Design and Determine the Spatio-Temporal Cadastral Data Infrastructure for LADM

Mehmet ALKAN and Zeynel Abidin POLAT, Turkey

Key words: Cadastre, Spatio-Temporal Cadastral Data, LADM

SUMMARY

Recently, the nature of land title and cadastral (LTC) data in the Turkey is dynamic from a temporal perspective which depends on the LTC operations. Temporal Cadastral data is the important part of managing land resources. When viewed from this aspect, land registration and cadastral system together play an important role in a society. Increasing complexity and flexibility of modern land use requires and different demands effect always land registration data and so land registration data is dynamic. On the other hand, temporal aspects of the cadastral data most important components for public and private sectors. Depends on the functional requirements has been investigated based upon interviews of professionals in public and private sectors. These are; Legal authorities, Land Registry and Cadastre offices, Highway departments, Foundations, Ministries of Budget, Transportation, Justice, Public Works and Settlement, Environment and Forestry, Agriculture and Rural Affairs, Culture and Internal Affairs, State Institute of Statistics (SIS), execution offices, tax offices, real estate offices, private sector, local governments and banks. In other respects, spatio-temporal LTC data inevitable component for creating infrastructure of Land Administration Data Model (LADM). For this reason, this paper investigates spatio-temporal aspects of the LTC data for creating data structure of Land Administration Domain Model (LADM, ISO 2012). Finally, in this study aim is to design and determine the spatio-temporal data for LADM temporal infrastructure for Turkey.

Design and Determine the Spatio-Temporal Cadastral Data Infrastructure for LADM

Mehmet ALKAN and Zeynel Abidin POLAT, Turkey

1. INTRODUCTION

LTC data has two components in Turkey; land title data and cadastral data. Land title data includes such information as the owner and ownership rights (Comert & Alkan 2004; Alkan and Comert, 2010). Whereas, cadastral data defines the location, shape and size. In Turkey these two components are handled by land title and cadastre offices which are separate state departments. Therefore, a real estate is legally defined by its "registered" information maintained by both departments. LTC data is a very dynamic nature. It ever changes in time for a number of reasons. Rapid urbanization in Turkey is one of the reasons. That is, more and more buildings, apartments, and offices are built every day. Another reason is the fact that real estates have always been amongst the most popular investment instruments in Turkey and the country has a very dynamic economy. That is, every single day and hour people buy and sell real estates. Similarly, subdividing or combining parcels geometrically when applying zoning plans or changing the ownership rights when setting a mortgage on a land parcel are amongst everyday transactions in a land title office. Either land title or cadastral data changes at the end of some transactions (Comert & Alkan 2004; Alkan 2005).

Land title and cadastral data is the important components for managing land resources for all over the world. When viewed from this aspect, land registration and cadastral system together play an important role in a society (Liang 2008). What are needed are the computerized database systems which would enable "quick" and "reliable" temporal analyses. Current database systems and popular Geographic Information Systems (GIS) have adopted some solutions. Increasing complexity and flexibility of modern land use requires and different demands effect always land registration data and so land registration data is dynamic (Leksono et al. 2011). Changing related to real property (e.g. land parcels) effects changing in land registration data where it could be categorized into two types: spatial changing (physical data) and attribute changing (juridical data) of a land parcel (Zevenbergen 2002; Liang 2008; Zhang & Tuladhar, 2006; Leksono et al. 2011). Zevenbergen (2002) explains three main things of land registration with regard to the dynamic of land registration system: (1) first land registration, (2) transfer of land rights (the whole land parcels) and (3) parcel mutation/splitting due to partial transfer of land rights. As stated by Leksono et al. (2011), the current land information system is not sufficient no longer to manage spatial changing of land parcels however it only can show the last spatial information. Consequently, there is a need of land information system (Abdulai & Ansah, 2014) that is proficient to store, manage and represent information of land registration including its changing either spatially or textually.

