

# **Towards a Standard for the Cadastral Domain: Proposal to establish a Core Cadastral Data Model**

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*For many decades researchers and managers of Cadastral systems have been stressing the differences in their systems: deed or title registration, centralized or decentralized, general or fixed boundaries, fiscal or legal cadastre, etc. However, looking at it from a little distance the systems are in principle mainly the same: they are all based on the relationships between subjects (persons) and objects (land, property) via rights. Further, one thing has become clearer everywhere, the Cadastral systems are influenced a lot by the Information and Communication Technology (ICT) developments. In this paper the authors propose the development of a standardized core cadastral data model based on the geographic standards from ISO and OpenGIS and to be developed in cooperation with the FIG.*

**Key words:** Cadastral Systems, Cadastral Domain, OpenGIS Standards

## **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 exists 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.

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 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):

- (i) Guarantee ownership and security of tenure;
- (ii) Support land and property taxation;
- (iii) Provide security for credit;
- (iv) Develop and monitor land markets;
- (v) Protect State lands;
- (vi) Reduce land disputes;
- (vii) Facilitate land reform;
- (viii) Improve urban planning and infrastructure development;
- (ix) Support environmental management;
- (x) 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 objects and subjects, 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. 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. 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.

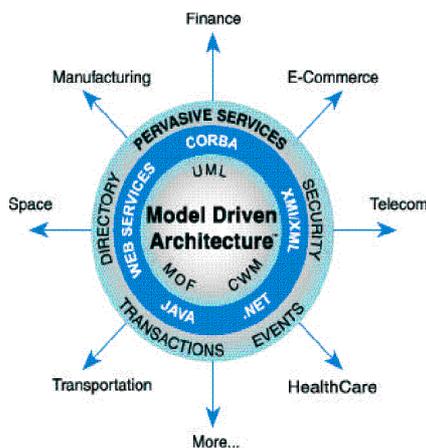


Figure 1: OMG's Model Driven Architecture (from Siegel, 2001).

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 from 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):

- ISO 19101 Geographic Information – Reference model
- ISO 19103 Geographic Information – Conceptual schema language
- ISO 19105 Geographic Information – Conformance and testing
- ISO 19107 Geographic Information – Spatial schema
- ISO 19108 Geographic Information – Temporal schema
- ISO 19109 Geographic Information – Rules for application schema
- ISO 19110 Geographic Information – Feature cataloguing methodology
- ISO 19113 Geographic Information – Quality principles
- ISO 19115 Geographic Information – Metadata
- ISO 19118 Geographic Information – Encoding

Main characteristics of features (Seifert, 2002):

- They have a unique identifier
- They belong to a class of features
- They have (semantic and other) properties (attributes); especially quality information has to be mentioned here. These properties have codes and definitions.
- They are spatially referenced or not. Spatial objects have a spatial reference and are optionally based on a geometrical or topological sub scheme
- Features are simple or compound
- Associations between features have to be maintained.
- 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.

