Some Spatial Data Management Issues towards Building SDI

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SUMMARY

Various Urban GIS projects have been produced by different public institutions in Turkey. But, coordination has not been provided among these public institutions that produce and use spatial data. Technical, Standard, and policy deficiencies result in time and effort losses on data production, management, and sharing. Spatial data users need to use the data collaboratively to provide noteworthy benefits to environmental, social, and economic context for sustainable management of urban areas. By this way, Geographic information strategy consistent with European Union INSPIRE and Turkey National GIS actions should be determined. As a preliminary work to build Spatial Data Infrastructure (SDI), before making the data enabled for multiple uses, Generic Conceptual Model components were determined to manage and harmonize spatial data and to produce application schemas of spatial data themes. These components were divided into two sections, Scope / Application Area and Technical Components. Scope / Application Area components include standard hierarchy, scale-resolution, generalization approach, and building province level SDI. Technical Components include principles, reference model, application schema rules, general feature model, spatial object identifier, spatial object versioning, and like this. As a case study, spatial data collected from different sources was managed for many applications from environment and land management to Urban GIS with Trabzon city example. As a result of this, these spatial data management issues were examined with the aim of using and sharing data effectively and clarity some needs for building SDI.

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1. INTRODUCTION

Geographic Information (GI) has a major role in addressing societal demands and exploiting the opportunities opened up by policy and technology. GI has economic value as a major component of Public Sector Information and has social and policy value for providing the basis to integrate policies and to provide tangible benefits to citizens, business, and governments (Craglia, 2004). GI users need to use the data collaboratively to provide noteworthy benefits to environmental, social, and economic context for sustainable management of urban areas.

Information Systems (IS) that support information management in concerned working group have been re-conceptualized as Information Infrastructure (II) concept that supports effective and corporate decision making by various institutions in a large user community. While Geographical Information Systems (GIS) were largely designed to serve specific projects or user communities, the focus is now increasingly shifting to the challenges associated with integrating these systems into a society perspective. Similar to II, this can be explained with Spatial Data Infrastructure (SDI) concept. SDI encompasses policies, technologies, standards for the effective collection, management, and access of GI to stimulate better governance, and to foster environmental sustainability by reducing duplication and facilitating integration at different administrative levels (Georgiadau et al., 2007). SDI concept started to develop on a perspective starting at local level and proceeds through state, national, regional, and global levels. Most countries in developing world are in the process of building SDI at different administrative levels in order to enable effective spatial data management (Aydinoglu and Yomralioglu, 2006).

There are technical and non-technical aspects to realize SDI. Among non-technical aspects, legal and organizational issues, such as copyright, pricing policy, and access rights, are important. As technical issus, SDI needs metadata made described in catalogues and web based services besides data content. Open Geospatial Concortium (OGC) and ISO/TC211 have developed a variety of standards in this area. To manage spatial data, there is now a wave of attempts to agree on complete data themes, covering both the spatial and non-spatial aspects. For example, within Infrastructure for Spatial Information in Europe (INSPIRE), 34 different data themes, such as administrative unit, address, topography, will be first agreed on the harmonized models and delivered for 27 countries of the EU. US Department of Homeland Security (DHS) Geospatial Data Model covers quite a broad number of data themes. Many countries are also in the process to design and manage spatial data with sharing data models all over the world (Scarponcini, etc. 2008).

In this study, current situation on GI management is determined towards building SDI. Requirements are discussed to develop data sharing model of Turkey. By this way, some spatial data management issues such as standard hierarchy, object identity, and versioning are examined with some case studies.

2. CURRENT SITUATION ON USING SPATIAL DATA IN TURKEY

Information and Communication Technologies (ICT) started to be used commonly in 1990s. Public Institutions increased investments for ICT hardware and software since 1995s. The importance of GIS has been realized by many public and private organizations within Turkey since 1990s (Yomralioglu, 2004). Analog maps were converted to digital format and used as a base map in some specific projects. General Command of Mapping (GCM) pioneered digital map production especially. Standard Topographic Maps (STM), smaller than 1:5000, are produced by GCM. Large Scaled Maps, 1:5000 and larger, are produced by Land Registry & Cadastre Directorate (LRCD) and State Provincial Bank. Other public institutions and municipalities also produce maps serving their own needs. As time goes by, the needs and requirements for geographic information have increased in Turkey like all over the world.

