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Reference System Modernization in Canada

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Canada

Outline

- Overview of the Canadian Spatial Reference System (CSRS) modernization plan
- Improved geometric reference system - NATRF2022
- Updated realization of the vertical datum - CGVD2013
- Modernized Canadian Geodetic Survey tools and services
- Reference frame roles and responsibilities in Canada



Canada is planning to modernize their spatial reference system in 2025

- As part of this plan we will replace **NAD83** with a new geometric reference system called the North American Terrestrial Reference Frame of 2022 (**NATRF2022**)
- We will also update our realization of **CGVD2013** with a new North American geoid model (**GEOID2022**) compatible with **NAPGD2022**
- These modernized systems are being developed as a collaborative effort between the U.S. and Canada

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov

New Datums Are Coming!

NOAA is Replacing NAD 83 and NAVD 88.
NOAA's National Geodetic Survey (NGS) will be replacing the datums of the National Spatial Reference System (NSRS), including the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88). NGS will provide the tools to easily transform between the new and old datums. Read the NGS Ten-Year Plan and visit the [New Datums Web page](#) on our site to learn more.

How You Can Prepare

- Learn if **legislations** or other formal documents referencing NAD 83 and NAVD 88 need to be changed in your state.
- **Transform existing data** to the latest NSRS datum and realization, i.e. NAD 83 (2011), GEOID20, and NAVD 88.
- **Obtain precise ellipsoidal heights** on NAVD 88 bench marks, and visit the GPS on Bench Marks Web page to learn more.
- **Require and provide complete metadata** on all mapping contracts. See our website for more details.

Benefits
The new reference frames (geometric and geopotential) will rely primarily on **Global Navigation Satellite Systems (GNSS)**, such as the Global Positioning System (GPS), as well as a **gravimetric geoid model** resulting from NGS' **Gravity for the Redefinition of the American Vertical Datum (GRAV-D)** Project.

The target accuracy of differential orthometric heights (heights relative to sea level) in the geopotential reference frame will be 2 centimeters over any distance, where possible.

What You Can Expect
The magnitude of change with the new datums will vary depending on the datum you are using and your geographic location. The new geometric datums will change latitude, longitude, and ellipsoidal height between 1 and 2 meters. In the contiguous United States (CONUS), the new vertical datum will change heights on average 30 centimeters, with approximately a 1-meter tilt towards the Pacific Northwest.

The new datums will extend across CONUS and U.S. territories. The geometric datum replacing NAD 83 will be consistent with geocentric global reference frames defining latitude and longitude. The geopotential datum replacing NAVD 88 will be based on a gravimetric geoid model, enhanced by data from NGS' Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project.

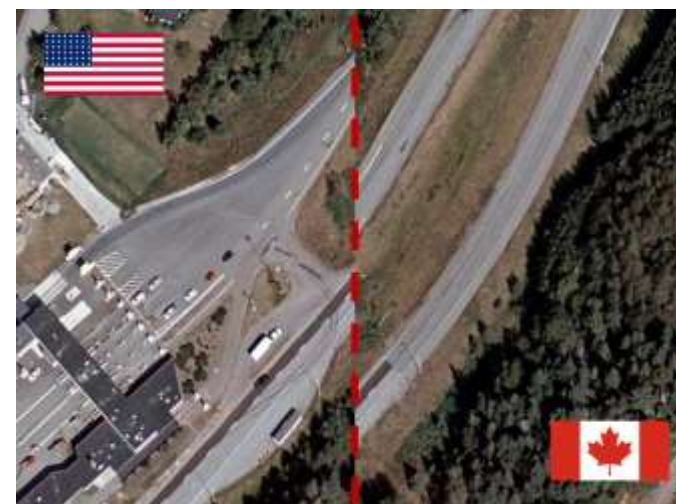
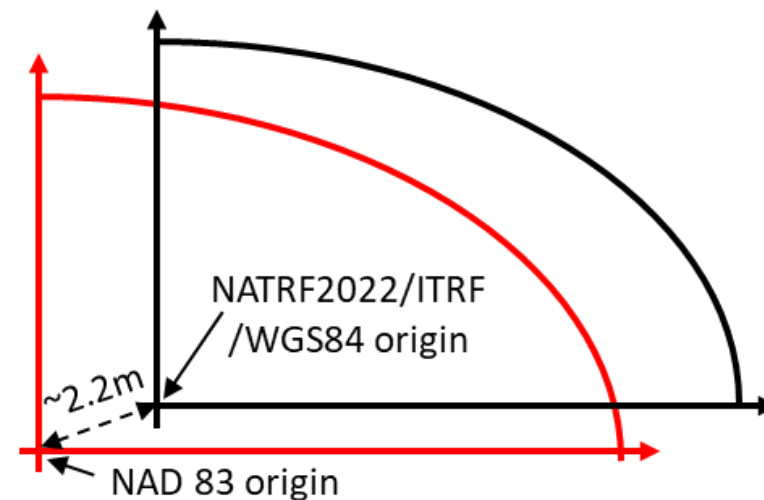
New Datums

