10 Years of "Law on Geoinformation" in Switzerland – Core Features of a Successful National Spatial Data Infrastructure

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Key words: Cadastre, Digital cadastre, Geoinformation/GI, GSDI, Legislation, Open Government Data, Web-services, Smart Cities

SUMMARY

This paper is one article in a series of four that are being submitted to the FIG-WW 2019 in Hanoi. The background is the 10-year anniversary of the "Swiss Federal Law on Geoinformation", which came into force on 1 July 2008.
This paper presents tools for the technical harmonisation and dissemination of geodata in the context of a national spatial data infrastructure (NSDI). The specifications for the technical harmonization of the several hundred data sets that are classified as official geodata must take place on a level which copes with the diversity of their contents. Specific requirements for the geodetic reference system, data model and representation model, data quality and feature capture rules and data exchange have been laid out.
Official geodata are managed on all three administrative levels. Several data sets such as spatial planning and cadastre are managed at municipal level, but are often used at cantonal and national level. The system architecture of the NSDI is thus based on decentralised storage at the data manager and centralised access, whereby decentralised use is of course also important. For efficient data exchange between the authorities, a backbone for data distribution is required in addition to maintain the consistency of the data models used and the exchange format INTERLIS. The so called "aggregation infrastructure" ensures that only data with sufficient data quality is transferred into the homogeneous structure. Organizational mechanisms also ensure that the data in the central infrastructure are always kept up-to-date.
Due to the importance of geodata for economic prosperity, many official geodata are not subject to access restrictions. In recent years, many organisations began to provide their data as Open Government Data (OGD). Through the intensified data usage, the harmonization of further data sets that are related to geodata, such as a housing register, has been promoted. By means of register harmonization, the data records managed in isolation can be easily combined with each other, so that a holistic view for the promotion of smart governance is guaranteed.
Different uses of geodata in apps on smartphones would not be possible without the NGDI and the underlying technical harmonisation. The developments over the last 10 years show that the scope of the legislation and the corresponding ordinances have been done in a sufficient level of detail. Only those requirements have been defined that have proven to be necessary in practice. This also seems to have resulted in an optimal cost-benefit ratio.

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1 INTRODUCTION

The wide accessibility of geodata is one of the core objectives of the Geoinformation Act (GeoIG). Due to the federal structure of the state, all three levels - federal, cantonal and communal - are responsible for the data in their area of authority. The law requires a geodata set for those sovereign tasks for which a corresponding requirement for spatial documentation such as a map, a plan or a cadastre is made in a sectoral law. The information identified in this way is subsequently referred to as *basic geodata* and is therefore subject to the GeoIG. Further geodata of the cantons or communes, e.g. data collected by local government for operational activities, can be voluntarily subordinated to the GeoIG.
Several data sets such as spatial planning and cadastre are managed at municipal level, but are often used at cantonal and national level. The system architecture of the NSDI is thus based on decentralised storage at the data manager and centralised access, whereby decentralised use is of course also important.
Although the data sets are maintained by various organisations, only if citizens and users have easy access to the geodata can the objectives of the law be achieved. In order to ensure accessibility, functions such as data catalogues (metadata), and portals with aggregated data inventories must be provided for presentation and download services in accordance with GeoIG specifications. With regard to map services, the law stipulates the technical aspects (which standards are supported) as well as the content implementation (the visualisation is described in the form of a representation model).
In order to achieve general accessibility to geodata, in addition to the technical infrastructures for providing the data, it must also be ensured that the data of different organisations fit together, i.e. that their content and form are harmonised. In order to minimise the effort required for data exchange - both between authorities and between authorities and citizens - technical harmonisation requirements must be met with regard to data exchange formats.

This paper presents tools for the technical harmonisation and dissemination of geodata in the context of a national spatial data infrastructure (NSDI). The specifications for the technical harmonization of the several hundred data sets that are classified as *basic geodata* must take place on a level which copes with the diversity of their contents. Specific requirements for the geodetic reference system, data model and representation model, data quality and feature capture rules and data exchange have been laid out.

2 ASPECTS OF TECHNICHAL HARMONISATION

2.1 Earlier developments

In very few cases is the responsibility and competence for a holistic representation of a real phenomenon united in one organisational unit. Due to different roles (e.g. owner, supervisory