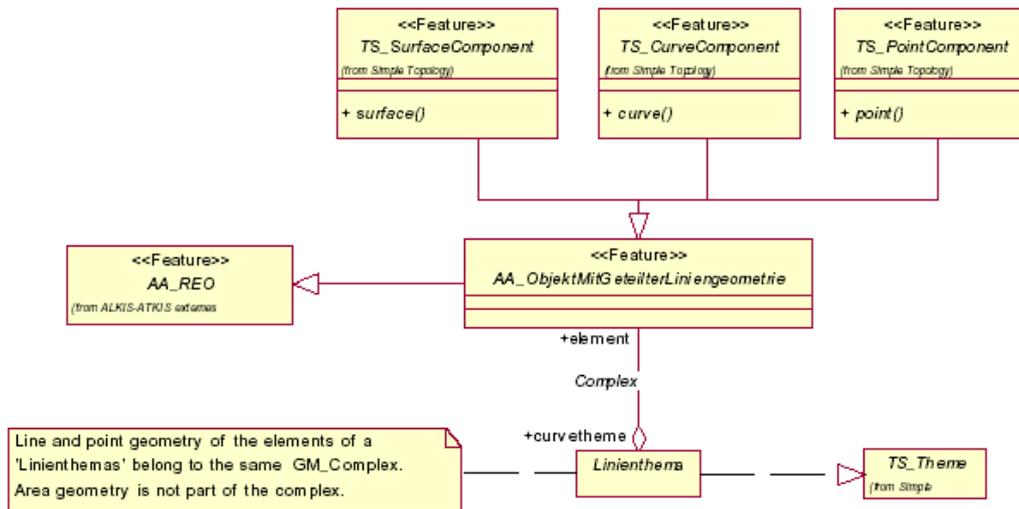


Figure 2: ALKIS Conceptual Schema (Seifert, 2002)

ALKIS (Official Cadastral Information System) becomes a core data set that can easily be combined with other data from various administrations, in order to build 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.

