# Exploring Options for Standardization of Processes and Transactions in Land Administration[1]

**Christiaan LEMMEN, Peter van OOSTEROM, Eva-Maria UNGER,**
**Kees de ZEEUW, the Netherlands and Mohsen KALANTARI, Australia**

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## SUMMARY

Processes and transactions in Land Administration are outside the scope of the Land Administration Domain Model Edition I published in 2012. Reason is that processes were considered to be country specific. Generic processes would be too difficult to model. This view needs reconsideration – given developments as Fit-For-Purpose Land Administration, Apps and blockchain.

In many countries different organizations have their own responsibilities in data maintenance and supply, but may communicate on the basis of standardized administrative and technical update processes. Operationalization and implementation of LADM requires attention to this aspect - at least at conceptual level (not prescriptive). This will an issue in the development of LADM Edition II and this is the issue that is explored in this paper.

[1] This paper was also presented to the World Bank Land and Poverty Conference, held in Washington DC, US, March 2018.

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## 1. INTRODUCTION

Land Administration in many countries develops and improves over time, the pace at times dictated by the rate of change in technology as much as societal demands. From the geographic, spatial, cadastre and land registry perspective, many tools are available to support and enhance this progress. Relevant in this progress was the development of the ISO 19152 – The Land Administration Domain Model (LADM). The LADM facilitates the efficient set-up of land administration and can function as the core of any land administration system. LADM is flexible, widely applicable and functions as a central source of state-of-the-art international knowledge on this topic.

In many countries different organizations have their own responsibilities in data maintenance and supply, but may communicate on the basis of standardized administrative and technical update processes. Operationalization and implementation of LADM requires attention to this aspect: maintenance of land ownership data requires further standardization. This will be at least an issue of discussion in the development of LADM Edition II and this is the issue that is explored in this paper. Are the differences between maintenance processes in land administration systems in different countries so big that standardization cannot be achieved? Or is it possible at conceptual level to define more generic "modules" with maintenance functionalities as: "reception of a request", "acceptance of an application request", "allocation to workflow depending on type of request (maintenance of data with transactions as buying/selling, establishment of mortgage, inheritance, valuation and taxation)", "update attributes", "send confirmation", etc.? to be implemented in a sequence that meets the requirements of the user. More generic approaches are expected to be feasible – for example based on the use of blockchain technology and modeled semantics. The word "options" in the title means that all proposals for inclusion of processes in the next Edition of LADM are optional and open for discussion.

Apart from update procedures based on transactions (see Section 2 of this paper) which may be based on blockchain technology (as discussed in Section 3) one can look broader. With modern technology participatory surveying (see Section 4) is possible where citizens collect the cadastral date themselves – with inclusion of legal/administrative data. Professionals and government representatives have roles in supervision, organization, data handling and quality management. Participatory surveying is a process. Participatory surveying is also possible with imagery. Generic processes can be designed in support to organizing availability of imagery in the field – see Section 5. Processes as spatial planning, designing, permitting, financing, construction, maintenance and suchlike require full 3D (or 4D). This fits also for life cycles of buildings and constructions. See Section 6. The paper brings concluding remarks in Section 7.

## 2. UPDATE PROCESSES

Updates in land administration concern for example: transactions of buying/selling, establishment of rights (including mortgage), subdivisions of parcels (and merging) and also quality improvements of existing data, processing land consolidation and land readjustment.

The currently established update procedures are expected to be simplified in the future. For example, to subdivide and sell a part of a parcel requires the involvement of professionals, such as notaries, surveyors and registrars, each performing certain sub-tasks. Based on authenticated identification of persons and trusted reference material (e.g. high-resolution and up-to-date georeferenced imagery), via web services, seller and buyer design and draw the new boundaries of the subdivided part of the parcel and complete the transaction.

Spatial units that are not yet included can be added to this type of infrastructure – e.g. conversion from social tenure to legal tenure and fit-for-purpose (FFP) approaches need facilitation. The required web services and protocols are currently developed and implemented, e.g. based on web feature transaction (WFS-T) services. The accuracy of digital reference material will become so high that there is no need to go outside to perform a survey. The reference material can also include 3D aspects. Integration of outdoor geoinformation with indoor spatial information and building information modeling is underway. The role of local authorities will be to provide the required infrastructure and links to other parts of the geoinformation infrastructure and to perform quality control and validate transactions.

