Quebec's geodetic reference: thinking differently

(white book) by André Verville, Kildir Technologies
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The current situation, inherited from the previous century

During my studies, like many of my classmates, I contributed to summer jobs in the Geodesy Department of the Ministry of Lands and Forests at the time. It was in the 1970s, the most active period in the establishment of the Quebec geodetic network.

In addition to the wonderful moments and memories that are now etched in my memory, there was this pride in contributing to a major project associated with taking charge of our vast territory. Years of training in scientific and technical rigor that later guided my small contribution, throughout my career, to a better geographical knowledge of the territory.

As the proactive pride that it originally represented, our geodetic network has subsequently endured decades of cost reductions where profitability, transfers of responsibilities, per-use funding and other mantras have collectively led us to diminish our interest in ensuring its maintenance and sustainability.

The advent of modern satellite positioning technologies has also contributed to the reduction of resources devoted to network inspection and maintenance. We realize today that landmarks location was originally wisely chosen to promote their inter-visibility and it was not uncommon to find them on mounds or rocky notches, when it was not downright the top of a mountain that we had to climb to reach them. The most accurate ones, those that provided the best long-distance inter-visibility, were always located on headlands, difficult to access seldom reachable by any road or even tracks. Precise measurements using GPS receivers have changed all this by completely changing the rules, measurement methods and geodetic markers location choices.

At the same time, surveyors and engineers begun using GPS receivers as viable alternatives to total stations, at least in open sky territories. Real-time kinematic measurements (RTK), with an accuracy of only a few centimeters, are now an essential complement to angle and distance measurement systems (total stations). This transition was made possible by the establishment of public networks of permanent satellite tracking stations at first, but especially by their commercial complement undertaken by receiver's manufacturers and distributors, using systems of paid subscriptions to Internet correction services accessible by cellular links.

No one doubts today the relevance of these correction services, which, even in cases where satellite positioning is not effective due to obstacles or over-dense vegetation, allow surveys integration into the national geodetic network, without vagaries and doubts about the stability and accuracy of geodesic markers whose position has not been checked since a while. It must be admitted in return that this coverage availability has almost sounded the death knell for geodetic networks of lower orders and precision. The markers remain in place but some of them are buried in road banks and are difficult if impossible to access in winter. For those anchored in urban sidewalks, questions are raised about the effect of frost and thaw, both in terms of position and elevation. Today, they are only used as a measure to validate gross errors in GPS surveys or to reattach existing networks.

Permanent markers on concrete pillars and accessible by car are rare. For example, there are only two in the territory of the Metropolitan Quebec Area, a first one on Lava University campus (93K2005 or E Pillar) and a second on the edge of Félix-Leclerc highway in Saint-Augustin-de-Desmaures (93K2002 or B Pillar) and even for the latter, their position validation measures dates back a few years (inspection in 2017 for E Pillar and in 2015 for B Pillar).

The Ministry of Energy and Resources has a network of 17 active stations, which transmit kinematic corrections continuously on the Internet and for which raw data can be downloaded for post-processing purposes. It is a minimalist cover that can only give centimeter accurracies in their immediate environment. They are not operated in collaboration with Canada's Natural Resource's other permanent stations and little information is available as to the consistency of their published position with local geodetic networks in their respective environments.

In this context, we understand Quebec surveyors and engineers to turn to private networks of reference stations, set up and operated by major equipment suppliers: Can-Net from Cansel/Trimble, SmartNet from Leica and TopNet from Topcon. These networks are at least unified ones for which there is a form of constant validation of integrity, with in addition corrections interpolation algorithms to reduce inaccuracies due to the distance between customer receivers and reference stations. In the southern inhabited part of Quebec, horizontal measurements can be obtained with an estimated accuracy of less than 3 cm in position and 5cm in elevation in the majority of cases.

In return for our governments' resignation from their responsibilities, suppliers and resellers have for years maintained a subscription system that represents a recurring expense of between $1,000 and $3,000 per year for each of the measuring devices used. These providers have also succeeded in getting some of their customers to invest in the implementation of their networks by deferring to them the acquisition costs for those permanent stations, in exchange for subscriptions and royalty on third-party subscriptions.

The consequences of our inaction

Despite technological advances and miniaturization, major manufacturers of satellite positioning technologies have dragged their feet to pass on price reduction benefits to their customers. It is known that GNSS equipment is often used in difficult weather conditions and/or on construction sites or heavy machinery and equipment must be robust and able to withstand abuse. Despite all this, paying tens of thousands of dollars to protect electronic components that require only a few hundred dollars in manufacturing costs no longer seems a realistic approach. A chip capable of adequately tracking dozens of satellites from the GPS, Glonass, Galileo, SBAS, QZSS and Beidou constellations is now installed for a few dollars in all smartphones, one imagines that additional phase measurement capabilities and multiple frequencies do not present such exceptional technical difficulties for manufacturers apart from the smallest number of units to be produced. After all, a GNSS receiver is nothing more than a digital radio programmed to perform certain calculations on the data embedded into the radio signal picked up by its antenna.

