Department of Primary Industries, Parks, Water and Environment
INFORMATION & LAND SERVICES
Office of the Surveyor General

Hobart GPO Box 44, Hobart, Tasmania, 7001
Ph 03 6233 2513
Web www.dpipwe.tas.gov.au/survey

Tasmania

Circular Memorandum No. 2 / 2012

TOPIC:	**Using RTK GNSS in Cadastral Surveys**
DATE:	**25 May 2012**

Real-Time Kinematic Global Navigation Satellite System (RTK GNSS)

It has become apparent that where favourable on-ground conditions allow, RTK GNSS is the cadastral survey method of choice, using either a surveyor-provided base station or a commercial correction service.

A review of registered survey notes indicates that while Static and RTK GNSS are most commonly used to provide a control framework for MGA coordinates and bearing datum, RTK GNSS is increasingly being used for direct measurements of existing boundary evidence and boundary mark stake-outs.

An incumbent part of surveyors' professional and ethical responsibilities is to have a working understanding of the technology used in their survey work. Without this knowledge, surveyors are working beyond their competence, with a greatly increased risk of making significant, undetected errors.

This circular provides a number of basic guidelines to assist surveyors with managing the limitations inherent in RTK GNSS technology and ensuring that surveys are compliant with the Survey Directions.

However, these guidelines do not replace a thorough understanding and competence in the use of GNSS technology and procedures, without which significant, undetected errors are still likely to occur.

Selected references to more detailed information can be found at www.dpipwe.tas.gov.au/survey.

Planning

While coverage is generally good, there are still occasional periods of poor satellite configuration that significantly impact RTK reliability and accuracy, particularly where overhead obstructions are present. On the day of survey, it is advisable to use a recent satellite almanac to conduct a pre-survey check of satellite coverage and PDOP graphs for the day.

Heightened solar activity and defective satellite operation may also affect RTK reliability. GNSS users should maintain currency with these events. A variety of internet-based information and subscription services are available for this purpose, including:

- Bureau of Meteorology Space Weather Service: http://www.ips.gov.au/Space_Weather
- NOAA Space Weather Prediction Service (SWPC): http://www.sec.noaa.gov
- Notice Advisory to NAVSTAR (GPS) users: http://cgls.uscg.mil/mailman/listinfo/nanu
- Notice to GLONASS users: http://new.glonass-iac.ru/en/index.php

System issues

GNSS-based systems should be regularly checked to ensure that they are operating correctly and that a link to the national standard of length is maintained. At a most basic level, this can be achieved by measurement comparisons with coordinate values for SPMs registered on SurCoM (2nd order or better) together with lengths measured by calibrated EDM.

It is important to ensure that the total system will produce results that comply with the requirements of the Survey Directions. The use of range poles with the rover can be the weakest link in a survey system. Particular attention should be paid to the correct adjustment of 'bulls-eye bubbles' and consideration should be given to using 'bipod' legs to add stability.

Dual frequency (geodetic quality) receivers will, in general, provide the most reliable result. When using single frequency GPS units, care must be taken to minimise the distance between base and rover in order to achieve the accuracy requirements of the Survey Directions. Distances greater than 10km should be avoided.

Surveyors should ensure that the geodetic datum (including the spheroid) and projection are set correctly in the instruments to be used.

Base station issues

Where a surveyor-provided base station is used, the surveyor should endeavour to ensure that the base:

- has adequate security
- as far as possible, has a clear view of the sky
- has the best possible line of sight for radio reception to the survey area
- avoids environments that are likely to involve multipath or electronic interference.

These requirements may involve a compromise and although direct occupation of a coordinated SPM of suitable order may appear the simplest course of action, it will often be better to establish a new point best suited to the above requirements and calculate a block shift from the SPM.

Use of a commercial correction service will avoid the issues above, but this presents its own issues:

- the base or network stations used by the service must be registered on SurCoM
- care must be taken to ensure the distance from the base station(s) used does not exceed that which will give the requisite positional uncertainty of coordinates and/or vector accuracy.

