

# Developing a logic of machine readable land and property transactions with the LADM standard

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**Key words:** LADM, Land Administration, Land Registration, concepts, transactions, digital transformation

## SUMMARY

The Land Administration ecosystem comprises of agencies who store and manage authoritative data. Authoritative data is fundamental to a range of formal and informal processes and inter-agency functions. Unfortunately, for the majority of jurisdictions, the products, services and processes of these agencies are not digitally integrated. This often results in the duplication of capabilities and inefficient inter-agency processes.

An efficient and effective Land Administration ecosystem will store these relationships once, with the authoritative agency, and share the results throughout the ecosystem using common identifiers and linked data. This is referred to as the *once-only principle*. The expectation is that the capabilities of agencies will evolve and become increasingly integrated. Such change requires *digital transformation*.

Government digital service transformation is about "*the reimagining and reinvention of the way public services are conceived, designed, operated and managed*" requiring the "*rethinking of the very plumbing of government*". There is an expectation that transactions will become machine readable leading to *entirely digital automated real-time registration*.

As a standard, the revised LADM should be foundational to such transformations. The revision of the LADM extends the scope of the 2012 standard towards addressing the needs of the broader Land Administration ecosystem. The LADM revision has the potential to do more than provide semantic interoperability between jurisdictions, it can support the delivery of *Government as a Platform or Service*. Within this context LADM is a standard that supports the re-definition and commoditisation of common behaviour to deliver well understood processes that are exposed as services using Application Programming Interfaces (APIs).

This paper describes a conceptual logic of machine and human readable transactions for Land Administration that are framed within the LADM. Core Land Registration processes have been defined that cover the alienation of parties (*ToP*), land (*VoL*), and rights (*AoR*). We also discuss the relationship between transactions and dispute processes. This provides clarity in terms of the foundational concepts, implementation patterns and generic business logic. This is essential to achieve the digital reforms envisaged by UNECE, FAO, and FIG.

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## 1. Introduction

The revision of the Land Administration Domain Model (LADM ([ISO TC/211, 2012](#))) is significantly changing the scope of the standard: the focus is shifting from the architectural requirements of the *agency* to the architectural requirements of the *ecosystem*. At the same time LADM is recognised as pivotal to the next phase of digital transformation where policy makers expect increased operational and process alignment between agencies in the ecosystem. This paper describes the conceptual background to these issues and then discusses how the LADM can support the digital transformation of the Land Administration ecosystem. To support digital transformation, LADM should provide clarity in terms of foundational concepts, implementation patterns and generic business logic. We argue that LADM should frame operational patterns that commoditise processes which in turn encourage others to collaborate, interact, and innovate. To illustrate this we propose commoditised core Land Registration processes framed by LADM primitives that detail the alienation of parties, land, and rights. We believe these approaches are essential to achieve the digital reforms envisaged by UNECE, FAO, and FIG ([UNECE, 2021](#); [FAO et al., 2022](#)).

## 2. Land Administration

*Land Administration* is the process of determining, recording and disseminating information about the ownership, value and use of land when implementing land management policies ([FIG, 1999](#); [Enemark et al., 2021](#)). Land Administration reflects the activities of different authoritative agencies that collectively create an ecosystem. [Sevatdal \(2002, p. 6\)](#) refers to this as: "*the group of institutions governing the control of land and distribution of land resources and the benefits accruing from land.*" This tends to include the following types of Land and Property functions ([Williamson et al., 2010, p. 119](#)):

- Land and Property Titling (Land Registry) – managing the registration and subsequent transactions (transfer and granting of rights from one party to another), and maintenance of the land register (in some jurisdictions the cadastral map may be managed by a different agency).
- Development (Planning Department) - regulating land and property development.
- Use and conservation (Departments of Heritage, Conservation, Environment, Fisheries, Forestry, and Agriculture) – regulating the use and conservation of land.
- Finance and valuation - valuing property and framing how revenue is generated from land and property through sales, leasing, and taxation.
- Disputes and conflict resolution - Land tribunals and other adjudicating agencies to resolve conflicts concerning the ownership and use of land.

Land and property are characterised by the interplay of complex real right relationships formalised through these different land administration stakeholders. Collectively these agencies provide the mechanism through which tenure is formalised. *Tenure* describes the

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ways in which parties can own and have other rights in immovable property ([FAO, 2022](#)).

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Through legislation and registration legal protections are provided ([Dale & McLaughlin, 1999, p. 26](#)). *Security of tenure* reflects the jurisdictions ability to protect and enforce these legitimately held rights ([FAO, 2002, p. 18](#)).

Each agency is different in its statutory focus, and requires a mix of professionals, including surveyors, engineers, lawyers, valuers, economists, planners, and developers. In addition, each agency has a mandate and powers to deliver that mandate: this includes holding authoritative data ([FIG, 2022, p. 139](#)).

## 2.1 Authoritative data and Digital Transformation

Authoritative data is officially recognised data that can be certified and is provided by an authoritative source: the implication being that data is up-to-date, credible, accurate, assured, well-governed and trusted. Authoritative data is fundamental to a range of formal and informal processes and inter-agency functions. Authoritative data should have primacy and, as described by [FIG \(2022, p. 139\)](#), should ideally be easily available and accessible. An efficient and effective Land Administration ecosystem will use authoritative data as a *core reference* and share it as a resource throughout the ecosystem to support integrated transactions and other operational processes (ideally as linked data using common identifiers). This is referred to as the *once-only principle* ([UNECE, 2021, p. 11](#)).

Unfortunately, for the majority of jurisdictions, the products, services and processes of these agencies are not digitally integrated ([UNECE, 2021, p. 11](#)). This is generally because the ecosystem has never been re-architected to capitalise on digital systems: rather agencies have evolved independently with integrations based on traditional approaches ([Brown et al., 2014, pp. 102-103](#)). This often results in the duplication of capabilities and inefficient intra-ecosystem processes. In other words: many current Land Administration ecosystems are represented by agencies operating predominantly within digital silos. This makes for an inefficient digital ecosystem.

[UNECE \(2021, pp. 3-4\)](#) discuss the impact of 11 different megatrends on the Land Administration domain. It was recognised by a team of domain experts that *Digital Transformation* is the key megatrend in the short-medium term. As described by [Brown et al. \(2014, p. 14\)](#) government digital transformation is about "*the reimagining and reinvention of the way public services are conceived, designed, operated and managed*" requiring the "*rethinking of the very plumbing of government*". This requires profound transformation which completely rethinks and reframes the ecosystem (as opposed to simply making paper-based processes digital: a point well made by [FIG \(2022\)](#) and [Križanović & Roić \(2023\)](#)).

