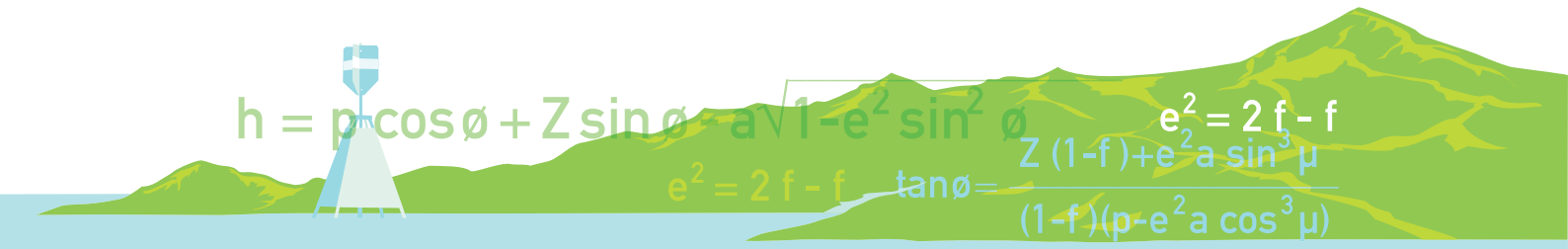
Land Information New Zealand
Toitū te whenua

New Zealand Positioning Strategy
2014



Land Information New Zealand

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Foreword

I am pleased to present the LINZ Positioning Strategy. This strategy builds on previous Geodetic Strategies and aligns with LINZ's 10 Year Vision 'the power of where' drives New Zealand's success. This vision is for the value generated by location information to grow tenfold over the next decade. It recognises this information as being at the heart of LINZ's strategic direction with benefits for our economy, the environment, our communities, for Māori/iwi and for the government.

There have been significant changes in the geospatial world over the past decade, with geospatial information becoming increasingly important to all decision-making and for enabling innovation. Fundamental to the use of this information is an accurate spatial reference frame and the ability to connect to it. Commonly referred to as a geodetic or positioning system, it is the most fundamental of the fundamental data themes as identified by the New Zealand Geospatial Office. Often referred to as "infrastructure for infrastructure" it underpins all location-based information and enables diverse geospatial data sets to be brought together to reveal new patterns and knowledge that improve our ability to tackle complex issues.

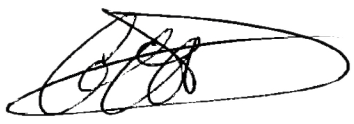
Traditionally, approaches to the positioning system in New Zealand have focused on the provision of geodetic survey marks. This continues to be an important driver but there are an increasingly broad range of uses and users that also need to be considered. Satellite based positioning systems, the internet, mobile devices and the explosion of location-based services are bringing more and more of us into contact with location information on a daily basis. People without specialised expertise in geospatial information, and, who are unlikely to even be familiar with the term, are using and interacting with geospatial information more and more. The positioning system also has an increasingly important contribution to make to the international reference frames which support global infrastructure such as GNSS[1] and the monitoring of global change such as sea level rise.

This is reflected by the United Nations recognising the vital economic importance of an internationally standard global geodetic reference frame for integrating geospatial information.

In recognition of these changing uses and users of the positioning system, this new strategy signals a shift in direction. While acknowledging the importance of supporting the cadastre, it puts a greater emphasis on the development of our national GNSS network and supporting the development of global reference frames. This will enable users to truly unlock the benefits of location information.

As Steward of the positioning fundamental data theme[2], LINZ will ensure that the requirements of all users of the positioning system are consulted and accommodated where appropriate as we continue its development. For this approach to succeed, we will need a system that reflects and anticipates the needs of New Zealanders, to ensure they get the greatest benefit from 'the power of where.'

I would like to thank all of those who have contributed to the development of this new strategy and in particular Matt Amos who has worked with me to update the strategy.



Graeme Blick
Chief Geodesist

[1] Global Navigation Satellite Systems
[2] Positioning is one of the 10 fundamental data themes in the national spatial data infrastructure (SDI) - www.linz.govt.nz/geospatial-office/fundamental-geospatial-data


Leica

Background

At its simplest, positioning data tells us the precise location of geographic features. This is what is meant when referring to the positioning data theme. The theme is made up of individual data sets such as survey control points, geodetic observations, as well as the frameworks that enable their consistent spatial representation.

