CDGPS
Canada-wide DGPS Service
A National GPS Correction Service for Canadians

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ABSTRACT

The Canada-wide DGPS (CDGPS) Service is a program designed to provide GPS users in Canada with free access to GPS corrections. The Service will provide metre-level solutions consistent with the national reference frame NAD83(CSRS), allowing users to directly relate their data holdings with the primary alignment layer of the GeoConnections Framework Data Node.

The provincial governments, the Territory of Nunavut, and the federal government are jointly funding the development of the satellite radio receiver and infrastructure to provide users access to Natural Resources Canada (NRCan)'s GPS correction signal (GPS·C) to be broadcast to all GPS users via the MSAT satellite. This paper will provide the background and status information of the CDGPS initiative scheduled for public availability late summer of 2002.

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Introduction

The current U.S. GPS Standard Positioning Service (SPS) Performance standard dated October 2001 [U.S. DOD 2001] states that horizontal system accuracy for a real-time GPS positioning (without corrections) should be less than or equal to 13 m (95%). This reflects the changes due to the removal of the GPS selective availability (SA) in May 2000. To improve on this positioning accuracy users must apply GPS correction information to their GPS observations. Differential GPS (DGPS) techniques have been developed over the years to provide this capability. DGPS can be of two flavours, local DGPS (LDGPS) or wide area DGPS (WADGPS).

LDGPS implementations provide GPS corrections via range corrections to each satellite, based on a single reference station with "known" coordinates. The user distance from the reference station dictates the accuracy of the user position after applying the corrections. LDGPS implementations are in use throughout the world and include networks such as the U.S. and Canadian Coast Guard DGPS service along the West and East coasts and along the St. Lawrence Seaway and Great Lakes. The Coast Guard implementation has become a world-wide standard in marine navigation. Corrections are communicated to users via a medium frequency radio link. For large service areas such as the landmass of Canada, a countrywide network of these local differential stations is not practical.

The WADGPS concept [Mueller; 1994] is based on a “sparse” network of reference stations over a large area. Observations from each station are collected at a central site and estimates of GPS satellite parameters (orbits, clocks etc.) are computed. These individual error components, as opposed to a single GPS range correction are then distributed to the users for application to their GPS observations. Ionospheric corrections for single frequency GPS users are also estimated based on the network and made available to the user in the form of an ionospheric grid. The corrections are applicable for any location in the area covered by the reference network (WADGPS implementation) and not as a function of the distance to the nearest reference station (LDGPS implementation).

The Geodetic Survey Division (GSD) of Natural Resources Canada (NRCan) has a mandate to establish, maintain, enhance and provide access to the Canadian Spatial Reference System (CSRS) for Canada. The emphasis over the last few years has been the establishment of a network of high quality GPS tracking stations linked with modern communication and computing technologies to provide a continuous GPS monitoring capability. This infrastructure is part of the Canadian Active Control System (CACS). Data products from the CACS include raw GPS data, station coordinates, high accuracy GPS orbits and GPS clock solutions. As the CACS evolved, a user need was identified for real-time GPS correction information to improve user real-time GPS positioning. This GPS correction capability is now part of the CACS and is called GPS·C. [Caissy et al, 1996]. GPS·C real-time corrections are based on the wide area differential GPS implementation (WADGPS) scheme as described above. The current GPS·C real-time tracking network is shown in Figure 1.

The delivery and use of local DGPS corrections broadcast by a communication satellite (MSAT-1) has been demonstrated through the British Columbia Base Mapping and Geomatics Services (BMGS) Global Surveyor™ service in British Columbia [Kassam, et al; 1999].

The Canada-wide DGPS (CDGPS) project is the development and implementation of the delivery of GSD NRCan's GPS·C correction information for Canada using a communications satellite and a CDGPS "radio" to receive these corrections.