The policy expectation is that the capabilities of agencies will evolve and become increasingly integrated. The need for such reform and associated digital transformation has been underlined by the covid pandemic ([FAO et al., 2022](#)). [Brown et al. \(2014, p. 92\)](#) recommend that governments take a '*lean*' approach to evolution with the aim of finding "*the most efficient and effective ways of delivering high-quality, timely and relevant services to citizens and businesses*". Such *digital transformation* will include the *once-only principle* to avoid redundancy, data duplication and inconsistency. There is also an expectation by

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[UNECE \(2021, p. 13\)](#) that transactions will become *entirely digital*:

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Principle 20: The land administration system offers real-time registration of transactions, largely subject to automatic digital checks only. Transaction documents are standardized for machine reading. Only complex cases are checked manually by the land administration authority.

Machine readable applications and automation both require reasoning frameworks (likely to be based on formal logic), which currently do not exist. It is within this context that we wish to consider the role of the LADM.

### 3. The Land Administration Domain Model revision

LADM is a conceptual model which supports the modelling of social relations with land articulated through rights. There are three principal concepts within LADM: the *party* (*the who*) that has a *rights relationship* (*the what*) with a *plot of land* (*the where*). As a standard, LADM dominates the domain and supports nuanced representations of Party-Right-Land relationships.

The first edition of the LADM ([ISO TC/211, 2012](#)) was published in 2012: it focussed principally on the needs of the Land Registration community ([Lemmen et al., 2023, p. 9](#)). *Land Registration* is the process of recording rights in land either in the form of registration of deeds or the registration of title to land ([FIG, 1999](#); [Enemark et al., 2021](#)). When articulating title, rights are described that either 1) **benefit** *the owner* as they are rights held directly by the owner or indirectly via the property; or 2) **encumber** *the owner* as they are rights held by specified third-parties. Encumbering rights introduce a *duty* on the property owner which within LADM are referred to as either:

- A *restriction*: "formal or informal obligation on the **land owner** to refrain from something", or
- A *responsibility*: "formal or informal obligation on the **land owner** to allow or do something"

Modelling *restrictions* and *responsibilities* in this manner frames encumbrances in terms of their impact on a *land owner* rather than the benefit that the *right holder* has over land *owned* by someone else. The distinction is subtle but important, and something we will return to later in this paper.

The revision of the LADM extends the scope of the 2012 standard towards addressing the needs of the broader Land Administration ecosystem ([Lemmen et al., 2023](#)). Given the range of agencies, parties, and activities associated with the ecosystem this is a significant change in scope. This is further reinforced by the expected benefits that will accrue be improved ecosystem integration delivered via digital transformation. The LADM revision has the potential to do more than provide semantic interoperability between jurisdictions; it can support the delivery of *Government as a Platform* ([O'Reilly, 2010](#)) or *Government as a Service* ([Brown et al., 2014](#)). As a standard, the revised LADM should be foundational to such transformations. Open standards support the re-definition and commoditisation of common behaviour to deliver well understood processes that are exposed as services ([Brown et al., 2014, pp 102-103](#))

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#### 4. Key components in the Land Administration ecosystem

Key to the functioning of the ecosystem is the Land Register which describes land and associated property rights which are created, modified or extinguished as part of the conveyancing process. Parties can ‘own’ land and property which, when spatially described, is known as a cadastral unit. Land and Property can be segmented into different juridically defined forms (e.g. leasehold, strata, units in real estate complexes etc.). We will describe these forms of Land and Property as *primary interests*. *Primary interests* can be owned by parties and traded in land markets. *Subordinate interests* are other rights which can provide benefits to third-parties but after their initial grant are not intrinsically tradeable (such as easements). The Land Register describes these primary and subordinate rights using Party-Right-Land relationships. The owner of a primary right tends to have powers to alienate a legally defined set of subsidiary *primary* and *subordinate* interests to specified third-parties. The Land Register also describes these transactions and their outcomes using Party-Right-Land relationships.

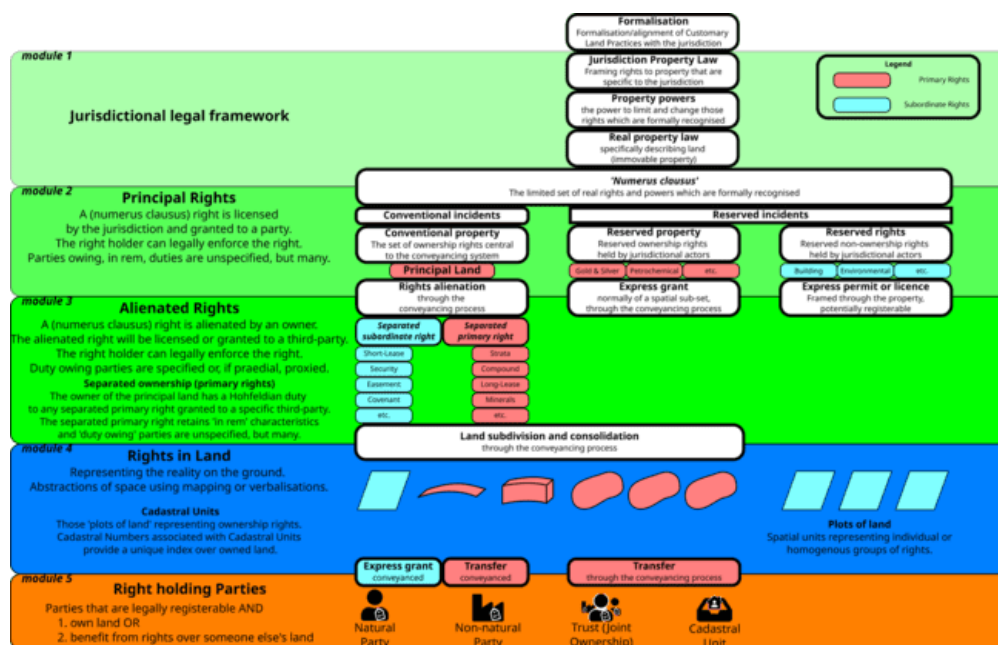


Figure 1. The modular arrangement of rights relationships describing conventional incidents (framing the conveyancing process) and reserved incidents [\(re-used under a CC-BY licence from Ant Beck\)](#).

