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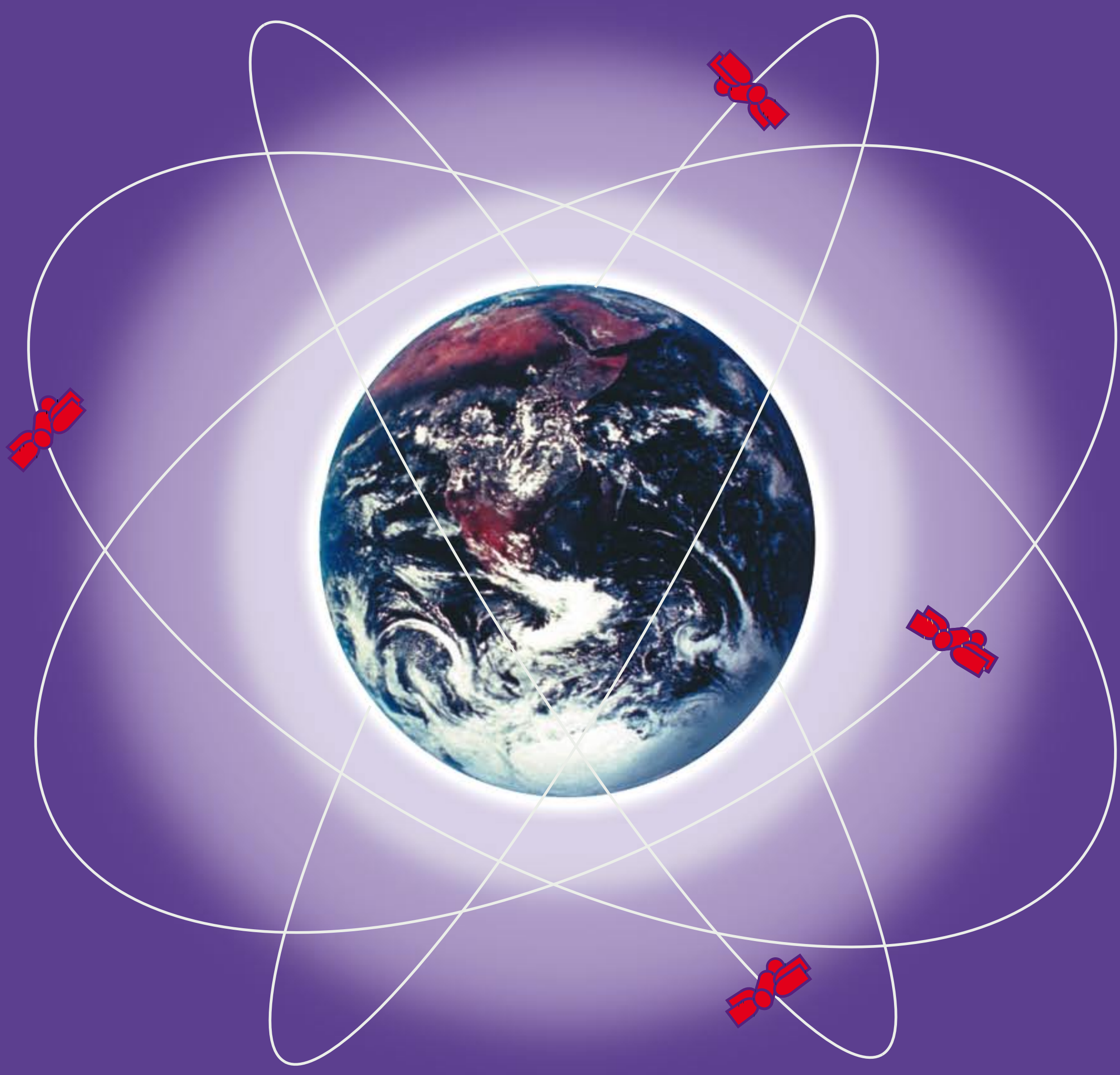

- Calibrating Minolta VIVID 910 3D laser scanner for medical mapping
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NEW ZEALAND INSTITUTE OF SURVEYORS

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- *Promoting ethical professional conduct amongst its members*
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- *Raising public awareness of the knowledge, skills and experience of surveyors.*

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REFEREE PANEL

COVER PICTURE

The cover continues our global theme and shows a view of planet earth from outer space encircled by a constellation of stylised satellites. This symbolises the global nature of surveying; the development of the Global Positioning System which succeeds through international co-operation and the New Zealand surveyor working throughout the world.

EDITORIAL

Educating Technical Surveyors

JOHN BALDWIN

Editor

Well educated, trained and qualified Technical Surveyors, Survey Technicians or Instrument-men are a vital part of our survey industry. Their availability is essential for the maintenance and advancement of the profession not least, to allow graduate surveyors to advance to senior management roles in our diversely skilled profession.

Without adequate numbers of trained technical surveyors, the graduate surveyors are often the only staff available in a multi-disciplined firm to competently carry out field surveys of even the most basic kind. While adequate and varied fieldwork experience is vital in the training of graduates before they get 'trapped in the office', for advancing their planning and design skills , it is equally important that they are not distracted by the demands on their measuring skills for jobs that are technician work.

This year, with InfraTrain, the Surveying Industry's Training Organisation (ITO) senior members of the Institute have been operating as a Technical Advisory Group (TAG) to review and revise our NZQA Level 6 National Diploma of Surveying curriculum and the content of each Unit Standard for which Surveying is responsible. The TAG is also reviewing the Level 3 Certificate in Surveying, the National Certificate in Surveying. The review is a two stage process. First the details of each Unit standard have been reviewed, then a revised selection of Unit Standards is made for the Diploma.

The NDS was established after a quiet employment period in the early 1990s so the course was designed to cover an array of topics seen as essential to provide certain employment, in private practices, central government and local government. Perhaps the NDS might have been more successful in this diversity if its teaching had been widely taken up especially by distance learning. As events evolved, only Unitec in west Auckland, and only with financial input from the Institute took up teaching the Diploma. The NZCLS course folded and many aspiring technician surveyors with partly completed qualifications were abandoned by the education system.

The NDS has not attracted large numbers of students and partly because of this has not been given priority treatment for all aspects of the course content as the new NZQA education regime has slowly evolved. InfraTrain, is our third ITO and appears much better established than its predecessors to support surveying. It is gradually gaining competence and staff with experience. Unitec and InfraTrain are the only registered providers for the Surveying Diploma but InfraTrain are not teachers. They help firms help themselves. Students away from Auckland need to be enrolled through InfraTrain.

If firms (probably NZIS branches) can handle work place learning programmes then the NZQA Framework model should be ideal. However, with no formal distance learning programme with detailed course material established yet, provincial town employees have been seriously disadvantaged. The NZQA Framework allows workplace training and education to gain a qualification without an employee having to leave town. InfraTrain has the responsibility of governing the quality of workplace training and any associated block courses.

If NZIS members can work effectively with InfraTrain to make quality course instructions available all surveying will be able to advance. Cooperating amongst firms for activities such as locally organised and run block courses may be necessary for some subjects. Although these will cost, a few days spent locally at agreed times can be attractively cost-effective compared to each firm sending staff to distant cities for similar instruction.

Having reviewed the content of each of our existing Unit Standards, the next task for the TAG is to assemble a new level 6 National Diploma curriculum appropriate for the next five years or longer. Throughout the country, there is a huge amount of highway and infrastructure construction, either new or deferred work for which modern-day technical surveyors with strength in civil engineering would be in high demand.

If NZIS Branches or groups of smaller firms can show some teamwork and cooperative efforts, surveying should be able to attract able school leavers to attractive surveying careers. NZIS is familiar with needing to punch above its weight and to get sustainable technician education functioning properly nationwide we must go these rounds to create meaningful education for technicians. Like the woodsman, making the time to sharpen the axe will bring better results than flailing away without making brave changes.

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Calibrating Minolta VIVID 910 3D laser scanner for medical mapping

ABSTRACT

The paper describes the calibration of a Minolta Vivid 910 3D laser scanner for medical applications such as denture, trunk, limb and craniofacial (face and skull) 3D mapping. The calibration of the scanner was essential to determine the accuracy and reliability of the instrument. The Vivid 910 was calibrated using three objects of different shape, size and surface texture. The objects used were: 1) a smooth-surface cylinder; 2) a dental cast; and 3) a mannequin. Each object was scanned five times and was later measured using close-range photogrammetry technique and/or a Microscribe 3D electronic digitiser system. The measurements obtained by the scanner were compared with the measurements obtained by the other two techniques. In addition, the close-range photogrammetry measurements were held as the true values. The results show that the scanner has accuracies ranging from 0.1- 0.3mm at one standard deviation depending on the shape, size and surface texture of the objects.

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His current research interest is in 3D modeling and measurement, deformation monitoring, least squares estimation and industrial metrology.

INTRODUCTION

The paper discusses the calibration of the Minolta Vivid 910 Laser scanner (Konica Minolta, Japan) for medical mapping. Generally, the scanning system consists of a red laser light source, a light projection system and a digital imaging system. A set of prisms and mirrors projects the Laser beam as an ultra-thin profile on the object, which is photographed by a CCD camera mounted close to the projector (Figure 1). The relative position between the internal reference point of the projection system and the camera lens is fixed. In addition, the angle of each projected laser profile plane and the angle of the camera optical axis were calibrated in advance. Subsequently, the x, y and z coordinates of the object-space position of each pixel on the object can be computed using the scale of the photography, the relative positional vector and the known angles. A least squares technique is used to compute a set of optimal 3D coordinates of the object surface. By and large, the texture and radiometric value of the CCD images are added to the 3D data to obtain a realistic 3D surface model of the object. Further information of the scanner design and specifications can be found in O'Grady and Antonyshyn (1999) and Bernardini et al (2001).

The scanner is fully supported by a suite of software, which includes limited system calibration, data capture and data editing. The data capture phase is fully automated. After conducting a scan, the 3D point cloud may be displayed and edited on the computer screen using third party software such as RapidForm (INUS Technology Inc. Soul Korea).

In the paper, the Vivid 910 was calibrated using three objects of different shape, size

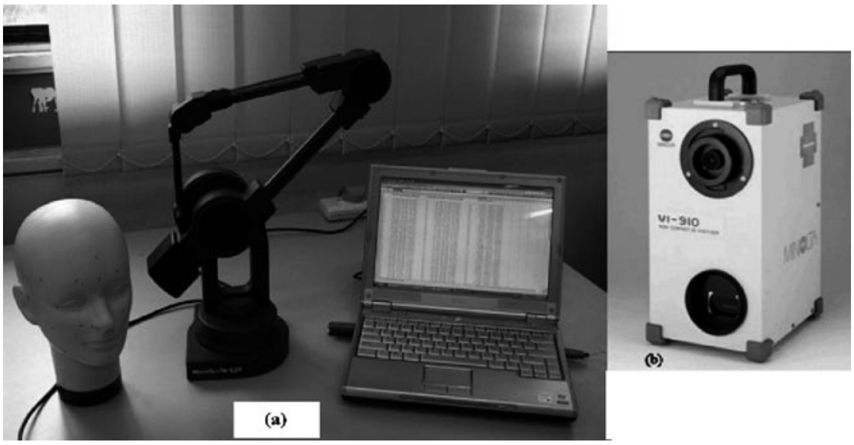

Figure 1: a) Microscribe 3D digitiser and b) Minolta Vivid 910 Laser scanner.

and texture: 1) a small cylinder; 2) dental cast; and 3) a mannequin. Subsequently, the objects were measured by close-range photogrammetry technique and a Microscribe 3D electronic digitizer system (Immersion Corporation, San Jose, CA) where applicable. The measurements obtained by the scanner were compared with the measurements obtained by both the close-range photogrammetry and Microscribe 3D digitizer system (Figure 1). The close-range photogrammetry measurements were selected as true values.

METHODS AND MATERIALS

Scanning the cylindrical object

A cylindrical object of width of 120mm and height of 196mm was chosen because of the simplistic curve-shape and smooth surface (Figure 2). The object was scanned five times and the averaged width and height were computed.

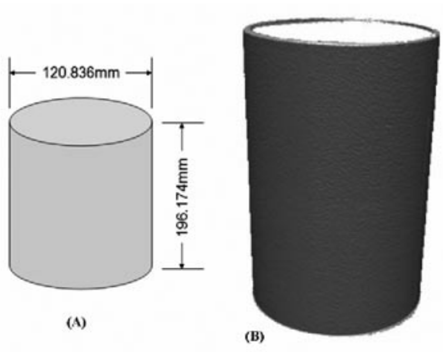

Figure 2: The cylindrical object: (A) is Drawing and (B) Laser Scan.

Scanning the dental cast

The dental cast was positioned at 650mm (S_d = 650mm) from the scanner (Figure 3). A telephoto lens (focal length = 25 mm) was used as the dental cast was small compared to regular objects as a human trunk. To build a complete 3D model two scans were required and the optical axis of the scan were set roughly to 25 degrees from the central line as shown in the figure.

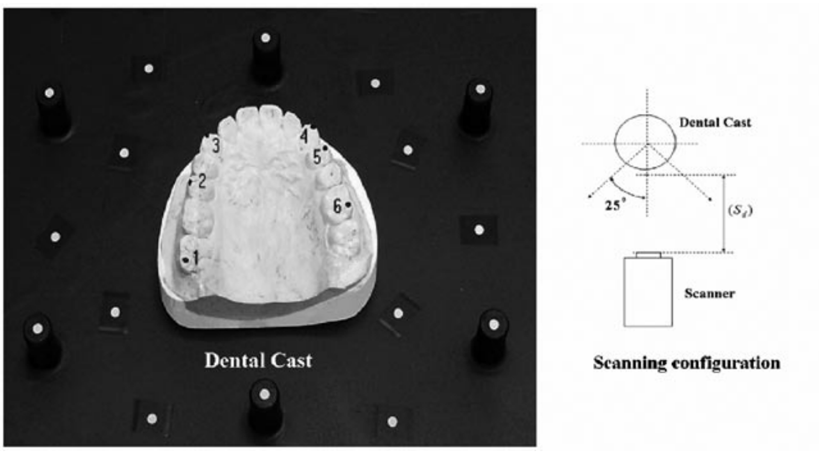

Figure 3: The dental cast and the scanning configuration.

After the scanning, pre-processing involved a 3D registration of the two scans (known as shell) to build a complete 3D model. The registration method uses a reverse engineering method programmed into the RapidForm 2004 3D modelling software (INUS Technology, Seoul, South Korea). Five corresponding points was measured manually on the left shell and the right shell respectively. After digitizing the five points, the registration proceeded automatically. Figure 4 shows the 3D registration process.

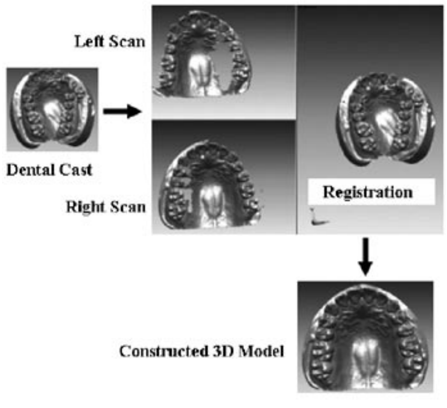

Figure 4: 3D shell/shell registration using Rapidform Software.

The accuracy of the 3D registration process was analyzed using shell/shell deviation method. The method calculated the deviation value between the left shell and right shell dental in the overlapping area of the dental cast. The deviations between the shells are displayed in colour scale method (Figure 5). The colour scale shows the registration accuracy was close to 0.1mm (average value of deviation).

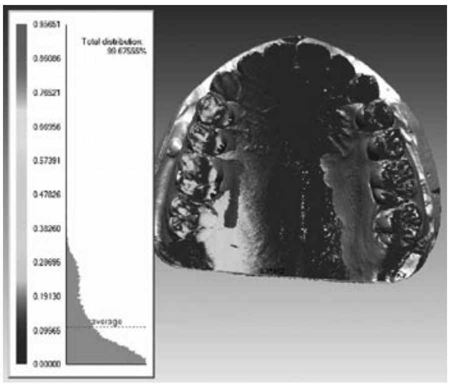

Figure 5: Shell/Shell deviation analysis of rebuilt dental cast surface model.

The final step in the processing of the scans is the 3D merging process. The 3D merging process could be executed if the accuracy of the 3D registration of the left shell and the right shell was within the accuracy required for the project. The accuracy required for the mapping project was 0.7mm and the value was larger than the 3D registration accuracy (0.1mm). Again, the 3D merging process was carried out using RapidForm software. The merging process involves combining the two overlapping shells into one shell or one 3D surface model. Figure 6 shows the merged dental cast model.