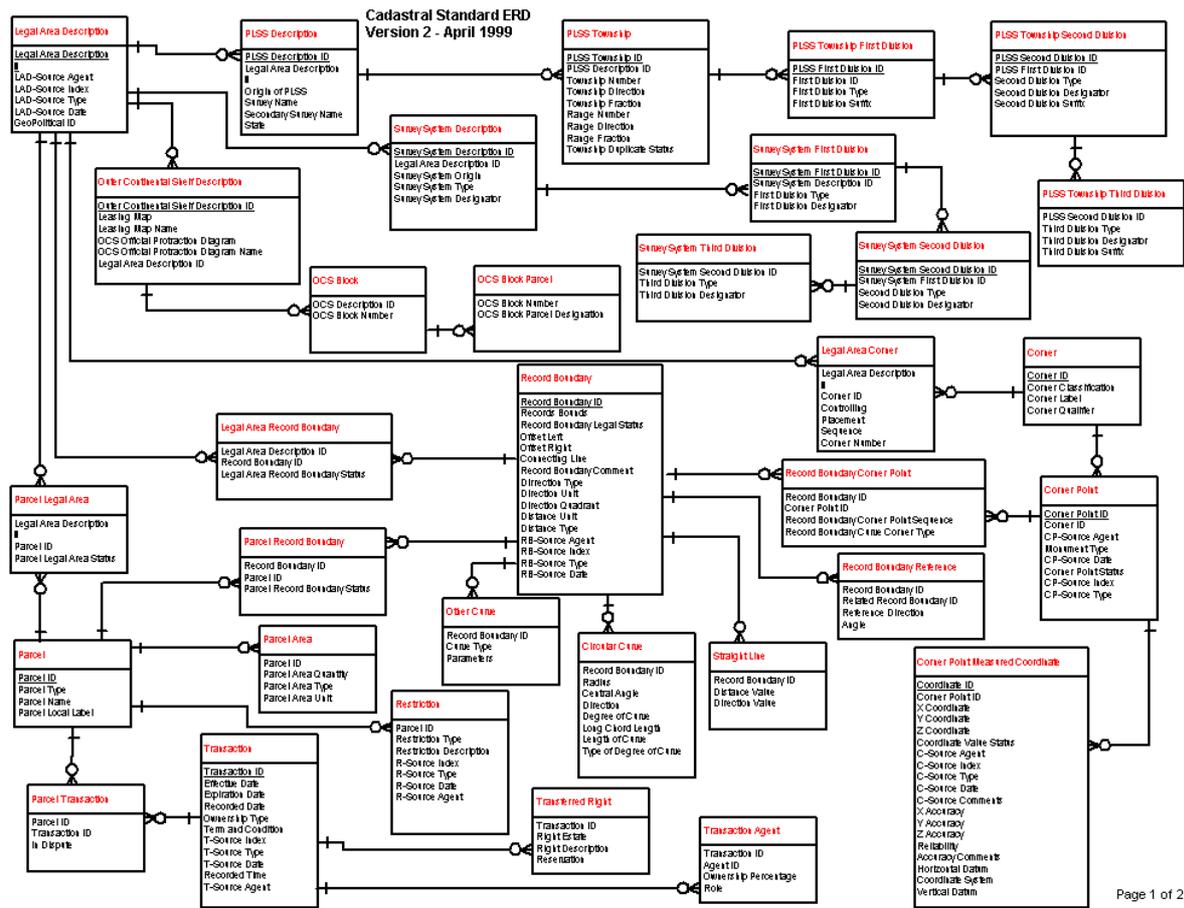


Figure 3: FGDC Cadastral Standard ERD.

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 U. S. Federal Geographic Data Committee (FGDC) Web site [www.fgdc.gov](http://www.fgdc.gov) for information on spatial data standards

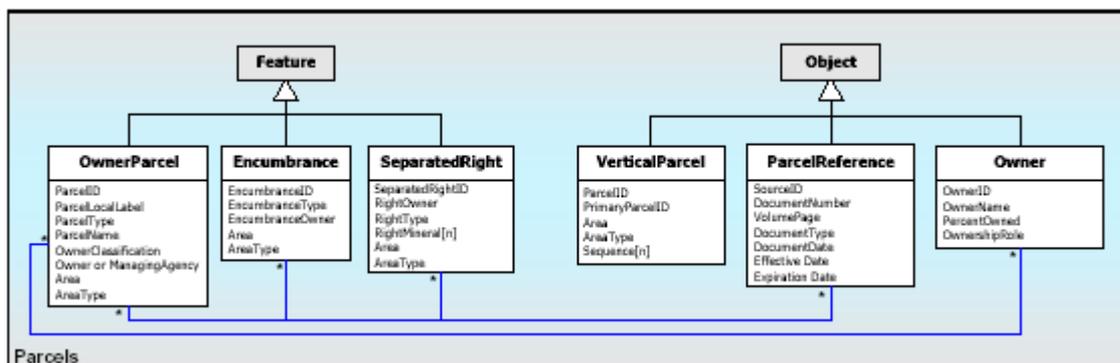


Figure 4: ArcGIS Conceptual Parcel Data Model (Nancy von Meyer, Scott Oppmann, Steve Grise, Wayne Hewitt)

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/](http://www.blm.gov/nils/parcel/)