## 3. BLOCKCHAIN IN SUPPORT TO TRANSACTIONS

The blockchain is a secure mechanism to handle and store transactions in a distributed ledger environment. Once a transaction has taken place it cannot be altered or erased from existence. 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 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, and it is publicly available and 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 development requires co-operation with ICO TC 307 on Blockchain. FIG is involved here.

Smart contracts are contracts whose terms are recorded in a computer language instead of legal language. Smart contracts can be automatically executed by a computing system, such as a suitable distributed ledger system. The smart contract is the layer that fully utilises the potential of blockchain technology. Smart contracts contain the computer code that executes the contract.

The simplest way to use the blockchain is by storing the hash values of documents on the blockchain. The hash value is unique to one document. 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 identifier of source documents.

The next solution is adding identifying information to the blockchain. Identifiers of subjects (parties) and objects (spatial units) from the source document can be stored in the blockchain. 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. The next step is to add the content of the transaction as described in the source document 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. Knowledge on the process resulting in a transaction can be added to the blockchain. Process information is information on who has to do what when approving the transaction. LADM has roles already included as well a series of dates as interaction to processes.

## 4. PARTICIPATORY SURVEYING PROCESSES

Cadastral survey requires the participation of neighbors, family members where everyone can monitor the on-site process in the field. During the initial field survey, the collected data can be transmitted from the mobile device directly to a cloud-based GIS environment, enabling everyone to follow the process remotely. The field survey is about creating an overview of all existing people-land relationships, including formal ownership and informal land use and also overlapping claims. Owners or claimants are invited to walk the perimeters of their land parcels and to point the vertex points of the boundaries themselves holding a GPS antenna. A surveyor or grassroots surveyor records the observations with an App installed on a mobile device. Satellite imagery of the area is displayed on the screen of the mobile device. Data collection is done in an integrated way: the perimeter is stored as a closed polygon together with the claimed type of right, combined with a photo of the face of the owner or claimant, and a photo of the owner's or claimant's ID. A preliminary identifier is used as linking key. The GPS antenna may be handheld-low-accuracy. The walked perimeters identify a boundary from two spatial units. If those are within a pre-defined tolerance the boundary demonstrates agreement.

Accuracy is not so much about the geometry, but is rather focused on linking spatial and administrative data or, in other words, linking people to polygons. The quality of this link is in many countries not so good, because of distributed responsibilities for cadastre and registry.

Since citizens are required to provide proof of their identity in this participatory surveying, the government has to be represented in the field. This is of general importance for the success of this methodology.

An alternative is in drawing the boundaries on top of an image where the owner or user draws the boundaries (in the field or even in office – digital or analogue).

It is crucial to get an overview of areas under dispute and to collect the geometry of the disputed area. ‘Dispute holders’ need to ‘agree’ on the area and the location of the dispute. During the adjudication process in the field, disputes may lead to the creation of overlaps between polygons. In that case, those overlaps are mapped and the corresponding authorities know the exact location and the type of land-related conflict. After field data collection, the data must be checked for completeness and prepared for public inspection. Some editing time was needed in order to present the spatial data – this concerned mainly the calculation of average locations of double observed boundaries (surveying by walking perimeters means that boundaries are observed twice). Usual procedures, such as public inspections, are conducted at village meetings – often in the local town hall – accompanied by trusted third parties. At a village meeting, community members gather to view all the collected data on a map and discuss and reconcile the results. Note: imagery can be collected from satellites, traditional aircraft or unmanned aerial vehicles (UAVs).

Digital pens may be used. Such pen can be used to draw identified boundaries on a paper with printed imagery. The paper is prepared and coded – the pen can read identified pixels on the paper image. This means that all drawn lines can be uploaded to a computer and visualised overlaying the digital version of the georeferenced image.

Community-based cadastral mapping can be integrated into LADM implementations through its functionalities for source documents for spatial and non-spatial data.

## 5. GENERIC PROCESSES SUPPORTING USE OF IMAGERY

Processes such as initial data acquisition may concern millions of spatial units (amongst them parcels) where people-land relationships have to be determined, documented and reviewed before publication can be organized.

The geographic data/software industry provides tools, products and services to support a number of processes required in Land Administration. Image-based acquisition of cadastral boundaries needs access to huge image libraries – including historical imagery – to support large-scale implementations. Detection and selection of cloud-free imagery is needed to create cloud free compositions, possibly from different sensors. Data collection based on imagery can be done in the field or during public meetings – where people identify the spatial unit on top of the imagery. In the latter case there may be a higher risk on interpretation errors. This could be reduced by inviting neighbors identifying their spatial unit independently.