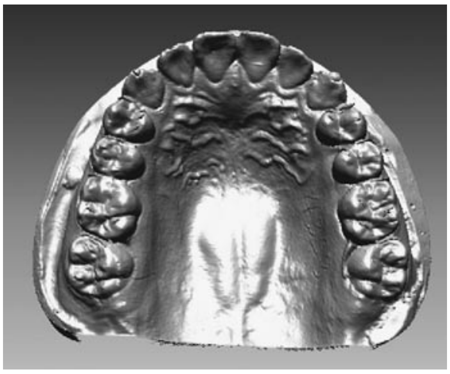

Figure 6: Merged 3D dental cast.

The accuracy of the 3D dental cast was evaluated by a comparison of the slope distances between anatomical dental points. Six anatomical dental points were selected (Figure 2). Ten slope distances was measured on the 3D model using point-to-point distance measurement function (RapidForm software). The average slope distances obtained from five constructed models were compared with the distances from convergent photogrammetric technique and the Microscribe 3D electronic digitizer system. Figure 7 shows an example of the slope distance measurement on the dental cast surface 3D model.

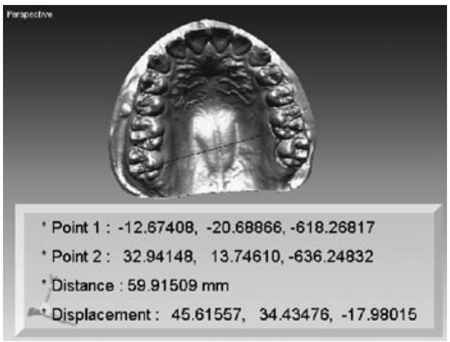

Figure 7: Slope distance measurement on dental cast surface 3D model.

Scanning the mannequin

The mannequin and the scanner were positioned as shown in Figure 8. Nine anthropometric marks were placed on the mannequin so that slope distances could be obtained from the scanned model for accuracy comparison. The mannequin was scanned three times and each time both the left and the right scans were captured as shown in Figure 8.

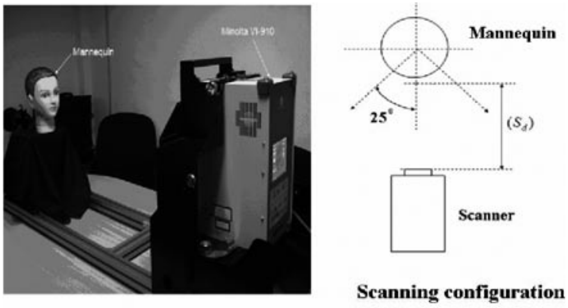

Figure 8: The mannequin and the scanner during the scanning. Note that the holding device can rotate the scanner along it vertical axis.

Photogrammetry technique

As mentioned elsewhere in the paper, measurements from the photogrammetric technique were selected as the true values. Consequently, it is essential to provide a short discussion as to the method of imaging, data capture and accuracy analysis of this technique. The object provided is based on the dental cast which is considered difficult to map because of its size. The dental cast was placed on top of a calibration range as shown in Figure 9. The range consists of retro-targets which can be digitised to one-hundredth of a pixel. The range was calibrated before the exercise (Chong 1999). Three sets of six-convergent images was captured and processed using Australis bundle adjustment software (Photometrix Pty Ltd, Kew, VIC. Australia). The average of the 3D coordinates of the anatomical dental points was used to calculate the distances between the points (Figure 3).

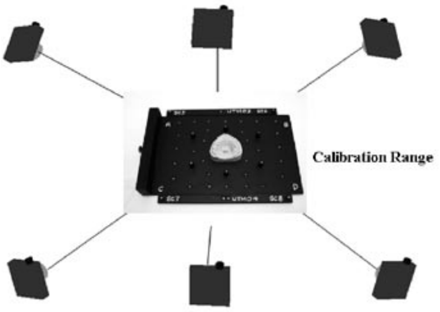

Figure 9: Measurement of dental cast using convergent photogrammetric method.

RESULTS AND ANALYSIS

The cylindrical object

The computed difference and standard deviation based on five sets of measurements are provided in Table 1. The standard deviation is within the limit of 0.7 mm as required by our medical mapping project.

Table 1: Measured and true dimension of the cylinder.

Dimension	Averaged dimension (mm)	True dimension (mm)	Difference (mm)	Standard Deviation (mm)
Height	196.591	196.174	0.366	0.191
Width	120.325	120.836	0.511	0.203

The dental cast

Table 2: Slope distance comparison between three measurement techniques.

Slope Distance	Scanner (mm) (A)	Photogrammetry (mm) (B)	Microscribe (mm) (C)	A-B (mm)	A-C (mm)
5-6	20.769	20.552	20.510	0.217	0.259
5-1	60.793	60.637	60.601	0.156	0.192
5-2	49.503	49.484	49.585	0.019	-0.082
5-3	42.919	42.865	42.929	0.054	-0.010
4-3	38.261	38.399	38.414	-0.138	-0.153
6-1	60.128	59.637	59.680	0.491	0.448
6-2	56.903	56.653	56.798	0.250	0.105
6-3	55.805	55.715	55.938	0.090	-0.133
2-3	17.161	17.257	17.102	-0.096	0.059
1-1	24.353	24.140	24.124	0.213	0.229
			Mean	***0.172***	***0.167***
			Std Dev.	***0.128***	***0.119***

Table 3: Slope distance comparison between photogrammetry and scanner.

Slope distance	Photogrammetry (mm) (A)	Scanner (mm) (B)	A-B (mm)
3-5	51.010	50.817	0.193
4-6	64.009	64.122	-0.113
3-7	105.197	105.464	-0.267
5-7	105.366	105.613	-0.247
3-2	83.003	83.079	-0.076
5-9	88.703	88.750	-0.047
		Mean	***-0.093***
		Std. Dev	***0.166***

The results of dental cast study show that there were no significant differences statistically between the three measurements (Table 2). All three techniques satisfied our project accuracy of requirement 0.7 mm at one standard deviation. However, the scanner is a very efficient method of capturing the 3D surface of the dental cast.

The mannequin

The results of the study on mannequins show that the differences and standard deviations were also within the limit required for our medical project (Table 3). In this case, measurements obtained by the photogrammetric technique were held as the true values.

DISCUSSION AND CONCLUSION

The calibration was carried out for three reasons: 1) the scanner can give the accuracy we needed for various types of object shape, object size (from size of the trunk to size of a finger nail) and surface texture; 2) our processing method gives the correct measurement; and 3) we would have calibration data to show our mapping products are accurate within the project specifications. In general, our models were computed based on an arbitrary coordinate system which made it difficult to compare the scan measurements with other techniques such as photogrammetry. Consequently, we computed and used slope distance in the comparison.

The results of the study show that Minolta Vivid 910 3D laser scanner satisfies the accuracy required for our medical mapping project. In addition, the time required to produce a 3D surface model is a fraction of the time it takes to produce a similar model using photogrammetric technique. Because the scanner does not freeze the scene as in the case of photogrammetry technique, movement of human subject can be problematic. Limited tests showed that the error of movement can result in the rejection of the many scanned models in craniofacial mapping.

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Implementing crime prevention through environmental design

ABSTRACT

Place-based crime prevention design and planning are diverse activities but one concept is particularly popular within New Zealand. In recognition of the increasing interest in Crime Prevention Through Environmental Design (CPTED) this paper introduces the concept before outlining the relevant national crime prevention context. The paper then reports on a national investigation into the diverse ways CPTED is engaged. It focuses especially on those factors that have assisted New Zealand's territorial local authorities in implementing this crime prevention concept and closes with recommendations for advancing national CPTED implementation. Surveyors have a key role in such implementation.

HANNAH BLACKFORD is a recent graduate of the University of Otago's Master of Regional and Resource Planning Programme. Hannah's Master's thesis investigated the implementation of Crime Prevention Through Environmental Design by New Zealand's local authorities. Through her research, Hannah has developed a keen interest in the development of quality urban environments, and is pursuing this interest in her work as a private planning consultant currently based in Queenstown.

RUTH PANELLI is a Senior Lecturer in Geography at the University of Otago where she specialises in critical social geographic research.

MICHELLE THOMPSON-FAWCETT is a Senior Lecturer in Geography at the University of Otago where she analyses practices surrounding planning and futuring.

INTRODUCTION

Crime Prevention Through Environmental Design (CPTED) is one of many related crime prevention concepts and techniques. Others include defensible space (Newman 1971, 1972, and 1981), environmental criminology (Brantingham and Brantingham 1981, 1991), situational crime prevention (Clarke 1997), and rational choice theory (Clarke and Felson 1993, Newman et al 1997). These theories are linked by their primary focus on the characteristics of the place-based and environmental contexts of a criminal event; thus contrasting with notions focused on psychological, social, or economic factors. Indeed, they consider specifically what it is about a place that causes crime to occur there.

Since Jeffery (1971) first articulated the principles of CPTED in his book entitled *Crime Prevention Through Environmental Design*, crime prevention practitioners and academics across all disciplines have debated the concept and its validity. While the response has been largely positive, there is an ongoing discussion over the politics and determinism of such a basis for design (Parnaby, 2006; Borch, 2005; Andrews, 2003; Steventon, 1996).

To this day, a definitive empirical verification as to whether CPTED really does deter or prevent crime remains elusive (Schneider & Kitchen, 2002). This is recognised as largely due to the complicated crime-environment relationship, which is significantly influenced by elements of both natural and built surroundings.

Despite these reservations, there is a growing body of evidence that place-based crime prevention strategies, including CPTED, are effective (Sherman et al 1997). Without disregard to the aforementioned deliberation, it is generally agreed that design does play a role, albeit difficult to characterise, in making crime more or less likely to occur within the built environment (Schneider & Kitchen, 2002). The central tenet of CPTED has therefore remained that "the proper design of the built environment can lead to a reduction in the fear of crime and the incidence of crime" (Crowe 2000:1).

CPTED PRINCIPLES

While the continuing refinement and evaluation of CPTED has meant there is no generic prescriptive process for applying the concept (nor could or should there be), territoriality, natural surveillance, natural access control, and maintenance and management remain the four core principles (Crowe, 1991). These principles aim to achieve 'natural' and 'people-focused' surveillance and enforcement measures, and are designed to promote both perceptions of safety and statistical safety within an urban environment.

'Territoriality' conceptualises the observation that people will protect space they define as their own as well as respecting the territory of others. Consequently, this principle focuses on how the built environment can be designed to visibly express active ownership and provide clarity as to which spaces belong to whom. The use of landscaping, landforms, or decorative fencing are examples of features which can be used to demarcate public and private space, thereby extending a sense of 'ownership' and increasing the sense of risk for a potential offender (Cozens, 2002).

The principle of 'natural surveillance' is grounded in the idea that criminals usually do not wish to be observed when involved in an unlawful act. The ability to casually monitor a public area, and the associated feeling of continuous observation by other people when in those public areas, can subsequently have a marked effect in securing that environment (Newman, 1972).

'Natural access control' highlights the notion that people exercise variable levels of control over a space. The use of physical and symbolic barriers to influence movement of people and define appropriate areas for public access enables access and control to be naturalised. By limiting access points and ensuring entry occurs in areas of enhanced natural surveillance, potential offenders are discouraged or are marked as an intruder (Sampson et al, 1998).

Lastly, 'maintenance and management' emphasise the vital importance of maintaining the built environment as a physical indicator for levels of social cohesion and informal social control. Physical deterioration is recognised as giving rise to safety concerns as well as creating the undesired impression that criminal activity in that area may pass undetected. Importantly, a well maintained space can be linked to the principles of territoriality and natural surveillance by projecting 'ownership' and frequent use of an area (Cozens et al, 2001).

In the present article, the context and mechanisms for adapting these CPTED principles in New Zealand is addressed. These are matters that surveyors have the potential to act on, especially via subdivision layout and engineering processes.

CPTED WITHIN THE NEW ZEALAND CONTEXT

While there is currently no legislation within New Zealand that specifically requires local authorities to assess crime risk, the Resource Management Act (1991) and Local Government Act (2002) position local authorities as responsible for the social, environmental, economic and cultural wellbeing of their communities. This includes playing a part in reducing crime. As a result, more and more local authorities are beginning to take account of crime prevention in their subdivision, planning and resource consent processes. These processes enable a forum for introducing the principles of CPTED as part of the design and development of urban environments prior to their construction.

In supporting and facilitating local authorities to achieve these new responsibilities, the Ministry of Justice has taken an active role through the establishment in 1993 of its Crime Prevention Unit (henceforth CPU). Together, the Ministry of Justice and CPU have developed various networks, funding, partnerships, strategies, and action plans, intended to support and guide local authorities in achieving localised crime reduction. Since November 2005, the Ministry of Justice has developed and released a national set of CPTED guidelines intended to provide a framework for all of New Zealand's local authorities to introduce the principles of CPTED in ways that are appropriate to the New Zealand context. This has been followed by the provision of $250,000 of funding provided by the Ministry of Justice in 2006 to assist with the development of localised crime prevention initiatives.

INVESTIGATING THE ADOPTION OF CPTED

In light of the increasing interest in crime prevention, and following the release of New Zealand's own CPTED guidelines (Ministry of Justice, 2005); it is timely to document those factors that have served to enhance local authority implementation of CPTED to date. Consequently, the present research sought to investigate the range of current approaches employed by New Zealand's local authorities to implement CPTED. Those factors that have served to facilitate CPTED have subsequently been identified for the purpose of improving the concept's future application. The work has also been completed to advance the widespread effective use and implementation of CPTED across New Zealand.

Specifically, a national survey of New Zealand's local authorities was conducted, and a series of key informant interviews with representatives from four local authorities utilising different means of CPTED implementation was completed. An in-depth case study of Dunedin's CPTED strategy was also undertaken, involving in-depth interviews with a range of the city's crime prevention stakeholders. Themes derived from the research findings were then used to support, modify, or extend existing conclusions in the relevant literature.

FACTORS THAT ENHANCE CPTED IMPLEMENTATION

Here, some of the research findings are presented in terms of those factors found to enhance the implementation of CPTED.

Training and education

As might be expected, it is acknowledged that a lack of CPTED awareness is problematic for widespread implementation (Olasky, 2004). Therefore, the importance of training and education has been strongly and consistently advocated within crime prevention literature as essential for CPTED success (Brantingham, 1989; Crowe, 1991; and Bell, 2005).

The New Zealand study showed local authorities identified the need for CPTED to become firmly embedded within the architecture, planning, surveying and consulting fields as from these come "the professionals actively involved in all major development work" (Waitakere City Council Representative, 2005). In addition, tertiary education for these related professions was also highlighted by research participants as important for ensuring that CPTED is integrated into the early stages of subdivision, design and planning processes. This initial incorporation was recognised as essential for ensuring that CPTED considerations are not left until the resource consent phase, when the opportunity to make changes is often restricted in regard to practicality and cost.

These findings strongly affirm Crowe's (1991) contention that the curriculums of surveying, urban planning, development, and design professionals should incorporate CPTED for the strategy to progress to wide acceptability and use. Importantly, it was identified that interest from certain developers, as well as the gradual incorporation of CPTED into existing relevant professional training programmes, are promising indicators that a foundation for building CPTED knowledge and awareness already exists among New Zealand's stakeholder groups.

Local authorities also strongly supported the need for wider general training and education beyond the immediate professions, in recognition that "the more people who know and understand the theory, the more people who can effectively contribute to its widespread use" (Invercargill City Council Representative, 2005). Training and education for relevant stakeholder groups such as members of the public, community organisations, and public health groups was also highlighted by research participants, with the belief that once people properly understood the concept, they "would realise it isn't rocket science", recognise the feasibility of producing effective tangible results, and subsequently be more willing to become involved in a CPTED initiative (Public Health South Representative, 2005).

Hence, the present study also extends the existing literature. This has been achieved by highlighting the need for CPTED training and education to be targeted towards a broader range of crime prevention stakeholders and not just the relevant professions.

A multi-agency approach

A second factor enabling the successful implementation of CPTED as identified within the literature is the need for a collaborative approach to crime prevention among all relevant stakeholders. For example, Goris and Walter (1999) argue that a multi-agency approach is necessary in order to reflect and appropriately address the multi-faceted nature of crime. The New Zealand study indicates that local authorities have been actively collaborating with a range of crime prevention stakeholders. In particular, local authorities, urban designers, and the wider community have had strong roles to play, while nearly every local authority noted significant involvement by local police.

Importantly, all research participants clearly supported the idea of multi-agency collaboration. This was due to recognition that CPTED and crime prevention is a multi-faceted concept that "requires input from a number of different stakeholders depending on what the focus is" (Waitakere City Council Representative, 2005). Each stakeholder was identified as providing a unique and important component in the implementation process. Thus, the present study identified a strong appreciation for the contention that no stakeholder group can effectively achieve crime prevention on their own (Crawford, 1998).

