Fact Sheet No.6

Summary of Provincial and National Coordinate Adjustments

Land Surveys Unit, Geodetic Control

Introduction

This Fact Sheet presents a brief overview of provincial readjustments of the Alberta Survey Control network as well as national (cross-Canada) readjustments that define the reference frame in Canada (and Alberta). It is important to note that with the advancement of least squares adjustment software in the 70's and 80's, the ability to carry out large scale readjustments has increased dramatically. This increase is reflected in the implementation and refinement of various 2-dimensional (NAD27) and 3-dimensional (NAD83) reference frames in Canada (including Alberta).

Local adjustment and readjustment (NAD27)

In Alberta, the North American Datum of 1927 (NAD27) was propagated from the primary network established in the 1920's by Canada. No provincial (or national) readjustment of any observational data to improve the Alberta derivation of NAD27 was ever carried out. In fact, only local adjustment and readjustment of horizontal coordinate data for Alberta Survey Control Markers (ASCMs) was ever undertaken using this datum. Of note, NAD27 is based on the Clarke 1866 ellipsoid that is best fit to North America (at a control point at Meades Ranch, Kansas, USA). Coordinate data was derived via triangulation and trilateration observations radiating out from Meades Ranch across North America and subsequently maintained using various types of observations including early Global Positioning System (GPS) observations. Given the lack of a national and/or provincial readjustment to address issues around systematic errors at the local/regional/provincial-level (and lack of compatibility with space-based positioning systems), NAD27 was discontinued for use for Alberta Survey Control Markers (ASCMs) on June 1, 1994.

International and National (ESHIBA/WSIHBA/NMIP93) Adjustments

In 1986, an international-based adjustment resulted in the establishment of the North American Datum of 1983 (NAD83) in 1986. This adjustment was a result of a joint effort by Canada, the USA, Mexico, and Denmark (Greenland) to establish a geocentric reference frame that was more compatible with space-based positioning methodologies. In Canada, this adjustment constituted approximately 8000 geodetic control points across the country, which also formed the basis for propagation of NAD83(Original) (as it is known) to Alberta and other provinces/territories in Canada. National adjustments were carried out for eastern Canada/provinces (Eastern Secondary Integration HELMERT Block adjustment – ESIHBA) and western Canada/provinces (Western Secondary Integration HELMERT Block adjustment – WSIHBA) , including Alberta, in 1989 and 1990, respectively. Further, in western Canada, two more adjustments were carried out in 1992 (i.e., Network Maintenance Integration Project 1992 (NMIP92)) and 1993 (i.e., NMIP93) with NMIP93 being accepted as the official adjustment establishing NAD83(Original) in Alberta. Data from Alberta included in this effort comprised triangulation and trilateration observations from various secondary/municipal networks, Doppler observations, Inertial Survey System observations, and some early GPS observations from various provincial mapping initiatives. Of note, constraints were introduced along the Canada-USA boundary for Alberta, Saskatchewan, and Manitoba with no constraints for BC. This adjustment also included some Very Long Baseline Interferometry (VLBI) observations.

Provincial Readjustment (NAD83(Original))

The first provincial-wide readjustment of the Alberta Survey Control network was completed and coordinates published on June 1, 1994. This adjustment was based on the results of the NMIP93 national adjustment combined with observational data (i.e., triangulation, trilateration, and GPS observations) collected at the provincial level since 1991. This Alberta-only readjustment (NAD83V0.3.-.AB.1) is known as the NAD83(Refresh) and is referenced to the NAD83(Original) datum.

