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Ongoing Development of Land Administration Standards

Blockchain in Transaction Management

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1. Introduction

This article in the special edition on blockchain and land transfer in the European Property Law Journal (EPLJ) discusses available standards in land administration and options for further standardisation, including standardisation of transactions of those rights, as a possible first step to implement a blockchain-based land administration system.

In the debate on the usability of blockchain technology applied to land administration different views and perspectives can be observed – such as: 'blockchain technology is not advanced enough to be used in land administration systems but actors should be prepared to invest in the next few years'. Or: 'the current experience lends itself to the conclusion that early innovators would benefit from jumping on the bandwagon/act now (but then what?)'. Or anything in between, that certain actors for instance real estate lawyers or brokers operate as 'Oracles' and need to do A and policy makers of the government need to do B, et cetera. And then there are statements in various media where blockchain is said to change the role of (almost) all intermediaries e.g. financial institutions, lawyers and governmental institutions. A World Economic Forum report (2016)[1] predicts that by 2025 ten percent (10 %) of GDP will be stored on blockchains or

1 Global Agenda Council on the Future of Software & Society of the World Economic Forum, *Deep Shift. Technology Tipping Points and Societal Impact*, Survey Report, September 2015, see: <www3.weforum.org/docs/WEF_GAC15_Technological_tipping_Points_report_2015.pdf#e=24.> accessed October, 14th 2017.

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blockchain related technology. It is often said[2] blockchain will fundamentally change our lives, although a growing number of reports[3], articles, blogs and posts on the Internet are addressing uncertainties and challenges that have to be solved prior to implementation of blockchain technology.

The development of a domain standard for land administration (2002–2012) was also related to a heavy debate between professionals. It was said that standardisation is impossible because of the huge differences between land administration in the context of history of a country, cultural and religious differences and different legislations. Others were looking for 'common denominators' in land administration – their view was that it is always about pieces of land, about people and about the relations between people and land. This debate resulted in the vision that a (flexible) standardised data model could be developed. Standardisation of the processes for maintenance (transactions) was considered not to be achievable: there the differences between countries are too big.

This intensive debate as input for design and development resulted in the ISO Standard called the "Land Administration Domain Model (LADM)" and was published by the International Standardisation Organisation in 2012[4, 5] (ISO, 2012; Lemmen et. al 2003).

In the view of the authors a similar comprehensive debate is needed on the application options of blockchain technology. This paper offers a contribution

2 Amongst others: GOLDSMITH, J., *Blockchain: the next big thing to hit lawyers?* <https://www.lawgazette.co.uk/comment-and-opinion/blockchain-the-next-big-thing-to-hot-lawyers/5059613.article> accessed October, 14th 2017, TAPSCOTT, D. & TAPSCOTT, A., *Blockchain revolution. How the technology behind bitcoin is changing money, business and the world* and MARVIN, R., *Blockchain: The Invisible Technology That's Changing the World*, <https://www.pcmag.com/article/351486/blockchain-the-invisible-technology-thats-changing-the-wor> accessed October, 14th 2017. and FRISBY, D., *The Incredible Technology Behind Bitcoin Is About To Change The World*, <uk.businessinsider.com/bitcoinblockchain-technology-dominic-frisby-2015-1> accessed October, 14th 2017.

3 E.g.: BOUCHER, P., NASCIMENTO, S. and KRITIKOS, M., European Parliamentary Research Service, Scientific Foresight Unit (SFU), *How blockchain technology could change our lives*, see: <www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf> accessed October, 14th 2017, and BOERSMA, J. and BULTERS, J., Blockchain technology: 9 benefits and 7 challenges. Disrupting multiple industries. See: <https://blog.deloitte.com.ng/blockchain-technology-benefits-challenges/> accessed October, 14th 2017.

4 <https://www.iso.org/standard/51206.html> accessed October, 14th 2017.

5 Lemmen, Christiaan, Paul van der Molen, Peter van Oosterom, Hendrik Ploeger, Wilko Quak, Jantien Stoter and Jaap Zevenbergen (2003) A modular standard for the cadastral domain. In: Proceedings of Digital Earth 2003 : Information resources for global sustainability : knowledge, networks, technology, economy, society, natural and human resources, policy and strategy, 21–25 September 2003, Brno, Czech republic.15 p.

from a standardisation perspective: the LADM may enhance with block chain technology for transactions on land rights.

Early 2014 Dutch Kadaster started some small research on blockchain and the feasibility of this technology on land administration processes. Many of the conclusions, assumptions and challenges that are recognized during this research has been addressed in a paper[6] for the WorldBank Conference on Land and Poverty Conference, March 2017. This article focusses on the available standards in land administration and possibilities for inclusion of blockchain for transactions (processes). This will bring a contribution and position in the debate – a debate that has to take place in order to learn and evaluate.

2. Land Administration

Land administration is defined in LADM Edition I as the process of determining, recording and disseminating information about the relationship between people and land (ISO, 2012). In the Edition II inclusion of land use and land value will be considered – this is normally under the definition of land administration. The development of Edition II is under preparation[7]. Land administration is seen by the authors as the 'combined cadastre and land registry'. This does not automatically imply the need to merge both functions of a cadastral system in one organisation, although there are many advantages to merge both functions.[8]

6 For a more extensive description on (some of the) challenges, uncertainties and pitfalls with regard to the feasibility of blockchain on land administration, see: VOS, J., LEMMEN, C.H.J. And BEENTJES, B., *Bockchain-based Land Administration, feasible, illusory or a panacae?*, in 17th Worldbank conference on Land and Poverty. Washington, D.C., USA, <https://conftool.com/landandpoverty2017/index.php/07-02-Vos-582_paper.pdf?page=downloadPaper&filename=07-02-Vos-582_paper.pdf&form_id=582&form_version=final> accessed October, 14th 2017.

