

From LADM/STDM to a Spatially Enabled Society: a Vision for 2025

Harry Uitermark, Peter Van Oosterom, Jaap Zevenbergen and Christiaan Lemmen,
The Netherlands

Motto: “Spatial enablement of society is only possible with forward planning and a shared vision of what is possible. This vision is at the heart of the next generation of Land Administration systems” ([Williamson et al, 2010](#)).

Key words

LADM, Land administration systems, STDM, Vision 2025, Africa, Kenya

Summary

The Land Administration Domain Model (LADM) is a draft International Standard (ISO 19152). LADM is partly based on ‘Cadastre 2014’. A prototype of a software tool, the Social Tenure Domain Model (STDM), is in its turn based on LADM. It supports the security of tenure of people in developing countries. With LADM and STDM, information-related components of Land Administration (LA) can be registered worldwide in a standardized way. It is our vision that in moving towards the year 2025, access to land-related information is enabled for everybody (via the internet), a ‘spatially enabled society’. Many ICT-related developments will strengthen the relationship between LA and other registrations.

1. Introduction

The Land Administration Domain Model (LADM) entered the stage of Draft International Standard (DIS) on March 1, 2010 ([ISO/DIS, 2010](#)). The design principles of LADM are partly based on ‘Cadastre 2014’. It is expected that in the year 2011, LADM will become an International Standard, labeled ISO 19152. Furthermore, in April 2010, the prototype of a software tool, named the Social Tenure Domain Model (STDM), was presented at the XXIV FIG International Congress in Sydney, Australia ([Augustinus, 2010](#); [Zevenbergen and Haile, 2010](#)). STDM, in its turn, is almost entirely based on LADM, and is meant to support the security of tenure of people in developing countries. From now on, with LADM and STDM, it is possible to register worldwide the information-related components of Land Administration (LA) in a standardized way.

With this in mind one may wonder what will be the consequences of this in 15 years time. This paper tries to give a perspective. First of all, some basic information regarding LADM and STDM is presented in [Section 2](#). Then, the urgent need to register of what is generally named as the ‘people – land relationships’ is presented in [Section 3](#). In [Section 4](#) this registration is more focused on the public domain, while in [Section 5](#) the undoubtedly large influence of ICT-related developments is treated. Finally, in [Section 6](#) we draw our conclusion.

2. LADM

In this section goals and basic features of LADM are explained in [Section 2.1](#), with more attention to the flexibility and adaptability in [Section 2.2](#), and the relationship between LADM and ‘Cadastre 2014’ in [Section 2.3](#). The relationship between LADM and STDM is considered in [Section 2.4](#).

2.1 Goals and Basic Features

LADM will serve two goals:

1. Provide a basis for the development of Land Administration systems (LA systems).

2. Enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary (that is, an ontology).

LADM defines a reference model, covering basic information-related components of LA. Basic components relate to the following:

1. Parties (people and organizations).
2. Rights, responsibilities, and restrictions (RRR's).
3. Spatial units (parcels, buildings and networks).
4. Spatial sources (surveying).
5. Spatial representations (geometry and topology).

LADM provides a terminology for LA, based on various national and international systems. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions.

2.2 Flexible and Extensible Components

All three main classes of LADM – spatial units, RRR's, and parties – have deliberately an open, flexible and extensible character:

