Cadastral mapping for underground networks: A preliminary analysis of user needs

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Abstract. In order to support the establishment of strong and well-verified land rights system, this paper proposes a preliminary analysis of spatial representation (2D and 3D) to visualise underground legal object like communication cables. Official land register system currently lack using cadastral mapping when legal objects are underground. Based on meetings with the end-users and three use cases scenarios, the study proposes various geometric and descriptive contents that may be applied to the cadastral map of underground communication cable. Nine cadastral maps are prebuilt and discussed with the end-users. The paper presents synthesis of those discussions and the final selection made in this prospective project.

Keywords: Urban Cadastre mapping, underground legal object, user requirements,

1. Introduction

Real estate transactions, consisting of the transfer of a unit of property between two or more parties, are common processes, crucial for a healthy economy in land and property markets. For example, in 2011 more than 247,900 real estate transactions were recorded in the Registre Foncier du Québec (Land Register) for an economic value of approximatively C$80 billion (Foncier Quebec, 2011). In Quebec, notaries are required to authorize real estate transactions by providing their professional opinion about the Rights, Responsibilities and Restrictions (RRR) that may affect legal objects. If they express an incorrect judgment, the impact may be critical for the owner (e.g. mortgage denied, ownership right disregarded). To support this process, notaries can usually count on cadastral plans, i.e., 2D maps of the land parcel (except for stratified ownership, or condominium, for which a vertical profile is provided). Surprisingly, when legal objects are underground, e.g., utility networks or communication cables, no cadastral representation (even in 2D) or other data on land parcel restrictions are available to support the decision making process. Yet, real estate transactions of underground object represent millions of dollars of investment and thus it is crucial to secure such transactions.

The central question addressed in this paper is what should be the content of spatial representation of legal underground objects (could be 2D map, 2D profile, or 3D model) for persons in charge of verifying real estate registrations and transactions related to them. The Quebec land administration system is selected as case study but the results presented in this paper do not refer to official report of government authority. To limit the study, only communication networks are investigated and the targeted end-users are notaries, working for government authorities.

The paper is organised as follow. Section 1 presents the methodology used to investigate the current practices of the selected end-users and as a result, three use-cases considered for spatial data representation of the underground legal object. The section 2 explains the potential content of the spatial representation and the selection made by the authority for communication cables. The section 3 concludes and summarizes the discussions made with the end-users.

2. Land Register and the registration of underground communication network

2.1. Quebec Land Administration system

In the province of Quebec, Canada, the real estates are registered into the Quebec Land Register. Foncier Québec, under the authority of the *gouvernement du Québec*, maintains the land registration infrastructure. We can distinguish in articles 2972.1 and 2972.2 of the Quebec Civil Code two mechanisms for registering real estate. The first category is related to immatriculated legal objects, like land parcels. They are stored in the Land Register through an index of immovable containing one land file and cadastral plan is mandatory. The cadastral plan, as shown in Figure 1, is a 2D map with the limits and the size of the lot (the parcel) where each property has its own unique lot number and official measurements (length, perimeter and area).

The second category of real estate is not immatriculated legal objects, like State resources and private distribution networks. Those legal objects are stored in registers complementary to the Land Register (called FITNO) where one land file is opened under a serial number, and no cadastral survey is available. This situation is not unique to Quebec (Döner and Biyik, 2013). For underground communication networks, the required information in the registration process is the name of the network holder and the name of the regional administration. A sequential number is also added for recording in the land file. The official title, that refers to ownership of the property, linked to the FITNO Land Register may also contain various textual data, including road names, address, description of the surrounding space, etc.

