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**DOI**

[10.1080/00396265.2018.1503481](https://doi.org/10.1080/00396265.2018.1503481)

**Publication date**

2018

**Document Version**

Final published version

**Published in**

Survey Review

**Citation (APA)**

Polat, Z. A., Alkan, M., van Oosterom, P. J. M., & Lemmen, C. H. J. (2018). A LADM-based temporal cadastral information system for modelling of easement rights–A case study of Turkey. *Survey Review*, 52 (2020)(370), 1-12. <https://doi.org/10.1080/00396265.2018.1503481>

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# A LADM-based temporal cadastral information system for modelling of easement rights – A case study of Turkey

Z. A. Polat<sup>1</sup>, M. Alkan<sup>\*1</sup>, P. J. M. van Oosterom<sup>2</sup> and C. H. J. Lemmen<sup>3</sup>

Type people to land relations are dynamic and, as a consequence, the nature of land title and cadastral data is of a dynamic nature. Land title and cadastral data are core components for a lot of property applications (e.g. taxation, valuation, mortgage). Those applications require up to date, complete and reliable data – including temporal data as in use in application forms and transactions. In this paper, the modelling of Rights, Restrictions and Responsibilities (RRR) is discussed with a focus on the modelling of easement rights in a case study in Turkey. Functional requirements with respect to the characteristics of easement rights are investigated based upon interviews with professional experts in the public and private sector. Then a prototype model was built based on a simple implementation of the Land Administration Domain Model (LADM) RRR classes and by conforming to the national cadastral data management standards related to land registration systems. This new proposed model includes temporal cadastral attributes related to easements. This is materialised in the ‘Administrative Package’ and illustrated in the Turkey LADM country profile. We show that the LADM can be used to describe for the time dimension of cadastral information in Turkey, but that there are semantic differences, similarities and mismatches of classes and attributes between the LADM and the cadastral information system in Turkey. Proposed LADM-based model for the time dimension of cadastral information will be of immense advantage to land administrators, the governments and land users in Turkey.

**Keywords:** Temporal LTC data, ISO 19152 LADM, Easement rights, Land registry, Cadastre, Turkey Country profile

## Introduction

Cadastral data are essential in managing land resources. For this reason, land registration and cadastre together play an important role in a society (Liang 2008). Land data are dynamic (Leksiono *et al.* 2011). Data are continuously changing because of changes in people to land relationships as a consequence of the increasing complexity and flexibility of modern land use (Kalantari *et al.* 2008, Doner *et al.* 2011). Economic activities such as area development and settlement needs cause changes in the shape of parcels, changes in the ownership and changes in the use of parcels (Ning 2006). Changing related to real property (e.g. land parcels) effects changing in land registration data where it could be categorised into two types: spatial changing (geometric data) and attribute changing (juridical data) of a land parcel (Zevenbergen 2002, Zhang and Tuladhar 2006, Liang, 2008, Leksiono *et al.* 2011). Zevenbergen (2002) explains three main things of land

registration with regard to the dynamics of land registration system: (1) initial land registration, (2) transfer of land rights (the whole land parcel) and (3) parcel mutation/splitting due to partial transfer of land rights.

Land information systems should be able to store, manage and represent information of a land registration, including its changes either spatially or textually. Spatial information with its temporal changing is required not only because of land registration function itself but also to enable the sustainability of land administration function (Wang *et al.* 2015). This temporal changing is also used to examine the history of land parcels and the development of areas as well for land dispute resolution (Sucaya 2009).

As stated by Leksiono *et al.* (2011), a data model for land registration which is able to manage data at the same time in terms of its geometry, its attribute and its time in databases is required to streamline the function of the land information system. For this reason, it is expected that the spatial temporal elements of land registration can be managed thoroughly.

Land title and cadastral data have a great variety of users, legal authorities, various state organisations, private sector companies, local governments, owners and many others need this data (Comert and Alkan 2004). This need is not only for updated but also for ‘historic

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data' which mean the data concerning the past transactions providing the history of ownership of real estates. Traditional land title and cadastre systems enable temporal analyses. Nevertheless, in most of the cases performing an analysis may be a tedious, time consuming, and error-prone task (Comert and Alkan 2004, Alkan 2005). Therefore, needed is a Temporal Geographic Information Systems for land title and cadastral data. As stated by Doner and Biyik (2013), Inan and Yomralioglu (2011), Ozcelik and Nisanci (2015), Land Administration Domain Model (LADM) could be used to the model land registration process in Turkey by involving party, Rights, Responsibilities, and Restrictions (RRR), land parcel, and also its spatial representation. By adding dimension of time, its start date and end date, for every type of data which requires investigation of its history, the type of data for a certain time could be acquired (van Oosterom and Lemmen 2001).

This paper investigates temporal aspects of the LADM (ISO 2012) associated to RRR situations within Turkish cadastral registration system. For this purpose, easements which are registered in the Turkish land registry system have been analysed in terms of temporal aspect and have been designed a conceptual model under the legal-administrative components (RRR) of the standard LADM.

This paper is structured as follows: the cadastral system in Turkey (including cadastral system structure and cadastral activities) is introduced in second section; the temporal aspect of cadastre in third section; a brief review of the LADM and its temporal aspects (including description of relevant concepts and land administration models) is given in fourth section; then the modelling of easement rights in LADM is developed in fifth section and finally in sixth section discussion and conclusions is provided.