National Oceanic and Atmospheric Administration National Geodetic Survey



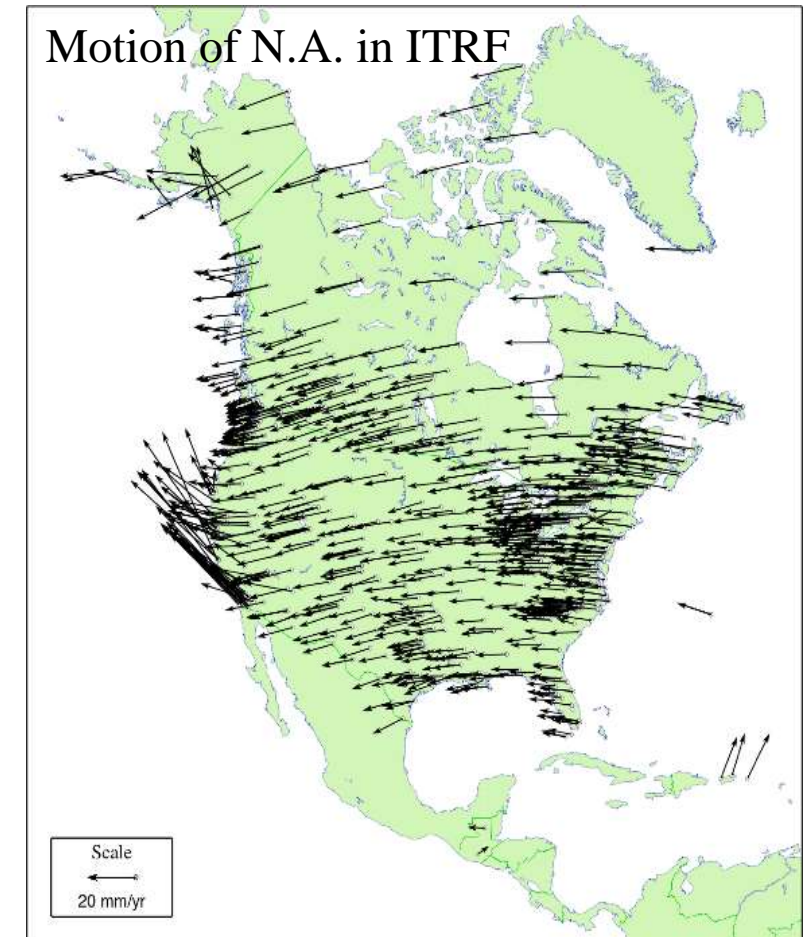
Rationale for CSRS modernization

- NAD83 is not a geocentric system as the origin is off by about 2.2m
 - GNSS systems (e.g., GPS) and the ITRF are geocentric
- NATRF2022 better supports precise positioning from space (GNSS)
- Supports compatibility along the Canada / U.S. border and with international standards
- CSRS modernization also provides an opportunity to unify reference system adoption across Canada