However, as described by [FAO \(2022, p. 6\)](#): "All parties should recognize that no tenure right, including private ownership, is absolute. All tenure rights are limited by the rights of others and by the measures taken by States necessary for public purposes." The "rights of others" predominantly refers to rights granted to specified third-parties by property owners through the conveyancing process. We call rights managed through the conveyancing process *conventional incidents*. The "measures taken by States necessary for public purposes" refers to rights that are reserved by the jurisdiction and managed by formal agencies empowered through public law. We call such rights *reserved incidents* which we see as a combination of

[reserved property and reserved rights](#), [Kitsakis et al. \(2022, p. 3\)](#) refers to *reserved incidents* The role of LADM (ISO 19152) in the digital transformation of the Land Administration ecosystem (12/32) Anthony Beck and Xu Lu (United Kingdom)

as Public Law Restrictions (PLRs). The relationship between *conventional incidents* and *reserved incidents* is summarised in [Figure 1](#).

From the point of view of the property owner *reserved incidents* encumber *conventional property* by restricting the rights the *property owner* is permitted to enjoy. These reserved incidents can be described using Party-Right-Land relationships. The authoritative agencies can grant permits to property owners that allow them to undertake what would otherwise be restricted activities (normally for a time limited period). Theoretically, the issuing of a permit to a property owner involves the use of data and concepts held by the Land Register and the relevant authoritative agency (see [Figure 2](#)). These permits can be described using Party-Right-Land relationships.

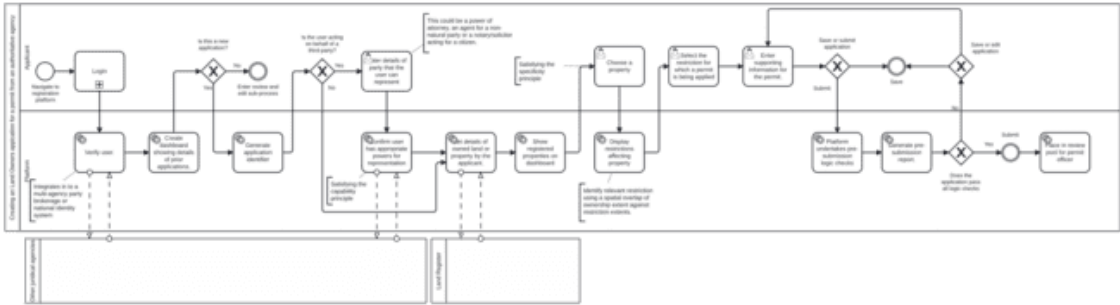


Figure 2. Conceptual representation of permit creation using Business Process Modelling Notation (BPMN). Note the agency relationships described in the process.

As described in [Figure 1](#) and [Figure 3](#), each jurisdiction creates a set of primary and subordinate rights which are recognised by the state and legally formalised. Clearly there are rights which have social relevance which are not formally recognised (e.g. customary, and indigenous rights). Such extra-legal rights may become formalised over time. However, this paper concerns itself with legally formalised rights which are represented in *numerus clausus*: the closed list of basic land and property rights recognised by the jurisdiction. Rights within *numerus clausus* represent both the *bundle* and the *sticks* in the *bundle of rights* model ([Merrill & Smith, 2011](#); [Smith, 2012](#); [Baron, 2013](#)). Key is that as *numerus clausus* changes to reflect evolving social need, so the nature and the number of sticks change. The actual relationship between the *bundle* and the *sticks* is determined when *title* is articulated.



Figure 3. The rights bullseye - describing real rights in land and their relationships to absolute dominium [\(re-used under a CC-BY licence from Ant Beck\)](#).

The property law that defines *numerus clausus* will also describe the *powers* associated with each right. *Powers* define how any right can be granted, licenced, alienated, discharged, or varied (see [Beck \(2022\)](#) for a detailed description of rights, powers and other Hohfeldian incidents).

### 5. Implications of the ecosystem: rights, duties and rights duality

Property as a concept depends on the idea that others are to be excluded from the thing which is owned ([Merrill & Smith, 2011, p. 24](#); [Penner, 2020, p. 74](#)). This exclusivity is *in rem*, that is, it is 'good against the world' and must be 'respected by all', or virtually all, of the subjects of the legal system. *In rem* exclusivity is an inherent social attribute of property. Where property is conventionally defined, such as being bounded by a hedge or fence, we intuitively know we are subject to *certain duties of non-interference*: not to enter it, use it, or take it. This *duty* applies to everyone and does not require a formalised contract with the owner. Hence, there is no need to enumerate the duty owing parties for the rights to have affect ([Merrill & Smith, 2001, p. 359](#); [Merrill & Smith, 2011, p. 9](#)).

*Conventional property, reserved property and reserved rights* all have *in rem* characteristics. While property rights are 'good against the world', from a practical point of view *reserved rights* are 'good against the set of property owners' ([Smith, 2012, p. 1706](#)). This is the relationship between an owner and the state ([Merrill & Smith, 2011, p. 12](#)). This means that, for example, a *building restriction* is a duty on *property owners* which correlates with a *right to build* which is controlled by a *planning department* (the state). In order to build anything that is restricted a *property owner* must get a *permit* or *licence* from the *planning department* (see [Figure 2](#)). The *building restriction* is defined by a geographical extent and affects ALL property within the geographical boundary. The *planning department* does not need to know the details of any specific *owning party* for the restriction to have affect. *In rem* duties have legal affect even though the duty owing parties are **unspecified**.

By contrast a property owner can vary their exclusivity by conferring rights on to *specified third-parties* (see [Figure 1](#) and [Figure 3](#)). This is well described by ([Penner, 2020, p. 76](#)):

Property is like a gate, not a wall, because the owner may open the gate, selectively allowing particular persons to enter, while at the same time leaving everyone else who is outside in the same position as before.

This provides enforceable rights to the *specific third-parties* which introduce corresponding duties on the *property owner* (and all *future property owners* while the right is enforceable). This relationship between rights and duties encapsulates the concept of *rights duality* as described by [Williamson et al. \(2010, pp. 88-89\)](#):

A right is not a relationship between an owner and land.

It is a relationship between an owner and others in relation to land, backed up by the state in the case of legal rights.

This duality of owners and others is also present in restrictions and responsibilities affecting landowners and users.

Each restriction/responsibility involves a duality that imposes obligations on owners in relation to the land for the benefit of others.