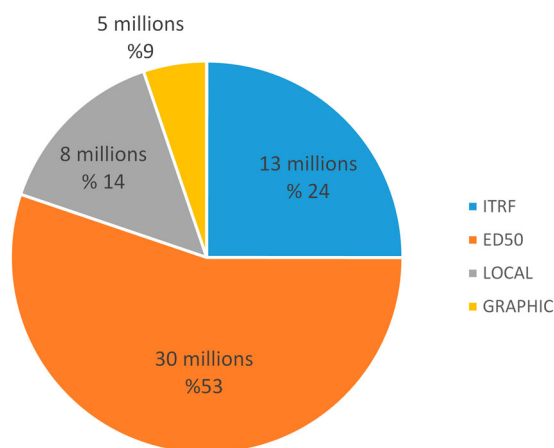
## The cadastral system in Turkey

The Cadastre system in Turkey concerns both cadaster and land registry (Alkan 2005, Doner and Biyik 2007, Alkan and Comert 2010, Doner and Biyik 2013). The basic unit is a 2-dimensioned parcel (Aydin 2008). While land registry and cadastral work is done under the control of General Directorate of Land Registry and Cadastre (GDLRC) (Alkan 2005, Doner and Biyik 2007, Aydin 2008), rights of property are under state guarantee (Cay et al. 2009). Cadastral works in Turkey started in Ottoman Empire period in 1912 but were left unfinished due to the war and were started again with Law No 658 in 1925 after the foundation of Turkish Republic (Doner and Biyik 2007, Ayazli et al. 2008, Aydin, 2008, Cay et al., 2009). Cadastral works made until 1950 were mostly limited to urban areas (Doner and Biyik 2007). After Second World War, there was a need for determining and registering agricultural areas and cadastral works covered all urban and rural areas (Alkan 2005, Kucukmehmetoglu and Geymen 2016). Works in this period were according to Land Registry Law No 5602 (Ayazli et al. 2008, Aydin 2008). This law was re-issued as Land Registry Law No 766 after the changes in 1964 and 1966. Cadastral works in rural and urban areas until 1987 were made under these two laws (Doner and Biyik 2007, Ayazli et al. 2008, Aydin 2008). Today all these cadastral works and regulations are made according to the provisions of Cadastral Law No

3402 coming into force in 1987 (Demir et al. 2003, Alkan 2005, Doner and Biyik 2007).

98% of two-dimensioned cadastre of Turkey has been completed (GDLRC 2015). Different measurement techniques, e.g. photogrammetric, orthogonal, tacheometric, graphic, and different coordinate systems and map scales were used during these works (Aydin, 2008). As the result of cadastral works started in the beginning of 1900s, 9% of cadastral information was produced in graphic – not related to a coordinate system, 14% in local coordinate system, 53% in ED50 coordinate system and 24% in ITRF coordinate system (Fig. 1) (GDLRC 2015). Conversion from analogue to digital of the cadastral maps could not be completed due to such different techniques and coordinate systems for cadastre used in time. Also available legal regulations do not give opportunity for the renewal of cadastre. When technical and legal deficiencies in cadastral system are considered, the need for passing to a multi-targeted cadastral model for a sustainable cadastral system occurred (Aydin 2008). Some studies in Turkey have been made in order to ensure the modern cadastral system in the direction with LADM. Döner (2010) examines the support of 3D cadastre by the LADM in his doctoral thesis titled 'Three Dimensional Approach for Turkish Cadastral System'. Inan and Yomralioglu (2011) examined the LADM in their work and proposed spatial modelling for the land administration in Turkey. Çete and Inan (2013) touched on the importance of the cadastre of Turkey by taking the LADM in their work. Aydınoglu and Inan (2014) have developed a land registry and cadastral-based data model and have associated them with the Land Registry Cadastre Information System (TAKBIS in Turkish) and the Turkish National Geographic Information System (TUCBS in Turkish) projects.

With the effect of technological developments, some projects and works were developed in order to develop to a modern, computerised cadastre in Turkey. A digital environment increases the level of cadastral service and brings a platform for improvement of data quality (Doner and Biyik 2007). The aim of the projects and works and related 2014 Cadastre principles (Kaufmann and Steudler 1998) are summarised in Table 1. Projects were partially successful, a three-dimensional cadastre after completing two dimensioned cadastre in the whole



1 Per cent of cadastral data prepared in different coordinate systems (URL 1)

**Table 1 The relationship between each project and Six Statements on Cadastre 2014 and their realisation percentages**

Name of activity/project	Start/end date	The Six Statements on Cadastre 2014					
		1- Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions	2- The separation between 'maps' and 'registers' will be abolished!	3- The Cadastral mapping will be dead! Long live modelling!	4- 'Paper and pencil - cadastre' will have gone!	5- Cadastre 2014 will be highly privatized! Public and private sector are working closely together!	6- Cadastre 2014 will be cost recovering!
Land Registry and Cadastre Information System (TAKBIS)	2005–2013	Related	Related	–	Related	–	–
Spatial Property System (MEGSİS)	2011–continues	–	Related	–	Related	–	–
Land Registry Archive Information System (TARBİS)	2005–2009	–	Related	Related	–	–	–
Land Registry and Cadastre Modernization Project (TKMP)	2008–continues	Related	–	–	–	Related	–
Map Data Bank (HBB)	2004–2008	–	–	Related	Related	–	Related
Turkey's National Geographic Information System (TUCBS) Project	2006–2011	Related	–	Related	–	–	–
licenced mapping and cadastre offices	2005–continues	–	–	–	–	Related	–
Tax and fees		–	–	–	–	–	Related
Applied percentages of Statements on Cadastre 2014 (in Turkey)		60–80	100	60–80	80–100	100	100

country is not yet achieved in technical terms. The other reason is insufficient regulations in legal terms to pass to multi-aimed cadastre.