As part of the positioning theme, LINZ provides an accurate geodetic system that ensures consistency and adds value by enabling the integration of diverse geospatial datasets. This system is part of New Zealand's spatial data infrastructure (SDI). We aim for a future state where everyone uses this common infrastructure for their positioning needs. An accurate positioning system is also crucial in the identification and assessment of geophysical and other natural hazards. It plays a pivotal role in both early warning systems for such hazards and helping to recover from resultant catastrophes.

The positioning system therefore contributes to increased security, a better use of resources, and sustainable development. It achieves this through the publication of coordinates, and services to obtain or generate them. It is supplemented with the reference frames, transformations and tools that are made available to users. LINZ proudly provides this data, as well as other products free of charge.

Users of the positioning system want better access to a more accurate geodetic framework so that that they can seamlessly determine their location and relate it to other geospatial datasets. Changes to the way that surveyors do their work, and the proliferation of mass-market positioning technology means we need to alter our services and the way we provide them.

We will continue to deliver accurate products and services that are relevant to the current and future users of the positioning system. In order for us to contribute optimally to New Zealand we need to improve the accessibility, availability and integrity of the information we provide. There is a need to provide products to agreed service levels so that others can develop applications and products that are dependent on them.

Our focus for the last fifteen years has been on the establishment of extensive networks of cadastral control marks, initially to support the development of the survey-accurate cadastre in Landonline, LINZ's system for managing land title and survey information. Latterly our efforts have been to provide a thorough coverage of marks across New Zealand to improve access to our national geodetic datum, New Zealand Geodetic Datum 2000 (NZGD2000).

The installation of the mark networks will soon be complete. At that point we will change our focus from extending our control networks to maintaining them, we will also actively maintain the models that define our datums. This will enable the development of new services that meet the positioning needs of users who do not want to just use coordinates. We must also place a greater emphasis on supporting and maintaining global and regional reference frames which we in turn rely on to ensure the accuracy of our geodetic system.

This strategy replaces the existing LINZ Geodetic Strategy 2003-2008 and provides a new focus for the development of New Zealand's positioning system for the next ten years.

Strategic Context

This strategy has been developed in terms of LINZ's outcomes as well as legislative requirements. These are detailed below.

LINZ Outcomes

The positioning system is fundamental infrastructure for New Zealand and directly underpins two of LINZ's three Outcomes:

- Increasing the productive use of location-based information
- Maintaining the integrity of the property rights system to encourage trade, commerce and wellbeing

Good management of Crown land depends on knowing where it is located in relation to other location-based datasets, and so the positioning system also indirectly supports LINZ's third Outcome:

- Enabling appropriate economic, environmental and recreational uses of Crown-owned and used land

Cadastral Survey Act 2002

The requirement for a geodetic system is legislated by the Cadastral Survey Act 2002 (CSA2002)

- s3(c) **Purpose**: "to provide for a national geodetic system and a national survey control system to be maintained"
- s7(1)(a, b) **Functions and duties of Surveyor-General**: "to maintain a national geodetic system and national survey control system"

Explanation of terms:

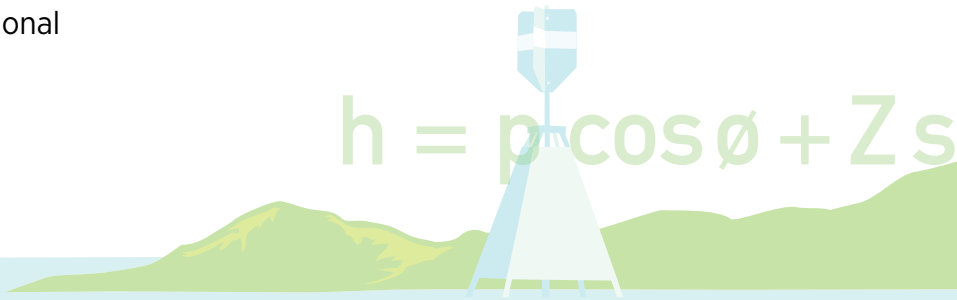
- Geodetic system: means a system that enables positions on the surface of the Earth to be determined by reference to a mathematical model that describes the size and shape of the Earth [s4 CSA2002]
- National survey control system: means a system used to determine the position of points, features, and boundaries in cadastral surveys, other surveys and land information systems [s4 CSA2002]

Geodesy Outcomes

The Surveyor-General has identified the outcome and objectives of the geodetic and national survey control systems from a regulatory perspective. These are used to determine the nature of any regulatory interventions, such as standards, needed to ensure the geodetic system meets the needs of its statutory users. These identify the fundamental purpose of the geodetic system as:

- A common reference system that enables diverse location-based data/information to be spatially aligned

The goals in this strategy all support the achievement of this outcome.



