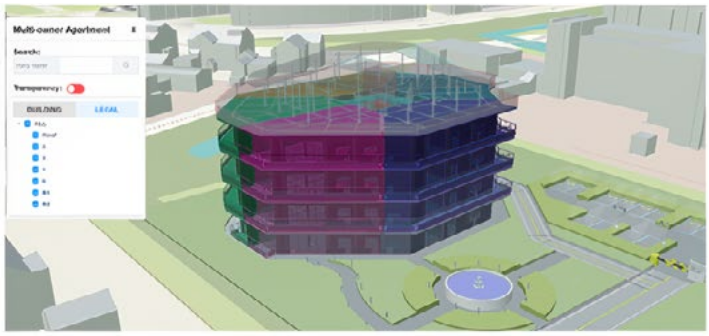
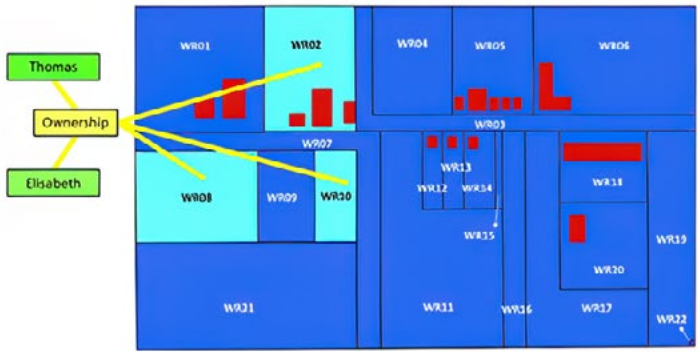
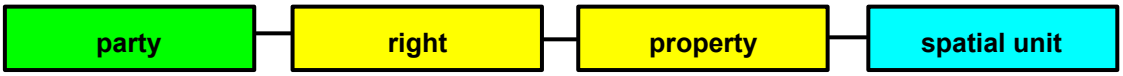
FIG GUIDE

FIG PUBLICATION
NO 84

The Land Administration Domain Model
An Overview







INTERNATIONAL FEDERATION
OF SURVEYORS (FIG)

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The Land Administration Domain Model
An Overview

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CONTENTS

FOREWORD

The Land Administration Domain Model (LADM) is an International Standard (ISO 19152) that concerns information on 'people to land relationships'. It has become a universal, conceptual, information model covering basic information-related components of land administration. This publication is intended for anyone interested in learning more about LADM: its necessity, demands, purpose, and benefits. An extended version of this overview, titled "LADM in the Classroom", focuses on training and higher education.

The design of the first edition of the Land Administration Domain Model (LADM), completed in 2012, was to facilitate the creation of a common view to land administration across the various stakeholders involved with it. In many countries, multiple public stakeholders are responsible for different aspects of land administration, e.g. land tenure, land value and land use plans. Therefore, regular and seamless information exchange among these stakeholders is essential for a successful land administration system. This ensures that information is ready for use, kept up to date, and supplemented or completed as needed. To achieve an effective and sustainable land administration system, coordination is required between the professionals and organisations that produce the information and the users who rely on it for both private and public purposes. This coordination fosters interoperability and information sharing, paving the way for future advancements in information infrastructures with land administration included.

The knowledge development of LADM is the result of a truly collaborative and committed approach by professionals and standards experts over two decades. The first edition of LADM was developed incrementally by the FIG community from 2002 to 2006. After much hard work with experts within ISO/TC 211 Geographic Information/ Geomatics, it was published as an ISO standard in December 2012. In 2019, ISO/TC 211 approved the development of the next edition as a multi-part standard, with each part representing a separate standard: 1) Generic conceptual model, 2) Land registration, 3) Marine georegulation, 4) Valuation information, and 5) Spatial plan information. Again, following a similar collaborative approach this second and revised edition was advanced through input provided by experts within ISO/TC 211, as well as from the LADM User Community during the FIG LADM & 3D Workshops. FIG Commissions 2, 3, 7, 8, and 9 have been actively involved. This collective knowledge is documented in the standard and in numerous professional and scientific publications.

LADM adoption is evident through the development of country profiles, which are adaptations of the model tailored to specific countries. As far as known more then fifty LADM country profiles exist, with approximately ten of these translated into land information system implementations. LADM's specialisation into the Social Tenure Domain Model (STDM) has demonstrated its versatility as a generic land information model. The geospatial industry recognises the benefits of LADM, and all of this bodes well for the future.

We would like to express our gratitude to everyone who contributed to the design and development of LADM. Special thanks go to the FIG Foundation and to Kadaster for their financial support to Abdullah Kara, editor of the standard. The model shows great promise in its applications and use, and it has the potential to contribute to a better world.

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EXECUTIVE SUMMARY

This publication marks the first time FIG provides an overview publication of the decades-long efforts to provide a generic, accessible, and available Land Administration Domain Model (LADM). The various reports and academic papers relating to LADM are numerous, each focussing on different aspects. This publication seeks to give a summarised view of the background, but, also introduction to LADM for a larger audience, especially management.

After ISO publishing the first edition in 2012 with a focus on land tenure, a revised edition has now been virtually completed. In addition to land tenure, this edition now also focuses on land value and planned land use.

In this publication the following questions are addressed:

What is LADM?

The LADM standard is a universal, conceptual information model that covers basic information-related components of land administration. It involves information on 'people to land relationships'. Its history is briefly reviewed.

Why LADM is needed?

Responsible stakeholders as surveyors, notaries, lawyers, planners, valuers, bank employees, brokers, colleagues in governments and citizens must share a common view of land administration. LADM provides this view. It serves as a common language that can be used by experts from different disciplines for land policy development and for land administration system and information infrastructure development and operation (information storage). It contributes to achieving the global agenda.

Which LADM demands are there?

The development of an LADM is based on user demands, providing a solid foundation. These demands are derived from global guidelines and requirements, as well as from the outcomes of several LADM and 3D Cadastre workshops. The general demands are briefly outlined, along with more specific demands from the perspectives of land tenure, land value, and planned land use.

How does LADM look?

The components are sub-models (called LADM packages) on parties, RRRs (rights, restrictions and responsibilities), spatial units, land survey, valuation information and spatial plan information on planned land use.

What are LADM benefits?

The key benefit is that a common language, a terminology is available now for communication between all experts, especially between land administrators and experts from the GIS and DBMS industry. Further benefits are in the possible use of country profiles, participatory approaches and the management of conflicts. LADM supports the creation of nationwide overview of responsibilities and required coordination in land administration.

Conclusions and recommendations

Conclusions and recommendations with proposals for future developments are given.

1 INTRODUCTION – WHAT IS LADM?

LADM is the Land Administration Domain Model, an International Standard published by ISO as ISO 19152.

It is a universal, conceptual information model that covers basic components of land administration. It involves information on 'people to land relationships'. This is information about land tenure, land value and (planned) land use, see Enemark (2005).

LADM is a terminology, a shared vocabulary (that is an ontology) for land administration. This terminology enables a shared description of different formal and informal practices and procedures, and relations between them, in different jurisdictions. The terminology provides a common language for domain experts as well as policy and automation experts. Knowledge of this language is important for success in development, maintenance and use of land administration systems. Those systems may be embedded in (spatial) information infrastructures.

The model provides a solid basis for national and regional profiles. These profiles can be used in designing and implementing land administration systems that support sustainability goals. The model helps develop land administration software applications and organise information exchange. This exchange is important when information needs to be transferred from 'field to office', such as during initial information collection and information maintenance. It also includes conversions of information from an analogue to a digital environment and the combined use of different types on land administration information (tenure, value and planned use).

LADM is a descriptive standard, not a prescriptive standard.

Standardisation

When setting up and using land administration systems, standardisation of information is a familiar and necessary phenomenon. In analogue systems, it involves things like the way of textually and graphically describing and identifying parcels, documents, persons, control points and many other aspects of the land administration domain. It is about the organisation of tables and indexes in relation to registration. It includes references or linking keys between records, for example, between source documents and maps. It is further about coding and the use of abbreviations for administrative areas in a country. And about workflows.

In reality, a land title is related to (a) person(s) and to a bounded area of land. The same should apply to the standardised representation of this reality in a register and on a map. During conversion from analogue to digital, inconsistencies surface from the paper-based system. There may be plots in the register that are not on the map and vice versa. In principle, these inconsistencies should not occur, but they do exist. Systems of registration are always imperfect. The impact of these conversions can be optimised with quality control based on LADM.

Model is core

The representation of legal reality in cadastral spatial databases and digital registers requires a land information model such as the LADM. Land information models are the core, the essence of a digital land administration system. When developing land administration infrastructures, this model is one of the first design steps. The following steps build on it.

