Report of the Sub-Commission for North America
IAG Commission X (Global and Regional Geodetic Networks)

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Operating on a informal basis since 1997, the Sub-Commission for North America was formally created in 1999, immediately following the IUGG General Meeting in Birmingham, U.K. The purpose of the Sub-Commission is to provide international focus and cooperation for issues involving the horizontal, vertical, and three-dimensional geodetic control networks of North America, including Central America, the Caribbean and Greenland (Denmark). Some of these issues include:

- Densification of the ITRF reference frame network in North America (the North American Reference Frame) and promotion of its use.
- Maintenance and future evolution of vertical datums (ellipsoidal and orthometric), including NAVD88 and the International Great Lakes Datum.
- Collocation of different measurement techniques such as VLBI, SLR, DORIS, GPS, etc.
- Effects of crustal motion, including tectonic motions along, e.g., the western coast of N.A. and in the Caribbean, and post-glacial rebound.
- Standards for the accuracy of geodetic positions.
- Outreach to the general public through focused symposia, articles, workshops and lectures and technology transfer to other groups, particularly in N.A.

The membership of the Sub-Commission presently consists of:

Michael. Craymer (NRCan/GSD, Canada, co-President)
Dennis Milbert (NOAA/NGS, U.S., co-President)
Per Knudsen (KMS, Denmark)
TBD (Mexico)
TBD (Caribbean)

No members have yet been identified for Mexico and the Caribbean, although contacts have been made with Mexico and the appointment of a representative is expected soon.

The members of the Sub-Commission are largely responsible for identifying the issues to be addressed and for forming working groups (WGs) to actively resolve these issues. The follow working groups have already been created:

North American Reference Frame (NAREF)
Reference Frame Transformations
International Great Lakes Datum (IGLD)

Activities within each working group are discussed below.

North American Reference Frame (NAREF) Working Group

This is the most active working group of the Sub-Commission. The primary purpose of the WG is to densify the ITRF reference frame in the North American region by organizing the computation and combination of weekly coordinate solutions and associated accuracy information for continuously operating GPS stations that are not part of the IGS global network. Cumulative solutions for coordinates and velocities will also be determined on a regular basis once a sufficiently long series of weekly solutions is obtained. The WG organizes, collects, analyzes and combines solutions from individual agencies, and archives weekly solutions. By the end of August, weekly solutions will also be made available to the public and submitted to the IGS Global Data Centers.

The goals of the WG and some of it's work have been promoted at various conferences over the past year and a half, beginning with the special session "Densification of the ITRF in North America" at the American Geophysical 2000 Spring Meeting (Craymer and Milbert, 2000; Craymer et al., 2000).

The current contributing members of the WG are:

Michael Craymer (NRCan/GSD, Canada – Chairman)
Mieczyslaw Piraszewski (NRCan/GSD, Canada)
Brian Donahue (NRCan/GSD, Canada)
Herb Dragert (NRCan/GSC/PGC, Canada)
Matthijs van Domselaar (SIO, U.S.)
Finn Bo Madsen (KMS, Denmark)
Remi Ferland (NRCan/GSD, Canada – IGS representative)

These members have been active in providing regional solutions and assistance in combining them. A plot of the current network is given in Figure 1. Clearly, the network only covers the northern half of North American. It is hoped that the U.S. National Geodetic Survey will soon provide weekly solutions for its CORS network and that

Mexico will also provide solutions for its own national network of permanent GPS stations. These contributions will then make the NAREF combinations truly North American in scope.

For more information about the NAREF working group and its progress, see Craymer and Milbert (2000a, b), Craymer et al. (2000) and Craymer and Piraszewski (2000a, b, c).

