TOWARDS REAL-TIME ACCESS OF THE CANADIAN SPATIAL REFERENCE SYSTEM

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ABSTRACT:
Recent technological advances in spatial referencing, including the Global Positioning System (GPS), have led to an evolved Canadian Spatial Reference System (CSRS), the national standard for referencing spatial data in Canada. New components of the CSRS have been developed to ensure that Canadian spatial data users have access to an accurate, seamless and globally consistent reference frame. For some time access to the CSRS has been available through the Canadian Active Control System (CACS), provincial Active Control Systems, such as the BCACS, and geodetic control networks, such as the Canadian Base Network (CBN). Recently, two real-time services have been introduced: Natural Resources Canada provides a national GPS correction service, GPS•C, for distribution through service providers; and Geographic Data BC offers a differential GPS service, the Global Surveyor™.

The CSRS provides the standard or foundation layer for spatial data used in GPS, GIS, and other positioning technologies. Regardless of the sources of the data, a common reference system ensures the exchange and integration of the data without complication.

This article explains how to use CSRS products and services, to ensure the data is accurate and compatible with nationwide initiatives such as the Canadian Geospatial Data Infrastructure (CGDI) for engineering, surveying, mapping and GIS applications.

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BACKGROUND:

The spatial reference system in Canada has traditionally been based upon geodetic survey ground-based benchmarks and monuments, each with published precise coordinates. Since 1909, Geodetic Survey has established and maintained a national network of these points in order that surveyors throughout Canada had a framework available within which they could reference their geospatial data. These points have been the basis for provincial programs that have extended the "framework" to establish close to 200,000 control points, including dense networks in the many municipalities across Canada.

CANADIAN SPATIAL REFERENCE SYSTEM (CSRS), A NATIONAL STANDARD:

A hierarchy of networks based on different technologies currently supports the Canadian Spatial Reference System (**CSRS**) (Figure 1). [1][5]

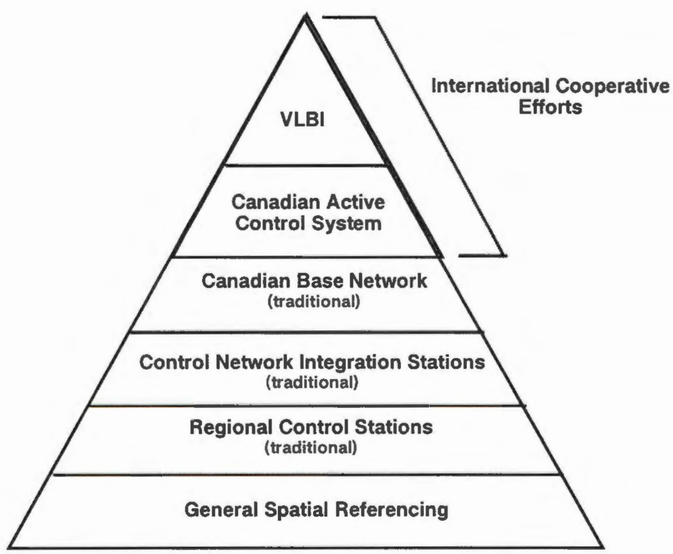

Figure 1: The Canadian Spatial Reference System (CSRS) hierarchy [1][5]

It is maintained and improved by Geodetic Survey Division (GSD), in collaboration with other federal and provincial government agencies and private industry, to provide an effective standard to the public. To guarantee that this national system is stable, accurate and consistent with international systems, GSD contributes to the activities of various international services. These agencies include the International Geodynamics Service (**IGS**) and the International VLBI Service (**IVS**), through data gathered and products generated from the Canadian Active Control System (**CACS**) and the Canadian Geodetic Long Baseline Interferometry (**CGLBI**) program.

The **CSRS** is the **national standard** for referencing spatial data in Canada. To ensure all users have access to the system, the CSRS comprises both traditional and space-based positioning components. These components provide the Canadian spatial data users with access to an accurate, seamless and consistent reference frame.

Very Long Baseline Interferometry (**VLBI**) uses radio astronomical observations from extra galactic quasars to provide an inertial reference system, upon which Earth-based systems are referenced. The Canadian Active Control System (CACS) is directly tied to the VLBI. A countrywide network of continuously operating GPS (Global Positioning System) satellite tracking stations (Figure 2) supports the CACS. The Canadian Base Network (**CBN**), stable monuments established using GPS, provides the link between traditional ground control points and the GPS-based CACS. [1]

