

The collaborative approach between the Federal Statistical Office and the Federal Office of Topography for maintaining a geocoded building and dwelling register used as a base for the production of geostatistical data

Romain Douard and Rainer Humbel¹

¹ Federal Statistical Office, 2010 Neuchâtel, Switzerland,
romain.douard@bfs.admin.ch, rainer.humbel@bfs.admin.ch

Abstract. The population census of 1990 was the first fully geocoded census in Switzerland. Since 2000, the geocoding process has been regularly improved and allows the geocoding of many statistics. During the last years, an ever closer cooperation was established between the Federal Statistical Office (FSO) and the Federal Office of Topography (swisstopo), fostered by the federal law of geoinformation which provides optimal legal conditions. This cooperation is an important basis for a reliable and sustainable implementation of our national statistical geospatial framework.

The approach is mainly based on a standardized update of the register of buildings and dwellings (RBD) in a close collaboration with the land surveyors. The local construction authorities notify the RBD of all building projects, using a standardized data exchange procedure. New buildings are announced with basic location data, such as address, approximate coordinates and land plot number as well as descriptive data such as number of floors, type of heating, number of dwellings, rooms, etc. During the registration process, the system provides a unique identification number to each building, each address and each dwelling. After that, these the building information number is communicated to the local surveyors. After completion of the cadastral survey process, its results are communicated to swisstopo, using a standardized interface. Finally, by accessing cadastral data the FSO can retrieve all necessary information for updating and validating the RBD data. It is then possible to publish an official list of addresses, including building and address identification number as a part of the national geodata infrastructure, on a free access basis. These identification number will be integrated in administrative and statistical datasets. Every dataset containing a building identification number can be geocoded easily during the statistic production process.

Keywords. Register of buildings and dwellings, geocoded address, statistic, cadastral survey

1 Introduction

The first georeferencing of population census began in 1970 as a research program at the Institute for Local, Regional and National Planning at the ETH Zürich. The production of geo-referenced statistics independent of the traditionally used administrative boundaries was decided in order to create a database for regional planning purposes. The population censuses from 1970 and 1980 were geocoded with the help of the local administrative authorities on a voluntary basis (Hase, 1970). As a result, the

georeferenced data from this two censuses cover only some regions of the country. In 1987, the federal government decided to start a national project for the georeferencing of the population census 1990.

In 1992, the parliament accepted the federal statistics law. According to this law, it was decided to regularly collect geocoded information on persons, households, buildings and enterprises. In order to avoid to collect every ten years all the informations on buildings by distributing questionnaires to every building owner and to all the property management agencies, it was decided in 1998 by the parliament to create a register of buildings and dwellings. The Federal Statistical Office (FSO) proceeded to create such a register of buildings and dwellings (RBD), based on the data collected during the census of 2000. It was also decided to allocate a federal building identification number (EGID) and to record coordinates for all buildings. This was done using cadastral data, and for those buildings which couldn't be located by the FSO, with the help of local authorities who identified them on paper maps. In order to keep the information up to date, a Web application was designed and launched, requiring the municipal construction authorities to report all buildings and/or dwellings which are built, converted or demolished. This Web application was also designed to collect the data for construction statistics, in order to discharge the local authorities from redundant statistical surveys. During the next decade, the FSO prepared the basis for the first register-based census, which took place in 2010.

In order to ensure the accuracy and reliability of the RBD's coordinates, a collaboration was established early with the Federal Office of Topography (swisstopo) which is in charge of the supervision of cadastral surveying. The registration in the cadastral data of the EGID for each building registered in the RBD was the first accomplishment of this collaboration. This could be intensified in the last years, and a revised federal regulation for the RBD has been adopted on the 1. July 2017, providing a legal basis to this collaboration.

2 The register of building and dwelling (RBD)

2.1 Legal underpinnings

According to the Swiss Constitution, federal authorities may issue regulations with regard to the harmonization and management of official registers with a view to minimizing the work needed for obtaining statistical information.