An administrative framework is robust and successful when it takes this duality into account and also identifies the appropriate managing or implementing authority.

The implication of *rights duality* is that a registered right that is legitimately held (and has corresponding tenure security) imposes a *duty* (either a *restriction* or *responsibility*) on the property owner. This is discussed in detail by [Beck \(2022\)](#) in terms of Hohfeldian incidents. The duality represents two relationships:

1. The *primary* or *subordinate* interest held by a third-party and
2. The corresponding *positive* or *negative* duty owed by the affected property owner.

The duality of rights and duties provides a finely nuanced mechanism to define relationships between parties framed through land and property. When viewed in this manner, *numerus clausus* does not represent a continuum of rights, rather it represents a formalised socio-economic relationship between right holders, duty owners and property owners. These relationships can be summarised as follows:

- Conventional incidents:
  - a. Primary rights which have an *in rem* effect which is *good against the world*.
  - b. Primary and Subordinate rights expressly granted in the conveyancing process to *specified third-parties* which introduce corresponding duties on the *property owner* (and all *future property owners* while the right is enforceable).
- Reserved incidents:
  - a. Primary rights which have an *in rem* effect which is *good against the world*.



- b. Primary and Subordinate rights managed by an authoritative agency which have an *in rem* effect on a *set of property* and can be enforced against the unspecified set of respective property owners.
  - Permits, or other licences, can be granted to property owners that allow them to undertake what would otherwise be restricted activities.

In this manner *reserved incidents* are *rights* controlled by authoritative agencies which create *duties* in the form of *restrictions* and *responsibilities* on any affected *property*. This has important ramifications when considering the whole Land Administration ecosystem. Rights duality dictates that if a Land Register records a duty (as a *restriction* or *responsibility*) then within the Land Administration ecosystem there exists a specified third-party or authoritative agency which holds the corresponding right. Do we register the right (the benefit for the right holder), the duty (the encumbering restriction or responsibility against the property), or both?

This is a difficult question and, in part, the answer depends upon the maturity of the ecosystem and the level of data, service and process integration between authoritative agencies. The *once-only principle* **demands** efficient recording: it does not matter whether it is the right or the duty which is recorded. What matters is that other agencies have the ability to infer the respective right or duty from the information which is exposed in the ecosystem. However, if an authoritative agency is **mandated** to record a right or a duty, then they are the responsible agency: no other agency should emulate this function as this would not be authoritative.

Unfortunately not all ecosystems are mature and most do not rigorously deploy the *once-only principle*. While such jurisdictions are being reformed it is important that *rights duality* is embraced. The authoritative agency should also record any appropriate ancillary data which is required so that the right or duty can be effectively re-used by other actors in the ecosystem. It is only by understanding the operational requirements of the ecosystem at a holistic level can the *once-only principle* be effectively implemented. This is not an easy task.

## 6. Implications of digital transformation: commoditisation of the ecosystem architecture

Making legacy government processes and structures digital does not result in improved functionality ([Brown et al., 2014, pp. 78-79](#)). Such approaches simply fossilise past processes, making it more difficult for organisations to transform and evolve. Digital transformation aims to rethink and reframe service provision. The end result should be more co-ordinated, consistent and cost-effective services driven by the needs of citizens and other consumers. Ideally services are built on commoditised digital components that can be integrated across the government estate. This is the philosophy which has delivered design and user-experience patterns across the UK government central services [replacing nearly 2,000 websites with just one](#). However, comparative data solutions are still maturing. The premise is that the significant majority of basic functionality can be achieved by using or adapting components which are already available. Novel or bespoke functionality should be created in a manner which integrates with these existing components. In doing so agencies need to consider capabilities, business rules and components so that appropriate pre-built solutions can be used ~~to accelerate delivery, allowing development effort to be prioritised and focused on business-~~

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specific needs. Such holistic communication frameworks are well described by [Brown et al. \(2014, p. 96\)](#):

When we talk about architecture therefore we are speaking less of a thing (such as a plan or document) than of a clearly defined, communicated and widely understood set of underlying principles flowing through each of our differently evolving public organizations like DNA. Just as biological DNA rewards some behaviours and penalizes others within an ecosystem, so too will a set of common principles - expressed differently in different organizations, but operating in relation to the whole.

How is this to be applied to the Land Administration domain (which is, after all, a subset of the broader government ecosystem)? Each jurisdiction is unique in the way it determines the social value of rights which are defined in property law. Property law also describes the powers that a right holder has to grant, licence, alienate, discharge, or vary a right. In summary, the relationships between parties and rights may be unique to a jurisdiction, while the abstract operations available through powers to change rights are broadly generic across jurisdictions. If the community agree with this statement, then the commodity components reflect these abstract operations. Further research is required to identify these generic rules and processes that can be used to define such change. This should be framed through the ISO19152 LADM primitives. Improved understanding and modelling of these processes will improve operations within ecosystems and interoperability between jurisdictions. The development of generic procedures and operations could ultimately lead to improved automation (as expected by [UNECE \(2021, p. 13\)](#)). In the next section we propose an approach to commoditise core Land Register transactional operations using LADM primitives.

## 6.1 Standardising and commoditising transactions within a Land Register

A holder of a primary incident has *powers* which allows them to transform their party-right-land relationship by a mechanism called *alienation*. While the specific nature of these mechanisms depends on the type of tenure, legal tradition and social need expressed in a jurisdiction, the broad nature of these mechanisms are, we believe, generic. [FAO \(2002, p. 10\)](#) describe *alienation* as:

- A right to alienate all rights to the entire holding (e.g. through sale), or to a portion of the holding (e.g. by subdividing it).
- A right to alienate only a portion of the rights (e.g. through a lease).
- A residuary right to the land, i.e., when partially alienated rights lapse (such as when a lease expires), those rights revert to the person who alienated them.