1. Spatial Units (a.k.a. Parcels). Spatial units are area's of land or water where rights and/or social tenure relationships apply. Those area's can be represented in LADM in different ways. A 'sketch based' spatial unit is used when a sketch is available. A 'text based' spatial unit is used when the definition of the spatial unit is entirely by descriptive text. This includes the 'bounds and metes' descriptions. A 'point based' spatial unit is used when the only information about the location are the coordinates of a single point within its area (or volume). A 'line-based' (a.k.a. 'unstructured' or 'spaghetti') spatial unit is used when the representation is allowed to have inconsistencies, such as hanging lines and incomplete boundaries. A 'polygon based' spatial unit is used when each spatial unit is recorded as a separate entity. A 'topology based' spatial unit is used when spatial units share boundary representations. This range of spatial units can cover different kind of land administrations: community-based, or rural, or urban, or other types of land administration, like marine and 3D cadastre ([Lemmen et al, 2010](#)).
2. RRR's (= Rights, Restrictions and Responsibilities). Rights may be formal rights, like ownership, apartment right, usufruct, free hold, or lease hold. But it may also be a 'social tenure relationship', as occupation, tenancy, non-formal and informal rights, customary (which can be of many different types with specific names), or indigenous rights. There may be overlapping claims, disagreement and conflict situations. There may be uncontrolled privatization. This list is extensible, to be filled by local tenancy relationships. With regard to this UN-HABITAT proposed 'the continuum of land rights' ([UN-HABITAT, 2008](#)). Restrictions are entitlements to refrain from something, like building within a certain area around a petrol station. Responsibilities are obligations, like cleaning ditches to secure proper water discharge.
3. Parties. Parties are persons, or groups of persons. A group of persons may be a tribe, a family, a village, a company, a municipality, the state, a farmer cooperation, or a church community. Also, this list is extensible, it can be adapted to local situations; based on community needs.

2.3 LADM and 'Cadastre 2014'

LADM has a clear relationship with 'Cadastre 2014' ([Kaufmann and Steudler, 1998](#)). Its design principles are partly based on 'Cadastre 2014'. [Kaufmann \(2004\)](#) formulated ten principles, of which seven apply to LADM:

1. Principle of spatial units. The land parcel of a traditional LA should be extended to also include and administer all spatial units, which have some social, legal or economic relevance.
2. Principle of the documentation of private and public rights, restrictions and responsibilities. Not only ownership rights will be documented, but also the rights, restrictions and responsibilities

established by different legislations having an impact on land shall be registered. In LADM this is extended with customary and informal rights.

3. Principle of legal independence. To be able to build a LA system, it is necessary to investigate the laws in a jurisdiction and to identify those with an effect on land. The different spatial units are to be arranged according to the laws by which they are defined. This structure allows the immediate adaptation of the land administration to the development of the legislation. It is not necessary to rearrange the information. New legal topics can simply be added by including a further information level. If a law is cancelled, the respective information level can be removed without reorganizing the other levels. In this way it is possible to deal with facts which are not formally written down in a law. Such informal and customary rights exist where tribes or clans are obeying unwritten rules. These tribes or clans may have living, hunting and fishing rights within a defined territory from which the boundaries are known, but not documented formally. The rightful claimants are certainly able to localize the outlines of their rights and the respective spatial unit can be included into the LA system. A form of ‘occupation rights’ exist in informal settlements in many areas of the world. Even when the occupation of the land may be contrary to the formal law, the rights of the involved settlers are informally defined by an unwritten code. The boundaries resulting from these informal arrangements can be localized and documented. So this principle can show overlapping rights and serve to formalize the situation, to regulate transactions, to monitor and to improve ambiguous situations. Indigenous rights normally overlap with a formal ownership system. The rights and the boundaries where they are in effect are well known and can be documented.
4. Principle of linking objects by geometry. The realization of the principle of legal independence results in a structure of independent topics. Spatial units are arranged in independent topics. In principle there is no explicit link between spatial units in different topics, and links between spatial units are normally not stored in the system but may be created when needed with the help of a GIS overlaying technique. However, in LADM this is extended with the possibility to store links explicitly between spatial units if needed.
5. Principle of unified Cadastre and Land Registry. Spatial units are linked directly with the information needed for registration.
6. Principle of Land Administration Modelling. The idea is to model objects in stead of thinking in graphical categories. Maps have no function as information repositories; their only purpose will be the visualization of information.
7. Principle of Information and Communication Technology (ICT) application. This principle implies that ICT is the best technical tool for land administration and the only way to achieve a low-cost land administration system.

2.4 STD M

STD M is a ‘specialization’ of LADM, that means, structurally it is a little less complex than LADM, but it contains almost the same functionality of LADM, under different terminology ([Lemmen, 2010](#)). Formal terminology, as used in LADM, may not always be applicable because of the informal environment. In STD M the same classes are used as in LADM, for example, class ‘RRR’ is named class ‘SocialTenureRelationship’.

