The Development of a Spatial Component to the Icelandic Cadastre

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SUMMARY

The spatial delimitation of ownership rights remains absent from the land registration procedure and this has created confusion in the registration process. A change in the nature of Icelandic society and land use combined with the increasing value of land has led to a situation where the current system is in need of reformation. This document presents the Land Registry of Iceland's (LRI) response to these changes.

The importance of a good strategy, which is open for discussion and development is essential and cannot be underestimated. The LRI´s vision is to develop a cadastral map component, within the current Land Registry Database, which will serve as a one-stop-access point to all information affecting land tenure. Initially emphasis will be placed upon parcels and in the future structures, address locations and utilities will be included. The design ideology will be built upon a model driven architecture influenced by the Core Cadastral Domain Model. The complete system will function as a service that either uses or is used by other services e.g. using WMS or WFS specifications.

Iceland is too large and sparsely populated to allow the LRI to request accurate boundaries on a nationwide basis. Thus a topological spatial model is preferred, supporting incremental build-up and later improvements of data. The emphasis is not on accuracy and measurement techniques but rather on intensive quality management enabling future refinements.

At present the goal is to complete the conceptual design phase before the end of 2006. The logical design and the implementation phase are scheduled to take place in 2007. The same year should also see refinements to the legal environment such as the definition of the roles and responsibilities of the different actors in the registration process. The testing phase is planned to be completed by the end of 2007, with the operation phase scheduled to start in 2008.

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1. INTRODUCTION

Spatial data in the form of boundaries and buildings lies at the heart of the Land Registry of Iceland (LRI). It is what the LRI collects information about, what it evaluates and analyses. However spatial data has to date remained separate from the registration process and there has not been any effective tool in place via which this information could be visualized and explored. It was decided that this situation should be remedied and the first steps are being taken towards developing a spatial component to the Land Registry Database (LRD), which is a centralized database containing data on real property units and buildings.

This paper will introduce the current situation regarding land registration in Iceland and explain the reasons why reform is required. It will subsequently explore the strategy for cadastral reform in Iceland and review the proposed plan of action, its estimated timeframe and envisaged obstacles.

2. LAND REGISTRATION IN ICELAND

Land registration in Iceland is administered by the government through the aegis of LRI. At the regional level they are supplemented by the services of the municipalities and Land Registry offices. The LRI was established in 1976 and falls under the jurisdiction of the Ministry of Finance. It has a complex role and services many other ministries. Its primary functions are to:

- Register real property units
- Conduct real property valuations and assessments
- Conduct reconstruction and insurance valuations
- Provide data for taxation purposes
- Provide economic statistics e.g. used to calculate consumer price indices
- Provide diverse institutes with certified statements on property ownership
- Administrate and operate the LRD

2.1 Land Registry database

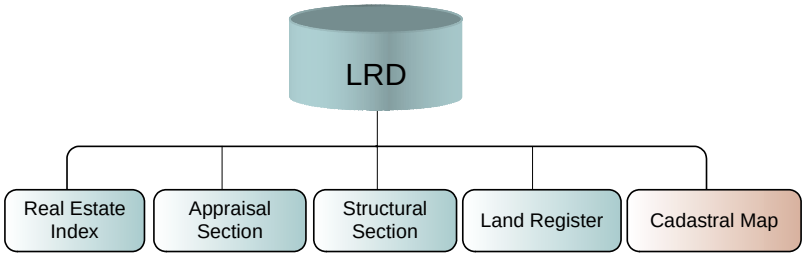
The LRD is the primary source for data concerning land and buildings in Iceland. It is an information service and data management system which records and manages diverse information concerning land, land parcels and properties throughout Iceland. Through using the LRD it is possible to find information upon:

- Real property units and identification (LandID, PropertyID, AppraisalID etc)
- Addresses (road name, house number, postcode and municipality)

– Building information (type of building, construction material, year of construction etc)
– Appraisal data (insurance value, estimated market value, lot value etc)
– Ownership (name, identification, type of ownership, ownership share etc)
– Land Register (deeds, mortgages etc)

The LRD is comprised of four components and it is envisaged that the *Cadastral map* will form the fifth component. It will replace the diverse data sources that currently are used to delimitate land.

