3D Cadastre: With or Without Subsurface Utility Network?

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SUMMARY

Within the global trend of designing and implementing 3D cadastre, this paper offers a discussion about the integration of subsurface utility networks in such land tenure systems. Three questions are addressed: Do we need to register underground objects? Should underground networks be registered in the Land Register, with the same specifications as land parcels? Which information should be part of the registration process? The case study of the Quebec jurisdiction is used to illustrate some aspects of the discussion. This paper attempts to help land administration authorities and stakeholders better assess the suitability of full 3D Cadastre.

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1. INTRODUCTION

To support establishment of a robust land tenure system, official authorities often propose systems to register land property units, and to manage and secure the transactions of a unit of property between two or more parties. As stated by Williamson et al (2008), and more recently by van Oosterom and Lemmen (2015), a land administration system acts primarily as a fundamental structure to support many functions such as registering land, publishing rights, securing tenure, taxing properties, and cadastral mapping and surveying. Land administration systems or, more precisely, cadastre systems, exist all over the world and while they currently provide quality and reliable services, many authors have proposed their enlargement to the third dimension (van Oosterom et al, 2001; 2011; 2012; 2014a).

Integrating the third dimension in a cadastre system may refer to several different definitions or concepts which, consequently, would have varying impacts on the system (Aien et al, 2011; Ho et al, 2013; Stoter, 2004). Managing the third dimension may refer to the legal aspects of the registration process (e.g., provide legal notification to indicate overlapping position of objects in space; co-ownership; right of superficies; easement; the concept of 3D property). Integrating the third dimension may also refer to the spatial representation (including modelling, visualization and management) of the boundary of the properties (e.g., having full 3D parcels, having 2D parcels with footprints of overlapping properties, having 2D parcels with tags of overlapping properties). Some people consider this second approach as a technical aspect of 3D cadastre.

It is important to first understand those aspects since this will directly impact the usability of the 3D cadastre system. For example, Paasch et al (2016) provided an informative discussion of the legal issues in describing real estate in 3D and the accompanying registration process. Additionally, many authors have explained that full 3D cadastre is not necessarily required, and 2D plans with tags are sometimes a suitable response for land administration purposes (Pouliot et al, 2011; Stoter and van Oosterom, 2007). In fact, in some ways, spatial object registration has always been 3D, since the reality is three-dimensional. But approaches—including documentation used to store the identity of the property and validate the Rights, Restrictions and Responsibilities (RRR) associated to it—vary from one country to another. And in the opinion of some (Pasch et al, 2016; Ploeger, 2011), registration is mainly 2D since the rights are documented in the horizontal plane and unrestricted vertically (e.g., easement), and thus the concept of 3D property does not exist yet.

Our paper will not address this interesting question of 3D property but if we take as hypothesis that many authorities foresee full 3D cadastre as a necessary next step for cadastre development, we can ask the question, "What should be the content and the practice regarding registration aspects of such a system?" More specifically, we examine the relevance of having underground objects like utility networks recorded or spatially represented (explicitly or

implicitly) in a 3D cadastre system. At first glance we may be tempted to answer that underground objects must be part of 3D cadastre system registration. Many authors argue in favour of having underground objects as part of 3D cadastre (Aydin 2008, Cervet, 2008; Ghawana et al, 2010; Hashim et al, 2010; Pouliot et al, 2015; Spirou-Sioula et al, 2013; Shojaei et al, 2013; Stoter 2004). Nevertheless, in our opinion, the answer is complex and several issues remain to be tackled. From registration and land management points of view, there is little doubt that the occurrence of underground networks needs to be recorded somewhere. Currently, we may say that utility networks are certainly recorded in systems managed by their owners. But do we have access to this information? How are such classes of object structured? Is their spatial representation normalized? Is their documentation adapted to the legal decision-making process (protect people and secure real estate RRR)?

2. CASE STUDY

To support our discussion and explain the context in which it takes place, we propose a short introduction to the cadastre and real estate registration rules in force in the jurisdiction of Quebec, a province of Canada. The land registration system is maintained by the *Government of Québec* in the legal framework of the *Civil code of Québec*. All real estate transactions are recorded in the Quebec Land Register (*Registre Foncier du Québec*). In the Quebec Land Register, cadastre plans are mandatory. Cadastre plans are 2D maps of the land parcel except for stratified ownership, or condominium, for which a vertical profile is provided.

