Application of the Land Administration Domain Model to the City of Johannesburg Land Information System

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Abstract

The paper explores the adoption of ISO 19152, Geographic information -- Land Administration Domain Model (LADM), in the enhancement of the current City of Johannesburg Land Information System (CoJLIS) data model. The CoJLIS was established to support integration of property data within various departments of the city. The current CoJLIS is designed for core land information only. There is a need for a comprehensive data model for all property information to support data management. The current CoJLIS upgrade coincides with the development of the LADM by ISO/TC 211, Geographic information/Geomatics. The LADM was published by the International Organization for Standardization (ISO) late in 2012 as an International Standard for modelling basic land administration (LA) information. The LADM aims to provide a common vocabulary within the LA domain. This research examined the core data model of CoJLIS against the corresponding LADM basic classes. The LADM presents an opportunity to adopt an ISO conformant model in the CoJLIS, thus leveraging the benefits associated with the LADM. We show that the LADM can be used to describe land administration information at a municipality in South Africa, but that there are semantic differences, similarities and mismatches of classes and attributes between the LADM and the CoJLIS. The current disconnect between different systems, each managing a different part of the land administration information at the CoJ, is a cause for concern. The research was restricted to the City of Johannesburg. The results improve the understanding of land administration at municipal level in South Africa, but more empirical explorations are necessary to examine the applicability of the LADM within different contexts, more especially in cadastre-less areas (e.g. informal settlements and rural areas).

1. Introduction

ISO 19152, *Geographic information -- Land Administration Domain Model (LADM),* was published by the International Organization for Standardization (ISO) as an International Standard on 19 November 2012 (ISO 19152, 2012). The LADM is a conceptual schema that facilitates the exchange and maintenance of different data sets by different organisations, especially in distributed systems. The schema may be implemented in one or more organisations, at national, regional or

local levels. The LADM design is based on the fact that different organisations have different responsibilities in data maintenance.

In distributed systems, databases are developed independently to serve specific purposes. This implies that the reality is modelled differently depending on the purpose. Various countries have developed cadastres based on different purposes. A cadastre is a 'public register of quantity, value and ownership of land in a country, compiled to serve as a basis for taxation' (Simpson, 1976). This public inventory is usually based on surveyed boundaries. The International Federation of Surveyors (FIG) defines a 'cadastre' as a parcel based, and up-to-date land information system containing a record of interests in land… It usually includes a geometric description of land parcels linked to other records describing the nature of interests, the ownership or control of those interests, and often the value of the parcel and its improvements' (FIG, 1998). It may be designed for fiscal, legal or land use management purposes, etc.

The most common alternatives of cadastral systems implemented in different countries are: 'centralised or decentralised systems; land registration with a separate or integrated cadastre; positive or negative systems of land registration, fiscal or legal cadastres; general or fixed boundaries and parcel identification methods; government-financed systems or self-financed; and systematic or sporadic adjudication' (Bogaerts & Zevenbergen, 2001). These alternatives led to different implementations within and across different countries. In the absence of common vocabulary, the alternative systems implemented by different countries do not facilitate easy exchange of data, particularly across national borders (Hess & de Vries, 2006).

In order to resolve the semantic heterogeneity, the LADM provides a shared conceptualisation within the land administration sphere. The LADM focuses on the rights, restrictions and responsibilities (RRRs) in land and their geospatial components. The LADM can be implemented in one or more organisations. This paper examines the application of the LADM in South Africa, using the City of Johannesburg's Land Information System (CoJLIS) as a case study. The remaining sections are as follows: section 2 discusses related work on the LADM; section 3 provides the CoJLIS background; section 4 presents a cross-mapping between the LADM basic classes and the CoJLIS entities; sections 5 and 6 present the research results and conclusion, respectively. The length limitation of a journal article does not allow a full description of the LADM and the South African system of land administration. We have added explanations and references where applicable and the reader is referred to these for additional information.

2. Related work

The LADM is based on the Cadastre 2014 vision which promotes the complete recordation of private and public RRRs in the future cadastral systems (Kaufmann & Steudler, 1998). It is not intended to be complete for any specific country, but rather aims to be the foundation from which a country-specific model can be established (ISO 19152, 2012). A country's land laws and land-related practices may restrict or allow for extension of the possible instances, attributes and other variables in the LADM (Griffith-Charles, 2010).

A number of countries considered the adaption of the LADM to their local needs. Examples documented in ISO 19152 (2012) are the country profiles for Portugal, Australia, Indonesia, Japan, Hungary, the Netherlands, the Russian Federation and the Republic of Korea. Elia *et al,* (2013) investigated the adaptation of Core Cadastral Domain Model (LADM's earlier version) in the Cyprus Land Information System (CLIS) with the aim of improving its data model. In Portugal, an object-oriented conceptual model based on LADM has been developed for the Portuguese Cadastre and the Portuguese Real Estate Register (Hespanha *et al,* 2009). Pouliot *et al* (2013) used the LADM in a comparative case study between condominium/co-ownership in Quebec (in Canada) and Alsace Moselle (in France).

The United Nations Food and Agriculture Organisation Solutions for Open Land Administration (SOLA) project in Samoa, Nepal and Ghana developed LADM based software and a data dictionary for the development of computerised Land Administration Systems (Lemmen 2012). The objective of the OSCAR project is to develop a cadastral application based on LADM (OSCAR, 2012).

The Federation of International Surveyors (FIG) and United Nations Human Settlements Programme (UN-HABITAT) developed the Social Tenure Domain Model (STDM) as a specialisation of the LADM (Augustinus *et al,* 2006). The STDM is a subset of the LADM for modelling the relationship between people and land in the pro-poor environments e.g. informal settlements, which are mostly excluded from the formal land registrations systems.

In Europe, the LADM was applied in the Infrastructure for Spatial Information in Europe (INSPIRE) in order to 'prove its compatibility' with the INSPIRE cadastral parcel model (ISO 19152, 2012). Further investigations were undertaken to examine the integration of LADM with the European Land Parcel Identification Systems (LPIS) implemented in the European Union. Recent research studies focus on the proper recording of 3D legal rights, especially in urban areas where space is limited (Van Oosterom, 2013; Paulsson, 2013). Navratil and Unger (2013) investigated 3D cadastre requirements for height systems. The LADM allows for inclusion of 3D cadastral registration.

