Swiss Cadastral Core Data Model – Experiences of the last 15 years

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Key words: cadastre, core data model, data modelling, INTERLIS, Switzerland.

SUMMARY

In Switzerland, the need for a standardized data exchange format for cadastral data has already been expressed in 1987. The requirement for a clearly defined data model that can be adaptated in flexible ways leads to the concept of a specific data description language, with which the whole cadastral core data model was defined. The data description language was named INTERLIS, while the data model for cadastral surveying became known as AV93, enacted in 1993 with a Federal ordinance.

The requirements for the core data model as well as the data description language evolved since. INTERLIS has been complemented and became INTERLIS2 in 2003. In 2004, a new revised core data model has been adopted, taking many of the discovered drawbacks into account. The revised core data model was named DM.01.

The concept of the data description language INTERLIS is very similar to the GML/XML concept that is in full development on the international level. This paper describes the experiences made with INTERLIS and the cadastral core data model in Switzerland over the last 15 years with the perspective of possible lessons learnt that might support international developments. The paper also includes two case studies illustrating the practical applications.

ZUSAMMENFASSUNG

Das Bedürfnis nach einem systemunabhängigen und normierten Datenaustauschmechanismus für Katasterdaten wurde in der Schweiz bereits 1987 ausgedrückt. Dies führte schliesslich zum Konzept einer spezifischen Datenbeschreibungssprache – als INTERLIS bekannt geworden – mit welcher das Datenmodell AV93 der Katastervermessung formuliert wurde, welches 1993 per Verordnung in Kraft gesetzt wurde. Die Beschreibungssprache wie das Datenmodell wurden seither den Anforderungen angepasst und sind nun unter INTERLIS2 und DM.01 bekannt.

Das INTERLIS-Konzept ist dem sich auf internationaler Ebene durchsetzenden GML/XML-Konzept sehr ähnlich. Dieser Artikel beschreibt deshalb die Erfahrungen, die in der Schweiz während den letzten 15 Jahren gemacht wurden im Hinblick auf heutige internationale Entwicklungen.

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1. INTRODUCTION

Data modelling, interoperability, spatial data infrastructure, OpenGIS and GML/XML are important key words in the context of efficient and transparent data access and eGovernment developments for cadastre and land administration activities. The role of geo-referenced information is crucial not only for cadastre and land administration themselves, but for many other decision-making processes that are related to land in one way or another.

The integration and sharing of geo-referenced data becomes more and more crucial, and there is an increasing need for efficient and reliable data exchange standards. In order to provide long-term security, these standards have to be independent from any specific hard- or software systems on the one hand, while for reasons of flexibility, they also need to provide a model-based approach. The following sections describe the experiences that have been made in Switzerland, where such a standard has been introduced more than ten years ago and where there already is a variety of experiences.

2. HISTORICAL BACKGROUND

In Switzerland, the need for a data exchange standard for digital cadastral data has already been expressed in the detail concept for the reform of cadastral surveying (Eidg. Vermessungsdirektion, 1987). In the light of the evolving digital technology, traditional cadastral maps on paper were not flexible enough and not suitable for the needs of the emerging information society. A project for the reform of cadastral surveying has been started in the mid-1980's, in which the conclusion was drawn that the need for a standardized data exchange mechanism arises out of four prerequisites:

- out of the need to transfer data from older to newer software systems;
- out of the tendency of devolution and networking, which leads to the situation that different problems require different solutions and systems;
- out of the fact that users prefer digital data in standardized ways;
- out of the high value of the cadastral data, which – for data security reasons – have to be kept on different systems and transferred back and forth.

A problem at that time was that software packages provided exchange standards that were proprietary, static and format- rather than model-based. Vendors had a certain vested interest to keep their software systems "closed" to any transfer of data into another system. As long as there were no cross-platform data exchange standards, it was possible to "lock" data into their specific system. Experiences from the late 1980's suggested that the costs for the transfer of geospatial data from one software system to another were nearly as high as the whole data acquisition process itself. This was of course not tenable for the maintenance of cadastral data that have to provide long-term guarantee – potentially much longer than the life span of hardware and software.