7 <http://wiki.tudelft.nl/bin/view/Research/ISO19152/> accessed October, 14th 2017

8 See e.g.: Notes by the Bureau of the Working Party on Land Administration (WPLA), ECE, United Nations numbers ECE/HBP/WP.7/2015/3 and ECE/HBP/WP.7/2017/4, available at <https://www.unece.org/fileadmin/DAM/hlm/documents/2015/WP7/ece.hbp.wp7.2015.3.en.pdf> accessed October, 14th 2017 and <https://www.unece.org/fileadmin/DAM/hlm/documents/2017/1_ECE_HBP_WP.7_2017_4_en.pdf> accessed October, 14th 2017 and also FETAI, B. (2015), *Analysing the effects of merging land registration and cadastre* <https://www.itc.nl/library/papers_2015/msc/la/fetai.pdf > accessed October, 14th 2017 and WOUTERS, R., DE VRIES, W.T., and LAARAKKER, P. (2016), *Land registration and cadastre, one or two agencies* in 17th Worldbank conference on Land and Poverty. Washington, D.C. , USA. For a more or less dissimilar opinion >Wim Louwman, *Advantages and disadvantages of a merger organization: the case of the Kadaster-Netherlands*, in 18th Worldbank conference on Land and Poverty. Washington, D.C., USA.

Land Administration Systems document the relationships between people and land, linked by (ownership or use) rights. Furthermore, the two main functions of every land administration are: keeping the contents of these relationships up-to-date (based on regulations and related transactions); and: providing information from the (national) registers.

The common pattern for Land Administration (systems) consists of a 'triple'[9, 10]: Object (spatial unit) – Right (rights in rem and/or personal rights) – Subject (the title holder of the right that is related to the object), despite the fact that the structural organisation of land registers differ.[11] This triple is the basic structure for all well-functioning systems and is quite easy to understand. Because of such a easy to understand system it seems relatively easy to digitalize a paper based system and create a computerized system on this basis. Despite the simplicity of the triple, things can get complicated in case of plurality within each of these three parts[12]. One of these complicating factors is when the bundle of rights is broken up and given to other parties or when the bundle of rights is combined with different shares in various rights. The most complex, yet not inconceivable, situations are the cases, although rather exceptional, where two or all three items within the triple are complex. An example of this complexity is a case where there are multiple persons, each entitled to different shares in various rights (e.g.: a right of bare ownership, encumbered with the right of usufruct and a building right), with a mortgage right on the right of ownership or another right, with regard to a building on a plot of land (parcel), which building has been divided into apartment rights.

3. Standardisation

We define standardisation as a process to develop (and possibly implement) technical standards, based on consensus of various parties. Standardisation is a well-known subject since the establishment of land administration systems. In

9 LEMMEN, C.H.J., (2012). A Domain Model for Land Administration. Delft University of Technology, Delft, The Netherlands (PhD thesis).

10 as is also incorporated as the 'ABC structure' in the semantic model for a European Land Registry Document in ELRA's project called IMOLA. This project will be discussed in the next chapter (chapter 3) of this article.

11 Inside the European Union most of the member states follow the so-called 'real folio' that is subject to the registration of immovables and not persons, as is the case in the personal folio structure. See, amongst many others: VELENCOSO, L.M., BAILEY, S. and PRADI, A. in *Transfer of immovables in European privat law*,Cambridge University Press (2017), p. 16 .

12 VOS, J. LEMMEN, CH. BEENTJES,B. (2017), ibid, p.6.

the case of land administration it concerns for example the identification of parcels, of all kind of documents, of persons and many other issues. Furthermore it concerns the organisation of tables in the registration and references from those tables to other components, e.g. source documents and maps; this includes efficient access to archives. Finally, it also concerns coding and use of abbreviations, e.g. for administrative areas. It should be observed that all this is valid for both paper based as well as for computerised land administration systems.

After conversion from analogue to digital the land data have been harmonised in many countries using extended or linked data models[13]; the data quality has been improved where and when possible; complete archives have been scanned and digital workflows have been introduced. Today in many countries products and services can be offered to users in society from complete digital cadastres. But data integration continues. Harmonisation of spatial data is a policy in the European Union in support to the implementation of environmental policies[14]. Next to that, in some cases Land related information can be accessed by integrated services[15]. In some (legal) systems, the cadastral parcel is a core element here, where others use a land registry object identification number. In cases where there is no merged organisation these unique identifiers (cadastral parcel and/or land registry object identification number) have to be connected somehow. New, user dominated, applications appear with the introduction of all kind of mobile devices and social networks. The next generation Europeans can work and live now with all the created digital data sets. This generation does not (want to) have a notion about paper maps or registers based on conventions on maintenance and use from another century. They are looking for integral information from several perspectives, e.g. topography, photography, personal data, spatial planning and land administration, for use in applications specific to their personal circumstances. This requires new levels of standardisation and interconnectivity of data. A lot has been achieved and developments are ongoing.

13 Sir Tim Berners-Lee laid down the four principles of Linked Data as early as in 2006, see <http://www.w3.org/DesignIssues/LinkedData.html> accessed 18 September 2017. With the use of Linked Data it is made possible to link data to other (open) data. By following the principles of Linked Data, (some) open datasets are available as Linked Open Data, see: BEEK, W. and FOLMER, E.: *an integrated approach for Linked Data browsing*, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-4/W2, 35–38, https://doi.org/10.5194/isprs-archives-XLII-4-W2-35-2017, 2017.

14 <http://inspire.ec.europa.eu/glossary/DataHarmonisation> accessed October, 14th 2017.

15 <https://joinup.ec.europa.eu/asset/eurlis/description> accessed October, 14th 2017.

Since 2005 Dutch Kadaster receives almost all deeds (approximately ninety-eight percent) in an electronic form, by the use of qualified electronic signatures[16]. Because of the introduction and frequent use of these electronic signatures, we were able to abolish the regional (15) registers and create one central land register where all deeds are stored ever since. After that we started the design of a system of automated processing of standardized deeds. By introducing the automated processing of standardized deeds, the Registrar's staff no longer has to scrutinize all deeds and enter the related data into the Cadastre registration. The Chain integration Deed-processing Program (in Dutch: *Ketenintegratie Inschrijving Kadaster*, abbreviated to: KIK) was born. To make use of standardized deeds we needed to draft templates in close cooperation with the notaries. At first notaries were not convinced of the creation and application of such deeds, but nowadays they see the added value and are asking for more possibilities within the existing templates. Although we are experiencing the added value of the use of electronic templates (called *stylesheets*), we do not believe all possible legal acts and factual circumstances will fit in a stylesheet.[17] This addresses the topic of this article: will it be possible to fit all possible elements, legal and factual circumstances and transactions in smart contracts, as elements within a blockchain-based land registry?