Vision

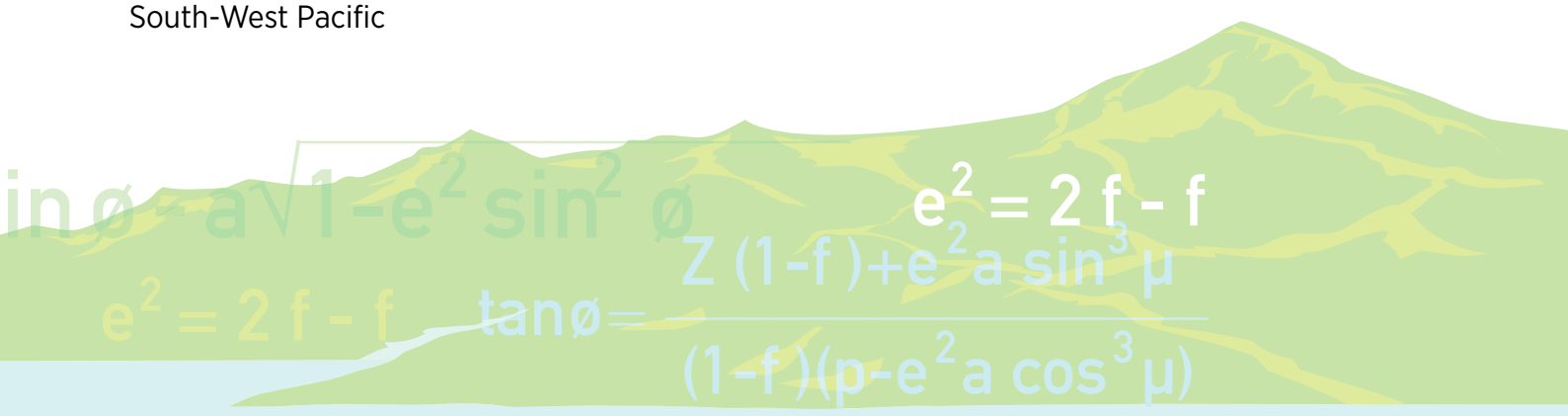
This strategy sets a vision of:

Accurately positioning New Zealand for the future

Ten Year Goals

This vision will be achieved through the following ten-year goals:

1. Enable the efficient definition of three-dimensional property rights through an accessible geodetic system
2. Measure temporal changes to the shape of the Earth's surface, model the gravity field and incorporate the effects into our reference frames
3. Support the maintenance of global reference frames and the connection of New Zealand's geodetic framework to them
4. Provide tools and services that enable accurate and reliable real-time positioning whenever and wherever it is required
5. Provide strong leadership in the development and use of the positioning system in New Zealand and support its development in the South-West Pacific



Ten Year Goals

Goal 1

Enable the efficient definition of three-dimensional property rights through an accessible geodetic system

Cadastral surveyors are, and will continue to be, primary users of the geodetic system as they play an essential role in accurately recording interests in land. The geodetic system has been developed over the last 150 years to support this need and enable the accurate horizontal spatial representation of the cadastre. However, there is an emerging need to consistently define property rights in three-dimensions that creates new demands on the national geodetic system.

In addition, surveyors' willingness to adopt new technology, such as Global Navigation Satellite Systems (GNSS), has changed the way that the geodetic network is used to define property rights. As fewer traditional theodolite-based surveys are carried out, there will be less need for marks to be located on hill-tops or under trig beacons. Instead, marks can be three-dimensionally positioned in locations that are easy and safe to physically access or that can be linked electronically by GNSS technology.

While the use of marks in the ground as a source of position may diminish, they remain a critical component of the geodetic system.
They provide a check on the quality and reliability of positioning carried out using space-based positioning technology and are invaluable for determining land deformation.

We will have achieved this goal when:

(a) Cadastral surveyors can easily define three-dimensional property rights in terms of the geodetic framework

To enable property rights to be defined in three-dimensions, such as in high rise buildings, the geodetic system will need to provide three-dimensional control where it is needed by cadastral surveyors. This could be in the form of surveyed marks or services that enable connection to the reference system.

The increasing need to accurately define offshore, subterranean and air-space property rights will also change the way that the geodetic network is provided to surveyors.

