Least Squares: An amazing tool for cadastral surveys.

By Phillip Swift, B.C.L.S. (N/P), O.L.S., O.L.I.P.

On my first day surveying in September 1971, I learned that we traverse because it is easier than measuring directly between property corners. It is a way of getting around obstacles.

The first job was a 200 acre parcel granted in 1875. After two weeks of climbing hills, cutting line, turning angles and chaining, we returned to our first hub to read the closing angle. We read every angle twice and every distance twice, plunging the scope in between.

All we had to do was record these angles, slopes and chainages, distribute the angle error, work out the bearings and horizontal distances, and then use the sine and cosine to rectify coordinates onto an orderly grid.

Of course, nothing ever worked out perfectly. There was error in every measurement, like a wrinkle in the fabric, and the compass rule could never iron it all out.

When the miracle of EDM arrived, the traverses swung even wider, zigging from ridges to valleys, and zagging across roads and creeks. We placed "control" to help reduce the error that accumulated through rough terrain and long distances. We used numbered "hub tags" to identify each traverse station and monument.

The layout of the network, careful use of the instrument, climbing hills, finding ancient monuments; they were all satisfying. The frustration started with balancing the traverse.

If you close the perimeter first, the cut-off loops produce unacceptable closing ratios (error divided by distance). That is because we used up so much distance around the outside that we did not have enough left to divide into the interior loops.

Things improved if you balanced the short loops first, or even better if you balanced the worst loops first (the Kerr method), but all these attempts to find the optimum priority meant repeatedly entering the same data into the Wang 600 or the HP-41 by hand.

When you have to wait for a squall to pass before you can get a shot to a distant ridge, you ponder how to do things more efficiently. What if...? What if you could put all of your measurements into a file, like ingredients into a pot, then stir them up and get the most probable result as easily as making a stew?

Years after these questions arose, my colleague Peter Thomson offered to teach me how to use a new least squares program that had been developed for surveyors. It took about an hour to show me how to enter the raw data and understand the results.

No explanation was needed on how or why it worked, because least squares had long been part of the syllabus for surveying. The great triangulation of North America had been adjusted by hand using "Gaussian elimination" decades before most of us were even born.

Peter had simply found a missing element in our collection of amazing tools, one that makes our work more satisfying and gives us more confidence in our results. Here are some of the ways that least squares enhances daily work:

- the raw data is never edited;
- the adjustment does the least harm to hard-earned observations;
- there is just one coordinate at any given point, no matter how many times and ways it was tied;
- angles to longer courses have more weight and are adjusted less;
- plumbing error can be assigned for the instrument and the rod;
- weights can be assigned according to the grade of survey equipment;
- the observations are more readable than the output from data collectors;
- the data files are like an organized diary showing the chronology of the work you have done;
- input data is entered once, and used repeatedly;
- edits made to point descriptors are maintained in future adjustments;
- networks grow over time and are hungry for more data;
- networks grow stronger as more measurements are added, particularly direct measurements between close things;
- redundancies improve the results and help to isolate problem areas;
- blunders are flagged: errors can be discovered, identified and repaired;
- free adjustments allow one to test the internal integrity of the measurements;
- unstable or moving points can be isolated;
- positional errors are listed for analysis by the surveyor;
- relative errors are also listed, for angles, distances, zenith angles, height differences and GPS vectors;
- working in 3D is easier, ensuring that scale factors are correct (eliminating a common systematic error) and ensuring that GPS can easily be combined with total station work;
- it is easier to work in either geographic latitudes and longitudes or projections because the computations are handled automatically by the software;
- there is a network plot showing:
    - the layout of the figures;
    - the connections between points;
    - the positional error ellipses;
    - the relative error ellipses;
    - the control points (1D, 2D and 3D).
- the raw data can be processed as:
    - a local plane survey, or

- geographical latitude and longitude, or
- a projection with convergence and scale factors for each point, or
- ECEF (Earth-Centred Earth-Fixed) coordinates, or
- with geoid heights from a geoid model,
- or all of these systems at once.

Today we have the recurring problem of producing ground-scale local surveys (where 100m on the plan is 100m on the ground) as well as UTM or MTM surveys for mapping, municipal purposes or for other clients. Least squares software gives you the results you need in local and grid simultaneously so you have confidence that these transformations are done rigorously and repeatably.

Finally, experience with least squares teaches us how to improve surveys. When I do take the extra effort to measure directly between property corners, the results improve, despite what I was told on my first day of surveying.

NEWS FROM 1043

Changes to the Register

Members Deceased

Howe, David	706	April 6, 2010
Chapman, Charles B.	1004	April 22, 2010
Cuthill, Ronald Robertson	1124	May 12, 2010
Johnston, William	1116	May 13, 2010

CofA's Issued

Alex Marton Ltd., Woodbridge, April 22, 2010

CofA's Relinquished

Skandarajah Surveying Ltd., Toronto, April 27, 2010

CofA's Revised

Was: Payette, Himma Delorme Ltd./Ltee
Is: Arpentage Payette Surveying Ltee/Ltd.
Was: John Vinklers, O.L.S.
Is: Vinklers Wallace Ertl Ltd. (A Division of Ivan B. Wallace Ontario Land Surveyor Ltd.)

Surveyors in Transit

Steve Vollick is now with ATCO Electric at 104 Birch Rd. NE, PO Box 720, Slave Lake, AB T0G 2A0.

The Barrie consultation office of **McNeice Harvey D'Amico Surveyors Ltd.** has relocated to 229 Mapleview Dr E., Unit 1, Barrie, ON, L4N 0W5. Phone and fax numbers remain the same.

Hopkins Cormier & Chitty Surveying Consultants Inc. now has the records of **W. R. Brick, O.L.S.**

New branch office - **Ivan B. Wallace** and **Larry Ertl** have purchased the assets of **John Vinklers, O.L.S.** and have moved his office to 20 Leslie Street, Suite 121, Toronto, ON, M4M 3L4. Phone and fax numbers remain unchanged at 416-609-2836 and 416-693-9133 respectively.

As of June 30, 2010, **Kevin P. Kujala** will no longer be working for **E. J. Williams Surveying Limited.** His new employer is **Tulloch Geomatics Inc.** of Huntsville.