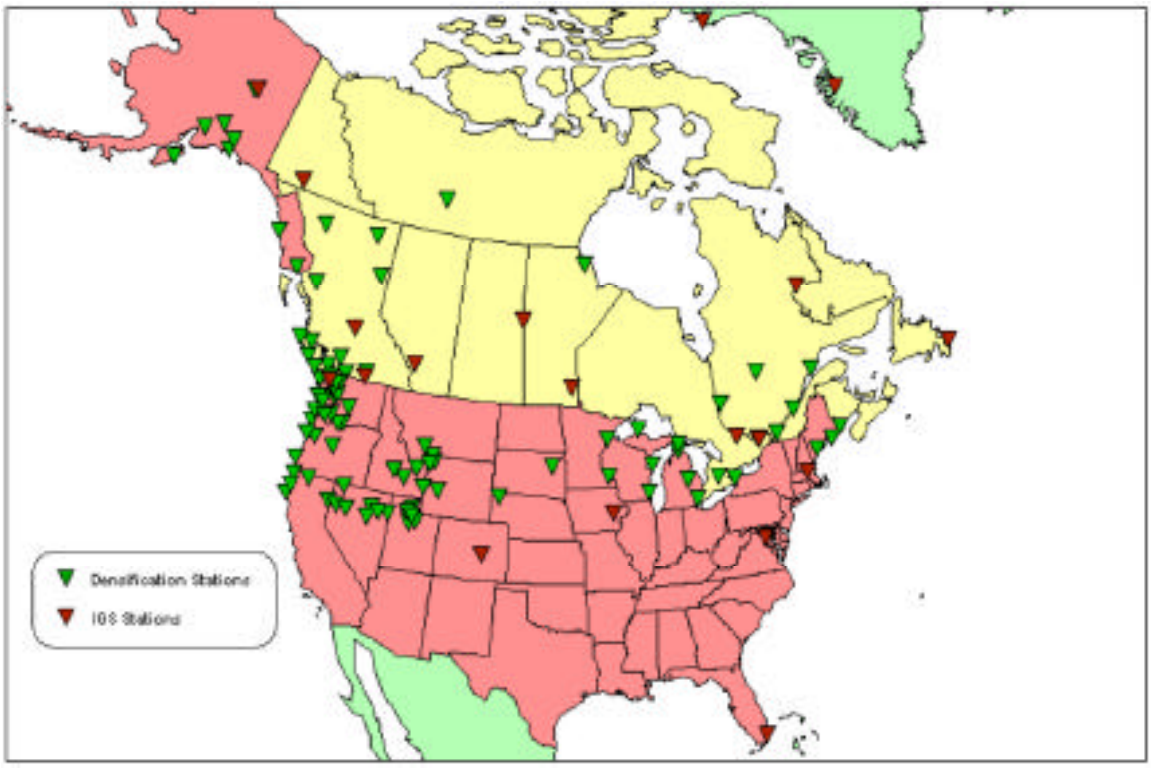

Figure 1: Current NAREF densification network. Red (dark) symbols represent the 20 stations in IGS global solution and green (light) symbols the 94 NAREF densification stations. Note that the two stations at Churchill and Yellowknife are shown as densifications stations as they do not appear in the IGS solution for the week used to produce the plot.

Reference Frame Transformations Working Group

The purpose of this WG is to determine consistent relationships between international, regional and national reference frames/datums in North American, and to maintain (update) these relationships as needed. The WG has been very active on an informal basis since 1997 and includes the following memebers:

Michael Craymer (NRCan/GSD, Canada – Chairman)
Richard Snay (NOAA/NGS, U.S.)
Tomos Soler (NOAA/NGS, U.S.)
Remi Ferland (NRCan/GSD, Canada – IGS representative)

The primary focus of the WG has been on maintaining the relation between the North American Datum of 1983 (NAD83) and the International Terrestrial Reference Frame (ITRF). In fact, NAD83 has now been defined in terms of a 7 parameter Helmert transformation from ITRF96 (Craymer et al., 2000). Transformations to/from other ITRF realizations are determined by adding the incremental transformations between ITRFs, as adopted the the IERS and/or the IGS.

This work has unified the fundamental definition of NAD83 in both the U.S. and Canada. Software tools have also been provide for users in both countries to make access to the NAD83 and ITRF reference frames easier than ever.

International Great Lakes Datum (IGLD) Working Group

The purpose of this working group is to consider problems related to the maintenance of the vertical datum for the management of the Great Lakes water system, including post-glacial rebound, the use of GPS/geoid techniques, lake level transfers through hydrodynamic models, comparisons with NAVD88 and the possible implementation of a revised height system.

So far, this working group has been inactive primarily because most of the work is being conducted under the auspices of the International Great Lakes Committee of **???** It is hoped that future interaction with members of the Subcommision will foster more input from the Subcommission, especially the NAREF WG in the area of GPS monitoring of crustal motion.

Other Activities

In addition to the formal activities of the Subcommission's working groups, all countries of the Subcommission have been very active in the past couple of years maintaining and enhancing their own geodetic networks. Here we report only on some of the highlights as they pertain to the activities of the Subcommission.

United States

The U.S. National Geodetic Survey (NGS) delivered two separate GPS contributions to ITRF2000 in the year 2000 (Marshall, 2001), and NGS will release ITRF2000 positions and velocities for the National CORS within the next few months. The GPS contributions to ITRF2000 were primarily completed by a three member NGS team (Dr. Mark Schenwerk, Mr. William Dillinger, and Dr. John Marshall) using the PAGES/GPSCOM software suite developed at NGS.