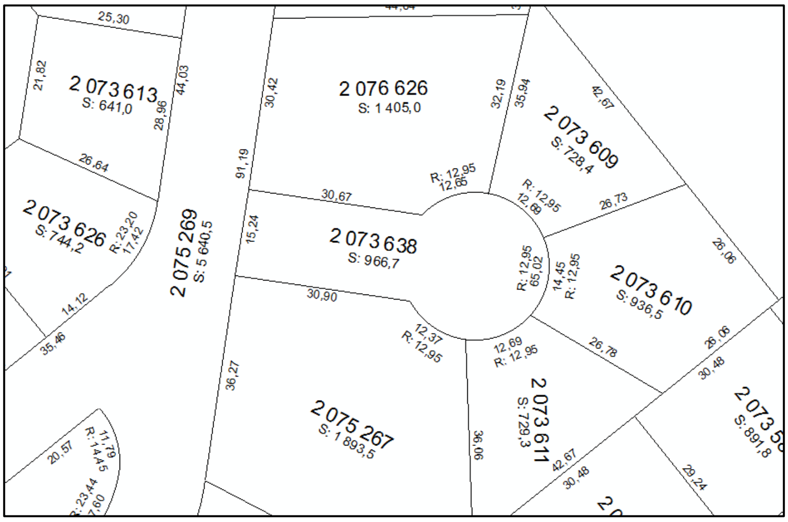


Figure 1. Example of Quebec cadastral map.

The distinction between the two categories of registration process is substantial and poses several limitations to the central importance of the Land Register. For instance, the localisation and the geometry of the second category of legal object (not immatriculated) is almost impossible to determine since no related information exists in the registration process, the spatial relationships with surroundings is approximate and difficult to certify by the authority. Furthermore finding a file referring to a specific not immatriculated object in the Land Register is a complex operation since the serial number is not an official code and no spatial reference is recorded. This is why the study focused on the second category of legal object, where the issues of using spatial representation were questioning in order to improve and solve such limitations. The following picture shows the class diagram of the FITNO land register for communication cables (built by retro-engineering).

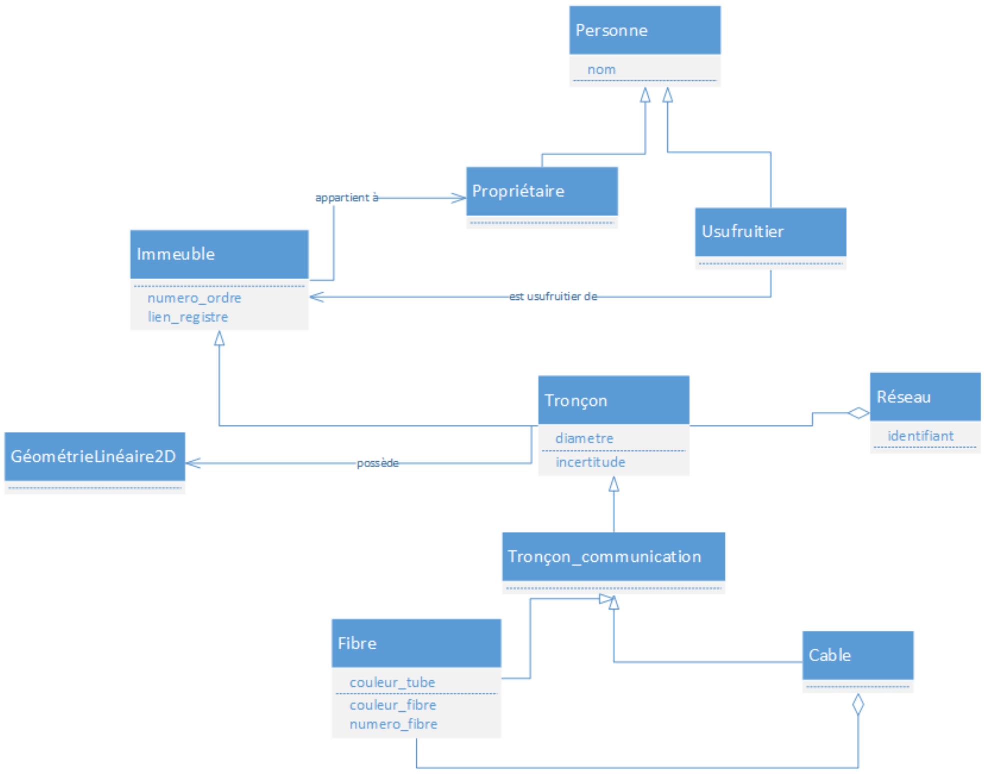


Figure 2. UML class diagram of the communication network contained in the FITNO land register (*in French*).

