A NEW GEOCENTRIC DATUM FOR NEW ZEALAND

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Abstract

The current New Zealand Geodetic Datum 1949 (NZGD49) has internal distortions of over 5 m present due to the limitations of the survey technology used to define it and the effects of earth deformation. Accordingly, the requirements for a modern accurate geodetic spatial infrastructure for the purposes of land information can no longer be met with the existing datum. Land Information New Zealand (LINZ) has approved the development and establishment of a new geocentric datum, New Zealand Geodetic Datum 2000 (NZGD2000). This will satisfy user requirements and identified business drivers, and will accommodate the effects of crustal deformation that continue to degrade the current datum. The reasons for a new datum, options considered, and final decision on the form of the new datum are discussed.

Introduction

The current geodetic datum, New Zealand Geodetic Datum 1949 (NZGD49), has satisfactorily served the cadastral system of New Zealand, and other user requirements, for the past 50 years. However, it cannot now meet the requirements of new survey technologies such as GPS and higher accuracy user requirements.

New Zealand Geodetic Datum 1949

When NZGD49 was established, it complied with the then current recommendations of the International Association of Geodesy (IAG) and utilised the then International Reference Spheroid. This horizontal datum (a vertical datum was not included) was a best fit between the local geoid and the International Spheroid and based on classical geodetic astronomy for fit and position. The position of the origin of this reference spheroid is displaced approximately 200m from the centre of mass of the earth.

Limitations with NZGD49

During the 1980's and 1990's the increased use of satellite based geodetic measuring systems - such as the Global Positioning System (GPS) - began to impact on the utility of the national datums of many countries including New Zealand. The inconsistency between NZGD49 and international reference systems started to impact adversely on navigation, scientific applications and on routine spatial data management. Prior to this, internal distortions of the datum, steadily increasing by about 5cm a year across New Zealand because of it's position astride the Pacific/Australian tectonic plate boundary, also began to impact on geodetic processing. The introduction of electronic distance measuring equipment highlighted variations in the definition of scale. The new observations were inconsistent with the distances derived from coordinates of geodetic stations. GPS, with its potential to efficiently meet existing survey accuracy requirements over very long distances, has significantly increased this problem. Distortions of up to 7m are now present in the existing datum (Figure 1).

Drivers for a New Datum

In deciding on the option for a new datum a number of business drivers were identified against which the various options considered were evaluated. The drivers were:

- geodetic and cadastral automation **(**LINZ is committed to the automation of the survey and land title system in New Zealand)
- support core government responsibilities. **(**This includes maintaining the cadastral system and administrative mapping, topographic mapping, hydrographic charting, transportation and safety, and defence)
- need to simplify the management of digital spatial data
- need to reduce risk to the Government
- need to reduce cost to the Government and the level of government intervention
- increased public usage of the core spatial infrastructure
- need to facilitate the use of international systems
- need to reduce client compliance costs
- changing government needs
- earth deformation **(**The current geodetic datum will not accommodate the effects of earth deformation)
- the need to anticipate future user requirements.

Options for a New Datum

Existing or New Datum

Three datum options were identified that could meet user needs and business drivers.

Option 1 - Status Quo: Under this option, NZGD49 would be retained as the official geodetic datum for New Zealand. Applications requiring use of global reference frames, such as one of the International Terrestrial Reference Frames (ITRF), would be facilitated through transformations which convert between NZGD49 and these global systems.

Option 2 - Computational Datum: Under this option, NZGD49 would be retained as the official geodetic datum for New Zealand. However computations would be undertaken in terms of a globally consistent and undistorted reference frame. The first step in any computation requiring survey accuracy would be to transform from

NZGD49 to the computational datum. The last step would be to transform final results from the computational datum to NZGD49.

Option 3 - New Datum: Under this option, NZGD49 would be decommissioned and a new datum would be commissioned as the official geodetic datum for New Zealand.