## Temporal aspects of Cadastre

Owing to the relations between human beings and land (e.g. residence, economic and nutrition) changes in the use, physical form and ownership information of land take place (Ning 2006). These changes cause changes in the land registry where data are examined under two categories; spatial changes (physical data) and feature changes (legal data) (Zevenbergen 2002). Every change occurring has a time component and this time information is needed to be able to register these changes. Information on (1) first register of land, (2) transfer of land rights and (3) geometric changes of the land are mostly recorded in traditional land registry systems (Zevenbergen 2002, Leksono et al. 2011). Today changes in land use in rural and urban areas require evidence that all physical and legal conditions above and under the land are met and, with that, acquirement of these information for the past (time record) by land information systems. Spatio-temporal data are required not only in land registry, but also for sustainable land management (Leksono et al. 2011). Further this time change in spatial information is used in the investigation of property rights for the land parcel's past and for solving land disputes (Sucaya 2009). In this regard, time information is crucial in decision making (Siejka et al. 2014). Langran (1992), Salzman et al. (1998), van Oosterom et al. (2006) and Siejka et al. (2014) summarised six main constituents of time as below:

- Surveying (inventory description) – case of cadastre and land registry.
- Analysis (explanation, estimate, planning) – very important function, especially in case of cadastral data use for spatial planning or land consolidation, as well as in analyses of trends of real estate price changes.
- Updating (replacing outdated information with new information) – this is the basic function of cadastre and real property registers. The owner can receive up-to-date cadastral data for his own purposes at any time.
- Quality control (monitor and evaluate new data, consistent with old data) – in case of cadastre and land registry this can be of importance in many cases, e.g. in case of cadastral map renovation,
- Planning (determination of appropriate order of data registration) – there are many examples of inconsistencies between real property registers and cadastral registers, due to different procedures of data entry and update.
- Display (generate maps or tables of a temporal process) – this could be a land consolidation process in case of cadastre and land registry.

Temporal dimension cadastre has different types. There are three distinct 'types' of time in cadastral databases van Oosterom et al. (2006):

### 1- Database time:

- history of cadastral database updates – e.g. for the supply of updates to users of copies of cadastral data who are maintaining their own databases).
- tentative updates – when the database is updated, but the update is not made public to everyone until it is 'signed off'.

### 2- Legal event time:

- date and time of signing transactions related to ownership and other real rights
  - date and time of acceptance of an application
- ### 3- Variation of the right with time:
- limitation of tenure – e.g. 99-year lease
  - future rights – will take effect in ...
  - periodic tenure – e.g. timeshare apartment, seasonal grazing right
  - 'Slow and Imperceptible' – property boundary defined by river or sea

Changes related to ownership can occur on rights that they vary with time, and pre-registration of time-varying rights can be required. According to van Oosterom et al. (2006), the types 1 and 2 are more of a recording nature (both real world and system times) and use time stamps in the past. Type 3 is a bit different and may also describe time in the future.

## Brief review of ISO 19152 LADM and its temporal aspects

Since traditional land registry systems are unsatisfactory in meeting all land requirements, the need for a sustainable land management model occurred in order to manage, present and archive land-related information and documents (Leksono et al. 2011).