The literature review on the LADM presented examples of various explorations into the application of the LADM in different countries and organisations. However, South African studies exploring the applicability of the model within its local context are not yet available. This research presents an initial exploration of the LADM application within the South African context.

3. City of Johannesburg Land Information System (CoJLIS)

The vision of the City of Johannesburg (CoJ) is to develop a unified repository of property information within its jurisdiction. Historically, the CoJ departments which dealt with property information operated separate databases and systems (Tjia & Coetzee, 2012). This mode of operation made property information maintenance and sharing across departments virtually impossible and resulted in data duplication and misinterpretation. The lack of integration of property data and systems negatively affected service delivery turnaround times for development applications (i.e. township development, subdivision, consolidation, etc.). This in turn affected the

economic growth of the CoJ. Because various departments used independent databases, customers often had to be referred from one department to the other in order to obtain a complete set of property data. This impacted negatively on the customer experience. Figure 1 shows the old CoJ Property Value Chain Model on which the CoJ Land Information System (LIS) is based.

The creation of a property in the CoJLIS begins at the stage when an applicant submits a development application (e.g. township establishment, subdivision, consolidation, etc.). Different processes can be followed: the township establishment process is conducted in accordance with the town planning ordinance; an alternative process is done in accordance with the Less Formal Township Establishment Act (LFTE); or a third alternative process is conducted in terms of the Development Facilitation Act (DFA). The LFTE and DFA processes were popular over the last decades; they were used to fast-tract development post-1994.

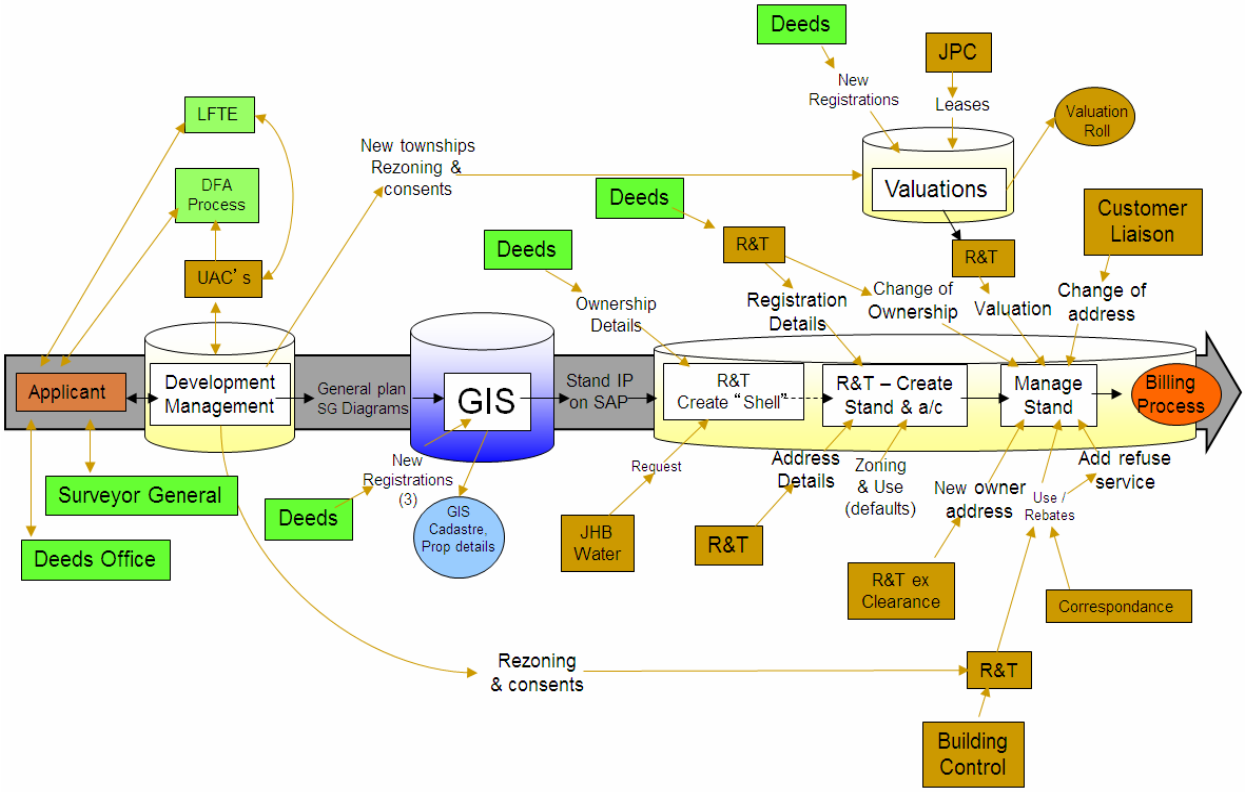

Figure 1. The CoJ Property Value Chain (Tjia & Coetzee, 2012)

A number of entities within and outside CoJ are involved in the development application process. The Utilities, Agencies and Corporatised Entities (UACs), such as JHB Water, City Power, and Jo'burg Water comment on services in the proposed development. The Surveyor-General Office approves the survey plans of developments. The Deeds Office provides the registered property ownership information. The CoJ GIS division captures the Surveyor-General approved plans and allocates street addresses. The Valuation division determines the property value. The Johannesburg Property Company (JPC) supplies the Valuation division with the CoJ lease properties. The Rates and Taxes (R&T) department captures the change of ownership from the deeds ownership data. The Customer Liaison division updates the change of address and also maintains the postal address details. R&T uses the ownership data (new owner's address) to

generate the tax clearance certificates. R&T creates a customer billing account. The Revenue division collects the revenue from the property assessment rates and services charges (e.g. water, sewerage, electricity, etc.). The CoJ property value chain of events is presented in Figure 2.