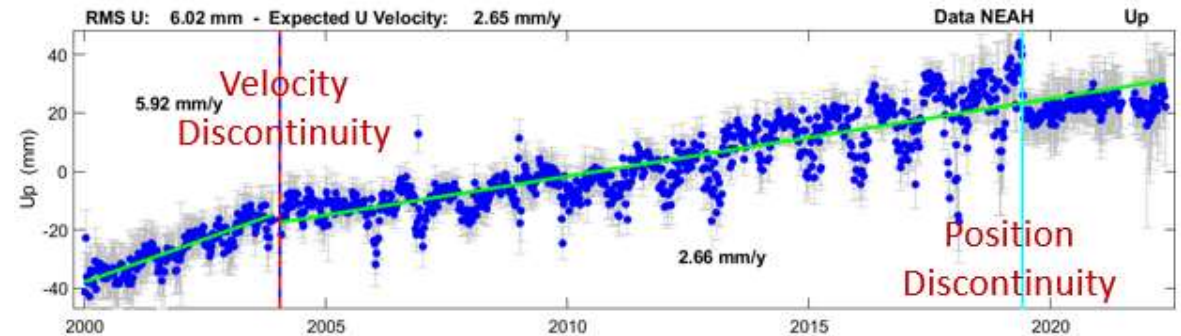
NATRF2022: An improved geometric reference system

- NATRF2022 will be equivalent to ITRF2020 at epoch 2020.0
- Frame will then be kept fixed to the North American plate using an accurate plate motion estimate
 - Defined as Euler pole parameters (EPP) and expressed as rotation rates about X,Y,Z axis
- Similar to the current NAD83(CSRS) definition with two significant improvements:
 - NATRF2022 will be geocentric at the cm level
 - Will have an improved plate motion model



NATRF2022: A dynamic reference system

- Earth is a dynamic planet and positions change in time
 - Can be due to dramatic events like earthquakes or subtle motions like glacial isostatic adjustment
- NATRF2022 will be realized by the coordinate functions of GNSS active and campaign stations
- Dynamic reference frames are adopted at a specific epoch (snapshot) in time and NATRF2022 will initially be adopted at epoch 2020.0

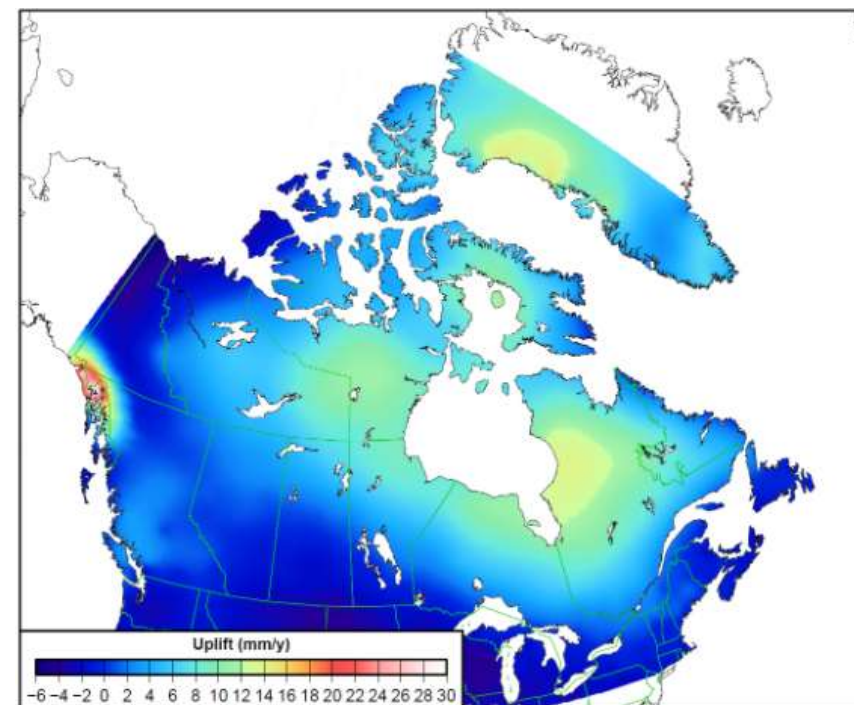


Maintaining accurate metadata is essential, indicating reference frames and epochs for all coordinates and geospatial files



NATRF2022: A dynamic reference system

- NATRF2022 will also include an **intra-frame deformation model (IFDM)**
 - Will account for any residual and/or local motions
 - Derived from estimated coordinate functions
 - Will be used for propagating coordinates to different epochs
 - Will be included in CGS tools (CSRS-PPP and TRX)
 - Initially (2025) IFDM2022 will use a similar model as the current NAD83(CSRS) national velocity model