In this study, firstly traditional Turkey LTC system is studied and explained. Also, this paper investigates spatio-temporal aspects of the LTC data for creating data structure of Land Administration Domain Model (LADM, ISO 2012). Finally, in this study aim is to design and determine the spatio-temporal data for LADM temporal infrastructure for Turkey.

2. CURRENT CADASTRAL AND LAND TITLE SYTEMS

In the current land title and cadastre system of Turkey, real estate's such as land parcels, buildings, apartments, business offices etc. are defined with two general types of information. These types are named as "land title data" and "cadastral data" in this article. Land title data involves ownership identities such as name, last name, father name of the owner. The date and transaction via which the ownership was obtained is also involved. In addition, ownership rights and responsibilities such as mortgages on the estate, rights of third parties on the estate are components of land title data. Cadastral data, on the other hand, determines the location in a coordinate system and the shape of the estate. At the moment, cadastral data is maintained in either analog or digital medium. In Turkey, both types of data are handled by two separate state organizations; land title offices and cadastre offices which are operated under the General Directorate of Land Registry and Cadastre belongs to the Ministry of Public Works and Settlement.

Various technical documents were produced via property cadastre and transaction of changes LTC data in the cadastre offices. Cadastral documents were archived in cadastre offices as a result of property cadastre. Other technical documents were archived in land title offices. In this part, cadastral document were explained on the cadastral archives.
Parcel Files: Parcel files were produced case of district or villages. Information paper was produced first section number start from 1 for each village or district. Thus, determine which parcel belongs to which section. Information of section, area and after and before data of parcels was shown parcel files. Parcels geometrical changes were traced via parcel files. This means that first record between last record information was also determined by parcel files.

*Table for Cadastral Block Monitoring***:** It is a table constituted to monitoring changes in sections. District based block numbers and sheet data of sections in concerned district are hold in these tables.

Parcel Dossier of Property Cadastre: It consist of boundary and survey sketches, calculations and benchmarks of triangulation points and traversings, surveys of cadastral parcels produced in property cadastre works. Parcel dossier of property cadastre is archieved as district/village and section based.

Parcel Dossier of Change Procedures: It includes all change projects produced after cadastral work and required official registration. Change projects are archieved in parcel dossiers of change procedures as district or village based. One copy of these projects is also archieved in the district office and in the land registry office.

Cadastral maps: These are the plans in which cadastral parcels is drawn in a specified scale.
There exist a number of registers in a land title office. Land title data has to be registered in these registers to become legally valid. These registers, shown on Table 1., are named as "main" and "auxiliary" registers. These registers are currently maintained manually. The function of each register is shortly explained below.

Table 1. Land Title Registers

Main registers	Auxiliary registers
Land title register	Owners register
Real estate register	Representatives register
Transactions register	Corrections register
Legal documents	Public owned lands register

In Turkey, land parcels are registered in the land title register while buildings, apartments, and business offices which are commonly called "independent parts" are registered in the real estate register. There is a separate page for each real estate in these registers. If the page is full then the registration goes onto another page which is maintained by a number. Land title register includes parcel and owner information and ownership rights and responsibilities. In addition to these, real estate register includes the share of the estate on the parcel it was built, and page number of the parcel in the land title register. To track the previous and next states of the real estates, there also exist "Previous" and "next" page numbers in these registers. Land title register and real estate registers are archived by district names.

Transactions register is for keeping the track of the transactions on the basis of hour and minute of the transaction. That is, any transaction on a real estate is recorded in this register by its time. Recorded information are the transaction number, the type of transaction, the hour and minute of transaction, the name and address of the person for whom the transaction is committed, the general location of the real estate, and the number of legal documents concerning the transaction. There is only one transaction register in a land title office. And transaction numbers start from "1" for each year.