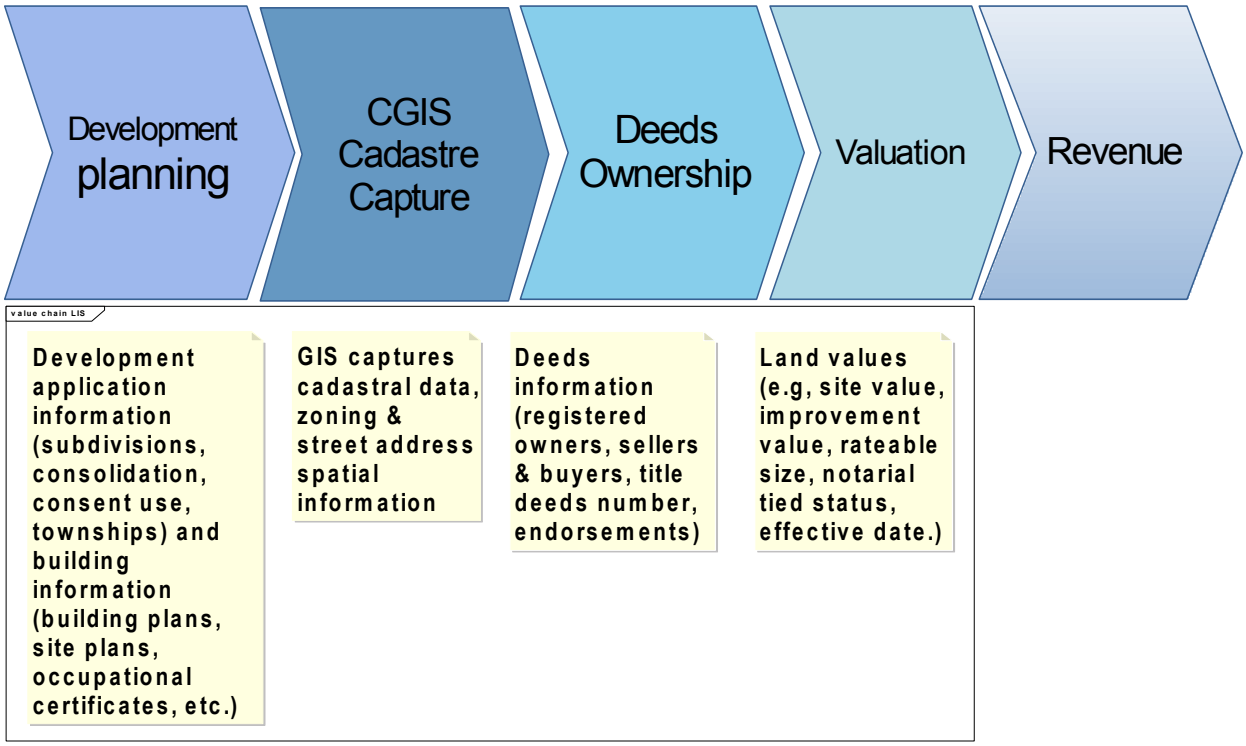

Figure 2. The CoJ property value chain of events

4. Comparison between the LADM basic classes and the CoJLIS

The LADM provides a conceptual framework and the actual implementation of the LADM is dependent on the development of an application schema. The application schema needs to be tested for conformance with the LADM in terms of package and level (ISO 19152, 2012). The LADM specifies three levels of conformance. For the purpose of this paper, the first level was examined which is limited to the basic classes of the LADM. For the first conformance level in the LADM, the following classes, are relevant: VersionedObject, LA_Party, LA_RRR and its specialization LA_Right, LA_BAUnit, LA_SpatialUnit and LA_Source and its specialization LA_AdministrativeSource. In this section the results of the tests for the classes, attributes and associations in the LADM are documented by showing a mapping between the LADM elements and the elements in the CoJLIS data model. Subsection 4.1 shows the class mapping, subsection 4.2 the attribute mapping and subsection 4.3 the mapping of associations. The data in the CoJLIS was inspected as a means to understand the model but it was not tested against the LADM requirements.

4.1. Class mapping

Figure 3 shows the cross-mapping of the LADM basic classes against the corresponding CoJLIS entities. The CoJLIS geodatabase schema was exported into the Enterprise Architect modelling tool using its ArcGIS workspace functionality. The information represented was extracted from sample

data from the CoJLIS database. For readability purposes, the stereotypes are displayed to group the related attributes. The CoJLIS look-up tables are shown as enumerations in Figure 3.