1. The real estate Index (identifies entities and properties)
2. The appraisal section (appraisal information and calculated values)
3. The structural section (information on building material, size and age etc.)
4. The land register (ownership, rights, mortgages, private restrictions and some public restrictions)
5. The cadastral map (spatial delimitation of real property units)



2.2 Sources for spatial cadastre

The LRI possesses or has access to a wide range of geographical data of diverse quality and reliability. The accuracy, coverage and availability of these spatial datasets are variable, particularly when it comes to land boundaries. Thus, the task of assembling the data required for inclusion in an Icelandic Cadastre is no small endeavour. The primary data sources are

Spatial data

– Address repository
– Farm boundary database
– Land Information Systems from some municipalities
– Governmental institutes
– Private companies

Non-spatial data

– Textual boundary descriptions
– Local knowledge

2.3 Ongoing Development

Land registration in Iceland is currently undergoing a period of review with regards to the manner in which data is stored and accessed. Issues, which are being addressed, include the conversion of all hard copy data into digital format, the development of a cadastral map component and the streamlining of information flows.

These issues represent a significant change in how the LRI will function, both with regards to working with data and in its relations with the public and private sectors. In order to begin this process of change the following steps have been taken:

- A cadastral mapping department has been established
- Workgroups have been formed to reengineer the cadastral model and define the prime entities of cadastral registration
- A workgroup has been formed to focus upon developing a cadastral map as a new component to the general model
- A governmental assigned workgroup has composed a new bill on cadastre which is now under debate

3. REASONS FOR REFORM

The reasons for reform of the current system of land registration are many and diverse. They are being created by both market forces and by changing land practices. In recent years real property prices have been increasing rapidly. Every square meter is starting to count and as a result the availability of detailed cadastral mapping is becoming ever more important.

The majority of farms in Iceland are defined simply by textual boundary descriptions, many of which date from the late 1800´s. These use local place names to describe where boundaries are located. However, this approach is no longer feasible as place names change and newer generations are not as familiar with the landscape and its history as were their ancestors. The landscape itself has in many cases changed dramatically (cultivation, natural influences) from when these boundary descriptions were first compiled. In some cases properties have simply been lost as they have never been spatially located or the knowledge to decipher their boundary descriptions has been lost

An example of a boundary description is displayed below:

> *Corner monument: The ruin close to Heiðrimakelda-spring, south of Oddholtsmúla-mound; from where there is a line of sight, west to Héðinslækjabotnar-hollow, from here the boundary follows Héðinslækur-creek, and then Höskuldslækur-creek to the Hvítá-river. To east of the above mentioned ruin close to Heiðrimakelda-spring the boundaries run south to Þverkelda-spring which runs from Galtatjörn-pond …* (Boundary description of Arnarbæli, Grímsnes, National Archives of Iceland, 1884).

The need for an efficient cadastral system has also been highlighted by the considerable debate which has arisen around the issue of farmlands being bought up subdivided or agglomerated and sold on for purposes other than agricultural. A nationwide cadastral map would provide a more efficient tool for regulating such changes in land use. At present there are many different bodies involved in collecting land boundaries and there is a lack of coordination between these various bodies (municipalities, government institutes). This can lead to the same boundaries being collected by different bodies using different methods and different sources and quality parameters. The result can be cadastral maps of the same boundaries which are incompatible thereby leading to further confusion. A cadastral map would help to prevent such duplication of work and reduce the confusion it can cause.

A cadastral map would also provide the LRI with and essential tool that would allow for:

- Spatial access to property information as part of LRD interface
- The possibility of complex spatial analyses
- A way in which to correct and validate property data already in the LRD
- A way in which to create and update data in the LRD (area surveys, management of appraisals, property-region and administrative areas)
- A better way for appraisers to ground their real property valuations
- The possibility to incorporate zoning plans and real property information
- The possibility to develop new services
- New sources of income

Many other, more general initiatives for the reform of a cadastre can be found described in Dale & McLaughlin (1999) and United Nations (2005).

4. REFORMATION OF THE ICELANDIC CADASTRE

As can be seen there is a need to reform the current system of cadastral registration and this section will outline the framework within which this shall take place.

4.1 Main goal & objectives

The main goal is:

> *To develop a cadastral map that will form an integral part of the LRD and enhance its potential for better land administration*

In order to achieve such a broad goal, several objectives have been defined. These are considered crucial to the success of the project and are as follows:

Reengineering the current registration model:
The model for cadastral registration in Iceland needs to be restructured. Currently there exists no model that describes the registration system in detail, either for the database or for

procedures (activities, roles & responsibilities). This has caused difficulties within the LRI. Understanding of terms and definitions (ontology) varies between different divisions, and the LRD is structured in such way that a minor change in a class can affect diverse aspects of the database. Thus, the system needs to be redesigned using a more model-driven approach (MDA), which would define the foundation packages and specify how they interrelate, while remaining independent from each other. After completing the reengineering and modelling of the cadastral registration system, adding a cadastral map component should be as simple as adding new package with spatial capabilities to the model. Both static and activity UML diagrams should be used extensively to describe the structure of the database, cadastral transactions and organizational roles & responsibilities.