Legal documents are deeds, plans, court decisions etc. related to the land title transactions. These documents are archived by district names, land title and page numbers. Owners register shows all the real estates which belong to an owner. There is a separate page for each owner. Through this, it is possible to see the previously and currently owned estates of an owner. Owners register is archived by owner's last name. Representatives register is for monitoring the legal validity of a representative of an owner at the time of a transaction. Corrections register is for correcting the errors which may occur during registration. Public lands register is held for the lands which are subject to common use.

3. TEMPORAL ASPECTS IN LADM

The LADM is based on 19152 and other ISO standards. To differentiate LADM object classes from other ISO object classes. This standard also provides so called blue print stereotype classes, with a minimal number of attributes, in case an LADM refers to external sources for parties, addresses, valuation, taxation or land usage. Furthermore, LADM allows user-defined elements to be added. It is likely that additional attributes, operators, associations, and perhaps even complete new classes, will be needed for a specific region, or country, or that parts of the LADM are not used at all. Traditional land registry and cadastral systems are unsatisfactory in meeting all land requirements. For this reason, need for sustainable land management model occurred in order to manage, present and archive land-related information and documents (Leksono et al. 2011). Even though many

scientific searches are made in order to provide standardization in land administration field, they were limited in many aspects (e.g. extensiveness, scope and content) because of the uncommon characteristics of Land Administration Systems (LAS) worldwide (Inan & Yomralioglu 2011).

The core LADM is based on three classes which are LA_Party, LA_RRR and LA_Recorded_Object. Also three classes has a temporal aspect that is version object (Figure 1,2). Class VersionedObject allows one to manage and maintain historical data in the database. This requires that inserted and deleted data is given a time-stamp in the database. In this way, the contents of the database can be reconstructed, as they were at any moment in the past. In order to provide standardization for the main common characteristics of LASs, spatial data modelling studies were brought up by van Oosterom & 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) under Land Administration Domain Model (LADM) in the latter stage. Later, the model was given a standard number after being accepted under the name ISO 19152 Land Administration Domain Model (LADM) by ISO in 2012 (Paasch et al. 2015). LADM has capability to provide an abstract description and conceptual schema (van Oosterom & Lemmen 2015; Lemmen et al. 2015; Aien et al. 2013b; Aien et al., 2013a) 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) (should be found as a figure in LADM overview) LADM also gives terminology (Paasch et al. 2015) for land administration based on either national or international system that is developed as simple as possible for practical purposes (Kalantari et al. 2015; Leksono et al. 2011).

