The New Zealand geodetic system part 2

Control system surveying and maintenance

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The New Zealand geodetic system is used primarily through physical marks in the ground. By connecting to these marks, surveyors and others are able to orient and coordinate disparate geospatial data in a consistent manner. To maintain and enhance the geodetic system, LINZ has a regular programme of geodetic surveying and physical mark maintenance.

Standards, guidelines and specifications

The geodetic survey and maintenance programme is governed at a high level by standards set by the Surveyor-General. There are two standards with which the geodetic programme must comply, as well as a guideline.

The *Standard for survey control system – LINZS25003* outlines the requirements of the various networks which comprise the geodetic control system in New Zealand. An associated guideline, the *Guideline for the provision and maintenance of the New Zealand survey control system – LINZG25704* provides further detail about how compliance with the standard can be achieved. Together, these documents outline regulatory requirements for survey control networks in the following general areas –

- Coordinate tier – network or absolute accuracy, and class – local or relative accuracy
- Control mark characteristics such as location, permanence and stability
- Mark names
- Control network accessibility
- Mark, coordinate and observation metadata such as beacon information
- Frequency at which marks must be reviewed for compliance

The numerical accuracy values associated with a coordinate are given in *Standard for tiers, classes and orders of LINZ data – LINZS25006*. These standards and guideline became effective from 21 September 2009. Some of the requirements are new, so the survey and maintenance programme for the next few years will focus on ensuring New Zealand's control networks comply with all relevant standards.

Based on these regulatory documents, LINZ has developed specifications for geodetic survey and maintenance work. Geodetic contractors work with these specifications, which have been developed to ensure compliance with the standards. The specifications are –

- Specifications for geodetic control survey
- Specifications for geodetic physical network
- Specifications for geodetic contract deliverables

All of these standards, guidelines and specifications are available on the LINZ website at www.linz.govt.nz/geodetic/standards

Setting the survey and maintenance programme

The geodetic survey programme over recent years has focused principally on generating new fifth-order control. Areas where additional control is required are classified into two categories – development areas and re-establishment areas.

Development areas are those where a greater density of control is required to meet expected development needs. Selection of these areas is based on feedback from surveyors and local authorities. This information is combined with data extracted from Landonline, such as the number of cadastral surveys in the area. The datum of these cadastral surveys is also extracted (Old Cadastral, NZGD1949, NZGD2000) and used to help with prioritisation of these recommendations. Development areas are primarily rural in character, although there are some smaller urban centres which are still to receive fifth- order control.

Fifth order adopted marks

The second category of new control is the re-establishment area. In 2009 LINZ began a programme of replenishing control where it is currently provided by the capture and adjustment of historical control traverses in terms of NZGD2000. These are often referred to as 'fifth order adopted' or '5a' marks. They can be distinguished from fifth order marks which have been surveyed with GNSS as the 5a marks do not have ellipsoidal heights.

Sometimes these 5a marks are inaccessible or have been destroyed over the years. Furthermore, their accuracy is often not sufficient for modern surveying requirements. Although they have been assigned fifth order accuracy, analysis has shown that many do not comply with all the requirements of the fifth order accuracy standard. In particular, many 5a networks do not comply with the

local accuracy standard, especially where adjacent marks do not have a direct observation between them.

Over the next five to 10 years, these marks will be replaced by GNSS-surveyed control. The re-established control will be distributed so that the vast majority of locations within a given area are within 200m of one of these new marks. At this density, control marks will generally not be intervisible, so the captured terrestrial networks will still be of use to surveyors working with terrestrial equipment. However, it is likely that these marks will be assigned sixth order, which gives a more appropriate indication of their accuracy.

Marks are selected for the maintenance programme based on a number of criteria, including –

- NZGD2000 coordinate order
- number of usages in cadastral surveys based on Landonline data
- type of protection structure, for example beacons have a higher priority than marker posts

The recurring maintenance schedule means that well used marks will be physically maintained every five to six years.

Areas selected for the 2008/09 survey programme coloured red

Procurement process

Until 1996, geodetic surveying and physical maintenance was carried out by staff of the Department of Survey and Land Information (DoSLI) and its predecessor the Department of Lands and Survey. LINZ was formed in 1996 and had a strong policy and regulatory focus. Operational activities, such as geodetic surveying, were outsourced to the private sector.

This is the situation which exists today, with all geodetic survey and maintenance work being outsourced. Most of the work is awarded by an open tendering process, using the government electronic tenders service. Any person or organisation is able to submit a tender, although there are some parts of the geodetic survey service which need to be signed off by a licensed cadastral surveyor.