Start simple - incremental refinements:
In a country with a small population but with a comparatively large land mass, the complete detailed mapping of cadastral entities is too large a project to complete in one attempt. The ambition is high but the resources are scarce. The intention is initially to emphasize parcel boundaries with the extent of structures coming second in order of priority (they can always be located via their implicit link to parcels). Utilities will be addressed at a later stage. By utilizing MDA the system can evolve slowly and new components added without disrupting the whole system.

Similarly the intention is to go from low to high accuracy. Data with low positional accuracy is not necessarily bad quality data as long as extensive quality management is employed. The Core Cadastral Domain Model (CCDM) provides for five stages through which the geometry of a parcel progresses in the cadastral database:

text parcel ➲ point parcel ➲ general boundaries ➲ fixed boundaries ➲ 3D parcel

3D cadastre is not currently planned but the MDA approach allows for the possibility of including it in the future.

Finally, by stipulating cadastral survey as an integral part of cadastral transaction, every time a property is transferred the cadastre will evolve and expand by itself. Land owners should also be encouraged to survey their parcels for inclusion in the system, e.g. by private surveyors offering special deals for several adjacent parcels, or by the financial/legal security a cadastral survey gives the owner. Some land is however rarely transferred as it is owned by municipalities, central government or public companies. These parcels will have to be systematically surveyed and brought into the system.

Use standards – Service Oriented Architecture
There are many standards available at different levels that deal with geographic information, e.g. regarding exchange of spatial data, presentation, metadata and classification etc. Standards such as these can enhance cooperation between users and prevent data redundancy. They help ensure that data is only maintained at the source level and serviced out on demand to other users via protocols such as WMS, WFS or WCS. It is planned that the reformed cadastral system will comply with, or use many of the spatial standards currently available.

This will make the system one service out of many which contribute to or use spatial information for land administration purposes.

Enhance current legal environment for cadastral registration:
The laws supporting current cadastral registration are many and are out of date and there is a need to adjust them to new era of cadastral registration. New laws and regulations will have to be developed to support cadastral mapping. The following are those issues which need to be considered:

- Certification of cadastral surveyors
- Defining entities and methods of registration
- Defining the necessary quality requirements
- Setting legal cadastral procedures/transactions
- Creating an organizational setup

Involve the private sector:
Given the resources currently available close cooperation with the private sector is regarded as the most efficient way in which to carry out cadastral survey in Iceland. This will be accomplished by creating a framework that will be maintained centrally by the LRI, with updating being conducted by municipalities, local Land Register offices and private surveyors. In order to achieve this, a consensus is required among all stakeholders, with everyone understanding the benefits of the new system. As to whether this framework will be developed by the LRI or outsourced to the private sector remains as yet undecided.

4.2 Concepts

There are number of factors that are vital of importance in completing this project. Several have been identified and are introduced below.

Designing the system architecture
Informix is currently the database solution used in the LRD; however the LRI is currently in the process of evaluating its potential to store spatial data and comparing it to other available options. There are a number of factors that mitigate against choosing Informix to manage a cadastral map. In the future will Informix become merged with DB2 and how will it change? Its current spatial ability is limited when compared to some of its competitors such as Oracle Spatial. Other potential solutions being considered are: DB2, Oracle Spatial and PostgreSQL/PostGIS. Of these Oracle Spatial appears from a spatial point of view to be the most efficient solution. Moreover, Oracle Spatial has been recommended to the LRI by cadastral developers in Denmark, Norway and The Netherlands.

The spatial database will be stored centrally at the LRI and the same concept will be employed as has been used for updating the cadastral register over the last few years, i.e. client-server technology. Users will connect remotely to the database and use a specially designed map client to submit updates or changes to boundaries. This client will allow

temporary locking of an area, while changes to it are exported and processed in a different system (CAD) before being imported at a later point.