STD M is an initiative of UN-HABITAT to support pro-poor LA. STD M is meant specifically for developing countries, countries with very little LA coverage in urban or rural area’s. It is also meant for post-conflict area’s, area’s with large scale informal settlements, or large scale customary area’s. The focus of STD M is on ‘people – land relationships’, independently from the level of formalization, or legality of those relationships. It is a search for a model that should support all forms of land rights, social tenure relationships, and overlapping claims to land.

3. The Registration of ‘People – Land Relationships’

In this section the urgency of the registration of land rights is demonstrated. First there is an example in [Section 3.1](#). Then in [Section 3.2](#) attention is given to unofficial land rights mapping networks, with more attention to slum mapping in [Section 3.3](#). How the need for a software tool as STDM fits in these activities is explained in [Section 3.4](#), with more attention to the development of LA systems for poverty eradication ([Section 3.5](#)), and how via national land policies ([Section 3.6](#)) informal rights can be transformed to formal ones ([Section 3.7](#)).

3.1 Land Rights for All

A quick look at the BBC news site brings to remembrance a heavy conflict between local people and the Peruvian government in June 2009: “At least 34 people died during weeks of strikes against the legislation, which allowed foreign companies to exploit resources in the Amazon forest. The violence provoked tension with Peru's neighbor, Bolivia, where President Evo Morales backed the Peruvian Indians’ tribal rights.” Another news from Brazil: “Our ancestors have known this land forever. The only thing the whites did was to steal the lands from the people of the forest and destroy them.” Along with Surinam, Brazil is the only Latin American country that does not recognize the right, enshrined in international law, of tribal people to own their land. “The government and the ruling classes see them as a bit of an obstacle to what they describe as development”. Just two cases. There are many.

3.2 Land Rights Mapping Networks

Many organizations have attention to the registration of land rights, and there are networks, like the Indigenous Mapping Network, established by anthropologists. The mission of the Indigenous Mapping Network is to connect native communities with the tools needed to protect, preserve, and enhance their way of life within the aboriginal territories. This endeavor often requires an amalgamation of traditional “mapping” practices and modern mapping technologies. Another network is the aboriginal network. According to [Chapin et al \(2005\)](#), the mapping of indigenous lands to secure tenure, to manage natural resources, and to strengthen cultures, is a recent phenomenon, that begun in Canada and Alaska in the 1960s, and in other regions during the last decade and a half. They recognize that indigenous mapping has shown itself to be a powerful tool and it has spread rapidly throughout the world. Their review covers the genesis and evolution of indigenous mapping, the different methodologies and their objectives, the development of indigenous atlases and guidebooks for mapping indigenous lands, and the often uneasy mix of participatory community approaches with technology. A recent workshop in Québec, Canada, on the Land Administration Domain Model, pointed out that this issue is still most relevant in Canada ([Egesborg, 2009](#)).

3.3 Slum Mapping

Also slum mapping in relation to tenure is an issue of international attention; see for example the discussions at the latest World Urban Forum ([UN-HABITAT, 2010](#)). Key findings towards securing tenure, according to a research from [Huchzermeyer \(2009\)](#), include the importance of various forms of mobilization, that accompany enumeration, and of the informal and formal knowledge generation, that results from the enumeration process. For a grassroots enumeration exercise to be successful, grassroots trust must be sustained for ongoing verification and updating of the enumeration data and the enumeration must link up effectively with the planning authorities. [OpenStreetMap \(2010\)](#) has a mapping of Kibera slums in Nairobi, Kenya ([Norwegian Council for Africa, 2010](#)).

Given the problems, related to urbanization, environment, access to land, access to food and water of the world today, there is a need to get a complete overview of who is living where, under what tenure conditions, and for which area’s. Overlapping claims to land need to be included. Illegal acquisition or occupation of land too. A continuous map of ‘people – land relationships’ is needed.

