# THE DESIGN AND DEVELOPMENT OF A TEMPORAL GIS FOR CADASTRAL AND LAND TITLE DATA OF TURKEY

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**ABSTRACT:**

Cadastral and land title data has a very large spectrum of users; 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, execution offices, tax offices, real estate offices, private sector, local governments, banks and owners need this data. This need is not only for updated but also for temporal 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 have motivated us to undertake a work on designing and developing a Temporal Geographic Information System (TGIS) 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. Finally, a TGIS which enables quick and reliable temporal analyses of cadastral and land title data has been explained. This paper summarizes this work and briefs the analyses which can be performed in the system.

## 1. INTRODUCTION

In Turkey Land title data and cadastral data defines are handled by LT and cadastre offices which are separate state departments. Land title (LT) data includes such information as the owner and ownership rights. Whereas, cadastral data defines the location, shape and size. LT and cadastral data is of 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 LT offices. Either land title or cadastral data changes at the end of some transactions. LT and cadastral data has a great variety of users; legal authorities, various state organizations, private sector companies, local governments, owners and many others need this data. This need is not only for updated but also for "temporal data" which mean the data concerning the past or history of real estates. Traditional land title and cadastre system enables temporal analyses. Nevertheless, in most of the cases performing an analysis may be a tedious, time consuming, and error-prone task. Therefore, needed is a Temporal Geographic Information Sytems (TGIS) for LT and Cadastral data.

There are different definitions of Narciso (1999) defines TGIS as a kind of GIS that not only handle attribute and geographic data elements of geographic futures, but also temporal data elements. According to Yuan (1996) a temporal GIS aims to process, manage and analyze spatiotemporal data. Montgomery (1995), a temporal GIS is a GIS where time is included as an explicit attribute of the features in the database. Zhao (1997) affirms that, a temporal GIS must be able to represent temporal changes in both spatial objects and their attributes. Langran (1993), a temporal GIS would trace the changing state of a study area, storing historic and anticipated geographic states.

In our view, Temporal GIS can be roughly defined as a GIS with temporal analyses capability. This definition implies a temporal database and a temporal data model. Various spatio-temporal data models have been proposed in the literature. Some of them are space-time cube, snapshot, space-time composite, 3D/4D TGIS, Vector Update, the triad framework. However, there is not a commonly accepted data model in place yet (Narciso 1999, Pang 1999, Pequet 2001, Langran 1993, Yuan 1996). In our view, these models may be classified under "layer-based" and "object-based" models. On the other hand popular GIS systems have adopted some other solutions. For instance, Arc/Info employs its versioning system to trace temporal changes. Intergraph uses a similar approach (Esri, 2002, Roux 2003). We have used the space time composite model in our work.

## 2. CURRENT LAND REGISTRY AND CADASTRE SYSTEM

In the current land title and cadastre system of Turkey, real estates 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 gained is also included. 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 (LTO) and Cadastre offices (CO).

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 are named as "main" and "auxiliary" registers (Karagöz 1999, Ayan 2000). These registers are currently maintained manually. The function of each register is shortly explained below.

In Turkey, land parcels are registered in the Land Title Register (LTR) while buildings, apartments, and business offices which are commonly called "independent parts" are registered in the Real Estate Register (RER). 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. LTR includes parcel and owner information and ownership rights and responsibilities. In addition to these, RER includes the share of the estate on the parcel it was built, and page number of the parcel in the LTR. To track the previous and next states of the real estates, there also exist "Previous" and "next" page numbers in these registers. LTRs and RERs are archived by district names.

Transactions register (TR) is for keeping the track of the transactions by hour and minute that the transaction took placing. That is, any transaction on a real estate is recorded in this register by its time. Owners register (OR) 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. 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. Representatives register is for monitoring the legal validity of a representative of an owner at the time of a transaction.

## 3. The need for A temporal CADASTRAL GIS

To determine the need for temporal analyses on LTC data, the needs of the related state and private sector organizations were investigated. Some of these organizations are the general directorates and branches of the State Owned Lands, Tax offices, LTC offices, the Ministries of Budged, Public Works, Culture, and Forest, local governments, banks, and private sector were taken into account. One of the areas where the need for temporal analyses is rather critical is the cases taken to courts. A great many of these cases require a backward analyses and in Turkey a great many of the cases are related to land and real estates. Therefore, these cases were also investigated. As a result, a number of temporal analyses were identified. Some of most striking examples are given below.