The role of champions and local authorities

Also supported by the present study was the need for a lead organisation to provide direction and coordination for effective multi-agency CPTED implementation (Crowe, 1997). Research participants noted that in general, local authorities were seen as the most appropriate lead agencies as they "have the regulatory and planning tools at their disposal" (Waitakere City Council Representative, 2005). The ability for local authorities to act as effective coordinators was also noted, while both local authorities and police were seen as having the ability to provide essential leadership and advice. These findings complement an increasing recognition of New Zealand's local authorities as playing a key role in localised crime prevention.

In line with Schneider and Kitchen's (2002) findings, the importance of CPTED champions was also strongly recognised. The present study revealed the positive impacts that result from having a champion for CPTED within each stakeholder organisation, and particularly within the relevant departments of local authorities. These impacts included the ability to "facilitate CPTED awareness, build links with politicians, and provide training opportunities" for successful CPTED implementation (Dunedin City Council Representative, 2005).

Overall, research participants argued that having a champion within the lead agency that has "respect and professional credibility and who understands the concept" is fundamental for endorsing CPTED and getting other stakeholders on board (CPTED Consultant, 2005). In addition, it was strongly noted that because CPTED requires collaboration and input from so many different organisations, implementing CPTED successfully is always going to be difficult "unless you've got real champions in the other agencies to call on" (CPTED Consultant, 2005).

Public participation

Members of the public or affected community are one of the major stakeholders in a multi-agency approach to CPTED, yet they are frequently overlooked. Public participation concerning various planning and development processes is often a contentious issue. However, it has been argued by crime prevention theorists, such as Bell (2005), that members of the public are commonly the most accurate source for information concerning the local environment. New Zealand research participants supported this notion, noting that while "members of the community may not necessarily know what CPTED is, they live and work in that environment and they know their community best and what the lighting is like at night and how it makes people feel etc" (Dunedin City Council Representative, 2005). This anecdotal evidence was identified as important for enabling an accurate CPTED assessment of an area, particularly in recognition that "while police can provide statistical crime data, anecdotal evidence in regard to unreported crime and safety perceptions can only come from members of the community" (Dunedin Police Representative, 2005).

While crime prevention literature supports public participation, the present study also identified clear benefits from public awareness of CPTED and, in areas where specific CPTED initiatives have been applied, for enhancing *perceptions* of personal safety when in that particular environment.

The New Zealand study has clearly identified an appreciation for the benefits of community involvement. However, it has also highlighted that while it is important for local authorities to respond to safety issues raised by the community, it must be considered that members of the community "would not generally have an understanding of what CPTED is and that it is a long term evolutionary strategy" (CPTED Consultant, 2005).

Regulatory versus non-regulatory implementation

Relevant literature identifies strong advocacy for implementing CPTED via regulatory methods. Authors such as Klepczarek (2002), Crowe (1991), and O'Malley & Sutton (1997), have argued regulation is necessary for achieving widespread adoption of CPTED. In contrast, the review of New Zealand's current CPTED implementation has identified that Auckland City Council is the only local authority within New Zealand that has adopted a regulatory approach to implementation by incorporating CPTED into its District Plan. This approach was chosen "so that all new large developments will be CPTED compliant and to ensure that CPTED becomes a regular part of the planning process" (Auckland City Council Representative, 2005). The Auckland City Council noted that this "still provides room for CPTED assessments of hot spots and one-off cases" and that importantly, the District Plan has "steered planners and other professionals at the Council to look at CPTED" (Auckland City Council Representative, 2005).

Importantly, results of this research have supported a number of benefits associated with a regulatory commitment to CPTED that have been identified within the literature. This includes recognition that CPTED can be easily overlooked unless it is incorporated into a District Plan, that regulatory concerns tend to be treated more seriously than non-regulatory ones, that regulation will result in more consistent CPTED application and thus outcomes, and that levels of CPTED awareness are likely to rise if there is regulatory application (Crowe, 1991; O'Malley & Sutton, 1997).

While the present study revealed that a number of stakeholder groups saw CPTED as ultimately moving down the regulatory path, the benefits of not doing so during the initial phases of CPTED awareness and buy-in were also identified. Significantly, initially developing the implementation process on a non-regulatory basis was identified as important for ensuring that stakeholders "came on board for the right reasons"; that is, they choose to become involved in CPTED "because they see the benefits, not because they are required to" (Wellington City Council Representative, 2005). The importance of champions, senior buy-in, and political support were identified as some of the ways in which support for CPTED can be gained on a voluntary basis, meaning that regulation is not required to the same extent.

While the New Zealand study has largely supported the advocacy for regulatory implementation highlighted within the literature, the benefits of an incremental approach to establishing regulatory compliance have been also been acknowledged. This approach has been recognised as important for the enhancement of multi-agency partnerships that are developed through goodwill, and for providing the opportunity to produce tangible localised CPTED results that can advance initial stakeholder buy-in.

Moving forward with case studies

New Zealand's varying strategies for implementation provide a perfect opportunity for those local authorities more advanced in CPTED implementation to share their experiences. In addition, a significant lack of literature available on the implementation of CPTED has created "a real need for New Zealand based case studies" (CPTED Consultant, 2005). This sharing of knowledge and information is seen as important for effectively progressing national CPTED implementation. For example, local authorities noted that "having a few early successes and publishing those results was important for establishing buy-in and increased awareness" (Dunedin City Council Representative, 2005).

While recognising that every implementation strategy will differ according to the local context, research participants were also in agreement that "it is useful to read what others have achieved in order to obtain background knowledge and learn from what has previously been done well and what hasn't" (Hutt City Council Representative, 2005). Offering a tool-kit that incorporated a 'how-to' guide for implementing CPTED within a District Plan, as well good examples and a best practice focus was subsequently identified as a useful resource for local authorities and other crime prevention stakeholders. Moreover, the ability to access information underpinning individual local authority strategies was viewed as important for a more efficient and effective implementation process.

ADVANCING CPTED IMPLEMENTATION WITHIN NEW ZEALAND

Current popularity of CPTED provides an opportune period for launching national awareness, training, and implementation procedures. While this momentum has already seen the initial development of various CPTED initiatives across local government, the retention of this interest and progression is seen as important for enabling those local authorities less advanced in CPTED to 'catch up'. To date, it is the urban authorities that have most frequently engaged with aspects of CPTED and the contrasting contexts and opportunities for rural place-based CPTED developments await further development. Ensuring New Zealand moves closer to nationwide adoption of the strategy will involve varied urban and rural strategies. Diversifying CPTED strategies in different local authority situations will further enhance relevance. Importantly, it is the incorporation of CPTED into everyday work procedures that is recognised as crucial for national advancement.

While it is appreciated that some local authorities already have established processes relating to CPTED use, this study has shown that many local authorities would benefit from some form of guidance and support. A national toolkit resource for CPTED implementation that incorporates case study information and accompanies the delivery of national training is identified as beneficial for CPTED advancement. It is recognised that with the support of CPTED champions across local government and other stakeholder organisations, New Zealand's Crime Prevention Unit has the capacity to facilitate this process.

Specifically, this research has focused on the conditions under which CPTED has been implemented across a varying range of methods for adoption. It is hoped that in turn, this will assist crime prevention at the local level to be maximised and contribute to successful national crime prevention outcomes. Importantly, the research is also intended to assist local authorities in ensuring that recent Ministry of Justice funding (as mentioned above) can help produce some significant results for CPTED advancement within New Zealand. Surveyors have a critical role to play in any such advancement.

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Maori Land Loss: A study of the processes of alienation – The Taieri Native Reserve

ABSTRACT

This case study of the process of Maori alienation from their land examines Maori occupation, use, attachment to and eventual loss of the land that was excluded from the Otakou purchase of 1844, and that was designated the Taieri Native Reserve. This example charts a unique situation of local land loss, but illustrates a range of methods by which Maori land rights have been alienated during the course of our post-Treaty history. Maori land has been exposed to settler demands, corporate and government negotiations, official purchase, survey definition, court adjudication, lack of use, and abandonment in a way that makes us question whether Maori ever had much chance of retaining an adequate land base in the face of the colonial take-over of New Zealand.

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LAND TENURE IN TE WAI POUNAMU

Maori land tenure rules have been well set out by experts such as Kawharu (1977) and McHugh (1991), and the basis for customary title rests on various *take* (claims): discovery, ancestry, conquest, and gift. All these must usually be supported by longstanding occupation - ahikaroa. In the case of the southern Ngai Tahu, the evidence of long and consistent occupation was rather different from that of the northern Maori.

The waves of Waitaha, Ngati Mamoe and Ngai Tahu migrations south were marked by the men taking local wives to settle alliances, to integrate into existing society and to benefit from family connections to more lands. Newcomers recognised the need to develop these connections and relationships with the land, and in doing so, multiple relationships were established, and individuals often maintained multiple land and home bases.

The state of land tenure in the Otago area in the early part of the 19th century was far from settled. Anderson (1998) describes the problems that were "muddying the waters of land tenure" throughout Te Wai Pounamu. Apart from the population being regularly itinerant, there was still significant land abandonment in the face of significant depopulation in the years immediately following European contact, and resettlement by the refugees from the various attacks and threats from Te Rauparaha and the Ngati Toa (Evison 1993).

Many Ngai Tahu, because of their migration from the north, may have had some rights by virtue of their residence, occupation and use, but no rights to have a say in any alienation (Anderson 1998). Consequently, land relations were uncertain, and colonial attempts to formalise tenure and to negotiate sales and exchanges forced Ngai Tahu to make hasty decisions about the land they needed to keep and the land they were prepared to alienate. Maori could hardly have foreseen a time when their access to land and resources would be so limited that they would barely be able to support themselves.

MAORI OCCUPATION AND USE OF THE TAIERI AREA

The lower half of the South Island is well beyond the range of cultivation for the kumara, so permanent areas of cultivation were not a part of Ngai Tahu life. The main food sources were spatially and temporally separated. Kai moana was a major component of the diet, and the management of these resources from the sea was governed by various rules of location as well as by the seasonal runs of barracouta, inanga (whitebait) and tuna (eels). But the southern Ngai Tahu also relied on birds: especially duck, weka and titi, and on other vegetable matter like fern root and ti kouka (cabbage tree root) (Anderson 1998). Much effort went into the preservation of fish by drying, and titi by storage in kelp bags. There was therefore a significant seasonal migration of people around the various food-gathering sources – from the titi islands in the far south, to the inland lakes for fish, ducks, and eels. Many of these sites were regularly used but only intermittently and seasonally occupied.

The Taieri is remembered in the oral history of Ngai Tahu. Stories tell of the Taieri taniwha, Matamata, who wound his way through the hills from central Otago, creating the upper Taieri gorge, settling down for a while, creating the Taieri plain depression, wriggling through the lower Taieri gorge and haunting that area before returning inland and forming the coastal hills. Other more recent histories of settlement and conflict recall many of the residents and settlements in the Taieri area (Te Marie Tau 2003).

The Taieri was something of a backwater in comparison with other Ngai Tahu settlements. It was remote from the trading and contact activities of the Foveaux Strait area, not particularly well connected to the Otakou settlements and bypassed by the other waves of settlement by Ngai Tahu hapu. There was considerable movement and transient settlement of the population, and it was rather difficult for the Europeans of the time to get a good idea of the numbers of Ngai Tahu living in the south, and of the relationship and connections they may have had with the land. Anderson (1998) states that the total population of the South Island south of Marlborough probably never exceeded 5000 people. It is probable that the number of Maori at the Taieri was never more than 50 at the two kaika at Taieri Mouth and at Maitapapa.

The Taieri plains were very much influenced by a tidal regime although there was no real inflow of salt water, but rather the regular holding back of the waters from the Taieri catchment. In other words, apart from it being flat and close to the newly planned settlement at Dunedin, it was not immediately apparent that the lands had any special value to the settlers. It was relatively easy for Pakeha writers of local history to disregard the relationship and connection Ngai Tahu had with the swampy Taieri wastelands. The Eurocentric dismissal of swamp as nameless, worthless and as wasteland is illustrated thus: "The swamp lands had no tradition, so that as far as can be traced there is no place name" (Smith 1941:10). On the other hand, Davis (1973) notes the records of the small nucleated settlements at the entrance to the Taieri gorge, but logically suggests that it was the resource rich wetlands of the plain that provided the attraction to those occupants, and that it was the swamp lands with which Ngai Tahu had the real relationship.

EARLY CONTACT WITH EUROPEANS

After the early examples of European contact, and the release of non-indigenous fauna and flora, Maori showed considerable adaptive capabilities in their diet and lifeways. Pigs, domestic fowl, wheat and other grains were recognised as significant new food resources, but it was the introduction of the potato to southern Ngai Tahu very early in the 1800s that enabled a new more permanent agricultural lifestyle to emerge. The potato enabled southern Maori to improve their nutrition, to produce ample surplus food, to remain in semi-permanent settlements and to trade with and support the settlement of whalers and sealers.

Contact with local Maori was essential for the whalers, sealers and the early settlers. Maori provided meat and vegetables for survival, assisted with construction of housing, and also provided wives as a civilising influence on the almost exclusively male European population for the first 40 years of the nineteenth century.

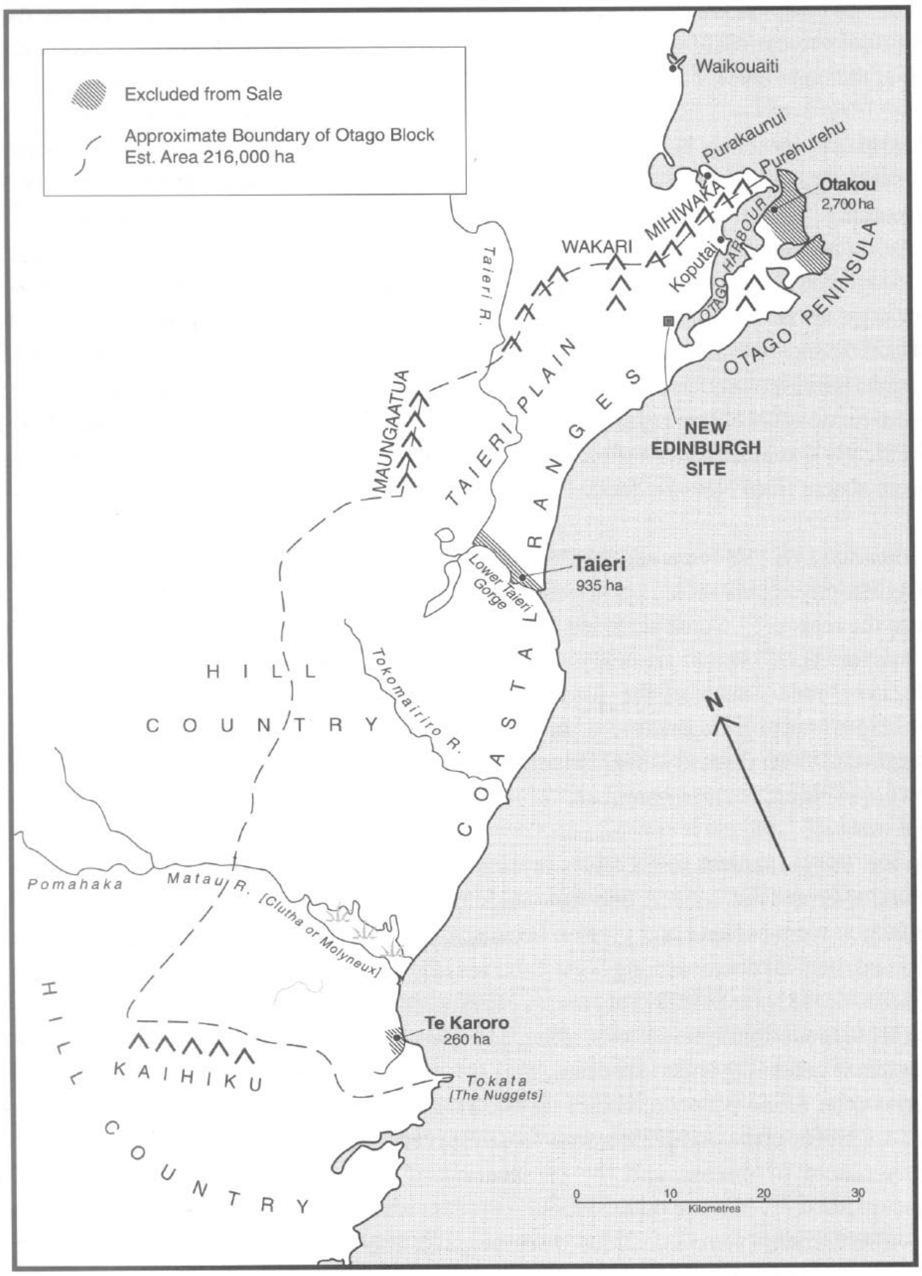
Maori had no reason to oppose the coming of the Europeans so long as Maori rights and laws were respected. Maori recognised the benefits of development and trade, and were mostly supportive of European occupation and resource use. Those early Europeans had little ambition to compete for land or traditional Maori resources – they were almost exclusively focused on whales and seals which were not a big part of Maori subsistence utilisation. Maori got on well with the whalers and sealers and although being exposed to alcohol and tobacco and some suspect trade practice (e.g. prostitution and gun trade), on many levels their standard of living (with the adoption of European technology; agriculture, tools, implements, food, fabrics and housing) was improved. Maori accommodated these newcomers and benefited from European settlement at this scale. The major downside for Ngai Tahu was that they were very vulnerable to the diseases (especially measles) introduced and spread by the coastal shipping crews.