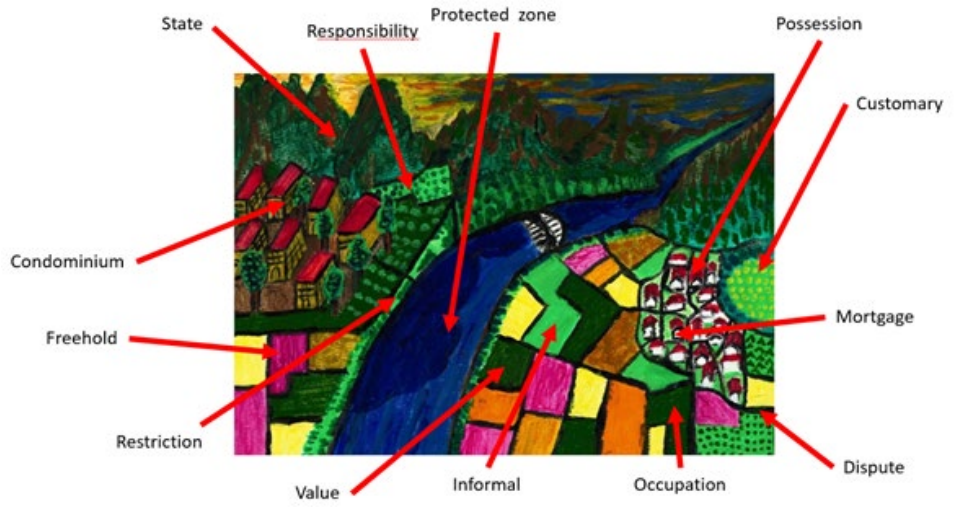

Figure 1: *Types of rights, restrictions and responsibilities*

In LADM, not only formal people to land relations can be represented, but also informal ones. See Figure 1 for some examples.

Revised version

FIG submitted a proposal to develop the first edition of LADM in 2008. The first edition of LADM was published in 2012, after further development within ISO/TC 211 Geographic Information/Geomatics. Standards in general, but also land information models in a country need constant attention to see if the usage requirements are still current. Therefore, between 2017 and 2025, a similar process to the 2012 edition was followed for a revised edition of LADM. Following preliminary discussions, ISO/TC 211 agreed to develop the revised version of LADM as a multi-part in 2019. Every part is a separate international standard:

- ISO 19152-1:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 1: Generic conceptual model*,
- ISO 19152-2:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 2: Land registration*,
- ISO 19152-3:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 3: Marine georegulation*,
- ISO 19152-4:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 4: Valuation information*, and:
- ISO 19152-5:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 5: Spatial plan information*.

Part 6 on implementation is proposed to be developed in collaboration between FIG, ISO/TC 211 and the Open Geospatial Consortium OGC. Parts 1 to 5 are highlighted in this publication.

Figure 2: *Sustainable development with land rights for all*

This publication

This publication seeks to give a summarised view of that background, but, also attention to LADM for a large audience, not just the stakeholders in the surveying and cadastral community, but, the broader land sector – including land use planners, land valuers, policy makers, technical managers, donors and supporters of land management projects, as well as teachers, students and citizens. The use of the Unified Modelling Language (UML) is avoided as much as possible.

This publication is a co-production between ISO/TC 211 and FIG. FIG is a long-time liaison member of ISO/TC 211, standards are applied in the daily practice of surveyors. It is a First Edition.

The publication supports sustainability goals, see Figure 2.

LADM in the Classroom

The publication 'LADM in the Classroom' forms a whole with this overview publication. 'LADM in the Classroom' is an extended version of this LADM overview publication.

Overview of this publication

The publication gives a quick overview of LADM: its introduction (what is LADM), its motivation (why is it needed) in section 2, its base (which LADM demands are there) in section 3 and the model (how does LADM look) in section 4. The LADM application (what are LADM benefits) is in section 5. Conclusions and recommendations are in section 6. This includes proposed future work.

2 MOTIVATION – WHY LADM IS NEEDED?

Land administration supports the security of tenure. It is a basis for fair valuation and taxation of property, for access to credit (as a basis for investment) and for sustainable land use. Its information can contribute to peacebuilding and security, to minimising land conflicts. It supports social justice, to better management of natural resources and to disaster management. It contributes to the development of smart and resilient societies, better protected environment, improvement of slums, access to housing and urban management with access to basic infrastructure.

Just as these things benefit from good land administration, land administration systems themselves benefit from good information standards in system development, information exchange and interoperability. Semantic interoperability too. Information attributes in themselves must have the same meaning for all stakeholders.

Common view

Responsible agencies and all information users must share a common view of land administration. Regular and smooth exchange of information between agencies is vital for a successful land administration system. This is important to keep information ready for use, up to date, supplemented and completed where necessary.

Who is responsible for what?

In countries with an existing land administration system, it may be necessary to identify the responsibilities of the various organisations involved. Who is responsible for what? Who is responsible (attributable or liable) for the quality of which represented feature? And most importantly, who is or will be responsible for the links between databases of different organisations involved? These are usually the land registry, the cadastre and the municipalities levying land tax and valuation and zoning. Cadastre and land registry often work from a national, regional and local level. The processes at and between those levels often lead to updates of information attributes. Moreover, these organisations use information from external databases such as the population register and the business register.

In analogue systems, names and addresses are often duplicated. This leads to inconsistencies and delays. It is better to store information once, by a mandated organisation. Moreover, there are also concerned professionals who have information in their offices, often source information such as deeds, titles and cadastral boundary reports – prepared by conveyancing experts, notaries, valuers and surveyors. Courts can also generate information.

Common language

A common language can be used with terms and concepts, definitions, names of information classes and attributes, data types, identifiers, linkage keys, code lists, quality labels, etc. If all organisations involved agree on this, a common understanding of the meaning of the information can be developed.

A common language is of paramount importance when developing a land administration system. It is essential when the system is digital and requires renewal or upgrading of systems and databases, or when a digital transformation is being implemented

through integration into a system of basic registries. It is also crucial when developing a (spatial) information infrastructure with digital twins, particularly with life-cycle approaches. Furthermore, a common language is important in situations where land records are incomplete, and information needs to be initially gathered. Analog records may need to be digitised, which requires A/D conversion and establishing links between data in different environments. In all cases, agreement on the meaning of data is essential.

Land administration involves the registration of formal property rights. This registration is done by organisations with formal mandates and territories. It is quite possible that informal land use rights and customary land rights are not recognised and not included in the registration. Registration itself is a formal process, as are definitions for objects such as "parcels". Recognition of informal and customary rights means inclusion of the related terminology, based on the collective experience of experts, relevant for land administration in the common language. In the terminology 'recordation' fits instead of 'registration', 'party' instead of 'right holder' and 'spatial unit' instead of 'parcel'.

Re-inventing the wheel

Digital land administration systems are being developed and renewed repeatedly. Sometimes countries even have more than one automated land administration system in different regions. When it comes to the development of information models for land administration systems, it can be said that the wheel is constantly being reinvented. The development of these models is unruly. What to include and how to structure a model? Experience teaches that it is far more difficult to start from scratch than starting with a conceptual information model "on the table" backed up by local experts. A model that can be adapted to the local situation where customary rights and informal occupation and land use may exist apart from formal property. A model that integrates different types of ownership, different valuation and planning approaches into one environment. The technical implementation could be in a distributed environment. Such a model is also important in case of development of land administration systems by the industry.

Global Agenda

The UN Committee of Experts on Global Geospatial Information Management guides the development of technology infrastructure to support land applications (UN-GGIM, 2022). UN-GGIM's Expert Group on Land Administration and Management developed the Framework for Effective Land Administration – FELA (UN-GGIM, 2020). This Framework directly endorses LADM as a tool for standardisation and LIS development. FELA itself is endorsed by the UN-GGIM Committee of Experts in August 2020.

The Food and Agricultural Organisation of the United Nations (FAO) has initiated and developed the 'Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security' known as the VGGTs (FAO, 2022, earlier version published in 2012). This guide recommends that states ensure that publicly held tenure rights are recorded together with indigenous peoples' tenure rights and private sector rights in a single, or at least linked, land registration system. Furthermore, UN-Habitat's 'continuum of land rights' approach is a widely accepted philosophy (UN-Habitat, 2008). In this approach, land rights are seen as existing along a continuum, that allows for the inclusion of those with the weakest tenure rights

in the environment of sufficient legal access. In addition to formal types of tenure, informal and customary types of tenure are also recognised and included.

Land is a cross-cutting theme in the global development discourse. The UN Post-2015 Development Agenda (UN, 2012, UN, 2015) includes consideration of land related issues across a wide range of objectives, one of them related to land tenure, Sustainable Development Goal (SDG) 1.4: *"by 2030 ensure that all men and women, particularly the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology, and financial services including microfinance".* LADM contributes in realisation of this.

FIG

FIG contributes and helps develop an ecosystem of concepts and tools to support cadastral surveyors and land administrators. The FIG Statement on Cadastre is from 1995 (FIG, 1995). The vision 'Cadastre 2014' (Kaufmann and Steudler, 1998) was an important inspiration in the LADM design. Implementation of 'Cadastre 2014' is supported by LADM, see (FIG, 2014a) The Social Tenure Domain Model (STDM) has been developed in cooperation between FIG, UN-HABITAT and the Global Land Tool Network (GLTN) to accommodate social tenure. STDM supports the documentation and management of a range of land rights that usually cannot be accommodated in traditional land administration systems (Lemmen, 2010), see also FIG, UN-HABITAT and GLTN, (2014). STDM is included as a specialisation in the LADM standard, see ISO 19152:2012 and ISO 19152-2:2025. There is attention to support for valuation of unregistered land, see Unger et al. (2024).