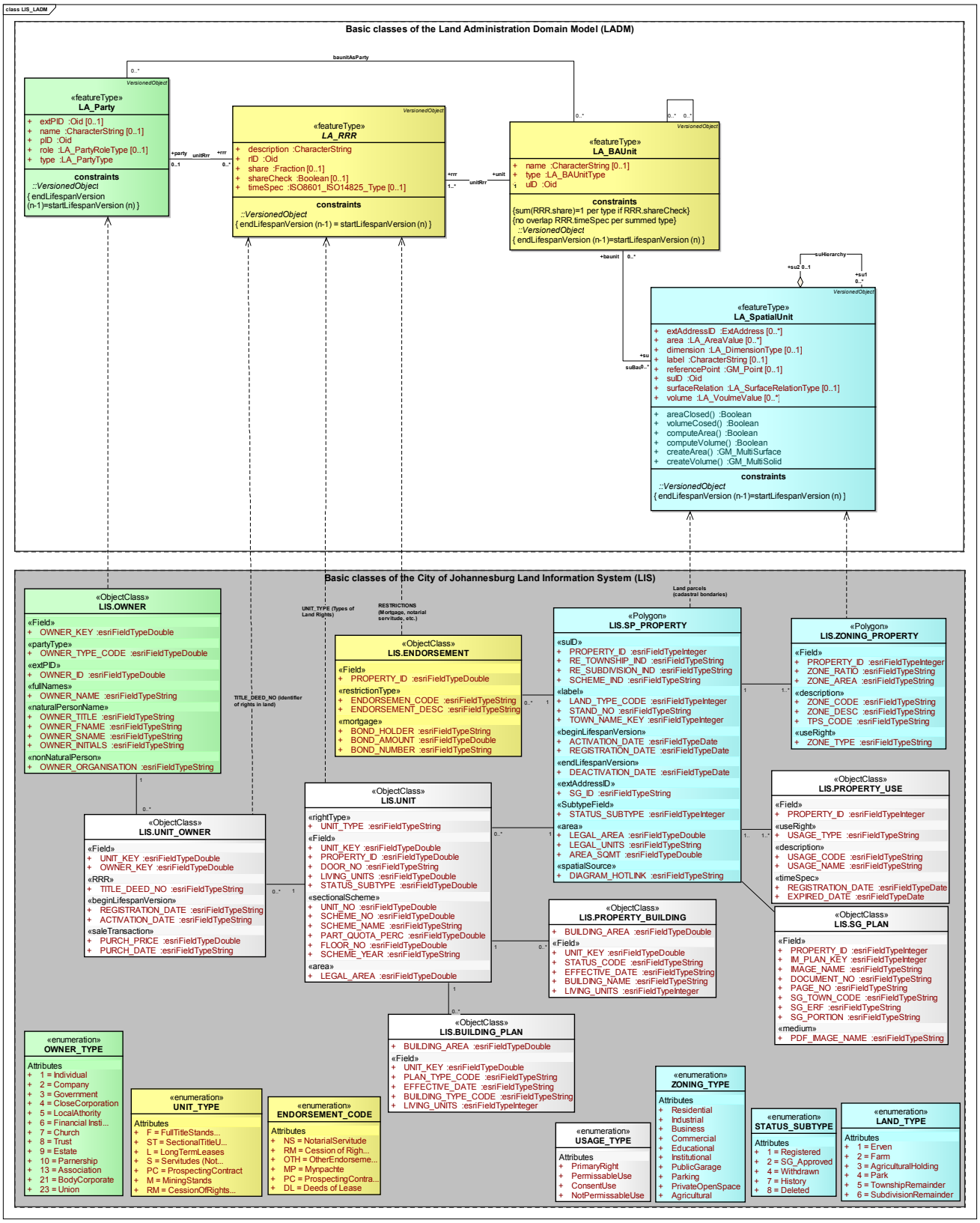

Figure 3. The LADM and CoJ LIS basic classes

The CoJLIS includes information corresponding to the LA_Party, LA_RRR, LA_Right, LA_BAUnit and LA_SpatialUnit classes. VersionedObject, LA_Source and LA_AdministrativeSource are not represented in the CoJLIS. Table 1 shows the mapping between the LADM classes and the CoJLIS entities.

VersionedObject is the superclass of all classes in the LADM. Its attributes store historical data, i.e. inserted and superseded data are given a time-stamp. In this way, the contents of the land administration data can be reconstructed, as they were at any historical moment. The CoJLIS data model contains lineage data (not included shown in Figure 3) for the spatial units only. There is a one-to-many relationship between LIS.SP_PROPERTY and the LIS.LINEAGE entity. The lineage includes descriptive information about the property development processes. CoJLIS does not include timestamps for each individual entity and therefore does not conform to the LADM.

Table 1. The LADM basic classes and their corresponding CoJLIS entities

LADM basic class	**CoJLIS entity**
LA_Party	LIS.OWNER
LA_Right (LA_RRR)	LIS.UNIT_OWNER
LA_Restriction*	LIS.ENDORSEMENT LIS.PROPERTY_USE LIS.ZONING_PROPERTY LIS.BUILDING_PLAN
LA_Responsibility*	-
LA_BAUnit	LIS.UNIT
LA_SpatialUnit	LIS.SP_PROPERTY
	-
LA_AdministrativeSource (LA_Source)*	LIS.SP_PROPERTY. DIAGRAM_HOTLINK
LA_SpatialSource*	LIS.SG_PLAN
VersionedObject	-

* optional class

4.2. Attribute mapping

In this subsection the attributes of the mandatory classes (see Table 1) in the LADM are mapped to corresponding attributes in the CoJLIS data model.

4.2.1. LA_Party and the corresponding CoJLIS OWNER class

The attributes of LA_Party are: extPID (identifier of party in an external database), type of party (e.g. natural and non-natural persons), name of party, the role of party, and the identifier of party (ISO 19152, 2012). Table 2 shows the LA_Party and LIS.OWNER comparison.

The LIS.OWNER entity class contains information about the owner(s) of a property in the role of rate payers or developers. The OWNER_TYPE_CODE attribute stores the code that represents the type of owner: individual, company, close corporation, trust, etc. The owners in the CoJLIS are identified in OWNER_ID by using the identity numbers as captured in the national population

register. Passport numbers are used for foreign nationals. The OWNER_NAME attribute stores the registered legal full name of the owner. The OWNER_TITLE, OWNER_INITIALS, OWNER_FNAME and OWNER_SNAME, as well as the OWNER_ORGANISATION attributes are populated by the Revenue department through the SAP billing system. The OWNER_ORGANISATION attribute represents the organisation's name or names of non-natural parties, such as companies, close corporation, trust, etc

There is duplication of owner names in the CoJLIS data model. The OWNER_NAME and OWNER_ID attributes are populated through the CoJLIS interface, while the OWNER_TITLE, OWNER_INITIALS, OWNER_FNAME, OWNER_SNAME and OWNER_ORGANISATION attributes are populated through the SAP billing system. There is a one-way flow of information from the CoJLIS to the SAP billing system, implying that the OWNER_TITLE, OWNER_INITIALS, OWNER_FNAME, OWNER_SNAME and OWNER_ORGANISATION attributes are available but empty in the CoJLIS data. This duplication results in discrepancies in owner information, for example, when the new owner is filled into the OWNER_NAME attribute but the SAP billing system does not yet reflect the new owner in the other five attributes.

Table 2. LA_Party and LIS.OWNER attribute comparison

LA_Party	LIS.OWNER	LIS.OWNER attribute description
extPID*	OWNER_ID	The ID number (or company registration number) of the owner
name*	OWNER_NAME	The full names of the owner (from the Deeds Office)
	OWNER_TITLE	The title of the owner
	OWNER_INTIALS	The initials of the owner
	OWNER_FNAME	The first names of the owner
	OWNER_SNAME	The surname of the owner
	OWNER_ORGANISATION	The organisation name
pID	OWNER_KEY	The system generated unique identifier of an owner.
role*	-	The CoJLIS model contains only the owners of property. Their role is not distinguished. However, the owner of a property may be a rates payer, buyer or seller
type	OWNER_TYPE_CODE	The type of party (i.e. individual, company, trust, etc.)