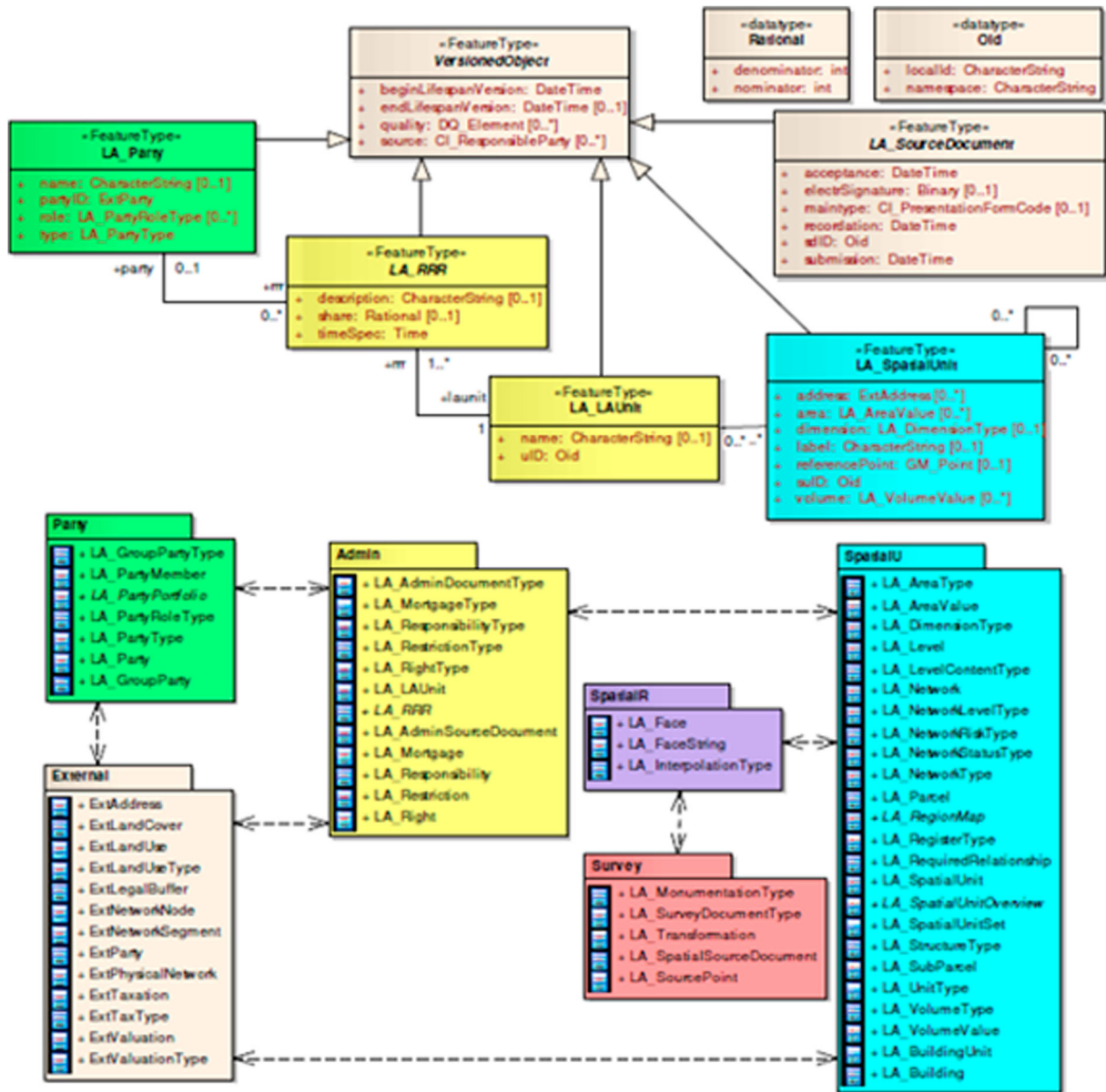
Although scientific studies are made in support to standardisation in the land administration field, they were limited in many aspects, e.g. extensiveness, scope and content, due to the uncommon characteristics of Land Administration Systems (LAS) worldwide (Inan and Yomralioglu 2011). In order to provide standardisation for the main common characteristics of LASs, spatial data modelling studies were brought up by van Oosterom and Lemmen (2002) in 2002 for the first time. These studies, called Core Cadastral Domain Model in the beginning stage, are managed in cooperation with International Federation of Surveyors (FIG) and called LADM in the latter stage. Later, the model was given a standard number after being accepted under the name ISO 19152 LADM by ISO in 2012 (Paasch et al. 2015)

LADM has capability to provide an abstract description and conceptual schema (Lemmen et al. 2015, van Oosterom and Lemmen 2015) concerning land administration components such as parties (person and organization), basic administrative units and RRR in case of ownership, spatial unit (e.g. parcels, buildings, and networks), spatial source (measurement) and spatial representation (geometry and topology). LADM also gives terminology (Lemmen et al. 2015, Paasch et al. 2015) for land administration based on either national or international system that is developed as simple as possible for practical purposes (Leksono et al. 2011, Kalantari et al. 2015).

The LADM is based on four (sub) packages classes (Fig. 2). The basic packages of LADM are described below.

### The party package

The definition of 'party' implies that a party may be a natural person, or a group of natural persons, or a non-natural person (Lemmen et al. 2010, Elia et al. 2013). The main class of the Party Package is the basic class LA\_Party (with party as an instance). LA\_Party has a specialization: LA\_GroupParty (with group party as an instance).



2 LADM core model representation and involved packages Ghawana et al. (2010)

Between LA\_Party and LA\_GroupParty there is an optional association class: LA\_PartyMember (with party member as an instance) (ISO, 2012, Tjia and Coetzee 2012, Elia et al. 2013i Lemmen et al. 2015). Parties are persons, or groups of persons, or juridical persons, that compose an identifiable single (legal) entity. A juridical person may be a company, a municipality, the state, a farmer cooperation, or a church community.