3.4 The Urgent Need for Registration

There is a lack of land information in developing countries, especially in informal settlements and customary area's. Less than 30% of LA coverage is in conformance with the situation on the ground. This means that over 70% of the land is outside LA systems. In many countries informal rights are not recognized as being legal. Customary land tenures are not included in the LA system. This has caused enormous problems, for example in cities, where over one billion people live in slums, without proper water, sanitation, community facilities, security of tenure or quality of life ([Enemark et al, 2009](#)). Where there is little land information, there is little land management. Conventional LA systems are based on the 'parcel-based' approach, applied in the developed world, and implemented in developing countries in colonial times. A more flexible system is needed for identifying the various kinds of land tenure in informal settlements, or in customary area's. Alternative representations of area's and alternatives for traditional land surveys are needed. Traditional land surveys are costly and time consuming, and proved not to work in many situations in developing countries. Handheld GPS, or the use of satellite imagery, are considered to be inaccurate by the surveyor's community; but this attitude results in a lack of LA coverage. There is a need for complete and up-to-date LA coverage. A more flexible system has to be based on a global standard like LADM, and it has to be manageable by the local community itself. It is here where the Social Tenure Domain Model (STDM) comes in. This kind of standardization allows for the integration of data collected by communities into a formal LA system at a later moment in time.

3.5 LA systems and Poverty Eradication, Sustainable Development and Economic Development

Civilized living in market economies is not simply due to greater prosperity but to the order that formalized property rights bring ([De Soto, 2003](#)). If the world's community is sincerely of the opinion that appropriate LA systems are required for the eradication of poverty, sustainable development and economic development, then it will be evident that attention should be devoted primarily to the LA systems of developing countries ([Van der Molen, 2003](#)).

Depending on the local situation different registrations or recordings of land rights are possible. In rural area's there can be spatial units covering customary area units, recorded in a decentralized system, described in text based or line based spatial units, derived from low accurate satellite images. The tribe may be represented by it's chief. Overlapping formal property-based spatial units concern formally registered ownership, identified by accurate field surveys. Boundaries of customary-based spatial units are more fuzzy and can be described in text, or can be identified from low accurate satellite images. Corridors for pastoralist tribes can be identified with fuzzy boundaries. Persons living in 'structures' in slum area's can be identified by fingerprints, the social tenure relationship to the spatial units can be represented by points, collected with handheld GPS, with a source document printed from OpenStreetMap ([Weston and Schwieger, 2010](#)). Spatial units in urban business district can be conventional parcels with highly accurate boundaries. Spatial units in residential area's may be derived from aerial photographs. If all data are collected in the same structure (Party – Social Tenure Relationship – Spatial Unit), upgrading of rights is possible depending on the local needs.

3.6 National Land Policies

The fact that in a country more social tenure relationships exist than statutory land rights, has to be accepted, especially at the political and higher administrative levels. This is best expressed by inclusion in a *national land policy*. The relevant land agencies and involved private practitioners need to be willing to adapt their ways of working to allow for dealing with the concepts of STDM, as compared to the 'conventional' LA approach, including recognition of a range of rights, and mechanisms to gather these rights on a community based participatory approach. Expertise is needed both in LA and in ICT for each office, where the STDM software is implemented. The dilemma between community access and the scale needed for ICT support needs to be solved. Awareness with regard to a culture of updating (the social tenure holders should realize that they should report changes

in their social tenure relationships). The administrative system supporting STDM should keep the requirements for reporting simple enough to remain accessible for all, including the poor. First the data need to be acquired. Communities (villages, co-operations, slum dweller organizations, non governmental organizations) can organize this. Later it should be possible to perform unconventional transactions, for example, to change a social tenure relationship from type ‘informal’, to ‘occupation’, and later to ‘free hold’.

3.7 The Transformation from Informal to Formal ‘People – Land Relationships’

How to go from informal social tenure relationships to formal ones? And from personal use rights to formal ones? The inventory of informal rights could be seen as a ‘what-to-do-list’, after integrating the land data collected by a local community to an LA authority (possible in co-operation with other institutions). Sometimes there are objections in recognizing informal rights, considered as ‘illegal rights’. This is neglecting what can be observed in reality. People need a shelter somewhere, and in many cases the government tolerated informal areas, but did not interfere for a long time. How to move from a conflict situation (conflicting claims) to a formal one? Again a ‘what-to-do-list’ for the government: upgrade the rights, or take other decisions based on the recordation (registration) of rights. A similar situation concerns ‘women’s access to land’: this can be organized by registering shares in rights. Data quality of spatial data may be improved in a later stage of development.