According to Turkey State Planning Organization (SPO) (LRCD, 2004), coordination has not been provided among public institutions that produce and use spatial data. Technical, Standard, and policy deficiencies result in time and effort losses on data production, management, and sharing. A variety of GIS Projects were produced by different public organizations. Public Institutions produce spatial data, depending on their responsibilities and rights legalized by the laws. E-transformation Turkey Project, following Europe+, triggered actions for building “Turkey National GIS” with participation of public institutions. With Action-47, current situation to build SDI was examined in 2004. In Turkey, It has not been determined which institutions produce which data on which standard or scale It was declared that 81 % of Public institutions have GIS software, but there is no a common use GIS software. There are no accepted international or de-facto standards in public institutions. 41% of Public Institutions use institutional standards in intra-organizations and only %19 of which use accepted national standards but base level (LRCD, 2004). Most municipalities in especially big provinces are trying to build Urban Information System (UIS) and e-municipality applications. According to UIS Survey executed by TURKSTAT (2007) to 3066 out of 3228 municipalities of Turkey, 18 % (543) of the municipalities have numbering unit and 4 % (126) of which work on Urban GIS.

According to 5216 numbered Municipality Law and 5272 numbered Metropolitan Municipality Law, municipalities are compulsory to build GIS and Urban GIS. Interoperability Circular (Off.Gaz., 2005) published by prime ministry of Turkey constitutes standards to build information systems in all central and local public institutions. It is emphasized to determine GIS interoperability standards on the scope of Turkish Standards Institute (TSE) Geographic Information Mirror Committee. With Action-36, Turkey National GIS concept and implementation models were determined in 2005. Building National SDI is required to share spatial data on different context and scale efficiently. Spatial data is produced by all public institutions, organizations, companies, and universities that participates in Turkey National GIS (LRCD, 2006). It is accepted to follow INSPIRE (2007) Directive. By this way, first, spatial data should be produced on common data specifications from national to local level.

Examining data specification on GCM STM Data Dictionary, each feature was identified by NATO DIGEST feature code and grouped in feature classes. Feature classes are not defined with attributes and relationships for using in various GIS applications, but include information for presenting the data on the maps. Large Scaled Maps are produced, depending on Large Scaled Map Production Regulation (BÖHHBUY). BÖHHBUY was revised and enclosed with feature / attribute catalog in 2006. This catalog was not designed to solve application-driven requirements for various GIS projects. However, spatial data specification is required to support various GIS applications and decision making processes (Enem ve Batuk, 2007). And these specifications should enable harmonizing spatial data coming from different sources. GIS applications of local governments were developed, depending on GIS software and related companies. Therefore, spatial data is not interoperable because public institutions use different conceptual model and feature catalogs (LRCD, 2006). For example; Interior Ministry are in process to combine the databases of National Address Database (UAVT) and National Citizenship System (MERNIS). And, also Building Following System is being built to work with these systems (Atalay, 2006). Land Registry and Cadastre Information System (TAKBİS) was built in 2004 and are being activated in all cadastre directorate of Turkey.

Beside this, GIS projects executed in local governments, LRCD, municipalities, and public institutions were not designed to enable data interoperability. Local Governments need high resolution and large scaled spatial data and maps for applications like zoning plan, real property management, and infrastructure (Yomralıoğlu, 2004).

According to Inter-Ministrial Map Progress Coordination and Planning Commission Report (2007), features and attributes required by institutions and organizations in their application should be determined. And, a common concept should be produced and should provide generalization rules for using the data from local to national level. These specifications include coordinate system, attributes, geometry, topology, generalization rules, relations, and like this. Data specifications should be defined for data themes to share and use the data corporately. Applications Schemas of the data themes should support updating National Data Exchange Format (UVDF) compliant with Geographic Markup Language (GML) 3.X.