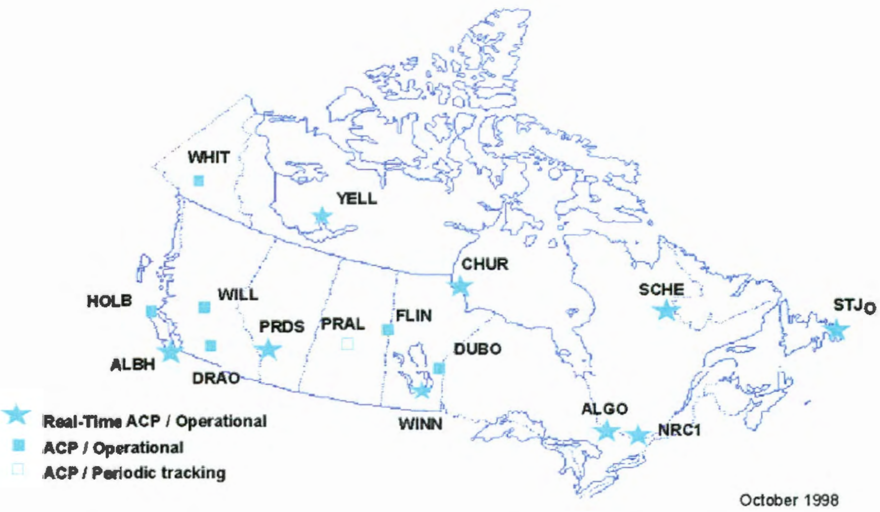

Figure 2: Network of automated stations supporting the Canadian Active Control System (CACS) [4]

Further, traditional geodetic control points support access to data consistent with the CSRS through the maintenance, integration and enhancement of regional control networks by the provinces and other agencies. Although geomatics professionals may use different methods to access the CSRS, first they need to understand each methodology or technology to ensure their data is consistent with the CSRS.

ACCESSING THE CSRS VIA TRADITIONAL METHODS:

Traditional access to the CSRS is accomplished by directly occupying a geodetic control point with published coordinates, i.e. the Canadian Base Network (**CBN**), provincial and municipal High Precision Networks (**HPN**) and other traditional lower order ground control. GPS technology has the advantage of being able to access reference station data over long distances without the need for a "line of sight" between monuments. Indeed, given the accuracy of GPS, a few centimetres accuracy can easily be accomplished over distances of several hundred kilometres, often spanning layers of older traditional networks and bringing high accuracy to the local level.

The CBN, consisting of only a few hundred markers maintained by the Geodetic Survey Division, provides a more accurate reference than the thousands of older control markers. These highly stable monuments, which have been established using GPS over a nominal spacing of 200 kilometres in southern latitudes, provide easily accessible high accuracy control for both traditional and GPS survey techniques. High Precision Networks (HPN), available in many provinces, provide a complimentary densified network of GPS-based control points for local users. The older, less accurate, traditional networks are often inconsistent with these GPS-based networks, and thus continued maintenance of the older networks is in doubt.

ACCESSING THE CSRS VIA SPACE-BASED METHODS:

Referencing GPS-based positions to the Canadian Active Control System (CACS) or via provincial Active Control Systems provides direct access to the CSRS. Users may access data from these systems either through Internet-based facilities for post-processing techniques or through real-time methodologies.

Post-Processing Access:

Active Control System products, from both the Canadian Active Control System (CACS) and Geographic Data BC (BC ACS), enable the GPS user to obtain positions through post-processing techniques, with accuracies ranging from a centimetre to a few metres in relation to the Canadian Spatial Reference System (CSRS), without actually occupying base stations or existing traditional control monuments.

CACS products include collected GPS observational data, in RINEX format, from Active Control Points (ACPs), and computed precise ephemerides (orbits) and precise satellite clock corrections for each of the GPS satellites. These data are presently available via subscription through an internet-based on-line product delivery service **(WWW_OPDS)**. The precise clock and ephemerides data reduces the main sources of GPS error about 100-times (Figure 3). Using these products make it possible to improve positioning accuracies to the submetre-level depending on the methodology and type of equipment used.

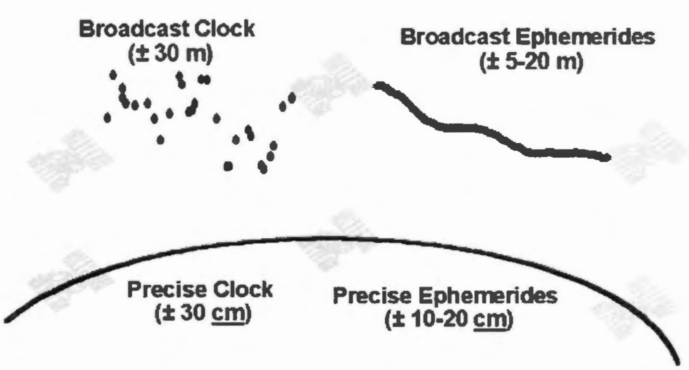

Figure 3: Satellite data improvements resulting from Canadian Active Control System (CACS) processing [1]

For applications using carrier phase measurements, the utilization of precise empherides and CACS observational data may help to achieve centimetre level static positioning accuracies, when appropriate GPS software and procedures are used. [1] Precise point positioning with a single receiver has been shown to achieve metre level accuracies. This second technique is supported by using CACS data with post-processing software such as **GPS*Pace,*** available from Geodetic Survey, and through several other vendors as noted on the Geodetic Survey web site (www.geod.nrcan.gc.ca).

