CCCM Procedural Guide re Geo-referencing Requirements on Canada Lands, 2008

Draft v.3

The document is work in progress that is intended to clarify the new geo-referencing requirements in Chapter D1 of the General Instructions which came into effect on April 1, 2008.

Background

Today cadastral data forms a foundation for land information infrastructure and will be increasingly used for a broad array of activities such as infrastructure management, emergency response and business geomatics. Geo-referenced cadastral surveys are needed to improve the relative and absolute accuracy of cadastral datasets in order to meet the widest possible user needs.

Spatial applications and Global Navigation Satellite Systems (GNSS) positioning technologies (e.g. GPS) are demanding more accurate data in a consistent reference system (e.g. NAD83CSRS). For example, digital imagery can now be obtained at the sub-metre level and is getting more accurate each year. In some cases, Google Earth imagery already has better positional accuracy than that of the cadastral data. Municipal and utility infrastructures are already requiring decimeter level accuracy.

In 2005 the Canadian Council on Geomatics (CCOG) passed a resolution whereby each province/territory agreed to develop and implement a plan to require geo-referencing for legal surveys according to the principles and standards set out in the resolution. The ACLS web site under *Members Publications* contains some of the background documents that led to the resolution, including; *Coordinates in Context, (Ballantyne et al. 1999)* and *Integrated Land Surveys (Ballantyne, 2002)*.

Benefits of Geo-referencing

Specific benefits to the Canada Lands Survey System include:

- Improves the accuracy of the cadastral data
- Enables digital submission of survey plans in a consistent reference system;
- Enables efficient updates to cadastral datasets;
- Provides a transitional bridge towards the broader use of coordinates in defining boundaries.

Specific benefits to the land survey profession and other geomatics users include:

- Cadastral data is consistent with GPS and other spatial positioning techniques;
- Precise geo-referencing as an aid to boundary location and evidence searches;
- Blunder detection routines enabled by comparing new surveys with existing cadastral data;
- Free access to accurate cadastral data for use in a wide range of geomatics projects and applications.

Past Geo-referencing Practices

The third edition of the Manual of Instructions for the Survey of Canada Lands published in 1997 required all surveys to be connected to existing federal or provincial survey control networks providing there are survey markers within one km of the survey. Failing that, the survey must be connected to the closest legal survey or survey marker, or a permanent feature identifiable topographic map or aerial photograph. These standards were primarily based on using ground based conventional survey techniques, and in many cases the control connections were impractical to complete. We now find that connections to weaker control markers (third and second order) provide little if any value to improve the accuracy of the cadastral data, because the data is, in many cases, more accurate. With the discontinuation of GPS Selective Availability (SA), it is now easy to obtain positions better than 3 metres in real time using a $100 recreational-grade receiver. The modernization of spatial reference systems and positioning techniques (GPS) requires the standards to be up-dated.

The current edition of the Manual (*General Instructions for Surveys of Canada Lands, e-Edition*) also requires surveys within Coordinated Survey Areas (CSA) to be integrated into a ground based control network. There are only a few CSA on Canada Lands, which include Whitehorse, Yellowknife, Inuvik, Hay River, Iqaluit, Jasper and Banff. Over the last 40 or more years, integrated surveys and more recent GPS control surveys have provided the control needed to accurately capture the cadastral data in these areas. The accuracy of most of the cadastral data in these CSA is better than 10 cm such that further conventional CSA ties provide little benefit because the accuracy of the data is close to that of conventional connections. It still makes sense to require the integration of new surveys that are outside the survey fabric or where the fabric is spatially weak, but this can be more efficiently and effectively done through GPS connections to a much less dense network of high precision markers. As a result, it is quite likely that the traditional CSA will be de-proclaimed.

Over the past twenty years there have been many large framework surveys on Canada Lands, particularly those of land claim parcels in the North. Most of the initial Inuvialuit Surveys done during the late 80s and early 90s were controlled by conventional techniques, whereas the surveys of parcels resulting from later Land Claim Agreements have primarily used GPS to control and geo-reference the surveys. These surveys together with GPS data capture control contracts has allowed CCCM to dramatically increase the accuracy of the cadastral data in the north such that the absolute accuracy of most communities and developed corridors in the North is now better than 0.3 metres. In some areas, where it is better than 0.1 metres, additional geo-referenced surveys generally will not help improve the accuracy of the data. But, there are many Canada Lands that have not benefited from these recent framework surveys where geo-referenced surveys are needed to improve the cadastral data.

Geo-referencing Standard

To minimize the impact on the survey profession CCCM is proposing a phased approach towards the eventual requirement for full geo-referencing of all surveys in 2 years. In the first phase, geo-referencing will be required for remote surveys and for surveys that are using GPS methods to control or measure part of the survey as specified in paragraphs 59 and 60 of Chapter D1 of the e-Edition. No geo-referencing is required in developed areas (rural and urban) in cases where the survey is done by conventional methods and is connected to part of the cadastral fabric.

59: GPS Controlled Surveys: *In cases where GPS methods are used to control or measure all or part of the boundaries in a survey, all monuments within the survey shall be geo-referenced to NAD83CSRS to an absolute accuracy of 20 cm or better.*

60: Remote Surveys: *All remote surveys shall be geo-referenced to NAD83CSRS to an absolute accuracy of one metre or better. A remote survey includes but is not limited to the following:*

a) surveys that are not connected to the cadastral survey fabric of inhabited urban or rural areas;

b) surveys connected to existing remote legal surveys; and

c) surveys within remote Indian Reserves which have less than twenty parcels.

The standards also include the following clauses:

> *58: All surveys shall be connected to one, and preferably two, monuments of the closest existing legal survey provided a legal survey lies within one kilometre of the current survey. Specific survey instructions may exempt connections between the new survey and nearby existing legal survey in cases where both the new survey and nearby existing legal survey are accurately geo-referenced to NAD83CSRS or other approved reference system.*
>
> *61: Specific survey instructions may exempt the geo-referencing specified in paragraphs 59 and 60 in cases where the survey is connected to an accurately geo-referenced existing legal survey.*
>
> *62: If it is difficult to meet the 20 cm absolute accuracies for all of the monuments in the survey then an authorized regional representative of the Canada Centre for Cadastral Management may reduce the absolute accuracy requirements for some of the monuments. This may occur with larger surveys where there is an extensive conventional survey between GPS control points.*