To publish the rights of utility networks, the Quebec official authority has created a complementary database, "the Register of Public Service Networks", which mimics Land Register operations. Each network is thus registered on a file, recorded with a sequential number, the name of the network holder, the name of the regional administration, and various but non-mandatory textual data, including road names, address, description of the surrounding space, etc. However, this utility network register is not supported by a cadastral plan or any spatial representation. The establishment of a complementary register with no cadastral map poses limitations to the efficacy of a registration system that is supposed to protect rights.

3. CONSIDERATIONS OF UNDERGROUND NETWORK REGISTRATION

Three questions are addressed to enable discussion of the relevance of having underground utility networks registered in the 3D cadastre system. This discussion is a follow-up to Pouliot and Girard, 2016.

3.1 Do we need to register underground objects?

We may start answering this question by asking if we know of the existence of a system or systems that register underground objects. Or, more concretely, do we know if underground objects that cross our own property? This question may seem futile, but when it was asked in May at FIG Working Week 2016, only half of the audience answered yes. The same audience nevertheless responded positively on the importance of knowing the existence of underground objects. Mainly, to answer this question, people intuitively refer to a calling service prior to a

digging project, like Call Before Digging in Canada, Call 811 in USA, or Dial Before You Dig in Australia. Such services manage inquiries about digging projects in order to prevent damage to underground infrastructure and maintain safe excavation. The service usually consists of marking the approximate location of underground utility lines. Although very helpful and effective for excavation companies, such systems have no link with the Land Register, or protecting the rights of the land owner or other underground real estate holders. Obviously this is not its purpose, even if it often supports claims regarding damages. Having reviewed Quebec jurisprudence, we have noticed many reported incidents of damage to underground networks (Info-excavation, 2014). In Quebec, damage due to accidents to underground networks has been estimated at 95 million CAD. For instance, in 2014, damages were reported 1200 times (almost 4/day), 34% of which were due to a failure to request a location and 5% were from inadequate localization. The underground networks affected were 7% electricity, 39% gas, 48% telecoms, 6% others. These are all problems which make the registration of underground network valuable.

The prime role of land registration systems is to provide guaranteed ownership for the owners or, to be more precise, to help land lawyers suitably exercise their professional judgment about the state of title to a particular legal unit. The registration process thus supports the establishment and publication of RRR, helps protect the owner's right and secures real estate transactions. Underground networks such as communication cables are obviously part of this community of properties. Consequently, we do believe that underground utility networks should be recorded in a public register, mainly devoted to ownership management, and be accessible by those concerned (the owners, the public administration, the land lawyer, the notary, the land surveyor, etc.).

Currently in Quebec land administration, registration and specifications for the designation of underground networks are not mandatory. New federal Canadian legislation is under preparation which may be foreseen as a first step, although as yet it is devoted to safety enhancements and not necessarily the protection of ownership rights. See BILL S-233, an Act enacting the Underground Infrastructure Safety Enhancement Act:

> *"This enactment creates a federal underground infrastructure notification system. It does so by requiring owners or operators of any underground infrastructure that is federally regulated or that is located on federal land to register the underground infrastructure with a notification system and provide information on the underground infrastructure; requiring persons undertaking work that results in a ground disturbance on federal land to inform of that project the owners or operators of underground infrastructure located on federal land and that can be damaged by the ground disturbance; and requiring owners or operators of underground infrastructure to mark on the ground the location of the underground infrastructure following a locate request."* [1]

[1] http://www.parl.gc.ca/HousePublications/Publication.aspx?Language=E&Mode=1&DocId=8052280&File=4

3.2 Should underground networks be registered in the Land Register, with the same specifications as land parcels?

If underground networks are registered, the next questions are: in which system to record them, and who will manage this system? For instance, should underground networks be registered in the same Land Register as cadastre parcels? Depending on priorities, having underground networks registered in the same and unique Land Register would make the registration process easier, more coherent and consistent. Besides, it would be simpler for professionals and other users to use the system, since only one registration framework would have to be understood.

