Integrated Surveys: Charting Ontario's Land in an Accurate and Consistent Manner

By Spiros Pagiatakis, PhD, P.Eng

We have recently completed the second series of continuing education seminars on the "*Practical Steps to Integration*", sponsored by the AOLS. These seminars focused on the practical aspects of integration based on the first series of seminars, given in 2010 that laid out the theoretical foundation. The seminars followed the "*Reverse Engineering*" or "*From Finish to Start*" approach that commenced with the requirements regarding the survey plan and its contents, it continued on with the data processing methodologies and strategies, and ended with suggested procedures in the field to achieve the accuracy requirements and overall high quality of the final plan.

The seminars made frequent links to Ontario Regulation 216/10 "*Performance Standards for the Practice of Professional Land Surveying*" that must be adhered to by all AOLS members regarding the integration of legal surveys into the national reference frame. Simple numerical examples and data processing demonstrations were given to accentuate the importance of rigorous data handling that ensures compliance with the accuracy and quality standards. Special attention was given to the field procedures and the concepts of geometrical strength of the observed reference points. Emphasis was also given on the variety of the on-line tools that are available from OMNR (COSINE) and the Geodetic Survey Division (GSD) of NRCan (Ottawa).

It is well understood that O.Reg. 216/10 requires that all legal surveys be referenced (integrated) to the national reference frame (NAD83). Since cadastral surveys are 2-D, at least for now, either realisations i.e., NAD83(original) or NAD83(CSRS+epoch) can be used as per O.Reg. 216/10. However, in order to achieve the required accuracy, at least in urban areas, it is strongly suggested to use NAD83(CSRS+epoch) where possible. As far as the actual field observations are concerned, there are many ways of integrating the surveys.

It appears that the majority of surveyors use the RTK network method to establish the required observed reference points (ORP) in the area of interest. Whereas RTK network providers have done a fabulous job in establishing, maintaining and providing access to their networks, there is a concern about the use of just one base station when establishing an ORP, particularly when the occupation time is very short. It has been emphasized that this approach does not provide adequate geometrical strength, and the use of a second base station would be very desirable, at least if urban accuracy is required.

Beyond the use of the RTK networks, other field methods are also possible and their description can be found in various documents published for instance by GSD and are also available on-line. These methods were discussed extensively during the seminars and are briefly summarized as follows:

a) Precise Point Positioning (PPP): This method may satisfy the surveys in remote areas when the ORP is occupied for long periods of time. Since the majority of the surveyors use GSD's on-line PPP processing tool, there should not be any concern regarding the transformation of the estimated positions, since the users can directly obtain the coordinates of the ORP in the NAD83(CSRS) frame. Caution should be exercised if other PPP software is used since the estimated positions may be given in the WGS84 system, in which case a transformation to NAD83(CSRS+epoch) will be required.

b) Direct connection of the established ORPs to Specified Control Points (SCP) via physical occupation: This is a well known approach, but the surveyor must be careful with the reduction of the observations. If doing a traverse using a total station, the measurements must be reduced onto the ellipsoid and then to UTM grid when using UTM coordinates for the SCP in the adjustment. Care must be exercised when reducing GPS baselines on the UTM grid. Once the observations are reduced onto the grid, UTM coordinates of the SCPs can be used to adjust the traverse or network.

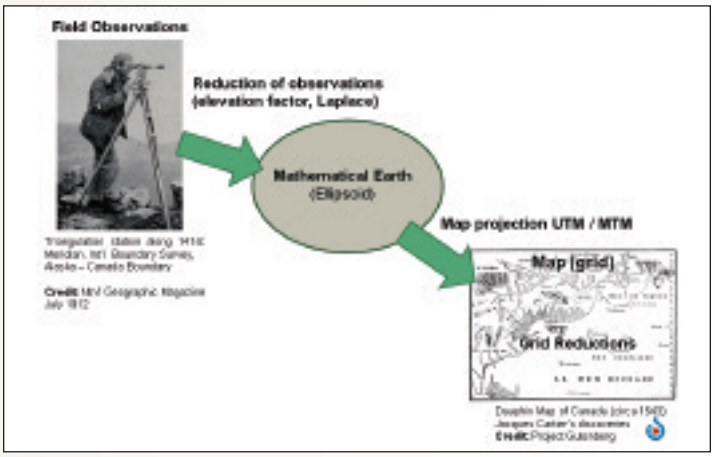
c) Advanced GPS users can follow the differential GPS mode to achieve higher accuracy estimates of the ORP coordinates. This would require two receivers, one at the base station (SCP) and the other at the ORP. Data must be collected at both stations and post-processed to obtain the ORP coordinates. Occasionally, the surveyor may use as a base station one of the continuously operating stations (e.g. CACS stations). In this case, CACS RINEX data from GSD for post-processing must be used. This approach will obviously require one receiver supplied by the user. Again, the surveyor should strive to have strong geometrical configuration to achieve the urban accuracy requirements. Transformations of the estimated baselines from WGS84 to NAD83(CSRS)