* optional attribute

The CoJLIS data model conforms to the LA_Party attribute requirements of the LADM. The OWNER_ID attribute corresponds to the extPID attribute, the OWNER_KEY attribute to the pID attribute and the OWNER_TYPE_CODE attribute to the type attribute in LA_Party. The name attribute in LA_Party is represented by more than one attribute in the CoJLIS data model. There is no attribute in the CoJLIS data model that corresponds to the role in LA_Party. However, this attribute is optional in the LADM.

The CoJLIS is designed to store information about owners of property with the purpose of collecting revenue from property rates and service charges. However, there are a number of other parties involved in the development process at the CoJ. The key parties include an applicant or developer who submits an application for development approval; the surveyor who prepares the

layout plan for the land proposed to be developed; and the conveyancer who collects rates clearance from the municipality and prepares the deed of sale and deed of transfer, certificate of title, etc. Adding the role of the party to the CoJLIS data model would enable representing the fact that parties may play different roles in LA. The current labelling of all parties as owners in the CoJLIS data model restricts inclusion of other parties who are not necessarily the owners but who are involved in the development process and property value chain.

4.2.2. LA_RRR and corresponding CoJLIS classes

LA_RRR is an abstract class with three specializations: LA_Right, LA_Restriction and LA Responsibility (ISO19152, 2012). LA_Right represents an action or set of actions that parties may perform on or using an associated resource. The rights are in the sphere of private and customary law. A restriction (represented by LA_Restriction) is an obligation to abstain from doing something. This can be either formal or informal in nature. An example of a formal restriction in South Africa is a registered servitude for the conveyance of electricity in favour of a specific community. According to the LADM, a mortgage is a special restriction type. A responsibility (represented by LA_Responsibility) is a formal or an informal obligation to perform something. An example from CoJ is the obligation to pay property rates and service charges, or an obligation to maintain the property by fencing it. The attributes of LA_RRR are: description of the RRR, rID, share, shareCheck, timeSpec. Table 3 shows the LA_Right class and LIS.UNIT_OWNER attribute comparison for a property ownership right.

Table 3. LA_Right and LIS.UNIT_OWNER attribute comparison

LA_Right	**LIS.UNIT_OWNER**	**LIS.UNIT_OWNER attribute description**
description*		
riD	TITLE_DEED_NO	The title deed number for the title deed document that is registered at the Deeds Office when the property was transferred to the current owner.
	UNIT_KEY	The system generated unique identifier for a unit.
share*	-	
shareCheck*	-	
timeSpec*	-	
type	TITLE_DEED_NO	The prefix and suffix of the title deed number indicate whether it is full title, sectional title, etc.
	REGISTRATION_DATE	This is the date of registration of the property at the Deeds Office or transfer date to the new owners.
-	ACTIVATION_ DATE	Activation of the ownership right.
-	PURCH_PRICE	The price paid for the property. In these cases one needs to order the copy of the title deed document to get more information.
-	PURCH_DATE	The date the property was purchased (i.e. offer to purchase)
-	OWNER_KEY	The system generated unique identifier for an owner.

* optional attribute

The CoJLIS data model includes the two mandatory LA_Right attributes, rID and type. The TITLE_DEED_NO attribute stores the unique identifier of a right and other interests in land. The data is sourced from the Deeds Office. The Deeds Office allocates unique title deed numbers or lodgement codes. The type of right (i.e. freehold title, sectional title right, leasehold, servitude, mineral right, prospecting right, etc.) is embedded in the prefix and/or suffix of the TITLE_DEED_NO attribute. Additional information about the property transaction is stored in the CoJLIS, namely the title deed registration or transfer date, the activation date, the purchase price, the date of purchase. This information is also obtained from the Deeds Office. In addition the system generated unique identifier of the owner is included in the CoJLIS as a means to link it to the owner of the right.

LIS.ENDORSEMENT in the CoJLIS corresponds to the LA_Restriction and LA_Mortgage classes in the LADM. Endorsements are restrictions registered against a particular property. A property may have zero or more endorsements. Endorsement types are bonds, notarial servitudes, notarial tie agreements, and long-term lease agreements. A mortgage bond is a limited real right and thus also a restriction. Table 4 shows the attribute comparison of LA_Mortgage, a specialization of LA_Restriction, with LIS.ENDORSEMENT for a bond. Corresponding attributes for the mandatory attributes in LA_Restriction and LA_Mortgage are included in the CoJLIS data model.

Table 4. LA_Mortgage and LIS.ENDORSEMENT attribute comparison

LA_Restriction	**LIS.ENDORSEMENT**	**LIS.ENDORSEMENT attribute description**
description*	ENDORSEMENT_DESC	The description of endorsement
rID	ENDORSEMENT_CODE	A unique endorsement code assigned by the Deeds Office.
share*	-	
shareCheck*	-	
timeSpec*	-	
partyRequired*	-	
type (LA_RestrictionType)	ENDORSEMENT_CODE	The type of endorsement (i.e., interdict, bond, etc.) is embedded in the prefix and suffix of the endorsement code.
amount*	BOND_AMOUNT	The amount of the endorsement. In the case of a bond this will be the registered bond amount. This amount is the amount registered and not the outstanding amount.
interestRate*	-	
ranking*	-	
type* (LA_MortgageType)	-	
-	BOND_HOLDER	The name of the bond holder, e.g. ABSA or Standard Bank.
-	BOND_NUMBER	The unique number for the bond assigned by the Deeds Office.

* optional attribute

The ENDORSMENT_CODE and ENDORSEMENT_DESC attributes describe the type of endorsement. These two attributes correspond to the description, rID and type attributes in LA_Restriction. LIS.ENDORSEMENT also contains the bond number, bond amount and the bond

holder. The BOND_AMOUNT in LIS.ENDORSEMENT corresponds to the amount attribute in the associated LA_Mortgage class.

LIS.PROPERTY_USE contains types of restrictions that relate to land use: actual use, permissible use, consent use or illegal (not permitted) use. Land use is regulated by the town planning ordinance of 1986 which makes provision of how land should be used. A change in the land use will result in a change in the market value of the property and ultimately a change in property tax revenue. The actual usage and monitoring of illegal use are defined by the Valuations department and managed by the Law Enforcement division, respectively. Consent use may be given over and above the permissible usage determined by the zoning. Table 5 shows the attribute comparison of LA_Restriction with LIS.PROPERTY_USE for land use restrictions.

