Further Progress in the Development of a Core Cadastral Domain Model

Christiaan LEMMEN and Peter VAN OOSTEROM, the Netherlands

Key words: Standardization, Cadastral Systems, Cadastral Domain, Open GIS Standards, and ISO Standards.

SUMMARY

In our paper 'Impact Analysis of Recent Geo-ICT Developments on Cadastral Systems' presented at the FIG Washington Congress in April 2002 we concluded that cadastral systems must be flexible and generic because user requirements keep on changing due to new legislation, new registrations, new technology. In addition we stated that (geo-) ICT developments, such as geo-DBMSs, Internet, GPS, and data exchange (XML) and modeling standards (UML), have greatly contributed towards the efficient implementation of effective systems. However, a core cadastral domain model supported by vendor software would have increased efficiency yet more. Such a model would enable application of Model Driven Architectures in the context of cadastral systems.

A draft cadastral core model has been developed. This model has been introduced to the Open GIS Consortium, Noordwijk, The Netherlands, September 2002, to the COST Working Group 'Modeling Real Property Transactions', Delft, The Netherlands, October 2002, and to the annual meeting of Commission 7 'Cadastre and Land Management' of FIG, Pretoria, November 2002.

First discussions with software providers (ESRI) are ongoing; scientists have reviewed the draft model. All this resulted in a second draft of the core cadastral model.

In this paper the second draft of the cadastral core model will be presented. Furthermore the progress in activities related to the development of this model will be reported. The need to eventually establish a Special Interest Group at OGC will be discussed.

Further Progress in the Development of a Core Cadastral Domain Model

Christiaan LEMMEN and Peter VAN OOSTEROM, the Netherlands

1. INTRODUCTION

The idea for the introduction of a Core Cadastral Domain Model has been launched at the FIG Congress in Washington (Oosterom, van, Lemmen, 2002a). During this meeting 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 the FIG Task Force on Standardization in the 'FIG Standards Network'. ISO TC 211 is interested in co-operation with FIG. See: www.isotc211.org/resolutions/resolu13.htm . During the FIG Working Week in Paris 2003 standardization is again one of the main themes of interest. Within FIG 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'.

In the developed world it can be observed that a lot of efforts in standardization of the Cadastral Domain are ongoing, an overview is given in (Oosterom, van, Lemmen, 2002b). The Open GIS Consortium already tried to establish a 'Land Title and Tenure SIG' three years ago, the US Bureau of Land Management expressed interest, but finally there was insufficient support. 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 for the Official Cadastral Information System (ATKIS) based on ISO standards. This conceptual model is object based and describes geographic and non-geographic features as well as their associations (Seifert, 2002). The Cadastral Subcommittee of the US Federal Geographic Data Committee developed a complete Cadastral Data Content Standard for the National Spatial Data Infrastructure (FGDC, 1999). The US National Integrated Land System (NILS) provides business solutions for the management of cadastral records and land parcels information in a Geographic Information System environment. The NILS concept provides the user with tools to manage land records and cadastral data in a "Field-to-Fabric" manner, www.blm.gov/nils. A Conceptual Parcel Data Model is available in ArcGIS (Meyer, von, Oppmann, Grise, Hewitt, 2001). In New Zealand (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). The Intergovernmental Committee on Surveying and mapping (ICSM) has developed a National Cadastral Data Model (ICSM, 1999). This model is based on a review of cadastral models supplied by the different jurisdictions in Australia and New Zealand. 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 standard (ICSM, 2002). 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 Landmäteriet Sweden has initiated a project for providing the market with a single point of access to land information across the borders (Ollén, 2002): the EULIS project, www.eulis.org. Nine organizations from different parts of Europe participate.

In developing countries the need for the introduction of a simple data model, which can be adapted and extended to the local requirements on Land Administration can be derived from van der Molen (2003). Comparable basic objects for ‘colonial systems’ and informal systems are identified. Mulolwa (2002b) introduces a prototype for an integrated land delivery process in Zambia based on ESRI's MapObjects using the Unified Modeling Language (UML). Approaches in data cadastral modeling for developing countries can be found thesis work at the International Institute of Geo-Information Science and Earth Observation (ITC).

There are warnings: computerization is one of the most difficult components in Land Administration reform in developing countries. It requires a major IT strategic plan and a long-term commitment. Simple, manual systems are often easier to introduce (Williamson, 2000).