Baring in mind the complexity and large diversity (with)in legal transactions in a national land registry system, it seems far more difficult to create a *stylesheet* for cross-border electronic conveyancing. Nevertheless, within the European Land Registry Association (ELRA[18]) the European Registrars have investigated the possibility to use standardised texts and formats to enable cross-border conveyancing in a project called Crobeco[19]. Within this project – and the follow up Project called Crobeco II, the European registrars aimed to facilitate and support

16 For a complete description and a more technical description of the used techniques and the responsibilities between notaries and registrars, please see VOS, J (2013), *The digitalization of Land Registration in the Netherlands: paving the road for cross border practices*,in: Ponencias y Comunicaciones presentadasal XVII Congreso Internacional de Derecho Registral | Colegio de registradores de la Propiedad y Mercantilles de Espana, Fundanción Registral (2013) and VOS, J. (2016), *Electronic & Cross-border conveyancing techniques*, in: XVIII Congreso Internacional de Derecho Registral IPRA-CINDER | 18th IPRA-CINDER International Land registration Congress, Ámsterdam 2012, Tirant – Valencia (2016).

17 Dutch Kadaster estimated that 70–75 % of all deeds could be updated in the Land Register automatically. The rest of the deeds we receive are (supposed to be) too complex to automize. VOS, J. LEMMEN, CH. BEENTJES,B., ibid, p. 25.

18 www.elra.eu.

19 www.elra.eu/crobeco/. This initiative was awarded by a Grant within the Civil Justice specific programme (JLS/2009/JCIV/AG/0002) of the European Union.

foreign buyers on the European real estate market by having the contract of sale executed in the language of the foreign buyer by a conveyancer from that country who is properly informed about in the country of the plot of land existing property rights, limitations and charges. For this, a framework is based on a process with tools to support foreign conveyancers, described in a Cross Border Conveyancing Reference Framework (CCRF).

After completing the first Crobeco Project by ELRA, the Notaries of Europe[20] started EUfides[21], a project where notaries can work in cooperation with a foreign colleague on cross border cases.[22]

To prepare and realize a cross border transfer of an immovable, land registry information is needed. Because many member states have a divergent legal system, different information models and deviant rights in rem that are fit for their own legal system, professionals cannot suffice with the current national information in a local language, without any explanation. In other words: there is a need for a standard means of accessing basic land registry information, paired with explanatory material. For this, ELRA – in close cooperation with Eulis and the Spanish and Dutch Registrars – initiated the IMOLA Project[23]. Within this project common elements were used to define a structure of key information, shared by the majority of land registry systems. IMOLA project, subsidized by the EC Civil Justice Programme, has performed in-depth research on these common key elements, developing interoperability solutions and facilitate cooperation with other networks in order to contribute to the development of a European real estate and mortgage market. It is possible to create a set form to present Land Registry information from various European countries, although the legal meaning of the rights in rem may diver. To find out the legal meaning of specific and Registry information and the legal consequences of this information, the semantic model – the European Land Registry Document – is supported by glossary[24] and semantic[25] information.

20 <www.cnue.eu> accessed October, 14th 2017.

21 <www.eufides.eu> accessed October, 14th 2017.

22 It would be recommendable to investigate whether it would be possible to merge both projects (Crobeco and EUfides) by uing the strong achievements of both projects, combined into one new project (or system) that will be accessible via the e-Justice portal of the European Union.

23 <www.elra.eu/imola/> accessed October, 14th 2017.

24 The Glossary is made of definitions of the specific property titles and other concrete legal concepts, according to each national legislation.

25 Semantics are generic concepts developed from common features of the different legal institutions, which are used as placeholders to organise the information of the different national systems in a common framework. It allows to work with the various concepts defined in the glossary, creating relations between them.

Another standardisation development that does not only cover the way of presenting information (IMOLA) or prescribes common text blocks (stylesheets) or a method to transfer ownership (Crobeco) concerns a domain standard for Land Administration.

The Land Administration Domain Model, in short LADM[26] covers basic information-related components of land administration including those over land, in water, below the surface, and above the ground. It is important to observe that interference with (national) land administration laws that may have any legal implications is completely outside the scope of the LADM. The model is in use in practise now for several applications – many of them outside Europe – where land administration is urgently needed for economic development and social equity. The LADM was developed by a group of about fifty land administration professionals from all over the world, but many of them from Europe[27]. It is published in its first edition by the International Organisation (ISO) for Standardisation in 2012[28]. In essence, a domain standard is an agreed way of doing something[29]. Standards are the distilled wisdom of experts in their subject matter. They are knowledge that help drive innovation and increase productivity. Standards can make organizations more successful and people's lives easier, safer and healthier. Preparations are ongoing in this moment for Edition II of the LADM. A white paper was discussed during the Land Administration and Land Management Expert Group Meeting of the UN GGIM[30] and at the 6th LADM Workshop[31], held in Delft, The Netherlands in March 2017 and also at the World Bank Conference on Land and Poverty[32] held in March 2017 in Washington D.C., United

26 <http://wiki.tudelft.nl/bin/view/Research/ISO19152/LadmPublications> accessed October, 14th 2017.

27 LEMMEN, C.H.J., VAN OOSTEROM, P.J.M., UITERMARK, H.T. and DE ZEEUW, K. (2013) Land administration domain model is an ISO standard now + powerpoint. In: proceedings of Annual World Bank Conference on Land and Poverty 2013, 8–11 April 2013, Washington DC, United States of America. 20 p.

28 <https://www.iso.org/standard/51206.html> accessed October, 14th 2017.