**General Directorate of National Estates (GDNE)**

GDNE is a state institution with the duty of determining and monitoring the real estates which belong to the state. GDNE often needs temporal analyses to detect and prevent misuse of State owned real estates. However, it has major weaknesses in performing its duty because of the current Land Registry and Cadastre system. One of the temporal analyses needed by GDNE is related to the Property Cadastre (PC), which is explained below.

Property cadastre is the process that real estates are first registered to land registry and cadastral map sheet for the first time. By the law, the real estates whose owners are unknown are registered in the name of national treasury. The real estates with the unknown owners may arise as a result of either unavailable heirs in inheritance cases or foreign owners who had left Turkey after the Republic period. Due to incorrect declaration of experts during the PC, such real estates may, completely or in part, be registered on behalf of a person. During our work it has been noticed that, almost all the real estates of the foreign owners have been registered on behalf of persons in the PC of Yomra county in Trabzon city. The case has been brought to the court for correction (Gülmez, 2003).

The temporal analysis needed by GDNE in such a case is to basically compare the ownership status before and after the PC process. The steps of such an analysis are explained below:

1) Searching for the LT data and boundary definitions which were valid before the PC process. This involves manually browsing through all the related land title and cadastral records on the basis of districts or villages. The resulting are manually written documents which include owner, area, and textual boundary definitions.

2) Searching for the "reason of right (rr)" and its explanation from the cadastral records of the PC process. Cadastral records are arranged manually for each real estate during the PC works. Therefore, what has to be done here again is to manually search many records and record the results manually.

3) Determining the LT and cadastral status of each real estate in the PC area, which were valid at the date of PC registration. For this search, all the pages of the LTRs of the PC region have to be browsed row by row. As the result, information about all the real estates with the information "PC" for the "reason of right" and registration date for the "date obtained" are retrieved. The resulting LT data are recorded manually. Determining the cadastral status, namely parcel geometry, is much more difficult. Because, it will not be possible to trace back the changes from a cadastral map sheet if the map does not contain each updated state. In this case, the cadastral status of the parcel has to be rebuilt from the original surveys. Applying this to an area, a cadastral map of the registration date can be generated. Although map drawing can be supported by CAD/GIS software, this is a tedious, time consuming, and error-prone operation. Furthermore, instead of corner coordinates, we might just have orthogonal or polar coordinates. In that case, the situation will be even worse.

4) Comparing the results of steps 1, 2 and 3. The resulting from this comparison the real estates which had mistakenly been registered by the name of an owner are determined. Actually step 2 and 3 yield to the general same results but the results of step 2 is more detailed. Because, they contain detailed explanation of the "reason of right". Determining cadastral status is needed to decide the

area which had mistakenly been registered. According to the results of this step, GDNE appeals to the related court for related corrections.

5) Searching for the updated status of the mistakenly registered real estates. Here, "updated status" means the status by the date of the search. Updated status might be rather different from the status of the date of PC registration since the real estates might have been sold, subdivided etc. after registration. This search will start from the pages of the step 3. If there are full pages, the searches should also check "next pages" for the continuing information of an estate. The information contained in the rows which had not been canceled already are recorded as the result of this search. The owner, share, area, and estate identity are part of this information. This information can then be used for needed corrections. According to this, the court point out the corrected registrations to the LT offices.

All of the above steps require lengthy searches in the traditional LTC system. Analyses are visual and information retrieval is manual mostly from paper documents. That is, the involved are tedious, time consuming, and error prone processes. As a result, such incorrect land registrations become very difficult to detect. For this reason, they are either omitted or take time for the courts to make final decision. In either of the cases, it means valuable losses in the National economy.

In an e-government infrastructure, it is particularly important for the LTC offices to offer these analyses as "web services" to the use of other public and private organizations. LTC offices can only do these by the support of a TGIS.

**Tax Offices**

In Turkey, taxes are collected by tax offices that operate under the Ministry of Budget. Tax base in all taxes of Turkish tax system is determined in respect to the taxpayer declaration (Pehlivan, 2000). However, this system yields to a high degree of loss in tax revenues due to incorrect declaration or no declaration at all. As a solution, Cömert and Akıncı (2002) propose a completely new system for real estate taxes. In the current system, tax offices often need to analyze real estate acquisitions in a certain period to determine incorrect or absent declarations. An example is the case of income taxes, which is explained below.