3. DEVELOPING GEOGRAPHIC DATA SHARING MODEL OF TURKEY

As a preliminary work to build SDI, before making the data enabled for multiple uses, GI sharing model of Turkey is designed. By this way, the base and harmonized geo-database model, named as National Geographic Data Exchange Model with UVDM acronym, can be accepted as a new approach on GI management in Turkey. This base model is a starting point to create sector models in different thematic areas. These sectors produce their data models depending on the rules described in the base model. Because all sectors share this base, interoperability between the sectors is greatly enhanced.

UVDM is a semantic model. Harmonized model provides common domain of interaction and the related information. This interchangeable information results in semantic standardization. The model should explain objects with properties and relations semantically. That is, interchange of GI is also possible and a variety of different kinds of organizations can operate in the same GI.

UVDM is an object-relational model. This approach benefits from opportunities of relational and object-oriented data model, enables the users to store spatial data and their associated attribute data in a single database system. By this way, this model provides some advantages such as indexing, transaction management, and like this.

UVDM is compliant with ISO/TC 211 standards, the expectations of INSPIRE data specifications that European countries follow to utilize in their country towards building European SDI, and Turkey National GIS actions.

UVDM is designed with Unified Modelling Language (UML) class diagrams that is a graphical modeling tool with well defined semantics and an underlying computer model in a model driven approach (MDA). A Geography Markup Language (GML) application schema as an exchange format can be automatically derived from the UML model for harmonizing the data model.

UVDM data themes are Administrative Unit (IB), Address (AD), Land Ownership/Building (MB), Hydrography (HI), Topography (TO), Geodesy (JD), Transportation (UL), Land Cover/Use (AR), and like these. Application schemas of the spatial themes define feature types with geometry, attribute, relationship, and constraints with documentation, catalogues, and schemas.

UVDM Conceptual Model specifies the components to determine application schemas of data themes. Conceptual Model components were determined to manage and harmonize spatial data and to produce application schemas of spatial data themes. These components were divided into two sections, Scope / Application Area and Technical Components. Scope / Application Area components include standard hierarchy, scale-resolution, generalization approach, and building province level SDI. Technical Components include principles, reference model, application schema rules, general feature model, spatial object identifier, spatial object versioning, and like this. Some components are examined below to enable a spatial data sharing model.

Application driven modeling

An application-driven model based on an analysis of the intended GI uses is designed to serve a set of useful thematic applications. In other words, the design of UVDM follows the requirements of application algorithms and use of information, rather than a specific organization’s workflow. According to the Field Work, information products and application needs relating to GI were determined for 37 of public/private institutions and organizations situated in Trabzon province of Turkey at local level. Because Provincial System is the main administrative system of Turkey, determining user needs at province level can be model for all Turkey. These were summarized and combined in a list including 85 of functions that explain GIS activities at local level. User requirements of these functions were defined as the data content, the level of detail, relationships between objects, data consistency and updating, and the temporal dimension of the data. These data needs were combined with current feature/attribure catalogs. By this way, these requirements meet GI needs from local to national level.

Standard Hierarchy

UVDM can be accepted as base and main data model for applications of different sectors. Sector models should be based on and compliant with UVDM base model. Land Ownership and Cadastre Information System (TAKBİS), State Hydro Information Systems (DSICBS), Urban GIS applications (KBS) of municipalities, topographic database applications, and like these should extend their geo-database from UVDM.

For example, National Address Database (UAVT) and Census and Citizenship Database (MERNIS) are in the integrating process under responsibility of Ministry of Interior. On this scope, if National Address Code (UADK) determined on UVDM:AD model is used, data harmonization and exchange on various databases will be possible. As seen on example of Figure 1, address information for a person can be obtained easily with identity number. Urban GIS applications of municipalities can be harmonized to UAVT and MERNIS database. The example shows to reach location information from citizenship or identity number through relating database based on UVDM data model.