NAD83(CSRS) v7.0 vertical velocity model

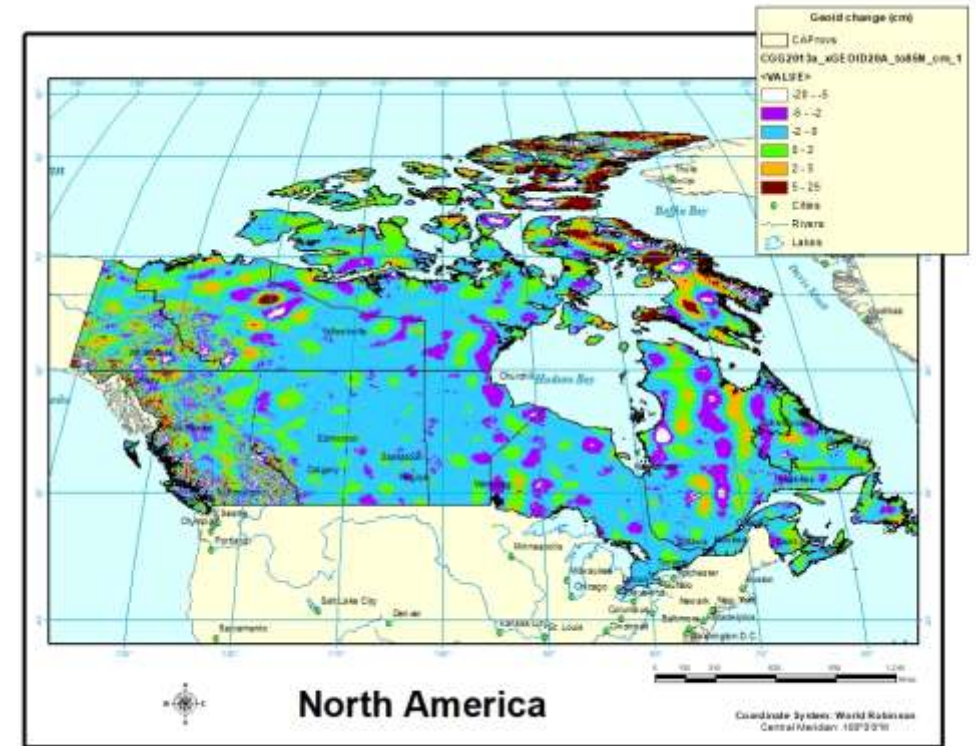
CGVD2013 / NAPGD2022 Details

- Canada adopted a geoid-based vertical datum in 2013 called the Canadian Geodetic Vertical Datum of 2013 (CGVD2013)
- CGVD2013 and NAPGD2022 have the same definition ($W_0 = 62,636,856.0 \text{ m}^2\text{s}^{-2}$)
- CGVD2013 is currently realized by the CGG2013a geoid model but Canada plans to update this realization in 2025 using a common N.A. geoid model with the U.S. (GEOID2022)
- The only small difference is that NAPGD2022 plans to have a dynamic component to the geoid model while CGVD2013 will adopt only the static component



Practical impacts of CSRS modernization

- NATRF2022 and NAD83 will have an approximate **1-2 m 3D geometric position difference** in Canada
 - Latitude, longitude, ellipsoidal height
- The updated realization of the vertical datum, CGVD2013(GEOID2022), will cause **orthometric height differences of up to several cm's** in southern Canada