The introduction of a simple, generic Core Cadastral Domain Model could encourage and support the flow of information relating to land property between different government agencies and between these agencies and the public. Whilst access to data, its collection, custody and updating should be facilitated at a local level, the overall land information infrastructure should be recognized as belonging to a national uniform service to promote sharing within and between nations (UN/FIG Bathurst Declaration, 1996). See also Bogearts and Zevenbergen (2001) and Williamson and Ting (2001). A Core Cadastral Domain Model in which classes and associations between classes representing objects, attributes and operations derived from different tenure systems could, in the opinion of the authors, definitively contribute to the fulfillment of local cadastral needs in an efficient way. Support of vendor software would increase efficiency even more. The ambition is to create a model with common elements of cadastral systems, if possible worldwide.

An overview of the progress made in the development of the proposed Core Cadastral Domain Model is given in Section 2. The classes are described in more detail in Section 3. As the development of a Core Cadastral Domain Model is a standardization issue, attention is given to the progress in activities within organizations related to the development of this model (Section 4); e.g. the need to eventually establish a Special Interest Group at OGC will be discussed. Conclusions are presented in Section 5.

2. OVERVIEW 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.

Please note that source documents can be available on paper, microfiche or as scanned documents.

The proposed Class Diagram, draft version 2, is presented in figure 1. 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/.

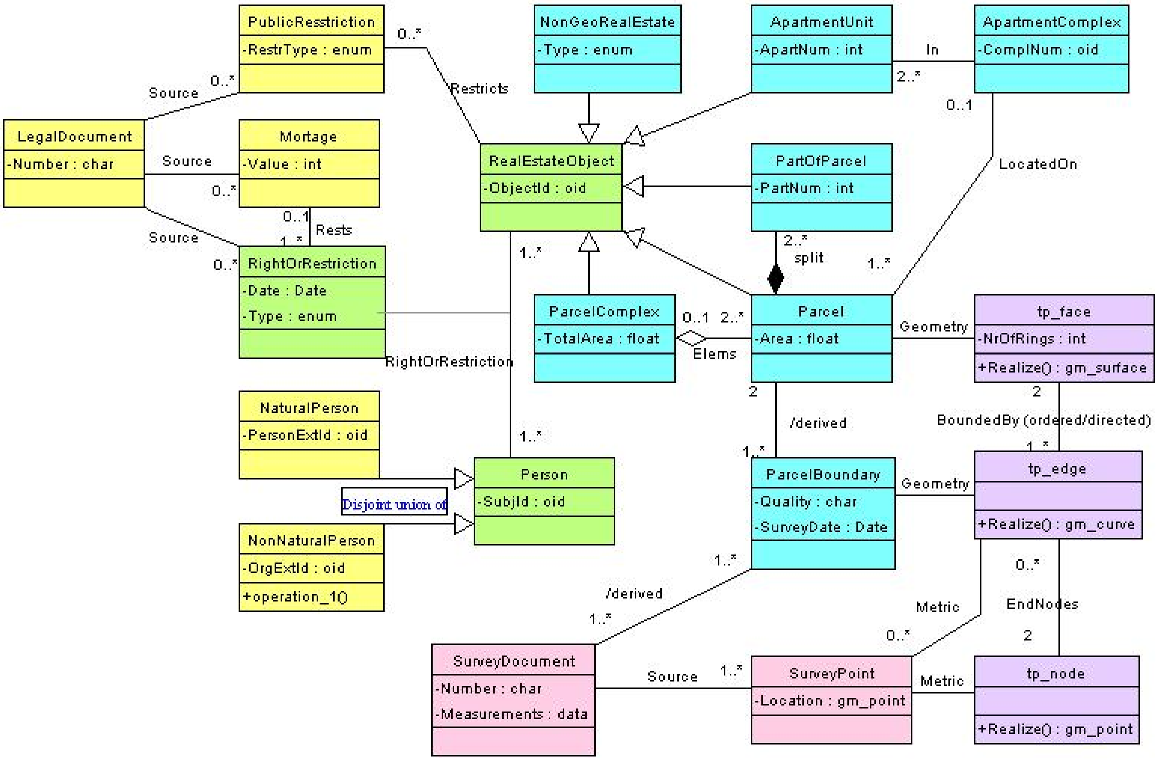

Figure 1. Second draft of the Core Cadastral Domain Model

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

- Green: real core,
- Green and yellow: legal/administrative aspects,
- Green and blue: real estate object specializations,
- 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. Of course implementation requires attention to other aspects, e.g. Use Case Diagrams, Activity Diagrams, etc. (Tuladhar, 2002).

3. SOME CLASSES IN MORE DETAIL

3.1 Core Classes

The relationship between real estate objects, (e.g. parcels) and persons via rights is the foundation of every land administration. Related classes, associations and multiplicities are depicted in the green part of figure 1, in which it is also shown that RightOrRestriction is an association class between the classes Person and RealEstateObject.

3.2 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 1.

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.

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, etc.