#### 4.2.3. Initiatives from Australia and New Zealand

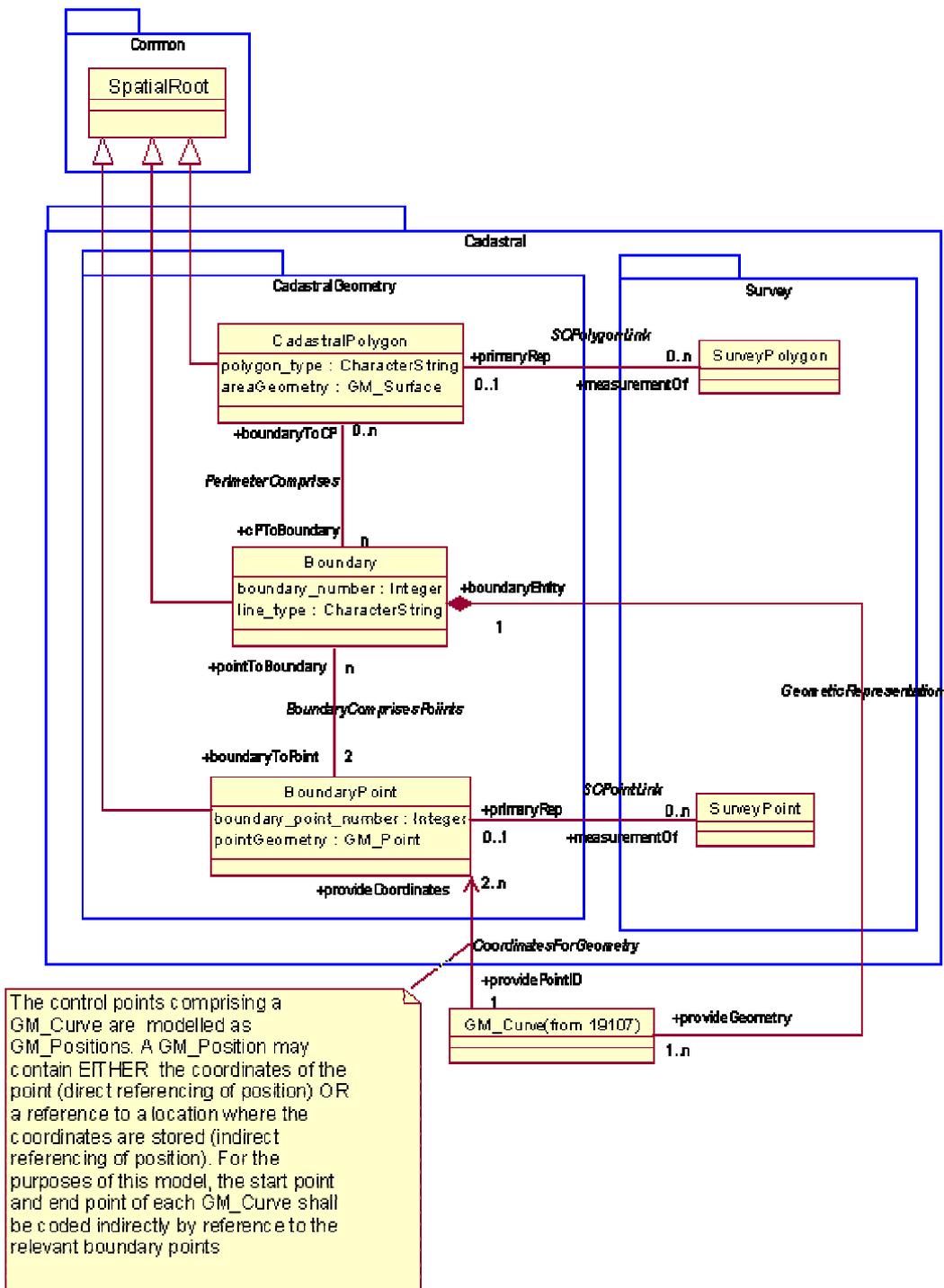
Several standardization initiatives have been undertaken 'down under' in the last couple of years. In New Zealand (LINZ, 2002), the new *Cadastral Survey Exchange Format*, as part of

the *Landonline* survey and title automation programme is based on the LandXML (2002) model. Though focused on the data exchange and the encoding in XML, the underlying conceptual model is implied. Land Information New Zealand (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 Zealand. 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) are shown in the figure 5.

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



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*Figure 5: Cadastral-Geometry and Topology Diagram, associations with Survey, Copyright ICSM*

#### 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.

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:

- Landmäteriet, Sweden
- National Land Survey, Finland
- HM Land Registry, (for England, Wales)
- Registers of Scotland
- State Land Cadastre (Lithuania)
- Kadaster, the Netherlands
- Ministry of Justice, Austria
- Norsk Eiendominformasjon, Norway
- 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 collection 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](http://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. 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 its 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](http://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:

- Identify the impact of advanced technology on land administration systems
- Focus on electronic conveyancing and electronic submission of documents
- Electronic signatures
- Focus on internet as a distribution channel
- Focus on standards (ISO as applied to 'cadastres')
- Develop recommendations
- Identify best practices
- Organise 1 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](http://www.isotc211.org/Resolutions/resolu13.htm)) :

- "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.
- It is acknowledged that this activity will serve to both test the 19100 standards and build on the existing collaboration between ISO/TC211 and the FIG.
- ISO/TC211 encourages FIG to suggest how ISO/TC211 could assist in this activity."