The Federal Statistics Act of 1992 fix the principle of the maintenance of the RBD by the FSO:

“The Federal Office cooperates closely with the cantons in the maintenance of a Federal Register of Buildings and Dwellings (RBD). Access to the Register for statistical, research and planning purposes and to fulfil statutory obligations is open to

the Confederation, and to each canton and commune in respect of the data pertaining to its territory. The Federal Council shall regulate the management of the Register and decree more detailed provisions on data protection. Insofar as no personal data is involved, the Federal Council may make the data in the register accessible to the public.”

2.2 Content of the RBD

The RBD contains all construction projects, all buildings with residential use in Switzerland, their address and their dwellings. Buildings without residential use may be registered on a voluntary basis. Based on the recently enforced legislation, this will become mandatory until 2020.

Every construction project, building, building address and dwelling is associated with a unique identification number. Further stable basic data, such as the age, the dimension, the energy supply, etc. provide an up-to-date view of the building and dwelling stock of Switzerland. Data on residents, property status, the level of rents and similar are, however, not contained in the RBD.

2.3 Organisation and update of the RBD

The Federal Statistical Office (FSO) manages the RBD in close collaboration with the specialised services of the Confederation, cantons and communes.

2.3.1 Role of the confederation

The FSO publishes the catalogue of attributes, which provides an overview of the structure, the definitions and the contents of the register. Entities and nomenclatures used in the Register as well as the individual attributes, including quality requirements, are explained in the catalogue. Any change to this document may only be made after consultation with the partners and the cantons.

The FSO may also publish recommendations and guidelines regarding the RBD. The FSO is in charge of maintaining the database and the application for collecting, managing and distributing data. Another task of the FSO is to monitor the continuous updating of the register and, in collaboration with the canton, to send reminder to the communes.

The management of the RBD may be delegated to cantonal authorities. Six cantons maintain their own registers and communicate at least monthly the changes to the FSO, using automated procedures.

2.3.2 Role of the cantons

The cantons may access the data of the RBD and use them for administrative, research and planning purposes. The cantons are consulted for all major change in the management of RBD. Cantons who maintain their own register must also plan, finance and manage the necessary infrastructure.

A so called “coordination service” is designated by each canton to serve as direct partner to the FSO and to act as a contact point between the confederation and the communes.

2.3.3 Role of the communes

The construction services of the communes must report every construction project requiring a building permit to the FSO (new constructions, transformations, demolitions) via the internet and a defined interface or via web services. The data survey takes place in coordination with the FSO’s construction statistics, and can be done continuously, but at least once every three months. This survey at the communal level is supervised by the coordination service of the canton.

3 The Cadastral Surveying

3.1 Legal underpinnings

The Federal Land Registry was established in 1912 with the introduction of the Swiss Civil Code. Cadastral surveying, an integral part of land registration, became a federal responsibility.

The National Land Survey is the responsibility of the confederation, according to the Article 75a in the federal constitution. The confederation shall issue regulations on official surveying and may issue regulations on the harmonization of official information relating to the land.

On the basis of this Article, the parliament passed the Federal Act on Geographic Information (GeoIG) in 2007. This act is the fundament for collecting, managing, archiving and distribute geodata. Article 10 defines the principle of dissemination of the geodata: *“Official geodata under federal legislation shall be accessible to the public and may be used by anyone, unless this is contrary to overriding public or private interests.”* Therefore, geodata are generally accessible to a wide audience and some basic data are published under OGD license.

The Act also explicitly obliges authorities to grant each other direct access to official geodata.

3.2 Organization

As described in the publication of the Federal Office of Topography (swisstopo) (Cadastral surveying in Switzerland, 2008), the cadastral surveying in Switzerland is an example for public private partnership and for close cooperation between all administrative levels (confederation, cantons and communes). The duties and task of each organization are described below.

3.2.1 Confederation

The Geodesy and Federal Directorate of Cadastral Surveying, a division of swiss-topo, is responsible for the strategic leadership in cadastral surveying.

This government agency defines, in consultation with the cantons, the national strategy for the implementation, renewal and further development of cadastral surveying and defines the quality requirements. The Federal Directorate of Cadastral Surveying checks the accuracy of the work delivered by the cantons and decides on the distribution of funding. The annual federal budget dedicated to cadastral surveying thus provides a major contribution to the legal safeguard of land ownership.