Until 2009, there was a system of geodetic accreditation in place. This meant that only companies which LINZ had assessed as being competent in geodetic surveying or geodetic maintenance were eligible to tender for work. Now that this requirement has been removed, LINZ relies on the information submitted in the tender to determine whether an organisation is capable of completing the work required.

Tenders are assessed using the weighted attribute method. A panel of three determines scores for each tender for –

- methodology
- Quality assurance, risk management and staffing
- Track record

These non-price attributes comprise 70 per cent of the final score with price the remaining 30 per cent. Pricing information is not released to the evaluation panel until all non-price attribute scores have been finalised. Full results of the tendering process, including details of the successful bidders and estimated contract prices are publicly notified on the website.

Mark selection

Although the areas for additional control are selected by LINZ, choosing suitable marks within those areas is the responsibility of the geodetic contractor, based on requirements outlined in the specifications. Almost all new fifth-order marks will be existing low-order geodetic marks or cadastral marks.

Other requirements specify, for example, that marks in live traffic lanes are not appropriate, given the traffic management requirements associated with using such marks. Likewise, marks with difficult access are not preferred. Although contractors are instructed to select marks they consider likely to have good long-term survival prospects, the efficiency of modern survey techniques means that the replacement of destroyed marks is not as arduous as it once was.

Mark reliability

Since the vast majority of new fifth-order control marks are existing marks, it is important to correctly identify them and prove that they are in the same position as they were originally placed. In the case of trigs or benchmarks, this assessment may be visual only. In the case of cadastral marks, the contractor is required to observe a cadastral survey origin using adjacent marks.

These reliability checks are signed by a licensed cadastral surveyor and scanned images of this data are available in Landonline and the geodetic database. Marks of proven reliability mean that cadastral surveyors can connect to geodetic marks via adoptions and have confidence that the adopted observations to the mark will be consistent with its coordinates derived from the geodetic survey.

Fieldwork

Surveys are carried out almost exclusively using GNSS techniques, primarily fast static and RTK. Occasionally terrestrial techniques may be used, where the mark selected cannot be physically occupied with GNSS, or sky visibility is poor. Contractors are free to use any method they deem appropriate, provided the required accuracy standards are met.

GPS set up for a geodetic survey

Data processing

Where necessary, fast static GNSS data is processed to compute baselines. All data is then analysed by the contractor using the LINZ network adjustment software, SNAP. GNSS data is entered into SNAP as geocentric baseline components DX, DY and DZ. The errors associated with the data are estimated based on the methodology and equipment used. Once SNAP has been set up, the following is tested in a least squares adjustment –

- Observation accuracy tests for the presence of outliers in the data
- Local relative accuracy tests the accuracy between every possible set of coordinates in the network even where there is no observation between the two sets of coordinates being tested
- Network absolute accuracy tests the accuracy of each coordinate relative to the fixed control in the adjustment.

Vertical geodetic control

LINZ no longer undertakes precise levelling, although existing benchmarks continue to be maintained. Vertical control is now provided through the provision of ellipsoidal heights on all new fifth-order and higher geodetic marks. The official geoid model, NZGeoid2009, can then be used to compute heights in terms of the desired normal-orthometric datum. This enables vertical control to be provided more efficiently across a much greater area than would be possible with precise levelling techniques.

Maintenance programme

The geodetic maintenance programme involves physical maintenance of marks and their associated beacons and protection structures such as marker posts. Common tasks required include –

- Installation of stainless steel pins in iron tubes
- Clearing vegetation
- Installation of ID plaques and plates
- Repairing and painting beacons, marker posts and post and rail enclosures
- Erecting new beacons

LINZ validation and Landonline loading

Geodetic survey and maintenance data is submitted to LINZ, where it undergoes a series of automated and manual checks to ensure that it complies with relevant standards and specifications. As a result of these checks, requisitions may be issued to the contractor, or the work may be accepted and loaded into Landonline. Final coordinates for survey work are generated from a least squares adjustment in Landonline and geodetic information is made available via Landonline and the Geodetic Database.

Geodetic mark A66F before maintenance

Geodetic mark after maintenance

Conclusion

The planning and management of this programme, as well as the processing of the geodetic data received is one of the core functions of the geodetic group at LINZ. The programme is driven by both regulatory requirements and the needs of users, particularly surveyors. The use of private survey firms to carry out the fieldwork and data processing enables LINZ to obtain the advantages that accrue from competitive, open tendering. But it also means that marks are being selected and surveyed under the direction of surveyors who are also regular users of the system for their other survey work.

A survey and maintenance programme is integral to ensuring that connections to NZGD2000 can be made as simply as possible. For the foreseeable future, this will be achieved through a regular, annual programme of geodetic control surveying and maintenance.

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