## 5. Proposal core cadastral data model

Based on mentioned the standardization initiatives mention in the previous section and also based on personal experience from the authors in the Netherlands Cadastre, and finally also based on the experience from Kadaster International in Bolivia, El Salvador, Paraguay and Guatemala, a core cadastral data model is proposed. This is just an *initial* proposal, of which the only purpose it to show how such a core cadastral model could look like and this model could then be the start of an international discussion within FIG and OGC. It should be remembered that not only the model itself is important, but the fact that there is consensus between the involved parties

### 5.1. Initial model

The relationship between objects (real estate objects, parcels) and subjects (persons) via rights is the foundation of every cadastral registration. This n-to-m relationship is depicted in the yellow part of the figure 6, in which it is also shown that right is a relationship entity.

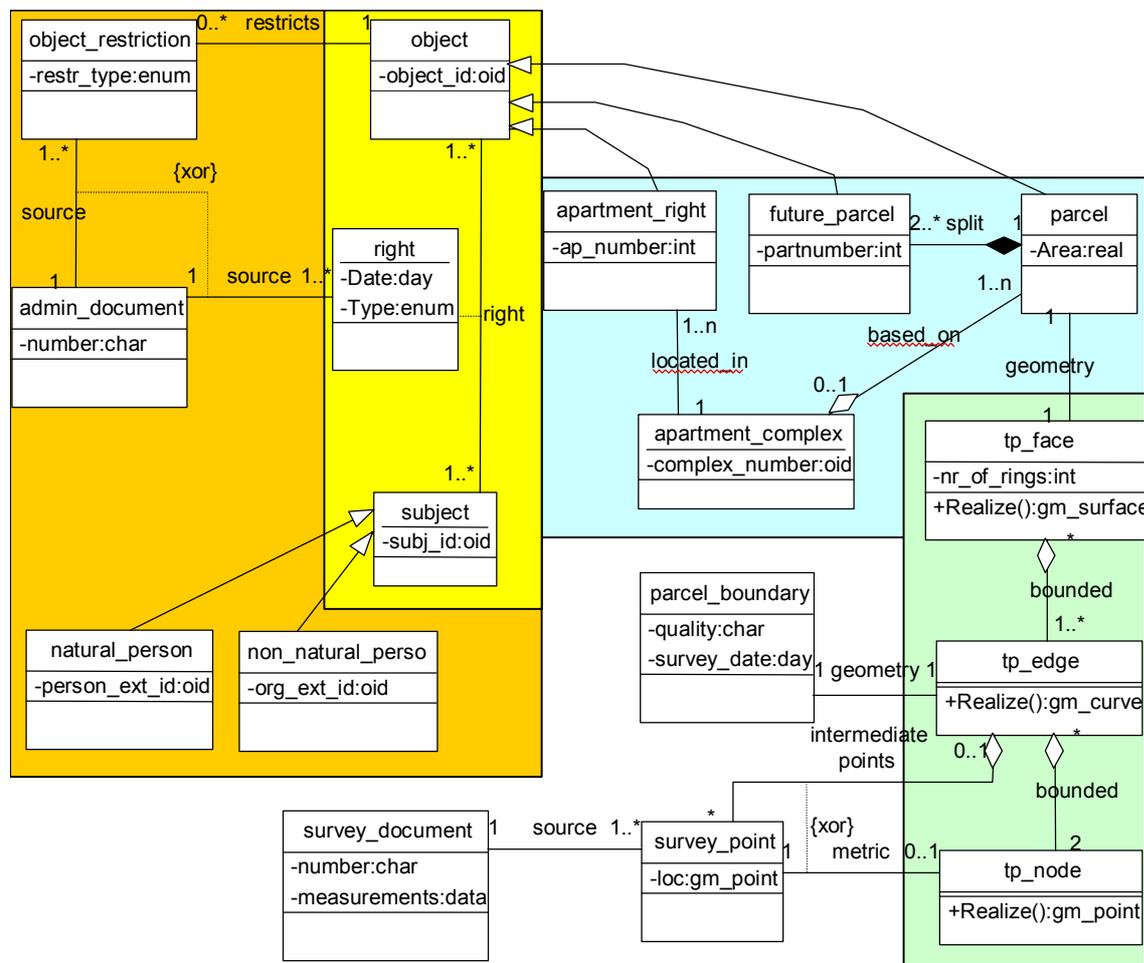


Figure 6: proposed core cadastral data model (in an UML class diagram)

The orange part of the data model does cover the refinements in the administrative side of the model. Persons are specialized into natural persons and non-natural persons (organizations). Further, there may be restrictions related to objects and not directly to the subjects otherwise this would also have been a right. This could be an encumbrance. Both rights and object restrictions find their origin in an admin (legal) source document: this can be a deed, depending of the type of cadastral registration. Only a few attributes are given for each entity. This has been done on purpose, for example based on this model it is still an implementation issue to maintain all subjects within the system (in this case many attributes should be added: name, day of birth, address, etc.) or outside the system (in this case only a reference to an external person-register has to be added).

The blue part of the model refines an object into three real estate entities all specializations of the class object: parcel, future parcel and apartment right. A parcel is a piece of land (including the constructions on this piece of land, but these are not explicitly modelled). A future parcel is a part of a parcel, which has already been sold in a legal real estate transaction, but which has not yet been surveyed (this is not possible in all countries of the world). An apartment right is a part of an apartment complex. An apartment complex is based on one or more parcels.