3.2.2 Cantons

The cantons are responsible for the operational management of cadastral surveying. They define the cantonal implementation programme, plan and direct the activities and lay down specific cantonal standards. They check the cadastral surveying carried out by contracted private land surveyors and approve the work after correcting deficiencies. With this approval the cadastral surveys become official public documents. Cantonal cadastral surveying agencies exist in 20 cantons while six cantons have turned over their operational management responsibilities back to the Geodesy and Federal Directorate of Cadastral Surveying itself.

3.2.3 Municipalities

Some of the larger cities have their own land surveying offices, which are responsible for cadastral surveying within their area of local authority.

3.2.4 Licensed land surveyors

Since the data from cadastral surveying is legally binding, only licensed land surveyors may carry out the surveys. There are some 190 private sector surveying offices across Switzerland, with around 2800 staff involved in the measurement, updating and management of cadastral surveying data. Each of them is supervised by a licensed surveyor.

3.3 Structure of the data

Cadastral data are available in a standardized format (INTERLIS). The data model is defined at Federal level and is structured in 11 thematic layers. Buildings are recorded in the land cover layer while land parcels are recorded in a dedicated layer. Another layer is dedicated to the building addresses and is used to record information on road names, house numbers, postal codes and locality names.

3.4 Updating of the data

All changes to ownership and changes to land cover due to human activities like construction of roads and buildings must be notified to the authority in charge of the

cadastral surveying. After the measurement is achieved by the land surveyor – this must be done within 6 months after notification, the data are updated. In order to detect changes that happened without direct human intervention, some periodic updates are carried out in regular interval under the supervision of the cantonal cadastral surveying agencies.

4 eGovernment and standardization in Switzerland

4.1 The eGovernment strategy

In order to promote e-government in Switzerland, the Federal Council adopted in 2007 the first eGovernment strategy (eGovernment Switzerland, eGovernment Switzerland: Strategic plan for 2017 to 2019, 2017). Its implementation is pursued together by the confederation, the cantons and the communes with four strategic aims (eGovernment Switzerland, eGovernment Strategy Switzerland, 2017)

- 1. Service orientation: electronic government services are easy to use, transparent and secure.*
- 2. Usefulness and effectiveness: eGovernment creates an added value for the general public, businesses and the authorities, and reduces the work of all those involved in processing official business.*
- 3. Innovation and promotion of the Swiss economy: eGovernment exploits innovations and thereby promotes Switzerland as a business location and as a place to live.*
- 4. Sustainability: multiple usage of solutions will be promoted. The confederation and the cantons ensure the sustainability of e-government services by setting requirements in terms of organisation, financing and operation.*

4.2 eCH Association

The eCH Association is one of the main organisations involved in the eGovernment strategy. The association is a public-private platform, whose objective is to facilitate cooperation through electronic transactions between government organizations and business units and citizens. The eCH association assumes the responsibility for the definition and development of standards. The association relies on expert groups working on a non-profit basis, composed from members from both the public and the private sector.

4.3 eCH standards

Today, more than 100 standards are published. The approved standards and best practices are publicly accessible and free of charge. The standards can be declared to be binding by public authorities.

One of the expert groups is dealing with standards regarding the exchange of data related to real estate information's. Experts from cadastral surveying, land registry, statistics, insurance and IT work together for the design of standards for exchanging data on real estate transactions, surveying, construction projects, buildings and building addresses.

5 Collaborative process to maintain a geocoded register of building and dwelling

The RBD maintained by the FSO records basic information on the structure for each building. The addresses are also stored in the RBD. The cadastral surveying maintained by the cantons documents their geometry. Combining these information sources can provide the basis for an integrated building information system.

5.1 The basics

In order to let all involved people work together, it's necessary to use a common semantic, which was established on a stepwise mode during the last 20 years. Today, the collaboration can benefit from many common foundations:

- Common definitions' on building, dwelling and addresses have been defined;
- Unique identifiers have been introduced for every objects (parcels, construction projects, buildings, dwellings, addresses, streets);
- The responsibilities of each of the actors are defined;
- Common nomenclatures are in use;
- Instruction for addressing buildings has been published;
- Instruction for registering and managing information in a common way in both systems have been published.