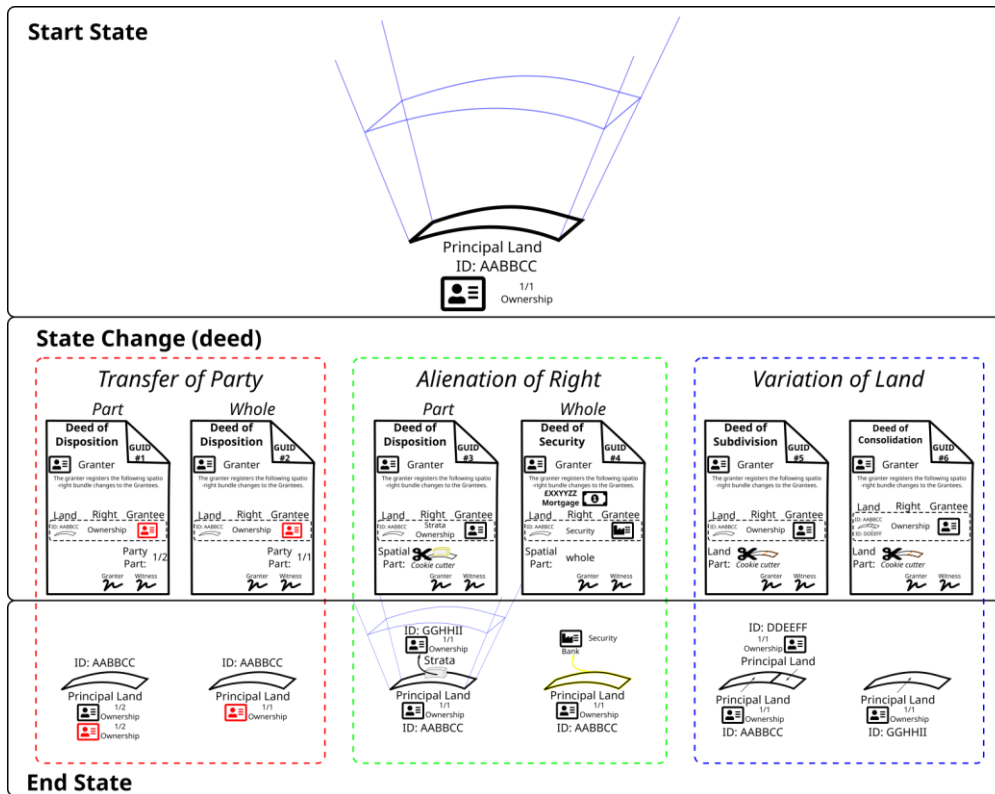


Figure 4. Transactions associated with Land and Property based on LADM concepts (re-used under a CC-BY licence from Ant Beck): (1) A Transfer of Party, (2) An Alienation of Right, and (3) Variation of Land.

To support transparency and interoperability such mechanisms should be grounded in the standard LADM primitives of party, right and land. Alienation can occur through a party, right, or land dimension (see Figure 4 and Figure 5). The ability to "alienate all rights to the entire holding (e.g., through sale)" is what we refer to as a *Transfer of Party* transaction: alienation through the *party* dimension. A ToP is the transfer of all or a proportion of the ownership to specified third-parties. The ability to "alienate all rights ... to a portion of the holding (e.g., by subdividing it)" is what we refer to as a *Variation of Land* transaction: alienation through the *land* dimension. A VoL is a subdivision of a cadastral unit to create two or more cadastral units or the consolidation of multiple cadastral units to create a single cadastral unit. The ability to "alienate only a portion of the rights, e.g., through a lease" is what we refer to as an *Alienation of Rights* transaction: alienation through the *right* dimension. An AoR is where rights can be separated from the body of a property (and subsequently transferred to third-parties).

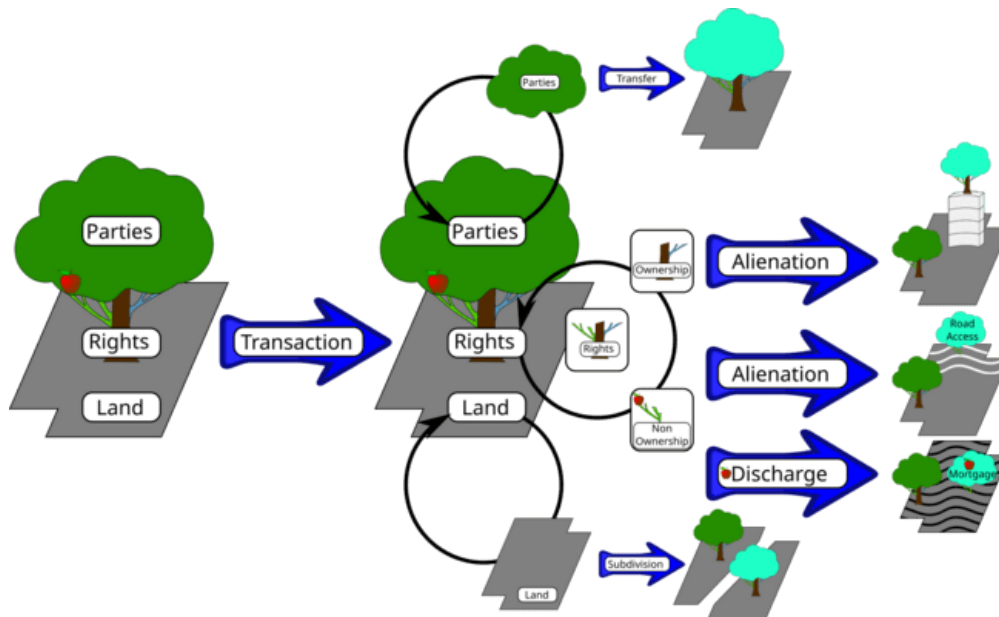


Figure 5. How *in personam* transactions can change Party, Rights and Land relationships ([re-used under a CC-BY licence from Ant Beck](#)). Similar thinking is seen in Figure 1 of [Bennett et al. \(2021\)](#) and Figure 4.8 of [Zevenbergen \(2002\)](#).

#### 6.1.1 Transfer of Party transactions - whole, part and consolidation

A ToP transaction, see [Figure 6](#), is where an **owning party** (granter) transfers all, or a proportion, of their **property** to a third-party (grantee). Fractional ownership can also be consolidated in this process. Sale, gift and inheritance are all *ToP* scenarios where a transaction transfers a right and *all associated powers* from one set of parties to another. Only a limited number of rights can be expressly transferred in this manner. Essentially rights which can be expressly transferred are closely correlated with rights which have a functioning market. These are defined by the jurisdiction but generally include:

- Freehold (and equivalent)
- Horizontal and vertical subdivision representing flats and compounds as leasehold or freehold (and equivalent)
- Long lease
- Securities

Any beneficial rights associated with the property '*run with the land*' and become benefits to the grantee. Further rights can be transferred by the property owner when they have been expressly separated using an AoR. This allows the granting of use and service rights between third-parties (including neighbouring cadastral units) and the establishment of property within a Real Estate Complex.