29 One example (of many) is the European Reporting Framework (ERF) in order to reduce the reporting burden for both recipients and reporting institutions, as discussed during the Seventh ECB conference on statistics, p. 31, <https://www.ecb.europa.eu/pub/pdf/other/centralbankstatistics201505en.pdf?32b6ab26b8a8dffcae85857b9a8666ef> accessed October, 14th 2017.

30 United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM)

31 <http://wiki.tudelft.nl/bin/view/Research/ISO19152/LADM2017Workshop> accessed October, 14th 2017.

32 <https://www.conftool.com/landandpoverty2017/index.php?page=browseSessions&form_session=666&presentations=show> accessed October, 14th 2017.

States. In this context the discussion is on the inclusion of processes and transactions into the model. This is where the relation to blockchain appears.

4. The Land Administration Domain Model

The Land Administration Domain Model is of one of the first domain standards within ISO TC 211. TC 211 is the Technical Committee on Geographic Information within the ISO. Worldwide there is a need for domain specific standardisation to capture the semantics of the land administration domain on top of the agreed foundation of basic standards for geometry, temporal aspects, metadata, and also observations and measurements from the field. This is required for communication between professionals, for system design, system development and system implementation purposes and for purposes of data exchange and data quality management. Such a standard will enable Geographical Information Systems (GIS) and database providers and/or open source communities to develop products and applications. In turn this will enable land registry and cadastral organisations to use these components to develop, implement and maintain systems in an even more efficient way. LADM provides a shared ontology, defining a terminology for land administration. It provides a flexible conceptual schema with three basic packages: parties, rights (and restrictions/responsibilities) and spatial units. LADM supports the development of application software for land administration, and facilitates data exchange with and from distributed land administration systems. An important aspect in the development of coherent (Spatial) Information Infrastructures (S) II is that the various standardised domain models are reusing the same model patterns as solutions for the same situations. The standard supports data quality management in land administration. Use of standards contributes to the avoidance of inconsistencies between data maintained in different organisations, because data duplication can be avoided as much as possible. It should be noted here that implementing a standardised data model can be supportive in the detection of existing inconsistencies.

The common pattern for Land Administration (systems), the 'triple', is the core of the LADM. The plurality within the elements of a triple[33] implies that in some cases subjects, rights and objects can be grouped. A group of objects for example is called "Basic Property Unit" (called Basic Administrative Unit in LADM) in some countries. It means that the ownership of a group of objects is considered as a whole. There may be groups within groups. It may be possible to

33 See: Chapter 2 (Land Administration).

bring those situations in alignment with blockchain-based Land Administration, yet it should be noted that data sets represented in the triple may be maintained and managed in an environment with distributed mandates and responsibilities. This does not seem to fit in a public blockchain, since there are no mandates or responsibilities[34]. Further requirements for the design of LADM are: the inclusion of the continuum of land rights (rights, restrictions and responsibilities), a continuum of land use claimants (persons and groups or entities) and a continuum of spatial units (land, objects and units). Using 'continuum approaches' requires the introduction of quality labels, for example the geometric accuracy of a geometric description of a spatial unit or parcel, or a label proving that the attribute is linked to its source.

Transparency and good governance should be applicable in a LADM based environment. Flexibility should be applicable to types of source documents as prepared by professionals and to field data acquisition. A main requirement in the design and development of LADM is in interoperability – exchange of data between organisations based on the principle of keeping data to the source and avoidance of duplications.

5. LADM Functionality

The LADM covers basic information related to components of land administration (including water and elements above and below the earth's surface). It includes agreements on data about administrative and spatial units, land rights in a broad sense and source documents(e.g. deeds or surveys). The rights may include real and personal rights, formal rights as well as indigenous, customary and informal rights. All types of restrictions and responsibilities can be represented. The standard can be extended and adapted to local situations; in this way it is argued that most, if not all, people-land relationships may be represented[35, 36].

The LADM is developed in Unified Modelling Language (UML). ISO uses the prefix "LA", that is " Land Administration" to identify classes in the domain. This language is used in software engineering. LADM has many optionalities that may be implemented in country profiles or not. The three main packages of the LADM

34 VOS, LEMMEN, BEENTJES, ibid, p. 31.

35 LEMMEN, C.H.J., VAN OOSTEROM, P.J.M. and BENNETT, R.M. (2015) The land administration domain model. In: Land use policy, 49 (2015) pp. 535–545.

36 VAN OOSTEROM, P. and LEMMEN, C.H.J. (2015) The Land Administration Domain Model (LADM) : Motivation, standardization, application and further development. In: Land use policy, 49 (2015) pp. 527–534.

consist of a party package, an administrative package and a spatial unit package with its sub package Representation and Survey.

A party is a person or organisation that plays a role in a rights transaction. An organisation can be a company, a municipality, the state, or a church community. A 'group party' is any number of parties, forming together a distinct entity. A 'party member' is a party registered and identified as a constituent of a group party. This allows documentation of information to membership (holding shares in rights). A party may have a role: such as conveyor, notary or surveyor – parties with such role may play in updating and/or maintaining the land administration in a specific land administration profile implementation.

The administrative package concerns rights, restrictions and responsibilities. In ISO LADM terminology a 'right' is an action, activity or class of actions that a system participant may perform on or using an associated resource. Examples are: ownership right, tenancy right, possession, customary right or an informal right. A right can be a personal use right, inclusion of this type of rights can be done in code tables with overviews of valid land rights in a territory. Rights may be overlapping in space or may be in disagreement. A 'restriction' is a state based or non-state based entitlement to refrain from doing something; e.g. it is not allowed to build within 200 m of a fuel station; or servitude or a mortgage as a restriction to the ownership right. A 'responsibility' is a formal or informal obligation to do something. A basic administrative unit (abbreviated as ba unit) is an administrative entity consisting of zero or more spatial units (parcels) against which one or more unique and homogeneous rights (e.g. an ownership right or a land use right), responsibilities or restrictions are associated to the whole entity as included in the land administration system. An example of a basic administrative unit is a basic property unit with two spatial units (e.g. an apartment or a garage). A 'basic administrative unit' may play the role of a 'party' because it may hold a right of easement over another, usually neighbouring, spatial unit. There may be relationships between basic administrative units.