The functionality for '3D Cadastres' in LADM is based on the outcomes of FIG LADM & 3D Workshops, see FIG (2024), (2023), (2022), (2021a), (2021b), (2018b), (2016), (2014b). A good overview is in the FIG Publication edited by Van Oosterom (FIG, 2018a). See also Van Oosterom et al. (2024), this is a Special Issue in the scientific journal Land Use Policy on 'Broadening 3D Land Administration'. Kara et al. (2024) published 'Design of the new structure and capabilities of LADM edition II including 3D aspects'.

A recent publication by FAO, UN and FIG (2022) on Digital transformation and land administration recognises LADM for its support to interoperability in land administration.

The World Bank, in collaboration with the International Federation of Surveyors, has promoted the Fit-For-Purpose Land Administration approach. This approach offers the opportunity to develop appropriate land administration systems within a relatively short time and at low cost, with the option to upgrade as needed. LADM supports these Fit-For-Purpose Land Administration approaches (Enemark et al., 2016; Enemark et al., 2014). The scientific journal Land published a Special Issue on Fit-For-Purpose Land Administration (Enemark et al., 2021).

"Easy"

It should not be forgotten that experience shows it is easy to make information models overly complex, but quite challenging to create and maintain simplicity. LADM is as simple as possible, based on its design.

3 BASE – WHICH LADM DEMANDS ARE THERE?

The design of the LADM is based on user demands, that have been collected, discussed and decided with (representatives) of the community of users.

The input for the developments is provided by (delegated) experts within the ISO/TC 211 development teams and also by the LADM User Community during FIG LADM & 3D land administration workshops, see FIG (2024), (2023), (2022), (2021a), (2021b).

FIG Commissions 2, 3, 7, 8 and 9 have been actively involved over the years. The knowledge has been recorded in many professional and scientific publications and special issues and article collections of scientific journals such as 'land use policy', see Van Oosterom et al. (2024), Van Oosterom et al. (2022) and Van Oosterom and Lemmen (2015). See further demands as in Lemmen et al. (2015), Lemmen (2012), Lemmen et al. (2007), Van Oosterom & Lemmen (2002). Kara (2023a) gives an overview of the 'requirements' as included in the LADM revised edition. These requirements are derived from the main LADM 'demands' as presented below in Table 1. This overview shows what LADM needs to meet.

Global demands are derived from international reports as introduced in section 2.

LADM is backward compatible, new editions can work with older editions and implementations. This means that the 2012 edition is fully integrated in the revised version.

The demands are presented in the overview Table 1. They are classified into 'general demands', demands related to 'land tenure' (see Figure 3 with a sample of a cadastral map), demands related to 'land value' and demands related to 'land use plan'. Following this overview, the demands are introduced in more detail.

Figure 3: *Cadastral map – fragment*

Table 1: *LADM Demands*

General demands

- all functions of land administration are supported: land tenure, land value, land use and development, all with administrative and spatial information
- land includes water, air or space and subsurface spaces
- land and water information are managed and used in an integrated environment
- all initial information and all information updates are source based, all extracted information in a DBMS (register) is linked to sources
- history of information can be managed, updates are traceable
- spatial units can be in 2D, 3D, with or without topology
- spatial source information is obtained from survey or design (BIM)
- changes in reference systems are accommodated
- all objects have a unique id and a quality label, external information can be linked
- information can be kept to the custodian, within (spatial) information infrastructures
- implementation as a distributed data set is possible
- formalisation and computation of relevant SDG indicators is supported
- editions are backwards compatible

Demands on representation of land tenure

- the triple 'party – RRR – spatial unit' can be represented and managed (people to land relations)
- spatial units with same RRRs can be grouped in basic administrative units (property units)
- the implementation of the continuum of land rights is supported
- fit-for-purpose LA approaches and Cadastre 2014 implementation are supported
- persons responsible for transactions can be included in the source information
- all types of parties and groups of them can be used (formal and customary)
- there can be shares in group membership and there can be shares in RRRs
- participatory data collection is supported

Demands on representation of land value

- determination of the value is in accordance with published procedures
- land value can be based on market values, mass appraisal or other valuation approaches
- registration of transaction prices and sales statistics publication are supported
- information on valuation units can be recorded and shared with society
- timely and effective dissemination of property values and input information for valuation to the general public is supported

Demands on representation of land use (plans)

- plan units can be organised in plan blocks ('accepted lowest level plans')
- registration of permits is supported
- spatial functions of plan units and blocks is based on code lists
- a planning hierarchy from national to local plans is supported via plan groups ('accepted higher level plans')
- open dissemination and visualisation of plan information is supported
- participatory plan monitoring is supported to avoid illegal development

General demands

First, the 'general demands' as outlined in Table 1 are introduced in more detail. These demands apply to all parts of the standard.

Land administration encompasses a wide range of systems and processes to manage, see Enemark (2005): land tenure, land value and planned land use (and development). Land tenure is the allocation and security of rights to land. This includes legal investigations; transfer of ownership and management of disputes. Land value is the assessment of value of land; taxation and the management of disputes. Land use concerns the control of land use through the adoption of planning policies and land use regulations at national, regional and local levels; the enforcement of (planned) land use regulations; and the management (monitoring) of land use conflicts. The functions of land tenure, land value and planned land use are modelled in LADM as separate, but interrelated, standards in LADM Parts 2, 4 and 5.

In LADM, land includes water, air or space and subsurface spaces. This is defined in the scope of part 1 (see section 4). Land and water information can be managed and used in an integrated environment in LADM, implementation as a distributed information set is possible. A new term is introduced: "georegulation". This is defined as an activity to delineate geographical spaces and to assert control over them through regulation – as in the international marine environment.

LADM is designed in such a way that all initial, new and changed information should be source based in principle, all extracted information in a DBMS (register) is linked to sources. Administrative sources can be as a deed or title, a spatial source can be for example a field survey sketch (or plan), an orthophoto or a satellite image including evidence of the location of boundaries (collected from the field). Conversions from legitimate to legal rights may have their own specific type of source document. Those conversions concern social tenure relations that have legitimacy but are not (yet) legally recognised and, for that reason, cannot be institutionalised. The related spatial units and right holders can be documented in order to prepare the conversion and to get overview.

A spatial source information can be obtained from survey or design, e.g. from Building Information Modelling (BIM).

In some jurisdictions, deeds registries only record deeds or administrative sources without documenting of rights, restrictions and responsibilities (RRRs). Additionally, in some common law jurisdictions, transactions may refer to a survey plan/spatial source (rather than a parcel number or spatial unit). The relationship between the party and the spatial unit is established by a legal instrument (source). See Kaufmann and Steudler, (1998).

LADM can be implemented as a versioned and distributed system. Users may not only be interested at the current state of objects, but may also need access to historic versions of these objects. To accommodate this, LADM uses versioned objects and time stamps. This approach works within a (spatial) information infrastructure, where multiple authorities maintain different but related information.

LADM can be used to monitor SDG indicators, see Chen et al. (2024).

Spatial units (parcels) can be represented in LADM in 1D, 2D, 2.5D or 3D.

A 1D representation is essentially a point cadastre, where addresses or attributes are linked to single coordinate points. This is sufficient for basic recording purposes, where

the boundaries of the landholding are not immediately important. Boundary information can be added later. An alternative is a text-based representation, where the location of the spatial unit is described in words within the system, with or without landmarks in the field.

A 2D representation refers to the depiction of customary areas or traditional parcel representations linked with rights. A 2.5D representation is a 2D representation where elevation is linked to coordinate pairs.

A 3D representation includes x, y, and z coordinates. All representations can be with or without topology. Possible representations of spatial units in an LADM-based system range from volumes, polygons, and line sets. It is also possible to refer to street axes or use video to describe the spatial unit.

A 3D representation is particularly necessary in urban environments with subsurface infrastructure for utilities and complex buildings.

Impact of changes in reference systems is accommodated in LADM , from information perspective, by versioned objects. Adjustments and management of related parameters can also be supported from information perspective.

All objects (parties, RRRs, spatial units, etc.) have unique id's in LADM as well as an optional quality label. External information can also be in the municipality or in the chamber of commerce and can be linked in information infrastructures.

LADM country profiles retain conformity with new versions (editions) of the standard.

Demands on representation of land tenure

Next the demands in Table 1 that are related to land tenure are introduced in more detail. Those demands are mainly valid for part 2: ISO 19152-2 on Land registration.

A land title is related to a person(s) and also to a bounded area of land. The same should apply to the standardised representation of this reality in a register and on a map.