Parcels have a geographic description, which is currently in 2D space, though the rights extend in the 3D space above and below the surface of the parcel. A parcel corresponds to the face in a topological structure as defined by the IC TC211 and the OpenGIS consortium (green part of the model). A face is bounded (in 2D) by its edges, which form at least an outer ring and potentially also one or more inner rings. An edge is related 1-to-1 to a parcel boundary, which may contain non-geometric attributes, such as quality and date of surveying. Every edge has exactly two end points, called nodes. In addition an edge may also have several intermediate points. Both the intermediate points and nodes are associated to the survey point. This entity is the only entity, which stores metric information (the standard type `gm_point`). The topological primitives, face, edge, node, have all a method called 'Realize' which can be used to obtain a full metric presentation. The source of every survey point is a survey document, which plays an identical role as the admin document for right and object restrictions.

## 5.2 Aspects not covered

- History. This includes 'parent/child' relationships between cadastral objects, e.g. in case of sub-division of a cadastral parcel. Another option is inclusion of `tmin/tmax` attributes to all tuples in the database. New inserted tuples get a `tmin`, equal to the check in time and a `tmax` equal to the maximal (integer) value. A deleted tuple gets a `tmax` equal to its check in time. In case of update of one or more attributes, a new tuple will be created (as copy from the old tuple with its new values for updated attributes) with a `tmin` equal to check in time and a `tmax` equal to a maximum value. The old tuple gets a `tmax` equal to check in 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 times the real dates of observation in the field can be included to manage history.
- Subject relationships, e.g. marriage or relations between other natural and non-natural persons.

- Other types of cadastral objects: airplanes and ships. Mortgage can be established here!
- Geodetic reference points, this type of points could have two sets of related co-ordinate sets, one set with real geodetic co-ordinates and one set for visualisation purposes in relation to other represented data. E.g. a reference point could be a corner point of a house. Because of inaccuracies in spatial data the real geodetic co-ordinates are not equal to the represented corner point.
- 3D Cadastral aspects (above/below surface)
- Mortgage as a (security) right, with a relation to mortgagees and a catalogue with other 'real rights', which can be different for every country, or within countries in case 'dual' systems (e.g. customary land tenure *and* freehold)
- Higher level admin units (aggregations: sections, municipalities,...),
- Land consolidation/reform, urban development, urban and rural cadastres
- Links to external registrations could include:
  1. Persons (e.g. via fiscal person identifier, or other approved identifiers)
  2. Companies/organizations (e.g. chamber of commerce)
  3. Addresses and zip codes, related to objects *and* subjects
  4. Buildings, or more general: topographic datasets, including geographic names, street names, point representations (symbols) etc. in relation to core cadastral data.