Rover issues

Surveyors should aim to achieve independent verification of the system's proper operation and all coordinates measured.

Verification of proper operation can be achieved by check measurements to independently coordinated marks on/close to the survey site. When using a commercial correction service, verification can be achieved by comparison with a coordinated SPM located en route, as close as possible to the site. Comparisons should ideally be made at the start and finish of the day's survey work.

Significant errors in individual measurements are often not detectable when using RTK GNSS. Certainty can only be assured by dual occupation of each point measured. This involves re-observation of the point following re-initialisation of the rover and – as a minimum – adjusting the antenna height by at least 0.2m between measurements. Ideally, there should be at least 15 minutes – and preferably 30 minutes – between

observations. It is also preferable that the two observations are made using different base stations. In general, surveyors should apply the principle that 'greater redundancy ensures greater certainty'. This should be verified by direct comparison of the dual observations in the field or office.

For optimal results, the rover elevation mask should be set at 15° (and no less than 10°) unless site conditions determine otherwise. Observation of at least five satellites (or six if Glonass satellites are involved) with a PDOP of <6 is always advisable.

As with the base, be aware of the effects of tree cover on signal-to-noise ratio, hard vertical or inclined surfaces creating multipath, and the possibility of electronic interference on GNSS signals and radio communications.

Be aware that the coordinate quality measure provided by the receiver is purely an internal measure and does not account for external factors degrading the accuracy of the positions being measured. It has been independently established that the coordinate quality indicators provided by GNSS rover equipment are often overly optimistic.

In this context, RMS values displayed by GNSS data collectors are a statistical estimate of internal precision – NOT accuracy – and are also generally measured at 1 sigma (68% confidence) level. More desirable 2 (95%) or 3 sigma (99%) values require the 1 sigma values to be multiplied approximately 2 and 3 times respectively.

Ensure that the rover has achieved ambiguity resolution before measuring a position, and that radio signal and satellite lock is maintained for the full duration of a measurement.

Each measurement should involve the averaging of several epochs of data over at least 15 seconds; one minute is preferable and will provide a large improvement in positioning quality.

MGA Bearing Datum

The use of RTK GNSS to determine a unique MGA bearing datum should involve observation of the two terminals of a line no less than 250 metres in length. Note that this is a minimum recommended separation. The use of a fixed tripod is recommended and it may be necessary to increase this distance to achieve the required vector accuracy in poor observation environments. Where a traditional traverse extends a long distance in relative terms from the bearing datum base line, the bearing datum base length may need to be extended or, for extensive surveys, further points around the survey perimeter should be coordinated by GNSS to control bearing drift.

Individual occupations should involve the averaging of two, one-minute continuous observations on each point to identify errors.

Ultimately, it is the surveyor's responsibility to consider all factors to ensure that the measurements defining MGA bearing datum are sufficient to determine the required positional uncertainty for cadastral corners.

Boundary measurements

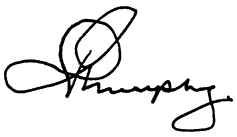
The nature of RTK GNSS measurements makes it difficult to obtain the vector accuracy requirements of the Survey Directions over shorter lines. This means that it is generally not a suitable technique for short line measurements or direct measurement of small lots. In addition, there is increased probability that surveys in an urban environment will be subject to degraded measurements due to signal disruption.

It is incumbent on surveyors to use sufficient redundant observations and checks or use conventional survey methods to ensure that all short line RTK GNSS measurements comply with the vector accuracy requirements of the Survey Directions.

Lengths

Surveyors are reminded that all lengths shown on survey notes and plans must be 'ground' distances. All lengths derived from coordinates must have the relevant MGA scale factor and height correction applied.

If you have any enquiries, please contact John VanderNiet on 03 6233 8798.



Peter Murphy
SURVEYOR GENERAL