2.2. Use-cases for the Land Register

To better understand how users manipulate the Land Register for not immatriculated object, three use-cases were identified. Users are notary working for the government authority. To limit the investigation, only underground legal object more precisely communication network (cables) were examined. Here is the description of each use-case:

- Find: Consist at finding in the FITNO land register a specific underground legal object. The available information to trigger the searching action are either the sequential number, the registration division or the name of the owner. Figure 3 shows an example of the interface of the FITNO land register when we know the sequential number of the legal object.
- Locate: Consist at determining the exact localisation and/or the geometry of the underground legal object. The localisation may be expressed as geographic or cartographic coordinates or address. The geometry refers to the shape, the dimension, the perimeter.
- Comprehend: Consist at identifying the RRR (Rights, Responsibilities and Restrictions) that may affect the underground legal object. It also consists at determining the spatial relationship of the under-

ground legal object with its surrounding. Spatial relationships may refer to geometric relationships as distance or angle, or topological relationships like disjoint, overlap, equal, contains, inside.

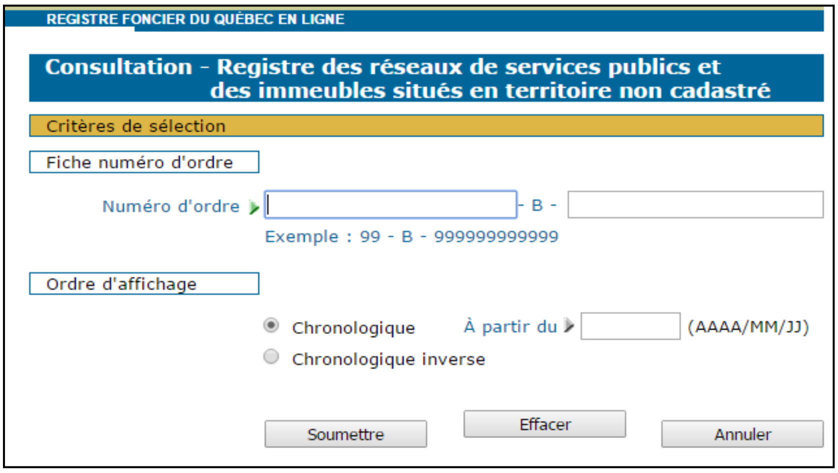


Figure 3. Example of the interface of the FITNO Quebec land register (*in French*)

3. Proposal of spatial representation

After having identified what kind of tasks users may require from the FITNO land register, the next step consists at determining the possible content of the spatial representation to be produced. To reveal the advantages of using spatial representation and in order to consolidate the discussion with the end-users, four analysis axes were proposed:

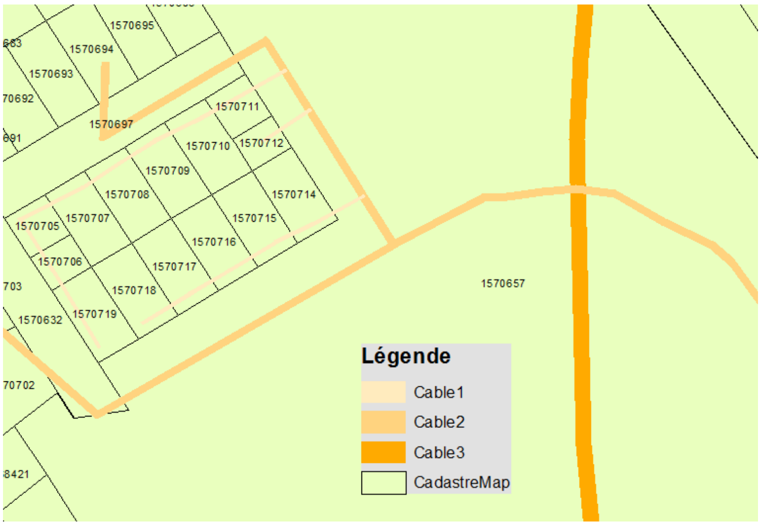
Axis 1 – Spatial characteristics of the data network: contain information about the relative or absolute coordinates, a unique identifier, descriptive data, uniform data structure.

Axis 2 – Data Network Reliability: contain information about existing geometric data or new collected data, internal or external to the current Land Register.