This extended period of contact indicated to Maori that both sides could live cooperatively on the land. Because the early whalers did not want to buy extensive tracts of land (with the exceptions of some such as Johnny Jones at Waikouaiti), nor take exclusive possession of the lands, Maori viewed the exchange of gifts which passed for land sales, in the context of being able to maintain their customary access to all land, river, and coast as before. Later negotiations of land sales with settlers were accepted on the same basis.

In June 1840, Major Bunbury was sent by Governor Hobson to bring the Treaty of

Waitangi to Te Wai Pounamu and gather signatures. Tuhawaiki who spoke and understood English well, was concerned about the effect of the Treaty. He required Bunbury to clarify in writing the guarantee of full and exclusive possession of their lands before he would sign (Evison 1986:15). They were clearly relatively well informed and were confident that they were not signing away more than they wanted to.

In 1840 the Wellers established their whaling station at Moturata (Taieri Island). Whaling here was always somewhat marginal and they expanded their operations into timber extraction initially, then they saw the potential for speculative profits from land purchases direct from Maori. They 'bought' large areas of land, anticipating the demands of potential new settlers. Although realising that they were restricted from buying land other than from the Crown, they had observed others making claims for lands, so they did likewise. In a letter between the brothers, a recommendation was made to: "sell as much land as you possibly can to parties who are well able to pay as it will be a drug on the market, and why not make a fortune, that way as by trading" (Weller 1840). In establishing their dubious title to the lands they had 'purchased' direct from Maori, the Wellers were keen to sell whatever they had to whomever they could: "the British Govt intend dispossessing us of all our lands, the best thing we can do is to sell as much as possible to the French people at whatever rate you can obtain, without guaranteeing the title except from the natives" (Weller 1840).



The Otago Purchase Land showing the three parcels of land reserved from the sale. Source: Evison 2006;50.

THE OTAGO PURCHASE

The colonial pressures for Maori to give up their lands to the government and settlers were increasing. Population losses and iwi disruption left Maori vulnerable to aggressive colonisation and land alienation. Maori were really given no choice about whether to sell or not. They were effectively told that land was to be taken anyway, but that they could choose small land areas to be reserved for them from the sale.

By 1844, the New Zealand Company was actively seeking a site for a New Edinburgh, their principal agent and decision maker being Surveyor Frederick Tuckett. Governor Fitzroy waived the Crown's right of preemption to allow the New Zealand Company to negotiate the purchase of up to 150,000 acres of land for the proposed new settlement.

Tuckett chose the site of the new settlement to be within the area along the coastline from the Otago Harbour, Tokata and the Nuggets in the Catlins, then about 20 kilometres inland to the ranges of the Maungatua to the west. This area included the Taieri Plains and the lower portions of the Taieri, Tokomairiro, and Clutha rivers and the lakes of Waipouri and Waihola, as well as the Otago Harbour, an area then counted as 400,000 acres.

Tuckett completed a reconnaissance of the land proposed for the Otago purchase, and on July 31, 1844 the Otago Purchase was effected (Evison 2006). About 150 Maori arrived at Koputai (Port Chalmers) to discuss the purchase, and the purchase price of £2400 was settled on.

The purchase specifically excluded three blocks of land; at Otago Heads, Taieri, and Te Karoro about 9615 acres (about 1.8% of the area). The real effect of this exclusion process was that the 'reserve' land remained as Maori customary land – land over which customary title was not extinguished, the Crown having no authority of title over it. This is unique to the Otago purchase because in later purchases of land from Ngai Tahu by the Crown, reserves were set apart after a complete alienation, and were thus Crown lands reserved for Maori.

The conditions of purchase also required that Maori were provided with land sufficient for their needs. It was NZ Company policy to negotiate the setting aside of 1/10 of the land purchased for the benefit of Maori – i.e. that one tenth of the subsequently surveyed land parcels should be made available to Maori. The reasons for this were that Maori should be able to participate in the settlement (both urban and rural) of developed land, to be part of the new society, integrated into the community and not segregated out on reserves (as was the case for the north American indigenous people).

The tenths would allow for Maori to gain by the general increase in the value of the land so considerably improved by the process of survey, Crown Grant, and surrounding economic development. Participants at the signing of the deed and later commentaries and enquiries confirm that an allocation of "tenths" was part of the verbal agreement. But by 1848, when the Otago lands were being opened up for settlement and a new governor and land administrators were in place, the provision for tenths was conveniently forgotten (Wanhalla 2004;122). Mantell records: "I am aware that there exists in the colony an opinion that [if] this and other questions [the setting aside of additional lands for Maori] can be shelved for a period, the natives will by their extinction relieve the government from the fulfilment of its promises" (Dacker 1994:43).

So the land excluded from the original purchase was all that Otago Ngai Tahu received. These areas were immediately labelled as Native Reserves as if they had been set aside by the Crown and were part of the compensation for the lands sold. This is clearly not the case and these lands should have been considered in quite a different light. Maori lost out in this process of negotiated purchase. It was as if the government (through the New Zealand Company) had said to Maori: 'we are here to stay and we need your land, we will allow you to keep some small portions of your own land as long as you sell all the rest of it to us for a nominal price.' Any dispute about this resulted in accusations of being insolent and turbulent. It was, quite literally, extortion: the oppressive exaction of an agreement to sell with no attempt to provide just or equitable recompense … but of course it was done in the nicest possible way!

THE ALLOCATION OF THE TAIERI NATIVE RESERVE

The area reserved from sale in the Otago purchase was in recognition of the importance of this area for Ngai Tahu, and to allow for continued resource access, both to the fish in the river, to the birds and the ti kouka in the surrounding countryside. There does not appear to have been any great dispute about this land being set aside for Maori, it was after all, of little strategic importance to the settler. The whaling station on Moturata had been active and important but was in decline by this time. The river was not a good prospect for a port although it was later officially established as a port for a short time for the better development of the Taieri plains. The land was steep, inaccessible and largely unsuited to any productive agricultural use.

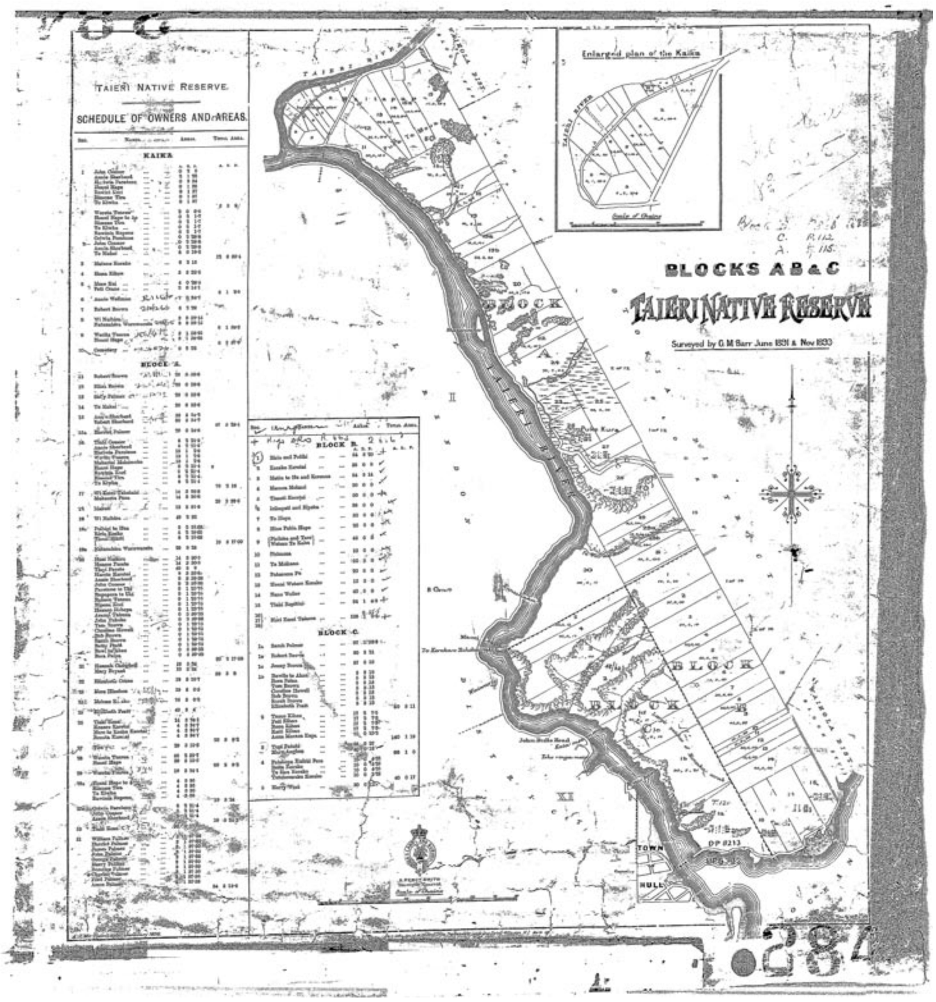
The selection of this area by Maori was based on the fact that there was some local settlement in the form of the two kaika. It was clear that the main and very valuable resource area was the swamp and lake lands of the Taieri plains. Surveyor Charles Kettle (1850) records that Maori almost certainly wanted and expected continued access to these resources even though their actual occupation (their physical presence on the land) was evidenced only by the kaika.

By the 1850s, the Taieri reserve served little cultural or subsistence purpose for the local Maori. What Ngai Tahu were left with was a reserve that was well located for the small Maori settlements and for access to a variety of food resources, but was otherwise rather useless. But this 'worthlessness' did not stop the settlers from seeking to acquire this reserve only 6 years after it was excluded from the Otago purchase. Kettle observed that the reserve as it was allocated was rather useless for those resident Maori. He was active in trying to encourage the sale of the reserve: "I endeavoured to shew that the greater part of their reserve, for all the use it was to them at present, might as well be at the bottom of the sea" (Kettle). The only apparent benefit of the reserve was to provide a small economic return by being leased to settlers for grazing (McLeod 1868).

In 1858 Cutten, the Commissioner of Native Reserves, reported: "A portion of this reserve at the western extremity is remarkably valuable for a site of a village." He suggested that if a town was laid out at Taieri then £10,000 might be obtained (presumably he means by that, the profit that would accrue to the Crown rather than to Maori!).

The Taieri Native Reserve was never a particularly attractive proposition for a successful continued occupation or the further development of local Maori economy or society. In 1891 Commissioner Mackay noted in his report of native claims: "The people residing at the Taiari [sic] are in the poorest plight of any of the Native communities. This is owing to a great extent to the limited quantity of suitable land for cropping, a large portion of the Taiari Reserve being altogether unsuitable for any but pastoral purposes" (Mackay 1891;5). This is true but history also shows us that even if the land was arable and had production potential, then location, remoteness, access to markets, access to development assistance, and other employment opportunities would have all been barriers to successful development of the reserve for the benefit of Taieri Maori, just as the subsequent allocation of remote parcels of land to the landless Maori under the 1906 SILNA Act (McHutchon & Strack 2001) provided little actual benefit.

The land allocation plans prepared by Colonel William Wakefield for the



Deeds Plan 284 showing the subdivision of the Taieri Native Reserve

planned settlement of Dunedin allowed for a distribution of land to settlers by the following formula: a quarter acre urban section, 10 acres of suburban land, and 50 acres of rural land. Once it was realised that the growing economy required pastoral (not arable) land use, this allowance was seen as much too small and hundreds or thousands of acres of pastoral land were needed in order to be economically viable.

Mackay reported that "care has been taken to secure to the natives adequate portions of valuable land in eligible situations, under arrangement that would secure them against their own inexperience and improvidence" (Dacker 1994:10). Maori were not excluded from taking title to additional lands, however it is clear that Taieri Maori were given little opportunity to acquire additional land, and were not expected to need or want more than the reserve as set aside. The quantum of reserve land set aside was considered to be enough so that the Maori wouldn't be a burden on the state but not so much that they would become wealthy off the land – they would have to be a labour force not a landowning class; about 10 acres each was seen as adequate.

Maori had adapted well to the new economy; extending their cultivations, breeding pigs, conducting trade, and operating ships for goods and passenger transport. In these endeavours they supported the small settler populations in the early years. Once the settlers began arriving in Otago in numbers and were provided with land for settlement and production, Maori were slowly excluded from their successful provisioning role in the settler economy. Maori retention of such a small amount of land, and that of low productivity, meant that they could not profit from the pastoral economy that was bringing such wealth to the settlers.

It was assumed that Maori could revert to their customary subsistence economy, and their access to more land was impeded by a policy of exclusion.

SURVEY DEFINITIONS OF THE TAIERI NATIVE RESERVE

The extent of the reserve was not formalised even after the touring party of Symonds, Wakefield, Clarke and Tuckett visited the Taieri to identify the land excluded from the Otago purchase. It appears that confusion remained about the definition of the landward boundaries. Charles Kettle was the first surveyor to attempt to define the reserve on the ground. An initial investigation of the Taieri area was required to point out to his contract surveyors what sections to start laying out within the Otago purchase area. The boundary decided upon was based on the least generous interpretation possible.

Davison undertook some survey work on the reserve in October 1847 and noted: "chained the central line of the coast block. The ground is extremely rough, the country the most rough I have seen laid out in sections; the upper line of sections may be boldly pronounced to be truly worthless in any aspect except mineral resources which appear to be great" (Sutherland 1962;27). Subsequent use of the land has failed to recognise any mineral wealth referred to here, and it has always been, and remains, marginal land.

The reserve was surveyed again in the 1860s. The reserved land was subdivided into three blocks; A, B, & C. Later surveys and plans by Donald MacLeod (ML 211 and ML212) show a further subdivision of the three blocks into Sections. A covering letter by Donald MacLeod to Chief Judge Fenton accompanying the plan to the native Land Court makes two revealing observations: firstly, that the area surveyed was of little use to the applicants, and secondly that Maori still disputed the extent of the reserve and the boundary as surveyed reduced the reserve area by a further 500 acres (McLeod 1868).

The reserve was treated as if it was land that had been sold to the Crown (or the New Zealand Company) and then surveyed into sections in order to return it to Maori, rather than land that had never been sold and was still Maori Customary Land. The survey of the reserve proceeded and a road reserve was laid out along the riverbank as if it was Crown land being surveyed. The road does not appear to have been negotiated, discussed, or even known about by local Maori.

The road reserve that was set aside in the survey ML215 was probably not intended to be formed but just to separate the land parcels from the river. This sort of road reserve was often used to provide for the sort of riparian reserves suggested by Queen Victoria's instructions of 1849, but also to deprive the land of any riparian rights.

The boundary surveys of the Taieri Native Reserve minimised the area of the land, and the subdivision survey served to create impractical and unusable parcels. Land use potential and land value was undermined by the process of survey.

THE INDIVIDUALISATION OF THE TAIERI NATIVE RESERVE

As has been expressed in many other contexts (Sorrenson 1956, Kawharu 1977, Gilling 1994, Williams 1999), Native Land Court processes brought whanau and hapu conflict into the open, drew rural populations into town for court sittings, created individualised and fragmented titles to what should have remained communal land, undermined local land productivity, and ultimately lead to native land depopulation and the fragmentation and dispersal of hapu groups (Ballara 1998:252).

The government was very aware that the Otago purchase 'reserves' were actually lands over which customary title had not been extinguished. The individualisation of other reserve land was promoted by the New Zealand Native Reserves Act 1856 and by the Commissioners of Native Reserves, with the specific intent to facilitate the break down of the communalism of Maori hapu which was seen as anathema to the capitalistic themes of colonialism. Because the Taieri Native Reserve was still customary land, the Commissioner of Crown Land had no jurisdiction to act in this case "unless the natives consent to extinguish their original title and accept a title from the Crown." (Mackay 1873:119).

The opportunity to convert the title to this reserve land came when one individual applied to the Native Land Court in 1868 to determine who had rights in the reserve (Davis 1973:184). Internal conflicts amongst the claimants of the Taieri Native Reserve allowed the Native Land Court to carry out its statutory agenda to individualise the parcels and bring the title within the jurisdiction of the Crown.

At the Native Land Court hearing in 1868 "various claimants appeared from north and south" (Shaw & Farrant 1949:90) and the parcels were individualised and distributed relatively widely. Maori were not confined to their reserves, there was no encouragement for them to occupy the reserve lands, and land was allocated without consideration of ahikaroa.