A 'spatial unit' in the spatial unit package can be represented as a text ("from this tree to that river"), a point (or multi-point), a line (or multi-line), representing a single area (or multiple areas) of land (or water) or, more specifically, a single volume of space (or multiple volumes of space). Single areas are the general case and multiple areas the exception. Spatial units are structured in a way to support the creation and management of basic administrative units. A 'spatial unit group' is a group of spatial units; e.g.: spatial units within an administrative zone (e.g. a section, a canton, a municipality, a department, a province or a country) or within a planning area. A 'level' is a collection of spatial units with a geometric and/or thematic coherence. The spatial unit package includes the surveying and representation sub-package. Points can be acquired in the field by classical surveys or

with images. A survey is documented with spatial sources. A set of measurements with observations (distances, bearings, etc.) of points, is an attribute of the class spatial source. The individual surveyed points are instances of class point. 2D and 3Drepresentations of objects in reality are possible. Co-ordinates themselves either come from points or are captured as linear geometry. A spatial unit may have a calculated and a legal area that are different. A spatial unit can be a parcel, an apartment or an area with a customary right.

Versioning of objects is included in LADM in order to reconstruct the complete history of a transactions and all changes in the land administration.

The LADM is not a dogmatic approach – it is flexible. Re-use of classes can be implemented in country profiles, new classes may be added when and where needed. The same is valid for attributes and contents of code tables.

6. Modelling of transactions

Updates and changes may concern parties and its attributes, rights, restrictions and responsibilities and related attributes, basis administrative units and related attributes. Common transactions are buying and selling, establishment of mortgage or rights (for example encumbrance, usufruct, but may be also tenancy).

A very specific transaction is the inclusion of the result of a land consolidation[37] or land readjustment of a bigger area. This may overrule the legal meaning of existing facts in the land administration or the result of a map renovation.[38] Coordinates change in this process and with that all the areas. Quality improvements in general result in changes that have to be documented. This may also concern the establishment of a proper link between land registry and cadastre in order to avoid situations where an object is not included in both datasets.

In the LADM it is assumed that all changes and updates are only possible using a source document – represented in a class source. A source is a document providing legal and/or administrative facts on which the land administration is based: right, restriction, responsibility, basic administrative unit, party, or spatial unit[39]. Examples: a source as the evidence of a party's right to a basic

37 Land consolidation is the process to eliminate (very) fragmented land holdings – each consisting of a number of parcels – into fewer blocks with larger parcels of land, according to DEKKER, H.A.L. (2016), *The Invisible Line: Land Reform, Land Tenure Security and Land Registration*, Routledge.

38 Map renovation is a quality improvement of the cadastral map in order to have a better representation of reality.

39 Any kind of document may be added as a source according to ISO 19115:2003, B.3.2.

administrative unit. In some land administration systems, sources are required to perform the transactions but these are not (always) archived afterwards. The registration itself then serves as such evidence. In other systems a document describing a transaction (a deed) or a judgement is needed to replace the register holder.

The LADM class source has two subclasses: administrative source and spatial source. An administrative source is a source document with the administrative description (where applicable) of the parties involved, the rights, restrictions and responsibilities created and the basic administrative units affected. A spatial source contains spatial representation of one (part of) or more spatial units; for example a field survey sketch, an ortho photo or a satellite image with evidence of the location of boundaries (collected from the field).

After this explanation of sources it should be highlighted that LADM covers both event and state based modelling approaches. In event based modelling, transactions are modelled as separate entities within the system (with their own identity and set of attributes). The event is represented by an instance of the LADM class source. When the start state is known, and all events are known, it is possible to reconstruct every state in the past by reversing the whole chain of events. It is also possible to represent the current state, and not to keep the start state (and go back in time via the 'reversal' of events). In order to have full support for event based modelling, the related process models should be described – the inclusion of those models is subject of consideration for LADM Edition II. Those models are not included in the current Edition I. In state based modelling, the states (that is to say, the results) are modelled explicitly: every object is assigned (at least) two dates/times which indicate the time interval during which the object is recorded in the system as actual version. Through the comparison of two successive states it is possible to reconstruct what happened as a result of one specific event. It is straightforward to obtain the state at a given moment in time, by selecting the object based on a time interval (tmin-tmax). The temporal aspect is inherited from class versioned object with its attributes begin lifespan and end lifespan. Rights, restrictions and responsibilities has an additional temporal attribute called time spec, which is capable of handling other temporal representations, such as a recurring pattern (every week-end, every summer, etc.).

7. Blockchain

Blockchain is the underpinning technology of bitcoin and many other cryptocurrencies. The technology has been described in many different ways. Harvard

Business Review[40] defines blockchain as '*an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way. The ledger itself can also be programmed to trigger transactions automatically*.'

Blockchain technology is a secure architecture to handle and store transactions. Once a transaction has taken place, cryptographical links mean that it cannot be altered or erased from existence. In other words, a transaction is irreversible. An additional advantage is that not only the transaction itself, but also the history of transactions is safely captured, making the data immutable and hence providing trust[41] by definition. Blockchain is also known as the 'distributed ledger'; it is the database that provides proof of who owns what at any given time. It is publicly available and (in case of a public[42] blockchain) publicly maintained.

A blockchain is transparent. That means: everyone who would like to see the transactions, is able to do so and verify the transaction. This makes the process of value exchange visible, so normal people can see any injustice. This is also in support to Good Governance Criteria (UNESCAP, 2009) (Al-Rodhan, 2009). Any record, input or transaction on the blockchain is immutable. This also means that transactions are irreversible as said already. To coordinate that a transaction can take place the right way, it is possible to execute a transaction by using so-called smart contracts. The smart contract is the layer that fully utilises the potential of blockchain technology. Smart contracts are computerized transaction protocols by which the main goal and the meaning of the terms of contracts are executed in case these conditions are met. They are not real contracts that are converted into

40 Harvard Business Review, no 119, January–February 2017, *The Truth about blockchain'*.

41 It should be noted that 'trust' in the sence of blockchain should not be confused by legal certainty. Two parties may trust each other while transferring ownership, but it might be the case that both parties are committing a malicious transaction. Except for these two parties, other parties are not willing to trust the transaction in all cases. It is our opinion that trust in the sense of blockchain should be understood as completing a transaction in a transparent way and in accordance with the rules that are put down in a smart contract or otherwise. Legal certainty is created in a situation where two parties may or may not trust each other, but in all cases they do trust the system. This system consists of a middleman (Trusted Third Party, an Oracle or any other term that is used within the blockchain discussions) who is being placed in between the two parties involved and is trusted by these two parties. The added value is created be putting in a trusted party somehow in the process.