4. The Registration of Public Goods

In this section, the attention of the reader is shifted to the public domain. First, the increase in the registration of public restrictions is treated in [Section 4.1](#). Next to this, the registration of public benefits gets attention ([Section 4.2](#)), followed the registration practices with regard to public land ([Section 4.3](#)), with a reflection on the registration of ‘public goods’ and its spatial extents ([Section 4.4](#)), with a finishing section on policy implications ([Section 4.5](#)).

4.1 Public Restrictions

Land registration, as a core component of LA, traditionally focuses on private land, private interests and restrictions. The main objective originally was to facilitate the land market by reducing the unbalance in information, especially for potential buyers, and by reducing overall risk. From this perspective, the first information, related to public law and administration that was added to land registers, deals with government imposed restrictions on private land. Such restrictions limit for instance the land use that is allowed, impose certain financial burdens, and even limit the free sale of the land. Some of these restrictions have full blanket coverage over the whole country (like eminent domain allowing compulsory purchase for public functions), but others are much more specific to an area, or even a parcel. In The Netherlands for decades, a few very clear examples, like the status of cultural heritage, have been entered as a restriction on every affected parcel. Other restrictions have only been recently added, like the fact that an area is a watershed to pump drinking water from, and thus activities with a high pollution risk are not allowed. For the latter, there is no natural link to parcels, but to a hydrological determined area (that might even be dynamic). The solution designed in the 1990s to administratively determine each effected parcel is now obsolete, and GIS overlaying of the two types of spatial objects is much more practical. Different restrictions are determined by different social-economic and natural phenomena and each have their own spatial object representing their sphere of effect. ‘Cadastrre 2014’ was already foreseeing this. It is not always easy to decide whether a certain government intervention is to be regarded as a restriction, since there are usually also beneficiaries (see [Section 4.4](#)).

4.2 Public Benefits

Although not easily forgotten to be mentioned by the seller, a complete overview of land related information will also include the *public benefits*, that relate to specific spatial objects. For instance, the

different types of permits allowing certain activities, should be as easily accessible as the restrictions, like erecting or changing a building, but also allowing certain land use. And again, the fact that a factory is allowed certain activities can be seen as a nuisance by a potential house buyer nearby in the same way as for the facilities discussed later. Also specific financial benefits should be recorded. Much of this information is already in databases throughout the government sector, but in many cases not easily accessible, and often not directly geo-referenced to specific spatial objects (but stored on address, or name of beneficiary). For good governance, such information should be more widely available within the public sector. Other interests, especially privacy, might call for some restraint in how much of this should be widely available on the web, also because many benefits are related more to the person of the beneficiary, than to the place he or she lives or works (even though this place might be a condition to get a certain benefit or permission).

4.3 Public Land

The fact that land registration traditionally focuses on private land, private interests and restrictions, also means that in many countries state land, or land in the public domain, is not included in the land registries, or even left out on the cadastral map. Land that is compulsory acquired by the government is even ‘taken off’ the register in many places. Separate inventories of public land are not uncommon, but often only tackle a specific type of land (usually related to one ministry – or part thereof – for example, the military, the highway department, or the national parks administration), and are not well coordinated between each other, and with the private land records. There is a risk that the boundary is not understood in the same way as between two systems, and an even greater chance that it is shown differently (due to, for example, low accuracy after digitizing, non-identical reference systems, or different approaches and definitions). Rights and responsibilities between the central and local governments are often also not clear, and even if the roles are clear, the area’s where they apply tend to be defined not too well. Furthermore, in many developing countries the inventory of public land is very weak, often one of the weakest components of the LA system.

Although progress is made on the computerization and coordination of public land inventories in many countries, the need for geospatial integration calls for more than just a good (geo)information infrastructure. Overlaying the different data sets is a first step, which will show overlaps (and even gaps) in the spatial coverage. These overlaps and gaps need to be reconciled to get to the full coverage we foresee for land information in the year 2025. A common spatial reference, which shows the boundary between different land types, does not necessarily mean that the different agencies cannot be responsible for the data of that type, especially the attribute data (which will differ for different public uses), and even the internal boundaries, although some consolidation might be possible in different countries.