The first contribution to ITRF2000 contained 165 global sites (second in size only to JPL's 170 site contribution) and was delivered in March 2000. The second contribution contained 60 CORS sites (considered a ``GPS Densification'') and was delivered in

December 2000. Six years of RINEX data (January 1, 1994 through December 31, 1999) were processed to arrive at the two contributions. NGS' 165 site contribution was in good agreement with the preliminary ITRF2000-P solution: 6-7 mm rms agreement in position and 3 mm/yr rms agreement in velocity.

In recent months NGS has processed an additional year of RINEX data (extending to December 31, 2000) to support the upcoming release of ITRF2000 positions and velocities for all existing National CORS. NGS is using a variety of data cleansing strategies to ensure the accuracy of these results including inspection of antenna heights, antenna types, receiver performance, and North-East-Up time series plots, for instance. Further, to maintain consistency with the published IERS positions and velocities, NGS will contrain its upcoming solution to those sites which compare favorably between an NGS multi-year minimally-contrained solution and the published IERS solution.

Canada

Most of the geodetic networks activities in Canada have been concerned with the maintenance and enhancement of the Canadian Active Control System (CACS), the addition of regional permanent GPS stations and the completion of the Canadian Base Network (CBN).

The Geodetic Survey Division (GSD) in partnership with Geological Survey of Canada (GSC), both of Natural Resources Canada, are presently operating the Canadian Active Control System (CACS) to provide improved GPS positioning capability for the Canadian surveying and geophysical community as well as for other spatial referencing needs.

GSD also contributes CACS data to the IGS and participates as an Analysis Center. Through the IGS, CACS data and related products are made available to international organizations such as the International Earth Rotation Service (IERS), the NASA Crustal Dynamics Data Information System (CDDIS), the US National Geodetic Survey (USNGS), the US Naval Observatory (USNO) and other organizations interested in Earth dynamics. Recently, GSD has also assumed the responsibility of Reference Frame Coordinator for the IGS.

More recently, plans have begun to install 11 new permanent GPS stations in the Summer of 2001. Two (Fredericton and Eureka) will be become part of the CACS network. Three others (Inuvik, Resolute, Holman) are being installed in the Arctic to support a joint project between GSD and GSC to determine relative crustal motions around the Beaufort Sea. The six remaining stations are being installed around Hudson Bay in a joint project with Geoforshungszentrum (Germany) and GSC to measure post-glacial rebound. Plans are also underway to install 4 more permanent GPS stations in 2002, collocated with tide gauges in the Arctic. These stations will be processed by GSD and integrated into the IGS global network as part of the NAREF densification network. It is expected that these stations will also contribute to the new IGS GPS Tide Gauge Benchmark Monitoring (TIGA) Pilot Project.

Finally, the Canadian Base Network (CBN) was completed in 2000 with the addition of 6 new stations in the Arctic. This completed the Canada-wide network of 154 monuments that provide a more traditional but very high accuracy control network for further densification by individual provinces. Remeasurement of the eastern half of network began in 2001 in order to monitor monument stability and to determine the effects of post-glacial rebound. Remeasurement of the western half of the network is scheduled for 2002. Thereafter, remeasurements are expected to occur on a 4-5 year basis or as needed to provide more accurate measurements of post-glacial reboud and thus more accurate, up-to-date coordinates.

Greenland

Five geodetic permanent GPS stations are now in operation in Greenland. The Geodetic Department of the National Survey and Cadastre of Denmark operates and maintains the stations at the Thule Airbase (THU1 and the newly established THU2) and in Scoresbysund (SCOB). Stations KELY and KULU in Kelyville and in Kulusuk, respectively, are operated by the University of Colorado. The stations THU1 and KELY are included in the IGS global network. THU2 was established in 1998 as a long-term stable station to complement the THU1 station. THU2 is equipped with a GPS/GLONASS receiver and has contributed to the IGEX and the IGLOS campaigns. Recently, THU2 was accepted for the IGS LEO network. A new station in southern Greenland is being established in Julianehaab to complete the coverage in the region.

Activities associated with the upgrading of the geodetic network in Greenland have been going on for several years. In 1996, the REFGR reference frame for Greenland was defined and includes eight globally positioned reference points. Since then, GPS points have been established throughout the populated parts of Greenland. In 2000, a special effort was made to complete this task. Sixty-seven settlements were visited and 171 new points established. Most new points were established at old reference points so that the classic geodetic triangulation measurements can be used together with the GPS coordinates in the computation of the new coordinates. The software for the combined adjustment of the new and the classic measurements was developed and new coordinates for most of the ice free parts of Greenland have been computed during 2001.

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