'. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague, The Netherlands as a computer scientist. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, were he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology (OTB institute) and head of the section 'GIS Technology'. He is the current chair of the FIG joint commission 3 and 7 working group on '3D-Cadastres' (2010-2014).

Jantien Stoter defended her PhD thesis on 3D Cadastre in 2004, for which she received the prof. J.M. Tienstra research-award. From 2004 till 2009 she worked at the International Institute for Geo-Information Science and Earth Observation, ITC, Enschede, the Netherlands (www.itc.nl). As associate professor at ITC she led the research group in the field of automatic generalization. She was project leader of an EuroSDR project on generalisation from 2005 till 2009. Since October 2009, she fulfils a dual position: one as Associate Professor at Section GIS technology at OTB and one as Consultant Product and Process Innovation at the Kadaster. From both employers she is posted to Geonovum. The topics that she works on are 3D, information modeling and multi-scale data integration. Since January 2010 she leads the 3D pilot that aims at establishing a 3D reference model in The Netherlands in a collaboration of 55 partners. In November 2010 she received a VIDI grant, which is a prestigious award given by the Netherlands Organisation for Scientific Research (NWO) for excellent senior researchers.

Hendrik Ploeger studied law at Leiden University and the Free University of Amsterdam, The Netherlands. In 1997 he finished his PhD-thesis on the subject of the right of superficies and the horizontal division of property rights in land. He is associate professor at Delft University of Technology (OTB Research Institute) and holds the endowed chair in land law and land registration at VU University of Amsterdam. His research expertise focuses on land law and land registration, especially from a comparative legal perspective.

Rik Wouters holds a degree (MSc) in Agricultural Sciences from Wageningen University, The Netherlands. He worked for five years for FAO, where he had assignments in watershed management and forestry projects in Africa and Asia. In the Netherlands, he worked over 15 years in IT-projects. In 1996 he joined Kadaster and was responsible for large and complex IT-projects among which a project dealing with the renewal of major parts of the land registration system. In 2006 he became regional manager for Kadaster International, where he is responsible for the regions Central and Eastern Europe and Asia. In recent years he carried out many review and advisory missions to ECA-countries for the World Bank, the Dutch Government and other donor-organisations.

Veliko Penkov obtained a MSc in Civil Engineering at the University of Architecture, Civil Engineering and Geodesy in Sofia, Bulgaria. Since 1992 he works on various projects in Bulgaria and Russian Federation in the field of Cadastre, Land Registration, Geographic Information Systems, Land Consolidation, Quality Management, funded by World Bank, EU funds and bilateral programmes.

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