Nevertheless, in doing so, and taking into account the fact that in the Quebec jurisdiction, cadastre map is mandatory for land registration, specific questions about data acquisition and mapping specifications (2D or 3D) are raised. In fact, the geometry and topology of underground networks are quite distinctive compared to land parcels. Underground networks present very long and linear shapes, they usually cross many parcels or other underground networks, they cannot be modelled under continue space specifications (since many gaps might occur), and finally they are not or rarely visible, creating a discrepancy for data acquisition and validation procedures. Can we expect that the same data acquisition and mapping conditions be applied to underground networks as for land parcels or condominium apartments? We doubt it.

Ideally, in a full 3D cadastre, recording all legal objects in the same register system seems to be the better solution. Nevertheless, if we take into consideration that most land administration systems do not manage 3D property for all kinds of real estate (as in Quebec), we estimate that the registration of underground networks does not need to be fully integrated within the cadastre system. We thus promote the approach based on the concept of "legal independence" as proposed in Cadastre 2014 and that encourage the autonomous but coordinate use of different sources of spatial data. However, if the decision is taken to store information on underground networks in a distinct Land Register, at a minimum, a non-ambiguous link between the land parcels and the path of the networks is required. This link may refer to an easement statement and a simple list of impacted land parcels. In the case of the Quebec Register of Public Service Networks, this link is loosely coupled. A recording file is not opened as soon as the network is built, but rather only when someone wishes to publish a mortgage, a sale, or any other real right on this network. For subsequent transactions, acts designate the network by its file number so that the right can be published. In that sense, this register strictly plays a role of publication of rights.
In fact, the same reasoning may be applied to mining rights or other kinds of underground features as groundwater disposal (Ghawana et al, have presented in 2010 an interesting discussion about this last issue).

3.3 Which information should be part of the registration process?

From jurisprudence, literatures, and the specific case of Quebec Land Register, we now propose the following list of components that, from our point of view, should be taken into consideration for the registration of underground networks.

3.3.1 Standards for the geometric and semantic description

No matter if registration of underground objects is stored in the same or a distinct Land Register, firstly, a precise legal definition of what is an underground network is required. The definition of a network provided by the *Civil Code of Quebec* is very broad. A network can be a railway line or a network of cable communications, water or gas distribution, a power line, oil or gas pipelines or sewage conduits. Path length or configuration does not matter in this legal definition. The only condition that must be met, in addition to what is dictated by the Civil Code, is right of superficies, i.e., that infrastructure ownership must be different from that of the land. We found a vast diversity of objects recorded in the register of utility networks and, in addition, a dozen ways for recording the information. For example, one holder registered a very long segment (several thousand kilometres) in only one file (one registration number), while another holder decided to register every single and segmented fibre-optic component by separate file number, resulting in hundreds of registrations.

Quebec law imposes few obligations in terms of geographic localization and none in terms of shape description of utility networks. The *Civil Code of Quebec* merely requires the designation of the "territory" the network serves. Any additional details are left to the discretion of the utility network owner or the official authority (notary). Having access to information about the real rights of the utility network requires the land file number, but this number is not published. While the name of the owner can be queried, if the same owner holds rights on several networks, it becomes impossible to identify the correct land file without consulting all its files. So we need to have information about the geographic location of the underground network.

The lack of minimal standards about length or path configuration creates a melting pot of hardly comparable objects. As mentioned by Stoter in 2004, she also noticed inconsistency in the registration information in the Netherlands cadastre system. For example, 43 parcels were intersecting a specific pipeline but only 38 parcels have a legal notification with the Company as subject. The Company and the Netherland Kadaster cleaned up the situation, manually, and then improved the registration process. But this experience, while published in 2004, revealed some complexities that are still, in our opinion, relevant for many countries:

> *"The information that can be obtained from the cadastre is fragmented, it is not possible to query the pipeline itself. The location of the pipeline itself is not registered. There is redundancy: for every parcel crossed by the pipeline, a reference is made to the same subject (holder of the pipeline). Cadastral registration of infrastructure objects is not uniform."* (Stoter 2004, p. 56.)

The localization, length and level of segmentation to be applied during the modelling process of underground network are thus important issues. Data acquisition specifications adapted to the legal and administrative context are clearly missing in the Quebec jurisdiction and in the literature. Lots of work have been proposed to detect buried infrastructure (like Benedetto and Pajewski 2015; Daniels, 2004; Sato 2001) and even little proposal for cadastre purpose (Cornette and Galley 2011; Hashim et al, 2010), but it still require investigations to better match the requirements to support legal decision making or cadastre mapping. Yet, there is a clear gap between engineering specialist and land lawyer approaches.