Scale-Resolution and Generalization Approach

Spatial data should be maintained at a level where the data is managed effectively. Geo-database should be collected for a province and it can be combined and generalized from local to national level for all provinces of Turkey. The only way to have consistent and current national datasets is to have transactional updates penformed by local datasets. These data can be combined, transformed, and integrated into national datasets.

In Turkey, county level is the most effective level that produces and use spatial data in GIS applications. Municipalities and Provincial Administrations, having high level Power/Interest and Geo-ICT/Data Requirements capacity, are managing the data larger than 1:5000 scales as BOHHBUY defines. Spatial Hierarchy Approach enables collecting the data at county (İlçe) level, larger than 1:5000 scale and 50 cm resolution once and then re-using at different level such as *Province* (İl), Region (*Bölge*), and Country (*Ülke*).

UVDM3 at large scaled level (>1:5000) is the base geo-database level for UVDM. Produced and combined geo-databases at this level can be used in the applications and information products with graphic and cartographic generalization. The geo-databases, at 3 numbered large-scaled level, can be converted to 2 numbered middle-scale level and 1 numbered small scale level with model generalization. Information Products and Applications of other levels can be produced inside these geodatabases.

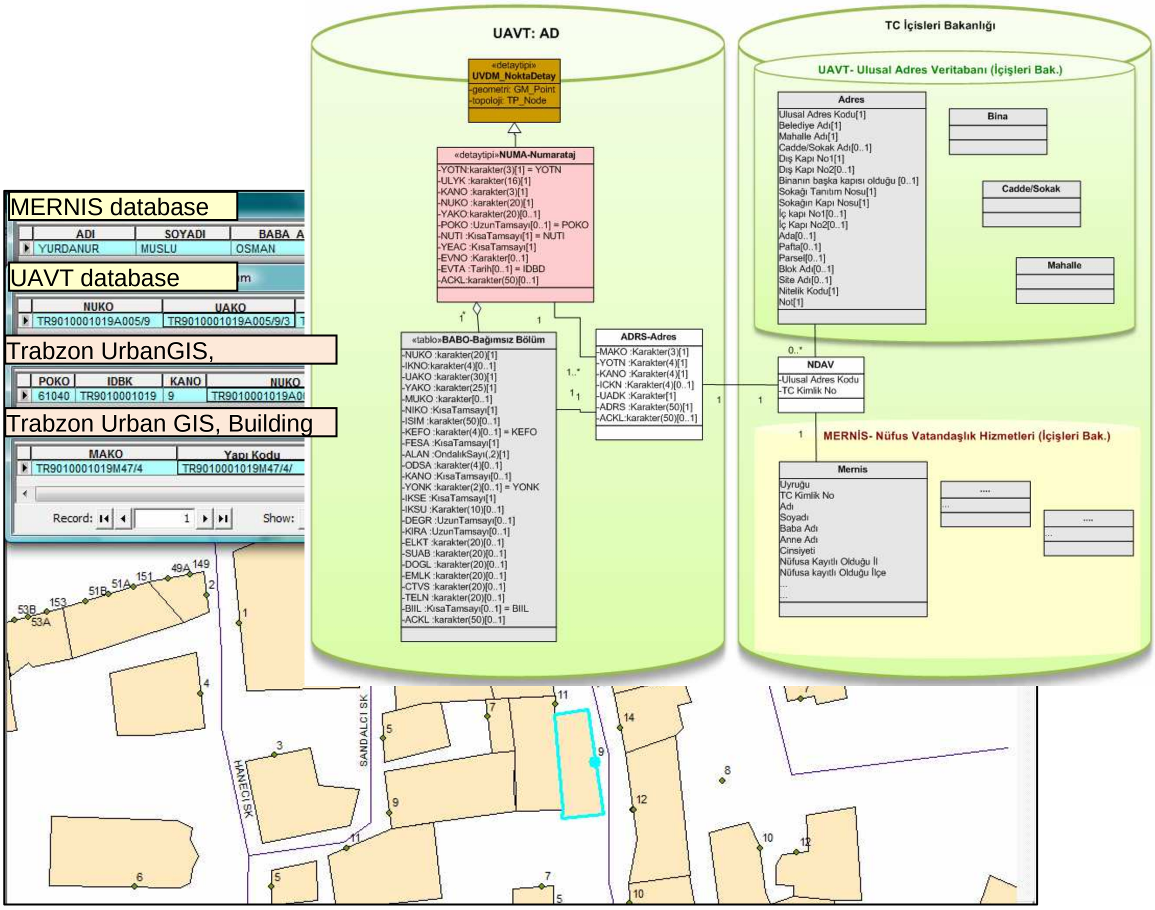

Figure 1.UVDM extension for UAVT / MERNIS database of Ministry of Interior of Turkey

For example, Trabzon geo-database named as TR90101 was built at large-scaled county level, UVDM3. As seen on Figure 2, the geo-database for Trabzon Urban Atlas was generated from TR90101 geo-database. To build urban atlas geo-database, UVDM:IB, AD, UL, and AR data were get from the main database. Large scaled Trabzon Urban Atlas and Internet web atlas were produced based on this geo-database.

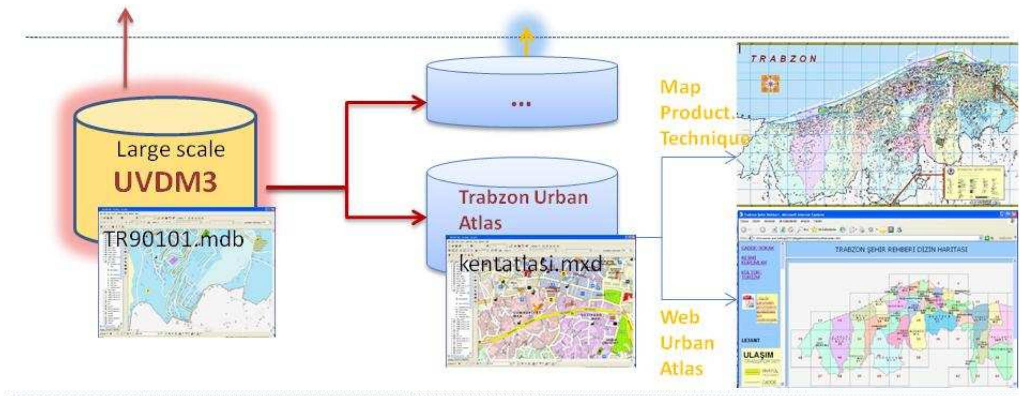

Figure 2. Urban Atlas production based on UVDM geo-database

Base Application Schema

Key properties of UVDM base application schema are explained on Figure 3;

- High level and base class of UVDM is *UVDM_CografiNesne* accepted as common and compulsory class.
- All spatial objects in feature classes have geometry and/or topology in a position.
- All spatial objects are referenced on a Geography Coordinate System named as *CografiReferans*.
- All spatial objects defined on feature classes of data themes are sub-class and specialization of *UVDM_CografiNesne*.
- *NesneTanımlayıcı* defines all spatial objects with unique identifier attribute.
- *NesneVersiyonu* defines and controls changes of the objects through time with attributes.
- *KullanımHakkı* defines data accession permission and sources with attributes.