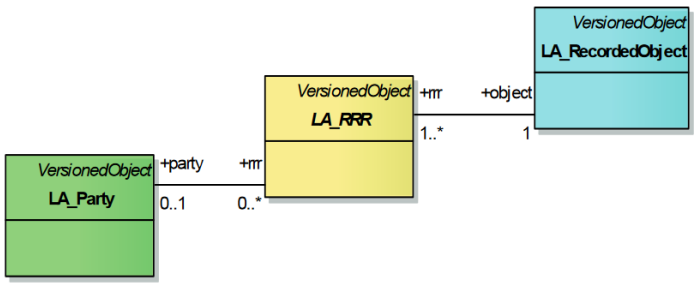

Figure 1. Core classes with temporal aspects of LADM

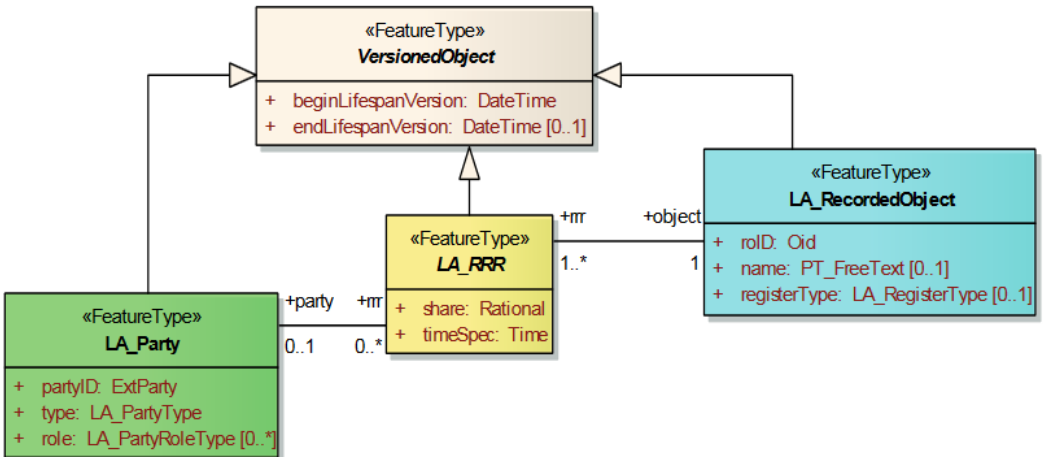

Figure 2. Class Version Objects for Spatio-temporal Data

VersionObject is a special class which is belongs to LADM structure. Also, VersionObject modelling is event based and state based modeling for LADM. VersionObject is very important for temporal modeling which is performed by defining the validity of time for each class. The temporal data in the database is managed and maintained in LADM by the introduction of the ClassVersionedObject (Figure 3) (Lemmen 2012). 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 principle, the updating, retrieving and management of the database is based on correct source documents, which cannot be changed (Babalola et al. 2015).

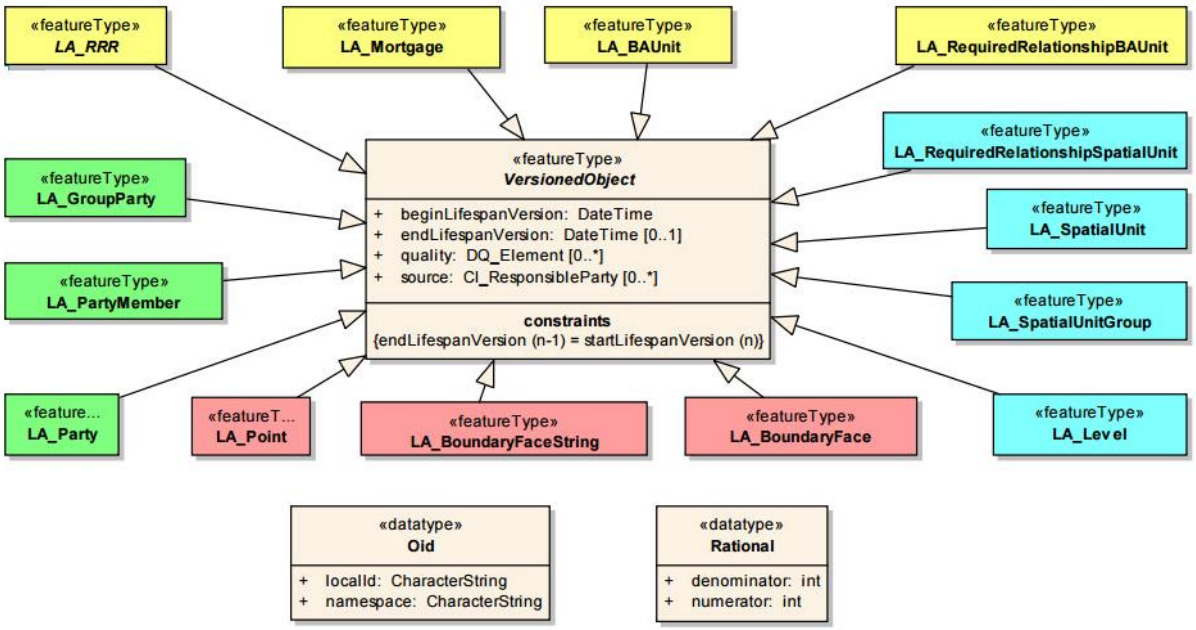

Figure 3. The representation of spatial temporal elements using LADM (Leksono et al. 2011; Babalola et al. 2015).

