Towards a Standard for the Cadastral Domain

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Abstract

Managers of Cadastral systems often stress the differences between their systems. The one end has a deed, the other a title registration, some systems are centralized, and others decentralized. Some systems are based on a general boundaries approach, others on fixed boundaries. Some cadastres have a fiscal background, others a legal one. Etcetera. However, looking at it from a little distance the systems are in principle mainly the same: they are all based on the relationships between persons and land, via (property) rights and are much influenced by developments in the Information and Communication Technology (ICT). In this paper the authors propose the development of a standardized core cadastral data model based on the geographic standards from ISO and OpenGIS. This cadastral model will be developed in cooperation with the FIG, the research is related to the framework of the COST (Co-ordination in the field of Scientific and Technical Research) Action G9: 'Modelling Real Property Transactions'. This paper gives an overview of progress made so far. A standardized core cadastral domain model will serve at least two important goals: 1. avoid reinventing and re-implementing the same functionality over and over again, but provide a extensible basis for efficient and effective cadastral system development, and 2. enable involved parties, both within one country and between different countries, to communicate meaningful based on the shared ontology implied by the model.

A part of this paper has been presented to the FIG Working Week meeting, held in Paris, April 2003, some other parts have been presented at the workshop 'Towards a Cadastral Domain Model', held in Delft, October 2002 (no official publication).

1 Introduction

In spite available standards for modelling (UML), exchanging structured information (XML) and geo-information (ISO TC211 and OpenGIS Simple Features, Web Map servers, GML, etc.), there is still one important aspect missing. This is a standard and accepted *core model for the cadastral domain*. This should include both the spatial and non-spatial (administrative) part and be based on the above-mentioned standards. During the meeting of the International Federation of Surveyors in Washington in April 2002 there was a lot of attention to the standardization issue: the FIG Guide on Standardization (FIG, 2002) was presented and it has been decided to continue the work of an FIG Task Force on Standardization in the "FIG Standards Network". In the work plan 2002-2006 of Commission 7, "Cadastre and Land Management", attention is given to the development of Land Administration standards in the context of appropriate ICT support for modern land administration and land management. This will be a task for Working Group 7.3, "Advances in Modern Land Administration" of Commission 7. From the side of ISO, this is supported by ISO Technical Committee 211 resolution 203, which states that developing a core cadastral domain model (by the FIG) on top of the ISO 19100 series of standards will serve in testing these ISO standards. Further, there exits a harmonization agreement between ISO TC211 and the OpenGIS consortium. Within the OpenGIS consortium there are already several special interest groups (SIGs) working on generic domain models on which specific applications can be founded by assembling parts adhering to this domain model. The generic domain models itself are based on the underlying technology models (such as for geometry, time, meta data, etc.). The standardized cadastral domain model should be described in UML schemas and accepted by the international organizations as FIG, ISO and the OpenGIS Consortium. This will enable industry to develop products. And in turn this will enable cadastral organizations to buy these components and develop (and maintain) systems in a more efficient way. Because different cadastral systems or parts of cadastral systems are based on a shared model, the semantic aspect of communication is supported. This is also important if one considers a cadastre as a part of the national/global spatial data infrastructure (SDI). Meaningful integration with other data sources, e.g. topography, addresses, within the SDI will become possible (assuming that harmonised models in the other domains also exist). In any case, the standardized core cadastral domain model will make meaningful interpretation by other possible, which is becoming more and more important, if one realized that trough the SDI also non-traditional and/or non-professional user may access the cadastral data.

In this paper an overview is given of requirements for cadastral systems and the relationship with relevant Geo-ICT developments, in order to get an impression on the cadastral domain. Some standardization developments and initiatives related to cadastral systems are highlighted. Based on these standardization efforts and own experience an initial proposal is made in order to show how a potential core Cadastral domain model could look like. Finally it is proposed to establish a cadastral SIG (Special Interest Group) within the framework of OpenGIS consortium (which implies ISO TC211 standards) with a link to the FIG work plan.

2 Cadastral Systems: Requirements (Un/Ece Land Administration Guidelines)

The UN/ECE Land Administration guidelines (UN/ECE, 1996) are based on the assumption that a formal system is necessary to register land and property and hence to provide secure ownership in land, investments and other private and public rights in real estate. A system for recording land ownership, land values, land use and other land-related data is an indispensable tool for a market economy to work properly, as well as for sustainable management of land resources. All industrialized nations with a market economy maintain some sort of land register system that fulfils the above requirements. A land administration system can incorporate various basic objects or units, land parcels being the most common. Real estate can consist of one or several land parcels. Many countries also allow buildings or parts of buildings to be registered as separate real estates, as well as structures under or above the surface. The latter are referred to as properties in strata. Defining the basic units is a major element in the design of any land information system. A good land administration system will (according to the guidelines of the UN/ECE, 1996):

a) Guarantee ownership and security of tenure;
b) Support land and property taxation;
c) Provide security for credit;
d) Develop and monitor land markets;
e) Protect State lands;
f) Reduce land disputes;
g) Facilitate land reform;
h) Improve urban planning and infrastructure development;
i) Support environmental management;
j) Produce statistical data.

A good land information system includes spatial and non-spatial data that are closely linked to each other. Spatial data are based on field surveys. Most of the countries with a formal land information system in place have already computerized their systems, or are in the process of doing so. The existing manual systems frequently limit the opportunities for implementing optimal solutions. Furthermore, the conversion of existing files and survey data requires huge resources. Countries building new land information system from scratch-or almost-will have the benefit of not being restricted by existing systems, and should therefore have the possibility to implement optimal solutions from the very beginning. This should include the application of computer technology, both for textual data and for the maps. However, in every country of the world one thing is sure: the system requirements will change over time due to changing legislation, new technological possibilities, added or reduced registration tasks, internationalization/globalization, etc. This implies that the systems should be flexible and generic in order to cope with these changes.

3 Geo-ICT and Cadastral Systems: Surveying the Cadastral Domain

Cadastral systems include a database containing spatially referenced land data, a set of procedures and techniques for systematic *collection, updating, processing and distribution* of data and a uniform spatial reference system. Recent developments in Geo-Information and Communication Technology (ICT) have a serious impact on the development of cadastral systems. Both theoretical and practical developments in ICT such as the ubiquitous communication (Internet), data base management systems (DBMS), information system modelling standard UML (Unified Modelling Language), and positioning systems will improve the quality, cost effectiveness, performance and maintainability of cadastral systems. Further, users and industry have accepted the standardization efforts in the spatial area by the OpenGIS Consortium and the International Standards Organisation (e.g. the ISO T211 Geographic Information/Geomatics). This has resulted in the introduction of new (versions of) general ICT tools with spatial capabilities; e.g. eXtensible Mark-up Language/ Geography Mark-up Language (XML/GML), Java (with geo-libraries), object/relational Geo-DBMS including support of simple geographic features.