An expertise in 1985 (Messmer, 1985) suggested a bi-level approach for the future data exchange standard in cadastral surveying, which then was further developed by Dorfschmid (as described in Dorfschmid, 1996). He proposed a data description language to describe data models in an orderly and precise way, while the data model itself had to be decided by the respective authorities. This proposal was based on the following thoughts:

- precision and flexibility in data description;
- data archiving according to principles of data and information security;
- formal and automated data quality control.

This proposal satisfied the expectations and was accepted by the steering committee. A detail concept was commissioned and led to the creation of the data description language INTERLIS and the data model for cadastral surveying.

The model-based concept has further advantages. It allows data exchange without information loss – as opposed to the format-based exchange standards – and thus provides a system-independent data exchange mechanism for the protection of the high financial investments in data acquisition. The principle of method and system independency was also the basis for the introduction of tendering projects because it became possible to define the final product rather than the method or the system.

3. CADASTRAL DATA MODELLING BASED ON DESCRIPTION LANGUAGE

The INTERLIS language has been developed in such a way that it can easily be read by human beings. The interpretation of INTERLIS models is nevertheless precise and unambiguous. The language is textual and well-suited to complement the graphical description language Unified Modelling Language (UML), but goes well beyond that. The INTERLIS concept also includes a transfer service, which can automatically generate the transfer file from the conceptual model.

INTERLIS has been designed for the interaction between information systems, in particular land information systems. It therefore is a conceptual description language with which the data model of the real world can be described. Such a description is called a "conceptual model". Properties and relations of real world objects are being described with clearly defined expressions and terms. Furthermore, INTERLIS makes a clear distinction of the description of the real world objects and their graphical representations.

INTERLIS is not geared towards a particular application. It is based on object-oriented principles and while coordinates, lines and areas are basic constructs, there are many others to describe other properties of the objects, enabling INTERLIS to also deal with non-geographic data and applications.

Data modelling in conjunction with system independent interface services is called model-based approach or model-driven architecture. Models can be defined on the basis of a common concept and standard, which is crucial from the perspective of semantic interoperability. For example, data can be transferred from a municipality to a higher administrative unit (cantonal or Federal level) without effort and without loss of semantic, topologic, and geometric information. It suffices that a common data model is at the basis and that each administrative level builds its model on the basis of the next level above.

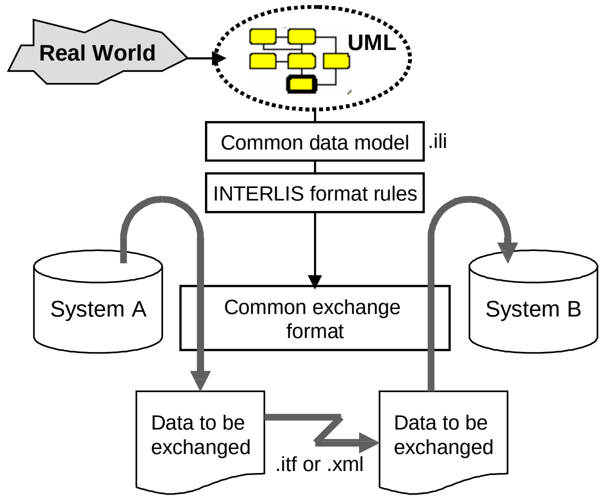

Figure 1: Data transfer between different information systems through a common data model defined through a common data description language.

The core data model for cadastral surveying data – initially called "AVS" then "AV93" – was defined with the data description language INTERLIS and became an integral part of the new legal basis for digital cadastral surveying introduced in 1993. The data model consists of eight information layers; the distinction into different information layers had mainly a data management purpose, namely to be able to assign distinct stakeholders and to separate and distinguish data acquisition for each layer.