agency, enforcement agency, technical competence centres), the collection, maintenance, control or approval of data elements is distributed among several bodies.
The legislator, recognising that responsibility is shared, has ensured in the law that the content of a data set must be specified in such a way that a homogeneous data set is generated independently of the data manager. When drafting the GeoIG, the experience gained in the digitisation of cadastral surveying could be drawn upon. In Switzerland, the cadastre has been a municipal task since the beginning. As the cadastre includes not only property boundaries but also information on the situation, it is essential that this data can be used for any base map. During the conversion from analogue to digital cadastre at the end of the 1990s, the foundations were laid for the decentralised collection and updating of data and their submission to the supervisory authority for verification via a standardised interface.
To simplify data exchange and quality assurance, the model description language INTERLIS was developed (Dorfschmid et al 1987). From the very beginning, INTERLIS was conceived as a system-neutral format in order to transfer a complete copy of a database from one system to another without loss. The current version 2.4 of the standard (eCH, 2016) is an object-oriented conceptual schema language (CSL) with which (spatial) data models can be precisely defined in textual form using a rigid, computer-processable syntax. An important characteristic of the language is that it is easy for application and IT experts to understand and thus closes the gap between application and IT areas (Germann et al 2018).
The Cadastral Survey Model published in 1993 was one of the first data models implemented. Due to the special importance of the Cadastre for the protection of property ownership, INTERLIS has focused on quality control from the inception. The semantic support of various conditions (mandatory attributes, topologies), which can be used in the data model, is a requirement for verifiability.
Abstraction and modelling are necessary to capture the real-world objects in a database, since not every detail of an object is relevant to a question. As a result of this simplification, the Universe of Discourse (according to ISO 19100 series of standards) is defined, i.e. the view of the real or hypothetical world that includes everything of interest. The documentation usually occurs in the form of a conceptual schema.
In order to achieve semantic interoperability, additional rules had to be defined for Cadastral Survey Model which objects should be represented in which way in the data model. These guidelines were documented as feature capture rules in textual and pictorial form.
In order to present a map for the land register in a uniform way, the - already in the analogue age - existing portrayal rules were adapted to the classes and attributes of the data model. In addition to symbols and signatures, these portrayal guidelines also contain filter criteria (which data is displayed at which scale) and the prioritization of the levels.
After the adoption of the technical regulations, each data set, after being processed in digital form, had to be submitted in INTERLIS format by the surveyor to the cantonal supervisory authority. The verification of the data included, on the one hand, the formal verification of the correctness of the exchange format, the conformity of the data set with the maps produced and compliance with the capture rules (including proof of compliance with the accuracy requirements).

2.2 Subjects of technical harmonisation in the GeoIG

2.2.1 Data product specifications

With the technical specifications in Cadastral Surveying and the specifications for data modelling and data exchange introduced in connection with their digitalisation, a good decade before the GeoIG was drawn up, important foundations for technical harmonisation were already in place. The requirements described in the law concerning the minimum specification for each basic geodata set were largely congruent with the ISO standard 19131 - Data Product Specification (DPS), which was developed during the same period. With regard to the description of the conceptual schema ("Content and structure" according to ISO 19131) and the data delivery ("Delivery format"), the specifications for all topics were given: the schema had to be described with INTERLIS (Version 2.4) and the INTERLIS format was also used for data exchange.
Since the DPS was the starting point for all further activities, it was considered indispensable to create a complete, consistent, understandable and unambiguous requirement profile (template DPS) for the scope of each basic geodata set. With the template of the DPS the basis for a quality model was prepared so that the representation of the real world in a geodata set could be sufficiently defined (Lüthy, 2016).

2.2.2 Web services

The use of information provided by the NGDI should essentially be based on interlinked geoservices at all levels (local, regional, national and international). By focusing on geoservices, it should be possible to considerably simplify and accelerate information on and access to the existing distributed databases at federal, cantonal and communal level (e-geo, 2008). The legislator has foreseen different forms of geoservices for the provision of geodata:

- Portrayal services for all topics referred to as publicly accessible basic geodata. The Portrayal service is defined as a service according to the OGC Web Map Service Implementation Specification (WMS) or Open-GIS Web Map Tile Service Implementation Standard (WMTS).
- Download services at least for the basic geodata sets identified in the ordinance. As a download service, "Direct Access" is defined by means of OGC-standards Web Feature Service (WFS).

In addition to the data-related services, other services were required for facilitating access and use:

- Search services for the access to the geometadata of the basic geodata
- interdisciplinary geoservices:
  - interlinked search service for the geometadata of all basic geodata, i.e. across all federal levels, in accordance with the OpenGIS Catalogue Services Specification (CSW);
  - interlinked search service for presentation and download geodata services;
  - services for the transformation between different geodetic reference systems and frames
  - Address services (localisation and positioning services).

3 PRACTICAL IMPLEMENTATION

3.1 Data product specifications

The bodies responsible for a basic geodata set were challenged not only to produce a data set optimized for their own needs as had been the case up to now. In ensuring that harmonization can function as required, the law already recognised the need for appropriate involvement of data producers and users. These entities are decisive for success in the long term; the legislator's objective can only be achieved with their willingness to adhere to the (jointly) developed specifications.