(b) The spatial definition of three-dimensional property rights in official databases is supported by the geodetic system

The cadastre has more benefit to surveyors when the spatial extents of property rights are accurately defined in three dimensions. Similarly, there will be an increasing demand to overlay the cadastre with other datasets to enable visualisation and support decision making.
At present the accuracy of the cadastre is maintained through the horizontal adjustment of survey observations. To support the definition of three-dimensional property rights, the geodetic system will need to provide control points to enable the integration of three-dimensional survey observations into the cadastre. A national vertical datum is an essential pre-requisite for the development of a national three-dimensional cadastre.

The enhancement of geodetic networks will be strongly focused on supporting multiple users and uses of the positioning system. For example, all marks will need to have published heights in terms of an official datum.

(c) The geodetic system will support the use of GNSS as a primary positioning technique used by surveyors

GNSS is becoming the primary positioning technique for surveyors and others working in situations with reasonable sky visibility. Other techniques, such as high-precision imagery, laser scanning and LiDAR, will gain increased acceptance for surveys. Similarly, new technology that enables accurate indoor and underground instantaneous positioning will be available in the near future.

The geodetic system will need to enable surveyors to use new and emerging technologies. It will also continue to be accessible through traditional techniques. However, the focus will be on enabling the use of GNSS as the primary observation tool.

The PositioNZ network of over 30 GNSS continuously operating reference stations provides a national infrastructure that delivers real-time GNSS data streams and products. Direct connection to the geodetic framework will be easily achieved through services based on the PositioNZ network. Alternatively, third-party commercial GNSS services based on PositioNZ infrastructure will be used by surveyors.

Data connections to the PositioNZ network will mean that surveyors have little need to physically visit geodetic marks outside their immediate survey area. Geodetic marks in the immediate vicinity of a survey will be used to validate the quality of positioning solution, rather than as a source of position. Marks placed by cadastral surveyors using the PositioNZ infrastructure will be able to be efficiently integrated into the three-dimensional geodetic system.

Goal 2

Measure temporal changes to the shape of the Earth's surface, model the gravity field and incorporate the effects into our reference frames

The surface of New Zealand is subject to continual change or deformation due to phenomena such as earthquakes, tectonic and volcanic processes, landslides and subsidence.

The accuracy of the national reference frames is limited by our ability to accurately measure and model continual changes in the Earth's surface. An accurate model of the Earth's gravity field is an essential component of the vertical reference frame. The model needs to be progressively refined, and reviewed when significant deformation events occur, to ensure that its accuracy is maintained.

The measurement of deformation requires infrastructure to be in place before changes occur. Traditionally this infrastructure has been physical marks, such as trig stations, that are either continuously or repeatedly observed, often with GNSS or by precise levelling. New techniques such as InSAR[3], which have the ability to rapidly measure change over wide areas, have the potential to complement more conventional deformation surveys.

Once deformation models have been developed they are incorporated into our reference frame to maintain the accuracy of the official coordinates that are based on it. Similarly, models need to be provided to users in a way that makes a common dynamic reference system accessible and easy to incorporate into their systems.

We will have achieved this goal when:

(a) Changes in the shape of the Earth's surface are accurately measured and modelled

Maintaining the accuracy of the national datum through the measurement and analysis of deformation will become one of the major activities of the geodetic system. Improvements to precise positioning technology (such as GNSS) will deliver improved accuracy with lower cost, thereby enabling the deployment of many more sensors. LINZ will also utilise a broader range of sensor types and information sources to measure and monitor the changing shape of the land. Deformation will be measured at the frequency necessary to maintain fit-for-purpose and up-to-date coordinates for features. This will enable a broader range of users to make better use of more accessible and accurate positioning technology. It will also ensure that recovery of the geodetic system from deformation events can be achieved quickly following events such as the Canterbury earthquakes.

(b) Gravity is modelled to enable heights to be determined using modern positioning techniques

Improved access to GNSS technology has made determining accurate ellipsoidal heights straight forward. However, most people need heights measured relative to sea level rather than a mathematical ellipsoid. An accurate gravity model, or geoid, is required to transform ellipsoidal heights to their gravity dependent equivalents, such as mean sea level.
LINZ's work on the vertical datum improvement project, particularly the development of a national airborne gravity dataset, will improve the accuracy of the national geoid from eight to three centimetres.

[3] Interferometric Synthetic Aperture Radar

The geoid can be affected by deformation events that result in significant displacements of the Earth's crust. It will be necessary to review the geoid following such events, and also to monitor it on an on-going basis to identify localised inconsistencies.