Those 'people to land relationships' are represented in the so called 'triple' in LADM. That is a 'party' related to a 'right' and a 'right' related to a 'spatial unit', the triple 'party – RRR – spatial unit'. This triplet has a strong historical basis in land administration and it can be managed in LADM. It is the common pattern for land administration and is the basic structure.

Spatial units can be grouped in basic administrative units (property units) when RRRs are the same for all spatial units. The term 'basic administrative units' is derived from the term 'basic property unit'. Because properties require formal registration the term 'basic administrative units' is used in LADM because it may include informal registrations.

The flexibility of the model is based on the recognition that people's land relationships appear in many different ways, depending on local tradition, culture, religion and behaviour. LADM merges formal and informal tenure systems into one environment. Land rights may be formal ownership, apartment right, usufruct, freehold, leasehold, or state land. It may be social tenure relationships like occupation, tenancy, non-formal and informal rights, customary rights, indigenous rights, possession, etc. There may be recordation (or registration) of overlapping tenures, claims, disagreement and conflict situations which must be resolved. See UN-HABITAT (2008).

Women's access to land can be arranged with LADM, there is for example support in conversion of use rights (on which women often depend) to formal rights, see Unger et al. (2023).

Fit-For-Purpose land administration approaches are supported (Enemark et al., 2014). Code lists offer a lot of flexibility and the possible use of imagery as source documents. Conversion from legitimate to legal rights can be guided. Also the implementation of Cadastre 2014 (Kaufmann and Steudler, 1998) is supported from an information management perspective. Participatory data collection is supported, some examples are given in section 5. Information collectors can be grassroots or paralegals guided by professionals. Collectors can be licensed surveyors or registrars. Information can be collected in the field or in a village using high or low resolution imagery defining visible boundaries. There can be all kinds of mapping tools and instruments such as total stations, GNSS antennas or mobile devices; even tapes, chains or plane tables.

Conveyancers and notaries are persons responsible for transactions that can be included in the source information. Those persons can be included in a LADM based system as parties. This means that a party can be a conveyancer or notary with or without ownership. Mix of interest should be avoided, as it is in existing systems.

All types of parties and groups of them can be used, this ranges from groups (or groups of groups) as right holders to individuals. Groups can have defined or non-defined membership. A right holder can be an individual or company, a married couple holding shares in a right etc. As a cooperative where individuals may have a share.

Shares in RRRs and group membership is supported in LADM. A denominator/numerator type of fraction can be used in order to express a share exactly, for example three parties each have an equal share of 1/3.

Demands on representation of land value

Now the demands related to land value and valuation in Table 1 are presented in detail. This concerns part 4: ISO 19152-4 on Land valuation information.

Determination, storage and publication of values is in accordance with published procedures

Land value can be based on market values, mass appraisal, or other valuation approaches. A market value approach is based on the highest price that a buyer will pay and at the same time the lowest price a seller will accept. Mass appraisal means valuing a group of properties at a certain moment in time, using standard methods, employing common data, and allowing for statistical testing. The required information can be stored using LADM.

The registration of transaction prices and sales statistics publication are supported in LADM. The sale price of a property can be seen as a transaction price. The type of transaction may be an exchange, family transfer, forced sale, inheritance, open market sale, voluntary transfer, etc.

In LADM, valuation is the process of estimating the value of any administrative unit, typically the BAUnit (see section 4). This may be a group of spatial units, where a building or an apartment can be a spatial unit. Information on valuation units can be recorded and shared with society. Sometimes valuation units are different from BAUnits, e.g., a social housing complex with one owner, but many houses rented.

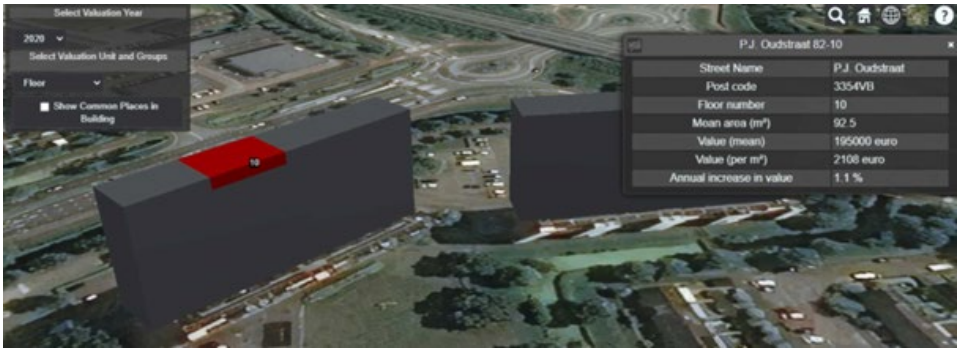

Figure 4: *Floor level implementation of a valuation visualisation prototype based on LADM (Kara et al., 2023b)*

Timely and effective dissemination of property values and input information for valuation to the public is supported for transparency and fairness reasons. See Figure 4.

Demands on representation of land use (plans)

Finally the demands related to planned land use (and development) as listed in Table 1 are presented in more detail, this is used in LADM part 5: ISO 19152-5 on Land use information.

In LADM it is possible to organise plan units in plan blocks. A plan unit is a homogenous area/space (2D/3D) with an assigned function or purpose representing the potential for land use development. This pertains to the largest scale, typically at the municipality level, where the lowest-level plans (as approved by the authorities, such as municipalities) are established.

Registration of permits is supported in LADM. A permit can be considered as an authorisation. This authorisation is granted by the authorities in accordance with the plan unit. It might be suitable to use plan unit identifiers in a permit document.

Allowed or intended spatial function types (e.g. agriculture zone, condominium zone, culture zone, etc) of plan units and blocks can be based on extensible code lists. This flexible instrument allows for locally agreed functions, zones and classifications.

A plan is a set of documents and zoning maps that establish the strategic spatial development direction of an area. A planning hierarchy exists from national to local spatial plans: e.g. national/federal, regional/state, municipality/city, neighbourhood, and so forth. Hierarchy is supported via plan groups with specific attributes for the administrative subdivision of a country.

Timely and effective dissemination of property values is an essential part of a transparent and efficient planning information system. 3D valuation units (e.g., condominium) and groups (aggregation of valuation units, e.g., a building floor in a multi-occupied building, a multi-occupied building, street, district or valuation zone) may be required in visualisation to better communicate with users,

Participatory plan monitoring is supported using LADM. This can be used to report possible illegal and negative developments against approved plans, to detect challenges and to evaluate alternative scenarios.

4 MODEL – HOW DOES LADM LOOK?

Based on the demands as given in section 3 the Land Administration Domain Model has been developed within ISO/TC 211 as a multipart standard. This section provides an overview and a first impression of the land administration domain model itself.

The scope[1] of the ISO 19152-1 *Geographic information – Land Administration Domain Model (LADM) – Part 1: Generic conceptual model*, is as follows:

This standard:

- *defines a reference Land Administration Domain Model (LADM) covering basic information-related components of land administration/georegulation*
- *provides an abstract, conceptual model with packages related to:*
  - *parties (people and organisations)*
  - *basic administrative units, rights, responsibilities and restrictions (RRRs)*
  - *spatial units*
  - *a generic conceptual model (sources and versioned object)*
- *provides terminology for land administration/georegulation, based on various national and international systems, that is as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions*
- *provides a content model independent of encoding, allowing for the support of various encodings*
- *provides a basis for national and regional profiles*
- *enables the combining of land administration/georegulation information from different sources in a coherent manner*

This scope provides a system boundary in LADM use and in LADM based developments.

UML Classes and packages

The model is designed and developed in Unified Modelling Language (UML) class diagrams (Booch, et al., 1999). The use of UML allows experts and professionals in land administration to share knowledge and to communicate the structure and meaning of land information with experts and professionals in information and communication technology (ICT) and other professions. This means that land administration experts and professionals need to master UML to make clear to ICT experts and professionals how land administration is structured.

In UML, a 'class' represents an object or set of objects that share a common structure and behaviour. Classes, or instances of classes, are common model elements in UML diagrams. UML classes represent the central objects in LADM: parties (right holders), RRRs (rights, restrictions and responsibilities), basic administrative units and spatial units. A 'package' is a set of logically related classes.

1 https://www.iso.org/obp/ui/en/#iso:std:iso:19152:-1:ed-1:v1:en

Prefixes

Classes have prefixes in LADM, see Table 2. The use of those prefixes is part of the 'common language' that LADM provides. Prefixes are used in other modelling domains, for example addresses.

Table 2: *Prefixes for LADM classes*

Prefix	Document	Title
LA	ISO 19152-1	Generic conceptual model
LA	ISO 19152-2	Land Registration
MG	ISO 19152-3	Marine georegulation
VM	ISO 19152-4	Valuation information
SP	ISO 19152-5	Spatial Plan information

People to land relationships

A party holds a right on a property that consists out of one or more spatial units. See Figure 5.

Figure 5: *Representation of 'people to land relationships'*

A property is called a 'Basic Administrative Unit' or 'BAUnit' in LADM. This implies that non-formal properties can also be included.