Option three, a new datum, was adopted as the most appropriate choice because it was the only option able to meet LINZ geodetic and spatial business drivers, particularly in the long term..

Local vs Geocentric Datum

Having made a recommendation to have a new datum, a further decision was required on the origin of the new datum. Two options were considered.

Option 1 - Local Datum: Under this option, the new datum would be designed to provide a best fit, in the average sense, to NZGD49. The origin and ellipsoid would be chosen so that the coordinate differences between the old and new datum would be relatively small (up to say 5 metres).

Option 2 - Geocentric Datum: Under this option, the new datum would be based on and would closely match, the International Terrestrial Reference System (ITRS) through one of its reference frames - the International Terrestrial Reference Frames (ITRF). This would be in line with the recommendation of the International Association of Geodesy (IAG). The ellipsoid chosen would be the Geodetic Reference System 1980 (GRS80) ellipsoid as also recommended by the IAG (IAG, 1980).

Option 2 was considered the most appropriate, primarily because of it's consistency with international standards and consistency across LINZ's areas of responsibility.

Method for Management of Dynamics

Another high level decision made regarding key characteristics of the new datum was management of the coordinate changes, either due to earth deformation, from improved survey information or a combination of the two. Three options were considered.

Option 1 - Static Datum: Under this option, the new datum is defined by the coordinates of key geodetic stations. The coordinates of these stations are held fixed. The existing NZGD49 is a static datum.

Option 2 - Semi-dynamic Datum: Under this option, the datum is defined by its relationship to a dynamic global reference frame at a specified epoch. The datum definition is frozen at this epoch and does not include time dependencies. Coordinates at the reference epoch may change slightly on acceptance of new data in order to maintain the defined relationship between the datum as a whole and the global reference system. Such changes would primarily be as a result of improved accuracy. However, larger coordinate jumps may be required as a result of earthquakes or localised mark movement. Modelling of more uniform time dependencies may be applied during calculations in order to remove systematic errors due to earth deformation. This modelling would be based on a velocity model and would effectively be a time-dependent transformation. All results would be converted back to the reference epoch and expressed in terms of that epoch.

Option 3 - Dynamic Datum: Under this option, the datum is defined by its relationship not to a specific reference frame at a specific epoch but continuously to a dynamic global reference system such as the International Terrestrial Reference System (ITRS). Time dependencies are included in the definition such as station velocities, rates of change for transformation parameters, etc. Coordinates, velocities, transformation parameters, etc., change as required to ensure that the datum axes, and thus the coordinates of points, closely maintain their defined relationship to those of the global reference system.

The option which best meets LINZ geodetic business drivers is Option 2, a semi-dynamic datum which can be treated as if it were a static datum by many users.

Adoption of a New Datum (NZGD2000)

The recommendations were proposed and adopted by LINZ in May 1998. To manage the generalised motion of points in New Zealand with respect to the ITRS a velocity model (Figure 2) for New Zealand has been developed to allow up to date coordinates to be derived at a date other than the reference epoch.

Time Table for Implementation

The design and build stage of NZGD2000 is expected to be completed by 1 January 1999. Implementation of the new datum will commence as the automated survey and title system is brought on line from mid 1999. A number of further projects including assessment of New Zealand's mapping projections and transformations between the new datum and existing datum/projections are also commencing.