NAD83(Original), NAD83(CSRS), and the move to ITRF

With improved positioning capabilities, it was quickly realized that NAD83 was in a fact not a geocentric system, being offset from the Earth's true geo-centre by approximately 2 m. Further, the initial realizations of NAD83 were 2-dimensional constructs where modern geospatial positioning wanted 3-dimensional positioning. Finally, introduction of GPS observations to the NAD83 datasets showed significant issues with systematic errors and other biases resulting in a less than ideal reference frame. In light of these issues, NAD83(CSRS) (or the Canadian Spatial Reference System derivation of NAD83) was conceived and combined with a high accuracy geoid to create a true 3-dimensional reference frame for spatial referencing. NAD83 (CSRS) defines the national standard for referencing spatial data in Canada. It serves as a link between Geographic Information System (GIS), Global Navigation Satellite System (GNSS) positions and the Canadian Geospatial Data Infrastructure (CGDI). By using NAD83 (CSRS) products, it is ensured that this data is compatible with a modern, high-accuracy reference system and can be exchanged and merged without complication. As a result, NAD83(CSRS) has by and large given users an accurate and reliable reference frame. However, the 2-metre offset from the geo-centre remains as well as some accuracy and stability issues. To address these problems, it was decided in Canada to keep NAD83(CSRS), but define it in terms of a precise relationship with the International Terrestrial Reference Frame (or ITRF). The ITRF (with associated Epoch) is the most accurate and stable reference frame available, based on VLBI, satellite laser ranging, and the DORIS satellite system observations. In the case of NAD83(CSRS), ties to the ITRF are facilitated through common VLBI stations used for both systems. The result is the derivation of a conformal 3D seven parameter transformation between both reference frames giving an accurate 3-dimensional NAD83(CSRS) datum defined in terms of the ITRF. In a practical sense, this means that NAD83(CSRS) is derived and maintained in relation to the most current epoch of the ITRF. For further reading on NAD83(Original), NAD83(CSRS) and the ITRF in Canada, please see the referenced articles at the end of this fact sheet.

NAD83(CSRS98) and NAD83(CSRS) Epoch 2002

NAD83(CSRS98) was adopted at the national level in 1998 and implemented in Alberta in 1999 via a 2-dimensional adjustment (NAD83V2.0.0.AB.1). NAD83(CSRS98) coordinates were published for a subset of the Alberta Survey Control network which formed the basis of the Alberta High Precision Network (HPN). With further refinement of NAD83(CSRS) to NAD83(CSRS) Epoch 2002, a second 2-dimensional readjustment (NAD83V4.0.0.AB.1) of the provincial survey control network was completed in 2004. Again, coordinate data was only published for the Alberta HPN ASCMs. Of note, the reason for only publishing NAD83(CSRS) coordinate data for a subset of ASCMs was a practical solution in that only the HPN ASCMs are considered to be able to physically and mathematically support Global Navigation Satellite System (GNSS) observations on a consistent basis. The ASCMs that make up this subset include those in various municipal HPNs and other select GNSS projects in the rest of Alberta. For further information, please contact Geodetic Control as noted as the end of this fact sheet.

NAD83(CSRS)v7 Epoch 2010

NAD83(CSRS)v7 Epoch 2010 is based on a transformation from the International Terrestrial Reference Frame of 2014 (ITRF2014). NAD83(CSRS)V7 was released by the Canadian Geodetic Survey (CGS) of Natural Resources Canada in 2019. In Alberta, it was implemented via a 3 dimensional readjustment, again constraining to the CACS stations and the CBN along with CGVD2013 for the vertical. For further information see Fact Sheet No.1 for NAD83(CSRS)V7 Epoch 2010 and Fact Sheet No.4 for CGVD2013.

Further Reading

Further information regarding readjustments and datums/reference frames in Canada can be obtained by reviewing the following articles:

Michael R. Craymer. 2006. **The Evolution of NAD83 in Canada**. *Geomatica*, Vol.60, No.2, 2006, pp 151-164; P. Heroux, J. Kouba, N. Beck, F. Lahaye, Y. Mireault, P. Tetreault, P. Collins, K. Macleod, M. Caissy. 2006. **Space Geodetic Techniques and the CSRS Evolution, Status and Possibilities**. *Geomatica*, Vol.60, No.2, 2006, pp 137-150; and Junkins, D. and G. Garrard. 1998. **Demystifying Reference Systems: A Chronical of Spatial Reference Systems in Canada**. *Geomatica*, Vol. 52, No. 4, pp. 468-473.

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