Paragraph 59 applies to any survey where GPS is used to control or measure some of the boundaries in the survey. This includes a survey that is using geodetic quality GPS receivers and carrier phase observations to measure baselines to cm accuracies or RTK positions to cm level accuracies. It does not include a survey that is using code observations to make ties to features or a natural boundary. If geodetic GPS measurements are being observed in the survey, it doesn't take much more effort to geo-reference the survey to an absolute accuracy of 20 cm by using CSRS-PPP, an on-line GPS processing service provide by the Geodetic Survey Division (GSD), NRCan. (more information at http://www.geod.nrcan.gc.ca/products-produits/ppp_e.php)

The surveyor most likely will use GNSS positioning methods to obtain the 1 metre accuracy for remote survey required by paragraph 60. Conventional ties to suitable ground control markers may also be used, but for remote surveys these markers are usually not available, and in many cases, the absolute accuracy of the weaker control markers are not known. It's expected that a surveyor will need to have at least a mapping grade receiver to obtain the 1 m accuracy requirement for remote surveys. A CSRS-PPP solution with 30 minutes of mapping grade data will produce 50 cm accuracies and 2 hours of data will produce 20 cm accuracies (accuracies from GSD testing).

Paragraph 60 attempts to define a remote survey in a few sentences, but it is subjective. In general it includes any survey that is outside an urban or rural area, a rural area being an inhabited area with a low population density and in which there are human or economic activities such as agricultural, mining or fishing. It also includes the smaller Indian Reserves, where there has been little activity and have not been geo-referenced, which includes many small remote reserves in B.C. If in doubt and the survey does not connect to part of the cadastral fabric that is already geo-referenced, it is considered remote and requires 1 m geo-referencing.

In some jurisdictions, such as New Brunswick and Quebec, it is standard practice to make ties to ground control markers. Although these ties are no longer required under the new standards (unless they are for a remote survey) they may still be made. If made, the surveyor should geo-reference the survey using the ties and report on the estimated absolute accuracy of the survey.

The 20 cm and the 1 m absolute accuracies required by paragraphs 59 and 60 are at the 95% confidence level, as per the definition of absolute accuracy in the Glossary of the e-Edition. CCCM may have to amend these paragraphs if there is too much confusion about this requirement.

It's important to note that paragraphs 59 and 60 specify the minimum geo-referencing requirements for the entire survey (see figure 1). This means the entire survey must meet a specified absolute accuracy, whereas the traditional accuracy requirements just apply to the directly connected points (also specified in CCOG resolution). This is one reason why CCCM elected to specify a 20 cm absolute accuracy rather than 5 or 10 cm, which are easily achievable by PPP. This absolute positional requirement for the entire survey does not normally impact smaller surveys, but there is an impact on larger surveys where there are extensive conventional surveys between connected points. Paragraph 62 provides some flexibility in cases where it may be difficult to meet the 20 cm accuracy requirement, e.g. long conventional traverses between GPS control points.

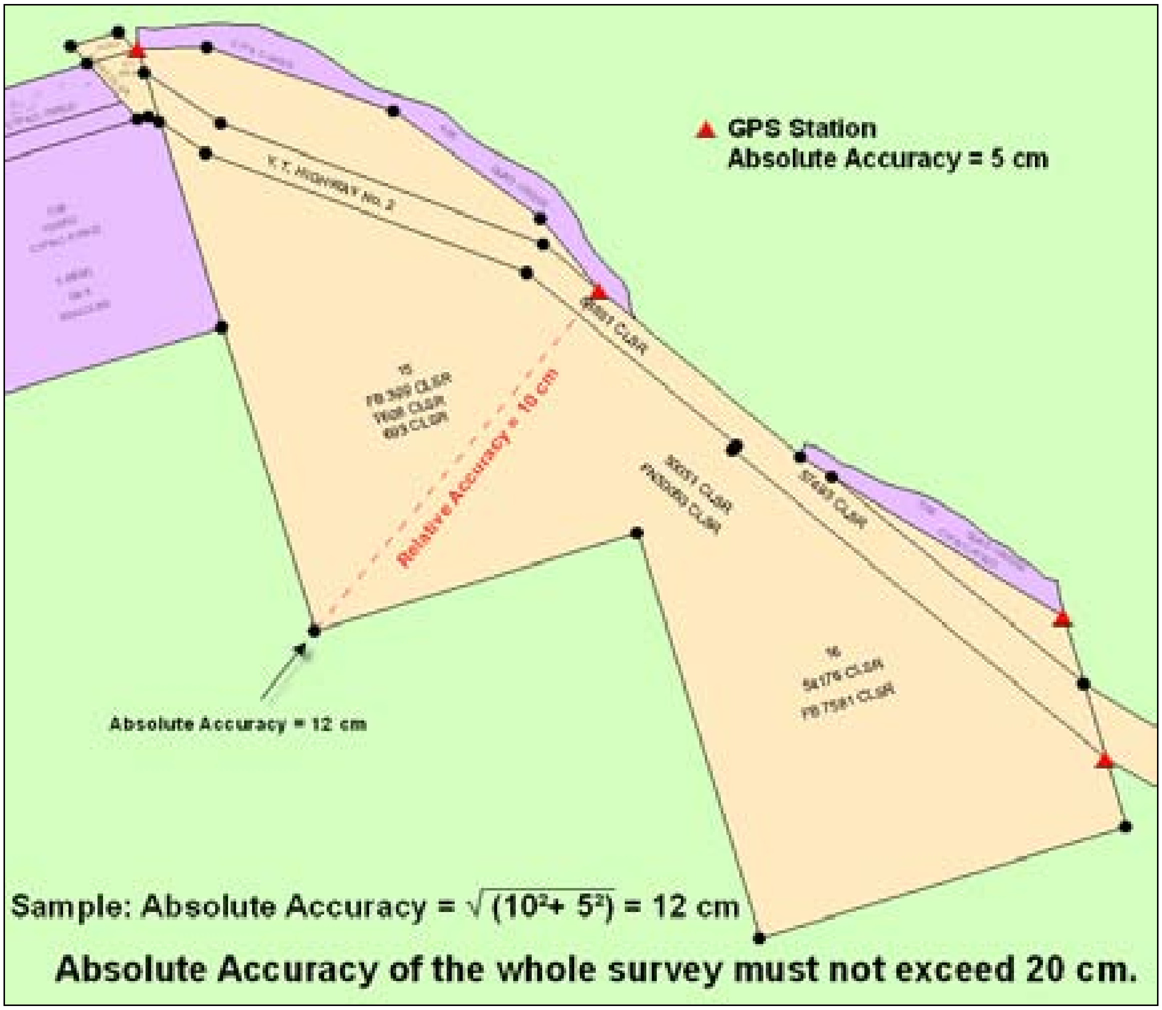

Figure 1: Absolute Accuracy of Survey

Paragraph 61 states that geo-referencing will not be required if the new survey is connected to part of the cadastral data that has reached a certain level of stability in terms of accuracy and repeatability. It is important to note that it will be the accuracy of the cadastral data that determines if geo-referencing will be required rather than the connections shown on an existing legal survey plan. In order to determine this, CCCM is currently capturing and tracking the accuracy of the data (more discussed below under cadastral data maintenance). The 1 m geo-referencing will not be required for a new remote survey if the new survey is connected to cadastral fabric that is already geo-referenced to better than 1 m. In cases where GPS is used, geo-referencing will be required in most cases until the data has proven to be very reliable, i.e. better than 5 cm.