It is the first time ever that such a set of worldwide-accepted standards and development tools are available (UML, XML, Geo-DBMS, OpenGIS standards). This creates new perspectives in both the development of new cadastral systems and in the re-engineering, improvement of or extension of existing cadastral systems. At the moment, the first Internet-GIS applications are already operational in a cadastral context. In the near future this will be extended to mobile GIS applications based on the (dynamic) current location of the mobile user and on the cadastral information. Mobile GIS applications are sometimes also called location-based services (LBS). Imagine mobile phone or PDA (personal digital assistant) users with an integrated positioning system (e.g. a GPS receiver), such as a civil servant of the municipality, a real estate broker, or a policeman, with their mobile using up-to-date cadastral information for their day-to-day tasks in the field: ‘who is the owner of this building?’; ‘when was this building sold and what was the price?’; ‘where is the boundary of this cadastral parcel?’; etc.

It can be concluded from this analysis that the development and maintenance of the cadastral systems can benefit a lot from the new Geo-ICT and even completely new functions are now becoming possible; e.g. Internet-based distributed GI systems, Mobile GIS, etc. (van Oosterom, Lemmen, 2002).

4 Initiatives on Standardization in Relation to Cadastral Systems

Standardization is a well-known subject since the establishment of cadastral systems. In both paper based systems and computerized systems standards are required to identify objects, transactions, relations between real estate objects (e.g. parcels) and persons (also called subjects in some countries), classification of land use, land value, map representations of objects, etc. etc. Computerized systems ask for even further standardization when topology and identification of single boundaries is introduced (Van Oosterom, Lemmen, 2001). In existing cadastral systems standardization is limited to the territory or jurisdiction where the cadastral system is in operation. Open markets, globalisation, and effective and efficient development and maintenance of flexible (generic) systems ask for further standardization. In this paragraph an overview is given of some initiatives and developments.

4.1 Land Title and Tenure SIG: first initiative in OGIS

More than two years ago the Technical Committee (TC) of the OpenGIS Consortium tried to establish a 'Land Title and Tenure SIG', or Cadastre SIG (Special Interest Group). It was recognized that many organizations might be interested in this area, from Insurance Companies to Utilities, Governments of all stripes and large companies. The US Bureau of Land Management

(BLM) expressed interest; there could be benefits in relation to the National Integrated Land System (NILS). But finally this SIG initiative was without success. Apparently there were not enough OGC members supporting this. This in spite of several other successful domain SIGs within the OGC, such as Telecommunications, Defence and Intelligence, Disaster Management, Natural Resources and Environmental, etc. It is time to join forces between the FIG and the OpenGIS Consortium and start working a standard and accepted core cadastral data model; also see Section 7. This model could be used in (nearly) every country. Of course, on top of this cadastral base model, parts of the system may be added for specific situations in a certain country. That is, the model can be extended and adapted according to the theory of object-oriented systems.

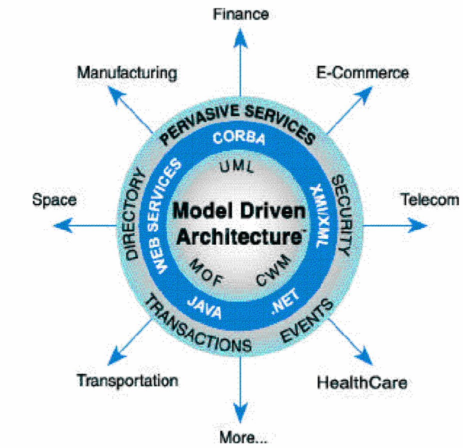

Figure 1: OMG's Model Driven Architecture (from Siegel, 2001).

As stated in the user requirements, see Section 2, cadastral systems need to be generic and flexible because of the changing requirements over time. Flexible information systems are also one of the main motivations behind the model driven architecture (MDA) al promoted by the OMG (Siegel, 2001). The MDA is based on models of information systems (components) being described in UML. Other advantages of the MDA approach, specifically for today's highly networked, constantly changing systems environment, are: portability, cross-platform interoperability, platform independence, domain specificity, and productivity. Figure 1 shows the MDA in relationship with the different technologies being incorporated (including UML) and the relationship with the different specific core domain models.

4.2 Standardization initiatives and developments in Cadastral Organizations

The fact that the establishment of the first 'Land Title and Tenure' SIG within OGC was not successful doesn't mean that no standardization efforts have been made in the cadastral domain. Cases are known form Germany, United States, New Zealand/Australia and Sweden (including the EULIS initiative). Furthermore companies like ESRI and AED graphics/SICAD provide "draft generic data models" in the cadastral domain.

4.2.1 Introduction of ISO Standards in Germany.

The Working Committee of the Surveyors Authorities of the States of the federal Republic of Germany (AdV) has started developing a new conceptual data model based on international GIS standards, which help to fulfil this task (Seifert, 2002). This conceptual model is completely object based and describes geographic and non-geographic features as well as their relations (associations). In order to describe this model in a standardized way it has been based on the ISO draft standards in the field of geographic information. In detail, the conceptual schema of the Official Cadastral Information System, is based on the following specifications (Seifert, 2002):

a) ISO 19101 Geographic Information – Reference model
b) ISO 19103 Geographic Information – Conceptual schema language
c) ISO 19105 Geographic Information – Conformance and testing
d) ISO 19107 Geographic Information – Spatial schema
e) ISO 19108 Geographic Information – Temporal schema
f) ISO 19109 Geographic Information – Rules for application schema
g) ISO 19110 Geographic Information – Feature cataloguing methodology
h) ISO 19113 Geographic Information – Quality principles
i) ISO 19115 Geographic Information – Metadata
j) ISO 19118 Geographic Information – Encoding

Main characteristics of features (Seifert, 2002):

a) They have a unique identifier
b) They belong to a class of features
c) They have (semantic and other) properties (attributes); especially quality information has to be mentioned here. These properties have codes and definitions.
d) They are spatially referenced or not. Spatial objects have a spatial reference and are optionally based on a geometrical or topological sub scheme
e) Features are simple or compound
f) Associations between features have to be maintained.
g) Features have a life cycle, for some features the history has to be documented.

There is a feature catalogue structure and a conceptual spatial schema, see figure 2.