Self employed persons pay income taxes through tax declarations in Turkey. However, incorrect declarations are not rare in this system. Tax offices may determine incorrect taxes by comparing the declared values to that of the previous years'. Incorrect taxes may also be noticed from the amount of declared values which are considerably low. In this case, tax offices make asset research to document low declaration and determine fine amount. An asset research may comprise both movable and immovable assets. In an immovable asset research, the real estates that a tax payer and his family has bought or sold in a certain period of time are searched. In addition, cancellations of previously established mortgages should also be determined since this is an income earning as well. The asset searches may be needed in many other court cases. The procedure is as the following:

1) Searching on OR and determining of LTR page numbers of the real estates of the tax-payer. In this process, OR is manually searched line by line with taxpayer's name, surname and father name. As a result of this search, LTR and RER page numbers are retrieved on the basis of districts. This step is completely manual.

2) Retrieving data from the corresponding LTR/RER pages. The values of the real estates which had been either sold or bought by the taxpayer in a given period are retrieved. In addition, the values of the real estates of the same taxpayer with revoked mortgages concerning a period of time are also retrieved. If the values are not available on the registers then related official documents are searched. These values are listed with estate id and officially sent to tax offices.

3) Comparing the declared and retrieved tax base. This is done by tax offices. If there is a missing declaration, the legal procedures are followed for the corresponding fines.

Like the previous example, all of the above steps require lengthy searches in the traditional LTC system. Analyses are visual and information retrieval is manual mostly from paper documents. That is, the involved are tedious, time consuming, and error prone processes. In short, detecting incorrect and missing tax base declarations is rather difficult. For this reason, tax base controls are generally omitted. This means considerable decreases the Country's tax revenues.

In an e-government infrastructure, it is particularly important for the LTC offices to offer these analyses as "web services" to the use of other public and private organizations. LTC offices can only do these by the support of a TGIS.

**Courts**

In Turkey, the rate of the cases between administration and citizens and between citizens has been rather high. Approximately 5% of the total cases are due to the objections to property cadastre (DIE, 2002). When the case of preemption, property, inheritance and transition added to these, the rate will increase significantly. Unfortunately, a certain statistical figure is not available from State Institute of Statistics (SIS) concerning this issue. Because SIS evaluates these cases under a single title called as "land titling cases" and these are the cases which have 5% percentage mentioned above. The courts need temporal analyses of land title and cadastral data related to property cases. The example necessary for inheritance and transition cases is explained below.

Inheritance and transition case starts with an heir's appeal to the related court for sharing of the inheritance. Courts take into consideration the real estates that litigant had declared pertaining to the testator in these cases. The court has to also consider whether the other heirs have an objection or not. If there is no objection, the court requests that LTR office determine whether related real estates are in testator's ownership when he died. However, litigant or one of the other heirs can declare that they do not know all the real estates of the testator. In this case, the court needs to determine the testator's real estates countrywide. The steps 1 and 2 of the previous example are also valid for this analysis.

The only difference is that there are more to be retrieved here. Namely province, county, district, share, mortgage, sequestration of testator's real estates are retrieved. Based on the results of the analysis, the court makes its decision that heirs are the shareholders of the rights and restrictions for each of the testator's real estates.

As explained above the temporal analyses needed in Inheritance and transition cases are slow. If the analyses involve searches countrywide then the search will be even slower and thus take time. This is one of the main reasons of the fact that only 35-40 % of the property cases are resolved within the same year of the appeal (DIE, 2003). This is rather annoying on behalf of the citizens. On the other hand, it creates an unnecessary burden for the courts.

Inheritance and transition cases are almost every day operations in Turkey. However, recording a heritage on behalf of the heirs via court cases is a burden for both citizens and courts. In the e-government implementation LTC offices may offer these analyses as web services for the others' use. By the participation of other parties to e-government the operations will performed much faster. For instance, the inheritance and transition processes could be initiated upon the death automatically and the results may be declared to the heirs. This duty might be assigned to the population and citizenship offices. Because, when a person died, his record is changed as died in population and citizenship offices. The family tree of testator could be retrieved from the MERNIS system (NVİ, 2004). Thus, both citizens and courts may be freed from inheritance cases. The citizens would be happy with such a high quality service and the workloads of the courts would be diminished substantially.