4. DESIGN AND DETERMINE SPATIO-TEMPORAL CADASTRAL DATA FOR LADM BASED INFRASTRUCTURE

In the cadastral system of Turkey, spatial objects are formed with parcels and buildings constructed within parcels. These spatial objects are represented with the "polygon" data type in the database. Therefore, temporal changes of spatial nature are only valid for parcels. Subdivision, consolidation, expropriation, and boundary adjustment operations change the geometry of parcels. Changes in land register data of parcels or condominiums also changes attributes. A sale changes parcel or condominium owner, a mortgage restricts ownership rights. A change in type changes the "type" attribute of a parcel. In this study, the application schema of temporal cadastral database was prepared applying UML notation, according to the ISO 19100 series standards methodology, as well. The first step was to choose 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 the Table 2.

Table 2: The main classes of Turkish temporal cadastral data model classes of Turkey's country profile and related ISO 19152 LADM classes.

The Turkish Model Name	Corresponding LADM Classes	Corresponding LADM Sub_Classes
TR_Easement	LA_Right	-
TR_Restrictions	TR_Restrictions	-
TR_Responsibilities	TR_Responsibilities	-
TR_RightOfSuperficies	LA_Right	LA_EasementRight
TR_RightOfUsefruct	LA_Right	LA_EasementRight
TR_RightOfPassage	LA_Right	LA_EasementRight
TR_RightOfWater	LA_Right	LA_EasementRight
TR_RightOfResidence	LA_Right	LA_EasementRight
TR_AdministrativeSourceType	LA_Source	TR_AdministrativeSourceType
TR_TypeOfRealPropertyRelatedToRights	LA_Right	LA_EasementRight
TR_DuruationOfEasement	LA_Right	LA_EasementRight
TR_CostOfEasement	LA_Right	LA_EasementRight

In this context, 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_EasementRight, TR_AdminisrativeSource and TR_SpatialSource were presented in Figure 4.