Corresponding to Switzerland's federal system, technical and technical specifications are developed by the responsible authority in cooperation with other authorities, but also by relevant specialists outside the administration. For the preparation of the documentation, a so called professional information community (PIC) was therefore formed by the responsible authorities for each basic geodata set. It can however be argued that in many topics a number of conventions are developing as to how this information should be collected, described, updated, presented, interpreted and applied. Often, these conventions have arisen from the cooperation between producers and consumers. In various cases, however, user cultures have developed that are unknown to manufacturers (see also e-geo 2008). In a number of topics, the elaboration of the documentation also showed that semantic interoperability between data sets structured in models that were actually defined and agreed upon did not exist, because ultimately the understanding of the collection, filtering and presentation of information varied greatly. Due to the cooperation of experts from different organizations in the PICs, important discussions about processes, data and usage were conducted.

Over the past 10 years, several hundred basic geodata have been extensively debated and specified. In many cases, the minimal Federal models have been extended and refined at cantonal level. Thanks to the extensibility of INTERLIS models, the Cantons were able to concentrate on extending the model. By including the federal models in the cantonal model description (inheritance principle), it can be ensured that changes on the Federal level are always automatically incorporated in the Cantonal versions.

The model documentations are publicly accessible on the homepage of the respective Federal Office or the Cantonal agencies. The technical descriptions of the data models in INTERLIS can be found in machine-readable form in the model repository at http://models.geo.admin.ch at the Federal Government. Various Cantons also operate such repositories.

3.2 Dissemination of Data

3.2.1 Presentation and data provision services

In the implementation regulations for the law, the various geoservices required were based on OGC standards, which meant that most of the technical implementation could be carried out using existing tools. Because the use of map services requires a suitable client for the user, it was obvious that the (basic) geodata would also be made available to the population via map portals.

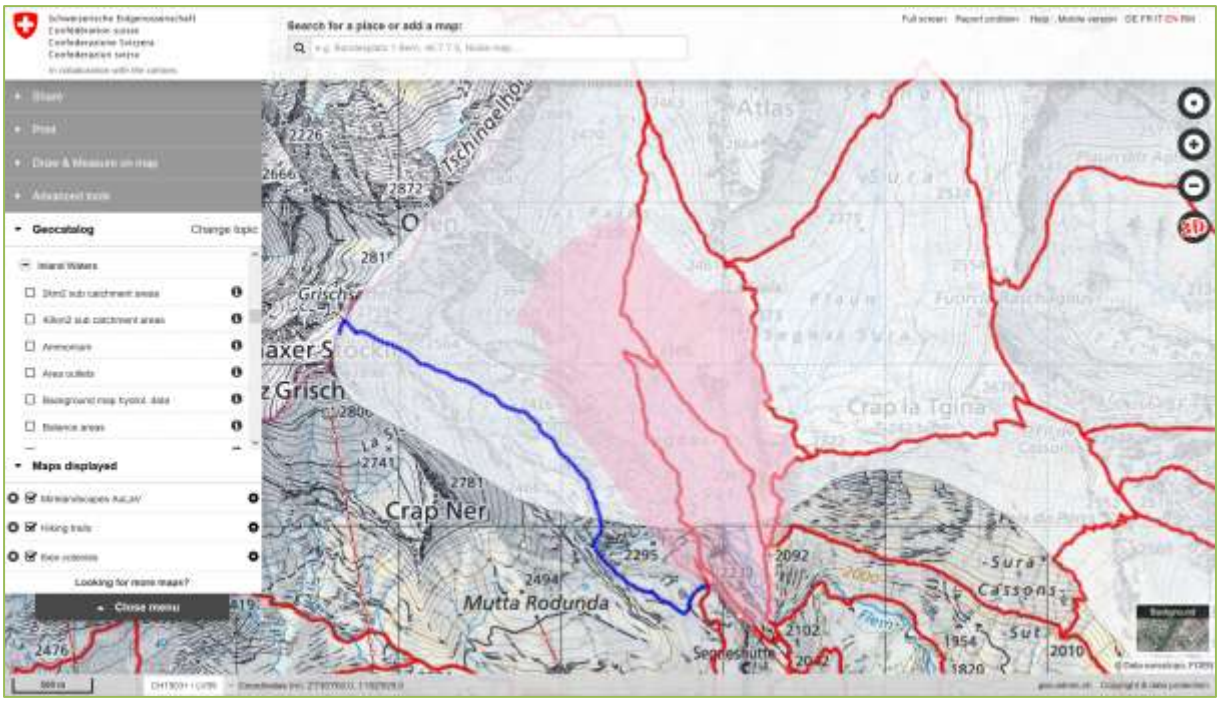

Figure 1 - Convenient access to Federal geodata via the map portal http://maps.geo.admin.ch