Classnames are preceded by prefixes, see Figure 6.

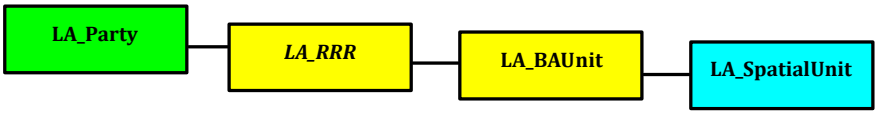

Figure 6: *Classes representing 'people to land relationships' – classes are preceded by prefixes in LADM*

Party package

See Figure 7 for a visualisation of the party package and its classes. This refers to natural and non-natural persons in LADM, represented in the class LA_Party. The information related to these parties is typically managed in the population register and the business register.

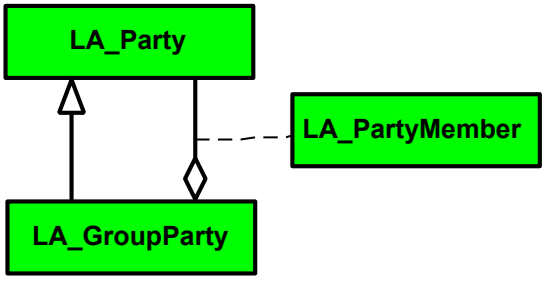

Figure 7: *LADM Party package*

The main class of the party package is the class LA_Party. It includes attributes such as party identifier (pID), name, role, photo, fingerprint, signature, sex, and civil status.

A natural person typically refers to the holder of a right on a spatial unit (parcel). In addition to being a rights holder, a party can have a role in the land administration process. Role types can include right holder, surveyor, conveyancer, notary, registrar, grassroots surveyor, paralegal, chief, and others. A non-natural person can be an organisation, such as a municipality, state, tribe, farmer cooperative, church community, etc.

A 'party member' is a party registered and identified as a constituent of a group party. This is not mandatory, there can be defined or undefined membership. A 'group party' (LA_GroupParty) is any number of parties, together forming a distinct entity, with each party registered. A party or group party should be assigned a unique identifier (pID) when registered or recorded.

Administrative package

See Figure 8 for a visualisation of the administrative package and its classes. This is about RRRs, those data and documents are usually managed in the land registry.

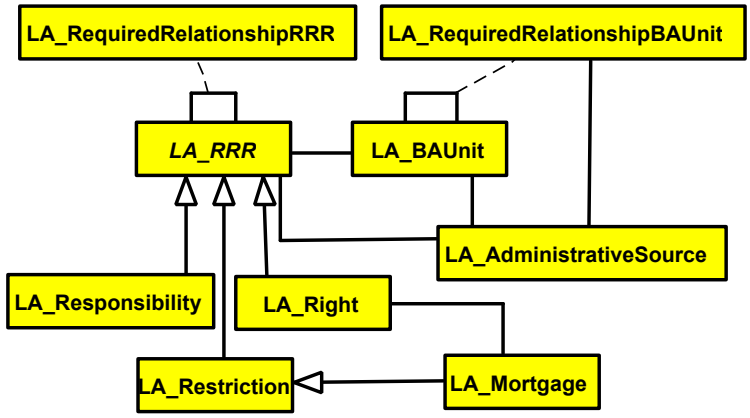

Figure 8: *LADM Administrative package*

In LADM a 'right' (class LA_Right) is a formal or informal entitlement to own or to perform an action. Examples of land rights are: formal ownership, usufruct, freehold or leasehold, etc. It can also be a social tenure relationship like occupation, tenancy, non-formal and informal rights, customary rights, indigenous rights, and possession. There can be a share (fraction) in a right. A 'restriction' is a formal or informal obligation on the right holder to refrain from performing an action. Examples of restrictions are situations where it is not allowed to build within certain distance to a fuel station. Or a buffer zone along a road or highway where it is not allowed to establish buildings. A mortgage is a restriction to an ownership right. Servitudes (right of way) can be seen as restrictions. A 'responsibility' is a formal or informal obligation on the right holder to allow or perform an action. Right holder implies owner, leaseholder, usufruct holder, etc. Examples are the responsibility to clean a ditch or water canal on private land, to keep a snow-free pavement, to remove icicles from the roof during winter, or to maintain a monument.

A RRR, and its relationships, are documented in an administrative source document (LA_AdministrativeSource). A 'source' is a document providing legal and/or administra-

tive facts on which the land administration object is based on. A RRR and administrative source document should be assigned a unique identifier when registered or recorded.

BAUnit

Apart from parties, rights and spatial units the LADM administrative package includes 'basic administrative units' (class LA_BAUnit) abbreviated as 'BAUnit'. See Figure 8.

A BAUnit is an administrative entity, which can be subject to registration (by law), or recordation (based on an informal or customary), consisting of zero or more spatial units against which, one or more, unique and homogeneous rights, responsibilities or restrictions are associated, as included in a land administration system. An example of a BAUnit is a condominium unit comprising two spatial units, an apartment and a garage.

There are countries that have land registry, but have no cadastre, that means cadastral map does not exist. Access to the registry is based on a party identifier or on BAUnit identifier.

Spatial Unit Package

Figure 9 shows the spatial unit package in LADM.

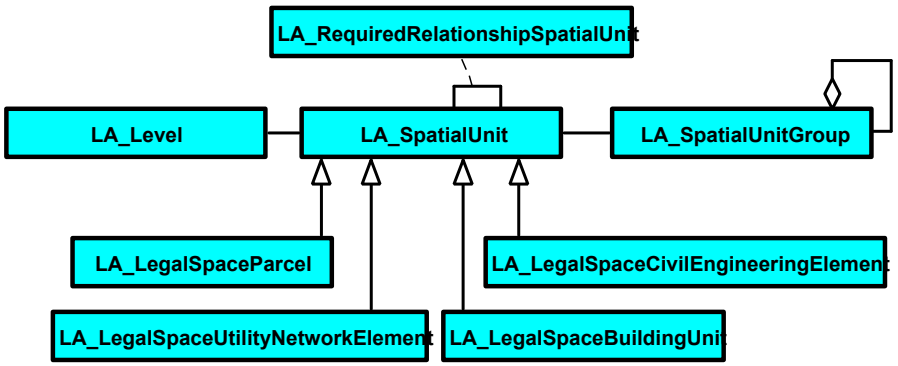

Figure 9: *Spatial unit package of LADM*

Spatial units (class LA_SpatialUnit) are the areas of land (or water, air, subsurface) where the people-to-land relationships apply. The term *land parcel* usually has a formal definition and is applicable for formal land rights. Apart from formal rights the LADM may include informal or customary rights. Or marine rights. For this reason the term 'spatial unit' was introduced. Spatial unit is a neutral term. A 'spatial unit' is a feature type related to land administration with associated spatial and thematic attributes. Spatial units can be represented as a text (i.e. 'from this tree to that river'), as a single point or set of points, as a set of (unstructured) lines, as a surface or polygon, as a 3D volume(with or without topology), etc. Surveys concern the identification of spatial units based on survey observations in the field with an instrument, on a photograph or image or on a topographic map. Rights may be overlapping, or may be in disagreement. Land conflicts could be visualised (using cartographic symbols) on a cadastral map. If the dispute is resolved then the cadastral map would be updated to show the new state of ownership. A 'spatial unit group' is any number of spatial units, considered as an entity. A spatial unit group can form an administrative zone such as a section, a canton, a municipality, a province, or a country. Note: BAUnit is not attached to spatial unit group,

only to spatial unit. A spatial unit should be assigned a unique identifier (suID) when registered or recorded.

LADM allows multilayers; those layers are called levels in the LADM. A 'level' (class LA_Level) is a collection of spatial units with a geometric and/or topologic and/or thematic coherence. Examples: one level with spatial units (cadastral parcels), one level with buildings, one level with disputes.

Spatial units, feature type related to land administration/georegulation with associated spatial and thematic attributes are refined into four specialisations: parcels, utility networks, building units and infrastructure. Parcels can be separated (specialised) in this way from other spatial units.

Survey package

The survey and representation package is visualised in Figure 10. Coordinates themselves either come from points (class LA_Point) or are captured as linear geometry. Points, lines, surfaces and volumes can be acquired in the field (with classical topographic surveys, or with satellite navigation systems), in an office (reusing input from design, e.g. in BIM/IFC), or compiled from various sources, for example using forms, field sketches or orthophotos. The acquisition of points, lines, surfaces or volumes (through a cadastral or topographic survey) may concern the identification of spatial units. Cycloramas or pictometry methods (multiple images from different angles) may also be used for that purpose. 2D and 3D representations of spatial units is possible.