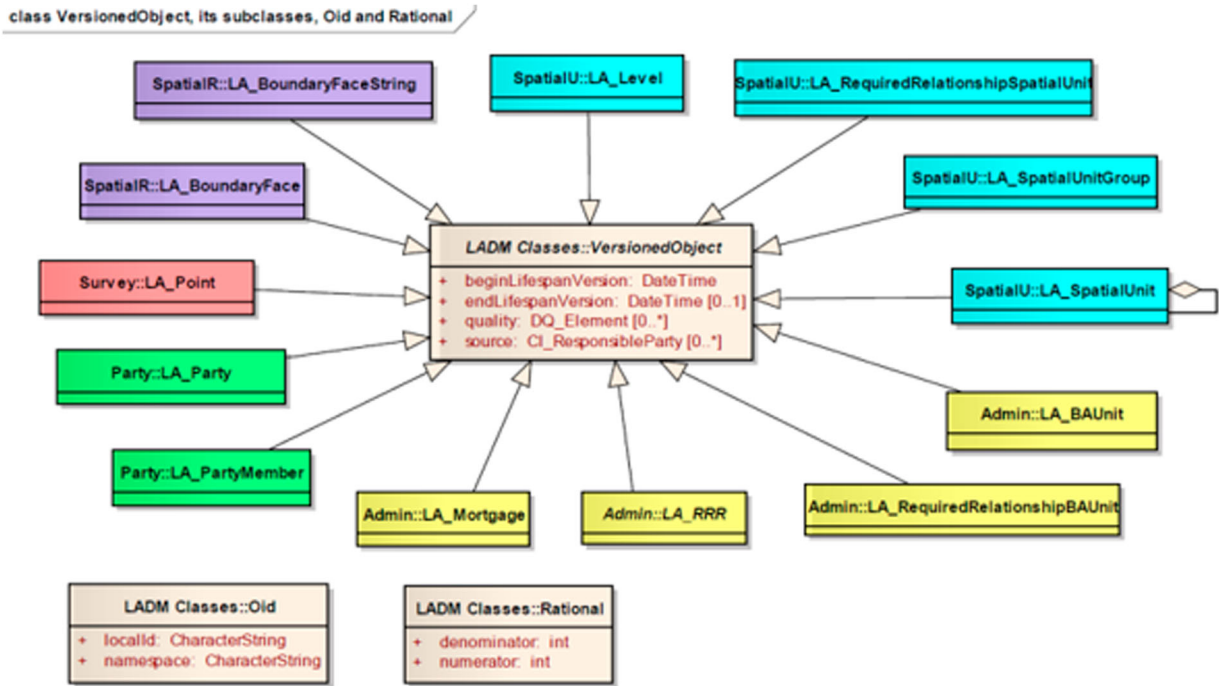
The administrative package

LA\_RRR and LA\_BAUnit are the core classes of the main Administrative Packages. LA\_RRR has three classes as specialisations (LA\_Right, LA\_Restriction, and LA\_Responsibility) (Kalantari et al. 2015, Lemmen et al. 2015). LA\_Right; a right is an entitlement to own; it is an action or activities that a system participant may use associated resources (Zulkifli et al. 2013, Babalola et al. 2015). A right in any case can be formal or informal use right; it may be overlapping, or may be

in disagreement. LA\_Restriction; The example of restriction may be disallowing building within 200 meters of a fuel station; or giving specific meters in which a building can be erected along the major roads. Restrictions, usually, remain valid when the right to the land is transferred or mortgaged. LA\_Responsibility, it is a formal or informal obligation to do something for example (Babalola et al. 2015). The responsibility to clean a ditch, to remove a snow-free pavement, to keep save the survey beacon in around owns land parcel, to maintain a monument (Lemmen 2012, Lemmen et al. 2015).

The spatial unit package

A spatial unit is a single area or multiple areas of land and water or volume single or multiple of space with the main core class LA\_SpatialUnit (Lemmen 2012). In other words, a spatial unit can be a parcel, grouped into two forms of sub-spatial units or sub-parcels; this is the grouping of spatial units into parts (Babalola et al. 2015). The



3 The representation of spatial temporal elements using LADM Leksono et al. (2011); Babalola et al. (2015).

spatial unit group in the case is any number of spatial units (an entity) a municipality is an example of the spatial unit group.

**The surveying and spatial representation sub-package**

Surveying and spatial unit represent sub-package used for the identification and representation of the spatial units (Babalola et al. 2015, Lemmen et al. 2015). Spatial units are structured in such a way to support the creation basic administrative units. The spatial unit package has one sub-package of surveying and spatial representation with classes as LA\_Point, LA\_BoundaryFaceString,

and LA\_SpatialSource. Surveying involves the identification, analysis and the acquisition of point location of boundaries of spatial units (Siriba and Mwenda 2013).

The historical data in the database is managed and maintained in LADM by the introduction of the Class VersionedObject (Fig. 3) (Lemmen 2012). This modelling is performed by defining the validity of time for all class except LA\_SourceDocument. This special class plays important role in forming spatial temporal database (Leksono et al. 2011). The inserted and superseded data are given a time stamp. At any historical time, the contents of the database can be represented as they were (Babalola et al. 2015). The generic data type Oid is introduced to provide support for object identifiers in LADM. In