Regarding the semantics and geometric modeling, some motivating proposals exist as proposed by Becker; Nagel; and Kolbe for CityGML UtilityNetwork ADE, the Canadian Standards Association S250-11 Mapping of underground utility infrastructure (CSA, 2016), the guideline published by the American Society of Civil Engineering (ASCE, 2002) for the collection and depiction of existing subsurface utility data. LADM (ISO-19152) and Geographic Information (TC-211) standard series are certainly other interesting sources of information. Nevertheless, their implementation has not occurred in Quebec and their proposals are often too general or at a conceptual level difficult to understand by land professionals. Similarly, using such standards in the context of a registration process involving different professionals (lawyer, engineering, land surveyor or administrator) who do not necessarily talk the same language, may not be aware of the concerns of other groups and, moreover, have varying priorities and interests. Certainly, there is still place to generate and improve collaborations between those distinctive communities.

In our opinion, standards will have limited impacts without the imposition of strict designations for the registration of underground utility networks. In some countries, legislation exists; readers may find an overview of them in the world-wide inventory of 3D cadastre (FIG, 2014; van Oosterom et al, 2014b). For example, in Switzerland an official cadastre for subsurface pipes exists, in which the position of the infrastructure is partially available in 2D with an optional height attribute. In Australia, the network infrastructure is represented on 2D plans.

3.3.2 Spatial representation

The absence of a cadastral plan for utility networks, combined with unclear designation makes localization of underground networks hardly possible using the public data in the Quebec jurisdiction. Even in the cases where we found designation is precise in terms of endings, length and path, it was still impossible to know which land parcels were affected by a given network. The location of utility networks is therefore almost impossible to determine since no related information exists from the registration process, and spatial relationships with surroundings are approximate and difficult for the authority to certify. For example, in the online interface of Quebec Land Register, we can query the system based on the name of the owner. But it returns all the real estate transactions in relation to this party, and thus to find a specific network we have to consult all files of that owner. This may represent several thousands of files for some telecommunications companies which often perform excessive file subdivisions of their fibre-optic networks. Finding a file referring to a given network, and as a corollary the rights published on it, is thus a complex operation because the file number (a sequential number) has no spatial reference.

To circumvent this problem, notaries and surveyors are tempted to use easements to implicitly locate networks. Unfortunately, mapping the associated RRR as a surrogate is hazardous. The Law offers utility network owners implied easements, which are enforceable without registration. Also, when an easement is registered on a land file, its concordance with network location is not guaranteed by Law.

Furthermore, the fact that the Register of Public Service Networks is not supported by a cadastral plan makes operations related to the opening, handling and consultation of files

somehow intangible. In the Land Register, a file will be opened as soon as a new cadastral lot is delimited by a surveyor. These lots can then be subdivided, cancelled, replaced or unified. Still, there is always a tangible link with the physical reality of the immovable. This is not currently the situation for utility networks.

The next question may address whether to have a 2D map, a 2D profile and/or a 3D model. As indicated, the 3D model would probably be the best solution to provide full spatial representation and thus move toward the concept of 3D property. But as most register systems are still 2D, our analysis, presented in Pouliot et al (2015), shows that users are currently satisfied with 2D maps that include the projection of the central line of the underground networks, with the identifier and diameter of the network, and some contextual data such as land parcel boundary lines and their lot number, administrative boundaries and their official name, name of the streets (not the geometry), orthophotography. Figure 1 shows an example of the proposed interface appraised as suitable for the Register of Public Service Networks.

Figure 1. Visualization of communication cables (orange) with land parcels (blue) and the name of streets superimposed over orthophotography

3.3.3 Designation of impacted land and easements

As indicated, in the case of using distinctive registers and in absence of 3D spatial representation, the underground network registration process should at least require having the list of parcels affected by the presence of a network. From the perspective of publishing and protecting property rights, this approach appears particularly helpful and informative because it provides a direct link among the underground network register, the Land Register and the cadastral map. This information is easy to decode, appears rich enough in land data and gives a sufficiently accurate geographical location. Considering the availability of spatial

analysis tools, nowadays, this list can be achieved in seconds even for large networks. Nevertheless, such a list cannot be truly useful if no mention is made directly on the land file of the parcels concerned. We believe that network owners would benefit from having proper easements published in the Land Register.