(c) Positions of features on or near the changing Earth's surface can be coordinated in relation to the national reference frame

Positions can only be accurately determined in terms of the national reference frames if the deformation and gravity field models are included in the calculations. The modelling of vertical deformation and movements will become increasingly important.

As the application of deformation models is not a simple process, appropriate tools and services will need to be provided to ensure that the models are correctly applied. Similarly, the models must be provided in a form that is accessible to users, and this will involve working with the international community to develop appropriate standards where none currently exist.

Goal 3

Support the maintenance of global reference frames and the connection of New Zealand's geodetic framework to them

New Zealand's reference frames are aligned to and dependent on accurate international reference frames. This is especially relevant for New Zealand as we sit on the edge of a large ocean that comprises a large part of the Earth's surface. Without local data the accuracy of the international systems will be compromised in our region, thereby limiting the accuracy of our datum and hindering global efforts to better understand our changing Earth.

There has been a move away from using country-specific reference systems, such as NZGD2000. The increasing accuracy of international frames means that they can be used directly, albeit with local enhancements. LINZ has a responsibility to ensure that local information is included in global solutions. This can be achieved by providing it ourselves and through collaboration with other international and regional organisations.

Our primary contribution to international systems is by providing local GNSS data to global processing centres. We also support the operators of other sensors, including VLBI[4], DORIS[5] and absolute gravimeters, which help to define the global reference frames. By processing the GNSS data that we currently collect and by participating in relevant forums and groups we can better meet our own deformation modelling outcomes and usefully contribute to the international geodesy community. We are more likely to be able to ensure that international systems meet our needs if we actively contribute to their definition.

We will have achieved this goal when:

(a) New Zealand is a valuable contributor to the definition of international reference frames

We collect and archive large quantities of GNSS and other global positioning data as an important contribution to the international community. By processing the data we collect, submitting our results to regional programmes and by sharing our knowledge, we can provide a valuable contribution to the definition of the orientation, rotation, scale and gravity field parameters of global reference frames. We also contribute expertise to appropriate international organisations to develop and define standards for global reference frames.

By developing our capability to process our data we will be able to develop our own models of New Zealand's deformation environment, and reduce our reliance on other agencies to do this work for us. The knowledge that we develop will enable us to meaningfully contribute to international discussions on the incorporation of deformation into national, regional and global reference frames.

We are actively investigating other technologies, such as InSAR, to determine their suitability for deformation modelling and reference frame maintenance. Our work to collect and integrate a national airborne gravity dataset into our vertical datum is internationally significant. We can also make an international contribution by supporting the operation of two geodetic observatories where multiple sensors can be operated together (GNSS, VLBI, SLR, DORIS, absolute gravity).

[4] Very Long Baseline Interferometry
[5] Doppler Orbitography and Radio-positioning Integrated by Satellite

(b) International reference frames are sufficiently accurate in the New Zealand region

The development of international systems can only be influenced to the benefit of New Zealand if we actively contribute to their definition. Our need to incorporate the effects of our dynamic environment means we are ideally placed to be a leader in the development of practical geodetic systems. We champion this internationally through participation in relevant forums so that what we do is adopted as best practice. We also need to be a strong supporter of, and contributor to, regional systems such as the Asia-Pacific Reference Frame (APREF).

Goal 4

Provide tools and services that enable accurate and reliable real-time positioning whenever and wherever it is required

Consumer-level positioning technology will soon enable users to determine their locations in real-time at the decimetre level using mobile devices. To ensure the relevance of the geodetic system, and the data integration benefits that it brings, appropriate tools and services need to be provided to make data conversion as seamless as possible.

As a government agency it is not appropriate for LINZ to directly participate in providing consumer-level positioning solutions. This is already a significant commercial market. However, LINZ does have a role in providing the positioning infrastructure that others can build on to deliver ubiquitous consumer positioning services. We will contribute the most value to New Zealand by providing efficient tools and services that the developers and manufacturers can embed into their consumer products.

It is likely that the provision of these tools and services, and the details about how they work, will be hidden from most users. To ensure that LINZ services are adopted by developers they will need confidence they can place a high level of reliance on their continuing availability. Users will want to determine their location anywhere, any-time and in real-time, and so we need to provide our products with sufficient resilience to enable this.

LINZ needs to lead improved collaboration between government, private CORS[6] operators and the providers of positioning applications to deliver a suite of tools and services that achieve this goal.