3.3 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. Mostly 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 can be only one SurveyDocument. The association between a ParcelBoundary and SurveyDocument is *derived* via the classes SurveyPoint, tp_node and tp_edge.

3.4 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 3.2. 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 of ApartmentComplex or ApartmentUnit, associated rights are in reality of course 3D (Stoter, et al. 2002).

3.5 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: Person is a disjoint union of NaturalPerson and NonNaturalPerson.

3.6 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 modeling 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.

3.7 Further Developments

The second version of the Core Cadastral Domain Model presented is just a proposal and a potential start for the final model. Many more things have to be done (and perhaps modeled in additional packages ore 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 option is inclusion of tmin/tmax attributes to all classes. New inserted instances get a tmin, equal to the check in time and a tmax equal to the maximal (integer) value. A deleted instance gets a tmax equal to its check in 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 time and a tmax equal to a maximum value. The old instance 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. One more option is the introduction of a TimePeriod class to maintain historical data.
- Other types of RealEstateObjects: airplanes and ships. Mortgage can be established here!

- 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.
- 3D Cadastral aspects (above/below surface)
- 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.

4. ACTIVITIES RELATED TO THE INTRODUCTION OF THE MODEL

The ‘technical’ activity of the development of the Core Cadastral Domain Model is just one aspect of the standardization activity. The embedding of this model within the different involved organizations is one other important task. In this section a short overview is given of the involved organizations. It is the intention that participants in these organizations will support the further development of the model.

4.1 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

- To improve the transparency of real property markets and
- 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
- Assessing the economic efficiency of these transactions.

The modeling activity of the action intend to develop a frame work 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 modeling within the framework of this COST G9 research has been presented 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.

4.2 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. 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 modeling, sequence and collaboration modeling, state and activity modeling. 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. 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 seam to be a problem in this case as during the OGC TC meeting in Noordwijk, The Netherlands in September 2002, there was enough interest after the presentation of the first draft of a core cadastral data model.
3. A *chairperson*, willing to chair the SIG and organize the necessary activities.

4.3 FIG and ISO

As already explained in the introduction, 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). Answers to questions “What are the common elements in all cadastral systems?” and “Which should be the basic elements in a DCDB to operate as a key element of a national or global spatial data infrastructure?” have been discussed. This definition of basic elements that should be found in each DCDB can be helpful for easier land

transactions on an international level (e.g. European Union, Americas) as well for planning processes on a national or international level.
The description of these basic elements will be carried out by using the ISO standard modelling language UML. The use of UML will enable data base specialists all over the world to understand what the Working Group want. It is not necessary to define the basic contents of a DCDB as a 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.

5. CONCLUSIONS

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.

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.

ACKNOWLEDGEMENTS

The authors would like to thank all person 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, Jaap Besemer, Erik Stubkjaer and Hans Mattson.

REFERENCES

Booch, Grady, James Rumbaugh, and Ivar Jacobson, 1999, ‘The Unified Modeling Language’. User Guide. Addison-Wesley Technology Series, Addison-Wesley, 1999.

Boagearts, T. and Zevenbergen, J., 2001, 'Cadastral Systems - Alternatives', in: ‘Computers, Environment and Urban Systems’, Theme Issue ‘Cadastral Systems’, p. 325-337, Volume 25, number 4-5, 2001, Elsevier Science, New York.

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, May 1996.

FIG, 2002, ‘FIG Guide on Standardisation’, FIG Publication No. 28
www.fig.net/figtree/pub/figpub/pub28/figpub28.htm

Greenway, Iain, 2002, ‘Standards and Surveyors: FIG’s past and Future Response’, FIG XXII Congres, Washington DC, USA, April 2002,
www.fig.net/figtree/pub/fig_2002/JS3/JS3_greenway.pdf

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, 1999a, ‘Geographic information - Spatial schema’, Technical Report second draft of ISO 19107 (15046-7), International Organization for Standardization, November 1999.

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

LandXML, 2002, ‘LandXML Schema, v1.0’, www.landxml.org/spec.htm

LINZ, 2002, ‘Cadastral Survey Data Exchange Format – LandXML, Release v1.0’, New Zeeland 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

Molen, van der, 2003, 'The Future of Cadastres - Cadastres after 2014' FIG Working Week, Paris, France 2003.

Mulolwa, Augustine, 2002a, ‘Appropriate tenure models for sub Saharan Africa’, FIG XXII Congres, Washington DC, USA, April 2002,
www.fig.net/figtree/pub/fig_2002/Ts7-7/TS7_7_mulolwa.pdf

Mulolwa, Augustine, 2002b, 'Integrated Land Delivery, towards improving Land Administration in Zambia', PhD Thesis, Delft University Press, Delft, The Netherlands.