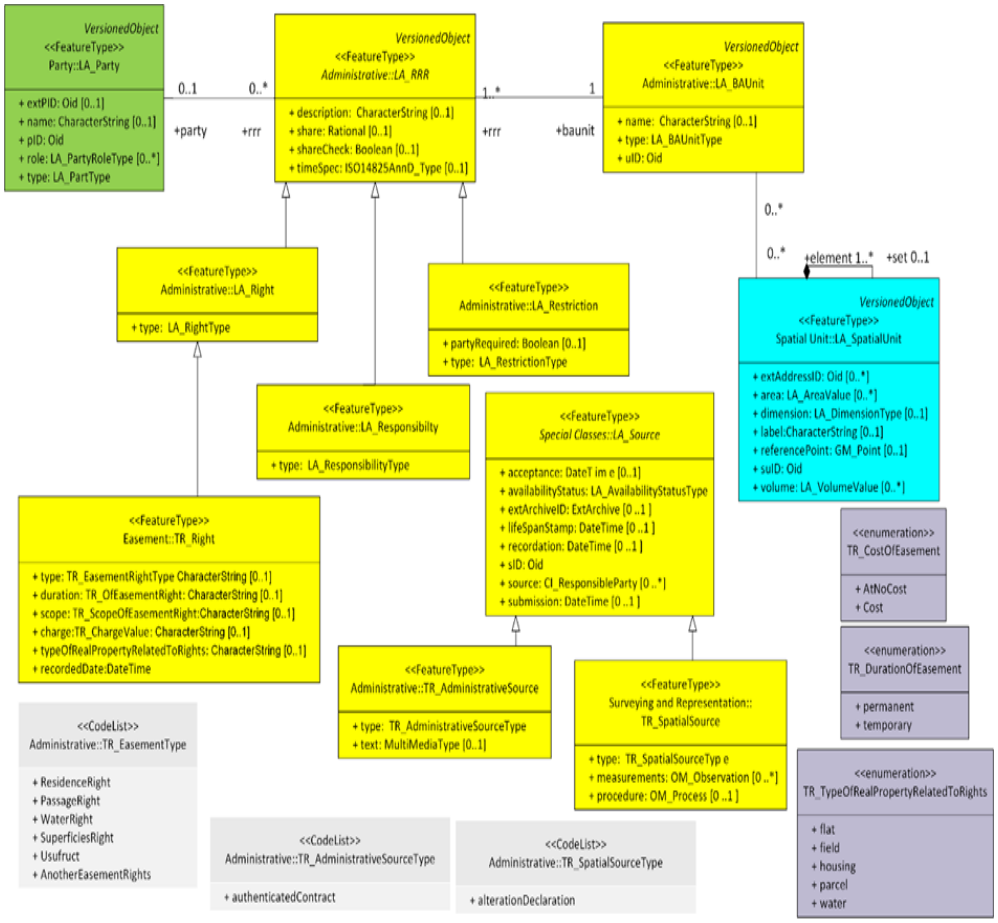

Figure 4. Schema of relationships between classes concerning Parties and Rights (Easements) to Properties of Turkish temporal cadastral data model.

5. CONCLUSIONS

Based upon the previous descriptions of the paper, LADM database that integrates spatial elements (land parcels), attribute elements of land registration, and validity elements related to time of spatial and attribute of land parcels, is required in order to manage spatial temporal elements of land registration. As in LADM, spatial temporal database are formed by defining the geometry 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. These have been proven by performing a spatial temporal analysis in a given time, a spatial temporal analysis in a certain period, a hierarchy analysis of a land parcel, a spatial temporal analysis related to the condition of a certain area and spatial temporal analysis of a certain attribute using GIS with its spatial extension. Cadastral Spatio-Temporal model and analyses are important components of LADM. With respect to need for a temporal cadastral GIS based on user needs assessment; the writers developed a temporal GIS for LRC data and associated functions to satisfy the functional requirements. In this work, the need for temporal analyses on LRC data was determined first. Also, depends on the requirements, this paper proposes a spatio-temporal cadastral data model based on the Land Administration Domain Model (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 System have been selected for the implementation this model. Due to designed model, ıt 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 tovarious fields as cadastral information management.

REFERENCES

Abdulai, R.T., Ansah, A.O., 2014. Land information management and landed property ownership security: Evidence from state-sponsored court system. *Habitat International*, 42, 131-137.

Aien, A., Kalantari, M., Rajabifard, A., Williamson, I., Wallace J., 2013a. Towards Integration of 3D Legal and Physical Objects in Cadastral Data Models. *Land Use Policy*, 35, pp. 140-154.

Aien, A., Kalantari, M., Rajabifard, A., Williamson, I., Bannet, R., 2013b. Utilising data modelling to understand the structure of 3D cadastres, *Journal of Spatial Science*, 58:2, 215-234

Alkan, M., 2005. Tapu ve Kadastro Verilerine Yönelik Zamansal Coğrafi Bilgi Sistemi Tasarımı. Doctoral Thesis. Karadeniz Technical University, Institute of Natural Sciences. Turkey (In Turkish).

Alkan, M., Comert, C., 2010. A design of temporal geographic information systems (TGIS) for Turkish land register and cadastre data. *Scientific Research and Essays*, 5(7), pp. 700- 708.

Babalolaa, S.O., Rahman, A.A., Choon, L.T., Van Oosterom, P.J.M., 2015. Possibilities of Land Administratıon Domain Model (LADM) Implementation in Nıgeria. ISPRS Annals of the Photogrammetry, *Remote Sensing and Spatial Information Sciences*, Volume II-2/W2.

Comert, C., Alkan, M., 2004. The Design and Development of a Temporal GIS For Cadastral and Land Title Data of Turkey. *International Society of Photogrametry and Remote Sensing, XXth Congress*, 12-23 July, İstanbul, Turkey.