The two new ordinances that were introduced in 1993 were "VAV" ('Verordnung für die Amtliche Vermessung' or Ordinance for Cadastral Surveying) and "TVAV" ('Technische Verordnung für die Amtliche Vermessung' or Technical Ordinance for Cadastral Surveying). The objective was to renovate the cadastral surveying system and to introduce the digital data format. Due to the versatility of data in digital form, the 'raison d'être' of cadastral surveying data had been extended from a sole legal purpose to multi-purpose, serving not only for land registration but also for "any kind of land information system". The data description language INTERLIS is a crucial element for this extension of purpose because it is well suited as basis for the definition of data models in any other domains (compare also Figure 3).

The cadastral map in digital format consists of eight information layers. By definition, the two layers "land cover" and "ownership" cover the whole territory in a complete way, i.e. without overlaps nor gaps, while other layers have different structural definitions. Buildings are part of the "land cover" layer. The separation of the data into the eight information layers has the advantage that the layers can be acquired independently from each other. Each of the information layers is object-oriented and defined by an entity-relationship diagram, representing the data model and basis for the translation into the INTERLIS data exchange format (Figure 2).

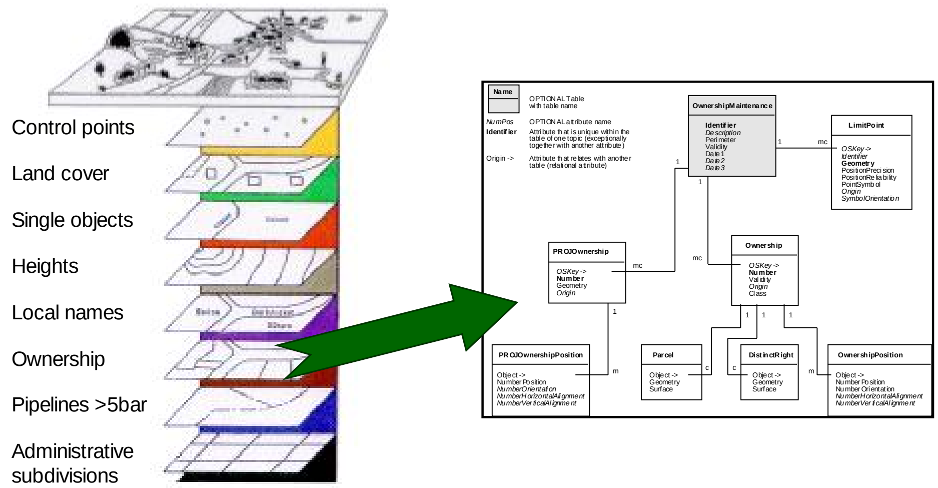

Figure 2: The eight information layers of cadastral surveying and example of entity-relationship diagram for layer "ownership".