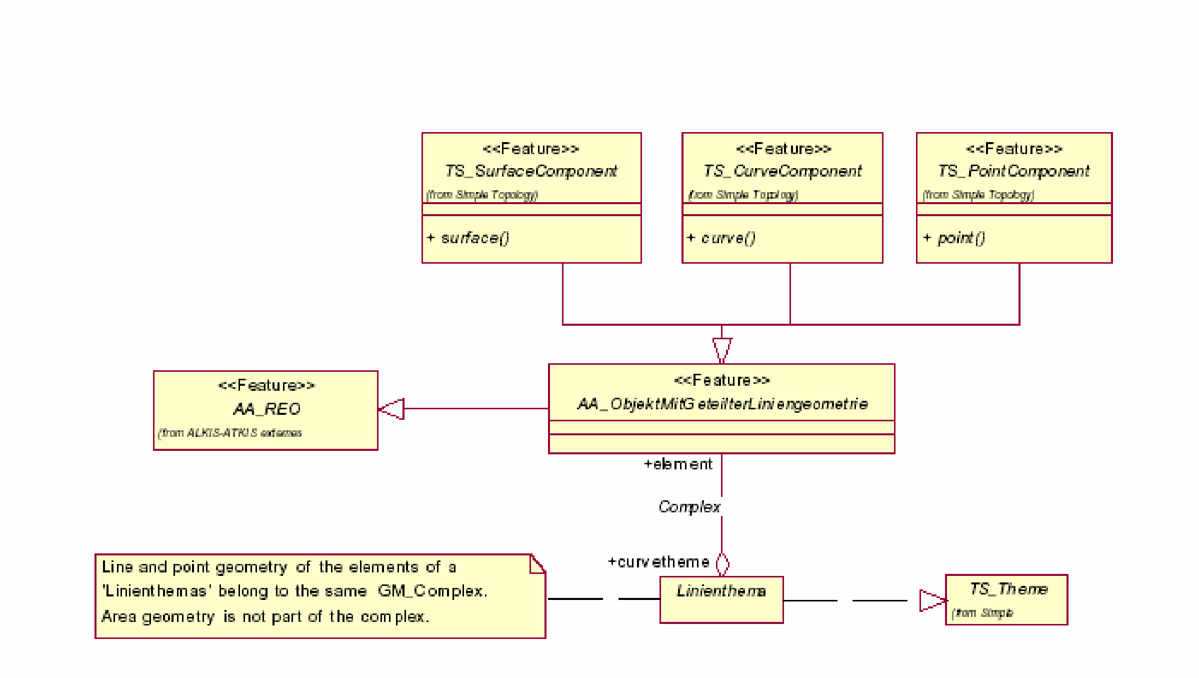

Figure 2: ALKIS Conceptual Schema (partly) in a UML class diagram (Seifert, 2002)

ALKIS (Official Cadastral Information System) becomes a core data set that can easily be combined with other data from various administrations, in order to built op a spatial data infrastructure for Germany. Therefore ALKIS will standardize the cadastral datasets in Germany.

4.2.2 US National Integrated Land System

The Cadastral Subcommittee of the US Federal Geographic Data Committee (FGDC, 1999) developed the Cadastral Data Content Standard for the National Spatial Data Infrastructure. The first version was released in 1996 and the current version 1.1 is dated April 1999. The standard has a high ‘data dictionary character’ as it mainly defines the relevant entities, their attributes and the relationships. The overall model is given in the form of an entity-relationship diagram (ERD); see figure 3 below.

The National Integrated Land System (NILS) is a joint project between the Bureau of Land Management (BLM) and the US Department of Agriculture (USDA) Forest Service in partnership with the states, counties, and private industry to provide business solutions for the management of cadastral records and land parcel information in a Geographic Information System (GIS) environment. The goal of NILS is to provide a process to collect, maintain, and store parcel-based land and survey information that meets the common, shared business needs of land title and land resource management.

The NILS concept would provide the user with tools to manage land records and cadastral data in a "Field-to-Fabric" manner: the user would be able to use field survey measurement data directly from the survey measuring equipment, manipulate this data into lines and points, and create legal land and parcel descriptions to be used in mapping and land record maintenance. This concept implies the development of a common data model that unifies the worlds of surveying and GIS. This unification concept is fundamental for land records managers and maintainers of cadastral mapping databases to improve the accuracy and quality of the data, to create standard land descriptions and cadastral data that can be used by anyone. Commercial off-the-shelf (COTS) GIS technology will form the foundation of NILS. Based on industry standards and object-oriented (OO) technology, the software will provide a modern development platform for NILS. Object-oriented software engineering techniques will be used to extend the COTS to meet to meet the specific needs of NILS's users. The NILS project has four major components Survey Management (S), Measurement Management (M), Parcel Management (P), and GeoCommunicator (G). There is a link to ESRI's ArcGIS Land Parcel data model - used as the foundation for building NILS Parcel data model. NILS uses the data and geospatial metadata standards developed by the U.S. Federal Geographic Data Committee (FGDC) in support of the National Spatial Data Infrastructure (NSDI); see the U. S. Federal Geographic Data Committee (FGDC) website www.fgdc.gov for information on spatial data standards