## 6. Conclusion

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. In order to establish such an OGC SIG a proposal has to be made in which the three necessary elements are:

1. A *clear mission statement*: This could be the development of the core cadastral data model, but it could also be wider than only developing the data model: use-case modelling, sequence and collaboration modelling, state and activity modelling. Another dimension of potentially widening the scope could be not to look at only cadastral systems (central and local approaches supporting land ownership registration, land consolidation, land reform and urban development), but also to include other information systems, such as valuation systems, mining registrations, fishing and agricultural registrations, registration of polluted areas for environmental purposes, registration of pipelines and cables, etc. Finally, it is good OGC practice not to work on the theory only, but also to test (and further develop) the standards in a test bed environment (perhaps first prototype implementation of EULIS?). In such a test bed, or interoperability program initiative, not only conceptual standards (models) are important, but also the actual implementation aspects such as the encoding of information for data exchange (e.g. in XML/GML).
2. At least *three OGC members* wanting to be an active member of the SIG. This does not seem to be a problem in this case as during the OGC TC meeting in Noordwijk

(Sept. 2002), there was enough interest after the presentation of the concept of a core cadastral data model.

3. A *chairperson*, willing to chair the SIG and organize the necessary activities.

Based on the input received and the contact made at the meetings in 2002 (FIG Washington, OGC TC Noordwijk and COST Delft), the scope has to be decided and by the proposals for how to implement the FIG work plan 2002-2006 and creation of an OGC SIG on Cadastres have to be made.

A core cadastral data model should serve at least two purposes: 1. Enable effective and efficient implementation of flexible (and generic) cadastral information systems based on a model driven architecture (as argued in this paper), and 2. 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.

### **Acknowledgements**

The authors would like to thank all persons involved in the discussion related to the creation of a core cadastral data model: Ian Greenway, Winfried Hawerk, Gerhard Muggenhuber, Carl Reed, Greg Buehler, Ron Lake, Andrew Jones, Jonathan Doig, Andrew Frank, Peter Woodsford, Arbind Tuladhar, Rolf de By, Markus Müller, Martin Ameskamp, Jürgen Ebbinghaus, Jantien Stoter, Wilko Quak, Paul van der Molen, and Jaap Besember.

### **REFERENCES**

*Booch, Grady, James Rumbaugh, and Ivar Jacobson, 1999, 'The Unified Modeling Language'. User Guide. Addison-Wesley, 1999.*

*Buehler, K. and L. McKee, 1998, 'The OpenGIS guide - Introduction to interoperable geoprocessing'. Technical Report Third edition, The Open GIS Consortium, Inc., June 1998.*

*FGDC, 1996, 'Cadastral Data Content Standard for the National Data Infrastructure', United States Federal Geographic Data Committee (US FGDC) Secretariat, Proposed Final Version, [www.fgdc.gov/pub/standards/cadastral](http://www.fgdc.gov/pub/standards/cadastral), May 1996.*

*ESRI, 1999, 'Managing Spatial Data: The ESRI Spatial Database Engine for Informix'.*

*FIG, 2002, FIG Guide on Standardisation, [www.fig.net](http://www.fig.net)*

*ICSM, 1999, 'National Cadastral Data Model', version 1.1, Intergovernmental Committee on Surveying & Mapping (ICSM), Cadastral Data Working Group, June 1999.*

*ICSM, 2002, 'Harmonised Data Manual – The Harmonised Data Model', Intergovernmental Committee on Surveying & Mapping (ICSM), 2002.*

*ISO TC 211/WG 2, 1999, 'Geographic information - Spatial schema', Technical Report second draft of ISO 19107 (15046-7), International Organization for Standardization, November 1999.*

*ISO TC 211/WG 3, 1999*, 'Geographic information - Meta data'. Technical Report draft of ISO 19115 (15046-15), International Organization for Standardization, June 1999.