The web-based java-client being developed by Statens Kartverk in Norway appears very promising. It is being built largely by using open-source innovations e.g. GeoTools & GeoServer (www.matrikkel.no/matrikkel). Using this technology makes it easy to update all clients at once without troubling the end users. Another interesting solution is being developed in Denmark where the Danish cadastre (KMS), in close cooperation with Intergraph, is developing the MiniMAKS cadastral client (www.kms.dk).

Data modelling
The data model employed at the LRI is one which has developed over the years more by accretion and trial & error rather than by any overall guiding design. This has meant that the data model as it is today has been created without any of the extensive documentation and ontology that is required in order for it to be properly understood, to function efficiently and to evolve as the need arises. The LRI needs to find a way to redesign the data model so that:

- It functions more efficiently with regards to the changing nature of land and land administration in Iceland
- There exists an ontology which will allow for better communication between all the parties involved in land administration in Iceland

It is within this context that the CCDM has been mentioned as being having the potential to be of use in reengineering the LRI´s data model.

The CCDM is an initiative being developed under the auspices of *The International Federation of Surveyors* (FIG). It was recognized that the field of cadastre lacked a means to support efficient communication, data exchange and interoperability between different systems. The CCDM is presented as a means of rectifying this situation by creating a generic model with a common ontology and development architecture. Such a model is intended to function as a framework via which to implement cadastral systems and to provide a common ontology and structure via which different cadastral systems can exchange data and interact. This framework is being designed by employing MDA and adherence to international standards relating to spatial data as defined by the Open Geographic Organization and The International Standards Organization (ISO) (Oosterom et al. 2005). It has been suggested that the LRI could adapt this methodology & ontology and use it to extend its model and to help guide further refinements to the Icelandic system of cadastral registration.

Topological spatial data model
The selection of an appropriate spatial model for this system is of vital importance as it will determine how cadastral mapping will evolve in near future. Representing parcels as simple polygons is at first glance the most obvious method to use. However when examined more closely it is not necessarily the most practical as it gives rise to several issues:

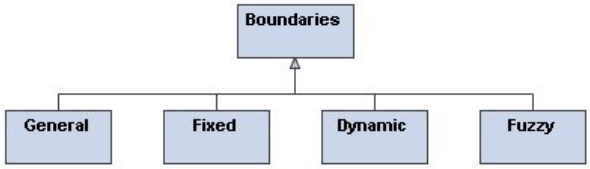
- Storing the same boundary in two adjacent polygons causes redundancy

– There is a risk of inconsistency if two polygons always have to be adjusted in order to fix one boundary
– It is impossible to attach survey data to boundary polygons
– Computing relationship queries can become very memory consuming

The use of a topological spatial model instead of a simple geometrical one would solve these issues however it is much more complex to implement. The proposal is to build upon the spatial model used in the CCDM and outlined in the ISO-19107 Spatial Schema.

Dynamic boundary types
The Icelandic landscape is dynamic in nature with natural features subjected to constant motion and changes in extent and shape. This can affect the location of boundaries. The CCDM mentions the possibility of fuzzy boundaries that can be applicable in such circumstances. However in its current form the CCDM does not elaborate upon this concept.

The LRI is considering how to adopt the CCDM so as to best accommodate it to Icelandic requirements and it has been suggested that one way to do this would be to by conceptually defining a number of new boundary types.



The suggested boundaries and their interpretations are as follows:

General boundaries: Boundaries whose veracity has not been established and can only be identified by further research
Fixed boundaries: Boundaries that have been surveyed according to requirements as defined in laws and regulations
Dynamic boundaries: Boundaries between public and private lands that are subject to change over long periods, e.g. coastline change, glacial movements, or because of individual events, such as volcanic activity. These boundaries are considered as fixed at each period of time.
Fuzzy boundaries: Boundaries that are subjected to shorter periods of change and on a smaller scale, e.g. river bed. Fuzzy boundaries can also be used to indicate areas of conflicting interests.

4.3 Action plan and success factors

In order to ensure to success of the project an action plan has been developed which will allow us to measure progress and keep development focused. This plan outlines seven phases that the project will pass through, from initial strategy to implementation and operation.