The CCOG resolution standard requires 5 cm urban, 20 cm rural and 1 m remote relative accuracies for the control connections. At this time, CCCM will require 1 m accuracies for all remote surveys and a 20 cm absolute accuracy in cases where GPS is used to control or measure some of the survey. The following reasons support this approach:

- 1 metre point position accuracies using mapping grade receivers and 3- 5 cm point position accuracies using geodetic grade receivers are easily obtained using the CSRS-PPP service. This recent PPP service is reducing the need for high accuracy ground control markers, except in cases where cm level accuracies are required.
- A new remote survey geo-referenced to 1 m provides much more value than that positioned by a pin-pricked aerial photograph or by a topographic map (old standards of the General Instructions)
- 1 metre accuracies will help up-grade the existing remote cadastral data in cases where the new geo-referenced survey is connected to the existing cadastral fabric.
- In more developed areas, higher accuracies are required to up-grade the cadastral data; 5 cm would be great, but this may increase the cost of the survey by too much.
- Most Canada Lands do not have the control infrastructure that will support 5 cm accuracies.
- Control connections to weaker ground control markers do not usually help up-grade the accuracy of the cadastral data. An absolute accuracy requirement requires the surveyor to ensure they are only using accurate ground control markers or other methods, e.g. PPP.
- CCCM's data maintenance approach somewhat limits the achievable accuracy of the cadastral data – a 5 cm absolute accuracy is generally as good as it gets. A measurement based approach is required to take advantage of more accurate geo-referenced surveys.
- The 20 cm accuracy will only be required in cases where geodetic grade receivers are being used to measure or control part of the survey thereby minimizing the additional cost to geo-reference the survey. Currently, approximately 25% of surveys on Canada Lands are using geodetic grade receivers, e.g. GPS bearing derivations, static retracement ties, RTK techniques.
- Requiring a 20 cm homogeneous approach avoids over-complicating the standards, which otherwise would need to specify how many control connections are required for each category (urban, rural and remote), and what control/positioning methods must be used (e.g. use only high precision control stations).

Summary of Geo-referencing Methods

The Geodetic Survey Division of NRCan website at http://www.geod.nrcan.gc.ca contains several good posters under their education link that provide a quick overview of various GPS techniques and their resulting accuracies at http://www.geod.nrcan.gc.ca/edu/index_e.php. More detail on various GPS techniques and the CSRS can be found in various papers under their publications link at http://www.geod.nrcan.gc.ca/publications/index_e.php.

CSRS–PPP solutions

Precise point position solutions can be computed by submitting RINEX data from GPS receivers to an on-line application operated by the Geodetic Survey Division of NRCan. Two hours of dual frequency data will produce 4 cm level accuracies, 12 hours of dual frequency data will produce cm level accuracies; 30 minutes of mapping-grade receiver data will produce 50 cm accuracies and 2 hours of mapping –grade data will produce 20 cm accuracies (accuracies from GSD testing).

NAD83CSRS Federal and Provincial Ground Control Markers

GNSS or conventional ties may be made to NAD83CSRS coordinates of ground control markers published by the federal and provincial governments. These markers include: Canadian Base Network (CBN) pillars; and High Precision Network markers derived from GPS observations (provincial extension of CBN, municipal high precision networks, federal GPS on benchmarks). These stations have known accuracies that are published with their coordinates; stations typically have cm level accuracies but can be up to 5 cm for the weaker GPS benchmark stations.

NAD83CSRS Control Markers Established by Recorded Legal Surveys

GNSS or conventional ties may be made to NAD83CSRS coordinates of ground control markers that have been recorded in the Canada Lands Survey Records, provided the markers have known accuracies that are much better than the required accuracies, and they are proven to be stable. The survey report that accompanies the recorded plan should specify the accuracy; the recorded accuracy should be at least twice as good of that required, e.g. 10 cm recorded accuracy if 20 cm is required.

Active Control Stations

GPS baseline ties may be computed using GPS data logged at federal and provincial active control stations such as the federal Canadian Active Control System (CACS) or BC's Active Control System (BCACS). Positional accuracies will depend on the distance to the ACP and the equipment used. Centimetric level accuracies are possible with geodetic quality receivers and shorter baselines (e.g. less than 50 km).

Reference Station RTK

Some commercial suppliers such as Cansel CAN-NET and Sokkia PowerNET provide RTK service in some metropolitan areas of Canada. A partnership between BC's Base Mapping & Geomatic Services and the municipalities in the Greater Vancouver Regional District (GVRD) also provide RTK service in the GVRD. In some areas, Cansel offers the so-called Network RTK or Virtual Reference Station solutions while others provide single or multiple reference station RTK service. Centimetric level accuracies are possible with the Network RTK solutions and 4 cm accuracies at 95% are quoted when using a single reference station for RTK positions. The surveyor must consult with the supplier and test their own equipment with the service to verify accuracies.

Other GPS Reference Station Services

GPS data is provided by other private suppliers; surveyor must consult with the supplier and test their own equipment with the service to determine accuracies. Care must be taken using them.