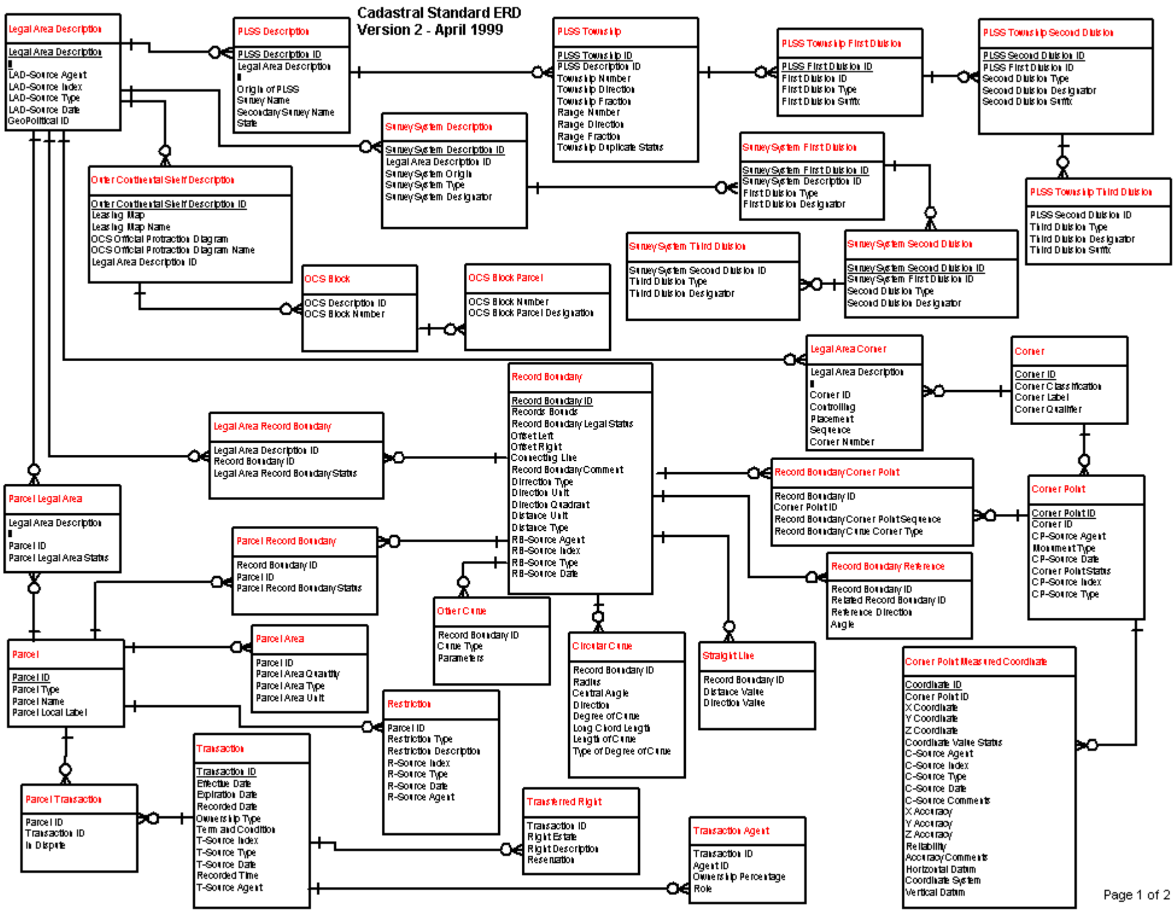

Figure 3: FGDC Cadastral Standard ERD.

The purpose of the ArcGIS Parcel Data Model (Figure 4) is to describe parcel information to support government. Parcel managers and GIS professionals can use the model as a starting point for defining parcel information in the ArcGIS environment. Decision makers will be able to apply the outcome of the model to integrate land ownership information with other data. (ArcGIS Parcel Data Model, Version 1, July 2001) Use cases have been worked out and are available on the web, www.blm.gov/nils/parcel/ .

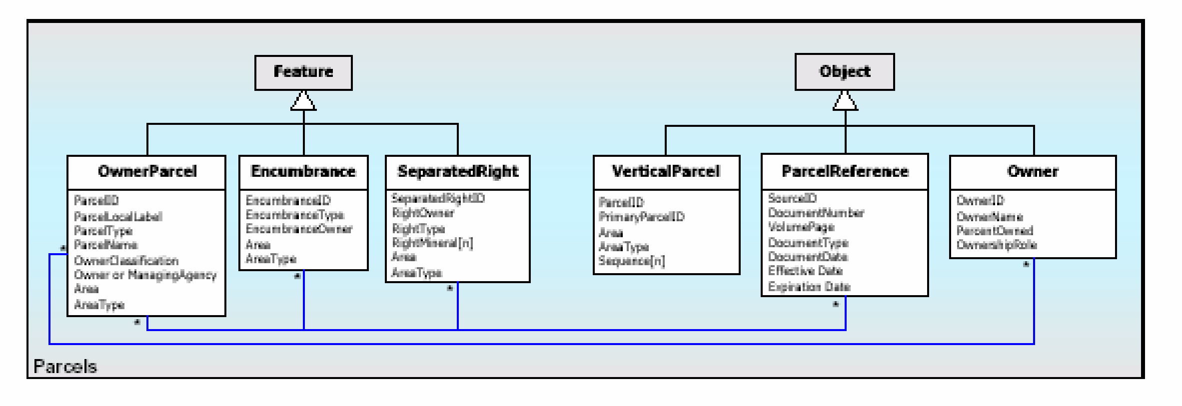

Figure 4: ArcGIS Conceptual Parcel Data Model (partly) in a UML class diagram (Nancy von Meyer, Scott Oppmann, Steve Grise, Wayne Hewitt)

4.2.3 Initiatives from Australia and New Zeeland

Several standardization initiatives have been undertaken 'down under' in the last couple of years. In New Zeeland (LINZ, 2002), the new *Cadastral Survey Exchange Format*, as part of the Land*online* survey and title automation programme is based on the LandXML (2002) model. Tough focused on the data exchange and the encoding in XML, the underlying conceptual model is implied. Land Information New Zeeland (LINZ) has made a selection of elements and their attributes from the LandXML v1.0 schema. Further, also some extensions are made to the schema by LINZ, e.g. to support the official identifiers (oID's) of the survey elements.

In several version/stages, the Intergovernmental Committee on Surveying and Mapping (ICSM) has developed a National Cadastral Data Model. This model is based on a review of cadastral models supplied by the different jurisdictions in Australia and New Zeeland. The current and last version is version 1.1 and dates back to June 1999 (ICSM, 1999). The standard contains a data dictionary with a definition of all entities and attribute terms. The model itself is described with an entity-relationship diagram. It was not expected that all jurisdictions would immediately convert to this standard. However, they should be able to import and export data based on the model according to the standard.

Based on the previous standards, the ICSM recently harmonized the data models (ICSM, 2002) from a number of fundamental data sets within the Australia Spatial Data Infrastructure (ASDI), to be specific: cadastre, topography, place names and street address (and hydrography in the near future). Common elements in these data sets are now only modelled once and based on the same definition. The resulting model seeks to be compliant with the ISO 19100-series of standards. The model is now also described in UML in a number of class diagrams of which a cadastral example (diagram 4.4, cadastral – geometry and topology, associations with survey) is shown in the figure 5.

4.2.4 Initiative from Sweden: The EULIS project.

In order to increase efficiency in handling all kinds of spatial data Sweden's Lantmäteriet is now developing ArcCadastre together with its partners ESRI and Leica. ArcCadastre is being developed to be a tool specially adapted for cadastral and mapping activities with different kinds of spatial management in different situations around the world. ArcCadastre is a solution that extends mapping functionality with survey and cadastre functionality (Ollén, 2002). ArcCadastre is well suited for customer and country specific extensions. The core product is the basic cadastral software and the tool for all mapping activities in the fields of large-scale, medium-scale, small-scale and utilities map production. The product contains all functionality needed for surveying and mapping purposes and for the greater part of the functionality that is common to cadastral workflow in different countries (Ollén, 2002). ArcCadastre has been designed as Flash-maps for

AutoKa-View, which is a program for quick viewing of maps, printout and quick search for information, is created in this way.