Figure 1. Current Real-Time GPS-C Automated GPS Tracking Stations

CDGPS Background

At a September 1999 Canadian Council of Geomatics (CCOG) meeting, an investment opportunity was discussed to provide a Canadian differential correction service. This service would be based on GSD's real-time GPS·C infrastructure and the MSAT communications satellite based DGPS technology developed under the British Colombia Base Mapping and Geomatics Services Global Surveyor™ program. The proposal outlined the high level view of the project that would allow access to GPS·C correction information and broadcast it to all Canadians via the MSAT-1 communication satellite. The project would also fund the design and manufacture of 1000 user radio receivers. Representatives from the Provinces, Federal Government and Territories were asked to consider the proposal as a means to provide Canadians easy and direct access to the Canadian Spatial Reference System. CCOG passed a resolution (99-03) supporting the proposal. A formal Memorandum of Agreement was subsequently signed by ten provinces, the Territory of Nunavut and the Federal Government in May 2000. The service to be developed was named the Canada wide Differential GPS (CDGPS) Service.

On behalf of the federal/Provincial/Nunavut partners, BMGS of the B.C. Ministry of Sustainable Resource Management are acting as the project manager. A contract is in progress to develop a user receiver and the MSAT "hub" system to allow for the

broadcast of GPS·C correction information. The service is expected to be on-line by summer 2002.

Prototype testing and demonstration of the performance of GPS·C has been carried out in conjunction with the Department of Fisheries and Oceans, Canadian Hydrographic Service, other Government Departments and private industry partners over the past 4 years. Some of these projects include;

- Canadian Coast Guard and Canadian Hydrographic Service Summer 1998 St. Lawrence River to Hudson Bay. [Lochhead et al, 1998, 1999]
- Canadian Hydrographic Service 1999 Mackenzie River and Western Arctic [Leyzack et al, 2000]
- Canadian Hydrographic Service 2000 Beaufort Sea and Western Arctic
- Canadian Hydrographic Service 2001 Beaufort Sea and Western Arctic
- Seavisual Inc Prudhoe Bay to Mackenzie River delta. 2001
- UNB GPS·C internet tests 2001
- Legal Surveys Pelly Bay 1999
- Ministry of Natural Resources Ontario testing 1999 [OMNR report 1999]
- Forest Engineering Research Institute of Canada (FERIC) testing in Quebec and Newfoundland 1999.

These prototype demonstrations/operations have been carried out using the Global Surveyor™ radios receiving GPS·C correction information via MSAT for specific work areas.

Typical single frequency GPS positioning performance achieved by applying GPS·C corrections is shown in Figure 2 as a plot of horizontal position differences with respect to a known surveyed point at the University of New Brunswick. Standalone GPS is shown in blue and GPS·C corrected positions are shown in green. The data was for a two-day period in August 2001. Standard deviations of the GPS·C corrected positions improved by 65% and showed 3d rms. positioning accuracies of 1-2 metres. [Horvath; 2002]

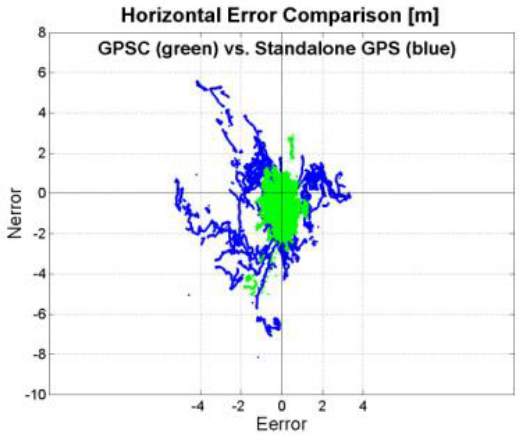

Figure 2: Position Differences of Standalone GPS and GPS·C Corrected positions at UNB August 13-14, 2001

CDGPS Description

The Canada wide DGPS service will deliver freely accessible, high quality GPS correction information across Canada to allow for improved GPS positioning directly referenced to the Canadian Spatial Reference System (CSRS).