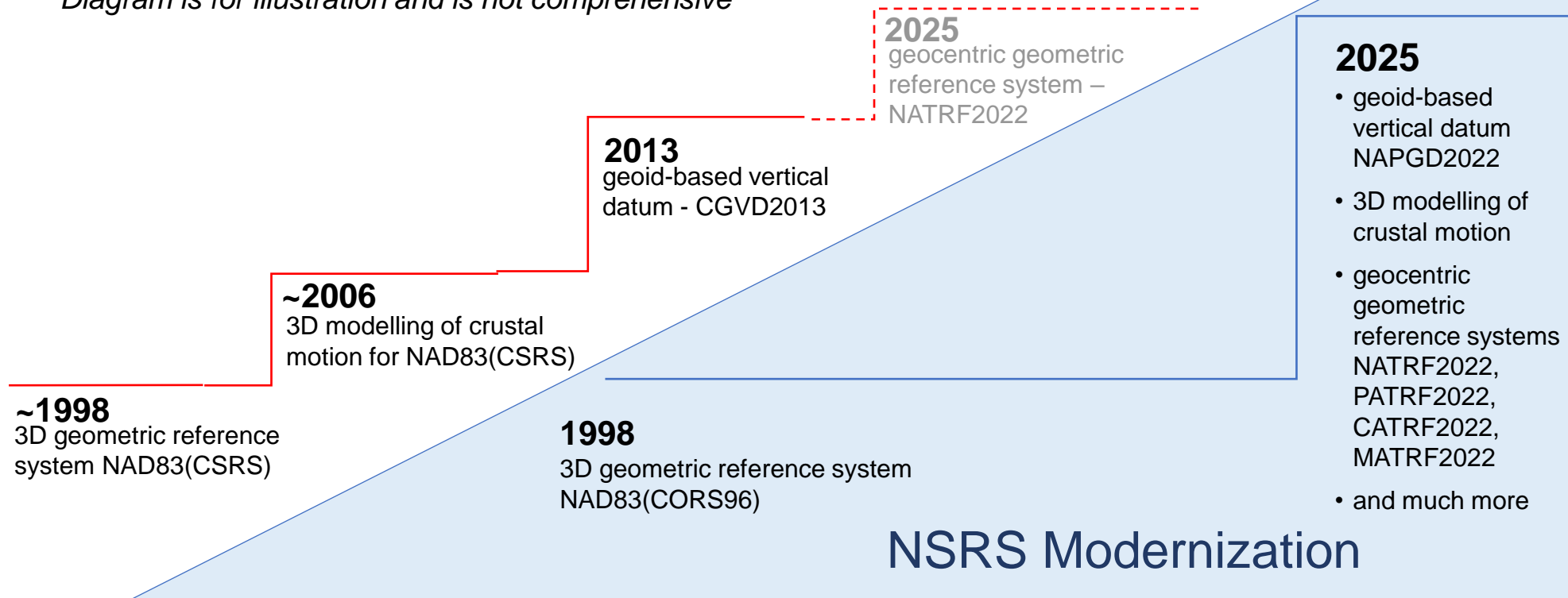
CGG2013a – xGEOID20A



NATRF2022 is the final step in the CSRS modernization

CSRS modernization

** Diagram is for illustration and is not comprehensive*



Working in the modernized CSRS

- By 2025, CGS will provide updated tools and data products to support users working in and migrating to the modernized CSRS including:
 - NATRF2022 **coordinate functions** for both public and commercial “compliant” ACS networks
 - The **CSRS-PPP** positioning service will be updated to provide solutions in NATRF2022 and CGVD2013(GEOID2022)
 - The coordinate transformation tool (**TRX**) will be updated to support NATRF2022 and the updated Canadian IFDM
 - The height conversion tool (**GPS-H**) will support GEOID2022 and a new standard geoid grid format (e.g., GGXF)
 - Updated **geoid models, IFDM, and NAD83<->NATRF2022 transformation parameters** will be available for download from CGS’ website