The following example intends to illustrate how the entity-relationship diagram resp. the data model is being translated into a machine readable file. It shows an extract from the "ownership" layer of the data model DM.01 for cadastral surveying. It also shows the hierarchical structure of INTERLIS with the main constructs MODEL–DOMAIN–TOPIC–TABLE.

```
TRANSFER INTERLIS1;

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!! Datenmodell 2001 der Amtlichen Vermessung "Bund" (DM.01-AV-CH)
!! beschrieben in INTERLIS Version 1 (SN 612030)
!! Version: 24 deutsch
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

MODEL DM01AVCH24D

  DOMAIN
    LKoord = COORD2 480000.000   70000.000
                    850000.000  310000.000;
    HKoord = COORD3 480000.000   70000.000  -200.000
                    850000.000  310000.000  5000.000;
    Hoehe = DIM1      -200.000    5000.000;
    Genauigkeit = [0.0 .. 700.0];  !! in cm
    Zuverlaessigkeit = (
      ja,  !! genuegend
```

```
      nein);  !! ungenuegend
    Versicherungsart = (Stein, Kunststoffzeichen, Bolzen, Rohr, Pfahl, Kreuz,
unversichert, weitere);
.........

  TOPIC Liegenschaften =
    DOMAIN
      Grundstuecksart = (Liegenschaft, SelbstRecht, Bergwerk);

    TABLE Grenzpunkt =
      Entstehung: -> LSNachfuehrung;  !! Beziehung 1-mc
      Identifikator: OPTIONAL TEXT*12;
      Geometrie: LKoord;
      LageGen: Genauigkeit;
      LageZuv: Zuverlaessigkeit;
      Punktzeichen: Versicherungsart;
      ExaktDefiniert: (Ja, Nein);
      HoheitsgrenzsteinAlt: (ja, nein);
    IDENT Geometrie;
    END Grenzpunkt;

    TABLE GrenzpunktSymbol =
      GrenzpunktSymbol_von: -> Grenzpunkt;  !! Beziehung 1-c
      Ori: OPTIONAL Rotation // undefiniert = 0.0 //;
    IDENT GrenzpunktSymbol_von;
    END GrenzpunktSymbol;

    TABLE Grundstueck =
      Entstehung: -> LSNachfuehrung
        // Gueltigkeit = gueltig //;  !! Beziehung 1-mc
      NBIdent: TEXT*12;  !! Beziehung 1-m zu Nummerierungsbereich
      Nummer: TEXT*12;
      !! Elektronisches Grundstueckinformationssystem
      EGRIS_EGRID: OPTIONAL TEXT*14;
      !! abgeleitetes Attribut: muss streitig sein, falls Liegenschaft,
      !! SelbstRechtvoder Bergwerk streitig;
      Gueltigkeit: (
        rechtskraeftig,
        streitig);
      !!unvollstaendig, falls z.B. das Grundstueck
      !! teilweise ausserhalb des Perimeters liegt.
      Vollstaendigkeit: (
        Vollstaendig,
        unvollstaendig);
      Art: Grundstuecksart;
      GesamteFlaechenmass: OPTIONAL DIM2 1 999999999;
    IDENT NBIdent, Nummer;
    END Grundstueck;

    TABLE Liegenschaft =
      Liegenschaft_von: -> Grundstueck // Art = Liegenschaft //;  !! Beziehung 1-mc
      !! NummerTeilGrundstueck ist fuer Teil Grundstueck noetig
      NummerTeilGrundstueck: OPTIONAL TEXT*12;
      Geometrie: AREA WITH (STRAIGHTS, ARCS) VERTEX LKoord BASE
        // Geometrie nur LFP1, LFP2, LFP3, Grenzpunkt oder Hoheitsgrenzpunkt //
        WITHOUT OVERLAPS > 0.050
        LINEATTR =
          Linienart: OPTIONAL (streitig, unvollstaendig);
        END;
      Flaechenmass: DIM2 1 999999999;
    NO IDENT
    END Liegenschaft;
```

```
  END Liegenschaften.

END DM01AVCH24D.
```

As mentioned above, the new ordinances introduced in 1993 required that the cadastral surveying data are to serve not only for land registration, but for any kind of land information system. The idea behind that stipulation was to integrate and share spatial information of public interest and to avoid double data acquisition. With the introduction of the INTERLIS data modelling concept, this demand became technically feasible. Spatial data can be integrated and shared in one information system only when they have a common geodetic reference framework and a common data modelling concept. As illustrated in Figure 3, data ownership and responsibility can still be retained without interfering in stakeholder interests and data acquisition and maintenance processes.