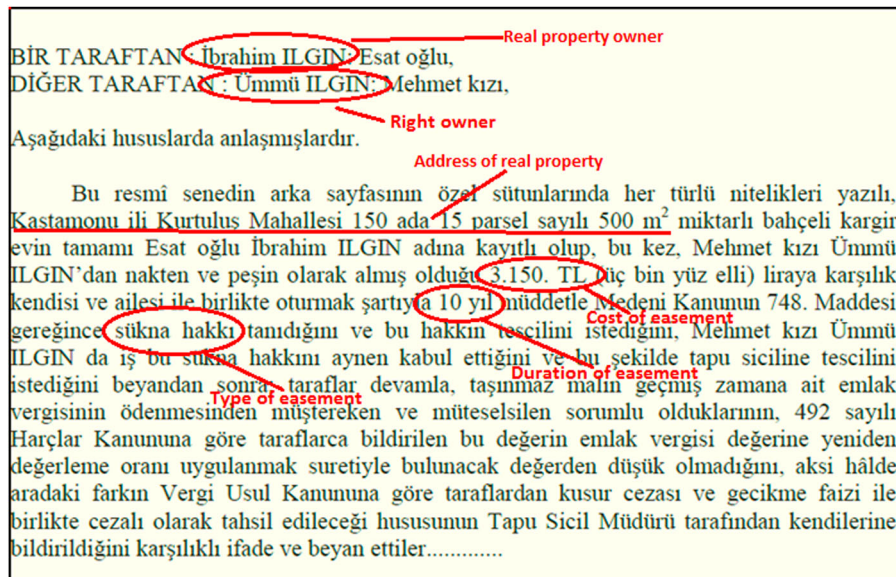
1 2 3 4 5												
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24 adet	Çelik sandalye	5.000 TL										
6 adet	Ceviz kaplama dolap	30.000 TL										
										20.5.1985 yevm. 763		
GAYRİMENKUL REHİN HAKLARI										DÜŞÜNCELER		
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B	I	Anadolü Bankası-Konya	150.000	---	25	II	Yıl	8.4.1985	271	2-B ilave Serbest dereceden	yararlanma hakkı vardır	
Lehine 5 yıl süre ile kira sözleşmesi 13.4.1985 yev.211												

4 The book of real property registers

**Table 2 Main characteristics of easement rights**

Type of easement	Scope of easement	Cost of easement	Duration of easement	Authenticated contract
Right of superficies	<ul style="list-style-type: none"> <li>Property to property right</li> <li>Person to property right</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established with money* or free of charge.</li> <li>* If the easement value is paid, the parties determine this value.</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established as temporary* or permanent**. The duration of the easement is determined by the parties</li> <li>* Less than 30 years</li> <li>** 30 years and more</li> </ul>	Necessary
Right of usufruct	<ul style="list-style-type: none"> <li>Person to property right</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established with money* or free of charge.</li> <li>* If the easement value is paid, the parties determine this value.</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established as temporary* or permanent**. The duration of the easement is determined by the parties</li> <li>* Less than 30 years</li> <li>** 30 years and more</li> </ul>	Necessary
Right of passage	<ul style="list-style-type: none"> <li>Property to property right</li> <li>Person to property right</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established with money* or free of charge.</li> <li>* If the easement value is paid, the parties determine this value.</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established as temporary* or permanent**. The duration of the easement is determined by the parties</li> <li>* Less than 30 years</li> <li>** 30 years and more</li> </ul>	Necessary
Right of water	<ul style="list-style-type: none"> <li>Property to property right</li> <li>Person to property right</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established with money* or free of charge.</li> <li>* If the easement value is paid, the parties determine this value.</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established as temporary* or permanent**. The duration of the easement is determined by the parties</li> <li>* Less than 30 years</li> <li>** 30 years and more</li> </ul>	Necessary
Right of residence	<ul style="list-style-type: none"> <li>Person to property right</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established with money* or free of charge.</li> <li>* If the easement value is paid, the parties determine this value.</li> </ul>	<ul style="list-style-type: none"> <li>Easement right can be established as temporary* or permanent**. The duration of the easement is determined by the parties</li> <li>* Less than 30 years</li> <li>** 30 years and more</li> </ul>	Necessary





## 5 Instance of authenticated contract related to right of residence

principle, the updating, retrieving and management of the database is based on correct source documents, which cannot be changed (Babalola et al. 2015).

## The modelling of easement rights in LADM perspective

### Land registry and easement rights in Turkey

Legal restrictions related to real properties in Turkey are defined by 'Land registry data' under the control of 'Land Registry Directorates' and 'Cadastral data' under the control of 'Cadastral Directorates'. Land Registry data is information such as the owner of a real property, share in the ownership and whether it is mortgaged or not. Cadastral data concern the geographic position; this is the representation of the boundaries of a real property in a certain coordinate system (Alkan 2005, Alkan and Comert 2010).

Land registry is the registry kept by the government and is under the responsibility of the government according to the real clarity system to publish the real rights on the real properties. Linking different real rights at the same or different times to a real property on behalf of same or different rightholders would be possible with the help of land registry again. A usufruct right in favour of person A, a mortgage in favour of person B and a right of passage in favour of person C can be established on a single real property. One right of mortgage can be established for persons D, E and F on a single real property at the same time. Ranking of different mortgages established on the same real property and at the same time is possible. As a rule, a real right over a real property should be ranked above the one established later. This is securely provided by the land registry.

In Turkey, all transactions subject to registry on the immovable are recorded on the title deed. There are two pages for each immovable property in the title deed. All the information about the immovable property is written on these deed pages. When this information is recorded,

the registry of the property is done. A sample page of title deed is indicated in Fig. 4.