cont'd on page 8

may also be required depending on the GPS ephemerides used (WGS84 or NAD83(CSRS)).

d) A combination of the above methods is also possible.

As per O.Reg. 216/10, the coordinates of all points in the survey shall be expressed as grid coordinates in a Universal Transverse Mercator (UTM) map projection or a Modified Transverse Mercator (MTM) map projection. The observations obtained in the field, regardless of how they were obtained, must always be projected (or reduced) onto the reference ellipsoid (horizontal datum – see figure) before



any map projection is attempted. The reduction of the observations onto the reference ellipsoid is dependent, first and foremost, on the choice of the ellipsoid. It is critical to choose the ellipsoid that has officially been adopted in the country, in our case the GRS80 reference ellipsoid. The geodetic coordinates (ϕ, λ, h) or their grid equivalents (Northing, Easting) of all reference stations used are therefore dependent upon the adopted reference ellipsoid. The reductions to the ellipsoid include primarily the elevation factor for distances. Azimuths measured on the ground may not be reduced by the Laplace correction since in Ontario it may only reach a few seconds or arc. In a second step, all geodetic quantities (distances, azimuths, angles) on the ellipsoid must be projected onto the mapping plane (grid) using appropriate reduction formulas that were extensively discussed in the seminar. Of these reductions, the most important are the projection scale factor (UTM factor) for the distances and the meridian convergence for the azimuths. Other reductions for the angles also exist (e.g., T-t) but they are negligibly small for the usual extent of the cadastral surveys and thus can be neglected. Finally, least squares adjustments must always be performed to obtain the best solution as well as be able to provide confidence intervals at the 95% level, as required.

It was very pleasing to see the elevated interest of the participants and their substantial interventions through very well posed questions, comments and statements. This made the seminars more interesting, comprehensive and most importantly, useful. I have always regarded continuing education activities as important and necessary exercises for maintaining relevancy, leadership, professional advancement, and competency, all of which are, and must be, the characteristic elements of a professional who serves the public. The initiative of the Association to organise these seminars was timely and necessary and I'm hopeful that it will continue in the future to provide the required education to the membership.

I thoroughly enjoyed teaching as well as learning from a wonderful group of eager professionals! I sincerely hope that they got as much enjoyment from the seminars as I did. Tim Hartley, who delivered a significant portion of the seminars, has been a magnificent partner and a great communicator. Many members from the AOLS Integrated Surveys Committee contributed to the success of the seminars with ideas and suggestions on the format of the presentation. I have also had a great time working with Phillip Swift on the "Interpretive Guide" and other aspects of the integrated surveys. As always, it is marvellous to work with the AOLS staff who flawlessly organised all the seminars across Ontario.

Spiros Pagiatakis, PhD, P.Eng is Professor of Geodesy and Chair of the Department of Earth and Space Science and Engineering. He can be reached by email at **spiros@yorku.ca.**

Insurance Advisory Committee Tips for Members

Practical Construction Tips

- Remind your field staff to always step back and have a good look at what they have staked. Does the layout make sense? If the top of the shoring is higher than the road, it is probably designed incorrectly or not staked out properly.
- When supplying temporary bench marks, always set two bench marks, preferably independent of each other and remind the contractor to use both.
- Report to your insurance advisor first. Do not admit liability.
- Always document your client's changes, especially with regard to onsite construction requests.