3.2.2 Aggregation Infrastructure for non-Federal basic geodata

In topics over which the Federal government has a supervisory function but the Cantons are responsible for enforcement, data management is the responsibility of the Canton or, in some cases, of the communes. The question therefore arose as to how these decentral organised data sets could be made centrally accessible. The Conference of Cantonal Geoinformation Offices (KKGEO[1]) developed the strategy for an aggregation infrastructure to fulfil this task. The following tasks are to be supported by the implementation of the strategy:

- The KKGEO infrastructure aggregates the basic geodata under the responsibility of the Cantons for the whole of Switzerland and makes it available for further use in an up-to-date, reliable, comprehensive and demand-oriented manner (see also https://www.kkgeo.ch/geodienstech).
- It provides the Cantons with long-term support in implementing their obligation to provide data in accordance with the Geoinformation Act and relieves them of inter-cantonal similar, recurring tasks.
- It is a recognised and efficient pillar of the national spatial data infrastructure and benefits from synergies with the Federal and Cantonal infrastructures.

The idea of the aggregation infrastructure (AI) is visualised in the following figure.

[1] For further information see www.kkgeo.ch

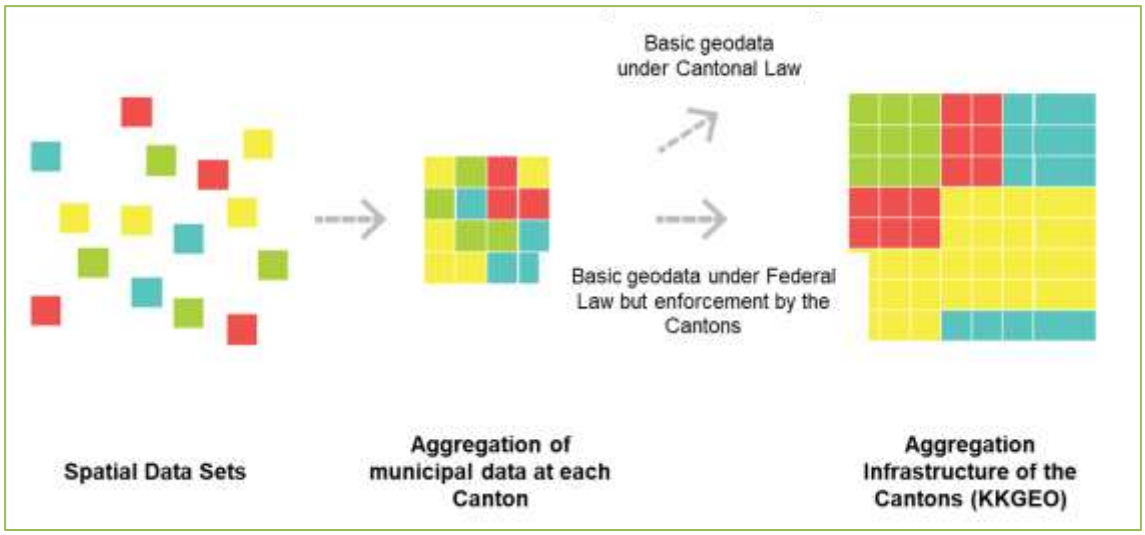

Figure 2 - Concept of the Aggregation Infrastructure

The system architecture of the common SDI of the Cantons is thus based on decentralised storage at the data manager and centralised access, whereby decentralised use is of course also important. For efficient data exchange between the authorities, a backbone for data distribution is required in addition to maintain the consistency of the data models used and the exchange format INTERLIS. On the side of the AI, the incoming data in INTERLIS format (abbreviated with the common file extension "xtf" in the following figure) is stored in the structure corresponding to the data model. An aggregated INTERLIS can be produced for any section of this dataset. A canton can, for example, obtain the data of all neighbouring cantons in this way and use it in its environment. In addition, the data is kept in an optimized structure. On this basis, map services are produced on the one hand and the data is made available as vectors in the formats GeoPackage, ESRI Shape and Web Feature Service on the other (see Figure 3 below).
The AI ensures that only data with sufficient data quality is transferred into the homogeneous structure. Organizational mechanisms also ensure that the data in the central infrastructure are always kept up-to-date.

As soon as the data of a basic geodata set have been processed by the Cantons, the AI can be set up as a central data set within a short time due to the technically uniform regulations. The established understanding of DPS, data modelling and model-based data exchange in the INTERLIS format are a key success factor. Through hierarchical data modelling with inheritance, both the specific needs of a Canton and the national requirements for the data set can be met with a single database. The ability to very easily check the logical and content quality of a data set in INTERLIS format is another important aspect for providing decentralised data in a homogeneous form via a central gateway.