42 See for an extensive explanation of the differences between a public, hybrid or private blockchain: VOS, J., *Blockchain-based Land Registry: Panacea, Illusion or something in between? Legal interference of Registrars in the e-conveyancing process*, in ELRA, 7th Annual Publication <https://www.elra.eu/publications/elra-annual-publication/> accessed October, 14th 2017.

computer language but more or less they are a set of business rules[43] and therefore, (in most cases) not easy to read for people (other then IT-experts).

Smart contracts can be automatically executed by a computing system, such as a suitable distributed ledger system. "If two users sign a smart contract, it will then contain logic that operates on the data in all parts of the shared ledger. This could facilitate the automation or removal of manual process in government and private sector institutions, which may drive efficiencies in productivity and growth." (GOS, 2016). Although a smart contract seems a perfect solution with regard to self-executing systems that result in the desired outcome, this is not always the case, as we have seen during the 'DAO-hack'[44]. The 'hack' fuelled the debate on 'Code is law'[45] and the lack of governance[46] and resulted in a hard fork.

Because a transaction of an asset (or an asset itself) cannot be altered or deleted after registered on the blockchain, this offers a chance for land administration, where corruption is often a problem in many (mostly developing) countries. The first signals are there: in Honduras, Factom, a Texas-based blockchain start-up company, recently worked together with the Honduran government to set up a blockchain-based land registry system[47]. However, the current status of this project is unknown. It seems as if the titles will be digitized first[48, 49] and afterwards a blockchain solution is considered.

Land Administration can be roughly divided into three stadia: (1) receiving and archiving of (source) documents, (2) changing the land administration (on the basis of these documents), and (3) issuing and publishing new titles (on the basis of these changes).

There are several ways to apply blockchain in land administration – for example based on the archive with deeds or titles, based on the transaction

43 The Dutch Kadaster chain integration project (KIK) also makes use of business rules (as do many other business programmes that are digitalized).

44 See: https://www.coindesk.com/understanding-dao-hack-journalists/ and <www.bloomberg.com/view/articles/2016-06-17/blockchain-company-s-smart-contracts-were-dumb> accessed October, 14th 2017.

45 A flaw in the contract can cause a lot of (legal) uncertainty, especially when there is no Trusted Third Party involved who is entitled to resolve the dispute.

46 As discussed in our paper for the Land and Poverty Conference last year, VOS, LEMMEN, BEENTJES, ibid, p.16.

47 <http://in.reuters.com/article/usa-honduras-technology/honduras-to-build-land-title-registry-using-bitcoin-technology-idINKBN0O01V720150515> accessed October, 14th 2017.

48 <https://www.reuters.com/article/us-un-assembly-trump/with-eye-on-north-korea-and-iran-trump-makes-first-appearance-at-united-nations-idUSKCN1BU0B3> accessed October, 14th 2017.

49 As described in Chapter 3 (Standardisation) this conversion seems a correct first step to standardisation and automizing a Land Administration system > accessed October, 14th 2017.

processes or based on transaction validation and issuing title. In the case of the Georgian pilot the main focus has been put on the archiving by putting 'some 160,000 registrations'[50] on a blockchain. The pilot will continue by including smart contract capabilities to streamline business operations from the National Agency of Public Registry (NAPR)[51].

The 'pivot' between LADM and the blockchain can be the source document. This document can be prepared by parties involved with or without involvement of Trusted Third Parties. A blockchain does not have one owner or one controlling entity. That means that there is no Trusted Third Parties, on which the reliability of the ledger depends. Instead, this reliability is spread. The question is if this can be applied to land administration. In any case checks and balances have to be applied in case a party gets access to a blockchain based transaction system for land administration. In other words: the first time a person gets or wants to get land rights. Is the person really the person who he or she says he or she is? Is a biometrical characteristic sufficient in such a case? Is he or she mentally capable of and willing to transfer ownership? These questions nowadays are answered (and checked) by a Trusted Third Party. It is questionable whether these parties may no longer be needed.

Something similar is valid for spatial units. This may be needed in case of subdivision or split of a parcel or apartment or in case of boundary disputes. Identification of spatial units usually includes the identification of the parties involved or representative of those parties in the field, the survey of the new boundaries or the reconstruction of existing boundaries, the calculation of the area or volume of the object and the provision of a unique object identifiers. Then this object can be linked to legal administrative data describing the subject, the type of rights and shares in rights. Objects, rights and subjects can be documented in source documents as deeds, titles, field works and maps. Again the question arises whether it is possible to act by parties themselves, without the use of a Trusted Third Party. How does one identify a spatial unit? How and by whom can a spatial unit be created within a blockchain-based system?

With today's technology it is already possible that a conveyor gives a set of wooden pegs to parties in order to demarcate boundaries by themselves. There can be a GPS-chip included which receives GPS signals in order to determine the field coordinates for each wooden peg. If there is no transmitter the parties have to provide the results. This would mean no surveyor is needed. But how to ensure

50 <https://www.economist.com/news/business/21722869-anti-establishment-technology-faces-ironic-turn-fortune-governments-may-be-big-backers> accessed October, 14th 2017.

51 <http://exonum.com/napr> accessed October, 14th 2017.

that existing boundaries have not been changed? Or how to set out a determined and agreed number of square meters (sqm) by laymen?