A *cadastral unit* (property) can act as a party and be granted rights over other *cadastral units* using a ToP. The benefiting (right holding) *cadastral unit* is called the *dominant cadastral unit*. The encumbered (duty owing) *cadastral unit* is called the *servient cadastral unit*. Rights

duality is clearly expressed in the relationship between the dominant and servient cadastral unit. When a *dominant cadastral unit* is transferred there is no need to expressly transfer any of the beneficial rights to the new owner as they are *praedial* and 'run with the land' ([Simpson, 1976, p. 6](#)).

Fractional parts of the property can be transferred to third-parties. We have referred to this as a *ToP part*. A *ToP part* results in ownership fragmentation due to multiple parties having shares in the same property. Each owning party has the power to independently transfer their share without consent of the co-owners. This ability to independently transfer ownership is the major differentiator in the way that multiple parties can share ownership in the same property (e.g. between *ownership in common* and *joint ownership*).

Fragmented ownership can be consolidated by the *collective transfer* of the fragmented ownership to a 'new party'. A *collective transfer* means that the fragmented ownership that is split between multiple parties is consolidated through a single transactional event.

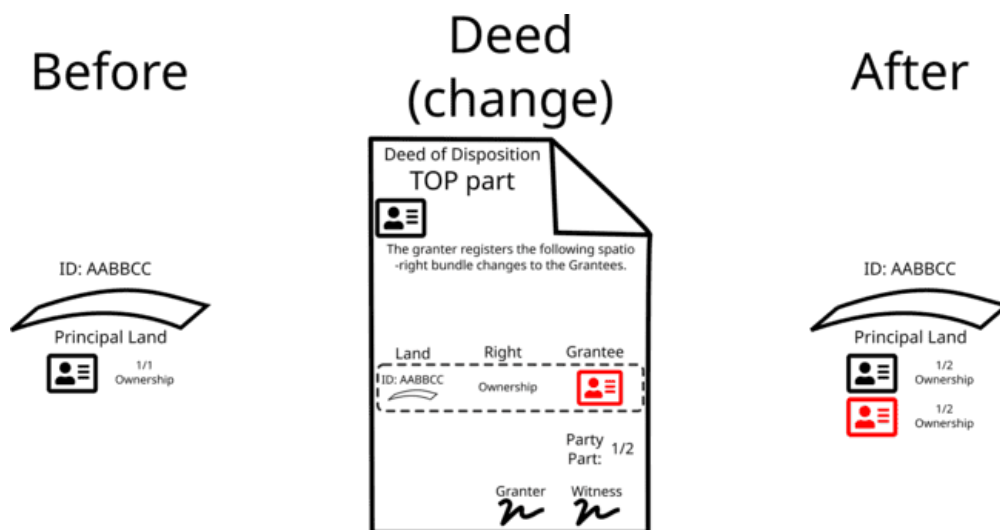


Figure 6. Transfer of Party part - a parent right in land has is partially transferred to one or many parties with the original owner retaining a part ([re-used under a CC-BY licence from Ant Beck](#)).

### 6.1.2 Variation of Land transactions - subdivision and consolidation

A VoL is where:

1. an owner **spatially subdivides** a *general cadastral unit* to create two or more smaller *general cadastral units* (see [Figure 7](#)) or
2. an owner of multiple *general cadastral units* **spatially consolidates** those cadastral units to create a single *general cadastral unit* (see [Figure 8](#))

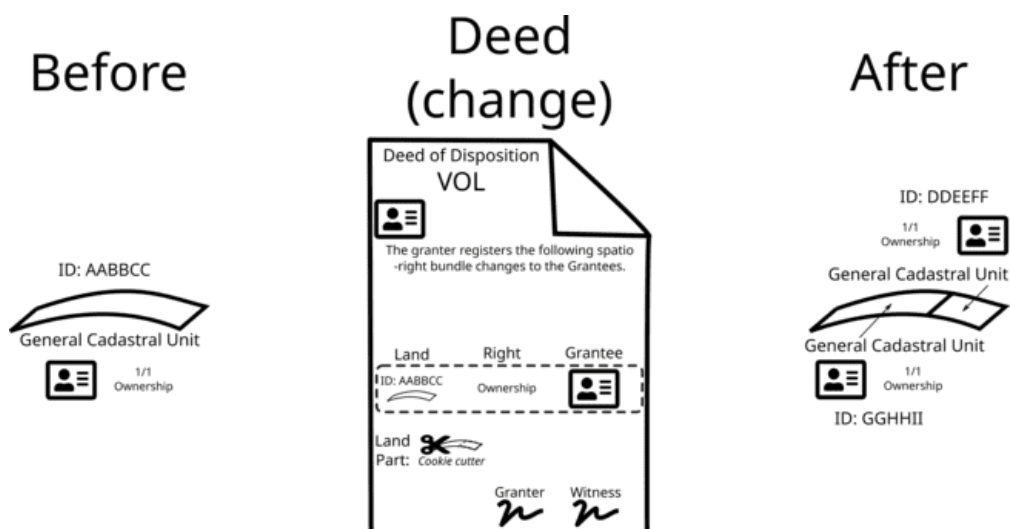


Figure 7. Variation of Land subdivision - an owner **spatially subdivides** a *general cadastral unit* to create two or more smaller *general cadastral units* ([re-used under a CC-BY licence from Ant Beck](#)).

The legislation and regulations provide details on how spatial representations are managed and the responsibilities of *land and cadastral surveyors*. A cadastral unit is subdivided (see [Figure 7](#)) under the following conditions:

- The owner(s) of the input cadastral unit is the owner of the subdivided cadastral units.
- New geometry is created representing the subdivided parcels.
  - The cadastral unit geometry is provided by land and cadastral surveyors (or other recognised parties).
    - The land and cadastral surveyors or Registrar should ensure boundary relationships remain topologically intact and that no gaps or overlap polygons are generated.
  - Cadastral unit identifiers are allocated based on the agreed specification.

As described by [Zevenbergen \(2002, p. 66\)](#) it is common for a VoL subdivision to be followed by a ToP transaction to represent a subdivision and subsequent transfer to a third-party via sale or gift. These two atomic transactions can be described within the same legal instrument. The ordering of such chained transactions is clearly important: if the transfer happened before the subdivision then the subdivision would be rejected as the grantor of the subdivision would not have the legal *power* to grant the transaction.