Article 779 of the Turkish Civil Code defines the right of easement. According to the article, an easement is charge imposed upon a real property (serving real property), in favour of another real property (dominant real property). As stated by Doner and Biyik (2007) this charge forces the owner of the serving real property to avoid using some benefits of the property right or forces the owner of dominant real property to use the serving real property in a specific way. The right of easement can be transferred, that is, when the parcel is sold, rights and restrictions of a related easement are taken over by the next parcel owner.

'According to the Civil Code Land Registry Law, real rights originate from registration and take their ranking and dates according to the registry (Civil Code Article No 930).' Easement can be registered definitely or indefinitely. Main easement rights registered in the land registry are *right of residence*, *usufruct right*, *right of water and superficies*. These easement rights may be regulated at the discretion of the parties as free of charge or price. At the same time, the duration of the easement right can be determined by the parties as temporary or permanent. Main characteristics of these rights are summarized in Table 2. Easement Rights in Turkey can be established by land registry office, notary, or court, but registration of the right of easement is obligatory to the title deed.

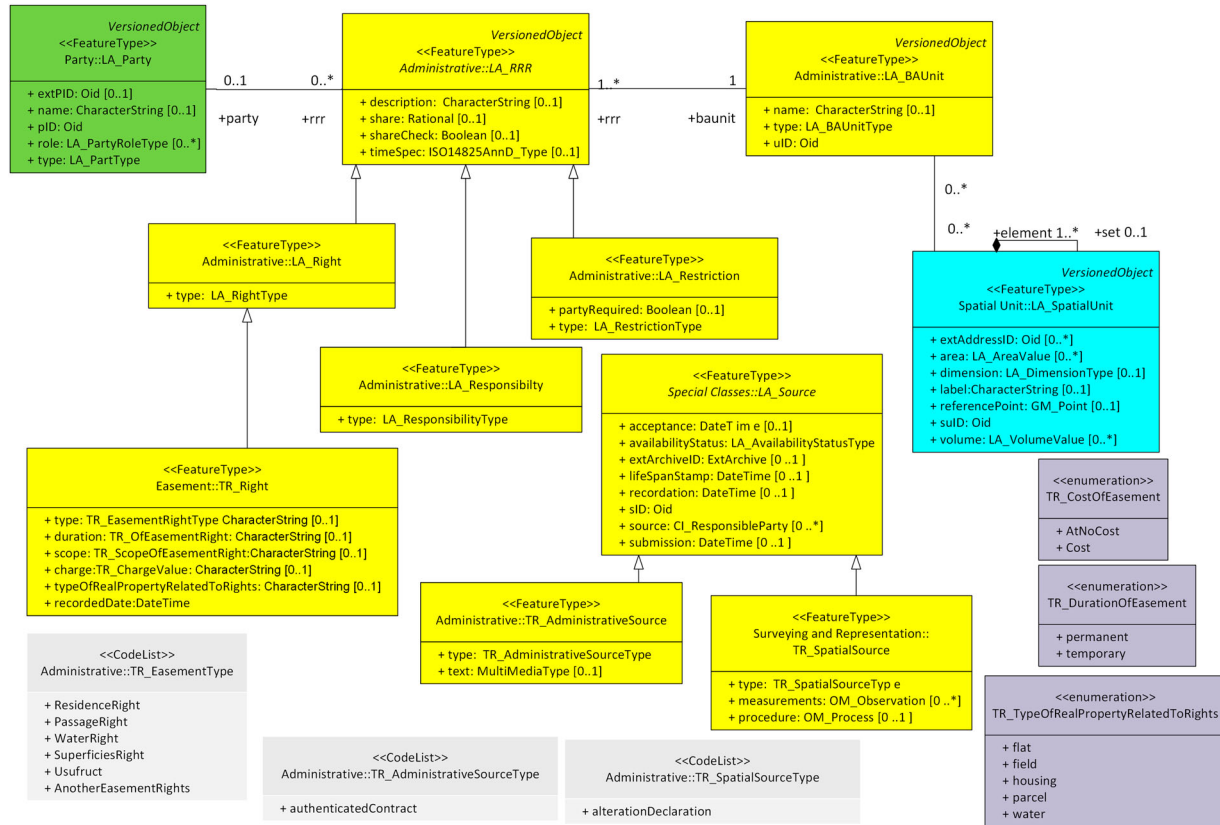
Formal deed should be issued in the directorate of land registry in order to establish some easements (e.g. right of residence). All details for the use of right (e.g. names of the parties, duration and cost of right) are clearly stated in this deed. An example of a legal deed issued for right of residence in Turkey is available in Fig. 5.