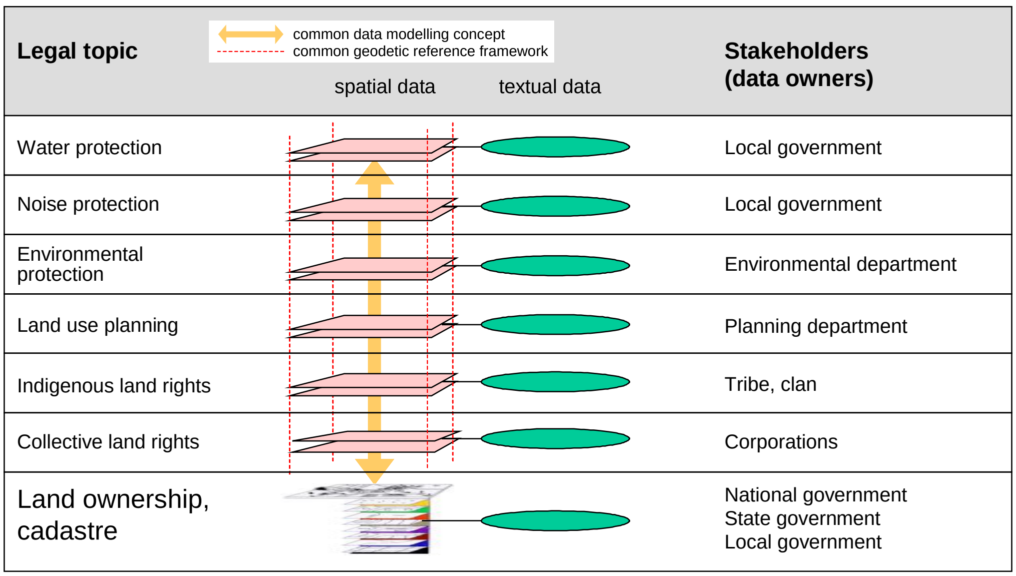

Figure 3: Concept of shared land information through common geodetic reference framework and common data modeling technique.

Data modelling plays a similar role as the geodetic reference framework. Both are not an absolute necessity for data integration and sharing, but they both provide the required ease of use for land information systems to work. This concept is at the core of spatial data infrastructures, which are very important in sharing information and ultimately the set-up of eGovernment services.

4. DEVELOPMENT OF INTERLIS2 AND COMPARISON WITH GML3

At the time when the data-modelling concept has been introduced, there were only few international standards available that were able to support it. One was the data description language EXPRESS, which however does not seem to have overcome the initial problems for practical implementation for geo-information.

INTERLIS was adopted as the description language in Switzerland and it also went through a difficult period at the beginning. However, after some initial problems, it was accepted in practice and was supported by the inclusion in several software packages. It became widely used in the cadastral surveying community as well as for the description and definition of many other municipality-based data sets.

Due to several minor, but important restrictions, INTERLIS had to be extended and complemented in 2003. It became INTERLIS2, which now offers new possibilities such as incremental updating, the definition and transfer of graphical representations, data views, and the description of units and coordinate systems. Also terms of the language have been altered for better readability and compatibility. For instance TOPIC has been altered to CLASS, OPTIONAL is replaced by MANDATORY, and IDENT by UNIQUE.

Instead of the specific INTERLIS file transfer format .itf, it is possible with INTERLIS2 to encode the data for transfer directly with the "eXtensible Markup Language" .xml. XML is expected to become the international standard with a large number of compatible software tools to be developed in the near future.

Users acquainted with INTERLIS will not have to face many changes when working with INTERLIS2. Various tools such as the commonly available INTERLIS2 compiler will facilitate the adaptation to the new version. Software producers who already had implemented flexible configuration possibilities in their systems with INTERLIS will find that their past investments will retain their value. Open accessible program libraries will support the full integration of INTERLIS2 into their systems.

In summary, INTERLIS2 does not replace the initial INTERLIS description language; it rather provides complements that facilitate new possibilities. The most important changes were:

- INTERLIS2 offers new extensions such as data types, constraints, data views, graphical descriptions, description of units, descriptions of coordinate systems, and user-specific extensions, such as e.g. line geometries.
- Possibility of incremental updating. Incremental updating requires that both the primary and secondary data bases support the transfer format (XML) and that new object identifiers be introduced.
- Instead of the .itf-format that INTERLIS used, encoding of the INTERLIS2 transfer format will be done with the eXtensible Markup Language (XML). This ensures that the national standard is compatible with internationally accepted standards.