We will have achieved this goal when:

(a) LINZ provided services are used by customers to determine real-time precise positions in terms of the official datum

The proliferation of GNSS-enabled devices comes with an expectation of being able to determine accurate positions by everyone, everywhere at any time. Users expect their devices to provide accurate coordinates without the need to understand the complexities of how they are derived.

Many positioning services will be delivered by other providers, and use LINZ's services and tools indirectly or invisibly. New Zealand's relatively small market will mean that manufacturers will be less likely to deliver locally customised solutions unless LINZ provides tools to simplify the process, for example our national geoid and deformation models. The tools and services that we need to provide must suit our differing customer groups by supporting a variety of formats and providing appropriate documentation to enable easy integration and use.

[6] Continuously Operating Reference Station

(b) Third-party products and services provide positions in terms of New Zealand's official reference frames

The integration of disparate geospatial datasets can be more easily achieved if the data is produced in terms of an official reference frame. From a user perspective it is simplest if their technology produces data in terms of the official system by default. At its simplest level, this can be achieved by our datums and projections being defined in terms of international standards, such as Transverse Mercator, so that they can be easily adopted.

Our role is to ensure that users and third-party operators can easily and reliably connect their products and services to our reference systems. Including private CORS stations in our national PositioNZ processing ensures that consistent official coordinates are available for the third-party operators.

(c) Positions can be determined across New Zealand in real-time with high integrity and known uncertainty at sub-decimetre accuracy

Most users want their positioning device to determine an accurate location in real-time and have little concern with the technical details of datums. Increasingly there is a need for the integrity and uncertainty of computed positions to be validated in addition to their accuracy. Commercial services currently provide real-time positioning at the level of a few centimetres in highly populated areas of New Zealand. Internationally, decimetre-level positioning services are often provided as public infrastructure. We need to consider whether such a public system is appropriate for New Zealand.

(d) Our reference frames are used by people across New Zealand

Using a common reference system will enable users to consistently locate datasets across New Zealand, its off-shore islands, continental shelf and the Ross Sea Region of Antarctica. We need to provide reference frames that can be accessed by users outdoors, indoors, off-shore and underground. Our references frames and their derivation need to be fully understood by users so that they can be applied appropriately. Our products, tools and services need to be appropriate to our differing users to enable them to relate their data to common reference frames.

Goal 5

Provide strong leadership in the development and use of the positioning system in New Zealand and support its development in the South-West Pacific

LINZ is the Steward of the positioning fundamental data theme and Custodian of many of the datasets. This is a national infrastructure that includes the individual data sets that allow multiple geographically dependent data sources to be integrated into a single geographic reference frame.

As Steward LINZ takes a national perspective across the entire positioning theme to ensure there is a common aspiration that all are working towards. With our statutory mandate to manage the geodetic system, LINZ is well placed to take this national view and provide a common positioning infrastructure that all users of spatial information can use.

As the agency responsible for a highly developed geodetic system we should also assist our South-West Pacific neighbours to enhance their systems to a standard that meets their requirements and where they can also contribute to the enhancement of global reference frames.

We will have achieved this goal when:

(a) LINZ is the respected leader of the geodetic system and Steward of the positioning theme

Stewardship requires inclusive decision-making and leadership. This can only occur if LINZ actively engages with current and potential users of our products and services.

We will need to interact with a broader range of organisations with an interest in the positioning theme, for example the transport sector, and promote collaboration among public and private sector organisations to deliver improved geodetic services. We also must continue our active involvement in the international positioning community to ensure that international standards, products and services meet New Zealand's needs.

(b) LINZ is a trusted Custodian of the core geodetic datasets within the positioning theme

LINZ has a statutory requirement to maintain a number of core geodetic datasets, datums and projections. Users need confidence that LINZ, with its products and services, is the trusted source of geodetic information in New Zealand. As such, LINZ needs to promote usage of our products and assist people to gain benefits from their use.

LINZ may not be the exclusive Custodian of all positioning datasets. Where other organisations provide datasets we need to work with them to ensure they are complementary and can be easily integrated by users.

(c) Geodetic systems of South-West Pacific countries improve as a result of LINZ advice and assistance

As the national geodetic organisation for New Zealand, we need to share our knowledge with colleagues from other South-Pacific government agencies. For example, incorporating GNSS data from South-West Pacific nations in our routine processing will improve the quality of our network, as well as international reference frames in those regions and across the wider region as a whole. We will also actively participate in the development and enhancement of the regional Asia Pacific Reference Frame (APREF).

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