5.2 The main process

Every construction project (new construction, transformation, demolition) must be approved by the construction authorities of the municipalities. The land owner (or the architect) has to fill in a construction application. It can be a "traditional" paper form, or in some cantons, the application can be fulfilled in a digital form.

At the time of issuing a permit, the construction authority must notify the local surveyor as well as the RBD about the project, its buildings, dwellings and addresses. That happens using the interactive application provided by the FSO, or using Web services programmed according to eCH standards. Approximate coordinates will also be indicated, using an interactive map service. During the registration process, each object is assigned a unique identification number. The numbers, as well as other public attributes are immediately available to all authorized users.

The FSO manages also a Web service, which can be used by local surveyors to be informed about projected buildings and about building identification numbers. At regular intervals, updated cadastral data are transmitted in a standardized form from the local surveyor to the responsible cantonal authority, and finally compiled at swisstopo. The FSO can retrieve the geometric information needed to update the building and address coordinates in the RBD from that database.

As long as the buildings are planned or under construction, the coordinates have provisional status. The completion of the construction works is notified by the commune to the FSO. The surveyors can then carry out the survey work and update the cadastral database. The RBD will afterwards be updated and the definitive information on building and address are tagged with the status “approved”.

5.3 Dissemination of address data

Swisstopo, in charge of the management of the federal geoportal, can access the RBD and extract address information which will be made available to the public, on a free access basis. Published information includes for each building the address and the building identification number, the building address, the coordinates of the address and the name and the official number of the commune. Addresses can also be retrieved using web services (REST). A further development will also include the possibility to retrieve street information using similar services.

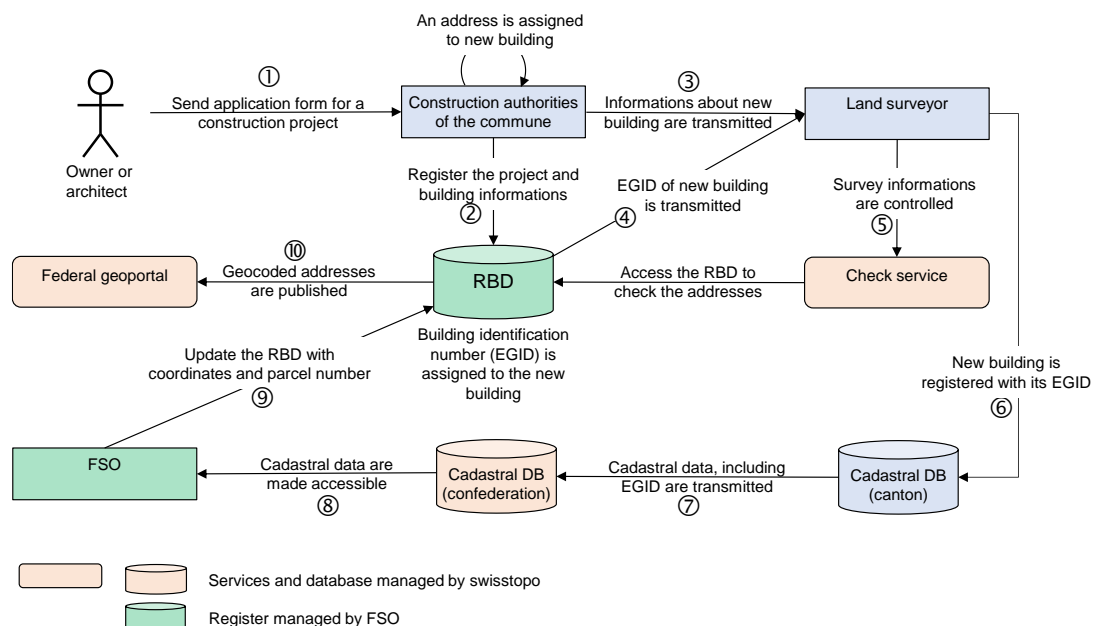


Fig. 1 Maintenance of the geocoded register of building and dwelling

Published address information are binding for public authorities. The retrieval and use of geocoded addresses is free of charge, in order to promote the use of official and conform addresses by everybody for all activities requiring the identification and/or the localisation of a building.