By using orthophotos to produce spatial frameworks, the imagery is typically linked to the national geodetic reference frame through GNSS. Furthermore, automated feature extraction and feature classification appear to be very promising developments for the generation of coordinates from visual objects in an imagery, as well as Lidar and radar technologies can also be used for this purpose. ‘Pre-defined’ boundaries resulting from feature extraction may be plotted on paper or visualized in interfaces, and can then be declared identical to cadastral boundaries in the field.

## 6. INTEGRATION OF THE FOURTH DIMENSION

The increasing complexity and flexibility of modern land use requires that land administration systems will need an improved capacity to manage spatial units in three dimensions, i.e. not only in two dimensions as a representation of parcels on a conventional cadastral map. A temporal (fourth) dimension can be integrated with the spatial dimensions, or as separate attributes. In the long term, for future versions of LADM, an integrated 4D registration of all objects will be the most effective solution. The 4D integrated space/ time paradigm, as a partition of space and time without gaps and overlaps, is a very generic and solid basis.

When considering the complete development life cycle of rural and in particular urban areas, many related activities should often also support 3D (and temporal) representations. Not just the cadastral registration of the 3D spatial units associated with the correct RRRs and parties, but also activities such as spatial planning, designing, permitting, financing, construction, maintenance and suchlike should be conducted in full 3D (or 4D). Furthermore, information should be shared among the various phase of the life cycle without too much effort and without information losses. Therefore, several of these activities and their information flows need to be structurally upgraded from 2D to 3D representations. Because this chain of activities requires good information flows between the various actors, it is crucial that the meaning of this information is well defined – an important role for standardization. Relevant are ISO 19152 LADM and ISO 19156 Observations and Measurements.

Closely related and partially overlapping is the scope of the OGC's LandInfra Standards Working Group, with more of a focus on civil engineering information, e.g. the planned revision of LandXML: InfraGML (to be aligned with LADM). 3D cadastre registration is being tested and practized in an increasing number of countries. For example, for buildings (above/below/on the surface or constructions such as tunnels and bridges) and (utility) networks, the overlap between LADM and InfraGML is clear (in the context of full life-cycle support) and was already discussed in the LADM Workshop held in Delft, The Netherlands, in March 2017. LADM is focused on the spatial/ legal side, which could be complemented by civil engineering physical (model) extensions.

It is important to reuse existing standards as a foundation and to continue from that point to ensure interoperability in the domain. Data sharing means the data is collected once and used many times through establishing linkages with for example SDIs. Duplicative efforts in data collection and maintenance can be avoided. Data has to be 'kept at the source'.

## 7. CONCLUDING REMARKS

With LADM and also its specialization the Social Tenure Domain Model (STDM), information-related components of land administration can be registered worldwide in a standardized way. The standard focuses on flexibility based on a variety of continuums – on land rights, spatial units and accuracy. All this is needed for the implementation of FFP approaches in land administration. The FFP approach focuses on the purpose of the systems such as providing security of tenure for all and managing the use of all land. The land administration system can then be upgraded and incrementally improved over time.

Further steps are needed to operationalize those FFP methods and related processes, at scale. The Open Geospatial Consortium initiated such development and there is cooperation with the International Standardisation Organisation in this respect. This development requires, apart from attention to data models, also attention to process models to support data maintenance and transactions in land administration. If this could be included in a new edition of LADM there would be a basis at conceptual level (not prescriptive) and allowing understanding of each other's processes.

The highlighted developments can provide the foundation for further development of LADM, where needed.

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## BIOGRAPHICAL NOTES

**Christiaan Lemmen** is full Professor Land Information Modeling at the Faculty of Geo-Information Science and Earth Observation of the University of Twente in the Netherlands. His other main job is as Senior Geodetic Advisor at Kadaster International, the international branch of the Netherlands Cadastre, Land Registry and Mapping Agency. He is director of the OICRF, the International Office of Cadastre and Land Records, one of the permanent institutions of the International Federation of Surveyors (FIG). He is chairing the Working Group Fit-For-Purpose Land Administration of the Commission 7, Cadastre and Land Management of the International Federation of Surveyors (FIG). He is contributing editor of GIM International, the worldwide magazine on Geomatics. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152 and the designer of the Social Tenure Domain Model (in co-operation with UN HABITAT and FIG). He holds a PhD from Delft University of Technology, The Netherlands. Title of his thesis is 'A Domain Model for Land Administration'.