A well-functioning Land Administration system is provided with (sometimes multiple) checks and balances. Depending on the state of the art technology there seems to be or will be created a number of options – from a fully automated system with or without Trusted Third Parties, depending on the complexity of or accuracy in a case to a system with the intervention of a Trusted Third Party who will close a transaction (on the blockchain or in a more traditional (digital) land administration system). There is a continuum of professional involvement. The next generation of Europeans will decide.

An alternative to the source document as pivot is the make a choice for square meters as a unit of transactions. By taking a conceptual step in thinking, it is possible to move from bitcoins being transferred with blockchain technology to bitsquares being transferred by blockchain technology; squares of land replace coins as the units of transaction. Each square has a unique ID and the rights holders are now in a blockchain environment. Transactions on the land market can be followed visibly and openly in the blockchain. It is possible to identify illegal transactions for those areas where a land market does not exist – in case of customary tenure or in case of protected nature areas, for example. All this can be published in a completely transparent way to the world. What3words[52] is such a system: a grid that divides the world into 57 trillion 3m by 3m squares of land, each with its own unique three-word address. The related geocoder turns geographic coordinates into these three-word addresses and vice versa. The use of words means that even non-technical people can accurately find any location and communicate it more quickly, more easily and with less ambiguity than any other system based on street addresses, postcodes, latitude and longitude coordinates or mobile short links. FOAM is a system that 'tokenizes' space in a 3D way, based upon the Ethereum Blockchain. It enables a vertical Z axis, which is the token balance of the address and the stack of smart contracts that reference the address of the physical address. Therefore it seems possible and more easy to administer certain rights in(side) buildings. There may of course be some georeferencing problems in overlapping conventional parcel representations but these can be overcome with the right attention – and then the revolution can start. Again, in the 'continuum approach' method a continuum of spatial units can be a solution for all types of situations and cases. There is noneed to be overoptimistic here: high precision cadastres are needed – and this type of cadastre is not widely available.

52 <http://what3words.com/> accessed October, 14th 2017.

8. Applying blockchain to land administration

The blockchain can be applied in different ways to processes. Depending on the way the blockchain is used, it will deliver different levels of trust to the process.

The simplest way to use the blockchain is by storing the hash values of documents on the blockchain. A hash value is a number that can be derived from a document using a mathematical function. The odds of two documents having the same hash value are negligible, so that for all practical purposes the hash value is unique to one document. When an alteration to a document is made, the hash value automatically changes, making it impossible to change a document unnoticed. This type of blockchain application can be used as an audit trail. By assigning hash values to all documents involved in the land administration process and storing these hash values on the blockchain, one can prove the authenticity of documents and any documents changed or gone missing will be noticed.

Using the blockchain in this way can improve the integrity of the land administration mainly because it will prevent illegal changes to the land administration, and by being able to prove the authenticity of documents used in the land administration process and possibly kept by parties involved. Hash values can be included in LADM as an identifier of source documents.

The downside of this type of blockchain application is that it doesn't store the document itself in the blockchain. The documents are (still) represented in LADM. LADM can be implemented in a land administration that functions in a distributed an decentralised environment where different organisations have mandates in the process resulting in distributed data sets. There is no way to recreate the document from the hash. Therefore it is important to store the document at a safe way and environment[53]. This is especially a challenge for poor countries with dysfunctional public administrations and a poor record of governance.

Putting a blockchain solution under an existing land administration system in this way is relatively easy; the technology exists[54] today and is accessible. In cases where the land administration is decentralised and documents are kept by different organisations , the use of an integral audit trail on the blockchain can substantially improve the reliability of the system as a whole. A substantial number of the current uses of blockchain technology in land administration and other registration processes fall into this category.

53 New initiatives like BigchainDB (www.bigchaindb.com/features/) aspire to creating such an environment, combining Blockchain with reliable distributed storage facilities.

54 Although blockchain technology is rather 'untouched', the various elements e.g. hashing and encryption technology, already exist for a long time.

The next solution is adding identifying information to the blockchain. We can store identifiers of subjects (parties) and objects (spatial units) from the source document on the blockchain. When a land administration is decentral and documents on the same object or subject can be stored in different locations, this type of blockchain can be used to create a national index of these documents, making it easier to find all documents relating to a specific object or subject. This can greatly improve the accessibility of the land administration and will decrease the number of problems where transactions suffer from problems because relevant information wasn't found at the right time. This type of solution requires that objects and subjects can be identified uniquely nationwide and that it is possible to reliable extract this information from the documents stored. These requirements make it harder to implement this type of blockchain, since at first it has to be agreed on that standardisation is needed and secondly, this standardisation method has to be put into practice. After all objects and subjects have been labelled by a unique identification the content of the transaction as described in the source document can be to the blockchain. This can be information on what rights are transferred, the price of the transaction, the location of the parcel and other information relevant to a land administration. By adding this information to the blockchain, the land administration becomes even more accessible and reliable. Instead of having to retrieve the information from documents that are stored off-blockchain, the information is now available on the blockchain. The downside is that to be able to create a complete land administration on the blockchain, all transactions must be registered, the transaction information must be extracted from the documents and stored in a standardised manner on the blockchain. LADM could be used to bring structure in all those data. Doing this for all new transactions may be doable, but recording all historical transactions on the blockchain is normally a job too big to handle.

The main benefit of this approach is that, when done correctly, it can improve the efficiency and reliability of the real estate chain, by improving the accessibility of information and the reliability of the transactions based upon this information.

The reliability of the information on the blockchain is related to the reliability of the processes that create this information. Because these processes take place outside of the blockchain, the reliability is not guaranteed. Steps can be missed, checks can be skipped. For this reason standardised activity diagrams will be considered to be included in LADM II. To increase the reliability, this knowledge on the process resulting in a transaction can be added to the blockchain. Process information is information on who has to do what in approving the transaction. Despite the fact that blockchain itself has the possibility to have a track-and-trace-functionality, LADM has roles already included as well a series of dates as

interaction to processes. As said: in LADM II standardisation of processes is to be done. In this way it is not only known what the transaction is about, but also how this transaction was executed . This way it can be controlled whether the process has been followed correctly and what the source of a problem is.