Table 5. LA_Restriction and LIS.PROPERTY_USE attribute comparison

LA_Restriction	LIS.PROPERTY_USE	LIS.PROPERTY_USE attribute description
description*	USAGE_CODE	A code to describe the usage
	USAGE_NAME	The descriptive name of the usage
rID	-	
share*	-	
shareCheck*	-	
timeSpec*	-	
partyRequired*	-	
type	USAGE_TYPE	Type of usage (i.e. primary right, permissible use, consent use, non-permissible use)
-	REGISTRATION_DATE	Date of registration of the restriction.
-	EXPIRED_DATE	Date when the restriction expires (could be null).
-	PROPERTY_ID	The unique system generated property identifier.

* optional attribute

The mandatory type attribute in LA_Restriction is included in the CoJLIS data model, but there is no unique identifier for a land use restriction.

LIS.ZONING_ PROPERTY is a spatial layer that records the zoning details associated with individual properties. The ZONE_CODE and ZONE_DESC attributes describe the zoning. The ZONING_TYPE enumeration class shows the zoning types, i.e. residential, industrial, business, etc. In the CoJLIS there is a one-to-many association between a spatial unit and the zoning of that spatial unit, but similar to the land use restriction there is no unique identifier for a zoning restriction.

The CoJ examines and approves building plans within its jurisdiction. A building plan describes the restrictions for buildings on a unit. The approved building plan is a legal document. LIS.UNIT may be associated with zero or more building plans (LIS.BULDING_PLAN). A building plan is a diagrammatic representation of a building. In the CoJLIS a building plan has the following attributes: building plan type, building area, building type, living units and effective date. The information in LIS.BUILDING_PLAN is maintained by the Building Control department within the

Development Management division. In the CoJLIS there is no unique identifier for a building plan; it is associated with a unit through the UNIT_KEY.

In this section we described how rights and restrictions are represented in the CoJLIS data model. The data model does not include responsibilities in the way they are represented in the LADM. Responsibilities, such as maintenance of the property by the owner, e.g. fencing of the property, are commonly found in the deeds document and in the conditions of township establishment. The responsibility information is contained in the original deed document. The valuation and legal administration departments maintain copies of the deeds documents as part of the development application process.

4.2.3. LA_BAUnit and the corresponding CoJLIS UNIT class

The basic administrative unit (LA_BAUnit) in the LADM corresponds to LIS.UNIT in the CoJLIS data model. The LA_BAUnit may consist of 'zero or more spatial units against which one or more unique and homogenous rights, restrictions and responsibility are associated to the entire entity as included in a land administration system' (ISO 19152, 2012). A right, restriction or responsibility may be held by one or more parties for the whole LA_BAUnit. A right, restriction or responsibility can relate to a specific portion of a spatial unit where the geometry of such portion is absent: for instance, the right of way servitude of which the area and location are described textually (and not specified with coordinates or reference points). The attributes of LA_BAUnit are: name, type and uID (identifier). Table 6 shows an attribute comparison between LA_BAUnit and LIS.UNIT.

LIS.UNIT_TYPE identifies the type of basic administrative unit, including full title, servitude and long term lease. Many of the attributes in LIS.UNIT are related to a sectional title unit only, which could lead one to think that the entity represents only sectional title units. The DOOR_NO, FLOOR_NO and LIVING_UNITS attributes are populated by the Valuation department. The LEGAL_AREA and PART_QUOTA_PERC attributes are used for the valuations. The sectional title unit information is represented in SCHEME_NO, SCHEME_NAME, UNIT_NO and SCHME_YEAR and is imported from the data from the Deeds Office. LIS.UNIT includes the two mandatory attributes (type, uID) specified for a LA_BAUnit in the LADM.

Table 6. LA_BAUnit and LIS.UNIT attribute comparison

LA_BAUnit	LIS.UNIT	LIS.UNIT attribute description
name*	-	
type	UNIT_TYPE	Identifies the type of unit: full title, sectional title, long term lease, servitude, prospecting contract, mining stand or cession of rights.
uID	UNIT_KEY	System generated unique identifier for the unit.
-	DOOR_NO	Door number of the unit, which could differ from the unit umber. Only applicable for sectional title schemes.
-	FLOOR_NO	Floor number of the unit. Only applicable for multi-storey sectional title schemes (e.g. flat blocks).
-	LIVING UNITS	Number of living units (households) on the unit.
-	LEGAL_AREA	Legal area of the unit.
-	PART_QUOTA_PERC	The legal area as a percentage of the total area of the sectional title unit. Only applicable for a sectional title unit.
-	STATUS_SUBTYPE	Status indicator of the unit, i.e. registered, approved, withdrawn, etc.
-	SCHEME_NO	Number of the sectional title scheme. Only applicable for a sectional title unit.
-	SCHEME_NAME	Name of the sectional title scheme. Only applicable for a sectional title unit.
-	UNIT_NO	Unit number in a sectional title scheme. Only applicable for a sectional title unit.
-	SCHEME_YEAR	Year in which the sectional title scheme was registered. Only applicable for a sectional title unit.

* optional attribute

4.2.4. LA_SpatialUnit and the corresponding CoJLIS SP_PROPERTY class

The LADM defines a spatial unit as 'a single area (or multiple areas) of land and/or water, or a single volume (or multiple volume) of space' (ISO 19152, 2012). Spatial units support the creation and management of basic administrative units. There are different types of spatial units: sketch-based, text-based, point-based, line-based, polygon-based, or topology-based. The attributes of LA_SpatialUnit are: area, dimension (of the spatial unit), extAddressID (link(s) to external address(es) of the spatial unit), label (a short textual description of the spatial unit, e.g. for local purposes), referencePoint (a co-ordinate set of a point inside the spatial unit), suID (spatial unit identifier), surfaceRelation (above or below the surface) and volume (in case of a 3D spatial unit). Table 7 shows an attribute comparison between LA_SpatialUnit and LIS.SP_PROPERTY.

LIS.SP_PROPERTY contains information related to the geospatial component of the rights. Sectional scheme and township boundaries are not included here, but are modelled separately in the CoJLIS. The property data is captured from approved Surveyor-General general plans and diagrams. LIS.SP_PROPERTY has a corresponding attribute for the single mandatory attribute (suID) in LA_SpatialUnit.