Cadastral units are consolidated (see [Figure 8](#)) under the following conditions:

- The owners of the land to be consolidated **MUST** be the same (parties and proportion held).
  - This may require a reallocation of ownership shares in advance of the spatial consolidation process. This is a separate transaction.
- ~~A new geometry is created representing the consolidated parcel.~~

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- A cadastral unit geometry is provided by land and cadastral surveyors (or other recognised parties).
  - The land and cadastral surveyors or Registrar should ensure boundary relationships remain topologically intact and that no gaps or overlap polygons are generated.
- A cadastral unit identifier is allocated based on the agreed specification.

### 6.1.3 Alienation of Right transactions

Property ownership is conceptually a container for a bundle of other proprietary rights which can be granted to third-parties. Rights granted in this manner could be considered as the equivalent of *sticks* in the *bundle of rights* model (see [Simpson, 1976, p. 7](#); [Merrill & Smith, 2011, p. 10](#); [Baron, 2013](#)). By alienating '*use and service*' rights and granting them to specified third-parties, owners can develop nuanced governance and transformation strategies over their property. Such an approach is necessary when registering relationships between neighbouring properties (such as easements between neighbours or the complex rights conditions within condominiums and compounds).

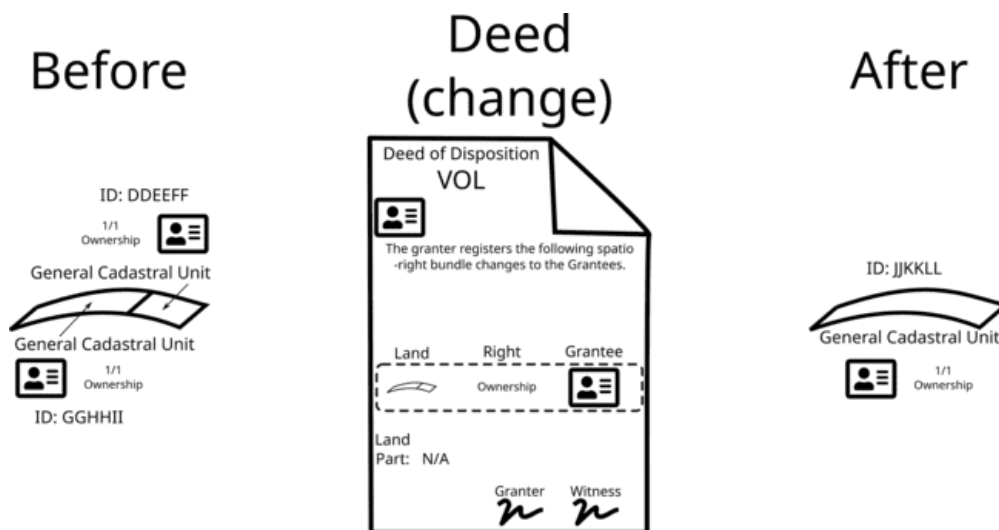


Figure 8. Variation of Land consolidation - an owner of multiple (contiguous?) *general cadastral units* **spatially consolidates** those cadastral units to create a single *general cadastral unit* [\(re-used under a CC-BY licence from Ant Beck\)](#).

An AoR transaction is where an owner or authoritative agency (grantor) separates rights from the body of a **property**. These separated rights are then normally transferred to a specified third-party. An AoR essentially creates a right for the grantee which introduces a correlative duty (i.e. responsibility or restriction) on the **owner of the property**. Once alienated these rights have their own lifecycle and, subject to the powers associated with the alienated right, can be transferred, varied or discharged.

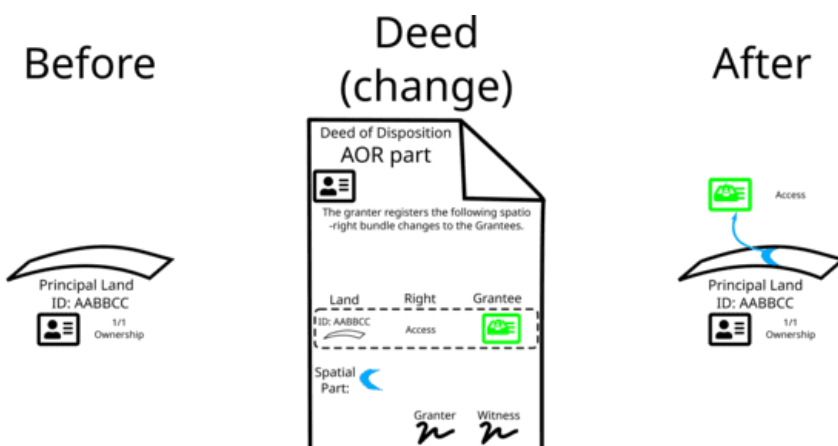


Figure 9. Alienation of Right part - servitude/easement: a parent cadastral unit is legally subdivided to create a separated right. In this instances the right is a servitude/easement over part of the extent of the cadastral unit [\(re-used under a CC-BY licence from Ant Beck\)](#).

An AoR can be *whole* or *part*:

- **AoR: part (AoRp)**: see [Figure 9](#), where the spatial extent of the right is a **spatial part** of the spatial extent of the parent cadastral unit (at the time of the transaction).
- **AoR: whole (AoRw)**: see [Figure 10](#), where the spatial extent of the right is **coincident** with the spatial extent of the parent cadastral unit (at the time of the transaction).

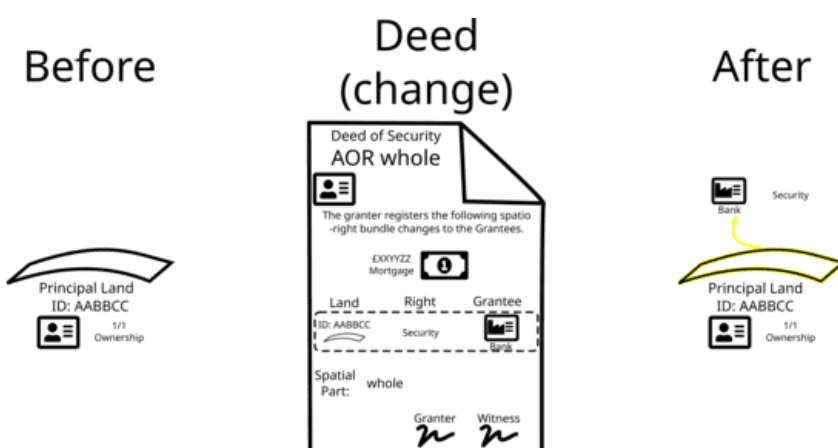


Figure 10. Alienation of Right whole - security: a parent cadastral unit is legally subdivided to create a separated right. In this instances the right is a security over the whole extent of the cadastral unit [\(re-used under a CC-BY licence from Ant Beck\)](#).