5.4 Quality management

5.4.1 The quality management of the cadastral surveying

In order to guarantee the quality of the data, surveying specialists are well educated and can only work under the supervision of a licensed surveyor. The work done by private contractors will always be checked by the cantonal survey authorities.

In order to simplify the quality management survey, swisstopo maintains a so called “check service”, which allows an automatic control of survey data which has to be submitted in a standardized form. The check service first verifies the form of the data regarding the data model. In a next step, data geometry and attributes are checked. More than 400 rules have been defined in order to check the topology, the accuracy, the cardinality, the integrity of the keys, etc.

Only controlled data can be approved by the cadastral authorities and published.

Possible errors in published data will be communicated to the cadastral authorities, who demand the necessary corrections.

5.4.2 The quality management of the RBD

The RBD is managed centrally at the FSO. Quality can be checked and monitored centrally. Hundreds of quality rules are implemented in the Web application of the RBD.

Errors and warnings are categorized in 4 classes. The first class groups all errors affecting identification attributes, like identification numbers or buildings addresses. The second category comprise errors affecting the attributes needed for the production of short-term statistics. The third category includes errors affecting the attributes needed for the production of structural statistics. Other errors or warnings are grouped in the last category.

For users using the Web GUI form, errors are reported in real time. For users working with web services, error reports will be transmitted using a dedicated service. For cantons maintaining their own register, a special interface allows the transmission of cantonal data to the FSO. After each data delivery, a receipt is returned to the canton, accompanied by a quality report.

Municipalities must fix all errors affecting data of her territory at quarterly. Only municipalities have write permission on the data of the RBD, except for coordinates and parcel number, which are centrally updated by the FSO based on cadastral survey data.

5.4.3 Quality management of the whole system

The collaboration between cadastral survey and RBD implies new rules in order to ensure the quality of the whole system.

Write permission policies have been defined in order to avoid inopportune data updating. Municipal construction authorities are in charge of registering and maintaining business data on construction projects, building and dwellings. Surveying authorities are in charge of cadastral data and therefore of building and address coordinates.

Because coordinates are not exactly surveyed for projected objects, the municipal construction authorities get write permission for coordinates, as long as they are missing in cadastral data. Once the surveying for new buildings and / or addresses is completed, coordinates are updated in the RBD and write permission is disabled for all users. From this moment, coordinates from the RBD can only be updated through processes using surveying data. Parcel numbers registered in the RBD are updated in a similar way.

Address information is handled as a special case. According to the law, municipal authorities (or cantonal authorities in some cantons) have the authority for assigning addresses and surveying authorities are in charge of managing address data.

A special process has therefore be designed for registering and updating addresses. For new buildings, addresses are registered provisionally in the RBD by the municipal construction authority. This will be sent to the surveyor, which will check address data on a formal basis. If errors are detected (for example in the spelling of the name), the surveyor will report the mistake to the municipality. The address becomes the status “approved”, once it is definitely adopted from the authorities. If an address must be corrected, the same process is adopted.

Another challenge is to keep both systems up to date. In order to avoid discrepancies between survey and RBD data, the “check service” of the cadastral surveying as been completed with new rules. Survey data sent to the “check service” are compared with RBD data. Data are matched using the identification numbers, and the values from the attributes shared by both system are compared. Errors or warnings are reported. Correction will be made from the authority in charge of the attribute. Once the update is completed, the data will be sent again to the check service for a last control.

On a quarterly basis, the FSO map recent cadastral survey data with the RBD. On that basis, inconsistency are communicated to the Coordination services of the cantons, which are in charge to coordinate the correction of the data.

6 Benefits of the geocoded RBD

6.1 Benefits for the society

Basic information on buildings and especially on addresses plays an even more important role in many activities: postal delivery, emergency services, delivery of goods, tourism, delivery of services (water, telecomm), cartography, etc. It is an important component of the infrastructure of a digital society. The development of the technologies (GPS, smartphones) makes reliable and up-to-date addresses unavoidable.