There is evidence in the subdivision of the Taieri Native Reserve that some consideration may have been made to Maori systems of land and resource allocation. There seemed to be some considerable effort made to ensure that the majority of parcels had frontage onto the river (or a road adjoining the river) and also shared parts of the rough hill country. This often resulted in either somewhat disjointed boundaries (as evidenced by sections 1-9 at the kaik), or many long narrow sections extending from river to hills as with most of the sections 16-28 (see Deeds Plan 284). This distribution of land with all members of the community sharing access to all the resources is illustrative of wakawaka (Anderson 1998:114). The problem was however that such boundaries and parcel configurations were meaningless, being totally unsuitable for occupation and utilisation for anything other than subsistence use.

The land was divided up and titles were issued to Ngai Tahu of Taieri, Otakou and further afield. These recognised the range of Ngai Tahu who could claim some relationship with the land, but further undermined any hapu cohesion, any potential productive utilisation of the land by occupiers, and any practical benefit to Ngai Tahu owners.

ABANDONMENT OF THE TAIERI NATIVE RESERVE

There was a continuing remnant occupation by Taieri Maori for several decades, but no sign of any potential advantage of land ownership here. Several successions and numerous alienations were recorded. There was a last ditch attempt to revive the Maori community at Maitapapa in 1900 with the construction of the Te Wai Pounamu hall at the kaik (Wanhalla 2004;212). It was opened with appropriate ceremony and hope for the future, but by 1921 it was removed and became a hay barn on the Taieri plains. After World War I, few Maori returned to the kaik "and it became the first of the communities of Otago in the 20th century to lose its coherence as a distinct Maori Community." (Dacker 1994;94). By 1930 only one or two houses were still occupied.

The majority of the Maori titles to the parcels of land within the Taieri Native Reserve have been lost. This happened relatively slowly however, as the parcels were small, the land was poor and external demand for the land was almost non-existent. Many have now been sold out of Maori hands and several have now been vested in the Maori Trustee under previous Maori land legislation which sought to avoid further fragmentation of title by continuing succession.

There are still several parcels that history and land records have forgotten, which are still registered in the names of the 1880s owners. There must logically be numerous descendants of these owners who could claim a beneficial interest, but the incentive to do so is minimal. The land is very difficult to clear for any productive purposes, the boundaries are totally unsuitable for effective land management and any investment, even the cost of lodging an application for succession to the Maori land Court, would give a poor return for money.

Maori became virtually invisible in standard histories of Otago. Their time was over, they died off or disappeared into the settler ways of life. "Maori had been overwhelmed" Olssen reports, "The Ngai Tahu had become a remnant, although near their kaiks they continued to adapt their inherited traditions to new realities." (Olssen 1984:49). Maori of the Taieri were increasingly marginalised and soon quietly forgotten by settler New Zealand (Jones 1999:74). It is only in very recent years that any attempt has been made to recognise the process of this disappearance. Wanhalla (2004) meticulously records the Taieri Ngai Tahu families up till 1940, noting not their disappearance but rather their adaptations to new cultural and economic imperatives – the intermingling of Ngai Tahu by marriage to Pakeha, and the move from native village to farms, cities and other modern lifestyles.

NGAI TAHU EXPERIENCE OF LAND LOSS

The Ngai Tahu iwi was relatively fragmented and barely recognisable as an integrated iwi organisation in the early nineteenth century; there was no recognised paramount chief, no organisational structure beyond the myriad of familial relationships that existed. However they soon sought to assert their unique identity by recording iwi membership in an internal census in 1848, by maintaining constant pressure on governments for redress for the losses, and ultimately by submitting their claim to the Waitangi Tribunal and becoming recognised in statute. This had the effect of ensuring that the iwi could be recognised as a legitimate grouping of people, and arguably, today Te Runanga o Ngai Tahu is perhaps the most clearly structured and successfully functioning iwi corporation in New Zealand. However as a large corporate entity seeking to address wider group goals it is possible that at times, the corporation has overlooked many examples of local issues and grievances. The local has been lost to the whole. The Ngai Tahu claim and the Ngai Tahu Natural Resources Management Plan barely mention the Taieri Native Reserve and it would appear that there is little remaining administrative connection to the area.

CONCLUSION

Observational evidence now shows the boundaries of the reserve and the sections within it are obliterated by encroachment of unmanaged vegetation and abandonment. The boundaries are meaningless and the nature of the fragmented tenure remains an impediment to productive utilisation. There is little evidence of a continuing relationship between Ngai Tahu and this land. The land has great historical and cultural importance but the cultural, administrative and structural forces of colonialism have been extremely successful in obliterating manawhenua here. The manner of Ngai Tahu loss of this land is a story told often enough of the process of colonisation, but such special history deserves to be remembered. Land too easily becomes either a featureless commodity or just more topography when the cultural landscape is lost. And Maori heritage is dishonoured by the abandonment of this remnant of once extensive iwi estates.

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Note: This paper derives from a chapter of my PhD thesis in progress that focuses on the relationship between Taieri Ngai Tahu, the Native Reserve and the Taieri River, while this paper is confined to Ngai Tahu relationship with the Taieri Reserve.

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Extracting co-seismic deformation of Bam earthquake with differential SAR interferometry

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ABSTRACT

Differential synthetic aperture radar interferometry (DInSAR) is a newly developed technique for monitoring large scale ground deformation. This paper shows and analyses the interferometrically-derived measurements of the co-seismic surface deformations caused by Bam, Iran earthquake (MW = 6.5) which occurred on 26 December 2003. The data processing is based on three C-band SAR images collected by the ASAR sensor onboard satellite ENVISAT on 3 December 2003, 7 January and 11 February 2004, respectively.

From the generated differential interferograms, the co-seismic surface deformation patterns can be clearly identified around a total area of 107 km × 40 km. They can be classified into four inconsistent deformation patches: one for subsiding and other three for uplifting. It can be estimated that the maximum slant range shortening and lengthening due to the main shock are up to 29.6 and 17.2 cm, respectively. Moreover, the two crossing faults ruptured on surface can be viewed and located by analyzing the four inconsistent deformation patches. The two faults were newly generated by the earthquake but fully detected using the interferometric analysis. One of the two faults was firstly detected in this study. The DInSAR results with fine spatial resolution can be used by seismologists as the input data for further interpreting the mechanism of this earthquake and predicting some post-seismic activities.

KEYWORDS

Differential interferometry; synthetic aperture radar; co-seismic deformation; earthquake

INTRODUCTION

Differential synthetic aperture radar interferometry (DInSAR) is a unique tool for measuring large-coverage surface deformation related to such events as urban subsidence (Gabriel et al., 1989, Liu Guoxiang et al., 2001), volcano dynamics (D. Massonnet et al., 1995), co-seismic and post-seismic motion (Massonnet et al., 1993, Wu Jicang et al., 2002), ice sheet motion (Joughin et al., 1995), as well as landslide (Xia Ye et al., 2002). It is able to detect millimetric target displacements along the sensor-target [line of sight (LOS)] direction. Compared with other traditional methods such as GPS and leveling, DInSAR monitors the regional deformation with high resolution and low cost whereas GPS and leveling only measure displacements at some control points. Furthermore, DInSAR is characteristic of pantoscopic view, which has less influence from cloud cover and rain and has high automatisation. Thus it has the potential for monitoring large scale ground displacement even to a millimetric degree.

DInSAR use was first proposed by Gabriel (Gabriel et al., 1989) to map small elevation changes over large areas. In this paper, DInSAR is applied to extract the co-seismic deformation field of Bam, Iran earthquake (MW = 6.5) which occurred on 26 December 2003. The surface deformation and co-seismic faults were detected and mapped in the study.

THE BASIC PRINCIPLE OF DIFFERENTIAL INTERFEROMETRY

DInSAR is derived from synthetic aperture radar interferometry (InSAR) which has been devised to measure the relief of earth surface with interferometric phase generated by conjugating two SAR images gathered at different times with slightly different viewing angles (Franceschetti et al., 1999, Wang Chao et al., 2002). If the earth surface deformed at an interval of SAR repeat pass, the deformation will result in component called deformation phase in interferometric phase. One can extract the deformation component and calculate the displacement of earth target with double differential based on an external DEM or more SAR images.

Usually, three SAR images are used to complete the procedure, which is called three pass differential interferometry (TPDI) (Wang Chao et al., 2002). The simple geometry of TPDI can be illustrated in Fig.1. If the earth target has moved from position P_1 to P_2 While SAR secondly images at position S_2 with slightly different looking angle from S_1, the interferometric phase of two images can be equated as following:

$$\phi_{12} = -\frac{4\pi}{\lambda}(R_1 - R_2) = -\frac{4\pi}{\lambda}(R_1 - R_3) + \frac{4\pi}{\lambda}\Delta r \quad 1$$

Where

·R_1, R_2 and R_3 are slant range from satellite to target respectively at different times;

·λ is wavelength and about 5.6cm for C-band;

·Δr is the projection of deformation P_1P_2 on look of sight (LOS) $S_1 \rightarrow P_1$.

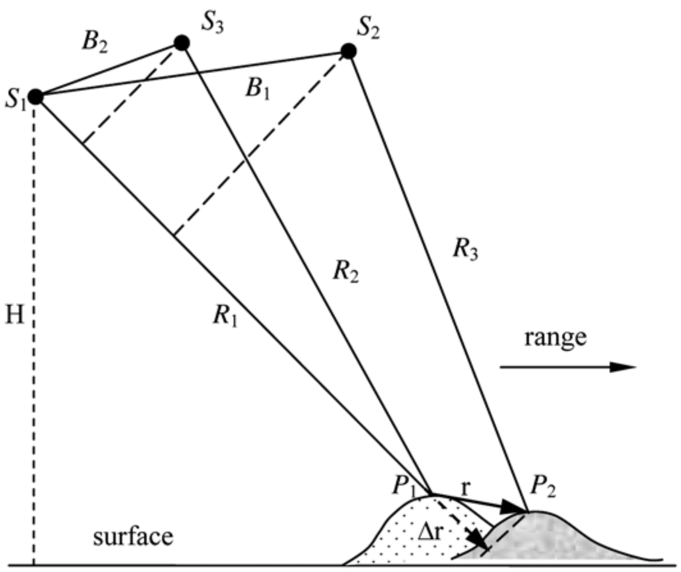

Figure 1: Illustration of three pass differiantial interferometry.

Here the interferometric phase contains the deformation component $\frac{4\pi}{\lambda}\Delta r$ and the topographic component $-\frac{4\pi}{\lambda}(R_1 - R_3)$. In order to extract the deformation phase $\frac{4\pi}{\lambda}\Delta r$, and measure deformation, Δr an extra single view before or after the deformation, such as S_3 should be involved to construct topographic phase $-\frac{4\pi}{\lambda}(R_1 - R_3)$ and remove it from interferometric ϕ_{12} by double differential. In doing so, the deformation phase is extracted as following:

$$\phi_{deform} = \frac{4\pi}{\lambda}\Delta r$$

After the deformation phase ϕ_{deform} is unwrapped (Dennis C. Ghiglia et al., 1998), one can calculate the earth target displacement along LOS. Positive displacement means the slant range lengthening (equal to surface subsidence) and the negative means the slant range shortening (equal to surface uplift). If surface deformation along LOS amounts to 2.8cm, a plus cycle fringe will generate in interferogram for C-band radar interferometry. Thus DInSAR can at least detect the deformation to within just a few centimetres. If the measured phase error was less than 2.24 radian, the theoretic precision of DInSAR will be less than 1cm and thus achieve millimetric precision . The following sections descrbes the detection of co-seismic deformation of Bam, Iran earthquake with DInSAR.

EXTRACTION OF EARTHQUAKE DEFORMATION

A. Study area and data

Bam is a famous historic city. It is located in southeast of Iran and about 1000km from its capital. The violent earthquake (MW = 6.5) took place under this area on 26 December 2003. Much of Bam city was destroyed in this disaster. In order to measure deformation generated by the earthquake in this area and provide some referential data for seismologists, the TPDI has been applied to detect the co-seismic deformation field. The data processing is based on three C-band SAR images collected by the ASAR sensor onboard satellite ENVISAT: on 3 December 2003, 7 January and 11 February 2004, respectively. The three SAR images can be assembled as two inteferometric pairs as shown in Table 1, one for topographic pair, the other one for deformation pair. The image collected on 7 January 2004 is selected as the common "master" image. The other two are assigned as "slave" for respective interferometric pair. The pair of images gathered on 7 January and 11 February 2004 are assigned as the topographic pair because they were both collected after the earthquake. Their interferometric phase is treated as only topographic information. The other pair of images is then are assigned as the deformation pair because they were collected spanning earthquake time. Their

Table1 ENVISAT images data in the study

Interferometric pairs	Date	Orbit	Normal baseline (m)	Parallel baseline (m)
Topographic pair	2004/01/07 (master)	9693	-520.6	-284.1
	2004/02/11 (slave)	10194		
Deformation pair	2004/01/07 (master)	9693	-520.1	-269.4
	2003/12/03 (slave)	9192		

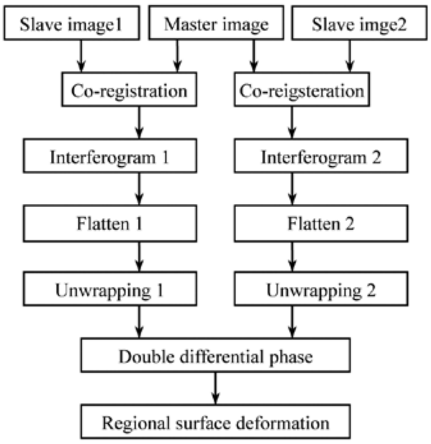

Figure 2: Flowchart of three pass differential interferometry.

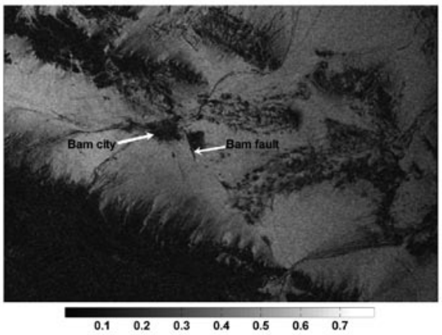

Figure 3: Coherence image of topographic pair. The old Bam fault and Bam city can be clearly identified. The low coherence area at left bottom results from radar geometric disortion caused by the high mountains.

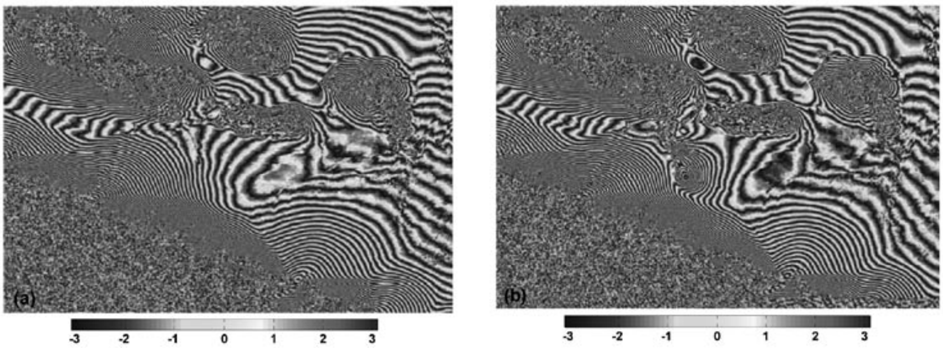

Figure 4: Interferograms of two interferometry pairs. (a) Interferogram of topographic pair, 7 January 2004 - 11 February 2004; (b) Interferogram of deformation pair, 3 December 2003 - 7 January 2004.

interferometric phase is composed of deformation and topographic components.

B. Co-seismic deformation detection

The data was mainly processed with the DORIS software of Delft University and some other necessary programs developed by this author. The two interferometric pairs were processed respectively at the interferometry steps displayed in Fig.2. A series of interim results were achieved during the processing, such as coherence (Fig.3), flattened interferogram (Fig.4) and so on. The phase indicating surface deformation was modulated by topographic phase (Fig.4a) into deformation the pair interferometric phase (Fig.4b). This was distinguished from deformation the pair interferometric phase by differential of the two pairs' interferometric phases (Fig.4a and Fig.4b). Fig.5 displays the fringes of surface deformation phase. A cycle fringe denotes the radian interval of , which indicates the relative surface deformation with half wavelength (2.8cm) degree.

After the deformation phase had been unwrapped, the integrated target displacement and co-seismic deformation field were calculated as indicated in equation (2). The co-seismic deformation contour map was determined as shown in Fig.6. From the differential interferogram (Fig.5)

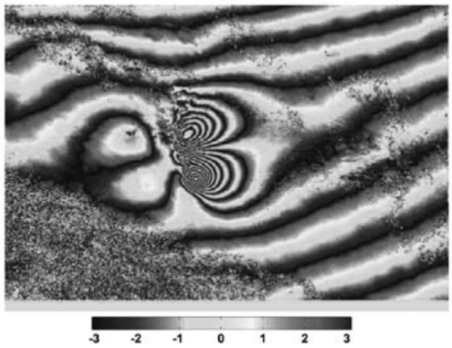

Figure 5: Map of deformation phase.