The GPS·C correction information is transmitted from Geodetic Survey Division to the communications uplink centre "hub" in Ottawa via a dedicated communications link. The hub assembles and prepares the GPS·C correction data for MSAT-1 upload. (Figure 3) The MSAT-1 will broadcast corrections over four MSAT beams; West, West Central, East Central, and East beams. (Figure 4)

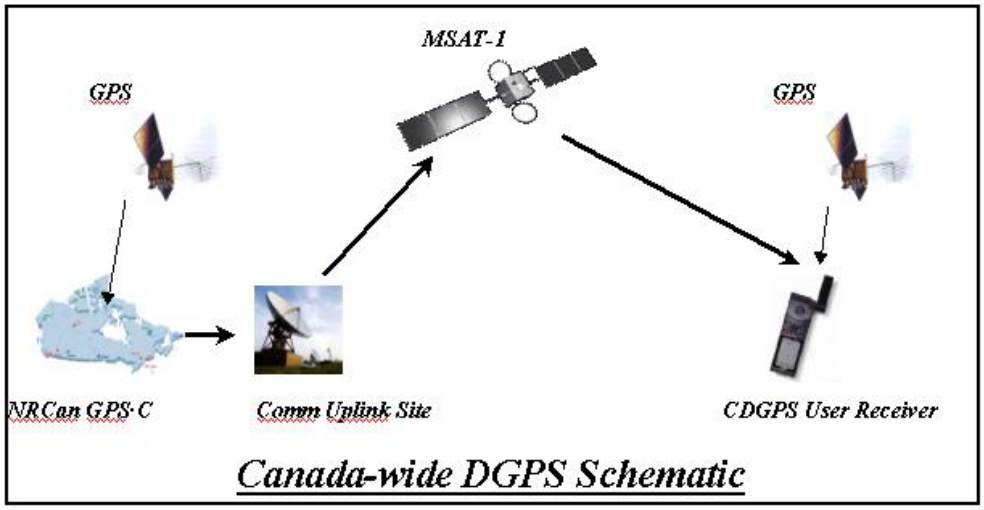

Figure 3. CDGPS Functional Diagram

The CDGPS broadcast protocol is an open specification and is made available describing the details of the MSAT-1 broadcast signal and data formats. This specification will allow other receiver manufacturers to build CDGPS capability into their hardware.

The CDGPS radio receives the GPS·C corrections through an L-band antenna, which is also used for GPS signal reception. The corrections are applied to the built-in GPS receiver observations and three outputs are made available from the CDGPS radio; GPS·C correction information, RTCM-104 differential corrections or GPS·C corrected positions in NMEA format. This allows the CDGPS receiver to be linked to the user's GPS receiver, to a laptop or palm driven GIS package to provide corrected position data or stand-alone GPS positioning. Although it will be necessary for users to purchase the CDGPS receiver at an estimated $1500 CDN, the signal will be broadcast at no charge.