Owners of property have a duty to allow the holder of each alienated right to enjoy their right. Each right-holder has a legal claim over the property owner to ensure they enjoy their right. The rights which can be alienated will be legally defined by the jurisdiction (and represented in *numerus clausus*) and may differ between different primary incidents.



However, as well as subordinate rights (see [Figure 9](#) and [Figure 10](#)) it is possible to alienate primary incidents (property) in the form of *child cadastral units*. *Child cadastral units* in their most simple form can be used to frame leasehold, sub-lease, and surface or sub-surface strata rights, but are also used to describe Real Estate Complexes: apartments or compounds with positive obligations (including the right to charge maintenance fees (see [Figure 11](#))).

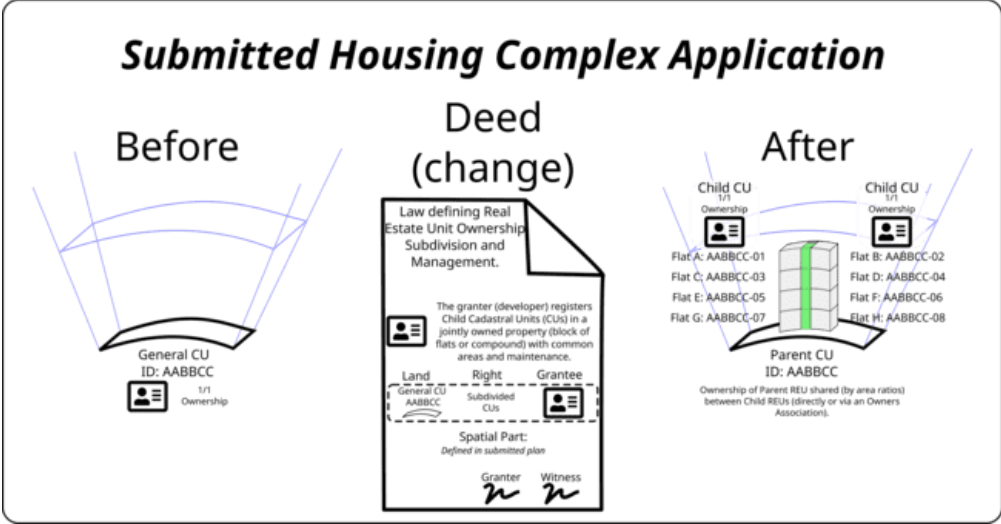


Figure 11. Exemplar application to create a Real Estate Complex ([re-used under a CC-BY licence from Ant Beck](#)).

There is an expectation that many *child cadastral units* will not exist in perpetuity and they will be amalgamated back in to the *parent cadastral unit*. This is clearly true for time sensitive primary incidents such as leasehold and sub-lease but is also practically true for real estate complexes. While real estate complexes could be granted using freehold, commonhold or other forms of ownership rights for the child units, the reality is that these units will go out of use, get demolished and subsequently re-developed. [Beck & Moss \(2022\)](#) discuss LADM patterns to support the efficient modelling of flats and compounds throughout their lifecycle.

**7. Conclusions**

We have argued that policy initiatives and the LADM standard are both moving from the architectural requirements of the *agency* to the architectural requirements of the *ecosystem*. This represents a significant change in perspective. Ecosystem wide digital transformation has the potential to disaggregate vertically oriented business functions into commoditised components which can be reassembled in a multitude of different REU ways across the ecosystem to the benefit of consumers ([Brown et al., 2014, p. 120](#)). This can enable flexible and responsible government services. The challenge is in how to frame and deliver such transformation.

We have considered this from the point of view of developing well defined generic processes grounded in legal, operational and standards-based concepts. Property law describes both *numerous clausus* and the powers that a right holder has to grant, licence, alienate, discharge, or vary a right. We argued that while the relationships between parties and rights may be

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unique to a jurisdiction, the abstract operations available through powers to change rights are broadly generic between jurisdictions. To reflect this we proposed that generic transactions on a Land Register can be framed through core LADM primitives: a transfer is a transaction in the party dimension; a subdivision or consolidation is a transaction in the land dimension; and a rights alienation or amalgamation is a transaction in the rights dimension. The 2012 revision of ISO19152 does not consider transactions in this manner. We recommend that further research is undertaken to provide improved operational interoperability and introduce generic commodity operations that support process interoperability. This includes explicitly modelling powers, rights, operations, and relationships. We need to find ways in which we can determine what services are common across the ecosystem, what are specific to a sub-set of the ecosystem and which are bespoke to specific agencies or domains ([Brown et al., 2014, pp. 105-114](#)).

The change in focus from the agency to the ecosystem highlights the importance of rights duality in delivering the *once-only principle*. While it is clear that the mandated agency should manage authoritative data, in a *once-only* ecosystem this agency also has the burden of ensuring the *once-only* data is suitable for re-use scenarios outside their mandated remit. Such understanding requires transparent communication between stakeholders. It is only by understanding the operational requirements of the ecosystem at a holistic level can the *once-only principle* be effectively implemented. This requires significant social engineering.

UNECE *principle 20* ([UNECE, 2021, p. 13](#)) predicts machine readable automation of transactions. It is likely that in order to deliver these aspirations a first-order logic semantic representation is required that supports automated reasoning and inferencing. This is likely to be necessary to, amongst other things, infer rights and duties when the *once-only principle* is implemented. While the current hierarchical thesauri formalisations provide essential structure (see, for example, the [Cadastre and Land Administration Thesaurus \(CaLAtThe\)](#) ([Stubkjær & Çağdaş, 2021](#))), there is a need to provide first-order logic based ontologies to support the domain aspirations.

LADM is pivotal to establishing and supporting these ecosystem wide principles. The LADM revision should provide clarity in terms of the foundational concepts, implementation patterns and generic business logic. While LADM was designed to provide interoperability between jurisdictions the revision should support interoperability between agencies within a functioning ecosystem. This is essential to achieve the digital reforms envisaged by UNECE, FAO, and FIG ([UNECE, 2021](#); [FAO et al., 2022](#)). We hope that the approaches in this paper can be refined and included within future versions of the LADM standard.

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