Other building and dwelling information are used in many administrative processes, like the management of energy or water supply, tax collection, etc. This information are also used for planning, research and statistics.

6.2 Benefits for the state

The existence of an official register of buildings, dwellings and addresses reduces the amount of work for the administration. Data has to be updated only once and the risk to develop uncoordinated solutions is minimized. It also avoid repetitive data matching, data validation and data correction. Despite the fact that some administrative units must renounce to the income from the sale of address data, the cost reduction for all other administrative units makes the balance sheet positive (Jarchow-von Büren, 2016)

6.3 Benefits for the private sector

Since geocoded will be available at an open data policy basis, the entire economy will experience a reduced charge in matching and correcting addresses. Parcel and goods delivery can be optimized and organized faster and cheaper. Costs can be reduced thanks to more efficient routing. In the long term, the potential in all processes requiring georeferencing of objects like GIS analysis, geographic search, decision making considering spatial patterns and developments, etc. is very important.

7 The geocoded RBD as a central infrastructure for the production of geostatistical data

Since 2010, population and business censuses are register-based censuses. They use administrative and statistical registers.

7.1 The population register

The FSO does not maintain a statistical population register, but instead uses information from different population registers at the federal, cantonal and communal level.

In order to carry out a register-based survey, the cantonal and communal population registers, which are kept according to different rules in each canton, are standardized matching the harmonization guidelines published by the FSO according to the Register Harmonization Act.

One of the task imposed to the municipalities by that Act is to add to the basic residents' information both identification numbers of the building and of the dwelling in which the person is living.

The FSO maintains the sedex (**secure data exchange**) platform which is set up to allow designated authorities to send their residents' data safely and securely to the FSO. Transferred data are compliant with the eCH-standard "Delivery from resident data to the statistic". A validation service helps the FSO to check the data delivered and gives feedback to the residents' registration offices on any improbabilities (warnings) and errors in the data they sent.

Validated data are saved in the SFO database and used as basis for the population census.

7.2 The Business and Enterprise Register (BER)

The Federal Statistical Office maintains also a Business and Enterprise Register (BER), which contains all businesses, enterprises and firms, including public sector enterprises, that have their registered office in Switzerland. The computerised database is updated continuously using information collected through surveys or already existing in other administrative registers.

Addresses registered in the BER are continuously mapped to those of the RBD and building identification number are added to each record from the BER. Most of the addresses match automatically, but about 20% need human supervision. Due to bad addresses about 1% of the enterprises can't be mapped with the RBD. These percentages should be reduced in the near future thanks to the increased use of standardized addresses.

The BER is used for statistical purposes, research and planning, as well as to respond to specific enquiries from the confederation.

7.3 The geocoding process of population and business statistical data

The FSO introduced in 2010 the new register-based population statistics and the building and dwelling statistics. The register-based structural business statistics took place for the first time in 2012.

For those statistics, the production process begin with the extraction of a snapshot of register data. The day of reference is always the 31 of December.

During the statistical production process, the building identification number is kept in all datasets. Once the data are consolidated, it is possible to proceed to the geocoding of the statistical data.

Using the building identification number, coordinates are extracted from the RBD and attributed to the individual data in each dataset.

For individual data with missing building identification number, the address of the person or of the business is extracted. Using the address information, the record will be approximatively geocoded, using a 3-step process.

The first step consists in a mapping between the street name of the record and the street names registered within the RBD. If a matching is possible, and if at least one address is already geocoded in the RBD, the coordinate corresponding to the closest address to the median coordinate of all the addresses of the street is attributed to the record.

For those records who can't be geocoded during the first step, a mapping is made between the ZIP code of the record and the ZIP codes from the RBD. A coordinate corresponding to the coordinate of the closest address to the median coordinate of all the addresses with the same ZIP code is attributed to the record.

During the last step, a coordinate corresponding to the centre of activity of the commune is attributed to the last individual records without coordinates.