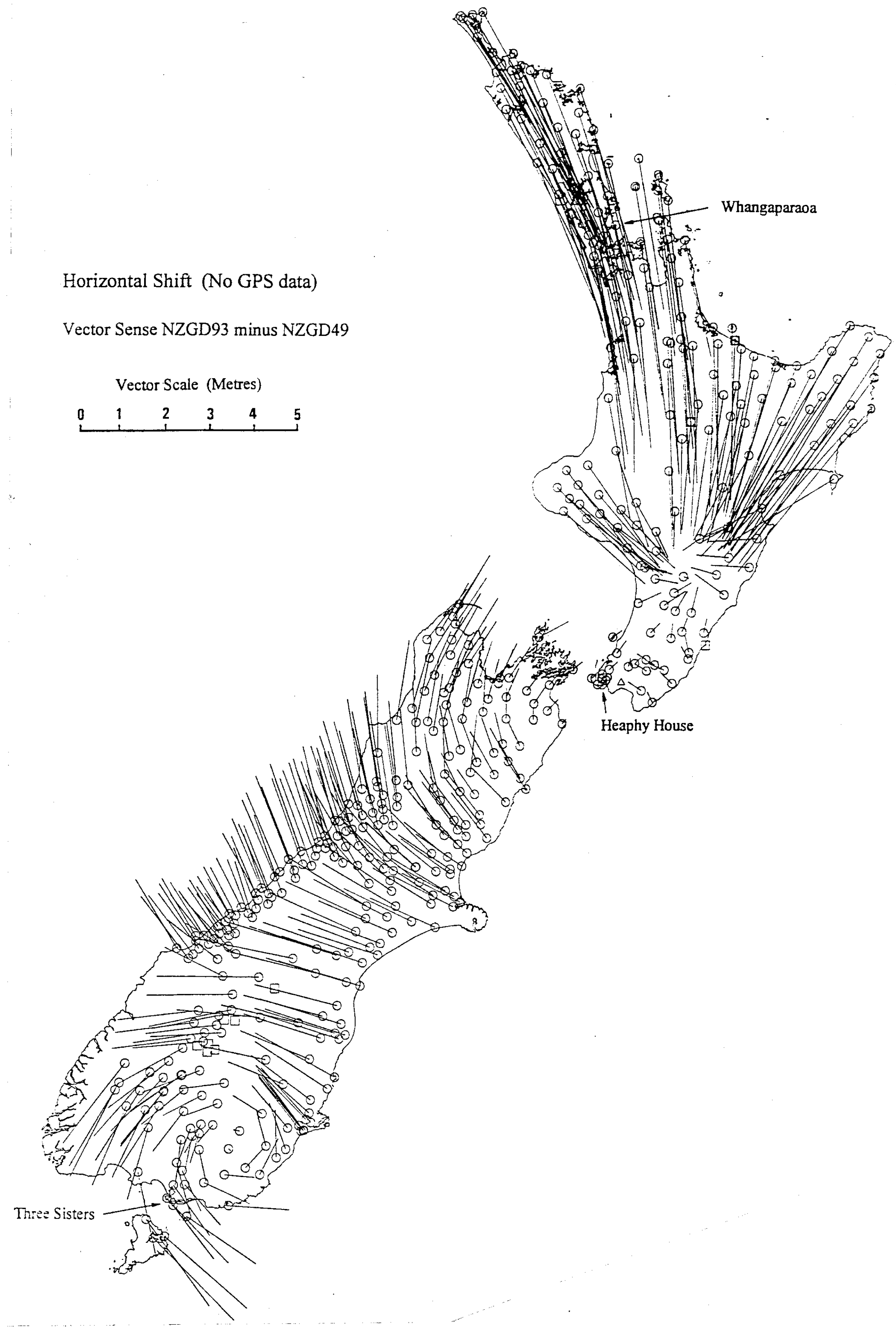

Fig. 1. Current distortions in NZGD 1949 [Taken from Bevin, A.J. and J. Hall. 1995: The review and development of a modern geodetic datum. *New Zealand Survey Quarterly. Issue 1: 14 - 18.*]