4.4 Different Spatial Objects Related to Public Goods

Public functions obviously concern more than land parcels, and an increasing number of ‘public goods’ relates to other spatial objects than just land parcels. Furthermore, many ‘public goods’ have different spatial extents to which they are related, that is to say, an area in which land use is restricted, or a zone that is benefiting from the public good. As an example, the dykes in The Netherlands, which take up a strip of land (usually along a body of water), have an area with land use restrictions (like no digging, no building, and no planting of trees within a certain distance) and the whole ‘polder’ (low lying hinterland) that is protected by this dyke. Restrictions, if not too generic throughout the country, might already be recorded as an ‘RRR’ in the LA system, and ‘dyke’ as such is part of the public domain we just described. The benefiting area is also important for good governance, e.g. for fair payments by the real beneficiaries, but also as input into physical planning, where these different zones might be a reason to intensify (or not to intensify) the land use in certain area’s. For facilities like schools, hospitals, sporting facilities, and public transport hubs these zones are more fuzzy, and tend to be shown as concentric rings (or, more oddly shaped forms related to roads and railway lines).

Service providers are increasingly making overviews of such facilities for clients, who are considering buying a certain house, and some of the information is made accessible through government websites. To a certain extent this is still done ad hoc and often the service only allows viewing of data collected for a particular spot. We envisage that it will become possible to combine a large amount of such data on the fly, as the core data (the spots of the facilities, as well as the standard models of ‘influence’) will be available as services on the web.

4.5 Better Information, Better Policy and Implementation?

The increase in land related information from the public sector side will create an information base for much better analysis, prediction and decision making. However, the policy makers need to be aware and willing to rely on these possibilities. This is not always the case to the extent what is possible. Furthermore, there is a chance that implicit choices in the models, support some policy options more than others. The Dutch National Institute for Public Health and the Environment ([RIVM, 2010](#)) has been criticized for some of their environmental models in the past. Nevertheless, we believe that the available data and knowledge in the public sector will become increasingly available, especially in geo-referenced ways, that gives it an integration framework. Policy making and implementation will follow this trend, be it, as always, lagging behind. Partially this is just getting used to it, but partially it also about reduction of discretionary space in decision making. The ‘push’ from geo-ICT, and the ‘pull’ from the call for better governance, especially more transparency, will nevertheless cause a substantial use of geo-referenced public sector land information. This will allow for much more integrated land management, that needs to deal with increasing urban complexities, more sustainable rural land use, and increased overall land pressure. But since this land information will be part of the wider (geo)information infrastructure, it will not only affect land management but allow for overall spatially enabled governance and society.

5. Vision 2025

It is our vision that, in moving towards the year 2025, many developments will help to strengthen the complex relationship between land registrations and other public basic registrations, in their true 3D complexities (or, even 4D, when the temporal dimension is integrated), helped by ICT-developments. In the next sections our vision is sketched by describing *ten* developments, that are expected to be operational by the year 2025.

5.1 Mature Information Infrastructure

The information society, which is currently in its infancy stage, will be more mature by the year 2025, with as a result several well established *domain standards*, enabling meaningful information exchange at a global level, but also at a national or local level, between different domains or disciplines. The information infrastructure will provide the environment for integrated and ‘seamless’ access to all these sources. Furthermore, the information infrastructure will also provide the environment in which these sources can be maintained in a consistent manner. Domains will have links with other domains, which require that updates take care of consistency with related registrations. For LA systems, as cornerstone of the information infrastructure, these links with other registrations are numerous, for example, persons, buildings, rights, or topography. Besides 7*24 hours access over the network, this requires certain mechanisms to be in operation, like every registration must maintain history (in order to avoid ‘dangling’ references from outside, not aware of certain changes), update alert or notification systems must be established (in order to inform related registrations about changes, which may also need an update in the related registrations) and providing adequate solutions for performance and robustness; for example, via replicated, proxy servers. For an organization, for its primary task, in order to rely on a registration of another organization, some kind of *information assurance* must be established: a legal and financial framework. In case of a failure, which should of course be avoided as

much as possible, there will be a compensation, which is proportional to the damage of having no access to required information.