*Greenway, Iain, 2002*, 'Standards and Surveyors: FIG's past and Future Response', FIG XXII International Congress, Washington DC, USA, April 2002

*LandXML, 2002*, 'LandXML Schema, v1.0', [www.LandXML.org](http://www.LandXML.org), draft 20 February 2002.

*LINZ, 2002*, 'Cadastral Survey Data Exchange Format – LandXML, Release v1.0', New Zealand Land Information, Survey & Title Automation Programme, *Landonline* Stage Two, February 2002.

*Meyer, Nancy von, Oppmann, Scott, Grise, Steve and Hewitt, Wayne, 2001*, 'ArcGIS Conceptual Parcel Data Model', March 16, 2001. [www.blm.gov/nils/bus-req/arcgis-parcel-3-16-01.pdf](http://www.blm.gov/nils/bus-req/arcgis-parcel-3-16-01.pdf)

*Naylor, J, 1996*, 'Operations Management', Pitman Publishing, London, United Kingdom.  
*Ollém, Joakim, ArcCadastre and EULIS-New tools for higher value and increased efficiency in the property market, FIG XXII International Congress, Washington DC, USA, April 2002*

*OpenGIS Consortium, Inc. 1998*, 'OpenGIS simple features specification for SQL', Technical Report Revision 1.0.

*OpenGIS Consortium, Inc, 2000a*, 'OpenGIS catalog interface implementation specification' Technical Report version 1.1 (00-034), OGC, Draft.

*OpenGIS Consortium, Inc., 2000b*: 'OpenGIS grid coverage specification', Technical Report Revision 0.04 (00-019r), OGC.

*OpenGIS Consortium, Inc., 2000c*: 'OpenGIS recommendation - Geography Markup Language (GML)' Technical Report version 1.0 (00-029), OGC.

*OpenGIS Consortium, Inc., 2000d*: 'OpenGIS web map server interface implementation specification', Technical Report revision 1.0.0 (00-028), OGC.

*Seifert, Markus, 2002*, 'On the Use of ISO standards in Cadastral Information Systems in Germany', FIG XXII International Congress, Washington DC, USA, April 2002

*Siegel, Jon and the OMG Staff Strategy Group, 2001*, 'Developing in OMG's Model Driven Architecture', Object Management Group White Paper, November 2001

*Snodgrass, R.T., I. Ahn and G. Ariav, 1994*, 'TSQL2 language specification'. SIGMOD Record, 23(1):65-86.

*UN/ECE, 1996, United Nations/Economic Commission for Europe*, 'Land Administration Guidelines', Geneva, Switzerland.

*W3C, 2000a*, 'XML Schema part 1: Structures and XML schema part.' Technical report, World Wide Web Consortium, October 2000. Candidate Recommendation.

*W3C, 2000b*, 'XML Schema part 2: Datatypes.' Technical report, World Wide Web Consortium, October 2000. Candidate Recommendation.

*Van Oosterom PJM and Lemmen CHJ 2001*, 'Spatial Data Management on a very large cadastral database', in: 'Computers, Environment and Urban Systems', Theme Issue 'Cadastral Systems', p. 509-528, Volume 25, number 4-5, 2001, Elsevier Science, New York.

*Van Oosterom, Peter and Lemmen Christiaan, 2002*, 'Impact Analysis of Recent Geo-ICT developments on Cadastral Systems', FIG XXII International Congress, Washington DC, USA, April 2002

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