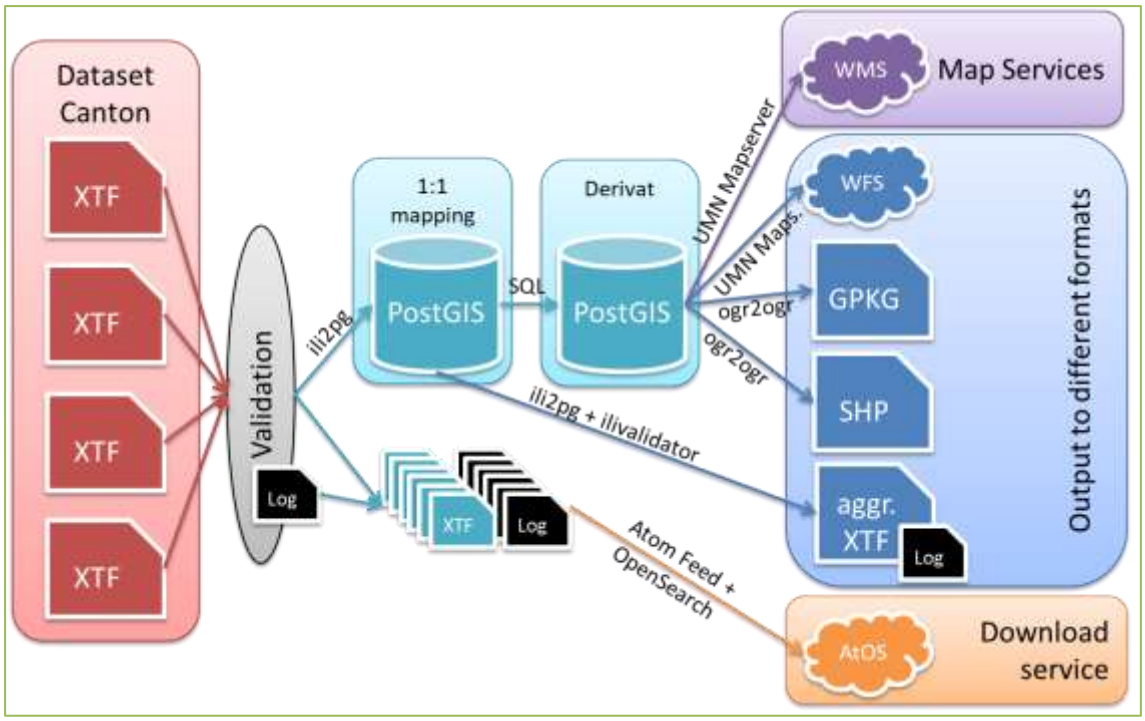

Figure 3 - Data flow in the Aggregation Infrastructure

All applications underlying the AI (as shown in Figure 3) are based on freely available OpenSource components. This applies not only to the more popular applications such as PostGIS or UMN Mapserver, but also to all components for processing INTERLIS files (ilivalidator, ili2pg) and for format conversion (ogr2ogr).

3.2.3 Open Government Data

Due to the importance of geodata for economic prosperity, many basic geodata are not subject to any access restrictions according to the Ordinance. In recent years, many organisations have begun to make their data available as Open Government Data (OGD). It is therefore obvious that publication under the OGD license should be aimed at.
Within the OGD initiatives, free and open access to Cadastral Data is always at the top of the wish list, which proves its relevance for Geodata in general and Cadastre in particular. To strengthen the role of AAA (Accurate, Authoritative and Assured) records, it is important to include this type of data (often cadastral) in this free-of-charge initiative. By using these data sets as a tax base, the legal basis for them is usually quite extensive. But most of the laws governing the use and charging of geodata were written in the analogue era and are neither appropriate to today's technical possibilities nor to the requirements of the OGD. The establishment and management of the spatial data infrastructure in the OGD era therefore required a change in the legal basis, irrespective of the requirement for a download service in the GeoIG.
Three major issues have to be fixed by legal ordinances (cf Lüthy et. al. 2017).

1. A service on a base level for spatial data must be accessible without costs. To strengthen the role of AAA-Datasets (Accurate, Authoritative and Assured) it is important to include this type of data (often cadastral data) in this cost-free-policy.
2. The data-owner has to declare his data free for reuse in a comprehensive way. This can be done by individual decision for each dataset or more efficiently with a legal based principle for free reuse for all public spatial data.
3. A legal concept is needed to handle the questions of limitations by personal rights.

The backbone of the OGD consists of a preparatory and an operational part. The preparatory measures are in principle the data harmonisation tasks required by the GeoIG. From a technical point of view, the publication of geodata as an OGD dataset can therefore be achieved in Switzerland for every geodata set without special effort. Through the intensified use of Cadastral data, the harmonisation of further geodata-related data sets, such as a housing register, was promoted. Thanks to the harmonisation of registers, the individually managed data sets can easily be combined with each other, thus ensuring a holistic view to promote smart governance.