In a recent study, Nebiker (2004) compares the concept of INTERLIS2 with GML3. His findings can be summarized that INTERLIS2 is an established 'de jure' standard with rather slow, pragmatic development pace and a mainly national basis. The pace of development for

GML is much faster and through an international, mainly US-based industry consortium. With the integration of GML into the ISO standardization process, the pace of development will however be slowed down and thus the integration into practice being improved. Both INTERLIS2 and GML offer constructs for the description of spatial objects including their properties and mutual relations.

The way of modelling is very similar with both languages. INTERLIS is slightly superior in the modelling of overlaps and the specification of plausibility checks, while GML offers some functionality not available in INTERLIS2, e.g. modelling of 3-dimensional objects or the support of different coverage types. GML bases its XML schema on a well known IT standard, which is being supported by a large collection of software tools. Models in XML can very easily be checked against errors with these software tools, however are not easily readable by human beings.

Table 1: Strengths and Weaknesses of INTERLIS2 and GML3 (Nebiker, 2004).

	Strengths	**Weaknesses**
INTERLIS2	• precise and lean • version 1 already passed the test of practice • evolution rather than revolution • many software tools • UML and text	• only modelling and transfer • 'island' solution (national solution) • too good version 1 • yet unclear role of XML (schema) • how to deal with further extensions?
GML3	• large basis in market • pragmatic modelling language • part of a standard family • application language	• flood of versions • large and complex • restrictions of the XML schema • cryptic model descriptions • lack of practice • lack of producer support

Nebiker (2004) also lists the commonalities between INTERLIS2 and GML3. They are both model-based and object-oriented and they both support domain specific application schemas and data transfer with XML. Differences are: different modelling languages; INTERLIS can create three different representations of the data model; INTERLIS can separate model description and data transfer description; INTERLIS is tested in practice for several years now and has a pragmatic and somewhat slower standardization pace; INTERLIS is readable by human beings while GML is difficult to interpret.

The objective of the study was to evaluate the further advancement of INTERLIS2 in view of the technical developments around the UML, GML and XML standardizations. The recommendation was that Switzerland should continue to use INTERLIS2 for the description of data models, mainly for the following reasons:

- there is a well established industry to deal with INTERLIS2, while GML – although an accepted international standard – is still in rapid development
- many software tools are available for INTERLIS2 (parser, compiler, checker)
- data described with INTERLIS2 are compatible with the .xml format

- the compiler for INTERLIS2 has been extended and now provides the basis for the generation of GML application schemas and XSL style sheets for data transformation
- data services can easily be set up on the basis of OGC
- INTERLIS2 supports incremental updating
- there are control tools in INTERLIS2 that do not exist for XML yet
- INTERLIS2 can describe graphic representation, which is not possible in GML

The GML and XML developments will of course be closely monitored. The suggested continuation with INTERLIS2 provides the required stability for the industry. The Swiss geo-information community has a tool that provides the required services and it has the privilege not having to rush into a new standard.

5. CASE STUDIES

5.1 Cadastral Surveying Data Model DM.01

The initial data model AV93 of cadastral surveying was very successful in its implementation, but due to the developments and experiences over the first few years, it had to be adapted to newer requirements. The new version of the data model was named "DM.01" and it was enacted in early 2004. DM.01 takes many of the earlier discovered shortcomings into account.

One of the crucial shortcomings was that AV93 contained too many "cantonal options", which were sort of political requirements at the beginning. Cantons were given the choice of optional data or to include specific data in their cantonal data model. This however had a diverging effect and led to– although very similar – different cantonal data models. The amalgamation of cantonal data sets into a national one became more and more difficult.

The revised core data model DM.01 is more restrictive and defines one clear Federal model; Cantons – in their political autonomy – are still permitted to maintain their own data models, but are required to provide data in the format of the Federal model. This concept now allows a hierarchy of data models, which is well-suited for the federative and decentralised political and administrative structures of Switzerland.