**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. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he is professor at the Delft University of Technology, and head of the 'GIS Technology' Section, Department OTB, Faculty of Architecture and the Built Environment, Delft University of Technology, The Netherlands. He is the current chair of the FIG Working Group on '3D Cadastres'. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152.

**Eva-Maria Unger** is a Land Administration Advisor at Kadaster International since 2017. She obtained an MSc in Geo-information and Surveying in 2011 from Vienna University of Technology, Austria. Her MSc thesis was focusing on the semantic transformation of the Austrian Cadastre System into the INSPIRE Cadastral Parcels Theme. From 2011 until 2017 she worked at the Austrian Federal Office for Metrology and Surveying in Vienna. Since 2013 she is enrolled as a PhD student at ITC University of Twente focusing on Land Administration and Disaster Risk Management. She is a member of the UN-Habitat GLTN STDM Advisory Board and since 2014 chair of the FIG Young Surveyors Network. Within her role as the chair of the FIG Young Surveyors Network she organised various Training of Trainer events of STDM around the world. Within her work and research she is constantly working with the LADM and its specialisation the STDM. She sees the LADM and its application as the key for the realisation of Fit-For-Purpose Land Administration and ultimately as the key to work towards the Sustainable Development Goals (SDGs).

**Kees de Zeeuw** is Director of Kadaster International at the Cadastre, Land Registry and Mapping Agency (Kadaster), The Netherlands and chair of the United Nations Group of Epxerts on Land Administration and Management (UNGGIM: EG-LAM). He holds an MSc degree in land and water management (1989). After long term contracts in Rwanda and Bolivia he has been working more than 10 years in environmental and geo-information sciences at Wageningen University and ResearchCentre. After being responsible at Kadaster for product and process innovation (2007 – 2010), he now is responsible for the coordination of Kadaster's international activities and international cooperation projects. Kadaster International provides worldwide advisory services in the domain of land administration, e-governance, geo-information services and SDI.

**Mohsen Kalantari** is a Senior Lecturer in Geomatics at the Department of Infrastructure Engineering and Associate Director at the Centre for Spatial Data Infrastructures (SDIs) and Land Administration. Dr. Kalantari teaches Land Administration Systems (LAS), Building Information Modelling (BIM) and Spatial Analysis. His area of research involves LAS and SDI. He has also worked for four years as a technical manager at the land administration authority of Victoria, Australia.

**CONTACTS**

Christiaan Lemmen
University of Twente, Faculty of Geo-Information Science and Earth Observation/ITC
P.O. Box 217
7500AE Enschede
THE NETHERLANDS
Phone: + 31 6 52481717
E-mail: c.h.j.lemmen@utwente.nl
Website: www.itc.nl
and
Cadastre, Land Registry and Mapping Agency, Kadaster International
P.O. Box 9046
7300 GH Apeldoorn
THE NETHERLANDS
Phone: +31 88 183 4417
E-mail: Chrit.Lemmen@kadaster.nl
Website: www.kadaster.nl

Peter van Oosterom
Delft University of Technology, Faculty of Architecture and the Built Environment
P.O. Box 5030
2600 GA Delft
THE NETHERLANDS
Phone: +31 15 2786950
E-mail: P.J.M.vanOosterom@tudelft.nl
Website: http://www.gdmc.nl

Eva-Maria Unger
Cadastre, Land Registry and Mapping Agency, Kadaster International
P.O. Box 9046
7300 GH Apeldoorn
THE NETHERLANDS
Phone: +31 88 183 4417
E-mail: Eva.Unger@kadaster.nl
Website: www.kadaster.nl

Kees de Zeeuw
Cadastre, Land Registry and Mapping Agency, Kadaster International
P.O. Box 9046
7300 GH Apeldoorn
THE NETHERLANDS
Phone: +31 88 183 4417
E-mail: Kees.DeZeeuw@kadaster.nl
Website: www.kadaster.nl

Mohsen Kalantari
University of Melbourne
Parkville Victoria
AUSTRALIA 3010
Phone: +61 3 8344 0274
E-mail: mohsen.kalantari@unimelb.edu.au
Website: www.csdila.unimelb.edu.au