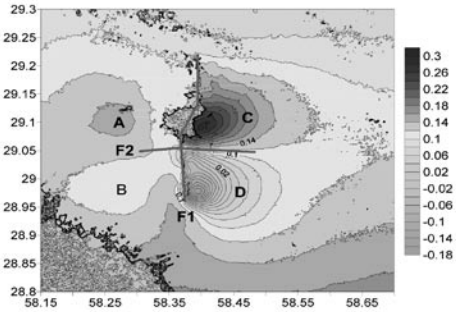

Figure 6: Contour map of co-seismic deformation of Bam earthquake. F1 and F2 are the sketches of two new faults.

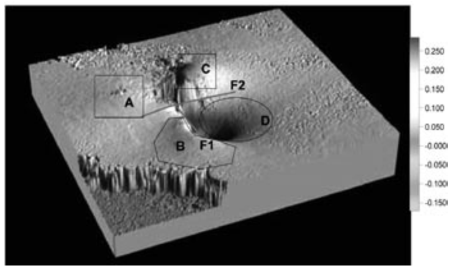

Figure 7: 3D view of deformation.

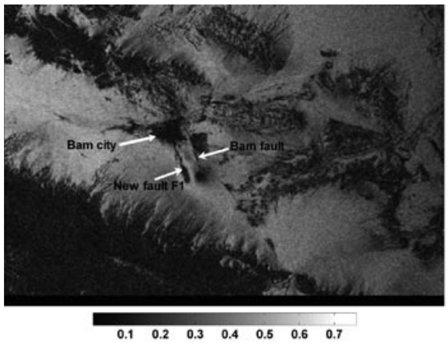

Figure 8: Coherence image of deformation pair. The Bam city, old Bam fault and new fault F1 can clearly identify with low coherence. The new fault F1 generated by the earthquake is parallel to the old Bam fault.

and deformation map (Fig.6), the co-seismic surface deformation patterns can be clearly identified around a total area of 107 km × 40 km. They can be classified into four inconsistent deformation patches (Fig.6): one for subsiding (section D) and the other three for uplifting (section A, B and C). It can be estimated that the maximum slant range shortening and lengthening due to the main shock are up to 29.6 and 17.2 cm, respectively.

Furthermore, there is difference in deformation degree among the four deformation sections. Section C and D have the most deformation but A and B are less. The noise area denoted as yellow (refer to colour version of paper at www.surveyors.org.nz), between deformation section A and C in Fig.5 is Bam City. Because of the violent shock, the city was badly destroyed, which resulted in the decorrelation noise.

Moreover, at least two crossing faults ruptures on surface can be viewed and located by analysing the four inconsistent deformation patches based on displacement direction and their extent. They were both newly generated by the earthquake and can be directly viewed and sketched on contour map (Fig.6), especially on 3D view of deformation (Fig.7). Fault F1 travels in a south-north direction. It can be divided into three segments, northern segment, middle segment and southern segment. The northern segment can be superposed to the northern part of old Bam fault by analysing Bam geology map and report of Xia Ye (Xia Ye.,2005) and Stramondo (S. Stramondo.,2005). The middle and southern segments are new faults generated by this 2003 shock. The middle section just crosses Bam city at southwest direction, then turn to south and extends to the end point (E58.3774, N28.9624), which forms the completely new southern fault. The southern fault is nearly parallel to the old Bam fault. It can be clearly identified and accurately located in the coherence image of deformation pair (Fig.8). The new fault F1 indicates the place where most earthquake power was released. This was also one of the major reasons for the destruction of the city of Bam.

Another new fault F2 also can be determined on contour map and deformation map. From a 3D view of deformation (Fig.7), deformation section C and D can be seen to have have the opposite displacement direction. However, section C and D have different deformation amounts although they moved in the same direction. So it is very possible that a latent fault F2 lies between deformation patch C and D, and extends slightly to west. This fault has not been reported by any other researchers before. Of course, its existence ne needs confirmation on the site.

CONCLUSION

This paper introduced briefly the principle of differential synthetic aperture radar interferometry. Then discussed the co-seismic surface deformation field caused by Bam, Iran earthquake (MW = 6.5) which occurred on 26 December 2003. Its effects were measured through DInSAR using three C-band SAR images collected by the ASAR sensor onboard satellite ENVISAT. The co-seismic surface deformation patterns were classified into four inconsistent deformation patches. The maximum slant range of shortening and lengthening due to the main shock are up to 29.6 and 17.2 cm, respectively. Two crossing faults extending east-west and south-north direction respectively were detected in the study. The middle and northern segment of the fault extending from south to north is mainly the place where the earthquake power is released. The apparent fault extending from east to west has not distinguished by any previous researchers.

It has been shown in this study that differential synthetic aperture radar interferometry is a new and powerful tool for research of earthquakes. It can be used not only to analyze the co-seismic deformation field, but also to detect the series of surface displacements and structures generated during an earthquake's evolvement: the fore-seismic, the co-seismic and the post-seismic effects. The DInSAR results with fine spatial resolution provide important reference data for seismologists wanting to forecast earthquakes, further interpret the earthquake mechanisms and predict some post-seismic activities.

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Cadastral outcomes and the Surveyor-General's rules for cadastral survey

EDITOR'S NOTE

This paper was presented at the Combined 5th Trans Tasman Survey Conference & 2nd Spatial Industry Conference 2006 at Cairns, Queensland, September 2006.

ABSTRACT

"Optimal Regulation" is one of Land Information New Zealand's strategic goals. Government interventions (the most intense forms of which are legislation, regulations or rules) are primarily targeted at protecting some public interest or government outcome. Lesser forms of intervention such as guidelines, co-regulation, or education are also available. A one page document has been developed which contains a structured hierarchy of the outcomes and objectives of the cadastral system. These define the "what" of the cadastre – not the "how". Although developed for New Zealand, the concepts in these outcomes and objectives are thought to be broadly similar to those of most jurisdictions. The next step in achieving optimal regulation is to assess the risks of not achieving these outcomes and objectives and thus the level of government intervention which will most efficiently manage those risks.

This methodology has been applied to the Surveyor-General's Rules for Cadastral Survey (which have the power of government regulation). The process of revising the rules is still underway but some interesting results have arisen. In some areas, the current rules define the "how" of cadastral survey in a way that will increasingly constrain the efficient use of new technology. In others, it is considered that the surveyors and their clients will be better able to manage their risks without the full force of government intervention and existing rules could be relaxed or removed. Some current provisions relate to the exchange of information between surveyors which may be better managed through industry guidelines (co-regulation). Conversely, a few areas were discovered where the current rules do not adequately manage growing areas of risk as the density of land development and land value increases.

KEYWORDS

Cadastre, survey regulation, intervention, outcomes, objectives

INTRODUCTION

The regulations that govern the practice of cadastral surveying in New Zealand are being reviewed. The current processes for the approval of cadastral surveys are often tangled in technical compliance issues (cadastral validators tend to be error intolerant), rather than concentrating on the related risks. At the same time, the surveyor and their client's businesses are increasingly less tolerant of delays in approval, particularly if this affects the cost of finance, profit margins, etc.

Consequently surveyors and developers are increasingly challenging approval decisions and authority.

In recent times society's perception of the role of government has changed to the extent that government's "intervention" in the market place requires justification, with an increasingly common view that individuals and the private sector are often better able to take responsibility for the services they request and deliver.

A framework has been developed that commences with asking fundamental questions about the outcomes and objectives that the cadastral surveying system has to achieve to meet the needs of the nation. Rather than starting with the existing regulations, a "zero based" approach is being taken that tests the regulatory "interventions" against the risks of not achieving these fundamental objectives. While many of the resulting SG Rules for Cadastral Survey (these Rules are mandatory standards having the power of government regulations) may be similar to the current ones, the process is also revealing some options that challenge the traditional solutions.

The new Rules, when they are developed, are expected to provide a set of requirements that transparently link to the outcomes and objectives they are designed to achieve. The government sector will be clear on the risks to the cadastre and to the public that it is required to manage – the "what" of the cadastre. And the private sector will be clear on its role and be able to determine the best means of "how" it can meet the requirements. The Rules and the shared cadastral systems link the two sectors.

THE NEW ZEALAND REGULATORY ENVIRONMENT

Along with many other countries, New Zealand embarked on a privatisation programme in the 1980's which challenged the traditional role of government in delivering services and infrastructure. One of the predominant aims was to create an environment in which the "market" (i.e. the private sector) could determine "how" to the deliver the services, while the government would, where deemed necessary, determine "what" needed to be delivered, protected, or achieved.

This same ethos is being applied to the cadastral system. The "what" has to be focused on public or government outcomes and objectives, and intervention justified by assessing the risks of not achieving them. Ideally the interventions should enable the private sector to determine how to best manage its methods, technology, resources, business processes, etc. while still achieving the public and government goals.

THE CADASTRAL SURVEYING ENVIRONMENT IN NEW ZEALAND

All cadastral surveys in New Zealand are undertaken by either private sector or local government surveyors but no longer central government surveyors. The cadastral surveys are submitted to Land Information New Zealand, for approval and integration into the cadastral record. The surveys are assessed against the SG Rules for Cadastral Survey set by the Surveyor-General, who also works for LINZ. Surveyors take responsibility for the correctness of their survey and compliance with regulations. LINZ takes responsibility for the integrated cadastral record / system.

Only surveyors who hold a License from the Cadastral Surveyors Licensing Board are allowed to undertake cadastral surveys. The Surveyor-General is an ordinary member of the Board (i.e. not the chair) and does not sit on the Board during disciplinary hearings.

The roles of the Board, LINZ, and the Surveyor-General are enshrined in legislation: the Cadastral Survey Act 2002. Figure 1 depicts the key players in the New Zealand cadastral survey system and their key roles and relationships. The topic of this paper – the regulation of cadastral surveys – is circled ("sets standards for surveys").

THE REGULATORY ANALYSIS FRAMEWORK

A regulatory analysis framework has been developed and is being applied to several areas of LINZ's business (e.g. cadastral surveying; land registration; valuation). The framework has four sequential steps as shown in Figure 2.

The first step is to define as succinctly as possible the Outcomes, Intermediary Outcomes, and the related Objectives. At the highest level are **End Outcomes**. These are the end results experienced by the community from a combination of government interventions and external factors. These are high level results. At the next level are **Intermediary Outcomes**. These are expected to lead to a desired end outcome, but are not the results sought. Next are **Objectives**. Objectives

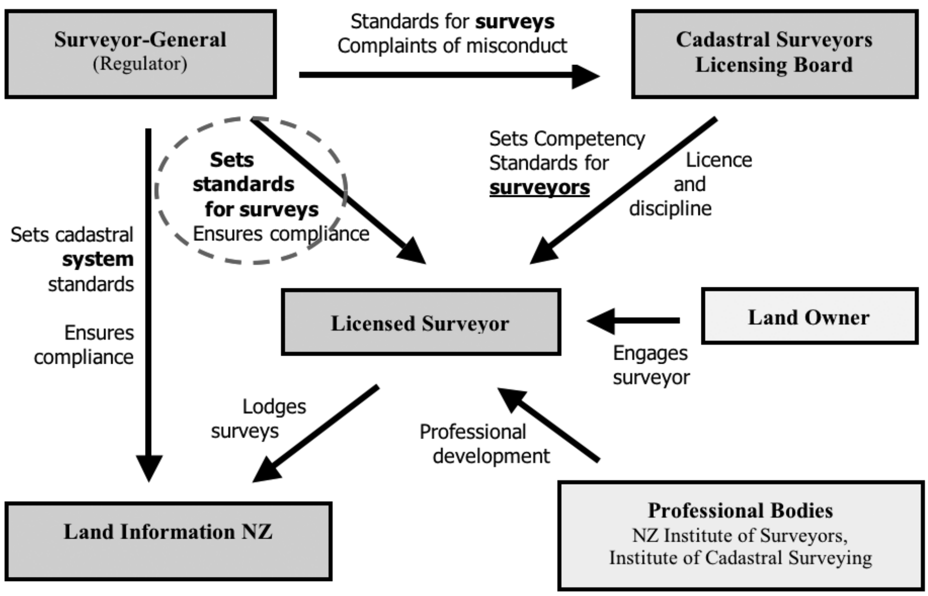

Figure 1 Overview of NZ Cadastral Industry/Regulatory Environment

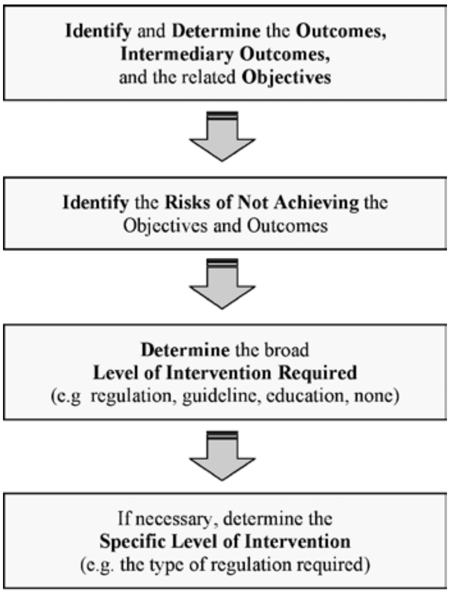

Figure 2 Regulatory Analysis Framework

are lower level results that must be achieved operationally in order to deliver on the intermediary outcomes.

The second step involves looking at the related processes and structures and identifying the risks of not achieving the desired outcomes and objectives.

The third step determines the level of intervention required to manage the identified degree of risk – see Figure 3. Levels of intervention include, in decreasing strength, legislation, regulation, standards, guidelines, and education.

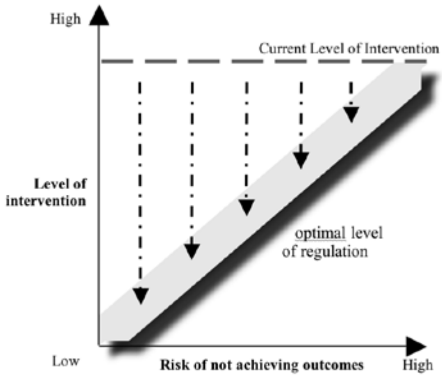

Figure 3 Optimal Regulation/ Intervention

Finally the details of the interventions are developed to match the related risks.

As an analogy, consider the setting of vehicle speed limits by transport authorities. The high level End Outcome could be stated as “Reduced social costs of accidents”. One of the Intermediary Outcomes could be “Reduced traffic speed” which is expected to contribute to the end outcome. An Objective might be that “traffic speed does not exceed a specified limit”. The risk that significant numbers of drivers will exceed a desired speed limit is then identified. Considering the appropriate type of intervention, while educating drivers might discourage many of them from exceeding the limit, the high risk to the End Outcome would justify legislation or regulation, including appropriate sanctions. Finally, the specific intervention could be regulations that specify speed limits that match the risks in different areas – e.g. 50km/h in urban areas.

THE CADASTRAL OUTCOMES

The Cadastral Survey Outcomes and Objectives articulate what we want the New Zealand survey system to achieve i.e. our end outcome. How we achieve that is a different question. It may require a variety of tools and activities. But the key question is what we are trying to achieve in the first place. These Cadastral Survey Outcomes and Objectives are shown in Figure 4.