## Model design based on ISO 19152 LADM

In this research, modelling easement rights based on Annex 1 of LADM in terms of temporal cadastre situations in Turkey was evaluated. For testing the designed

**Table 3 The main classes of Turkish temporal cadastral data model classes of Turkey's country profile and related ISO 19152 LADM classes**

Turkish model original rights name	Name in the Turkey's profile	Corresponding LADM class	Stereotype	Attribute
TK_İrtifakHakları	TR_Easement	LA_Right	«featureType»	
TK_Kısıtlılıklar	TR_Restrictions	TR_Restrictions	«featureType»	
TK_Sorumluluklar	TR_Responsibilities	TR_Responsibilities	«featureType»	
TK_ÜstHakkı	TR_RightOfSuperficies	–	«codeList»	LA_EasementRightType
TK_YararlanmaHakkı	TR_RightOfUsufruct	–	«codeList»	LA_EasementRightType
TK_GeçitHakkı	TR_RightOfPassage	–	«codeList»	LA_EasementRightType
TK_KaynakHakkı	TR_RightOfWater	–	«codeList»	LA_EasementRightType
TK_OturmaHakkı	TR_RightOfResidence	–	«codeList»	LA_EasementRightType
TK_ResmiBelgeler	TR_AdministrativeSourceType	–	«codeList»	TR_AdministrativeSourceType
TK_HakkınıİlgiliOlduğuTaşınmazTipi	TR_TypeOfRealPropertyRelatedToRights	–	«enumeration»	LA_EasementRightType
TK_İrtifakHakkınınSüresi	TR_DurationOfEasement	–	«enumeration»	LA_EasementRightType
TK_İrtifakHakkınınBedeli	TR_CostOfEasement	–	«enumeration»	LA_EasementRightType



6 Schema of relationships between classes concerning parties and rights (easements) to properties of Turkish temporal cadastral data model

model, the easements registered in the land registry were examined. The main types of recorded easements can be listed as follows (the Turkish terms are added in *italic*, in brackets).

- Right of superficies (*üst hakkı in Turkish*)
- Right of usufruct (*yararlanma hakkı in Turkish*)
- Right of passage (*geçit hakkı in Turkish*)
- Right of water (*kaynak hakkı in Turkish*)
- Right of residence (*oturma hakkı in Turkish*)

The application schema of temporal cadastral database is prepared using UML notation, according to the ISO 19100 series standards methodology. The first step was to chose the main classes of Turkish temporal cadastral model, provide them with English names and assign related LADM classes. The prefix ‘TR\_’ was added to the class name for application in the country profile instead of original prefix ‘TK\_’. The main classes of Turkish temporal cadastral data model applied in the country profile for Turkey are shown in Table 3.

The second step is analysis of diagrams presenting the Turkish temporal cadastral data model and identifying the key connections among its classes. First, the connections between main classes of easements section of Turkish temporal cadastral data model were identified. The relationships between classes like LA\_Party, LA\_RRR, LA\_BAUnit, LA\_SpatialUnit, TR\_Right, TR\_AdministrativeSource and TR\_SpatialSource is presented in Fig. 6. The code list and enumeration are designed and associated to the class TR\_Rights. Code lists for the Administrative Package in the LADM include a code

list for LA\_RightType: the LA RightType code list includes all the various easement right types, such as right of superficies, right of usufruct, right of passage, right of water, right of residence. The LA RightType enumeration list includes all the various easement right types such as enumeration of TR\_TypeOfRealPropertyRelatedToRights, enumeration of TR\_DurationOfEasement and enumeration of TR\_CostOfEasement.

## Discussion and conclusion

The incorporation of a specialised classification of RRRs in the LADM is of value for more addition of data on social tenure in international land administration (Van Oosterom and Lemmen, 2015). As reported by Van Oosterom and Lemmen, 2015, Gozdz and van Oosterom (2015), Babalola et al. (2015), Pouliot et al. (2012) the LADM allows national and regional profiles to be added to the standard, though such profiles are also relevant within a country. These profiles are needed in cases where detailed data of interests in land have to be exchanged internationally. This requires maintenance of code tables representing the different RRRs in use within countries.

As stated in LADM, spatial temporal cadastral databases are formed by defining the position of the boundaries of land parcels together with its creation date and its removal date, the hierarchy of land parcels including the attributes that attach on them which are presented in cadastral maps, map plans and land books.

Cadastral and land title data are used by many users (e.g. legal authorities, Land Registry and Cadastre offices, private sector, local governments, banks and owners) in Turkey. This data need is not only for current but also for historic data. In the traditional system, the temporal analyses needed by all these users could not be performed in a rapid and reliable way. The reason for this is that the traditional land title and cadastre system is a manual archiving system. To date, considerable work has been done to carry out temporal analyses by the means of Geographical Information Systems (GIS). However the main problem of not having a spatio-temporal data model remains. That is, the solutions provided by these work are all application-oriented. This and the fact that there had been no work for this issue in Turkey has motivated us to undertake a work on designing and developing a Temporal Cadastral Information System which would enable temporal analyses of cadastral and land title data. To this end, after determining the need for temporal analyses of cadastral and land title data, how temporal analyses are performed in the traditional system has also been examined.

This paper proposes a spatiotemporal cadastral data model based on the LADM, ISO 19152, than described in the current standard the LADM's 'right', 'restriction' and 'responsibility' (RRR) class and associated code lists. Most recorded easement rights in Turkish Land Registry Sistem have been selected for the implementation this model. Owing to designed model, it was proven that all easement cases could be represented very well in standard LADM. Finally, a standard temporal cadastral information model establishment plan using ISO 19152 (LADM) has been suggested for efficient connection and integration between systems, information sharing, and smooth provision to various fields as cadastral information management. Proposed LADM-based model will provide an advantage to land administrators, the governments and land users for the management of the time dimension of cadastral information in Turkey.

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