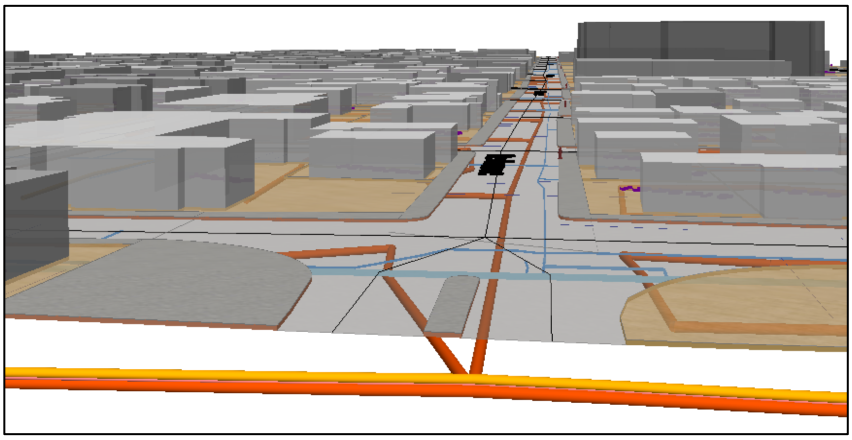
Axis 3 – Level of details for spatial representation: control the dimension of the representation space (2D or 3D), dimension of the objects (0D, 1D, 2D, 3D), annotation.

Axis 4 – Contextual data: express the requirement of having access to other kinds of spatial data like land parcel limits, orthophoto, topographic elements, administrative limits, point of interest, road network.

For each of the axes, the users have to specify its needs and interest of keeping or not the features. For demonstration purpose and based on this analysis framework, nine possible solutions were designed and presented to the end-users. For example, one scenario keeps the number of collected data as low as possible, one scenario matches the current Quebec vertical cadastre specifications, one scenario is a full 3D model. Figure 4 a and b show some of the proposed solutions.



a)



b)

Figure 4. Two possible scenarios for the content of the spatial representation of the communication cables (a=cable represented as 2D polygon with cadastral map, b= cable represented as 3D solid with 3D building and cadastral map).

The final solution selected by the end-users for this preliminary investigation is a 2D map with the X, Y absolute coordinates of the maximum extent of a linear (1D) geometric primitive of the network, including a unique identifier, the diameter of the communication cable, with contextual data that shows parcel and administrative limits, street name, and an orthophoto as background. Figure 5 shows an overview of the selected solution.

Figure 5. The spatial representation selected by the end-users.

This scenario stands as a good balance between existing and new acquisition of datasets. Here are brief explanations why this selection was preferred by the end-users.

Axis 1 – Spatial characteristics of the data network: The end-users want to facilitate the possible integration of the network data with external spatial datasets in using official coordinate system (reference system). The addition of a unique identifier was judged mandatory in order to easiness the retrieval of specific records and opens the linking with spatial database system. The only descriptive data foreseen as interesting for query request is the diameter of the communication cable. Combining the diameter of the communication cable and the 1D geometric primitive selected by the users will allow by extrusion the reconstruction of the 2D spatial extent of features.

Axis 2 – Data Network Reliability: As much as possible, the end-users want to take advantage of existing data of the FITNO land register (internal) and keep the control on the system. New spatial data that need collecting survey are position of the maximum extent of the communication cable, and the diameter.

Axis 3 – Level of details for spatial representation: The end-users want to keep the geometry of the object as simple as possible but clear enough to respond to the tasks. They selected having a communication cable represented by a line (1D) in a 2D space. No extra annotations are identified.

Axis 4– Contextual data: The end-users place a clear emphasis on having the geometry of the land parcel and the administrative limits, an orthophoto in background and the name of the streets (but not the geometry of the road network). Land parcels limits are foreseen require in order to respond to the use-case "comprehend". Furthermore, the official measurements of the current cadastre system are expected required. The administrative limits, the orthophoto and the road name will be used as localisation signpost.

4. Conclusion

This project may be seen as a first attempt to quantify user requirements for the spatial representation of underground legal objects. The selected scenario for representing the communication cable (2D space, 1D feature, 2 attributes) is quite simple to design and offers meaningful advantages. First it allows users to fully address the three use-cases (find, locate and comprehend). In the current version of the FITNO system, those operations are possible but limited since localisation and geometry of the legal object are incomplete and not accessible. Second, the selected scenario proposes the connectivity with the current cadastral system that allows having access of relevant information while keeping the independence and intern coherence of both systems. Web feature services would be achievable easily with such solution.

This preliminary experiment was limited to communication network and stands as prove of concepts. Other kinds of underground legal object (like mining properties, gas distribution) have to be investigated and outcomes may end with distinctive results. Nevertheless the four axes established for this analysis look valuable to extent the study to other kind of legal objects. Implementation constraints for the end-user context were not considered in this study and will have evidently to be assessed.

References

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