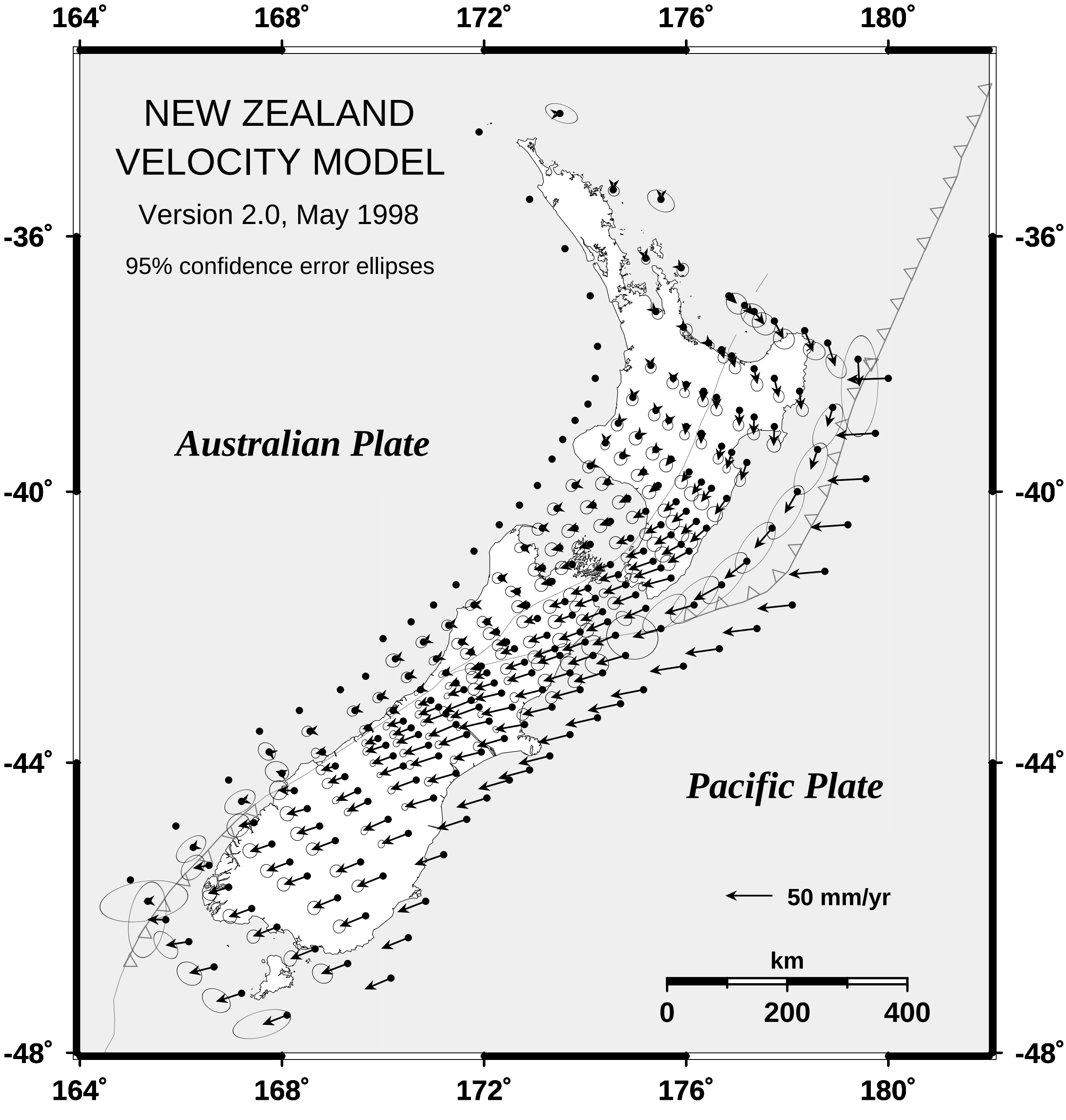

Fig. 2. New Zealand velocity model with Australian Plate held fixed. [Taken From Beavan, J. and A. J. Haines, Contemporary horizontal velocity and strain-rate fields of the Pacific-Australian plate boundary zone through New Zealand, *submitted to J. Geophys. Res., July 1998.*]