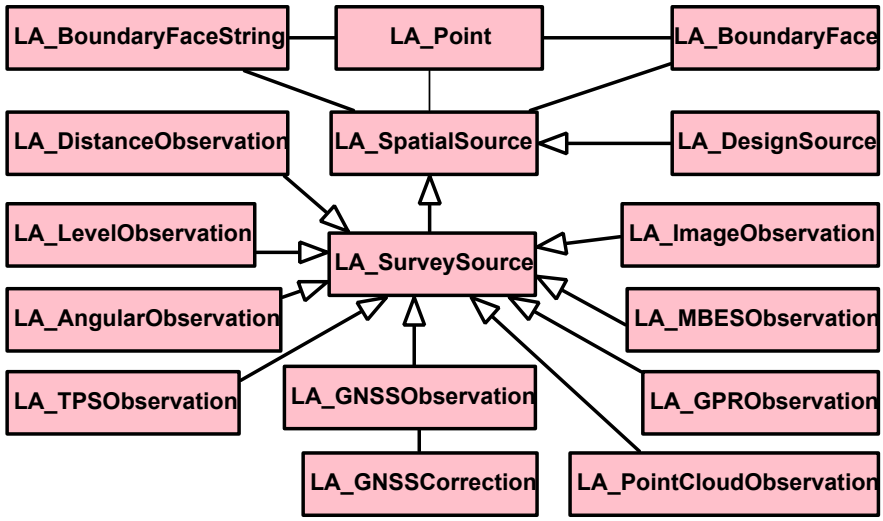

Figure 10: *LADM Survey and representation package*

The individual points are associated to a spatial source. While it is not required that the complete spatial unit is represented, a spatial source may be associated with several points. Geodetic control points, including multiple sets of coordinates for points, and with multiple reference systems, are all supported for representation in LADM.

The survey model is refined (see Shnaidman et el., 2019) and Kalogianni et al., 2020) with various measurement types based on the OGC's LandInfra/InfraGML standards.

Valuation information package

The valuation information package specifies the characteristics and semantics of valuation registries (Kara et al. 2018, Kara et al. 2020, Kara et al., 2021), see Figure 11. The terms and definitions in this package are taken from international valuation standards published by bodies such as the International Association of Assessing Officers (IAAO), the International Valuation Standards Council (IVSC) and the Royal Institution of Chartered Surveyors (RICS).

Valuation units (VM_ValuationUnit) are the basic registration units of valuation registries. The object of valuation may be (a) a land parcel, (b) a building, (c) land parcel(s) with/without building(s) combined property, (d) a condominium unit consisting of building part(s) (e.g., condominium main part, condominium accessory part, joint access facility) and (e) a share in land parcel(s).

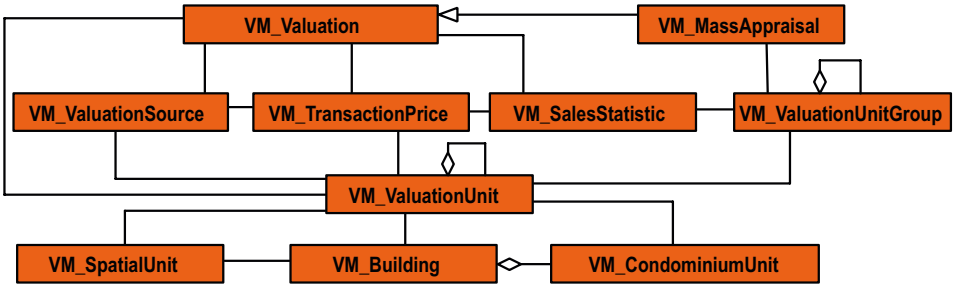

Figure 11: *LADM Valuation Information package*

A valuation unit group is a group of valuation units. Valuation units may be grouped according to zones (e.g., administrative divisions, market zones) that have similar environmental and economic characteristics, or functions of valuation units (commercial, residential, agricultural) that have similar characteristics. The class VM_SpatialUnit represents land parcel(s) subject to valuation. The class VM_building includes attributes required in valuation processes, for example date of construction, energy performance, use type, etc. A 'building' may be considered as a complementary part of spatial units, but can be valued separately from the parcels on which it is located. A building may represent a condominium building consisting of (i) condominium units (apartments, shops); (ii) accessory parts assigned for exclusive use (garages, storage areas); (iii) joint facilities covering a spatial unit, structural components (foundations, roofs), accession areas (entrance halls), and other areas of (staircases, heating rooms, etc.). A condominium unit is for exclusive use by the individual its owner and shares a condominium building.

The class VM_Valuation specifies output information produced within valuation processes, especially for administrative valuations including property tax assessment and includes mass appraisal. Mass appraisal is a process of valuing a group of valuation units using standardised procedures. The class VM_MassAppraisal describes mathematical models, mass appraisal analysis types (e.g., multiple regression analysis) and the sample size of the analysis. The class 'transaction price' characterises the information content of transaction contractor declarations, including the transaction price, date and type of transaction (sale, heritage, forced sale, and rent prices). 'Sales statistics' represents sales statistics produced through the analysis of transaction prices.

Spatial plan information package

The spatial plan information package is about information on planned land use or zones, see Figure 12. Zones can be converted into RRRs (Indrajit et al., 2020 and Indrajit 2021). In the development of the spatial plan information package the conceptual framework of Plan4all (Cerba, 2010) and the Land Use information theme of INSPIRE (2012) have been taken into account.

SP_PlanUnit represents spaces of zoning plan and their characteristics in zoning plan activities. It represents homogenous area/space (2D/3D/4D) with assigned function/purpose, e.g., office, education, or residential. A 'plan block' contains a collection of 'plan units' approved by authorities. The plan unit groups are the areas corresponding to the higher planning levels with related boundaries and space function as sketched by the higher plan level authorities. The class SP_PlanGroup is to accommodate hierarchy.

The class SP_Permit contains permit related information as issued by authorities to parties fitting in the relevant plan unit. A permit is an explicit proof of a right (to perform an action) granted by authorities and granted to parties fitting within the relevant plan unit, that is, the object having the correct function for the requested location.

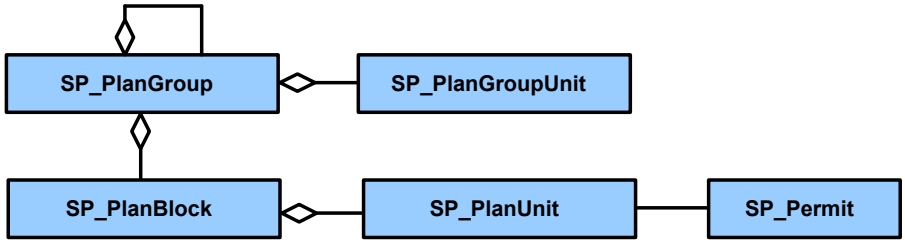

Figure 12: *LADM's spatial plan information package*

Transaction

The relationships between people and land are dynamic and subject to change. These changes require maintenance of the database based on source documents where updates are integrated in transaction workflows. Transactions include purchase/sale, establishment of mortgage, processing impact of inheritance, appraisal, taxation, acceptance or approval of plan blocks. etc. Updates must be adopted in such a way that the database takes place from a consistent state before the transaction to a consistent state after the transaction.

Versioned object

All information in a LADM database gets several timestamps. The date and time of insertion and deletion is included. This allows reconstruction of the information at a certain moment back in time. Or making an overview of changes within a certain period of time. The time stamps may concern the dates and times changes in reality and changes in the database. Deed based systems require maintenance of history. Title based systems may require maintenance of history, where duplicates can be avoided. In LADM information can be kept to the custodian (responsible for the information) within (spatial) information infrastructures.

Diagram LADM revised edition

Figure 13 shows the class diagram of LADM parts 1, 2, 4 and 5 and their relationships. The VersionedObject class and its relationships and some of the relationships of LA_Source and its subclasses, are not shown for readability purposes.