A cadastral system can be likened to a jigsaw puzzle. The pieces are individual parcels of land. The whole puzzle is the integrated

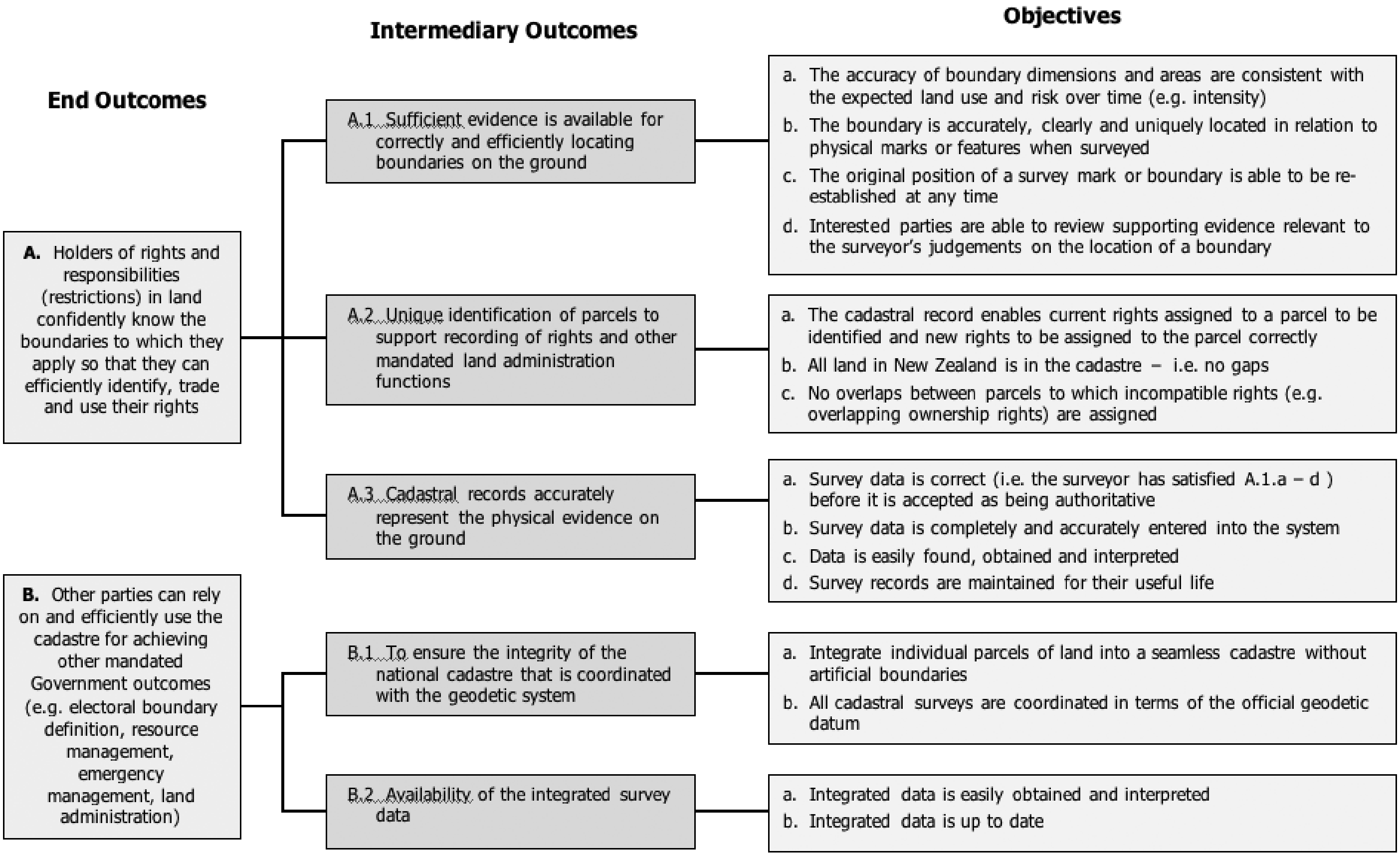

Figure 4 Cadastral Outcomes, Intermediary Outcomes, and Objectives

cadastre. We have identified two End Outcomes. The first and most important is Outcome A:

Holders of rights and responsibilities (restrictions) in land confidently know the boundaries to which they apply so that they can efficiently identify, trade and use their rights

This is the fundamental purpose of the cadastral system and relates to the pieces of the jigsaw puzzle and land-owners (right-holders) interests in land. Land-owners are interested in the boundaries of their land; that it is correctly described by its size, shape, orientation and position; and that it correctly fits in with adjoining land without gaps or overlaps – particularly overlaps.

Outcome B relates to the integrated cadastre and its role in good land administration:

Other parties can rely on and efficiently use the cadastre for achieving other mandated Government outcomes (e.g. electoral boundary definition, resource management, emergency management, land administration)

This is the whole jigsaw puzzle. Landowners have an indirect interest in the integrated cadastre but central and local government agencies have a direct interest in it. The Cadastral Survey Act 2002 recognises this role by requiring the Surveyor-General to have regard for (amongst other things) *"the use of cadastral survey data for purposes other than cadastral survey"*.

THE CADASTRAL INTERMEDIARY OUTCOMES AND OBJECTIVES

We do not have space in this paper to consider and describe all of the Cadastral Survey Outcomes and Objectives. We will trace one objective, A.1.c, to illustrate the purpose of developing this hierarchy and the use made of it in developing appropriate survey interventions.

Each objective must be considered in the context of the Intermediary Outcome and End Outcome that it contributes to. Therefore before discussing objective A.1.c, we will discuss its Intermediary Outcome:

Outcome A.1 Sufficient evidence is available for correctly and efficiently locating boundaries on the ground

The cadastre has not achieved its primary purpose unless boundaries are able to be located in the real world – i.e. the world in which right holders apply and exercise their rights. In this context, "right holders" includes neighbours and other affected parties, future holders of rights, and, in the case of public rights such as public access, also includes members of the public. In practice the locating of boundaries may be undertaken by right-holders themselves or by professional surveyors. The cost efficiency of boundary definition is particularly relevant because if it is too difficult, expensive or uncertain to locate boundaries, right-holders and others will tend to make assumptions or misrepresentations about their boundaries which is likely to lead to incorrect financial and other decisions being made on the basis of those assumptions.

Objective A.1.c is one of four objectives contributing to Intermediary Outcome A.1 described above. It has been chosen for discussion as it is a critical objective of the cadastral system from the landowner's perspective. This Objective is.

Objective A.1.c The original position of a survey mark or boundary is able to be re-established at any time

This objective comes into play after the survey has created a new parcel of land with new boundaries. It may be shortly after the original survey as the new landowner occupies the land for the first time and, for example, builds fences and a house. It may be many years or decades later as a new landowner seeks to further develop their land by adding buildings or to resolve a boundary dispute with a neighbour. It may come into play when a surveyor subdivides the property, first establishing the boundaries of the underlying parcel to prove that adjoining titles have been respected.

There is a long established (centuries old) common law principle that original evidence on the ground, particularly where it has been relied on by right holders, takes precedence over documentary evidence and even over the intended boundary location where this differs from the actual location. To over-turn this common law would require specific legislation and this is not envisaged. While cadastral administrators have debated moving from mark-based to coordinate based or vector based cadastres in the past, there appears to be no pressure from the land-owning public (or the survey profession) to replace the current mark-based cadastre (grounded in the real world, through physical evidence) with a theoretical cadastre (based principally on records and databases). The effects of ubiquitous and continuous earth deformation in New Zealand also count against a theoretical cadastre because vectors and coordinates slowly degrade with time. Therefore reliance on the original position of a mark or boundary (where it can be established) is taken to be a fundamental objective of the New Zealand cadastral system – in common with most other cadastres. This is supported by a number of court decisions and precedents in New Zealand and the Commonwealth.

Achievement of this sub-objective depends on both the surveyor and LINZ. When the boundary is first created its location must be clearly and correctly described (refer also objective A.1.b). This information must then be correctly copied or transferred into the cadastral record. For this purpose, the cadastral record is defined as the sum of structured and unstructured numerical, textual and graphical data held in digital and hardcopy form in authoritative cadastral databases.

When the surveyor goes to re-establish the boundary at a later date, they will need to find and extract all relevant cadastral records, and will need to find (without ambiguity) survey marks or physical features in the field that are located on or in relation to the boundary. Some marks will have gone but there must be enough marks left for the surveyor to establish a survey relationship with the ones that remain, thence the ones that are missing, and finally the boundary itself. In relying on disparate and potentially conflicting evidence, the surveyor will need to make judgements of the relative accuracy and reliability of conflicting survey information.

Risk Assessment for Objective A.1.c

Before considering the level of intervention required, we have identified the following risks of not achieving this objective (*"The original position of a survey mark or boundary is able to be re-established at any time"*).:

1. **Insufficient provision of marks or boundary evidence.** The risk is that insufficient marks and boundary evidence were provided by the original survey to support reliable re-establishment of boundaries at a later date. This risk may be realised when a search for physical evidence of boundaries fails to find adequate marks or other physical evidence. Currently this risk is managed by a requirement to place boundary marks (usually pegs). However pegs are routinely destroyed or disturbed by development works or fencing.
2. **Incorrect recording of marks or boundary location.** Marks are placed for boundary marking but the recording of the original position of a survey mark or boundary may be incorrect or misleading.This may result in original marks not being found and being reinstated incorrectly, or being found in conflict with the cadastral record. This may result in new surveys failing validation or not being able to be integrated into the cadastre due to conflict with the underlying cadastral record.
3. **Incorrect transfer of survey data into the cadastral record.** The survey may be correct and sufficient but the transfer of survey data from the surveyor's dataset to the authoritative cadastral record may be incorrect – i.e. new errors or deficiencies may be introduced during capture and recording. This may result in future surveys relying on authoritative records that are incorrect and boundaries being misplaced as a consequence.
4. **Insufficient survey marks survive for future definition.** Marks are placed to identify boundaries and are correctly recorded but the marks that remain in the field years later, may not be sufficient to re-establish boundaries. This may be either because the number of surviving marks is insufficient or because those that do survive do not have a reliable and accurate survey connection to the boundary.
5. **Information on boundary definition not retrievable from the cadastral record.** The original survey information on the position of a survey mark and/or boundary may not be readily found and retrieved from the Cadastral Record – either because it has been lost, because plans or images have been rendered illegible through deterioration, or are not discovered due to inadequate indexing. A crucial element of boundary evidence may be missed, affecting subsequent re-establishment of boundaries.
6. **Accuracy of original survey data is unknown.** Where conflict is found between different survey records, or between those records and field evidence, the accuracy tolerances of the original survey may be unknown or unclear. Consequently, invalid judgements may be made based on incorrect weighting of the evidence.

Risks 1, 2, 4 and 6 are currently managed through the Surveyor-General's Rules for Cadastral Survey, directed at surveyors. Risks 3 and 5 are managed by separate Surveyor-General's standards directed at the part of LINZ (Customer Services) that processes and approves survey transactions and manages the integrated cadastral record.

Assessment of Current Rules (Regulations) for Objective A.1.c

(Re-establishment of survey mark or boundary)

One of the current methods of controlling risk 1 (and to a lesser extent risk 4) is the mandatory requirement to place boundary marks (usually pegs) on new boundaries. Arguments can be made that this is not a very efficient or effective way of managing these risks for the following reasons:

- A relatively high proportion of boundary pegs are disturbed during the subdivisional development phase or shortly after. Thus they are relatively ineffective at managing risks 1 and 4.
- The surveyor's client may require boundary pegs at the time of selling or fencing new sections but this may be well after the survey and engineering works.
- Pegs affected by engineering works may need to be reinstated several times at some expense.
- There are other options for managing risks 1 and 4 – most notably witness marks or permanent reference marks placed to minimise the risk of disturbance.
- Survey technology is continuing to reduce, the cost of reinstatement of boundaries from secure and reliable witness or permanent reference marks, enabling reinstatement to occur at the time when actually required.

Therefore it is arguable that the need for, and timing of, emplacement of boundary marks, should be left to the surveyor and their client to negotiate themselves. In this case standards for the permanence of witness and reference marks, and for confidence in the survey relationships between them and the boundary, may be more effective tools for managing the risks.

PRELIMINARY ASSESSMENT OF CURRENT RULES

An assessment of other Rules has indicated that some of the information required to be lodged, such as traverse sheets, is arguably beyond minimum requirements. Traverse sheets are helpful for other surveyors but providing helpful (as distinct from essential) information might be better addressed through industry best practice guidelines.

Another interesting conclusion was the discovery that the current accuracy standards do not clearly apply to strata or other height-limited parcels. With increased density of development in urban areas, this is likely to be a growing area of risk and therefore an accuracy standard for vertical dimensions is probably justified.

CONCLUSIONS

A framework for determining the optimal level of regulatory intervention is been applied to the New Zealand cadastral system. It is expected to provide transparency through linking the proposed Rules for Cadastral Survey to the risks of not achieving the outcomes and objectives of the cadastral system. The full process has yet to run its course, but has already proven useful in developing non-traditional options for achieving the objectives.

This paper has taken just one of the objectives, identified related risks and suggested some options for intervention. There are fourteen other objectives. Further work is underway to apply the same analysis to these also.

It is expected that the resultant Rules for Cadastral Survey will provide appropriate freedom to allow surveyors to determine how to meet the outcomes and objectives.

Book Review

Harold Wellman – A man who moved New Zealand

Simon Nathan
Victoria University Press, 2005. 272p. ISBN 0 86473 506 5
A review by Elva Leaming

Simon Nathan's excellent title clearly states what his book is about; the life story of Harold William Wellman (1909-99), a man passionate about discovering how movements of the earth's crust make New Zealand's geology unique.

An informative introduction summarises Wellman's contributions to New Zealand geology (p.7):

> *"… his recognition of the Alpine Fault, … startling proposal that the opposite sides had moved apart by 480 kilometres. … the father of neo-tectonics in New Zealand – analysis of how the earths crust has deformed in the recent past, and how it continues to deform today…contributions in topics from coal rank to Cretaceous paleontology. This biography is an attempt to document and evaluate Wellman's achievements and place them in a broader context with changes in scientific concepts.*

Nathan certainly achieves what he sets out to do. The work is well organised, well researched, with an index, notes and a list of Wellman's works, both published and unpublished. I am not a geologist, but Simon Nathan involved me deeply in Wellman's discovery of the Alpine Fault. So much so, that on a recent South Island trip with a geographer friend, who was also reading Nathan's account of Wellman's life and works, we followed the Alpine Fault from White's Beach north of Blenheim, through Molesworth station, Lewis Pass and via West coast to Haast. Finding hot springs and the West Coast alluvial fans delighted us as did the discovery of the wall across the Alpine Fault near Lake Daniells, built by Professor J B Mackie in the early 1960s in order to discover the direction of seismic impact in future quakes. However, there has been very little movement at that point of the fault and the wall has only one or two minor cracks in it.

Following the Alpine Fault while guided by Nathan's account, showed that although writing for professionals, Nathan is a skilled storyteller and has the ability to interest the layperson. He tells how Wellman used the new theory of plate tectonics, and at the same time captures the man's personality; his determination, his tenacity, his originality of thought, his enquiring mind, his unpredictability, his reliance on his own convictions to the point of almost no return, and the way his character led to his fame. Nathan reveals this so well that the reader begins to predict Wellman's reactions to different situations. Nathan's admiration for this larger than life personality shines through; Wellman's energy, intolerances and most of all his tenaciousness in the field; going back time again and again to a location in order to prove a point which was so very often contrary to that of his colleagues.

The account of the first 30 years of Wellman's life is based on extracts from his own incomplete memoirs. Nathan edited Wellman's life story so wisely that the reader comes to appreciate Wellman's mind along with his geological discoveries, while experiencing the excitement of each breakthrough, and delighting at grasping the relationship between earthquakes and faulting. The story begins with Wellman's early life in Britain, roaming the countryside around Chard, exploring, recognising

Jurassic strata, discovering fossils, and asking questions of science.

In Wellman's words, we learn of his family coming to New Zealand, the beginnings of a surveying career, surveying in Napier after the 1931 earthquake, then with the depression years leaving this career to try his luck goldmining on the West Coast at Ross, Gillespie's Beach, Haast and later at Collingwood in North West Nelson. In 1935 Wellman secured a job as a temporary geophysical assistant working mainly in Southland and Westland. This autobiographical section ends with Wellman's account of a year long contract with the Shell Oil Company in the swamplands of Papua where he contracted malaria.

Wellman began his first permanent job with the New Zealand Geological Survey in 1938. His experience in drawing good geological maps culminated in his contribution to the Geological Survey's great 1947 Geological Map of New Zealand in which the Alpine Fault was first shown on the South Island map.

I loved this book because of Joan and the Wellman family. Family holidays, the beach, the outback, were all tied up with geology because for Wellman, geology was part of everything. School holidays were a chance for him to follow a geological idea when the family car was packed to overflowing with camping gear and geological tools. In fact, it is the family and Joan's never-ending support that softens the otherwise single-minded Wellman character. Her cooking, care for students, and her willingness to undergo the most rustic conditions and the long hours of driving, especially on the 1964-65 trip through India and Asia to Europe, show her as a remarkable gem and the support behind the man. Joan was a spirited pioneering-type woman, who met and married Wellman in a short time, knowing his worth and what she wanted. According to Joan:

" Bill was cleverer and more interesting than any of the other young men I had met…" and while tramping "I had never met a man who could light a fire in the rain before", and their wedding was to "fit in between the finish of Bill's BSc exams and before starting fieldwork on Orepuki".

Wellman was not alone as a geologist receiving such womanly support. This book is published almost simultaneously with two other biographies of geologists; Charles Fleming and Julius Von Haast, who both received tremendous support from their wives, Peg Fleming and Mary Haast.

Nathan tells us about the geologists who worked with Wellman, and introduces us to the geological structure of New Zealand, while tracing the pioneering discoveries about plate tectonics in New Zealand and elsewhere in the world. Good use is made of boxed side accounts, containing brief biographical details about other geologists, explanations of aspects of New Zealand geology, along with glimpses of family life such as Joan Wellman's recipe for home brew.