This type of solution requires that all parties with a role in the transaction process have access to the blockchain and can record their actions on the blockchain. This is a high level of automation for all parties involved. Because of the number of (professional) parties involved in land administration, it is not easy to realise this level of automation. Standards are needed describing all steps of the process and the information used, from all roles in the process: the real estate broker to the bank, the notary, the surveyor, the mapper, the cadastre and tax agencies. Descriptions and process diagrams of real property transactions are documented[55] – but not yet set as standards. These standards are not yet available – it is known that it will be difficult to develop this in LADM II; the same was valid for the first Edition of LADM. Information models used currently in different parts of the process are incompatible and harmonisation is non-trivial.

Potentially, this approach can lead to a substantial reduction of transaction time and process cost. When in this process the validity of the transaction is not automatically checked, we still need the consent of all parties and all checks and balances in the system.

To be able to determine automatically whether a process has been followed correctly and the transaction is valid, business rules (smart contracts) can be added to the blockchain. In this step, the blockchain becomes more or less autonomous, it can automatically approve parts of transactions or sometimes even complete transaction. To be able to do this, the quality of information and the business rules throughout the system should be perfect. Additional standards for business rules and checks on the effect of changes in one part of the process on other parts of the process are necessary. The current level of automation in land administration does not support this and added benefits over the previous level of automation seem limited.

To be able to completely replace the role of the Trusted Third Party, the governance process of the system itself must be distributed. In practice, there are several options to do this. One is the way bitcoin has implemented this: by creating versions of the code and activating code when more than half of the miners have implemented this version of the code, a sort of voting process.

55 E.g. ZEVENBERGEN, J.A. (editor) , FRANK, A. (editor) and STUBKJAER, E. (editor) (2007) Real property transactions : procedures, transaction costs and models. Amsterdam, IOS Press, 2007. ISBN: 978-1-58603-581-5.

9. Conclusions and recommendations.

Let us bear in mind that Gartner put blockchain at the end of the Peak of Inflated Expectations / at the beginning of the Trough of Disillusionment. Mainstream adoption is to be expected within 5 to 10 years from now. Gartner: "The shift from compartmentalized technical infrastructure to ecosystem-enabling platforms is laying the foundations for entirely new business models that are forming the bridge between humans and technology".[56] To start a programmable Land Administration standardization is needed. After all, before automizing a process of standardization is needed.

The European Land Registry Association (ELRA) has proposed a succeeding project[57] on creating a template for organizing Land Register information, the European Land Register Document[58]. This template, which will be refined in a successive project (IMOLA II), may be put on a (yet non-existing) European e-Justice blockchain in future.

The International Federation of Surveyors (FIG) is developing a new work item proposal (NWIP) to ISO/TC 211 to initiate a review of the LADM. This review will include considerations to include extensions in LADM to the legal administrative package with as starting point the "Legal Cadastral Domain Model".[59, 60] The Open Geospatial Consortium (OGC) and its members will be involved, as will be the Global Land Tool Network (GLTN), in order to bring support for developing countries. Collaboration will be further initiated with FIG, ISO/TC 211 and its members, OGC, World Bank, TUDelft, Kadaster, UN-GGIM, GLTN, Royal Institute of Chartered Surveyors (RICS), and others. With regard to standardisation it is to be avoided that – as we see nowadays in all kinds of blockchain solutions – many parties are (re)inventing a blockchain-based Land Administration system on their own. Instead it is recommended to surveyors, registrars, notaries, IT-specialists and other stakeholders to work closely together and to be around the table.

Nothing can be said in this moment on costs related to implementation of blockchain. From LADM Edition I it can be noticed that software developed by

56 <http://www.gartner.com/newsroom/id/3784363> accessed October, 14th 2017.

57 <https://www.elra.eu/letter-from-jan-moerkerke-new-elra-president/> accessed October, 14th 2017.

58 See Chapter 3 (Standardisation).

59 PAASCH, J.M., (2012). Standardization of Real Property Rights and Public Regulations – The Legal Cadastral Domain Model. KTH Royal Institute of Technology, Stockholm, Sweden.

60 PAASCH, J.M., VAN OOSTEROM, P., LEMMEN, C.H.J. and PAULSSON, J. (2015) Further modelling of LADM's rights, restrictions and responsibilities (RRRs). In: Land use policy, 49 (2015) pp. 680–689.

open source communities and commercial providers is available now and is becoming increasingly used.

Compared to the existing functionality within blockchain technology, extra functionality may be needed to manage changes in the territories of a land administration system (e.g.: merging and subdividing land administration territories).

For LADM Edition II a cooperation is under development between the ISO Technical Commissions on Geographic Information (ISO Technical Commission 211) and the ISO Technical Commission on Blockchain and Electronic Distributed Ledger Technologies (ISO Technical Commission 307). A liaison is established already. Whatever the (ultimate) technical solution may be, whether it will be Artificial Intelligence, IoT Platforms or blockchain, by standardizing the elements (the 'triple') it is made possible to implement this technological solution. The question remains whether a computer(ized system) is able to set up and maintain a Land Administration system without the intervention of a Trusted Third Party. Nevertheless, we recommend investigating how different uses of blockchain relate to a fit for purpose approach to land administration.

It is recommended to further streamline and coordinate a global debate on the usage of blockchain technology for land administration: debate and discussions in platforms as ISO, OGC, WorldBank, FIG, ELRA, IPRA|CINDER and others already started. ISO is already investigating possibilities in its Technical Commission 307. This will be linked to discussions in TC 211. Many options seem to be possible in a ranging from "no interference by Trusted Third Parties" to "no application of blockchain". A similar debate took already place in the development of LADM Edition I. As a result of that debate (2002–2012) it was concluded that processes cannot be included into standardized models for land administration.

Today the blockchain is widely recognized for its applicability in transaction based environments and this requires an open minded evaluation for land administration. The results may be different for various countries, which is why flexibility in standards is a prerequisite. In any case: from a technical perspective it can be concluded that it is possible to link and use blockchain technology to an established data or transaction model, such as LADM.

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