## 4. IMPLEMENTATION

According to the requirement analyses a database design was performed in the Relational model. Temporal data are traced by "tmin" and "tmax" attributes (Oosterom, Lemmen, 2001). Fig. 1 shows in part the relational schema used. Attribute data was stored in MS Access. Since it was not legally allowed to have LTR data, an experimental database was populated manually. GIS software used was MapInfo Professional 6.5. A space-time composite temporal model was used for our system. The interface for temporal analysis was developed in Microsoft Visual Basic 6.0 (MVB). Temporal queries and database modifications are performed from the interface. The relationship between attribute and spatial data is established over "Estate-id" (Fig. 1). Attribute queries are done via SQL. When spatial data is involved in the query then MapBasic commands are employed.

### 4.1. Temporal analyses in the developed system

In this part, how the temporal analyses needed in NGDE case are performed in our system is explained. The steps 3 and 5 can be handled in the system. That is, LTC data of the PC date and LT data of the query date are retrieved from the temporal database. PC date and query dates are entered to the form as "first" and "second" date. However, the step 5 has to be performed from the screen. For instance, it can be noticed form the tables that the parcel 122 had been subdivided into the parcels 135 and 136. Thus, a decision to hand the parcel in GDNE would affect 135 and 136. Both this and the results of the step 3 can also be arranged as a report. The steps 1, 2, and 4 can not be performed automatically in our system since the documents involved are in a analog medium. By scanning these documents and organizing them within the database, these can also be automated to a certain extent.

**PARCEL**

| Estate id | City | Town | District | Map No | Area | …… | tmin | Tmax |
|---|---|---|---|---|---|---|---|---|
| 201 | Trabzon | Merkez | Boztepe | 1 | 1502,75 | | 07.06.1998 | |
| 122 | Trabzon | Merkez | Boztepe | 2 | 2125,00 | | 07.06.1998 | 25.10.2000 |
| 136 | Trabzon | Merkez | Boztepe | 2 | 1100,00 | | 25.10.2000 | |

**PARCEL GEOMETRY**

| Old Estate id | New Estate id | Owner id | Lot | Obtained By | …… | tmin | Tmax |
|---|---|---|---|---|---|---|---|
| 122 | 135 | 1055 | Complete | Subdivision | | 25.10.2000 | 15.12.1998 |
| 122 | 136 | 1055 | Complete | Subdivision | | 25.10.2000 | |

**PARCEL OWNERSHIP**

| Estate id | Owner id | Lot | Obtained by | …… | tmin | tmax |
|---|---|---|---|---|---|---|
| 201 | 1051 | Complete | Cadastre | | 07.06.1998 | |
| 122 | 1055 | Complete | Cadastre | | 07.06.1998 | 25.10.2000 |
| 123 | 1068 | 5/36 | Cadastre | | 07.06.1998 | |
| 123 | 1076 | 31/36 | Cadastre | | 07.06.1998 | |

**PARCEL RESTRAINT**

| Estate id | Owner id | Lot | Restraints | …….. | tmin | tmax |
|---|---|---|---|---|---|---|
| 135 | 1055 | Complete | Mortgage | | 16.11.2002 | |
| 141 | 452 | 1/2 | Distraint | | 18.06.2003 | |

Figure 1. The relational schema with the data related to the GDNE case.