Geographic Data BC provides the **BC ACS** network, including nine continuously operating, permanent GPS base stations, linked via computer and telecommunications networks. These base stations provide data, which allow users to correct the coordinates obtained by a single GPS receiver, achieving positions accurate between 0.1 to 10 metres. BC ACS data, in RINEX format, is provided through a BC provincial web-based utility, called **LandData BC.** (http://www.landdata.gov.bc.ca)[3]

Real-time Access:
Recently, Natural Resources Canada **(NRCan)** and Geographic Data BC have introduced real-time access to the CSRS. The NRCan service, established by the Geodetic Survey Division (GSD), is based upon real-time estimates of GPS satellite clock and orbit errors computed through Canadian Active Control System (CACS). These real-time national GPS corrections, **GPS•*C***, provide the basis for enhanced GPS positioning and navigation services throughout Canada. The service will continue to provide the basic positioning accuracies offered by post-processing (one metre or better) but with the additional advantage of availability to users in real-time anywhere in Canada. [1][5]

To distribute the GPS•C corrections to the public, GSD has signed distribution agreements with service providers. At present these service providers include Premier GPS Inc. of Calgary, Alberta, Geographic Data BC **(GDBC)** of Victoria, BC, and International Telecommunication Consulting Service **(ITCS)** of Grande Prairie, Alberta. Contact information for these agencies is available at **http://www.geod.nrcan.gc.ca/**. The providers are in the process of developing their service delivery using communication technologies such as the Internet and satellite communications. Other possible technologies include cell phone, paging, and FM broadcast. Data may be rebroadcast directly or integrated with other services or information before redistribution (Figure 4).

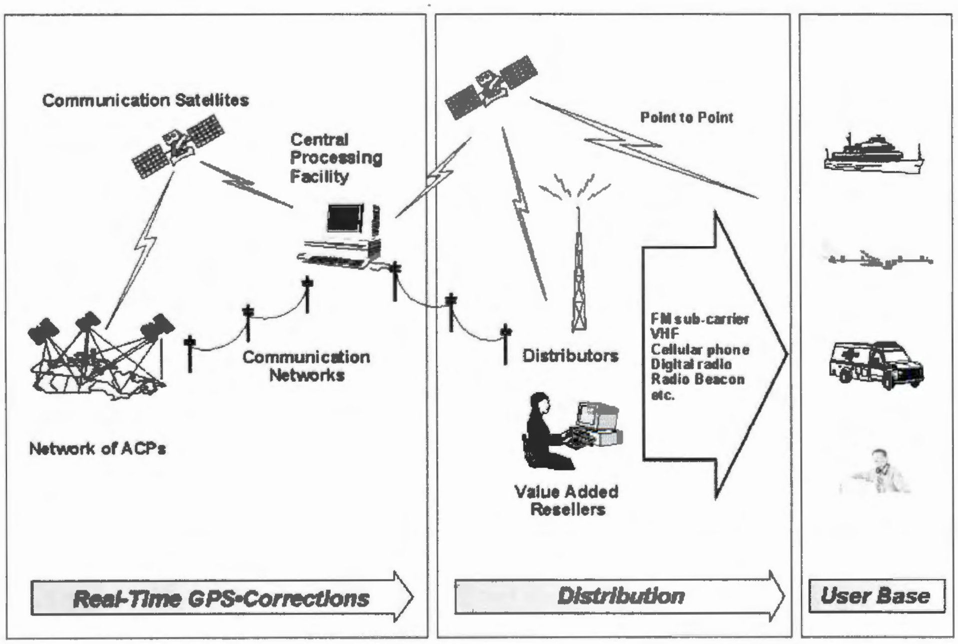

Figure 4: Integrated Global Positioning System (GPS) Correction Services [2]

The real-time CACS is designed to facilitate continuous real-time positioning and navigation over Canada and adjacent areas. The real-time GPS correction service (GPS•C) can complement local differential or wide-area differential correction services by offering service providers the opportunity to potentially reduce operating costs while increasing reliability and integrity, and directly tying into the Canadian Spatial Reference System (CSRS) in real-time.