ArcCadastre is based on OO technology; it provides a completely open solution for developers. Any development tool supporting COM, such as Visual Basic, Visual C++ or Delphi, can be used to develop components.

Diagram 4.4 - Cadastral - Geometry and Topology,Associations with Survey

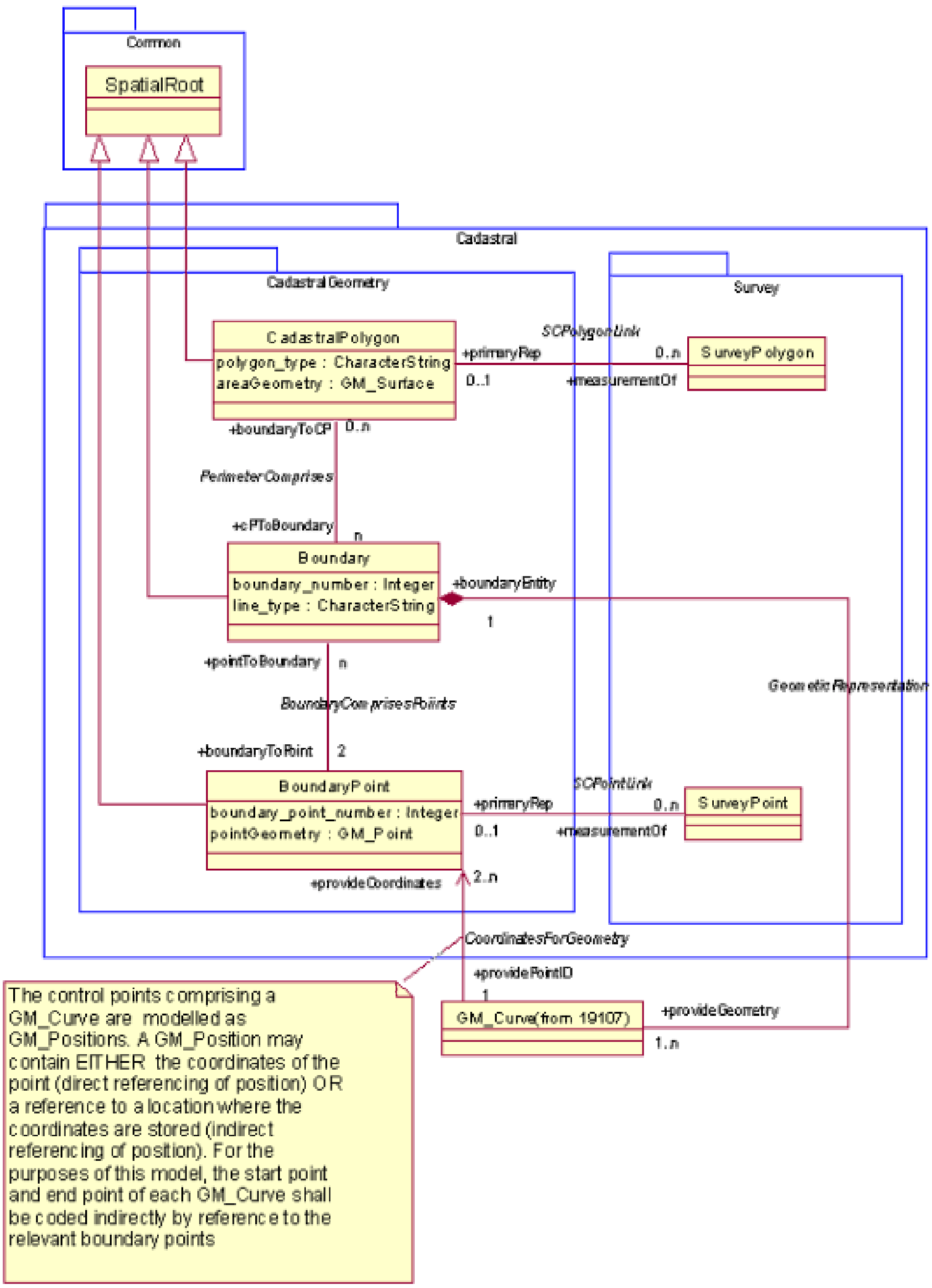

Figure 5: Cadastral-Geometry and Topology model in a UML class diagram, associations with Survey (Copyright ICSM)

To an increasing extend the European market is becoming more integrated. So far property transactions have remained quite national, and complaints have been made about the lack of a single mortgage market. In order to speed up the integration process Lantmäteriet has initiated a project for providing the market with a single point of access to land information across the borders (Ollén, 2002). This project, EULIS, is carried out by nine organizations from different parts of Europe:

a) Landmäteriet, Sweden
b) National Land Survey, Finland
c) HM Land Registry, (for England, Wales)
d) Registers of Scotland
e) State Land Cadastre (Lituania)
f) Kadaster, the Netherlands
g) Ministry of Justice, Austria
h) Norsk Eiendominformasion, Norway
i) University of Lund, Sweden

Although all participants have computerized national land information registers in operation, there are still certain inhibitors to the operation of the international market. There are, for example, no common principles for collecting and storing information, no common legal and regulatory framework and no common principles for access to information. The participating organizations have agreed to work together to explore how some of these difficulties could be overcome. An important part of such development would be the improvement of international access to land and property registers. The EULIS project will create a demonstrator that will show how improved access to information from eight national land registries could be provided on line. www.eulis.org.
It should be noted that EULIS would first focus on the administrative (legal) aspects of the cadastral data as this is the more 'easy' part (and comparable to other administrative information systems). In a second phase spatial data will be added as otherwise the administrative information will have no meaning without a proper relationship to the spatial information.

4.3 COST Research Activity Statement

Founded in 1971, COST is an intergovernmental framework for European Co-operation in the field of Scientific and Technical Research, allowing the co-ordination of nationally funded research on a European level. COST Actions cover basic and pre-competitive research as well as activities of public utility. http://cost.cordis.lu/src/whatiscost.cfm

The goal of COST is to ensure that Europe holds a strong position in the field of scientific and technical research for peaceful purposes, by increasing European co-operation and interaction in this field.

The main objective of the Action G9 ("Modeling Real Property Transactions") is

a) To improve the transparency of real property markets and
b) To provide a stronger basis for the reduction of costs of real property transactions by preparing a set of models of real property transactions, which is correct, formalized, and complete according to stated criteria, and then
c) Assessing the economic efficiency of these transactions.