Reporting coordinates on the plan and accuracy report

Section 78 of Chapter D1 requires the following shown in the diagram of the official field notes for surveys that have been geo-referenced. The specimen plans show examples of how this information shall be shown.

a) *a list of all published and adjusted coordinate values (e.g. UTM) of control survey markers used or established in the survey with a description of the marker. The list shall include a statement that specifies how the coordinates were derived;*

b) *ellipsoidal or orthometric heights of GPS control stations. Include a statement that specifies how the heights were derived, including the geoid model and the datum to which they are referred, if applicable;*

c) *the combined scale factor for each monument and control station unless one combined scaled factor for the entire survey is appropriate;*

d) a distinct symbol for GPS control stations and an abbreviation (e.g. "GPS") beside monuments which are also GPS control stations;

e) a sketch of the control network if it is not apparent in the diagram at plan scale;

f) where a survey is geo-referenced, a listing of coordinates of main monuments, such as those located at block corners, curve terminations, and deflection points, need to be tabulated;

The list of control survey markers used or established required by 78(a) consists of:

- Source control information, which may be published values of precise ground control markers or PPP derived positions. The absolute accuracy of this source control must be known. For published NAD83CSRS positions use the coordinate standard deviations included with the published positions (double the s.d. to get 95% confidence level). If there is no standard deviation listed, the control marker should not be used to geo-reference the survey. For PPP positions, use the estimated accuracy (coordinate sigma and convergence plots) output by the PPP application (double the sigma to get 95% confidence level). The combined accuracy of the source control and the boundary survey must be meet that required by sections 59 and 60, being 1 m for remote surveys and 20 cm for GPS controlled surveys.
- Established control stations, which usually consist of GPS control stations that are used to control the conventional boundary survey. This includes RTK base stations if RTK techniques are used the measure part of the survey. The coordinates of RTK occupied rover stations do not need to be listed, but there must be a statement on the plan that indicates that part of the survey was measured using RTK as per paragraph 77(f). The report must also provide some further information on the RTK measurements indicating in more detail what stations were occupied (may be general) and what independent redundancy checks were used per 1(h) of Chapter D15.

The heights of the GPS established control stations are required by 78(b) because it is valuable information for any subsequent GPS survey that connects to these stations. In many cases, the GPS established control station may used as the source control for a subsequent survey or it may be used as a check.

Paragraph 78(d) requires distinct symbols to be placed by the GPS control stations so that both CCCM and other surveyors can quickly see how the survey was controlled and what accuracies are expected. CCCM will input these stations into the cadastral data as reference stations to be used to adjust the data and to qualify the accuracy of the data. Users of the cadastral data will also have access to the reference station data (see more detail below).

Paragraph 78(e) requires a sketch of the control network (typically a GPS network) used to control the boundary survey if it is not apparent in the plan diagram. Again, this is needed so that users can quickly see how the survey is controlled and what accuracies are expected. For larger networks, the sketch may be shown in supplementary field notes in book form, which typically will include the survey report and control network adjustment results.

Section 1 of Chapter D15 requires survey report to include the following:

g) where surveys are geo-referenced, the general method by which surveys were positioned, including the accuracies achieved;

h) for surveys utilizing GPS systems, the system used and the method of operation, giving sufficient information to verify the accuracy of the derived position and measurements. In particular, report on the independent redundancy checks of any RTK observations; and

The accuracy report of a geo-referenced survey shall provide a summary of the internal and absolute (integration) accuracies of the survey. It should, if applicable, contain the following:

- The estimated accuracy of the source control used to derive the coordinates.
- A least squares adjustment of the control network, listing the station and relative error ellipses and/or standard deviations. The source control used to fix the adjustment is usually entered as errorless in the adjustment so the absolute accuracy of each station would be calculated from the absolute accuracy of the source coordinates plus that of the error ellipses.
- A summary of the internal accuracy of the control points relative to the source control. For example, one may report that the semi-major axis of the relative error ellipses at the 95 % confidence level ranged from 1 cm to 4 cm.
- A summary of the absolute accuracy of the control points may read: *Using the published standard deviations of the fixed control points of 2 cm and the relative accuracies produced by the GPS network adjustment, the resulting absolute accuracy of the control points with respect to the CSRS are less than 7 cm at the 95% confidence level.* This is the important number to CCCM; it will be input in the cadastral data as the accuracy of the control (reference) point. If there is a significant range in accuracies within the survey, its likely CCCM will use the data in the least squares adjustment to input the accuracy for each control point.
- A summary of the conventional traverse closures between the control points to indicates that the absolute accuracy of all monumented points within the survey is 20 cm or better at the 95 % confidence level. It's too much to expect surveyors to run both their GPS and conventional observations through a least squares adjustment to prove they met this accuracy.

NAD83CSRS and Crustal Motion

It's often asked why do surveys need to be geo-referenced to NAD83CSRS instead of NAD83(original) or some other provincial reference system (e.g. ATS77)? There are some excellent papers in the Number 2, 2006 edition of Geomatica on the Canadian Spatial Reference System that answer this question (http://www.geod.nrcan.gc.ca/pdf/geomatica.pdf). In summary, the following reasons for NAD83CSRS are:

- It is the current reference system adopted as a national geo-referencing standard by most federal and provincial agencies in Canada and is endorsed by the Canadian Council of Geomatics [CCOG 2006] (*Craymer 2006*).
- As Canada Lands is a national system, it is preferred that we use one national reference system.
- It reduces the distortions (errors) in NAD83 caused by the limited accuracy of conventional horizontal control networks; average error between NAD83 and NAD83CSRS is 0.3 m, but can exceed 1 metre.
- Its promotes the use of high precision control markers or satellite based methods, which avoids distorting higher accuracy surveys (GPS networks) to weaker control markers
- It includes known absolute accuracies of high precision control markers whereas other reference systems may not include this information.
- It is linked to a 3D global reference frame so it is aligned it with GNSS observations
- It doesn't depend on ground based control networks, of which is very sparse in the majority of Canada Lands. Therefore GNSS methods such as PPP can readily be used to geo-reference surveys without requiring access to ground control networks.
- Many provinces have developed NTv2-type distortion models to convert NAD83 data to NAD83CSRS (*Craymer 2006*). These conversion models are intended to be used to convert existing NAD83 databases to NAD83CSRS. Exercise caution if the model is used to geo-reference new data

from NAD83 control markers; the absolute accuracy will be dependent on the accuracy of the model, the accuracy of the NAD83 coordinates and of the survey.

- CCCM wants to move to NAD83CSRS now to ensure the cadastral data is properly adjusted rather than trying to play catch up later with data which was subject to NAD83 distortion.

The North American continent is moving by about 2.5 cm per year with respect to the global International Terrestrial Reference System (ITRF). To ensure NAD83CSRS coordinates are stable, they are fixed to the North American plate using a motion model of the plate movement. However, there are some internal crustal motions and deformations that may necessitate future time tagging of positions in some regions (West Coast).