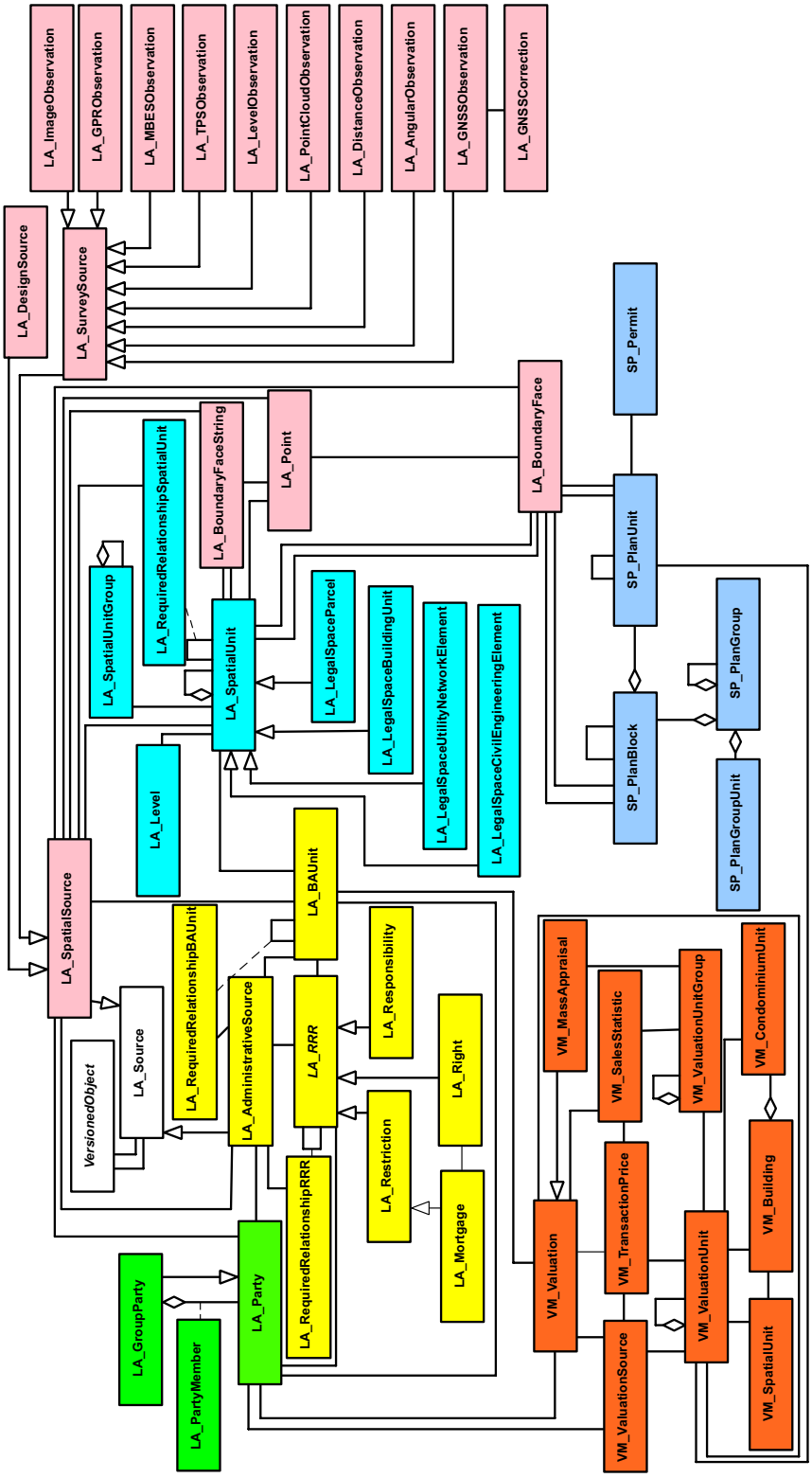

Figure 13: *LADM revised edition*

5 APPLICATION – WHAT ARE LADM BENEFITS?

In the development of land policy, of land taxation, of land use plans, of a land registry, of methods in land surveying it is crucial that all participants in that development, and its future users, speak the same language. Using the same terms with the same concepts. When different languages are spoken at the ends of a communication link, things go wrong. But also if different signals, in different protocols, are sent through that connection, communication fails. Communication and connectivity require a standard language, especially if it is used on a large scale in our networked society.

This includes not only the land as such, but also the people who use or own the land. Land administration is people centric.

Global land community

There is a clear challenge for the global land community and for the global geospatial community: secure land rights for all people, in all places, at all times. The biggest challenge is to keep the information on land rights up to date and accessible at the appropriate level of accuracy. This requires information exchange which can be based on LADM, for example to supports a transaction where a citizen from Belgium buys a property in Spain with a German mortgage.

LADM country profiles

The LADM allows user-defined elements to be added. Additional attributes, operators, associations, or perhaps new classes, will be needed for a specific region or country. It is possible that parts of the LADM are not used. Therefore, country profiles can be used for customising the LADM, to meet specific needs. In this moment there are about ten countries implementing LADM and more the fifty with a developed LADM profile. A methodology for developing a country profile is available (Kalogianni, 2021).

Extensions as for management of nature rights in a country, or carbon, wind and solar rights can be included based on code lists.

Country profiles can be used for system development but even more for coordination and creating overview on responsibilities. A good overview of 'who does what' opens up the possibility of setting up well performing distributed land administration system functioning in information infrastructures. A knowledge standard on land administration is needed helping in organising the overview. LADM is a proven communication tool for this purpose.

Achieving an effective and sustainable land administration system requires coordination between professionals and organisations who produce the information and the users who use it for many private and public purposes. This coordination should result in interoperability and information sharing in (spatial) information infrastructures with land administration included.

Semantics

LADM is a spatial domain standard. It captures 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.

GIS and DBMS industry

The geographic information software industry provides DBMS based tools, GIS and survey products and services to support a number of processes required in land administration. LADM is crucial in this context in order to get interoperable land administration systems in a distributed environment. This also counts in development of model driven architecture for digital transformation and development of digital twins. Optimal communication between land experts and ICT experts is key to success in system development.

Other standards aligned

In essence, a standard is an agreed way of doing something. Standards are the distilled wisdom of experts in their subject matter. Standards are knowledge that help drive innovation and increase productivity. They can make organisations more successful and people's lives easier, safer and healthier (Martin, 2018). LADM is a knowledge standard. A standardised LADM (adapted to the local situation) supports in knowledge sharing at local, regional, national, federal or international level.

LADM uses and refers to a number of standards, the alignment between these standards is well provided for.

Imagery

Image-based acquisition and data maintenance of visual cadastral boundaries is supported in LADM.

Conflicts

LADM allows polygon based approaches. In case of conflicts the conflict holders can show the polygon that best describes their right in their own opinion. The overlap between polygons can be used for conflict resolution. LADM allows different approaches to represent conflict cases.

Participatory approaches

New data acquisition methods can be applied. Those allow grassroot surveyors and paralegals with professionals as supervisors to collect data. People in the village can follow the process. Mobiles can be used to support different languages, dialects and also illiteracy.

See the example from Colombia in Morales et al. (2021). In this example a polygon based approach is used where each right holder collects data in the field by walking the perimeter of his or her land property or occupied land. It means that each boundary is included twice, this is a solid basis for quality management by the supervising surveyor. This is an innovation, a new way of data acquisition for land administration, see Figure 14 and Morales et al. (2021).

Mobile devices – grassroot surveyors

Mobile devices have functions as telecom, camera, positioning, fingerprints, voice and conversion to text, See Figure 15. Very useful in data collection for land administration, especially for grassroot surveyors and paralegal in the field. In the field application LADM can be integrated in a downloadable app for data collection. See also the report from RICS (2011) on Crowdsourcing Support of Land Administration.

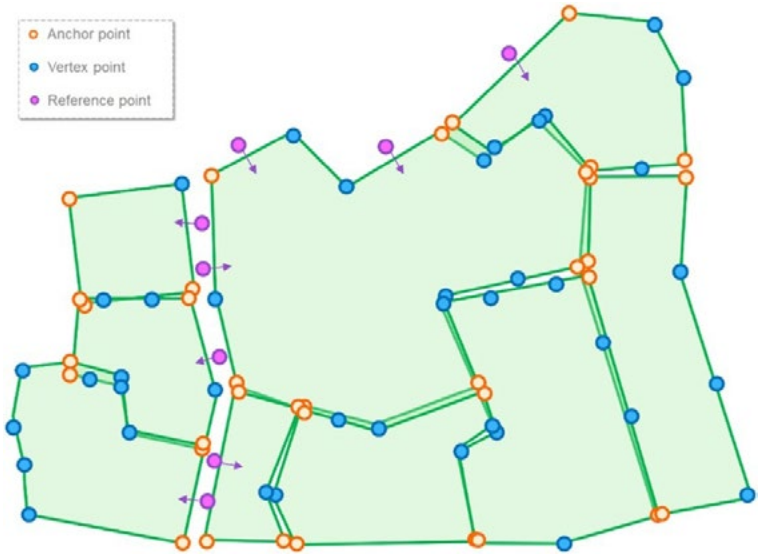

Figure 14: *Polygon based data acquisition. Each right holder walks the perimeter of his or her land with a GPS antenna (Morales et al., 2021)*

Figure 15: *Mobile devices have many functionalities for land administration*

STDM

In STDM, most of the same classes as in the LADM are used, but sometimes under different terminology, for example, class RRR is named class SocialTenureRelationship – an extension of the LADM vocabulary. Conversion from social to legal tenure is supported by LADM.

SDGs indicators

FIG is dedicated to promote the SDG's. The Sustainable Development Goals (SDGs) and related land indicators will re-shape and influence our profession profoundly in the decade to come. LADM can be used to further formalise and monitor SDG indicators.

Community of practice

LADM is a very tangible tool that enables dialogue between country contexts and practitioners. Previously, there were limitations in this. Certainly, there was big barriers between language groups and colonial backgrounds. Discourse between French, Land and English/Germanic systems of origins was not seen in depth. There were limitations, at least in English, to discussions on fixed vs. general boundaries, or title vs. deed registration.

LADM provides a much richer ontology or language – enabling all these groups to profile themselves against, then discussions and debate can flow from there. LADM has greatly improved the level and depth of global level discourse around land administration.

6 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Semantics

LADM is a spatial domain standard. It captures the semantics of the land administration domain.