1. *A detailed strategy plan.* This will outline the goals, objectives and targets of the project.
2. *A guideline for the technical design of the system*. This will consider the type of system architecture to be adopted and the data models to be used. What spatial model will be used and what form will the cadastral transaction model take?
3. *Implementation phase*. The database solution and the cadastral interface will be developed and tested. The methodology and procedural models will be refined and documented.
4. *The organizational and legal framework* will be adjusted to allow them to better function within a system of cadastral registration. This will involve the drafting of new bills dealing with cadastre and the certification of cadastral surveyors.
5. *Preparation, trial and revision*. This stage will involve extensive documentation of the system, its promotion and introduction to users.
6. *System becomes operational*. The system formally becomes an integral part of the registration procedure. State and publicly owned lands are systematically brought into the system.
7. *Operation and evaluation period* during which the experience is periodically evaluated and the system revised as required

Exactly how long each phase will last is at present undefined as the strategic plan is still very much under consideration. The targets that have been considered so far are as follows:

- To complete the conceptual design phase by the end of 2006
- To complete the design of the system architecture, data model and modelling of transaction procedures by mid 2007
- To complete the refinement of the legal environment and organizational setup by the end of 2007
- To complete the testing of the system by the end of 2007
- To commence operation of the system at the start of 2008
- 75% of all parcels in Iceland should have surveyed boundaries by 2015

5. CONCLUSIONS

The successful implementation of this project depends upon several factors which are important to bear in mind. It is vital to ensure that sufficient financial support and capacity exists which will allow the project to be completed. It is also crucial that the project sticks to its schedule and that the legal environment is in place on time to support its technical implementation. Without a legal and organizational framework to stipulate cadastral mapping as a part of the cadastral transaction, there is a danger that the system will not function as planned.

Technical issues will also play an important role i.e. how reliable and stable will the system be? Of particular concern is how the topological model will be implemented in practice and how will this affect system performance?

A general consensus among stakeholders is necessary in order for the successful completion of the project. All involved parties will have to agree upon the desirability and effectiveness of the solution in order for its successful implementation and administration. In order to insure this outcome then the project will have to be introduced to geo-society and stakeholders in particular. A process will have to be established which will accept and process opinions and recommendations as to how the system could be better structured, designed or implemented. Finally, property owners and tax payers will need to understand the benefits of such a system so as to provide the impetus required to ensure its completion

The guiding principle of this project is that, *a well laid foundation will ensure a strong future.* It is appropriate to end this report with a quote that reflects this aim, taken from Williamsons report on *The Evolution of Modern Cadastres*:

> *A key to success is to start simple but incorporate sufficient components to allow the system to evolve and grow to serve multi-purpose uses in the future (Williamson, 2001, p.11)*

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BIOGRAPHICAL NOTES

Tryggvi Már Ingvarsson graduated with BSc in Physical Geography from the University of Iceland in the year 2001 before starting work as a consultant at Loftmyndir ltd., a private company that specializes in aerial photographing, photogrammetry and GIS. In the period 2003-2005 he studied MSc in Geomatics and became the first student to graduate with that degree from the Technical University in Delft, The Netherlands. After completing his thesis on the 'CCDM and Open Source Applications, in Context of Implementing Cadastre in Iceland' he began his career as a GIS expert at the Land Registry in Iceland. He is a member of project teams responsible of reforming current cadastral practices at the registry and to establish cadastral map component to the whole system. He has also had a hand in the

development of the Core Cadastral Domain Model and is titled as co-author in one of its newest releases.

Tom Barry graduated with an MA in Geography from the University of Cork, Ireland in 1995. Since graduating he has worked in the GI industry focusing on designing and implementing GIS systems. He is a board member of LÍSA the Icelandic Association responsible for the promotion and development of Geographical Information in Iceland. Since 2001 he has been employed as a GIS expert at the Land Registry of Iceland. He is a member of project teams responsible for the reformation of current cadastral practices at the registry and the establishment of a cadastral map component to the whole system. He also lectures in GIS and spatial analysis at the University of Akureyri, Iceland.

Margrét Hauksdóttir graduated as a lawyer from the University of Iceland in 1989. Upon graduation she commenced employment at the Ministry of Justice and worked there until 1990. Since 1989 she has been a member of various governmental committees dealing with legal issues. During 1992 – 1993 she was employed as a trainee at the EFTA Secretariat in Geneva. Between 1994 – 1997 she lectured on family law at the University of Iceland. In 2000 she moved to the Land Registry of Iceland and in 2003 became its Vice Director General. She was a member of the project team responsible for establishing the centralized Land Registry Database. Currently she is the chairman of a number of project teams who are responsible for the reformation of cadastral practices at the registry and for the development of a cadastral map component to the whole system. She is also a member of a governmental workgroup which is composing a new bill on cadastre. She has been member of the Bureau of the UN/ECE WPLA since 2005.

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