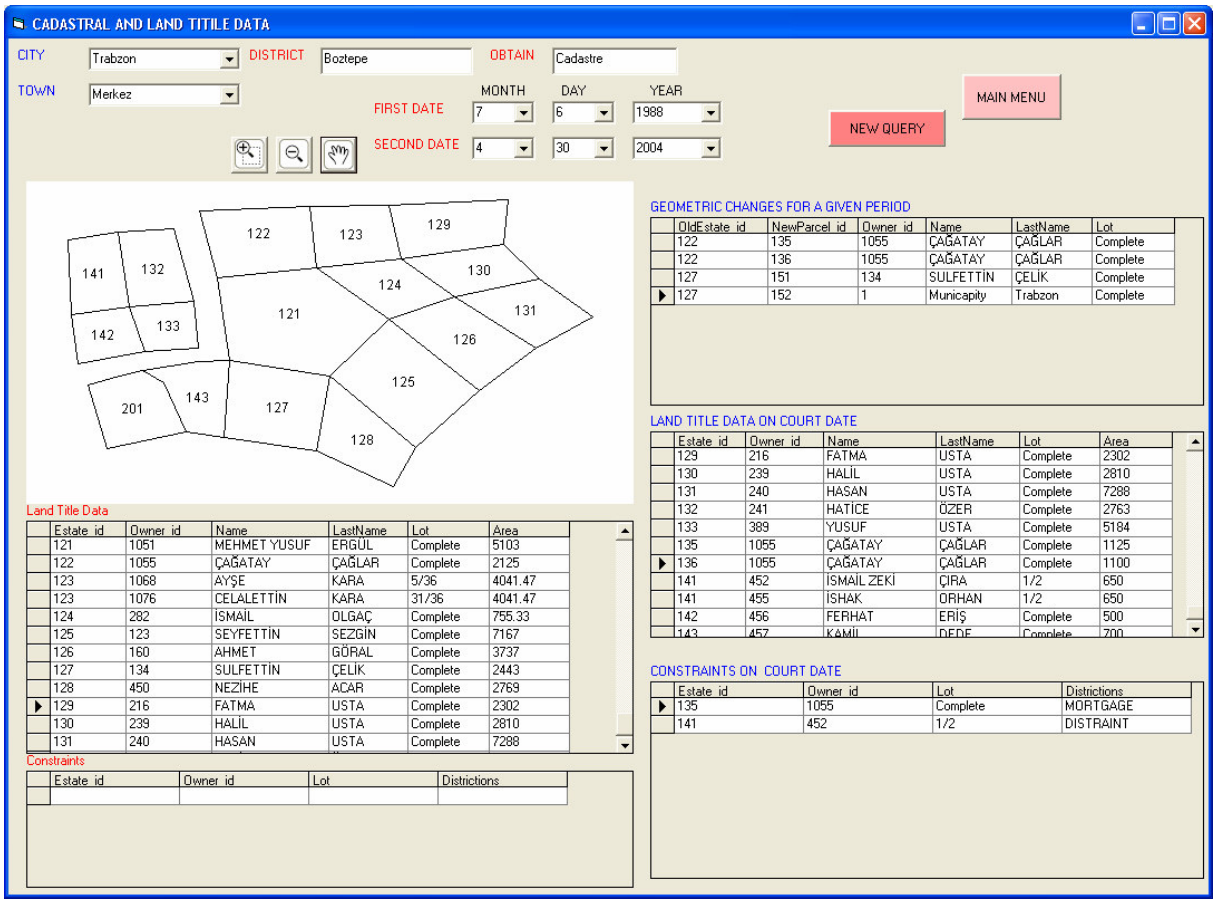


Figure 2. LTC data of the PC date and LT data of the query date

## 5. CONCLUSION

Temporal analyses require lengthy searches in the traditional LTC system. Analyses are visual and information retrieval is manual mostly from paper documents. That is, the involved are tedious, time consuming, and error prone processes. This means rather poor quality of services on behalf of both citizens and all other parties that LTC offices should serve. It also means a high degree of economical losses for the Nation's economy. In this work, a temporal GIS has been designed and developed for the LTC data. To determine the need for temporal analyses on LTC data, the needs of the related state and private sector organizations were investigated. Some of these organizations were the general directorates and branches of the State Owned Lands, Tax offices, LTC offices, the Ministries of Budged, Public Works, Culture, and Forest, local governments, banks, and private sector were taken into account. One of the areas where the need for temporal analyses is rather critical is the cases taken to courts. A great many of these cases require a backward analyses and in Turkey a great many of the cases are related to land and real estates. Therefore, these cases were also investigated. As a result, a number of temporal analyses were identified. According to the requirement analyses a database design was performed in the Relational model. Attribute data was stored in MS Access. GIS software used was MapInfo Professional 6.5. A space-time composite temporal model was used for our system. The interface for temporal analysis was developed in Microsoft Visual Basic 6.0. Temporal queries and database modifications are performed from the interface. A temporal Cadastral GIS is especially important for the National Spatial Data Infrastructure (NSDI) and thus e-government infrastructure. Because, it is particularly important for the LTC offices to offer these analyses as "web services" to the use of other public and private organizations. And LTC offices can only do these by the support of a TGIS.

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