Currently, GDBC, the British Columbia agency responsible for the development and management of provincial land related information and systems, offers a real-time local Differential GPS service. This service called **Global Surveyor™**, is now available from a number of distributors and dealers in British Columbia and Alberta. More information is available at the GDBC web site:

http://www.env.gov.bc.ca/gdbc/gsn/glblsrvy.srv_accs.html

A subscription to the 24-hour service includes rental of a custom-designed lightweight, handheld MSAT receiver and real-time access to GPS correction data in RTCM SC-104 format from one of two GPS reference stations (Williams Lake and Terrace, BC). Distributors may provide custom service packages for individual requirements. [3] Although this service is available at present for only BC and Alberta, Geographic Data BC is developing a nationwide delivery of GPS•C via the MSAT mobile satellite.

During the summer of 1998, the Canadian Coast Guard **(CCG)** and Canadian Hydrographic Service **(CHS)**, in cooperation with Geodetic Survey, conducted a shipborne GPS•C demonstration project. The goal of the project was to demonstrate the capabilities of GPS•C in the Canadian North using a prototype system providing GPS•C data over the MSAT satellite to a Global Surveyor™ receiver. The project demonstrated GPS•C capabilities as far as 70 degrees North latitude Where the Coast Guard DGPS was available, GPS•C was consistent at the 2-5 meter range with the Coast Guard system. (Figure 5) Based on the early success of the demonstration, CHS used GPS•C operationally during their Hudson Bay hydrographic surveys in the summer of 1998. [4]

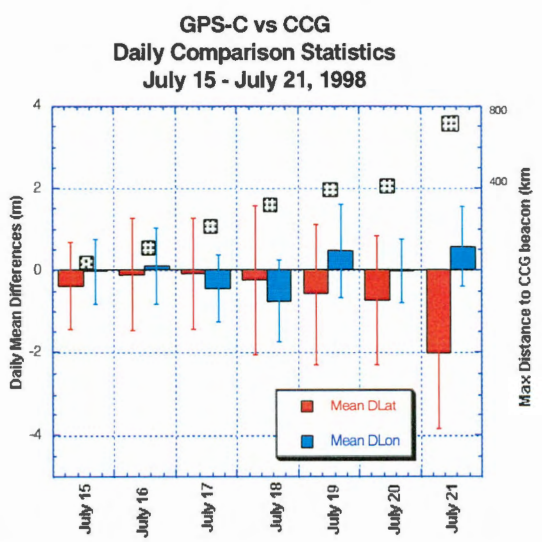

Figure 5: Daily Summary of Position Differences (GPS C versus CCG DGPS) and Maximum Distance to CCG DGPS Beacons [4]

WHY REFERENCE POSITION DATA TO THE CSRS? :
Users of spatial data need to know to what the data is referenced and how well in order to accurately merge or share this information. For example, spatial data sets from several sources such as mapping organizations, transportation agencies, and utility companies, may be based on different reference systems and must be transformed to a consistent standard. If spatially referenced data is gathered and entered into a GIS, it is possible to ensure that the positions are referenced to the CSRS through one of the methods previously described.

The CSRS provides this standard or foundation layer and guarantees that the user can exchange and merge the data without complication. For instance, CSRS consistent data is accurate and compatible with nationwide products such as the Canadian Geospatial Data Infrastructure (**CGDI**). Geospatial data entered in the CGDI should be consistent with the CSRS.

SUMMARY:
Engineering, surveying, mapping and GIS users of GPS data can achieve accuracies of less than one metre or even centimetres using ACS related technologies. The paper stresses the importance of a national Spatial Reference System in ensuring a standard for the compatibility of geospatial data within Canada. As positioning technologies evolve into an everyday utility for the average citizen, the need for a standard positioning reference will become more important.

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BIOGRAPHY:
Sheryn McGregor-Sauvē (B.E.S.) started with Geomatics Canada in 1977. In 1987, Sheryn graduated with honours from the University of Waterloo in Environmental Studies (Geography). She has worked with Geodetic Survey as a survey technologist, with the National Atlas of Canada as a research geographer, and is a graduate of the Geomatics Professional Development Program. Sheryn is now the Geodetic Survey Marketing and Communication Coordinator.

Doug Scott (P. Eng) is a graduate in Engineering from the Royal Military College (RMC), Kingston, Ontario, and the School of Military Survey, United Kingdom. Prior to joining Geodetic, Mr. Scott was an officer with the Canadian military. Since joining Geodetic Survey

Division in 1980, he has gained experience in a variety of field survey and office positions, most recently as the Business Development Coordinator.

Amin Kassam, P.Eng., A.L.S., is a Surveying Engineering graduate from the University of New Brunswick and he holds a Surveying Technology diploma from the British Columbia Institute of Technology (BCIT). He has practiced land surveying in Alberta and been engaged in the management of provincial geospatial reference programs in both Alberta (1983-1989) and British Columbia (1990-present).