Ollén, Joakim, ‘ArcCadastre and EULIS-New tools for higher value and increased efficiency in the property market’, FIG XXII Congres, Washington DC, USA, April 2002,
www.fig.net/figtree/pub/fig_2002/Js8/JS8_ollen.pdf

Oosterom, van 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.

Oosterom, van, Peter and Lemmen Christiaan, 2002a, ‘Impact Analysis of Recent Geo-ICT developments on Cadastral Systems’, FIG XXII Congres, Washington DC, USA, April 2002 www.fig.net/figtree/pub/fig_2002/Js13/JS13_vanoosterom_lemmen.pdf

Oosterom, van, Peter and Lemmen Christiaan, 2002b, 'Towards a Standard for the Cadastral Domain: Proposal to establish a Core Cadastral Data Model', COST Workshop ‘Towards a Cadastral Core Domain Model’, Delft, The Netherlands, 2002, http://www.i4.auc.dk/costg9/

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 reversion 1.0.0 (00-028), OGC.
Seifert, Markus, 2002, 'On the Use of ISO standards in Cadastral Information Systems in Germany', FIG XXII Congres, Washington DC, USA, April 2002 www.fig.net/figtree/pub/fig_2002/JS4/JS4_seifert.pdf
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.
Stoter, Jantien et al., 'Towards a 3D cadastre', In proceedings: FIG, ACSM/ASPRS, April 19-26-2002, Washington D.C. USA, http://www.fig.net/figtree/pub/fig_2002/Ts7-8/TS7_8_stoter_etal.pdf
Stubkjær, Erik Denmark: 'Modelling Real Property Transactions'. Paper presented at the XXII FIG Congress, Washington, D.C. USA, April 19-26 2002, www.fig.net/figtree/pub/fig_2002/Js14/JS14_stubkjaer.pdf
Tuladhar, Arbind Man, 2002, 'Why is Unified Modeling Language (UML) for Cadastral Systems?', COST Workshop 'Towards a Cadastral Core Domain Model', Delft, The Netherlands, 2002, www.i4.auc.dk/costg9/
UN/ECE, 1996, United Nations/Economic Commission for Europe, 'Land Administration Guidelines', Geneva, Switzerland, 1996, www.unece.org/env/hs/wpla/welcome
UN/FIG, 1999, 'The Bathurst Declaration on Land Administration for Sustainable Development', FIG Publication No 21, 1999, www.fig.net/figtree/pub/figpub/pub21/figpub21.htm
Williamson, Ian, 2000, 'Best Practises for Land Administration Systems in Developing Countries, International Conference on Land Policy Reform, Jakarta, Indonesia, 2000
Williamson, I. and Ting, L., 2001, 'Land Administration and cadastral trends - a framework for re-engineering, in: 'Computers, Environment and Urban Systems', Theme Issue 'Cadastral Systems', p. 339-366, Volume 25, number 4-5, 2001, Elsevier Science, New York.
Zevenbergen, Jaap, 2002, 'Systems of Land Registration, Aspects and Effects', PhD Thesis, Publications on Geodesy 51, Netherlands Geodetic Commission, Delft, The Netherlands

BIOGRAPHICAL NOTES

Christiaan Lemmen has held the post of assistant professor at the International Institute for Geo-Information Sciences and Earth Observation (ITC), Enschede, The Netherlands, since 1999. Further he is geodetic advisor for the Netherlands Kadaster, where he has held several appointments since 1983. He is vice chair Administration of FIG Commission 7 ‘Cadastre and Land Management’. His areas of special interest are in land administration systems, land consolidation, performance measures, total quality management and workflow management.

Prof. Peter van Oosterom has held a chair in ‘GIS Technology’ at Delft University of Technology since 2000. His previous employers were the TNO Physics and Electronic Laboraty (1985-1995) and company staff of the Netherlands Kadaster (1995-2000). His main research topics are geo-databases, generalisation, distributed GIS architectures and cadastral applications. Professor van Oosterom received his PhD from Leiden University, with a thesis entitle ‘Reactive Data Structures for GIS’.

CONTACTS

Christiaan Lemmen
International Institute for Geo-Information Sciences and Earth Observation (ITC)
Hengelosestraat 99
7514 AE Enschede
THE NETHERLANDS
Tel. + 31 53 487 4523
Fax + 31 53 487 4575
Email: Lemmen@itc.nl
Web site: www.itc.nl

Prof. Peter van Oosterom
Department of Geodesy
Delft University of Technology
Thijsseweg 11
2629 JA Delft
THE NETHERLANDS
Tel. + 31 15 278 6950
Fax + 31 15 278 2745
Email: oosterom@geo.tudelft.nl
Web site: www.geo.tudelft.nl