Although the PPP service is a great method to obtain accurate positions to cm level accuracies, there are a few regions in Canada where some caution should be exercised when using it to improve the absolute position of the cadastral data. These regions are on Vancouver Island, the Queen Charlottes and Southwestern Yukon where crustal motions are occurring as a result of collisions between the North American tectonic plate and that of the Juan de Fuca plate and the Yakutat block. Vancouver Island is moving by up to 1 cm per year in a NE direction towards the mainland and Southwestern Yukon is moving in a northerly direction by rates of about 5 mm per year (*Henton et al .2006*).

This crustal motion means the NAD83CSRS coordinates of ground stations are moving in these regions. A point positioned to NAD83CSRS ten years ago may have moved by up to 10 cm. As a result new PPP derived positions in these regions may be 5 to 10 cm different from that measured ten years ago, assuming both the old coordinates and the new PPP coordinates were established to cm level accuracies. CCCM’s Yukon office believes a recent land claim survey in the Kluane Lake area of Southwestern Yukon may have detected this movement. The survey compared several accurate PPP derived positions to those previously derived from precise ground control markers with differences of 5 cm in a northerly direction, which matched the crustal motions being detected by a campaign GPS deformation survey. The differences may be due to other reasons; further measurements are required to verify why there is a difference. Nevertheless, the survey held the previously derived ground positions to best fit the new claim surveys to the existing cadastral data.

It is recognized that there are some deficiencies in the NAD83CSRS reference system which includes: it is not geocentric which requires shifts of about 1.5 m to align it with space-based global reference frames, e.g. WGS84; the motion model for the North American plate used to fix NAD83CSRS can be improved; coordinates of ground data points in regions subject to crustal motions need to be up-dated if spatial applications demand more accurate positions in a global reference system. Sometime in the future it is possible that, after further analysis and consultation with stakeholders, a new reference system such as Stable North America Reference Frame (SNARF) may eventually replace NAD83 as the official datum for geo-referencing in both Canada and the US (*Craymer 2006*).

In regions where there is crustal motion, the cadastral data should be referenced to high precision ground control markers that move with the cadastral data. These positions and the cadastral data may need to be shifted every 10 to 20 years to account for deformation and tectonic movement in order to keep them aligned with reference frames used by GNSS.

Industry Feedback

The ACLS Standards of Practice Committee requested feedback on the new standards from all of the ACLS membership in October, 2007. Approximately 30 members responded, 80% of which had no concerns with the new standards. Some concern was expressed about the official datum in some provinces is not NAD83CSRS, e.g. Nova Scotia official datum is ATS77. Due to this, it is expected that there will be a short transitional period in these provinces to accept something other than NAD83CSRS.

Cadastral Data Maintenance

Getting all the cadastral fabric on Canada Lands to a similar degree of accuracy is taking considerable work and resources. As discussed above, a significant contributor to this accuracy improvement has been the northern Land Claims program, which has vested roughly $85 million to date in accurately positioned surveys. In addition, when resources become available, CCCM has been able to issue contracts to the private sector to provide GPS positions on the cadastral data, and adjust or rebuild the data. There is still much to do, which requires further geo-referenced surveys.

CCCM will only require geo-referenced surveys if the survey is going to be used to improve the cadastral data. New geo-referencing will not be required if the new survey is connected to part of the cadastral data that has reached a certain level of stability in terms of accuracy and repeatability, which is about 5 cm for all data. An accuracy assessment of the data is required to waive geo-referencing.

Adjustments to the cadastral survey data are usually performed as new surveys are input into the data. In many cases, these adjustments are being deferred until there is enough new survey data to properly adjust the data. In order to increase the efficiency of the data up-dates, CCCM will be requiring a digital spatial file of the survey, which is prepared in accordance the new specifications outlined in Appendix E5 of the General Instructions. CCCM is also investigating new application tools, such as measurement based systems, to more efficiently perform the parcel data maintenance process, especially related to the adjustment of new geo-referenced surveys.

As for the accuracy of the cadastral data, CCCM is trying to maintain the relative accuracy as the absolute positional accuracy is improved. The relative accuracy can be seen as attempting to maintain the configuration (i.e., size and shape) of the parcel as shown on the survey plan when connecting it with abutting or near by parcels. The absolute accuracy is the positional accuracy of the parcel within Canada.

Quantifying the spatial cadastral fabric's accuracy is an on going process. For a large part, this information has been retained by a few staff members within CCCM. We have developed a system within the data to track the accuracy and are currently capturing this knowledge. This will help identify weaknesses in the cadastral fabric so that when new geo-referenced surveys or resources become available, this poorer quality data can be improved through adjustments or in some cases rebuilding the cadastral fabric. Figure 2 shows reference (control) points in the data that are used to control and assess the accuracy of the data.