3.3.4 Tools that support multiple spatial analysis

With the advances in geo-TIC (or Geographic Information Systems) and Web services, it is surprising to observe that decision-makers such as notaries or land lawyers are rarely aware of, or use, such spatial decision support systems. GIS offers several tools to integrate and query multi-source databases. Consequently, we invite the legal community working in legal aspects or laws to incorporate tools that support multiple spatial analysis (2D and 3D) to determine the relationship with overlapping land parcels or other legal objects and thus promote the establishment of multi-layer cadastre system.

4. CONCLUSION

The notion of 3D cadastre is supported by many conceptual models. The minimalist one does not consider underground infrastructure such as cables, pipelines or roads, and thus does not register such objects. Considering the increasing number of underground objects, mainly in urban areas, registration of these legal objects is, nevertheless, becoming a must. Similarly, surveying and managing such underground networks are of major interest for municipalities in order to provide secure and reliable services to citizens.

In our paper, we support the obligation of owners to register underground networks and for the authority to create such a registering system tightly linked with the cadastre system. In 2011 more than 247,900 real estate transactions were recorded in Quebec, with an economic value of approximately 80 million CAD (Foncier Quebec, 2011). Real estate transactions of underground objects represent millions of dollars of investment.

In the absence of 3D models, spatial representation of all kinds of legal objects must be mandatory and distinct configurations for the spatial representation of underground networks compared to land parcels is to be given a priority. Having the localization (X, Y) of the central line of the path of the underground network and the depth are the minimal spatial data required. The segmentation rules of the underground network should not be dependent on parcel boundaries; a link between the parcel number and the underground infrastructure must be compulsory. The operation of spatial decision support systems such as GIS is highly recommended. In this sense, major promotion efforts have to be done with land lawyers and politicians. Adaptations to land-law education should be made to consider this new reality.

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REFERENCES

ASCE (2002). Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data (38-02). ASCE report C-I 38-02, New York.

Aien, A., Rajabifard, A., Kalantari, M. and Williamson, I. (2011). Aspects of 3D Cadastre – A Case Study in Victoria. In Proceedings of FIG working week 2011. Copenhagen: International Federation of Surveyors (FIG).

Aydin, C. (2008). Usage of Underground Space for 3D Cadastre Purposes and Related Problems in Turkey. Sensors, 8, pp. 6972-6983.

Becker, T. Nagel, C. and Kolbe, T.H. (2011). Integrated 3D Modeling of Multi-utility Networks and their Interdependencies for Critical infrastructure Analysis. Kolbe, König, Nagel (Eds.), Advances in 3D Geo-Information Sciences, Springer, Berlin, Heidelberg, pp. 1-20.

Benedetto, A. and Pajewski, L. (2015). Civil Engineering Applications of Ground Penetrating Radar. Springer.

Cevdet, C.A. (2008). Usage of Underground Space for 3D Cadastre Purposes and Related Problems in Turkey. Sensors, 8 (11), pp. 6972-6983.

Cornette, G. and Galley, V. (2011). Géoréférencement des réseaux enterrés : des techniques de relevé à la gestion d ' un cadastre du sous-sol. Revue Cadastre 6 aout, pp. 24–28.

CSA (Canadian Standards Association), 2016, S250-11 Mapping of Underground Utility Infrastructure.

Daniels, D.J. (2004). Ground Penetrating Radar – 2nd Edition. The Institution of Electrical Engineers.

FIG, 2014. Worldwide Questionnaire on the Status of 3D Cadastres. Organised by FIG joint commission 3 and 7 Working Group on 3D Cadastres.
Available at: http://www.gdmc.nl/3dcadastres/participants/.

Ghawana, T., Hespanha, J., Khandelwal, P. and van Oosterom, P. (2013). 3D Cadastral Complexities in Dense Urban Areas of Developing countries: Case Studies from Delhi and Satellite Towns. FIG Working Week, Abuja, Nigeria, 6-10 May, 2013.

Hashim M., Jaw, S.W. and Marghany, M. (2010). Subsurface Utility Mapping for Underground Cadastral Infrastructure. 31st Asian Conference on Remote Sensing (ACRS), Volume: 2.