Other changes in the revised data model concern the improvement of the suitability and homogeneity of data. Additional attributes have been defined that were required by on-going projects such as agricultural areas (grazing land, pasture), interface to land registration (additional identifiers for use in new information system; new relation between entities 'parcel' and 'property'), provisional products (new quality standard), and address data (more precise and nationally unified attributes) (Eidg. Vermessungsdirektion, 2004).

The Cantons are not required to use INTERLIS2 for the revised data model DM.01, the older version 1 of INTERLIS is still functional and accepted. It is however recommended that Cantons switch to INTERLIS2, because it provides more and better possibilities for data management. The full data model including commentary and entity-relationship diagrams can be viewed on the Internet at http://www.interlis.ch/mo/index.php?language=d (in German, French, Italian).

With the introduction of the new data model DM.01, the Federal Directorate for Cadastral Surveying (Eidg. Vermessungsdirektion) also introduced a new web service, which allows to automatically check data sets. The possibilities are:

- check service with INTERLIS1: Federal data model DM.01 + data
- check service with INTERLIS2: any data model + data

These new possibilities also demonstrate the advantage of using standardized data description languages.

5.2 Interface with land registration offices

Land registration and cadastral surveying offices are operating separately in Switzerland. In spite of this institutional separation, there is a close cooperation between the two organizations and data are being shared readily. While cadastral surveying has defined the digital format of its data, land registries were slower to adapt. Over the last few years, however, digital data have become standard in land registration as well and since 2001 there is a project going on to get access land registration data through an information system. A first subproject embarked upon the definition of the interface between land registration and cadastral surveying data to facilitate the transfer of data. The relevant entities that are being transferred are 'landowners', 'parcels', and 'mutations'.

There are several software and database systems that are being used in land registration and cadastral surveying. The transfer of data however had to be independent from any system and it therefore was decided to take the same data modelling approach as in cadastral surveying. The data model was therefore described with INTERLIS, also taking benefit from additional advantages such as for example incremental updating. It was also important to have a future-oriented solution.

The data model was divided into four sub-models in order to separate the legally valid data from projected data and to respect the independence of the two data stakeholders. The four sub-models are 'ownership circumstances', 'parcel description', 'mutation table' and 'execution matter'. The four sub-models reflect the procedures for typical transactions (BJ-EGBA and Swisstopo-V+D, 2003):

- *ownership circumstances:* information from land registry to cadastral surveyor for finding owner of a property (compare Figure 4);
- *parcel description:* information from cadastral surveyor to land registry describing the property respective to its legally valid situation;
- *mutation table:* information from cadastral surveyor to land registry describing the properties before and after the mutation, illustrating the provisional, projected and definitive situation;
- *execution matter:* information from land registry back to cadastral surveyor confirming the closure of the mutation (e.g. the definitive parcel number).

The concept report for the interface between land registration and cadastral surveying (BJ-EGBA and Swisstopo-V+D, 2003) lists the data models of those four sub-models in file format.