The modelling activity of the action intend to develop a framework for the future information systems through a comparative analysis of the existing, cross-organizational transactions and the databases regarding real property. A workshop on cadastral data modelling within the framework of this COST G9 research has been organized in Delft, The Netherlands, October 10-12 2002: 'Towards a Cadastral Core Domain Model, 3rd workshop and 4th MC meeting of the COST G9 action'. The development of a Core Cadastral Model is included in this research now.

4.3.1 The International Federation of Surveyors (FIG)

FIG as an organization is able to participate in the activities of standardization bodies (Greenway, 2002). The process of creating a standard is complex and time consuming. But the work of ISO grew out of manufacturing. It is therefore of no surprise that the activities of the technical commissions of FIG are well covered by international standards. It is important for FIG to co-ordinate it's influencing and informative efforts with other international Non-Governmental Organizations (NGO's) to ensure that the combined efforts are co-ordinated to best effect. Within the FIG the FIG standards network has been established at XXII International Congress, April 2002, Washington DC, www.fig.net.

The working group 7.3 of Commission 7, "Cadastre and Land Management" of the International Federation of Surveyors will touch standards issues. The terms of reference of this group are as follows:

a) Identify the impact of advanced technology on land administration systems
b) Focus on electronic conveyancing and electronic submission of documents
c) Electronic signatures
d) Focus on internet as a distribution channel
e) Focus on standards (ISO as applied to 'cadastres')
f) Develop recommendations
g) Identify best practices
h) Organise a symposium on use of advanced technology

The working group tries to find answers to the questions: "What are common elements in all Cadastral Systems?" and: "Which should be the basic elements in a Digital Cadastral Database to operate as a key element of a national- or global spatial data infrastructure?". This definition of basic elements that should be found in each Digital Cadastral Database can be helpful for easier land transactions on an international level (EU, Americas) as well as for planning processes on a national and international level.

Using the same standard modelling language as ISO, UML (maintained by the OMG, see section 4.1), the description of these basic cadastral elements shall be carried out. The use of UML will enable information systems specialists all over the world to understand what is required. ISO TC 211 is interested in a co-operation with FIG in this field by testing the ISO 19100 series of standards in practice. This is expressed in ISO/TC211, resolution 203, which literally states (www.isotc211.org/Resolutions/resolu13.htm):

a) "ISO/TC211 appreciates the FIG proposal to develop a model of the basic contents and design of a cadastre using the ISO 19100 series of standards.
b) It is acknowledged that this activity will serve to both test the 19100 standards and build on the exiting collaboration between ISO/TC211 and the FIG.
c) ISO/TC211 encourages FIG to suggest how ISO/TC211 could assist in this activity."

As already explained, it was decided within the FIG that the standardization issue in relation to Cadastre (ISO as applied to 'cadastres') will be managed by the Working Group 7.3 of Commission 7, 'Cadastre and Land Management'. The FIG will further continue the work of an FIG Task Force on Standardization in the 'FIG Standards Network', in which close cooperation with ISO TC 211 will be established.

Standardization of the Cadastral Domain will be one of the issues to be discussed during the FIG Paris Working Week in April 2003. During first discussions about the future work in WG7.3 focus has been on one very interesting investigation about the basic contents of a Digital Cadastral Data Base (DCDB). It is not necessary to define the basic contents of a DCDB as a closed (final) standard itself, but we think it helps different jurisdictions to design or re-design their cadastral systems by using this work as a good practice guide. The Working Group plans to publish the results as good practice guidelines via Internet or/and a booklet.

The item of standardisation was the key issue of a Workshop on Cadastral Data Modelling organised at International Institute of Geo-Information Science and Earth Observation, ITC, in Enschede, The Netherlands, March 17 and 18, 2003. This workshop was sponsored by FIG, ITC and ESRI. Basis for discussion was the Cadastral Core Model as presented in this paper, paragraph 6, and the vision as presented in Cadastre 2014 (Kaufmann, Steudler, 1998). Main outcomes of the discussions: the core model has to be extended with geometric representations for (public) restrictions (this means several layers with geometric data have to be included); the surveying 'package', the model should be presented in full accordance to the UML standards. Documentation related to this workshop is presented at www.oicrf.org , keyword 'WCDM'.

5 Overview of the Core Cadastral Domain Model

In order to give an impression of how the future standard core cadastral domain model could look like, a possible model is presented here (based on the ingredients of models presented in Section 4.2). This model could be the start of a true international cadastral standardization and everybody is encouraged to react on or contribute to the proposed model. The proposed UML class diagram is already draft version 2 and is shown in figure 6. This proposal contains improvements/extensions of an earlier version of the model, presented to the COST workshop 'Towards a Cadastral Domain Model', which was held in Delft, October 2002; http://www.i4.auc.dk/costg9/.