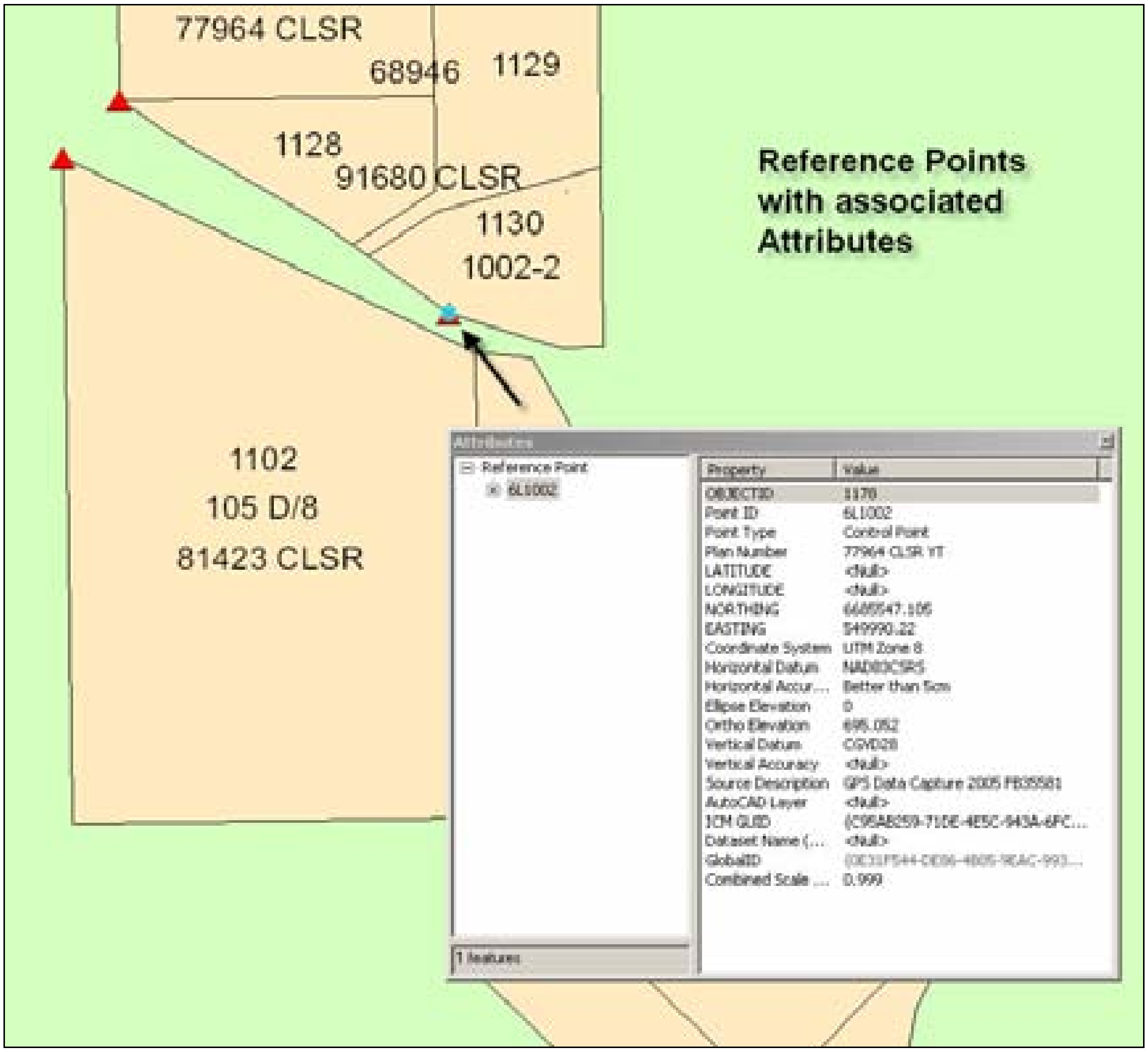

Figure 2: Reference Points in Cadastral Data

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APPENDIX 1

CCOG Resolution S05-10, National Standards for Integrated Surveys, 2005

Whereas the Canadian Council on Geomatics (CCOG) has shown support in the area of National Standards for Integrated Land Surveys through the ratification of a number of related resolutions in the past few years;
Whereas since 1997, considerable work has been done by both provincial and federal working groups to research and analyze the issues around National Standards for Integrated Land Surveys;
Whereas the Surveyor General of Canada and his provincial counterparts desire to now bring closure to this issue and adopt a series of principles and standards related to the integration of land surveys across Canada;
Be it therefore resolved that:
CCOG endorses the following principles and standards related to the integration of surveys and recommends that serious consideration be given to their adoption at the appropriate time in each jurisdiction.

Basic Principles:
Given that the country is moving towards the adoption of the homogeneous NAD83 (CSRS), surveys should only be integrated to the NAD83 (CSRS) as represented by HPNs, CACS or other control monuments that have been properly integrated to NAD83 (CSRS) where sub metre accuracy relative to the NAD83 (CSRS) is sought.

HPNs should be supplemented in major urban environments by additional integrated and prominent points, such points to be parts of the built urban environment (e.g. building corners) and accessible by resection.

Surveys should not be integrated relative to the now unmaintained monumented geodetic control network, unless the distortion relative to NAD83 (CSRS) is known, and the accuracy required is no better than the known distortion between NAD83 (CSRS) network and the other available network.

Integration of surveys does not alter the hierarchy of evidence for the re-establishment of survey monuments.

Administration:
Publishing coordinates on plans or other documents recorded in the Land Registry or Land Titles Systems is optional.

Each coordinated point should have a unique identifier for inclusion in the database.

Integrated surveys are to receive the same scrutiny, or be subjected to the same quality monitoring processes as are already in place in each jurisdiction for all surveys.

Implementation:
Integration of surveys to better than 1-metre accuracy relative to the NAD83 (CSRS) should be implemented only when there is sufficient and easy access to the reference framework.

Implementation should only proceed when the profession has been given sufficient time to obtain the proper instrumentation and be trained in its use.

The administrative and regulatory structure, if necessary, should be in place prior to implementation.

Implementation need not take place at the same time across the country.

Standards:
All new survey must be tied to NAD83 (CSRS) through the best available means if there is a reasonable availability of HPNs, CBNs or ACS monuments.

The standard to which land surveys are integrated to NAD83 (CSRS) should be a function of parcel location and land use, with the connections qualified by the surveyor to meet the following minimum relative accuracy @ 95%:

Location	Accuracy
Urban Areas	5 cm
Rural Areas	20 cm
Remote Areas	1 m

Appendix 2: WROC Notice

ENCLOSURE 2 **March 27, 2008**

New Geo-referencing Requirements For IOGC Surveys

APPLICATION:

The changes with respect to geo-referencing in the new Chapter D1 apply to two specific situations. The first applies to surveys **where GPS is the primary tool used**, and the second applies to remote surveys. Different accuracies are required for each.
The pertinent paragraph for the first situation is as follows:

> 59. In cases where GPS methods are used to control or measure all or part of the boundaries in the survey, all monuments within the survey shall be geo-referenced to NAD83CSRS to an absolute accuracy of 20 cm or better.

This change will enable users to more easily integrate cadastral and other geospatial information, it will aid users in blunder detection and evidence searches, and it will ensure that the data is consistent with present day technologies and public expectations.

For the remote surveys, the work must be geo-referenced to an absolute accuracy of one metre or better no matter what surveying tools are used to control or measure the boundaries. The paragraph to refer to is:

> 60. All remote surveys shall be geo-referenced to an absolute accuracy of one metre or better. A remote survey includes but is not limited to the following:
> a. surveys that are not connected to the cadastral survey fabric of inhabited urban or rural areas;
> b. surveys connected to existing remote legal surveys; and
> c. surveys within remote Indian Reserves which have less than twenty parcels.

This change will greatly improve the ease with which users will be able to navigate to remote sites and begin searches for evidence. It will enable users to do this in a manner consistent with present day methods.

SPECIFICS:
When the above noted changes apply, changes and additions to survey plans will of course, be required. As well, a small survey report will be needed to document the GPS work. Though no new specimen plans have been created specifically for IOGC plans, these changes have been illustrated on several newly created specimens. For guidance, please refer to the specimen plans indexed as “Registration plan – Full Survey” and “Registration plan – Partial Survey” from chapter D5, and specimen plans indexed as “Field Notes of Survey – Jurisdictional Boundaries”, “Plan of Survey – Jurisdictional Boundaries”, “Plan and Field Notes of Survey – Jurisdictional Boundaries”, and “Plan and Field Notes of Survey – Bilingual” from chapter D1.
As a further aid, please review the following specific items.