Table 7. LA_SpatialUnit and LIS.SP_PROPERTY attribute comparison

LA_SpatialUnit	LIS.SP_PROPERTY	LIS.SP_PROPERTY attribute description
extAddressID*	-	
area*	AREA_SQMT	The area as calculated by a cadastral capturing tool.
dimension*	-	
label*	SG_ID	The complete description of the property by land parcel type, stand number, registration division identifier, township number. For example, 'Erf 45 Braamfontein'.
	STAND_NO	Unique stand number within the proclaimed town, e.g. '45'.
	TOWN_NAME_KEY	The foreign key that links LIS.SP_PROPERTY to the township name entity (not represented in CoJLIS core of this article).
referencePoint*	-	
suID	PROPERTY_ID	The unique property identifier
surfaceRelation*	-	
volume*	-	
-	LEGAL_AREA	This area is captured from the Surveyor-General approved plans or diagrams.
-	LAND TYPE_CODE	The type of land: erf, farm, agricultrual holding, etc.
	ACTIVATION_DATE	Date on which this property was activated in the CoJLIS.
	REGISTRATION_DATE	Date on which this property was registered at the Deeds Office.
	DEACTIVATION_DATE	Date on which this property was deactivated in the CoJLIS, e.g. if it is not approved and thus will not be registered at the Deeds Office.
	STATUS_SUB_TYPE	Status indicator of the property, i.e. registered, approved, withdrawn, etc.
	LEGAL_AREA	Legal area of the property
	LEGAL_UNITS	Units in which the legal area is represented, e.g. ha or m^2
	DIAGRAM_HOTLINK	Link to a copy of the document. See explanation in 4.5.

* optional attribute

A property is identified by a unique property identifier which is made up of an external identifier (SG_ID) and additional digits to represent the complex urban environment of the city. The SG_ID is the identifier of the land parcel (cadastral property) in the Surveyor-General's cadastral information management system. There are two types of areas in the LIS.SP_PROPERTY: the legal area and the area calculated by a cadastral capturing tool.

LIS.SP_PROPERTY contains only 2D representations of land parcels, therefore the dimension and volume attributes are not relevant. The surfaceRelation attribute is not applicable, because the CoJLIS does not distinguish whether the property is on, below or above the surface.

There are different registered types of property, namely: erven (i.e. cadastral parcels in an urban area), farms (normally associated with rural or areas outside the cadastral demarcations), agricultural holdings and others (refer to the LAND_TYPE enumeration).

In the LADM the LA_SpatialUnit class has two specializations: LA_LegalSpaceBuildingUnit and LA_LegalSpaceUtilityNetwork. The LA_LegalSpaceBuildingUnit provides for the registration of legal space in a building as opposed to traditional models where registration of legal space was limited to land parcels only. In the CoJLIS LIS.UNIT may be associated with zero or more

buildings (LIS.PROPERTY_BUILDING). A building property has attributes such as a building name, building area, effective date, a status code and living units. The BUILDING_AREA attribute represents the legal space that can be covered by a building.

4.2.5. LA_AdministrativeSource and the CoJLIS

Table 8. LA_AdministrativeSource attribute comparison

LA_AdministrativeSource	LIS.SP_PROPERTY	LIS.SP_PROPERTY attribute description
acceptance*	-	
availabilityStatus	-	
extArchiveID*	DIAGRAM_HOTLINK	A link to the title deed document
lifeSpanStamp*	-	
maintype*	-	
quality*	-	
recordation*	-	
sID	-	
source*	-	
submission*	-	
text*	-	
type	-	

* optional attribute

Table 8 shows the attribute comparison for LA_AdministrativeSource. The LA_Source and its subclass LA_AdministrativeSource provide information about the availability and type of a source document, e.g. a title deed document for a property ownership right. An optional attribute in LA_AdministrativeSource specifies in which multimedia format the document is available. In the CoJLIS there are no entities corresponding to these two classes, but the DIAGRAM_HOTLINK attribute of the LIS.SP_PROPERTY class provides a link to the external source document. However, the link is not yet functional in the CoJLIS implementations (i.e. nothing happens when clicking on it). The CoJLIS data model is thus incomplete when compared to the LADM requirements about LA_AdministrativeSource.

4.3. Association mapping

Table 9 maps LADM associations to the corresponding associations in the CoJLIS data model. The associations in the CoJLIS are either equivalent or more restrictive than those in the LADM, except for LA_BAUnit's associations to LA_Right and LA_Restriction. In the LADM there is a mandatory association between a basic administrative unit to a right or restriction, but in the CoJLIS this association is optional.

Table 9. Comparison of mandatory associations in the LADM and CoJLIS

LADM source class	**LADM Destination class**	**CoJLIS Source entity**	**CoJLIS Destination entity**
LA_Party (0..1)	LA_Right (0..*)	LIS.OWNER (1)	LIS.UNIT_OWNER (0..*)
LA_Party (0..1)	LA_Restriction (0..*)	LIS.OWNER (1)	LIS.ENDORSEMENT (0..*), via LIS.UNIT_OWNER, LIS.UNIT and LIS.SP_PROPERTY
		LIS.OWNER (1)	LIS.PROPERTY_USE (1..*), via LIS.UNIT_OWNER, LIS.UNIT and LIS.SP_PROPERTY
		LIS.OWNER (1)	LIS.ZONING_PROPERTY (1..*), via LIS.UNIT_OWNER, LIS.UNIT and LIS.SP_PROPERTY
		LIS.OWNER (1)	LIS.BUILDING_PLAN (0..*), via LIS.UNIT_OWNER and LIS.UNIT
LA_Party (0..1)	LA_Responsibility (0..*)	n/a	n/a
LA_BAUnit (1)	LA_Right (1..*)	LIS.UNIT (1)	LIS.UNIT_OWNER (0..*)
LA_BAUnit (1)	LA_Restriction (1..*)	LIS.UNIT(1)	LIS.ENDORSEMENT (0..*), via LIS.SP_PROPERTY
		LIS.UNIT (1)	LIS.PROPERTY_USE (0..*), via LIS.SP_PROPERTY
		LIS.UNIT (1)	LIS.ZONING_PROPERTY (0..*), via LIS.SP_PROPERTY
		LIS.UNIT (1)	LIS.BUILDING_PLAN (0..*)
LA_BAUnit (1)	LA_Responsibility (1..*)	n/a	n/a
LA_Right (0..*)	LA_AdminstrativeSource (1..*)	LIS.UNIT_OWNER (0..*)	LIS.SP_PROPERTY. DIAGRAM_HOTLINK (1), via LIS.UNIT
LA_Restriction (0..*)	LA_AdminstrativeSource (1..*)	LIS.ENDORSEMENT (0..*)	LIS.SP_PROPERTY. DIAGRAM_HOTLINK (1)
		LIS.PROPERTY_USE (1..*)	LIS.SP_PROPERTY. DIAGRAM_HOTLINK (1)
		LIS.ZONING_ PROPERTY (1..*)	LIS.SP_PROPERTY. DIAGRAM_HOTLINK (1)
		LIS.BUILDING_PLAN (0..*)	LIS.SP_PROPERTY. DIAGRAM_HOTLINK, via LIS.UNIT
LA_Responsibility (0..*)	LA_AdminstrativeSource (1..*)	n/a	n/a