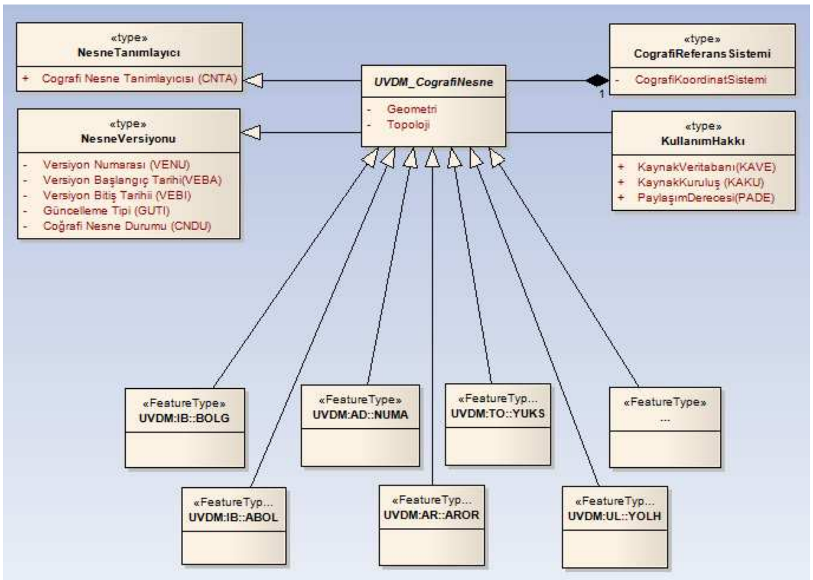

Figure 3. TURKVA:UVDM Base Application Schema

Spatial Object Identification and Versioning

A common framework is determined for the unique identification of spatial objects. These identifiers can be used to ensure interoperability among databases under national systems. This means all spatial objects shall carry a unique identifier property. In order for a unique identifier to remain meaningful, it must persist throughout the lifecycle of the object it refers to.

For example, Public Institutions such as Turkey Statistics Institute (TURKSTAT) and General Directorate of Local Governments use different hierarchical definitions related to administrative units. There is no IDBK that is defined from national to local level hierarchically. Therefore, IDBK should be produced in respect of country's administrative hierarchy. Administrative Unit definitions used in public institutions were combined. In Administrative Unit data theme (IB), Administrative Unit Code (IDBK) was produced to form relationship among the databases representing administrative units. IDBK with 12 digits was used on Administrative Unit Spatial Data Sets at the lowest level. Also, object identifier for cadastral parcels and addresses were produced, based on the lowest level administrative unit code, Village /District (Koy /Mahalle) code.

Feature Types defined on different data themes support data sharing for applications. For example; as seen on Figure 4, spatial data sets presenting Region (BOLG), Sub-region (ABOL), Provinces (N3IL), County (ILCE), Municipality (BELD), and District/Village (MAKO) can be combined with CNTA attributes describing IDBK. Numbering data sets (NUMA) in Address Data theme (AD) can be related to Building data sets (YAPI) in Ownership/Building data theme (MU) to support various local applications. And like this, similar combinations and data sharing possibilities provide opportunities to manage the data on Urban GIS applications.