5.2 Dynamic Process Models

After agreeing on the information content in LA, via initiatives such as the INSPIRE Data Specification for Cadastral Parcels (EU, 2007), and the ISO/TC 211 (and CEN/TC 287) Land Administration Domain Model (ISO/DIS, 2010), different processes in different countries will become more transparent. It will therefore be easier to compare the different processes and discover ‘best practices’. These in turn may be used in the future to harmonize the processes, as in an ever more global economy, that will be expected and appreciated by the users of LA systems. In addition, due to the fact that current systems more and more do maintain history, this will enable researchers to develop social and economic dynamic process models (for example, to analyze the effect of certain policies or economic developments on the land market). These dynamic process models will then be supportive in better predicting future developments in the land market and the effect of new policies.

5.3 3D (and 4D) Space+Time Administration

The increasing complexity and flexibility of modern land use requires that LA systems will need an improved capacity to manage the third dimension. As the world is per definition not static, there will be a need in relation to the representation of the temporal (fourth) dimension, either integrated with the spatial dimensions, or as separate attribute(s). In the long term, 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 (in space and time), is a very generic and solid basis. Initially, this approach may seem an overkill, and only to be applied for some more complex objects such as construction works and utility networks. However, by the year 2025, the technological challenges related to 4D registration will be solved, and this will be the most effective base for registering all objects.

5.4 Parcel Design Applications

Today LA systems are mainly used in ‘registration’ mode, but with all information available within these systems, and related registrations within the information infrastructure, it may be well situated to be used in ‘design’ mode. Traditionally, in many countries LA systems have been involved in (rural) reallocation, land consolidation projects, or in physical planning. In our dynamic environment, both in rural zones, urban zones, and transitional zones, the design capabilities of the LA systems will have to be further developed in order to solve complex situations. As this will also happen more and more often in dense urban areas, it will be required that these designs (similar to the administration) will support 3D (both topographically and legally). In designing new spatial units, the future information infrastructure will be heavily used as the design requirements are related to many other geo-information sources, like soil and land value, or accessibility to roads and water. This will support in decision making for food and energy provision.

5.5 More Than Traditional Rights, Restrictions and Responsibilities

The proven capabilities of LA systems (and trust or confidence of society in its content) to register a range of different rights, restrictions and responsibilities will also be used as starting point for a range of new registrations. A characteristic of all these registrations is that somehow people, spatial objects or spatial phenomena (and the relationships between these) are important. Emerging examples of this are: registration of ground water quota (note that this has clearly a 3D and temporal character), carbon credit quota registration (as a tool to assist in taking measures against global climate change), or rights of all kinds of natural resources (such as mining). But also the physical plans and the associated rights, restrictions and responsibilities they bring along, will belong to this category of ‘new’ registrations in LA systems. Instead of unrelated registrations, by the year 2025 society will benefit from a

harmonized system of registrations of all these spatial and temporal objects and the involved (formal and informal) rights, restrictions and responsibilities.

5.6 Faster and More Direct Updating by Actors

The currently established update procedures will be simplified by the year 2025. For example, to split and sell a part of a parcel, require nowadays professionals, such as notaries, surveyors, and registrars, each performing certain sub-tasks. Based on authenticated identification of persons (e.g. in The Netherlands the well accepted ‘Digid’ system; [Digid, 2010](#)) and trusted reference material (e.g. high resolution and up-to-date geo-referenced imagery), seller and buyer will together, via web-services, draw the new boundaries of the split part of the parcel and complete the transaction, including payment via a web-service of the bank (e.g. in The Netherlands the ‘iDeal’ system for digital payment is in use; [iDeal, 2010](#)). The required web-services and protocols are currently being developed and implemented; e.g. WFS-T (Web Feature Service with Transaction capabilities; [OGC, 2010](#)). The accuracy of digital reference material becomes so high that there is no need to go outside for a survey. The reference material can also include the 3D aspect; e.g. in The Netherlands by 2012 the completed AHN2 elevation data set is available and has an accuracy of 2-3 cm, about 10 points per m², with a nation-wide-coverage ([AHN, 2010](#)). Also integration of outdoor geo-information (GIS) with indoor spatial-information (CAD/BIM) will be completed by the year 2025 and can be used. The role of the LA authorities will be to provide the required infrastructure, at least the LA part and the links to other parts of the geo-information infrastructure (GII), and perform quality control and validate transactions: “are all steps performed correctly?”.