The OGD portals are currently organised mainly on a cantonal basis. Access to the OGD data is usually via the metadata catalogue for all (geo-)data sets in a Canton. With the growing supply of data sets, the nationwide portal (https://opendata.swiss) should establish itself in future as the primary access point for all OGDs in Switzerland.

4 IMPLEMENTATION EXEMPLIFIED BY LAND USE PLANS

4.1 Historical Development

The way in which ground may be used is regulated in Switzerland by the instrument of Land Use Plans. They distinguish between construction, agriculture and protection zones. The Land Use Plans are established by the municipality. As the lowest federal level, they must take into account the regulations of the Cantonal Master Plans. The Master Plans are less detailed than the Land Use Plans and specify the general development objectives of regions. The Master Plans issued by the Canton must in turn comply with the Sectoral Plans issued by the Confederation.
In general, Land Use Plans consist of graphical specifications and regulations for use, expressed more simply in terms of a map and the building and zoning regulations. These include elements of both building law and planning law.
The four basic land uses are:

1) building zones,
2) agricultural zones,
3) protection zones and
4) additional zones.

The municipality responsible for Land Use Planning must in principle determine the permissible use of the land spatially inclusive and comprehensive. According to the Spatial Planning Act, basic land uses may overlap. For example, there may are also protection zones within the building zones. The superposition of Land Use Plans and land ownership defines

the allowed use per parcel. Due to the special importance of Land Use Planning for the development of the municipality, the Land Use Plans were prepared in digital form at the end of the 1990s. Since the sovereignty of the planning ultimately lies with the municipality, the data were structured and administered non-uniformly.

4.2 Model documentation

With the GeoIG coming into force, the conditions were in place to develop a data model and corresponding model documentation for the topic of Land Use Plans (see Giezendanner 2017). As the Land Use Plans belong the Rules, Right and Restriction (RRR) topics, it was also stipulated that the model must meet the higher requirements of the *Cadastre of Public-law Restrictions on landownership* (PLR-cadastre).
As a result of this special status, not only the geometric part of the Land Use Plans had to be described, but also the legal provisions. These are regulations, rules, etc. which are adopted together with the geodata in the same procedure. In the Land Use Plans, for example, there are building and zone regulations as well as regulations for special land use plans such as development regulations, structure plans, protection regulations, etc. The legal regulations are to be assigned to the respective geometric objects.
Another speciality of the classification as a PLR topic was the support of different states. According to the framework model for the PLR cadastre, the attribute *legal status* can assume the values "in force" or "ongoing change". According to the PLR Ordinance, the data for the PLR Cadastre must meet the following requirements:

a) They represent ownership restrictions that have been established and approved by the competent body in accordance with the procedure prescribed by the relevant legislation.
b) They are in force.
c) They have been reviewed for conformity with the decision under the responsibility of the competent body.

By periodically revising the Land Use Plans (alignment with the current development strategy), they must not only reflect the current status, but can also - in the sense of the preliminary information provided to the owners - represent the future development or the historical status (e.g. for traceability in the event of long-lasting legal disputes) by appropriate measures on the application side.

Due to the grown structures in the data sets on Land Use Plans, aspects such as standardisation of object structures (unbundling of main use and superimposed use), harmonisation of terms and, above all, the specifications for the portrayal model were of great importance in the PIC. Since the uses are geometrically defined by an administrative act, the subject of the feature capture rules was of secondary importance.
In the following figure, the federal model is depicted as a class diagram using the basic geodata set for Land Use Plans.