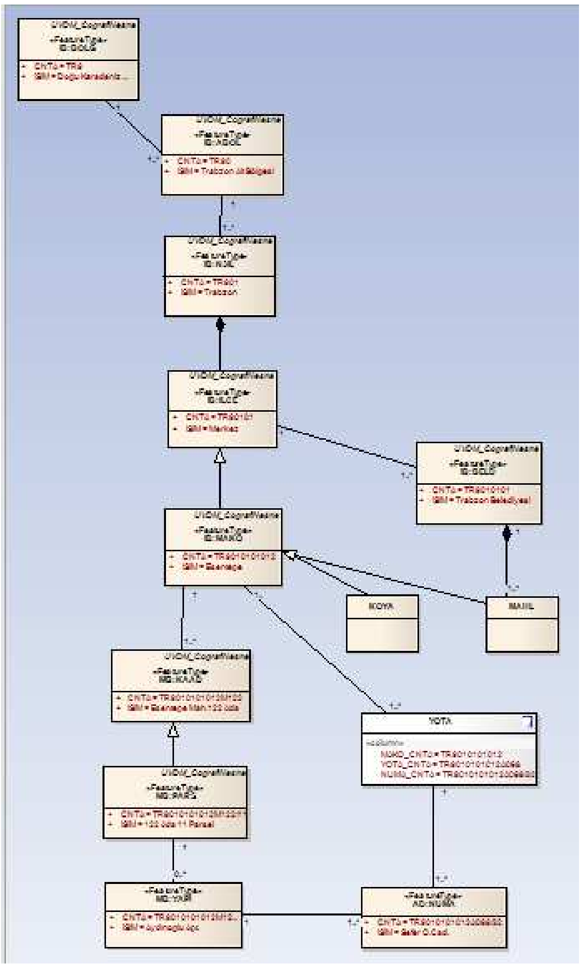

Figure 4. Managing spatial data in sharable environment

Temporal feature class is produced for each feature class to manage the data temporally. This class defines attributes such as Geographic Data Identifier (CNTA), Versioning Number (VENU), Version Starting and Finishing Date (VEBA and VEBI). Old versions of an object can get from temporal class, with the using of attribute CNTA. In addition to this, life cycle of an object was defined with some rules.

For example, Urban GIS applications of Trabzon city were produced based on UVDM. This provides data harmonization to manage the data corporately. Also, all these data have unique object identity and versioning attributes. As seen on Figure 5, numbering feature class (NUMA) in AD data theme and building (YAPI), parcel (PARS), block (KAAD) feature classes in MB data theme can be shared. And, it is possible to get the versions of data at different time. Feature classes of Trabzon City-Esentepe district-397 block can be seen on Figure 5. As a result of attribute query of VEBA and VEBI on feature and temporal feature classes; NUMA, PARS, KAAD, and YAPI features can be get and mapped on specific data, like Figure 5-1 for 01.01.2007 and Figure 5-2 for 01.06.2008.

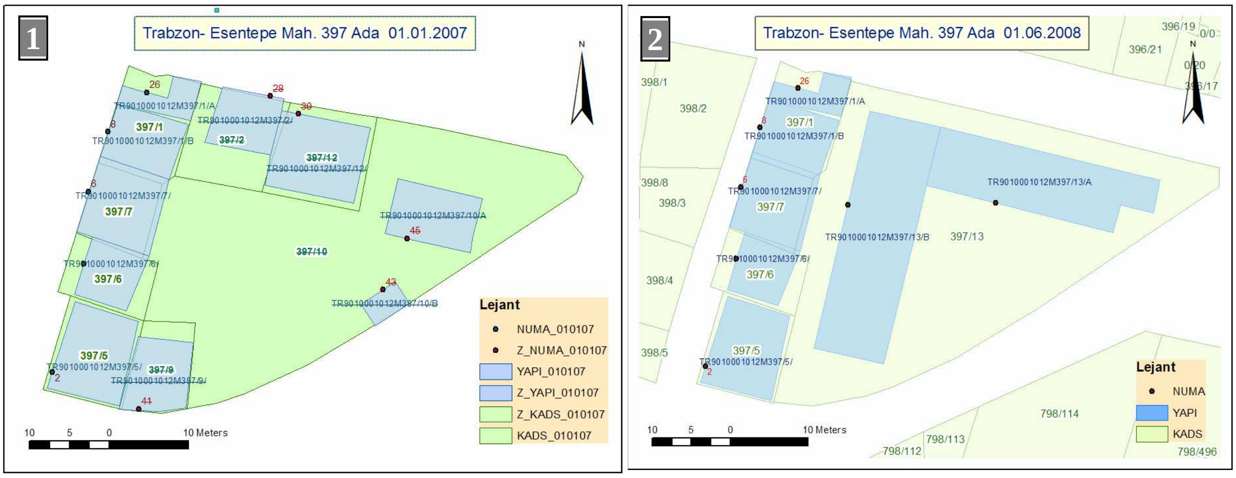

Figure 5. Versioning example for Numbering, Building, Parcel, and Block Feature Classes

CONCLUSION

Geo-database Model, also called Geographic Data Sharing Model or Feature/Object model, can provide an effective approach on spatial data management. Common terminology and definitions are key factor for data harmonization. Conceptual components enable to manage the data in terms of linking, sharing and reuse with unique and persistent identifiers. UML data modeling also supports inheritance, aggregation, composition, and association among feature classes, but it needs new tools to define spatial relations and constraints. By this way, this common approach enables to balance heterogeneity on spatial data management towards building national SDI.

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BIOGRAPHICAL NOTES

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