The bottlecap has even been pushed further by imposing highly complex antenna systems on permanent station receivers. The sickly fear of multi-path signals made sense when a very small number of satellites entered the receiver antenna. With sometimes more than twenty satellites and sophisticated algorithms for filtering inconsistent measurements, $5,000 "choke-ring" laboratory calibrated antennas for millimeter positioning of their phase centers is, in my opinion, a waste of money and resources. These antennas are useful for organizations that measure Earth crust deformations or contribute to the precise determination of satellite ephemeris or international time,

but certainly not to provide local corrections. The fear of accuracy problems sells a lot, we must believe...

All this to say that it is abnormal for a survey-grade GNSS receiver to cost tens of thousands of dollars. After all, a GNSS receiver is a digital radio equipped with an antenna, a battery and communication interfaces. And in this, it does not differ much from a smartphone. Several manufacturers have demonstrated this recently, including EMLID, who started with crowdsourcing and managed to assemble all the necessary electronic components and integrate them into a waterproof and resistant case for a fraction of the cost we were used to.

Situation status summary

Before looking into our Crystal Ball, it may be wise to take a look at the present and establish an objective state of mind. Here are the main findings:

1. Traditional polygonal geodesic networks are outdated and unreliable due to the large number of landmarks, some of their bases subjected to unpredictable soil movements, the maintenance and verification costs they impose, and the many constraints on their all-season access.

2. Of these geodetic networks, there are no reliable and periodically verified regional millimeter-level reference capable of serving as validation references and/or attachment for precision work or the determination of temporary or permanent reference stations.

3. Real-time kinematic correction networks (RTKs) have a proven background for more than 25 years now. Unfortunately, the public authorities have left the field open to commercial products from the major suppliers with regard to systematic territory coverage, satisfying themselves with pointly reference resources. The government's public geodetic reference has thus been invaded by the private sector that made it a business by itself.

4. The very nature of precise satellite positioning requires the use of precise ionospheric corrections and these corrections degrade rapidly when they are not known and verified within ten kilometres of the measurement station. Statistical “FIX” conditions, i.e. centimeter phase lock becomes impossible at long distances. Good territory coverage by a network of GNSS base stations operating at known points remains the only method yet known to provide such information. Today this requires discipline but only a fraction of the efforts that were once required for the establishment of monumented geodetic networks.

5. The cost of acquiring GNSS receivers to observe, measure and transmit such corrections has dropped dramatically and permanent installations can be carried out at a cost between $1,000 and $5,000 per station. A regional infrastructure of 5 to 10 stations could therefore be put in place with an initial investment of less than $50,000. In this context, monthly subscription fees between $1,000 and $3000 per user device to access such infrastructure have become prohibitive. Free or minimalist subscription fees can and should be considered.

A vision for the future

In view of these findings that show the many weaknesses of the current situation, here is an innovative approach that would correct the mistakes of the past and start up on new grounds:

1. The Québec Government and its Ministry of Energy and Resources have largely disengaged from the geodetic reference sector and its resources are limited in this regard. It made it clear in

recent decades that it now counts on Quebec's municipal authorities to continue the task. I do not see how I could count on anybody in this Ministry for any other duty than possible advice on the accuracy and integrity of a network of permanent stations.

2. Municipal and regional authorities are currently the only ones with public buildings scattered throughout their territory and the public works infrastructure and resources required to install permanent reference stations. They also have the resources to install and maintain permanent pillars and have the authority to ensure their access (parking, snow removal). I therefore suggest that regional resources be federated in this regard.

3. Access to GNSS corrections can now be made possible by a large number of low-cost or free software resources, which could be distributed among a very large number of users. I therefore recommend a mixture of free access and/or the establishment of a cooperative/non-profit structure, completely independent of any commercial activities from manufacturers and resellers (even though I belong to this category myself!), from which the only contributions accepted would be donations of equipment, software or promotional. Everything else would simply be purchased by the non-profit organisation or its members.

4. Membership in this open organisation must involve all types of users. For example, a private member could participate by adding his own reference equipment, but making its correction data freely accessible to the cooperative and respecting a spec sheet regarding the quality and sustainability of his installation. I talk about engineering and surveying firms, as well as farmers, foresters and other users of the geodetic reference. I imagine that one day, if their business model is no longer sustainable because of this "unfair" competition that I suggest to their pay services, the big manufacturers might even one day come to transfer some of their current resources into the assets pool of this organization.

The future vision of this project: a precise and free centimeter geodetic reference, throughout Quebec..

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