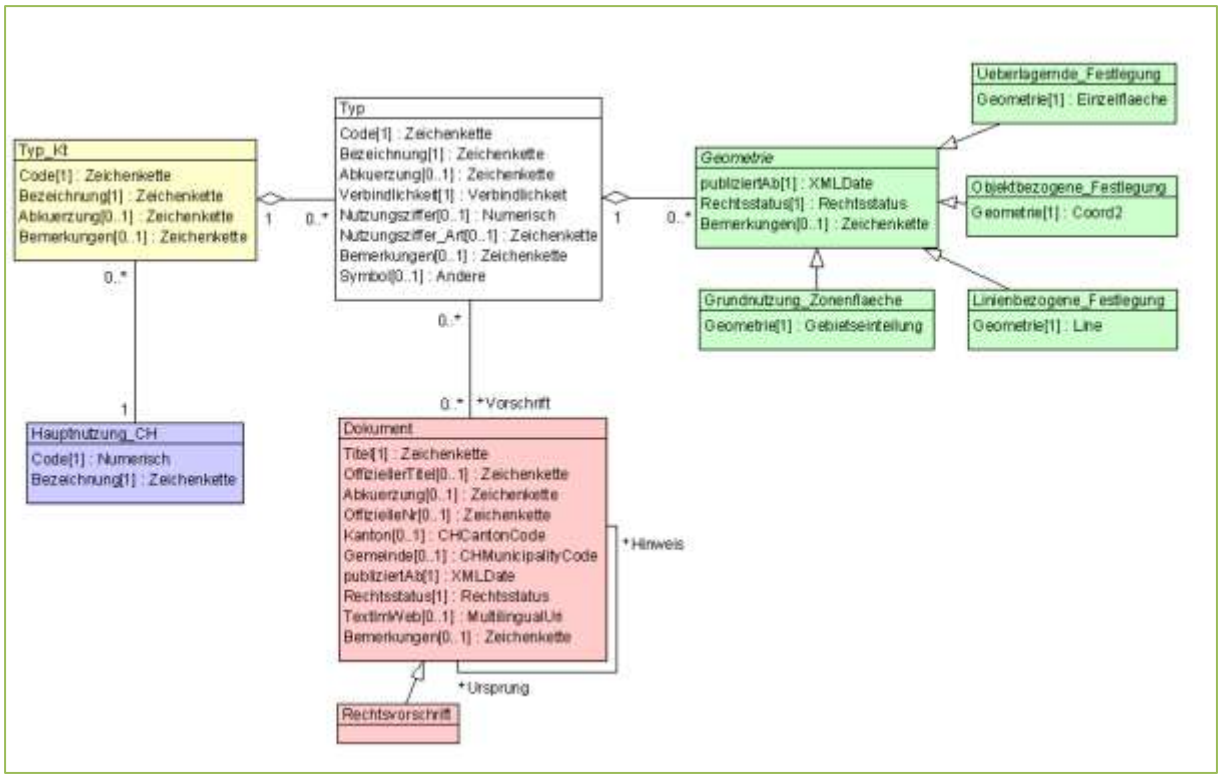

Figure 4 - Class Diagram Basic Geodata Set No. 73 Land Use Planning. In blue Class representing the structure given by the Federal level, in yellow the structure for Cantonal typification, in red the legal regulations and in green the geometric characteristics (both for municipal level).

4.3 Integration of the Land Use Plans in the PLR Cadastre

The concept of Cadastre 2014 as published by Kaufmann et al. (1998) has been adapted in the Swiss legislation with the GeoIG under the name of *Cadastre of Public-law Restrictions on landownership* (PLR-cadastre) which was put to force in 2007. The corresponding ordinance was put to force in October 2009 (cf. Kaufmann 2010). The Federal Office of Topography, swisstopo, proposed for the introduction of the PLR-cadastre only space related objects. For each Canton an organ accountable for the PLR-cadastre should be defined. This organ is responsible for the provision and operation of a Cantonal infrastructure. For the data transfer between the parties responsible for the maintenance of the individual data sets (being textual or spatial) a transfer model on the base of INTERLIS has been defined (see further Lüthy 2015).

The PLR register requires data from all three federal levels. This application is therefore a perfect example of how new applications can be realized through the harmonisation of the geodata required by GeoIG.
Right from the start, Land Use Plan was one of the most important topics in the PLR cadastre, since it prescribes the (maximum) possible use across the whole area. The work on the model documentation, the data cleansing and the infrastructure for the PLR cadastre was carried out in parallel, also because the practical application and the data model influenced each other.

The following figure shows a query from the PLR cadastre in the canton of Nidwalden. By selecting a parcel, a spatial intersection with all levels of the PLR cadastre is carried out. The topics concerned are listed as map legends with a link to the detailed legal provisions in the left part. In the map, the two-dimensional signatures show the basic uses mentioned above, the hatches represent superimposed use regulations.