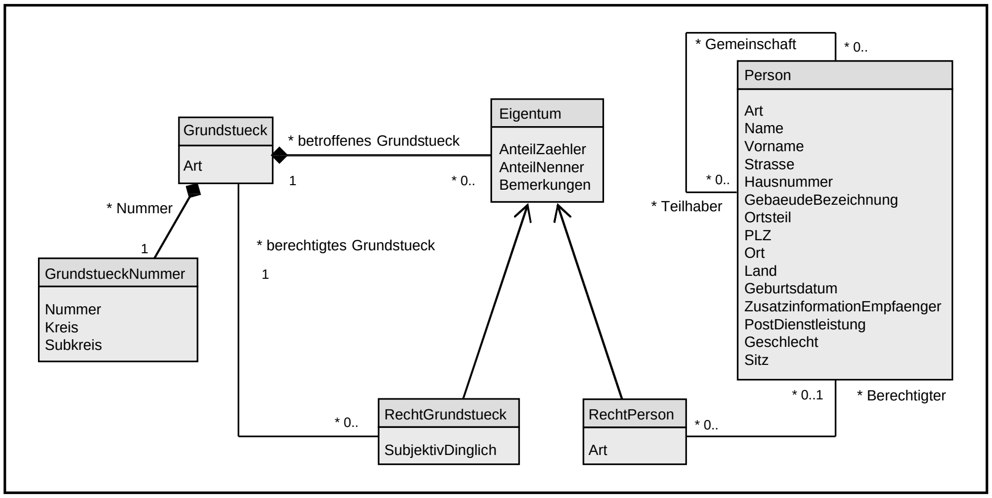

Figure 4: UML respective data model of ownership circumstances.

6. IMPORTANT LESSONS LEARNT

During the preparatory and implementation phase of the INTERLIS concept from the late 1980's until today, there were important lessons to be learnt. They were the following:

- The constant dialogue between authorities and the private sector software producers were crucial and important during the development. This helped to find a feasible solution.
- The fact that data are the most expensive element in cadastre – as in any geo-information project – and therefore have to be protected against the fast hard- and software system changes was a strong and crucial political argument in the decision for this concept.
- Although the development of the INTERLIS concept has been discussed extensively with private sector companies prior to its introduction, the acceptance in practice was not very high initially. The concept by itself, although considered a valuable one, was not enough to convince the surveying community and to guarantee its use. Only the development and provision of software tools made a difference and produced tangible benefits.
- The creation of a competence centre for data modelling and data exchange provided the crucial support for the INTERLIS concept. The competence centre became a platform and contact point for data modelling in general and it initiated and supported the development of software tools, which finally were the breakthrough from a mere "nice concept" to practical application.
- The supervising body for cadastral surveying on the Federal level – the Federal Directorate for Cadastral Surveying, who initiated the reform for the digital format and who had the responsibility to carry it out – used its subsidy system to put financial

pressure on the implementation of the INTERLIS concept. This was crucial for the implementation of the INTERLIS concept.

- It was important to recognize and to communicate that the data model as well as the description language are in constant development; the first revisions have now been made with DM.01 and INTERLIS2. Even when it again takes some time for the industry to digest such development steps, they receive better acceptance with clear and transparent communication.

7. CONCLUSIONS

The introduction of the new data-modelling concept for the description of cadastral surveying data in 1993 also triggered the development of SDI in Switzerland. The data-modelling concept with INTERLIS has initiated the definition of more than 100 other spatial data domains since 1995, enabling the use of the same data exchange mechanisms as in cadastral surveying. In 1998, a new agency (COSIG) has been established to foster the coordination, acquisition, and use of spatial data within the federal administration. COSIG promotes the INTERLIS concept for the definition and handling of all spatial data. This concept is also at the core of the new eGovernment initiative, which attempts to bring digital spatial data closer to the users. INTERLIS has become the accepted approach within the Swiss geodata community for the modelling and exchange of data.

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BIOGRAPHICAL NOTES

Daniel Steudler graduated from the Swiss Federal Institute of Technology (ETH) in Zurich in 1983, earned the Swiss license for cadastral land surveyor in 1985, and did his M.Sc.Eng. degree at the University of New Brunswick, Canada from 1989-91. Since 1991, he is working with the Swiss Federal Directorate of Cadastral Surveying with the responsibilities of supervising and consulting Swiss Cantons in organizational, financial, technical, and operational matters in cadastral surveying. Since 1994, he is involved in the activities of FIG-Commission 7, of which he became the official Swiss delegate in 2003. In March 2004, Daniel received a PhD degree from the University of Melbourne, Australia, under the supervision of Prof. Ian P. Williamson. The main research topic was to develop a framework and methodology for evaluating cadastral systems in the context of land administration.

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