Item: New Bearing Statement (Please note: when the above noted changes apply, each and every applicable IOGC plan will require a bearing statement)
Pertinent paragraphs:

77. Provide in the legend of the official field notes:

   a. a statement describing the type of bearings (e.g. grid), how the bearings were obtained (i.e. the type of observations and points at which the observations were made or the line from which bearings were adopted) and the meridian to which the bearings are referred;

87. Provide in the legend:
    a. a statement describing the type of bearings (e.g. grid) how they were obtained (i.e. the type of observations and the points at which observations were made or the line from which bearings were adopted), and the meridian to which the bearings are referred;

Examples:
Bearings are MTM grid derived from the calculated bearing 90°46'33" between station 200 and station 201 and are referred to the central meridian MTM Zone 9 (76°30' West), NAD83 (CSRS) datum.

Bearings are UTM Grid derived from GPS observations holding geodetic control markers 157461 fixed (3D) and are referred to the central meridian UTM Zone 10 (123° West), NAD83 (CSRS) datum.

Item: New expression of units statement

Pertinent paragraph:

Though no specific paragraph directly addresses this change, it will be required nevertheless. It has become essential in order to ensure overt clarity. By including a statement in this form, there will be no question as to whether the shown distances are ground or grid.

Examples:
Distances shown are horizontal at general ground level and are expressed in metres and decimals thereof (except shown otherwise).

Distances shown are horizontal at general ground level and are expressed in metres and decimals thereof.

Item: New coordinate system and scale factor statements

Pertinent paragraph:

77. Provide in the legend of the official field notes:
    d. if a coordinate system is used, a description of it, including a statement identifying the conversion factor used to convert ground level distance to the projection plane;

Examples:
Coordinates were derived from a least squares adjustment of static GPS observations holding the published value of geodetic control station 157461 fixed.

To compute UTM coordinates, distances have been reduced to the projection plane by multiplying by a combined scale factor of 1.000088

To compute MTM coordinates, distances must be reduced to the projection plane by multiplying by the combined scale factor 0.999623.

Item: New statement that GPS was used

Pertinent paragraph:

77. Provide in the legend of the official field notes:
    f. if GPS observations are used to derive some or all of the dimensions of boundaries, a statement describing the GPS observations shall be added such as “GPS observations were used to derive part (or all) of this survey” or “Real time kinematic GPS observations were used to derive part (or all) of this survey”.

Examples:
Coordinates were derived from a least squares adjustment of static GPS observations holding the published value of geodetic control station 157461 fixed.

Real time kinematic GPS observations were used to derive part of this survey.

Item: New control stations coordinate table including heights and scale factors

Pertinent paragraphs:

78. Show in the diagram of the official field notes:
    a. a list of all published and adjusted coordinate values (e.g. UTM) of control survey markers used or established in the survey with a description of the marker. The list shall include a statement that specifies how the coordinates were derived;
    b. ellipsoidal or orthometric heights of GPS control stations. Include a statement that specifies how the heights were derived, including the geoid model and the datum to which they are referred, if applicable;
    c. the combined scale factor for each monument and control station unless one combined scaled factor for the entire survey is appropriate;

Example:

GPS Control Stations
MTM Coordinates, Zone 9, NAD83 (CSRS)

STATION	NORTHING	EASTING	COMBINED SCALE FACTOR	ORTHOMETRIC HEIGHT
200	5183075.467	344077.656	0.999623	265.54
201	5183073.253	344241.115	0.999623	265.40

Coordinates were derived from GPS observations using the Precise Point Positioning (PPP) service and are referred to NAD83 (CSRS).

Orthometric heights are derived from GPS observations using the (PPP) service and the HTv2 geoid model.

Item: New main monuments coordinate table

Pertinent paragraphs:

78. Show in the diagram of the official field notes:
    f. where a survey is geo-referenced, a listing of coordinates of main monuments, such as those located at block corners, curve terminations, and deflection points, need to be tabulated;
88. Show in the diagram of the plan:
    p. where a survey is geo-referenced, a listing of coordinates of main monuments, such as those located at block corners, curve terminations and deflection points need to be tabulated;

Example:

MTM Coordinates, Zone 9
NAD83 (CSRS)

MONUMENTS	NORTHING	EASTING
60	5183256.62	344434.93
61	5183161.69	344475.23
3	5183135.54	344534.21
68	5182796.41	344268.29
6	5182866.05	344177.53
7	5182914.23	344140.54
70	5182907.47	344117.47
9	5182868.62	344062.43
11	5182932.18	343969.54
12	5182925.95	343977.86
13	5182952.49	343967.36
14	5182937.54	343915.88
15	5182918.97	343882.38
77	5183014.37	343762.67
17	5183153.70	343741.77