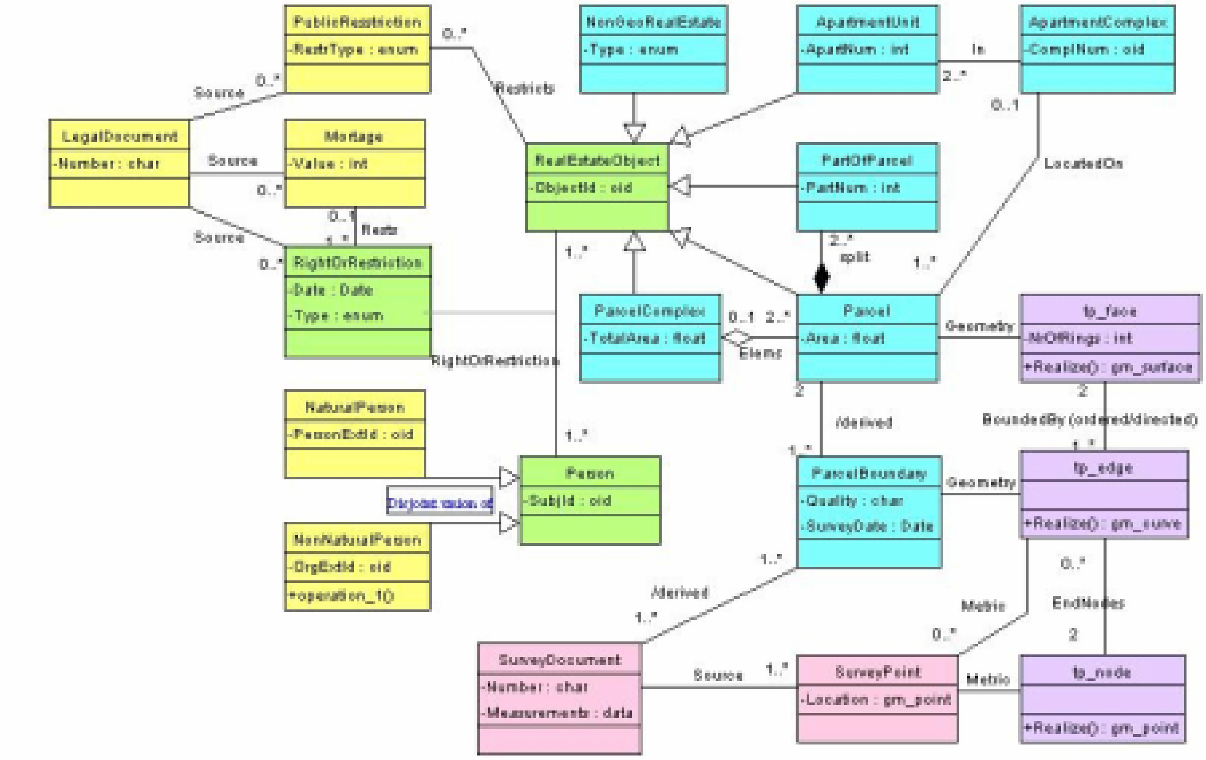

Figure 6: Second draft of the Core Cadastral Domain Model

A class diagram describes the types of objects and the various kinds of structural relationships that exist among them like associations and subtypes. Furthermore the class diagrams show the attributes and operations of a class and the constraints that apply to the way objects are connected (Booch, Rumbaugh, Jacobson, 1999).

The here proposed class diagram for the cadastral domain contains both legal/administrative object classes like persons, rights and the description of real estate objects. This means in principle that data could be maintained by different organizations, e.g. Municipality or other Planning Authorities, Private Surveyor, Cadastre, Conveyancor and/or Land Registry. The model will most likely be implemented as a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model (diagram), thereby using other parts of the model. This underlines the relevance of this model; different organizations have their own responsibilities in data maintenance and supply and have to communicate on the basis of standardized processes in so called value adding production chains.

One should not look at the whole model at once as the colors are supposed to represent different 'packages' or aspects:

a) Green: real core
b) Green and yellow: legal/administrative aspects,
c) Green and blue: real estate object specializations,
d) Blue, pink and purple: geometric/topological aspects.

Focus in this paper is on the class diagram, which is considered to represent the real core of the Domain. The class diagram should further be completed by diagrams covering other aspects, e.g. use case diagrams, activity diagrams, etc. (Tuladhar, 2002).

6 Some Classes in More Detail

6.1 Core Classes

The relationship between real estate objects, (e.g. parcels) and persons (sometimes called also called 'subjects') via rights is the foundation of every land administration. Besides rights, there can also be restrictions between the real estate objects and the persons. Related classes, associations and multiplicities are depicted in the green part of figure 6, in which it is also shown that RightOrRestriction is an association class between the classes Person and RealEstateObject.

6.2 Specializations of RealEstateObject: object detail classes

A RealEstateObject is an abstract class, that is, there are no object instances of this object class. However, it has specialization classes (which have object instances), such as Parcel, ParcelComplex, PartOfParcel, ApartmentUnit, and NonGeoRealEstate. This is represented in blue in figure 6.

A ParcelComplex is an aggregation of Parcels. The fact that the multiplicity at the side ParcelComplex is 0..1 (in the association with Parcel) means that this is optional. A ParcelComplex situation might occur in a system where a set of Parcels -could be in one municipality or even in another administrative unit- has a legal/customary meaning.

A Parcel can be subdivided in two or more PartOfParcel's. This case could occur when 'preliminary' Parcels are created during a conveyance where Parcel will be split and surveying is done afterwards. It could also be helpful to support planning processes, based on cadastral maps, where establishment of Parcels in the field is done later in time.

An ApartmentComplex is associated with one or more Parcel's. There can be at most one ApartmentComplex located on a Parcel. There can be two or more ApartmentUnit's in an ApartmentComplex. Note that an ApartmentUnit is intended in the general sense, not only unit for living purposes, but also for other purposes, e.g. commercial. In other words, all building units with legal/registration significance are included here.

Parcel's are defined by ParcelBoundaries and have a geometric/topological description (Oosterom, van, Lemmen, 2001). The class ParcelBoundary always has two neighbor Parcel's, where territorial ParcelBoundary's have one 'zero-Parcel' as neighbor, representing the external territory. There can be more then one ParcelBoundary's between two neighbor Parcels, depending on attributes and the geometric configuration. Exclaves and enclaves from territorial perspective can be managed in this approach. In general this approach implies that individual Parcels are not represented as 'closed polygons'. Attributes can be linked to individual boundaries; this allows for example classification of individual boundaries based on the administrative subdivision of the territory. In this way double, triple or multiple storage of the same boundary can be avoided, thus avoiding all kind of 'gap and overlap' problems, which don't have a relation to reality.

The class NonGeoRealEstate can be useful in case where a (complete) geometric description of the RealEstateObject does not (yet) exist. E.g. in case where only one co-ordinate inside the RealEstateObject is observed, using Satellite Images or GPS. Or in case of fishing rights, mining rights, which are not directly related to a specific location, etc.

6.3 Surveying Classes

Object classes related to surveying are presented in pink color. A cadastral survey is documented on a Survey Document, which is a (legal) source document made up in the field. Most importantly, this document contains signatures. Files with terrestrial observations -distances, bearings, and referred geodetic control- on points are attributes of SurveyDocument, the Measurements. Both ParcelBoundary and SurveyPoint are associated with SurveyDocument. From the multiplicity it can be recognized that one SurveyDocument can be associated with several SurveyPoints. In case a SurveyPoint is observed at different moments in time there will be different SurveyDocuments. In case a SurveyPoint is observed from different positions during a measurement there is only one association with a SurveyDocument. The association between a ParcelBoundary and SurveyDocument is *derived* via the classes SurveyPoint, tp_node and tp_edge.

6.4 Geometry and Topology: imported OpenGIS classes

Object classes describing topology are presented in purple. The Cadastral Domain Model is based on already accepted and available standards *on geometry and topology* published by ISO and OGC (ISO, 1999a, 1999b, OpenGIS Consortium 1998, 2000a, 2000b, 2000c and 2000d). *Geometry* is based on SurveyPoints (mostly after geo referencing, depending on data collection mode: tape, total station, GPS, etc) and is associated with the classes tp_node (topology node) and tp_edge (topology edge) to describe 'shapes' between points, metrically based on SurveyPoints.