5. Discussion of the results

The study compared the key entities in the CoJLIS data model concerned with parties, rights, restrictions and responsibilities, administrative and spatial units of land against the LADM basic classes. While there are corresponding CoJLIS entities for the relevant LADM basic classes, there are semantic differences between them. For example, the parties in the CoJLIS are modelled as owners. This restricts the inclusion of other parties involved in the land administration process. Another difference is that the CoJLIS data model contains descriptive lineage data for the spatial

units only, whereas the LADM prescribes timestamps (but not descriptive information) for any change to an instance of most classes.

The duplication of owner name information in LIS.OWNER and the one-way flow of this information from CoJLIS to the SAP billing system, results in discrepancies in owner information. For example, when the new owner is filled into the OWNER_NAME attribute but the SAP billing system does not yet reflect the new owner in the other five attributes. Such discrepancies have been the cause of billing problems and bad publicity for CoJ in the past.

The CoJLIS data model includes the relevant mandatory attributes specified for rights and restrictions in the LADM. However, additional information about the property transaction is included for the ownership right in the CoJLIS data model.

The identification of the nature of registered rights in the CoJLIS is not straight forward. It requires the interpretation of codes used to describe the types of rights. For example, the prefix and suffix before and after the serial number and year in the title deed number specifies the nature of the deed or document. This system of codes originates from the South African Deeds Office. Similarly, the identification of restrictions is a function of interpreting codes.

Information about restrictions on land, such as land use, zoning and building plans, are included in the CoJLIS but they do not have individual unique identifiers, as prescribed in the LADM. The reason is that these restrictions are managed in different systems at other CoJ departments. The disconnect between these systems and the CoJLIS is a cause for concern. Additional restrictions, such as coverage of buildings, floor area ratios, building lines and other general restrictions are not represented at all in the CoJLIS, which is another cause for concern.

Responsibilities, such as maintenance of the property by the owner, e.g. fencing of the property, are commonly found in the deeds document and in the conditions of township establishment. The responsibility information is contained in the original deed document, but the CoJLIS does not include responsibilities. Responsibilities are not required for the first conformance level of the LADM.

In the LADM there is a mandatory association between a basic administrative unit to a right or restriction, but in the CoJLIS this association is optional. CoJLIS does however include the two mandatory attributes (type, uID) specified for a LA_BAUnit in the LADM.

The type of spatial units in the CoJLIS include are land parcels. These are 2D representations of property boundaries. In the absence of 3D cadastral boundaries, the sectional title units in a flat or multiple-story building are not accurately represented geospatially. CoJLIS does not specify whether the property is on, below or above the ground. One of the attributes of the spatial unit in the CoJLIS links to a source document, i.e. a one-to-one association. This association is more restrictive than specified in the LADM, which allows multiple source documents for a basic administrative unit.

The cross-mapping of the LADM basic classes and CoJLIS entities revealed that there are semantic differences in terms of class naming and attributes. There are also mismatches and similarities in terms of attributes that are stored in the LADM and the CoJLIS. The attribute naming

in CoJLIS allows different interpretations. For example, the UNIT_TYPE attribute represents types of rights and the ENDORSEMENT entity represents private restrictions registered against the property by the Deeds Office. The ZONING_PROPERTY and the PROPERTY_USE entities contain public restrictions set according to the town planning ordinance applicable to the CoJ. Such ambiguous interpretations can be the cause confusion.

6. Conclusion

This research compared the CoJLIS data model to the LADM, an internationally standardized conceptual land administration domain model. The LADM offers an opportunity for the CoJLIS upgrade project to develop an integrated property database model based on international standards. We have shown that the LADM can be used to describe land administration information at a municipality in South Africa, but that there are some semantic differences, as well as similarities and differences between classes, attributes and associations. Semantic differences are evident in the terminology discrepancies between the CoJLIS and the LADM. A first step for CoJ could be to convert the CoJLIS terminology to correspond to the internationally accepted LADM terms and definitions. This would already improve communication about land administration within the CoJ.

The current disconnect between different systems, each managing a different part of the land administration information at the CoJ, is a cause for concern. It is our understanding that work on a single integrated system has started.

The results of this research improve the understanding of land administration at municipal level in South Africa, but additional work is needed to describe the deeds and cadastral information produced by the Surveyor General's and Deeds Offices, i.e. a full South African profile of the LADM. For example, the CoJLIS relies heavily on data received from the Deeds Office, where the type of the deed or document is embedded in the title deed number.

The CoJLIS is based on the formal land registration system in South Africa which deals with registered land rights at the Deeds Office. For this reason, the CoJLIS model does not accommodate other property rights which have been created by the South African land reform programme. For the future, the incorporation of informal land rights is critical for the regularization of CoJ informal settlements. The concept of spatial unit could represent informal settlements in the CoJLIS. Further investigation into the possible use of the STDM is recommended.

7. Acknowledgements

The authors acknowledge the assistance of officials from the City of Johannesburg, the Surveyor-General's Office in Pretoria and the Chief Registrar of Deeds Office for their support in sharing valuable information. This is an extension paper of a paper titled 'Land administration domain model: application to the City of Johannesburg land information system, South Africa', presented at GISSA Ukubuzana 2012, Kempton Park, South Africa, October 2012.

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