

Closing the Gap with Satellites

By David H. Gray, B.A.Sc., M.A.Sc., P.Eng., C.L.S.

Did the 3rd year University of Toronto (U of T) Civil Engineering students realize when they measured precise angles at stations A, B, C, and D along the shores of Gull Lake that they were actually duplicating what had been done at hundreds of thousands of triangulation points across Canada? In fact, these points can be considered part of national geodetic framework of Canada and thus are the starting points for such things as the national topographic mapping.

During the decade following the establishment of the U of T Survey Camp in 1920, Professor L.B. Stewart proceeded to triangulate from two primary geodetic points; one eight kilometres west of camp and the other 31 km. south of camp through five secondary, four tertiary and 18 fourth-level points of which A, B, C and D are the final points. One of the secondary points, GULL LAKE, is on a rocky hill 200 metres west of the highway curve field that the students know so well. To do that survey, Professor Stewart had to build 78-foot inner and outer towers and 44-foot towers at two of the secondary points – no small feat.

Also, all those traverse points in the woods, along the shore, and in the open field – and there are about a hundred of them – were all interconnected by traversing by Survey Camp staff over the years so that the points have a local X,Y Cartesian coordinate value.

That has been the *status quo* since the start of the Survey Camp program – geographic data computed on a geodetic datum which had its beginnings in 1901 or on the local grid. Over the years there has been no attempt to re-compute the data on the North American Datum 1927 or North American Datum 1983 – the latter being roughly compatible with GPS satellite positioning. There is a need to bring Professor Stewart's work into the 21st Century.

The first step is to use a modern computer least-squares adjustment program to compute the most probable mathematically consistent values for the angles and electronically measured distances. Step Two is to convert geographic coordinates from a geodetic datum in vogue in 1901 into satellite compatible 21st Century values. Step Three is to close the 566 metre gap between GULL LAKE and Station "A". Analysis of Professor Stewart's survey suggests that it has a plus/minus of about a quarter metre – hardly accurate surveying over such a short distance.

Since the first U of T Civil/Mining/Geological Alumni Dinner (Feb. 2009), I have assembled the data set of angles of all the stations from the geodetic control points to Station "A", added student observed angles and distances from various years, retrieved the modern and archived



A view of Gull Lake from Point A.

geographic positions of the main geodetic control points, and done the least squares adjustments. But to close the gap would require – as you can imagine – hundreds of metres of line clearing so that angles and electronic distances could be measured, or you could use GPS receivers to measure the 3-dimensional vector from one station to the other.

During Survey Camp 2009, Mohannad Al-Durgham (Ph.D. student) and I conducted a GPS survey using receivers loaned to the university by Leica of Canada. We simultaneously recorded GPS data at GULL LAKE and Station "A" for over eight hours, and have gathered sufficient data to say that the vector from GULL LAKE to "A" is 566.970 metres at 113° 23' 52.7" with a 95% probability of ± 3 mm.

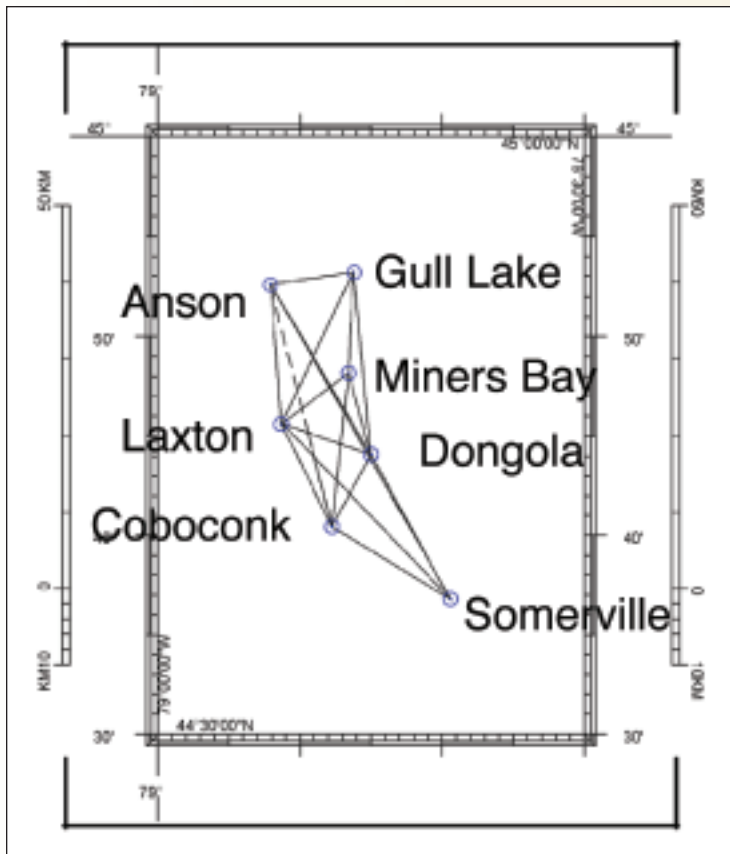
Thus, the survey net became a continuous loop and a closure adjustment could be performed. After that, the Universal Transverse Mercator Eastings and Northings were computed for GULL LAKE and "A", and an affine transformation was done to convert the local X, Y Cartesian coordinates into UTM coordinates. Thus, Survey Camp now has data totally compatible with outside mapping and geomatics agencies.

I suggest that another survey project be undertaken; namely, to find and validate the positions of the traverse points by occupying them with GPS receivers while simultaneously running a base station at "A". This will verify the transformation computation.

Modernization of the survey control at Survey Camp is well in hand and will serve the Staff and future students for years to come. Were it so simple to modernize the facilities!



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Map of Primary and Secondary Geodetic Points.