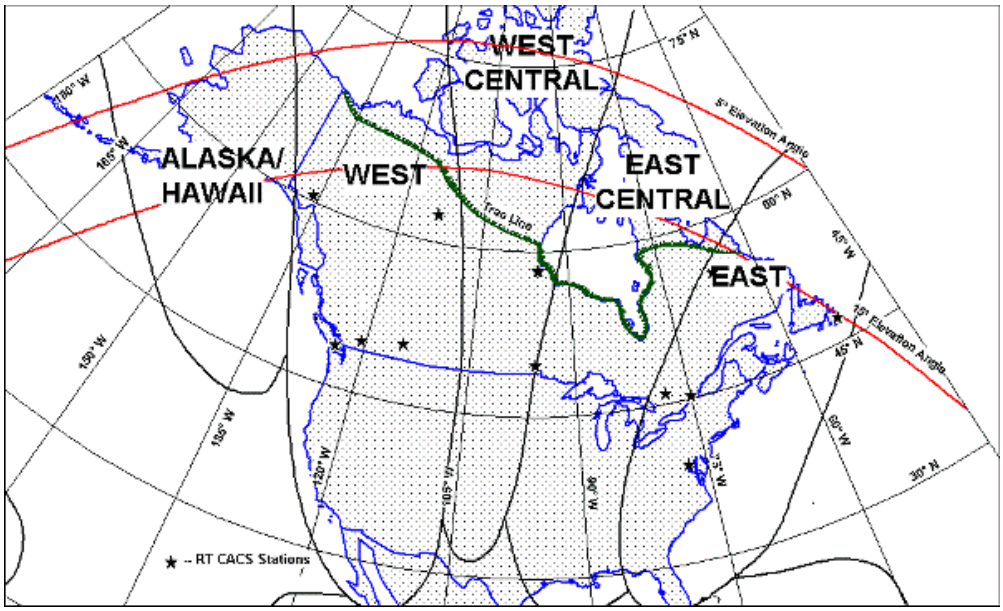

Figure 4. MSAT-1 Coverage

CDGPS Goals /Benefits

The CDGPS project is committed to:

- Providing the broadcast of the GPS corrections over MSAT-1 **free** 7 days/week, 24 hours/day (expected to begin in Summer 2002);
- Publishing an open MSAT-1 broadcast protocol in order to allow industry to build applications and to service the Canadian market place;
- Seeding the engineering and manufacturing of suitable satellite radios (called CDGPS receiver) and supporting satellite network infrastructure;
- Continually improving the GPS corrections in order to improve users' positioning results referenced to Canadian Spatial Reference System; and,
- Promoting the use and adoption of the service within partner jurisdictions.

The service will complement current DGPS systems (the Canadian Coast Guard DGPS service and the U.S. Wide Area Augmentation System (U.S. WAAS)) by providing the GPS corrections across Canada including the Canadian Arctic. Note that the CDGPS corrections are based on a Canadian network of GPS tracking stations and are applicable to the Canadian landmass. The CDGPS service is not intended to serve commercial aviation as planned by the U.S. WAAS nor is it intended to be guaranteed at levels deemed mission critical for public safety. It is a "Use at your own risk" service.

Applications for CDGPS range from surveying and mapping to precision agriculture and fleet / asset management plus other innovative uses of DGPS married with other technologies and business functions. GPS manufacturers, systems integrators and value-added service providers will be encouraged to embrace CDGPS in order to provide

effective solutions to meet Canadians' needs for various applications requiring precise GPS and ensure simple access to the Canadian Spatial Reference System for geospatial referencing.

CDGPS Status and Schedule for Delivery

A contract was awarded by the CDGPS project office to Mobile Knowledge Inc. of Ottawa (formerly SiGem Inc.) to develop the communication "hub" system and the user receiver. Mobile Satellite Ventures Corp (formerly TMI) was engaged as a sub-contractor to assist in the development and implementation of the communications hub.

Development of the CDGPS radio is progressing and prototype boxes have been produced. The radio itself measures approximately 5 inches by 6 inches by 1.5 inch and contains touch sensitive buttons allowing the user to switch between the four MSAT-1 beams and choose output types.

The contract with Mobile Knowledge Inc. to develop the CDGPS radios also includes the production of 1000 radios. The sponsoring agencies are allotted 500 units, with the remaining 500 to be sold through a commercial vendor. It is anticipated that a Request for Proposal (RFP) document will be developed and posted so that a vendor can be competitively chosen to actively market and distribute the 500 MSAT radio units that are not being taken by the government partners in the project.

NRCan has implemented a fully managed IT infrastructure for generation of the GPS·C corrections, and has contracted the Government Telecommunications and Informatics Services (GTIS) to manage the IT infrastructure used to generate the GPS·C correction information.

CDGPS Beta Trials are scheduled for the summer of 2002 with full operation of the service by late summer/ early fall 2002. [www.cdgps.com].

The CDGPS project industrial, government and academic partners are committed to continuous improvement of CDGPS, for example supporting dual frequency GPS users to enhance user position accuracy.

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CDGPS web site , www.cdgps.com