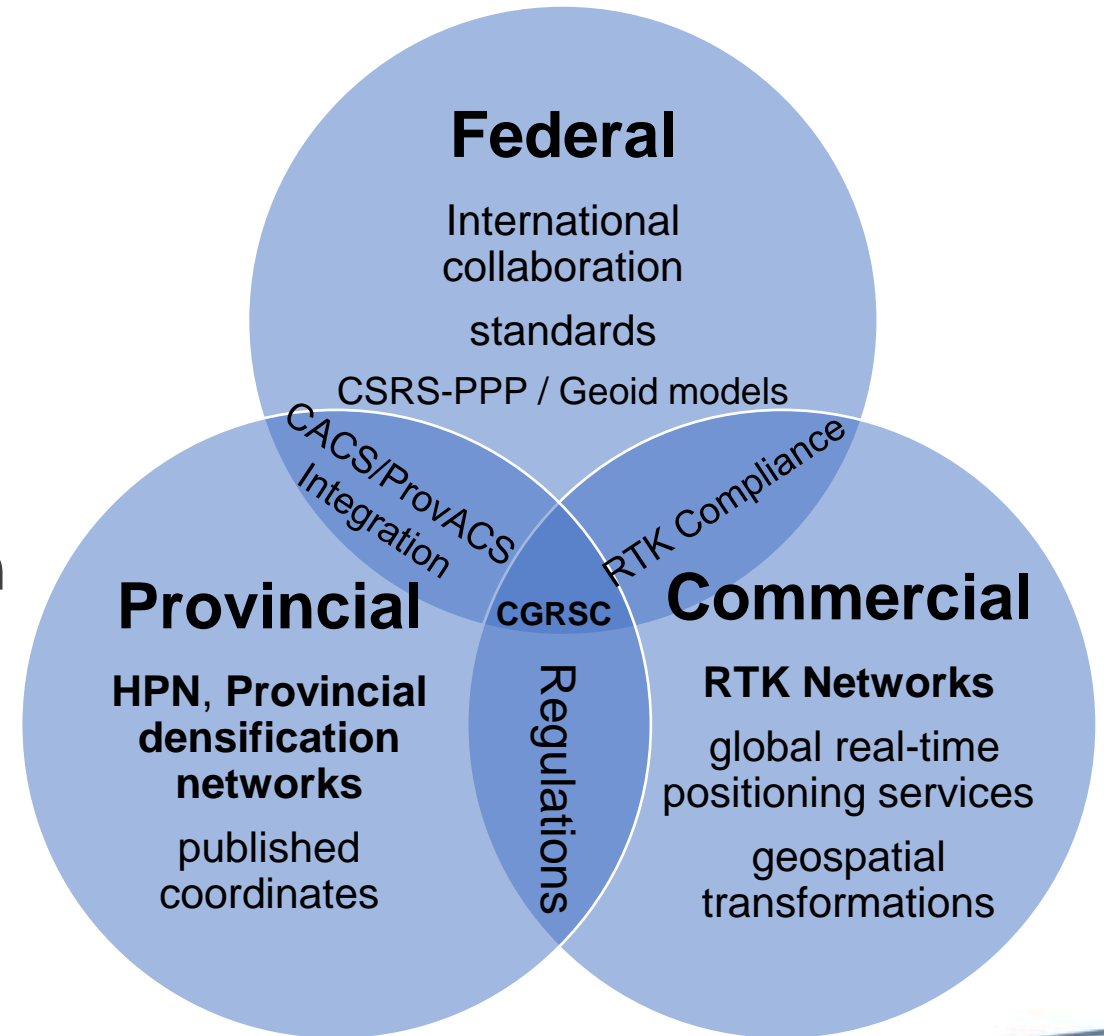
Role of commercial geospatial software providers

- Users also need geospatial software tools to help them move to the new datums
 - Need to ensure commercial geospatial software is ready for NATRF2022 and CGVD2013/NAPGD2022
 - Need to support dynamic datums, IFDMs, and transformations
 - This will allow geospatial agencies to migrate existing NAD83(CSRS) geospatial data holdings to NATRF2022 epoch 2020
 - Examples:
 - Federal road network - NAD83(CSRS) epoch 2010 -> NATRF2022 epoch 2020
 - Provincial cadastral fabric – NAD83(CSRS) epoch 1997 -> NATRF2022 epoch 2020
- Alpha & Beta products need to be provided by CGS & NGS to help developers prepare