Inan, H.I., Yomralioglu, T., 2011. Arazi İdaresi İçin Konumsal Modelleme. *HKMO Jeodezi, Jeoinformasyon ve Arazi Yönetimi Dergisi*, 2011/1 Sayı 104. (In Turkish).

Kalantari, M., Dinsmore, K., Urban-Karr, J., Rajabifard, A., 2015. A roadmap to adopt the Land Administration Domain Model in cadastral information systems. *Land Use Policy*, 49 552–564,

Leksono, B-E., Susilowati, Y., Windayana, S., Yunindra, I. , 2011. Managing Land Registration Spatio Temporal Aspects in National Land Information System. *FIG Working Week 2011, Bridging the Gap between Cultures*, Marrakech, Morocco, 18-22 May.

Liang, Q., 2008. User Demands and Access Model for Temporal Cadastre in China. Master Thesis. International Institute for Geo-Information Science and Earth Observation Enschede, The Netherlands.

Lemmen, C., 2012. A Domain Model for Land Administration. PhD thesis, Technische Universiteit Delft The Netherland.

Lemmen, C., van Oosterom, P., Bennet, R., 2015. The Land Administration Domain Model. *Land Use Policy*, 49, 535–545.

Paasch, J.M., van Oosterom, P., Lemmen, C., Paulsson, J., 2015. Further modelling of LADM's rights, restrictions and responsibilities (RRRs). *Land Use Policy*, 49, 680–689,

van Oosterom, P., Lemmen, C., 2015. The Land Administration Domain Model (LADM): Motivation, standardisation, application and further development. Land Use Policy, 49, 527–534.
van Oosterom, P., Lemmen, C., 2002. Impact Analysis of Recent Geo-ICT Developments on Cadastral Systems. XXII FIG Congres, Washington DC, USA.
Zevenbergen, J., 2002. Systems of Land Registration. Aspects and Effects. Publications on Geodesy, Netherlands Geodetic Commission, Delft, The Netherlands.
Zhang, N., Tuladhar, A.M., 2006. Modelling Spatio -Temporal Aspects of Cadastral System in China. XXIII FIG Congress, Munich, Germany, October 8-13.

BIOGRAPHICAL NOTES

Dr. Mehmet Alkan is an Associate Professor in the Department of Geomatics Yildiz Technical University, Turkey. He graduated from Department of Geodesy and Photogrammetry Engineering at KTU in 1994. He received his MSc in February 1997. He finished Ph.D. in March 2005. His Ph.D. thesis topic is "Design and Develop Cadastral Temporal GIS". He is research interests are Database, Geographical Information Systems, National Spatial Data Infrastructure, E-Municipality, E-government and Cadastral Systems. He is currently works at Land Management Division of the Department of Geomatics at Yildiz Technical University.

Zeynel Abidin POLAT Received his B.S. degree from Zonguldak Karaelmas University and M.S. degree from Bülent Ecevit University. Currently pursuing his Ph.D. in Geomatic Engineering at Yildiz Technical University and working at the same department as a research assistant.

CONTACTS

Associate Prof.Dr. Mehmet ALKAN
Yildiz Technical University,
Civil Engineering Faculty
Department of Geomatics
34220 Esenler /Istanbul
TURKEY
Tel. +90 212 3835295
Fax + 90 212 3835102
Email: alkan@yildiz.edu.tr
Web site: http://www.yarbis1.yildiz.edu.tr/alkan/en

Research Assistant Zeynel Abidin POLAT
Yildiz Technical University,
Civil Engineering Faculty
Department of Geomatics
34220 Esenler /Istanbul
TURKEY
Tel. +90 212 3835288

Fax + 90 212 3835102
Email: zapolat@yildiz.edu.tr
Web site: http://yarbis.yildiz.edu.tr/zapolat/en