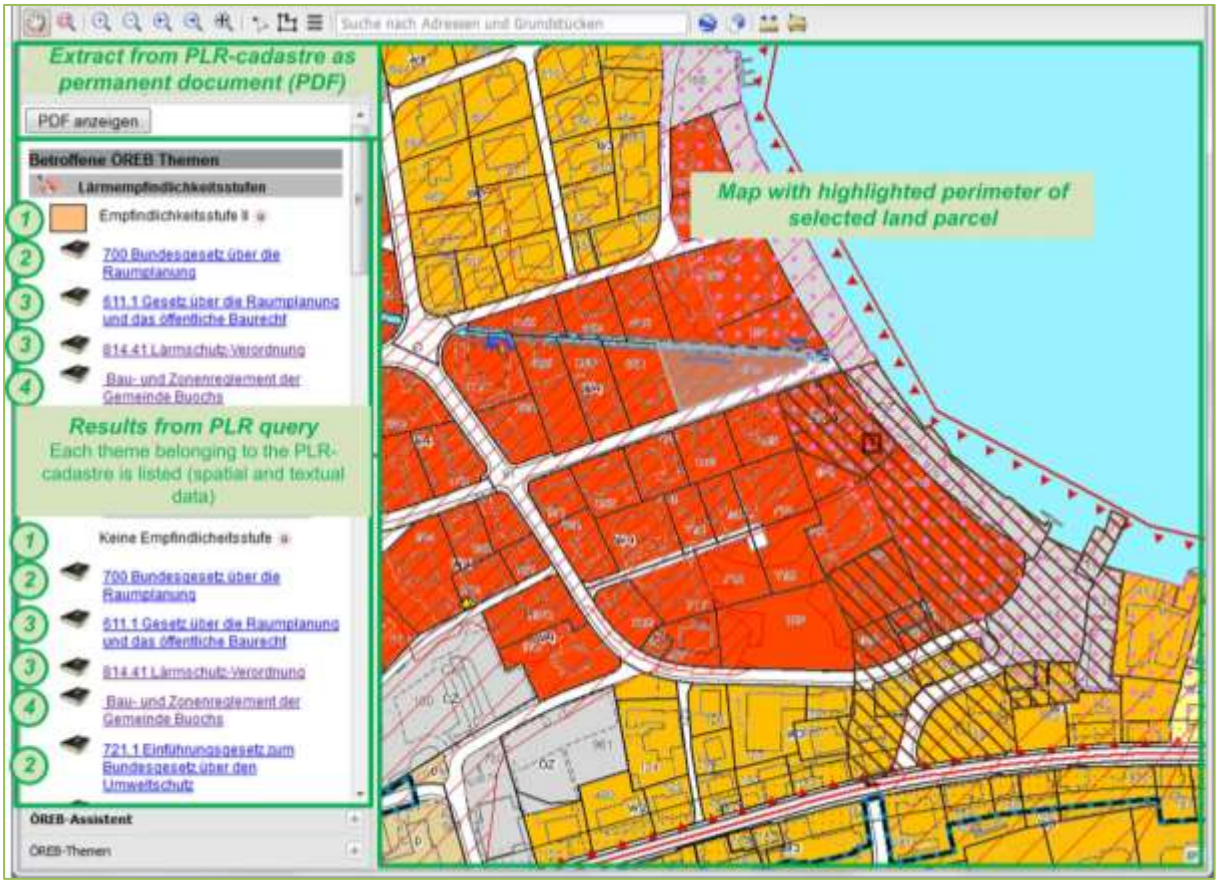

Figure 5 - Dynamic extract with spatial and textual results

Static PLR Cadastre extracts contain detailed information about the individual restrictions that apply to a given land parcel. All details are precise and correct. Since static extract serve as official documents they may be notarised if required.

The PLR Cadastre provides the population with an easy-to-use tool for viewing and querying public restrictions. This makes government decisions transparent and comprehensible. The principles for technical harmonization prescribed by the GeoIG are an essential aid for implementation.

5 CONCLUSION

In many areas of public administration in Switzerland, supervision and enforcement are not at the same administrative level. By simply exchanging data with the enforcement authorities,

the supervisory authorities can focus their activities on the actual task, i.e. the assessment of the content of the implementation of a legal requirement, rather than on the collection and harmonisation of data. The efficiency and effectiveness of the administrative tasks have been significantly improved thanks to the GeoIG. The citizens benefit from the GeoIG not only indirectly through well-organised administration, but also directly through easy access to a comprehensive spatial data infrastructure.

Different uses of geodata in apps on smartphones would not be possible without the fundaments elaborated for the digitalization of the Survey Cadastre. It paved the way for the harmonisation of several hundred data sets which facilitated the implementation of the national SDI. The developments over the last 10 years proofed that the (technical) scope of the legislation and the corresponding ordinances have been done in a sufficient level of detail. Only those requirements have been defined that have proven to be necessary in practice. This also seems to have resulted in an optimal cost-benefit ratio.

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BIOGRAPHICAL NOTES

Jürg H. Lüthy is member of the Management Board at Acht Grad Ost AG, one of the largest geomatics companies in Switzerland. He obtained a master's degree in 1996 from Federal Institute of Technology Zurich (Switzerland) in Rural Engineering and Survey. From the same institution he holds a PhD (2007). He has many years of experience in spatial data management, transition from paper maps to data centric systems and the operation of Spatial Data Infrastructures. His current focus lies in the provision of holistic information using modern web-technologies like designing information management platforms or building the technical infrastructure for Cadastre of Public-law Restrictions on landownership. He is the Swiss delegate to FIG Commission 3. Since 2016 he is president of SLM Swiss Landmanagement Foundation.

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