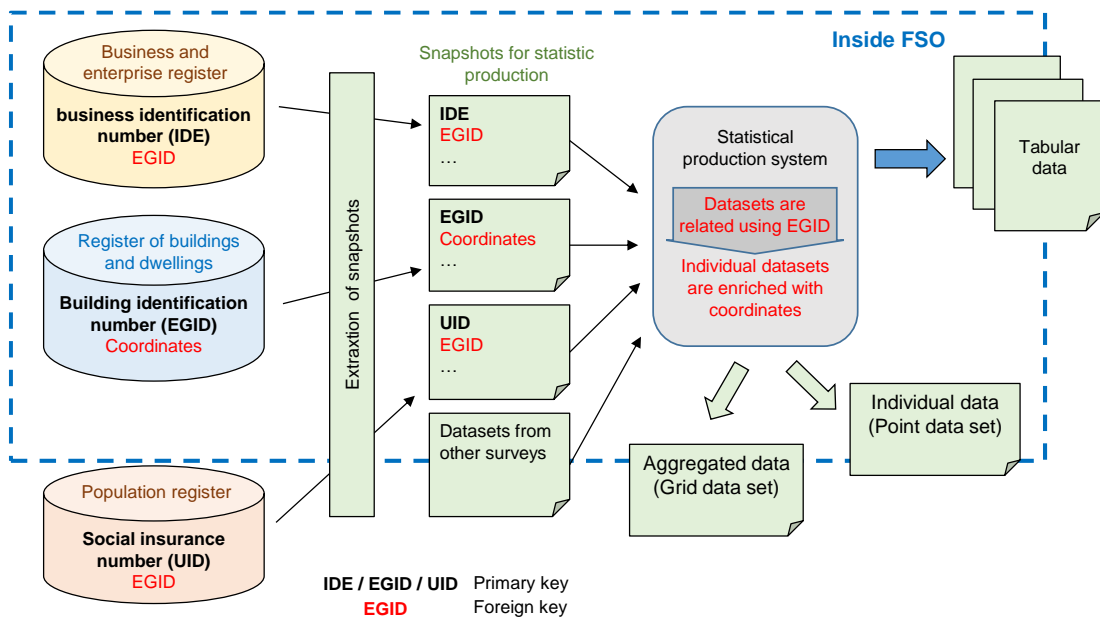


Fig. 2 Process chart of geocoding statistical data

7.4 Aggregation and dissemination

Geocoded individual data are finally aggregated on a 100m grid basis. In order to guarantee the confidentiality of the data, attributes values between 1 and 3 are rounded to 3. About 700 attributes from the censuses of population, of business and of buildings and dwelling are published annually.

The most basic attributes (population count, number of working places and employed persons) are published on the Swiss geoportal as a 100m grid and can be visualised

on a freely. The full datasets can be downloaded as CSV-formatted text files. The most frequently used attributes can be downloaded free of charge, while more specific detailed information is only available for customers who purchase an annual geo-data subscription.

8 Conclusions and outlook

This close collaboration between many organizations is the result of more than 10 years of work with a common goal. This is the result of many small successes. It opens the door on new horizon. For statistics, it is today possible to geocode many different datasets. The only crucial technical condition is to ensure that at least one key of the dataset can be related to the federal RBD. A building, a person or a business identification number can serve as a key allowing to efficiently enrich statistical results with coordinates.

Geocoded datasets can enhance statistical analysis by the spatial, geographic component. The FSO has already developed new products based on geocoded data, like a matrix of commuter flows used in the delimitation of agglomerations. Another product called “Services to the population” is published periodically. Here, the accessibility of services such as food market, post office or drugstore are analysed based on the travelling time required from each hectare grid cell to the next service of the tested type. A new project is the development of a residential property price index, which uses geocoded statistical data integrated into a hedonic model (Brand, Becker Vermeulen, Fischbach, & Carpy, 2017) to estimate the influence of geographic location influences such as neighbourhood, landscape, view, slope etc. on property prices.

The potential use of high qualitative geocoded data is huge, but also requires close cooperation between highly skilled workers from different organizations. It also necessitates well designed processes and the use of a common language, calling again for standardization and coordination.

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