Info-excavation (2014). Outil de rapport sur les dommages aux infrastructures (ORDI). Analyse et recommandation pour le Québec. Rapport 2014.

Paasch, J.M., Paulsson, J., Navratil, G., Vučić, N., Kitsakis, D., Karabin, M. and El-Mekawy, M. (2016). Building A Modern Cadastre: Legal Issues in Describing Real Property in 3D. Geodetski Vestnik, 60 (2), pp. 256-268.

Ploeger, H. (2011). Legal framework 3D cadastres - Position paper 1. In: van Oosterom, P., Fendel, E., Stoter, J., Streilein, A. (Eds.), Proceedings 2nd International Workshop on 3D Cadastres, 16-18 November, 2011, Delft, the Netherlands, pp. 545–549.

Pouliot, J., Bordin P. and Cuissard, R. (2015). Cadastral Mapping for Underground Networks: A Preliminary Analysis of User Needs. 27th International Cartographic Conference, Rio de Janeiro, Brazil, August 23-28, 2015.

Pouliot, J. and Girard, P. (2016). Subsurface Utility Network Registration and the Publication of Real Rights: Towards Full 3D Cadastre. FIG Working Week, Christchurch, NZ, 2-6 May, 2016.

Sato, M. (2001). GPR and its Application to Environmental Study. Annual Review of Earth and Planetary Sciences, Vol. 29: pp. 229-255.

Shojaei, D., Kalantari, M., Bishop, I. D., Rajabifard, A. and Aien, A. (2013). Visualization Requirements for 3D Cadastral Systems. Computers, Environment and Urban Systems, 41, pp. 39–54.

Spirou-Sioula, K., Ioannidis, C. and Potsiou C. (2013). Technical Aspects for 3D Hybrid Cadastral Model. Survey Review, 45:333, pp. 419-427.
Stoter J.E. (2004). 3D Cadastre. PhD thesis, Delft University of Technology, Netherlands.

Stoter J.E. and van Oosterom, P.J.M. (2007). Technological aspects of a full 3D cadastral registration. International Journal of Geographical Information Science, 19 (6), pp. 669-696.

van Oosterom, P. and Lemmen, C. (2015). The Land Administration Domain Model (LADM): Motivation, Standardisation, Application and Further Development. Land Use Policy, 49, pp. 527-534.

van Oosterom, P.J.M., Stoter, J.E. and Fendel, E.M. (eds) (2001). Registration of Properties in Strata. First international workshop on 3D cadastres, International Federation of Surveyors, Delft, the Netherlands.

van Oosterom, P.J.M., Fendel, E.M., Stoter, J.E., Streilein, A. (eds) (2011). Proceedings 2nd international workshop on 3D Cadastres, November, Delft, the Netherlands.

van Oosterom, P.J.M., Guo, R., Li, Ying, S. and Angsusser, S. (eds) (2012). Proceedings 3rd international workshop 3D Cadastres: Developments and practices, October, Shenzhen, China, ISBN:978-87-92853-01-1 (published by International Federation of Surveyors).

van Oosterom, P.J.M. and Fendel, E.M. (eds) (2014a). Proceedings 4th international workshop on 3D Cadastres., November, Dubai, United Arab Emirates, ISBN 978-87-92853-20-5 (published by International Federation of Surveyors).

van Oosterom P., Stoter, J., Ploeger, H., Lemmen, C., Thompson, R. and Karki, S. (2014b). Initial analysis of the second FIG 3D Cadastres questionnaire: status in 2014 and expectations for 2018. 4th International FIG 3D Cadastre Workshop, 9-11 November 2014, Dubai, United Arab Emirates, 2014.

Williamson, I., Enemark, S., Wallace, J. and Rajabifard, A. (2008). Understanding Land Administration Systems. Position paper presented at the International Seminar on Land Administration Trends and Issues in Asia and The Pacific Region, August 19-20, Kuala Lumpur, Malaysia.

BIOGRAPHICAL NOTES

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Philippe Girard acquired a PhD in biological sciences in 2008. After a few years at University of California – Berkeley and McGill University as a postdoctoral fellow, he started studies in geomatics sciences in 2013 and graduated in May 2016. During his studies, he developed a special interest in land rights. As a land surveyor, he wants to develop surveying expertise in this area, ideally around environmental issues. He currently works for the Ministère des Transports of Quebec.

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