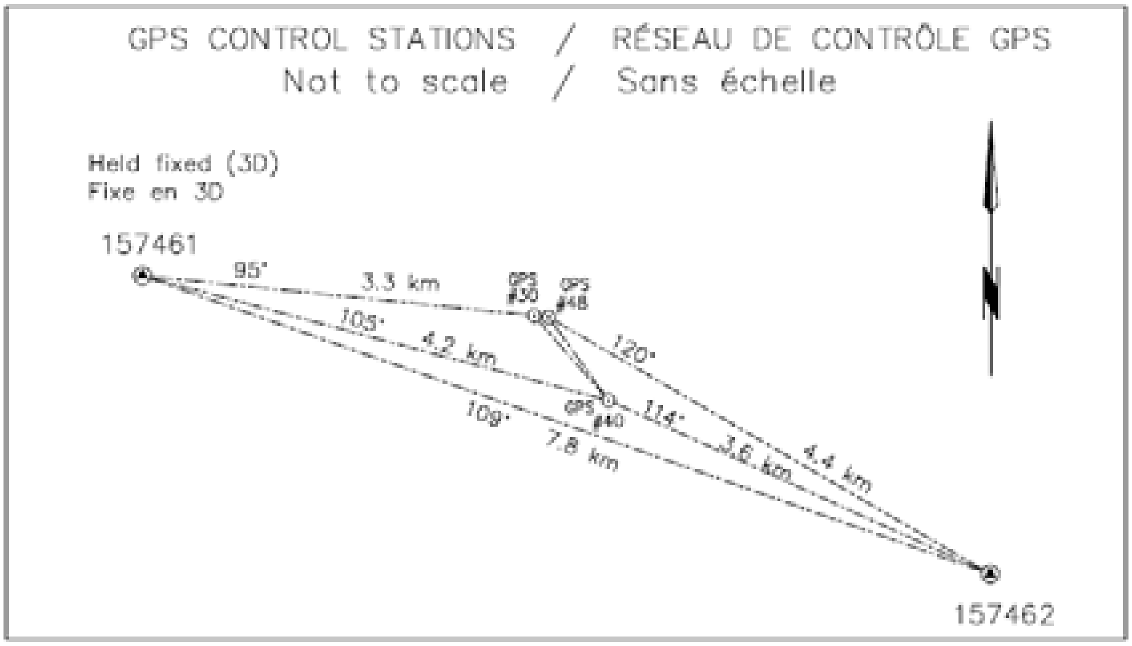
Item: New GPS network sketch

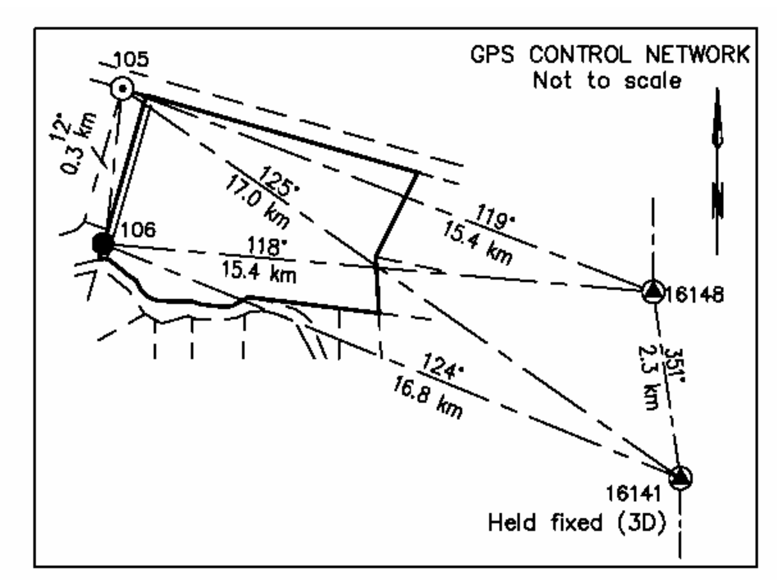
Pertinent paragraphs:

78. Show in the diagram of the official field notes:

e. a sketch of the control network if it is not apparent in the diagram at plan scale;

Examples:



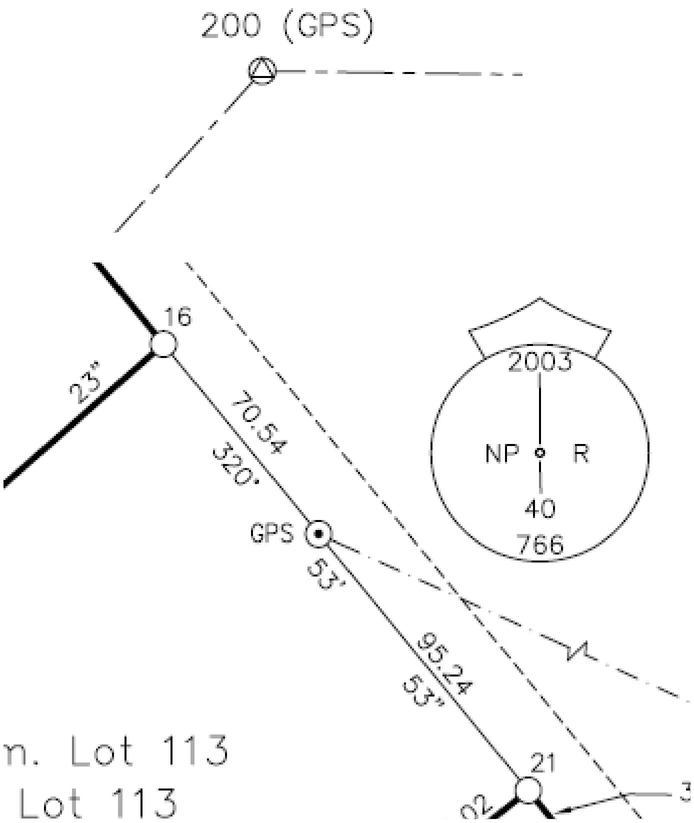


Item: Indication of which points are GPS control points

Pertinent paragraphs:

78. Show in the diagram of the official field notes:
    d. a distinct symbol for GPS control stations and an abbreviation (e.g. "GPS") beside monuments which are also GPS control stations;

Examples:



Item: Accuracy Statement

Pertinent paragraphs:

114. The returns of official surveys shall consist of:

b. a survey report as prescribed in Chapter D15, including an accuracy report as specified in subparagraphs 1(g) and 1(h) of Chapter D15;

Chapter D15 - SURVEY REPORTS

1. For every survey undertaken on Canada Lands, a surveyor shall submit for filing in the Canada Lands Surveys Records, a report describing:

   g. where surveys are geo-referenced, the general method by which surveys were positioned, including the accuracies achieved;

   h. for surveys utilizing GPS systems, the system used and the method of operation, giving sufficient information to verify the accuracy of the derived position and measurements. In particular, report on the independent redundancy checks of any RTK observations; and

Discussion:

To date, a survey report has never been needed for IOGC plans. From now on, for IOGC surveys where the new geo-referencing requirements apply, an accuracy report, as described above, will be a requirement.

The following list of required information for the above noted accuracy report will hopefully aid in its preparation.

Information Required in an Accuracy Report:

1. Methods of GPS surveying used. (e.g. Static, rapid static, PPP, RTK, etc.)
2. Sources and accuracy of control point information. (e.g. CACS, Provincial control, Federal control, Municipal Control etc.)
3. Methods of achieving redundancy. (including RTK observations, if applicable)
4. For each GPS Control Station (Please refer to the various specimen plans to get an appreciation of what is meant by GPS Control Station):

i) Latitude and longitude (NAD83 CSRS)
ii) Orthometric elevation, ellipsoidal height, and the geoid model
iii) Northing and easting, complete with the pertinent projection referred to NAD83 CSRS
iv) The combined scale factor.
v) The relative accuracy of each GPS Control Station with respect to each other GPS Control Station at the 95% confidence level.
vi) The absolute accuracy of each GPS Control Station at the 95% confidence level.