5.7 International Seamless Registration

Today LA is a national or local matter (province, state, or Bundesland). The effect is that on the boundaries the parcels do not always fit, but also that many systems may need to be visited to find all rights (properties) of a single person. Due to international standardization (INSPIRE and ISO), the content of these national registrations can be better exchanged and combined. Furthermore, the international GII will also stimulate the development and maintenance of an international coverage that ‘fits’ by the year 2025: seamless data across country or territory borders (with no international overlap or gaps), and all data accessible in the same client environment without bothering the end-users; even if sources or servers are different.

5.8 Semantic Web-Based Content

The differences in (legal) concepts, terminology and languages which are used in the different LA systems is today still limiting the access and understanding of LA data in an international context. However, legal concepts of the different countries will be formalized using semantic web technology, similar to all other kinds of knowledge. These formalized semantics are used in the mapping between the concepts and terminology from different countries, allowing the users to have access to all information in an unambiguous and understandable manner. So by the year 2025, via these semantic translators, foreigners can as well understand and trust the content of an LA system as natives do: so, the meaning is crystal clear to outsiders such as foreigners, but also to machines.

5.9 Mobile Applications

Augmented reality applications, precise positioning and orientation (for example, the Dutch company Layar with applications for smart phones, such as the iPhone): data accessible everywhere, all using authentic sources, but also for updating these sources by the community out-there. Furthermore, mobile applications can read the successors of bar codes of id-cards to identify people, and digital fingerprints, or iris scans will be available in the field.

5.10 Monitoring Applications

Satellites can monitor changes in area's, which have been identified as world inheritance: forest and nature, lakes, coast lines, glaciers, and polar zones. But also agriculture land, inundations, and draughts. This information can be linked to 'RRR' polygons and other GII layers for decision making in water and food provision, with attention to flora and fauna.

6. Conclusion

In this section we come to a conclusion. In [Section 2](#) we have presented the parallel development of both LADM and STDM. LADM will be an ISO-supported international standard by the year 2011. STDM, based on LADM, made its introduction as a software tool in 2010. The need for such tool was demonstrated in [Section 3](#). There is an urgent need to have a LA system that works differently from the conventional LA system; land tenure types which are not based on the cadastral parcel and are not registered, require new forms of LA systems. STDM is supportive in community based data acquisitions. This brings the feeling to the people that the data are their own data. Later on, the data can be formalized and integrated in formal systems. This is possible because of the standardized approach. The specifications of STDM have to be available for software developments by open source communities, or by commercial software suppliers ([Stuedler et al, 2010](#)). In [Section 4](#) attention was shifted to the public domain, with the increased attention to public restrictions, public benefits and the registration of public land, or in general 'public goods'. This increase in land related information from the public sector side will create an information base for better analysis, prediction and decision making. However, the degree to which policy makers are aware and willing to rely on these possibilities, is questionable. From a certain perspective, the developments described in [Section 5](#) are a kind of extrapolation of current developments. However, in the year 2025, the final effects and obtained results will be quite dramatic, and change the workflows at the side of the LA data custodians and the related professional sector, including surveyors, notaries, and the mortgage sector, but also at the side of the citizens using the data, all part of a 'spatially enabled society'.

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CONTACTS

Dr. Harry Uitermark
University of Twente. Faculty of Geo-Information Science and Earth Observation (ITC)
P.O. Box 6
7500 AA Enschede
THE NETHERLANDS
E-mail: uitermark@itc.nl
Web site: www.itc.nl

Prof. dr. Peter van Oosterom
Delft University of Technology. OTB, Section GIS-technology
P.O. Box 5030
2600 GA Delft
THE NETHERLANDS
E-mail: oosterom@otb.tudelft.nl
Web site: www.gdmc.nl

Prof. dr. Jaap Zevenbergen
University of Twente. Faculty of Geo-Information Science and Earth Observation (ITC)
P.O. Box 6
7500 AA Enschede
THE NETHERLANDS
E-mail: zevenbergen@itc.nl
Web site: www.itc.nl

Mr. Christiaan Lemmen
University of Twente. Faculty of Geo-Information Science and Earth Observation (ITC)
P.O. Box 6
7500 AA Enschede
THE NETHERLANDS
E-mail: lemmen@itc.nl
Web site: www.itc.nl