Parcels have a 2D geometric description. A Parcel corresponds one-to-one to the tp_face in a topological structure (as defined by ISO TC 211 and OpenGIS Consortium). A face is bounded by its edges in 2D. An edge is related one-to-one to a ParcelBoundary, which may contain non-geometric attributes as explained in 6.2. Every edge has exactly two end points, represented in tp_nodes. In addition, an edge may also have several intermediate points. Both intermediate points and nodes are associated with SurveyPoints. The topological primitives tp_face, tp_edge and tp_nodes, have all a method ('operation') called 'Realize' which can be used to obtain a full metric representation.

Please note that the here proposed draft version 2 of the model does not yet include a 3D geometric/topological description, associated rights are in reality of course 3D (Stoter, et al. 2002).

6.5 Legal/Administrative classes

Object classes presented in yellow cover the refinements in the Legal/Administrative side. All updates associated to RightsOrRestrictions are based on LegalDocuments as source. In principle legal data will not be changed without provision of a LegalDocument. The essential data of a LegalDocument are associated with ('can be represented in') the classes RightOrRestriction, Mortgage or PublicRestriction.

The abstract class 'Person' (that is again a class without object instances) has as specialization classes NaturalPerson or NonNaturalPerson like organizations, companies, co-operations and other entities representing social structures. If a Person is a NaturalPerson it cannot be a NonNaturalPerson and the other way around. That is, Person is a disjoint union of NaturalPerson and NonNaturalPerson.

6.6 Back to the Core Classes

Right (a subset based on the type attribute in RightOrRestriction) is compulsory association between RealEstateObject and Person, where this is not compulsory in case of restriction (the other subset in RightOrRestriction). For example, a restriction like encumbrance, is only associated with the land: the RealEstateObject.

Property and ownership rights are based on legislation. ‘Lookup tables’ can support in this, e.g. the right of ‘ownership’ might be ‘Norwegian Ownership’, ‘Swedish Ownership’, etc. etc. ‘Customary Right’ related to a region or ‘Informal Right’ can be included, from modelling perspective this is not an item for discussion.

The class RightOrRestriction allows for the introduction of ‘shares of rights’ in case where a group of Persons holds a fraction of a ‘complete’ right.

6.7 Further developments

As indicated in the beginning of this section, the presented second version of the Core Cadastral Domain Model is just a proposal and a potential start for the final standardized model. Many more things have to be done (and perhaps modelled in additional packages or refinements). Potential further developments could be:

Review on multiplicity to allow as much flexibility as possible in the introduction of separate ‘packages’ of the model, independent from the introduction of other packages.

History. This could be represented in ‘parent/child’ associations between cadastral objects, e.g. in case of sub-division of a cadastral parcel. Another temporal extension is inclusion of tmin/tmax attributes to all classes. New inserted instances get a tmin, equal to the check-in/transaction time and a tmax equal to the maximal (integer) value. A deleted instance gets a tmax equal to its check-in/transaction time. In case of update of one or more attributes, a new instance will be created (as copy from the old instance with its new values for updated attributes) with a tmin equal to check-in/transaction time and a tmax equal to a maximum value. The old instance gets a tmax equal to check-in/transaction time. This allows to query for the spatial representation of cadastral objects at any moment *t* back in time or to query for all updates between a moment *t1* and *t2* in the past. Apart from check-in/transaction times the real dates of observation in the field can be included to manage history.

a) Other types of RealEstateObjects: airplanes and ships. Mortgage can be established here!
b) GeodeticReferencePoints, could be a specialization associated with SurveyPoint. This will make SurveyPoint an abstract class with CadastralSurveyPoints and GeodeticReferencePoints as specializations. Further specialization could be CadastralCentroidPoint, in case only one point of a Parcel or NonGeoRealEstate is observed.
c) 3D Cadastral aspects (e.g. above/below surface)
d) Higher level admin units (aggregations: sections, municipalities,...)
e) Land consolidation/reform, urban development, urban and rural cadastres
f) Links to external registrations could include:
   - Persons (e.g. via fiscal person identifier, or other approved identifiers)
   - Companies/organizations (e.g. chamber of commerce)
   - Addresses and zip codes, related to objects *and* subjects
   - Buildings or more general, topographic data, in relation to core cadastral data.

7 Co-operation with the OpenGIS Consortium

Worldwide many efforts can be recognized related to standardization in the cadastral domain. It is proposed here to join forces between FIG and OpenGIS (ISO TC211) and to establish an OGC SIG for the Cadastral Domain. The activities of this SIG could be organized in close co-operation with the FIG.

OGC Seeks Sponsors for Property and Land Initiative as announced in a press release of March 25, 2003: ‘The Open GIS Consortium, Inc. (OGC) is issuing a Call for Sponsors for a Planning Activity that may support future development of an OGC Property and Land Information (PLI) Initiative. This planning activity will seek interested Sponsors to provide input on technology requirements and concepts to foster development of next-generation interoperable networked architectures and capabilities to enable broader sharing and application of property data and land information between collaborating organizations’. And: ‘The ultimate goal of the OGC Property and Land Information Initiative is to promote increased understanding of the application of OpenGIS® Specifications to the challenge of cross-organizational and cross jurisdictional access to critical information. The Initiative would seek to design, test and operationally validate open architectural frameworks for distributed property and land information networks. As part of the growing "Spatial Web", these networks will allow information to be easily exchanged between consumers, governments, and businesses for many different purposes. This information would be accessible online through OpenGIS Interface Specifications and other standards consistent with best practices defined as part of National and Global Spatial Data Infrastructures and E-Government initiatives. This initiative will demonstrate how standards-based distributed networks of databases and information services can help consumers and citizens to access vital data, businesses to offer premium customer services, and governments to provide more effective service to citizens'.

The introduction of a de facto standard on the cadastral domain, which is OpenGIS compliant, is a substantial effort. In any case there should be sufficient support world wide.

The model as proposed in this paper, and as it will be further developed, might contribute in this.

8 Conclusions

A core cadastral data model should serve at least two purposes:

a) Enable effective and efficient implementation of flexible (and generic) cadastral information systems based on a model driven architecture (as argued in this paper), and
a) Provide the 'common ground' for data exchange between different systems in the cadastral domain.

The later one has not been argued a lot in this paper, but is also a very important motivator to develop a core cadastral data model, which could be used in an international context; e.g. the EULIS project. The OpenGIS Consortium 'Property and Land Information Initiative', as announced in March 2003, underlignes the relevance of standardisation.

We would again like to emphasize that the current (second) version of the Core Cadastral Domain Model is just a proposal; it is incomplete and may even contain errors. We would like to encourage everybody to participate in the further development of this model in order to make this standardization effort really work.

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