Geodetic services are a shared responsibility in Canada

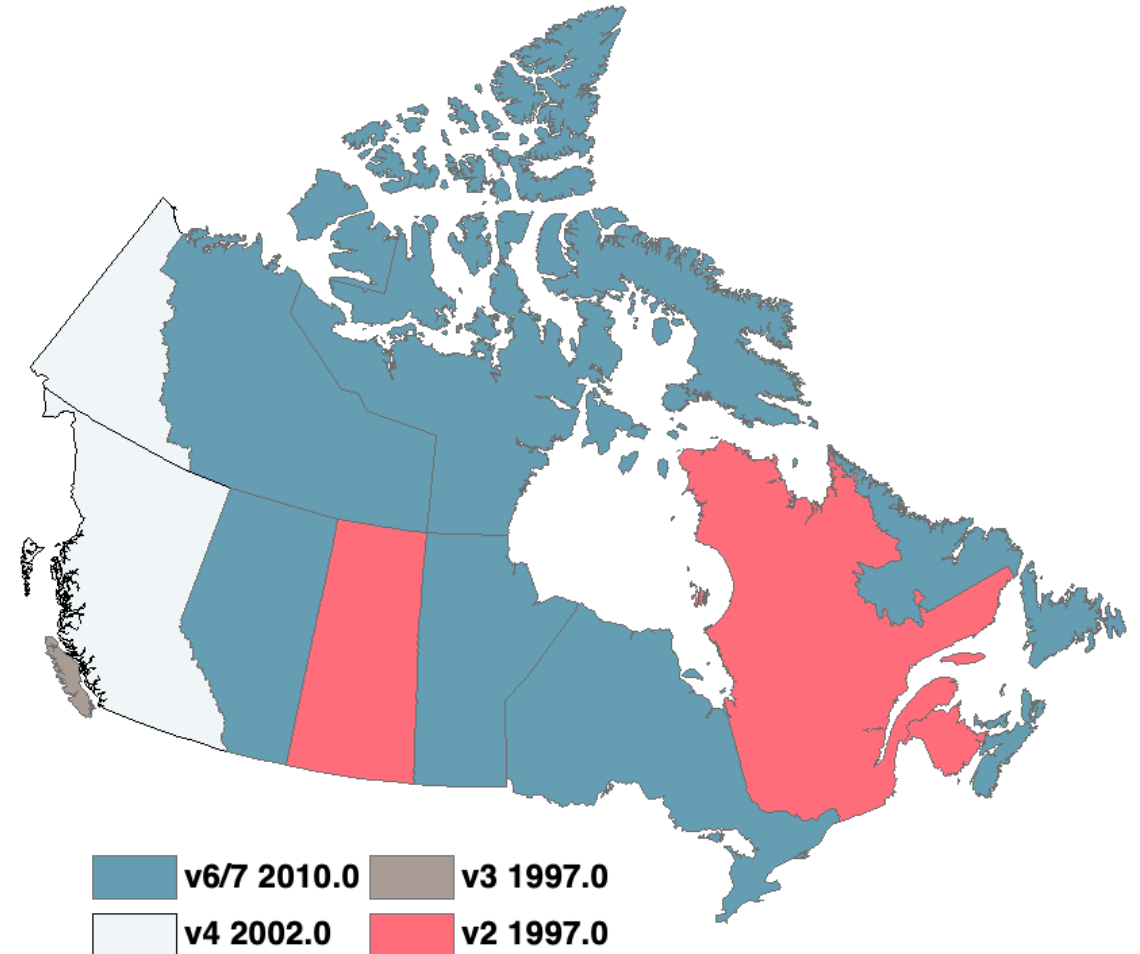
- Defining the reference system is a federal mandate (NRCan/SGB/CGS)
- Provinces have the authority to regulate reference system usage in their jurisdictions
- Delivering the reference frame is coordinated through the **CGRSC (Canadian Geodetic Reference System Committee)**, a subcommittee of the Canada Council on Geomatics



Reference frame adoption in Canada

- Different NAD83(CSRS) versions across Canada
- Differences between versions and epochs that must be properly addressed
- Confusing when working across provinces and for commercial services

NATRF2022 is an opportunity for a common reference frame in Canada



Important takeaways

- CGS will adopt NATRF2022 and update CGVD2013 in parallel with the U.S. modernization in 2025
- Unified adoption of the modernized reference frames will enable efficiencies but require both geodetic and geospatial tools
 - CGS will provide the tools to update coordinates but will rely on commercial geospatial software to provide the tools for data layer migration
- CGS is working with the Canadian provinces to plan for a unified modernization sometime after 2025



NATRF2022



We'd like to hear from you if you have feedback or questions regarding reference system modernization in Canada

CGS : geodeticinformation-informationgeodesique@nrcan-rncan.gc.ca

Thank you!