Communication

LADM supports communication between professionals, for system design, system development and system implementation purposes and for purposes of information exchange and data quality management.

Enabling GIS and base providers

LADM enables survey instrument providers, Computer Aided Design (CAD) providers, and Geographical Information Systems (GIS) and database providers and/or open source communities to develop products and applications. And 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.

Ontology

LADM provides a shared ontology, defining a terminology for land administration.

Conceptual schema

LADM 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 information 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.

Quality management

The standard supports data quality management in land administration. Use of standards contributes to the avoidance of inconsistencies between information maintained in different organisations, because data duplication can be avoided as much as possible. It should be noted here that implementing a standardised information model can be supportive in the detection of existing inconsistencies.

Multipart

LADM is developed as multipart in collaboration between FIG and ISO/TC 211. ISO 19152-1:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 1: Generic conceptual model* and ISO 19152-3:2024 *Geographic information – Land Administration Domain Model (LADM) – Part 3: Marine georegulation* are published. ISO 19152-2 *Geographic information – Land Administration Domain Model (LADM) – Part 2:*

Land registration; ISO 19152-4 *Geographic information – Land Administration Domain Model (LADM) – Part 4: Valuation information* and ISO 19152-5 *Geographic information – Land Administration Domain Model (LADM) – Part 5: Spatial plan information* are under development, approval phase (schedule for release in 2025).

Expanded scope

The revision process, which began in 2017, aimed to expand the model's scope, incorporating marine georegulation, valuation information, spatial planning information, 3D cadastres, cadastral acquisition techniques, and better implementation guidance -as requested by the international community.

User demands

Inputs (user demands) to the developments of both editions were given by experts within ISO/TC 211 and also by the LADM Users Community during FIG LADM & 3D land administration workshops. FIG Commissions 2, 3, 7, 8 and 9 are actively involved over the years. Knowledge is documented in the standard and in many professional and scientific publications, for example in Special Issues of Land Use Policy.

Recommendations

OGC

To make further standardisation efforts in cooperation the Open Geospatial Consortium on encodings and technical models for LADM implementation. This includes further integration with BIM/IFC, GML, CityGML, LandXML, LandInfra, IndoorGML, RDF/linked data, and GeoJSON.

Building material registration

To develop a foundation for building material registration. This is crucial for a circular economy of the built environment and is quite similar to land administration from the perspective of information collection, registration, information search and use. This could result in a new part of the LADM.

Future work

To develop research in relation to LADM and possible applications for sustainable development. This could be about nature rights, ground water rights, carbon rights, wind rights and solar rights. How to establish those rights (in 3D)? How to organise transactions. What are rights, restrictions and responsibilities. How to use LADM. Are extensions needed.

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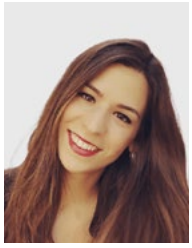
Peter van Oosterom obtained an MSc in 1985 from Delft University of Technology, Netherlands. In 1990 he received a PhD from Leiden University. From 1985 till 1995 he worked at TNO Physics and Electronics laboratory in The Hague. Till 2000 he was Sr information manager at Kadaster, Netherlands. Then he started as Professor in GIS Technology, Faculty of Architecture and the Built Environment, Delft University of Technology. He is the current chair of the FIG WG on 'LADM and 3D Land Administration' and co-editor of the International Standard for Land Administration Domain, ISO 19152:2012 *Geographic information – Land Administration Domain Model (LADM)* and is involved as co-editor in the revision of *Geographic information – Land Administration Domain Model (LADM)*.

Abdulllah Kara holds a PhD from Yıldız Technical University with a thesis on the extension of Land Administration Domain Model (LADM) with valuation information. This is a basis for the development of ISO 19152-4 *Geographic information – Land Administration Domain Model (LADM) – Part 4: Valuation information*. He worked as a post-doctoral researcher (2021–2024) at the GIS Technology Section, Delft University of Technology. He has worked as an assistant professor at Gebze Technical University starting from 2024. He has been actively involved in FIG working groups. He is is involved as co-editor in the revision of *Geographic information – Land Administration Domain Model (LADM)*.



Eftychia Kalogianni is PhD candidate in the 'GIS Technology' Chair, Digital Technologies Section, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. Her PhD research is about adopting a holistic approach for 3D Land Administration in line within the Spatial Development Lifecycle, in the context of the ISO 19152 *Geographic information – Land Administration Domain Model (LADM)* revision. She holds a MSc Geoinformatics from the National Technical University of Athens, Greece and a MSc in Geomatics from Delft University of Technology, The Netherlands. She is currently, co-chair of the FIG WG on 'LADM and 3D Land Administration'.

FIG PUBLICATIONS

The FIG publications are divided into four categories. This should assist members and other users to identify the profile and purpose of the various publications.

FIG Policy Statements

FIG Policy Statements include political declarations and recommendations endorsed by the FIG General Assembly. They are prepared to explain FIG policies on important topics to politicians, government agencies and other decision makers, as well as surveyors and other professionals.

FIG Guides

FIG Guides are technical or managerial guidelines endorsed by the Council and recorded by the General Assembly. They are prepared to deal with topical professional issues and provide guidance for the surveying profession and relevant partners.

FIG Reports

FIG Reports are technical reports representing the outcomes from scientific meetings and Commission working groups. The reports are approved by the Council and include valuable information on specific topics of relevance to the profession, members and individual surveyors.

FIG Regulations

FIG Regulations include statutes, internal rules and work plans adopted by the FIG organisation.

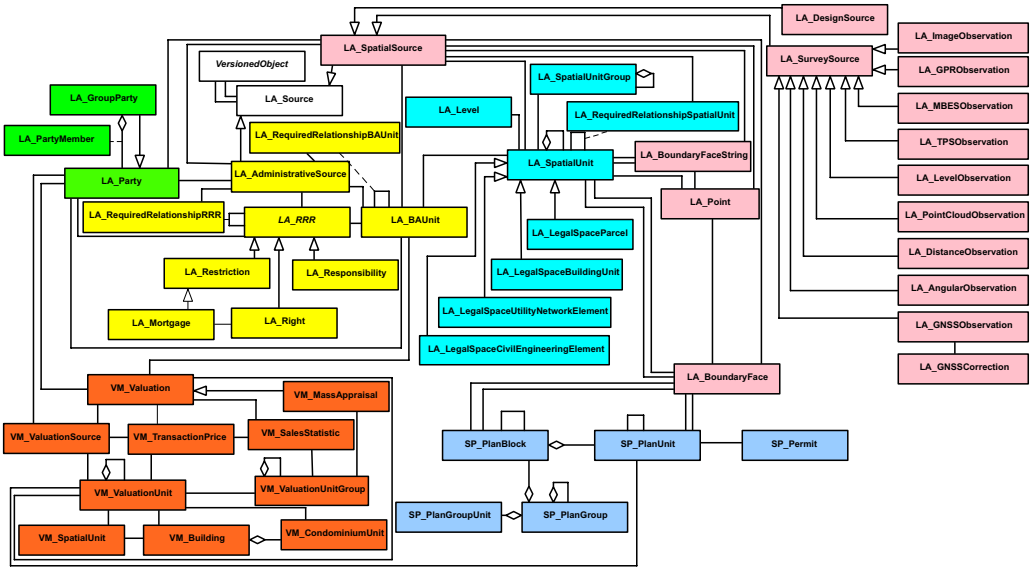
List of FIG Publications

For an up-to-date list of publications, please visit
www.fig.net/pub/figpub

ABOUT FIG

International Federation of Surveyors is the premier international organisation representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards.

FIG was founded in 1878 in Paris and was first known as the Fédération Internationale des Géomètres (FIG). This has become anglicised to the International Federation of Surveyors (FIG). It is a United Nations and World Bank Group recognised non-government organisation (NGO), representing a membership from 120 plus countries throughout the world, and its aim is to ensure that the disciplines of surveying and all who practise them meet the needs of the markets and communities that they serve.



In 2012, the Land Administration Domain Model (LADM) was approved as an official ISO standard. The LADM is a conceptual information model. It describes and structures the core of a land administration: information about people, about land and about people to land relationships.

LADM supports the establishment of a common view on land administration across stakeholders involved. It stimulates the development of software applications and accelerates the implementation of proper land administration systems in support of sustainable development. It supports interoperability in land administration. This is a real need because land administration is mostly implemented under distributed mandates with many stakeholders. The LADM provides an internationally recognised model and vocabulary, which provide a solid foundation for the development process. It covers the 'information-related' components of land administration, including those over water and land, and elements above and below the surface of the earth. This means in practice that the representation of all tenure types is being supported – even when overlapping – and that 3D land administration can be developed. There are now implementations of LADM all over the world.

This publication gives an overview. The publication is intended for anyone wishing to learn more about LADM: why is it needed, how is it designed, what is it and what are the benefits. This overview publication has an extended version titled 'LADM in the Classroom' with a focus to training and higher education.

ISBN 978-87-93914-23-0 (pdf)