Simon Nathan has done an excellent job in explaining Wellman's many fields of geological research as well as in providing biographical details. What inspired him to document Wellman and his achievements? On joining the New Zealand Geological Survey in 1967, Nathan was posted to Greymouth. His first job was to assemble a set of Wellman's unpublished manuscripts on the Cenozoic geology of the West Coast for use in oil exploration. He was overwhelmed by the tremendous amount of Wellman's unpublished work, and by how many of Wellman's ideas had been freely passed on in discussion only to be picked up and published by others.

This is a timely book because many people remember Wellman, whether as a colleague, or by recalling stories told by others. It reminds us of a time now past with mention of surveying instruments such as the Cook Troughton & Sims theodolite and the Brunsvega calculating machine. Personalities from the past also abound. Wellman met the Maori prophet Rua, studied under Charles Cotton and worked with colleagues such as Bob Clark, Sir Ernest Marsden and Max Gage. Further, he mentored many young University of Victoria geology students who were later to achieve significance in New Zealand geological circles. Whether in Antarctica, on White Island or attending a geological conference Wellman is remembered by many scientists today, perhaps as the master of a crackpot idea that is now an accepted part of University curriculum.

The book is excellent value retailing at $49.95. For collectors of geological books, scientific topics or even for the interested reader of biographies, it is a very good buy.

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Issues with maintaining spatial accuracy in a nationwide digital cadastral network

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ABSTRACT

New Zealand's cadastral data is held in a system called Landonline. Landonline contains cadastral observations, most of which are linked to the geodetic control. This connection to the geodetic control means that the cadastral data form one large network covering the country – a fully integrated, survey-accurate digital cadastre.

One of the key challenges in managing this network is maintaining the relative accuracy of nodes within a localised area. Five scenarios in which it is desirable to update the coordinates of cadastral nodes have been identified: datum readjustment, geodetic control updates, large deformation events, small deformation events and addition of new cadastral data. Failure to update nodes in these scenarios results in a failure of the spatial network accuracy standard, reducing the utility of the digital cadastre. Where coordinates are updated, they need to be tested to ensure that they continue to meet the relevant accuracy standard.

The current network maintenance methodology used in Landonline is not readily capable of testing for network compliance and updating large numbers of coordinates. It is therefore necessary to consider alternative methodologies, whether they be variants on least squares, or simple interpolation combined with some means of assessing accuracy.

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INTRODUCTION

Land Information New Zealand (LINZ) is the government department charged with managing New Zealand's geodetic and cadastral survey systems. New Zealand has a spatial digital cadastre, which is contained and managed in a system called Landonline. Most of the land parcels in Landonline are defined by survey observations, which have been entered from paper-based survey plans, or submitted directly by surveyors in electronic format.

It is convenient to consider the data in Landonline as belonging to various spatial layers. Two such layers are the geodetic layer and the cadastral layer. The geodetic layer contains geodetic nodes (marks), which provide the underlying spatial framework for the cadastre. By connecting to these geodetic nodes, surveyors are able to produce cadastral surveys that have high levels of both relative and absolute accuracy, forming a seamless digital cadastre covering the entire country.

A problem arises when updates to coordinates in the geodetic layer necessitate updates to the cadastral layers. Similarly, the addition of new cadastral data may require readjustment of the older, underlying data within the cadastral layer. Currently, there is no efficient process for the widespread updating of coordinates in spatial layers to reflect new data. An investigation was therefore carried out to identify the situations where widespread coordinate updates might be required, and review the current method for assessing compliance with accuracy standards. This investigation is a necessary pre-requisite for future work, which will identify a preferred solution to the problem of updating large numbers of coordinates in Landonline.

DEVELOPMENT OF THE SURVEY-ACCURATE DIGITAL CADASTRE

A survey-accurate digital cadastre provides major benefits to both surveyors and LINZ. For example, surveyors can use the electronic data to more easily find marks in the field, and data already contained in Landonline can be incorporated very easily into a new survey. Once the survey is submitted, LINZ can use automated processes to test it against the existing survey-accurate data. The digital data are also used by local and regional government, utility companies and GIS companies to assist with decision making and asset management.

In order to populate the Landonline database with survey-accurate data, a project was carried out to convert data (principally boundary dimensions) on existing paper-based plans into electronic format. The project focussed on converting parcels in urban and peri-urban areas – about 70% of the parcels in New Zealand. The converted data was adjusted in blocks to generate coordinates and assign orders to nodes. The order is a number between zero (high accuracy) and ten (low accuracy) which indicates the accuracy of the node to which it is attached. In general, orders zero through five are geodetic, while orders six through ten are cadastral. This process was designed to ensure the absolute and relative accuracy of the coordinates, and in this regard was largely successful. Full details are contained in Rowe (2003).

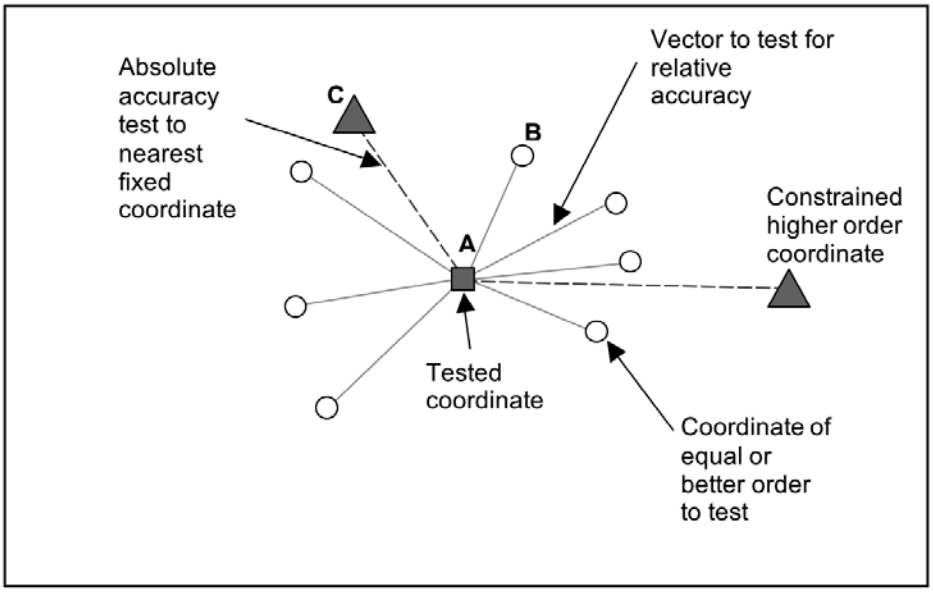

Figure 1 Graphical representation of accuracy tests

The maintenance and enhancement of this survey-accurate digital cadastre is one of LINZ's objectives for the survey system. If the accuracy of the cadastral network is not maintained, some of the benefits of the survey-accurate digital cadastre will be lost. Surveyors may find significant differences between observations made in the field, and the equivalent vector calculated using the coordinates in Landonline. The automated checks used by LINZ to validate new surveys may fail (requiring manual investigation), even though both the new and underlying data contain no significant errors.

To ensure that the cadastre is spatially accurate, the Office of the Surveyor General (OSG) has developed a standard for cadastral network adjustment (OSG 2003). This standard details the criteria which must be met to assign a particular order to a node, so that users are aware of its accuracy.

SPATIAL ACCURACY STANDARD

Orders are assigned to nodes in Landonline based on accuracy information obtained from the results of a least squares adjustment. There are two components to the accuracy standard. Any given node must pass both components to be assigned a particular order.

Component 1: Relative Accuracy

The relative component tests the accuracy of a node relative to all other nodes of the same or better order. Relative accuracy is distance dependent, so as the distance between the nodes increases, so too does the maximum error permitted. Compliance is assessed by comparing the error in the vector formed between two nodes with the maximum allowed by the standard.

Component 2: Absolute Accuracy

This component tests the accuracy of the node relative to higher order nodes in the adjustment. Two tests are used to assess absolute accuracy, both of which examine the error in the coordinates of the node. One test compares the coordinate error against a standard which depends on the distance to the nearest fixed node. The second test compares the coordinate error against a standard which is not distance dependent.

Example

In Figure 1, Node A would be tested against Node B and the rest of the nodes of the same or better order within the adjustment. For example, the relative error between A and B would be obtained from the covariance matrix for the coordinates output as part of the least squares adjustment. This error would then be compared against the maximum relative error permitted by the accuracy standard for those two nodes. If the error is less than the maximum permitted, the relative accuracy test is passed for that vector. If the rest of the vectors also pass, then Node A has passed the relative accuracy test.

To test for compliance with the absolute accuracy standard, the two tests discussed previously are applied, using the nearest fixed node (represented by triangles in Figure 1). If the error at A, again obtained from the covariance matrix, is less than the maximum permitted by the standard for each of the two tests, then the absolute accuracy test is passed for this node.

Maintaining Relative Accuracy after Geodetic Coordinate Updates

There is also a standard which is used to determine whether cadastral coordinates need to be updated in response to a geodetic coordinate change. This standard states that if the geodetic coordinate change is less than 25% of the maximum relative error permitted between the geodetic node and the "adjacent" cadastral nodes, there is no need to update the cadastral coordinates. This means that insignificant geodetic coordinate changes do not trigger cadastral coordinate updates. Adjacent nodes are those that fall within a distance threshold, which is loosely related to the density of geodetic control. Thus in an urban area, the distance threshold is 200m because beyond that distance, the geodetic control should ensure that relative accuracy in the cadastre is maintained. In a rural area, the threshold is greater as the geodetic control is sparser.

Problems with Statistical Testing

The methodology for testing network accuracy relies on every relevant node being included in the least squares adjustment, so that the required error information is included in the output covariance matrix. It is also reliant on the quality of the information contained within this matrix, which in turn is reliant on the information that is input into the least squares adjustment – the observations and their associated errors. There are several factors that call into question the statistical reliability of this information:

1) The data are often not genuine observations. For example, most of the cadastral data in Landonline are calculated rather than observed (for example, boundary "observations").
2) Individual observations are assumed to be independent. This assumption is reasonable for distances, but not for bearings. Bearings are calculated from observed angles, which makes them correlated (not independent). Also, the origin of bearings is usually obtained from an underlying survey, so any error in the orientation of the older data propagates through into the new survey.
3) The data have usually been subject to some kind of prior "adjustment" before they are recorded on a survey plan. For example, bearings are often adjusted to account for any circuit misclose and small calculated discrepancies in parcel dimensions may not be recorded in order that title dimensions are respected.

Some of these issues are compensated for by the fact that the standard observation errors used in the least squares adjustment of Landonline data are typically overestimates (Donnelly and Hannah 2006). Nevertheless, the statistical model used to derive the observation errors for the adjustment is flawed, which calls into question the veracity of the tests being applied to determine the order of a node. These statistical flaws are due to the nature of cadastral data, which is collected to support the spatial definition of land parcels, rather than to provide pure data for statistical testing. It should be noted that the factors listed above tend not to affect the coordinate values, as coordinates are influenced primarily by the values of the observations, rather than the errors associated with those observations. It is mainly the estimates of the errors of those coordinates that are affected.

The calculation of the covariance matrix required to test nodes for compliance with the accuracy standard is computationally intensive, and has detrimental impacts on the performance of Landonline for adjustments with more than a few thousand nodes. As the following section explains, the maintenance of spatial alignment often requires updates to more than just a few thousand nodes. Given the aforementioned problems with the statistical data associated with cadastral least squares adjustment, it is worth considering other methods that could be used to assess compliance with accuracy standards.

SCENARIOS FOR THE READJUSTMENT OF COORDINATES

A key aim of the investigation was to identify scenarios in which large numbers of coordinates might need to be updated in a digital cadastre. Five such scenarios were identified.

Scenario 1: Geodetic Datum Readjustment

Historically, the widespread readjustment of the geodetic datum, or implementation of a new datum, has been a rare occurrence. However, increased demands for accuracy relative to a global reference frame suggest that datum re-adjustment may be more common in the future. This is particularly true for countries such as New Zealand where there is extensive differential land deformation. Beavan and Blick (2005) have recommended that LINZ consider updating the National Velocity Model as errors in the existing model are at a level where horizontal accuracy standards will be compromised within the next few years. A new velocity model would update all of the geodetic coordinates, which in turn would require updates to the cadastral coordinates.

To estimate how many cadastral coordinates might need updating in a datum readjustment scenario, a series of simulations was set up in which the coordinates of the first order stations were altered. Three simulations were run to investigate the relationship between magnitude of movement of the first order coordinates and number of cadastral coordinates needing to be updated.

A least squares adjustment was set up external to Landonline which contained all of the geodetic data for the country for orders one through four. It also included the Auckland fifth order network. Other fifth order networks were not included to keep the adjustment to a manageable size. An initial adjustment was run with the first order stations held fixed at their existing values to generate coordinates for the rest of the stations. New first order coordinates were then created by adding random, normally distributed corrections to the existing coordinates (see Table 1). The adjustment was rerun using the new first order coordinates. The coordinates generated were compared with the coordinates calculated in the initial adjustment, and the magnitude of the coordinate change was calculated. For all those movements exceeding 0.005 m (and where the geodetic node was connected to the cadastre), the surrounding cadastral nodes were compared against the relative accuracy standard. This involved calculating the distance a given cadastral node would need to be from the geodetic node to still maintain relative accuracy, without needing to have its coordinates updated. All cadastral nodes within this distance would need to be updated to bring them into alignment with the new geodetic coordinate. The greater the coordinate change at the geodetic node, the further away a cadastral node had to be before relative accuracy was not compromised. Results of the three simulations are in Table 1.

The maximum coordinate change of 0.10 m was used as this is considered to be the largest possible error that could be accepted prior to updating the datum. Simulation 2 represents the most likely scenario, as it is at this stage that the horizontal relative accuracy standard of 0.05 m is just exceeded. There are currently over four million survey-accurate coordinates in Landonline. Extrapolating the results of Simulation 2 to the whole country, it is likely that in a datum readjustment about 2.3 million coordinates would need updating.

Table 1. Results of datum update simulations

	Simulation One	Simulation Two	Simulation Three
Changes to first order coordinates	0.02 ± 0.02 m	0.05 ± 0.02 m	0.10 ± 0.02 m
Auckland cadastral coords requiring updating	4000	744 000	963 000
Percentage of Auckland cadastral coords requiring updating	0.3%	59%	76%

Scenario 2: Geodetic Control Update

LINZ regularly makes updates to the fifth order geodetic networks that provide the control for cadastral surveys. The maintenance of these fifth order networks typically involves the addition of further observations, or extra constraints (fixed stations), to resolve discrepancies and strengthen the network. These additional observations and constraints can cause significant coordinate changes to existing nodes. When this happens it is necessary to update the adjacent cadastral coordinates. The updating of even a small number of geodetic coordinates can affect a large number of cadastral coordinates, particularly in urban areas.

Since geodetic control updates are regularly undertaken by LINZ, a real example was used to assess the impact on the cadastre. One of the largest fifth order adjustments is the Auckland network. A recent update resulted in 1,122 geodetic coordinates being changed. Using the methodology outlined for Scenario 1, the number of cadastral coordinates affected by those geodetic coordinate shifts was 23,000.

Scenario 3: Large Deformation Event

New Zealand's location on the boundary of two tectonic plates means that large scale deformation events (usually earthquakes) have the potential to cause several metres of movement, compromising large areas of the cadastre. To test the impact of a deformation event on the geodetic network, and hence the cadastral network, the results of a study done for LINZ by Geological and Nuclear Sciences (GNS) were used (Beavan and Wallace 2004). In this study, a model was used to predict movements of geodetic marks subsequent to a simulated major earthquake on the Wellington fault. It was predicted that nearly 33,000 geodetic coordinates would need updating. To examine the effect on the cadastral network, the same model was applied to the cadastral coordinates. If the coordinate change was greater than 0.005 m, then the coordinates would need updating. This analysis revealed that 1.2 million coordinates would need to be updated.

Scenario 4: Small Deformation Event

More frequent deformation events include slow landslides, where a hillside is moving slowly but significantly. Where sufficient data are available, it is possible to incorporate this movement into the National Deformation Model through the addition of patches onto the National Velocity Model (Jordan *et al.* 2005). Several areas have already been identified as requiring patches to account for localised deformation. The application of the patch will require the updating of the cadastral coordinates in the area affected by the patch. In one example, the localised deformation covered an area containing 3000 cadastral nodes.

Scenario 5: Cadastral Network Area Adjustment

In contrast to the previous four scenarios, which examined the impact of updates to the geodetic layer on the cadastral layer, this scenario concerns the problem of integrating new cadastral data with the existing cadastral data in Landonline. A wide area adjustment is required where there are conflicts between the two datasets. Wide area adjustments are also desirable where a number of new surveys have added data to a particular area. The integration of these new surveys in a single adjustment enhances the relative accuracy of the coordinates.

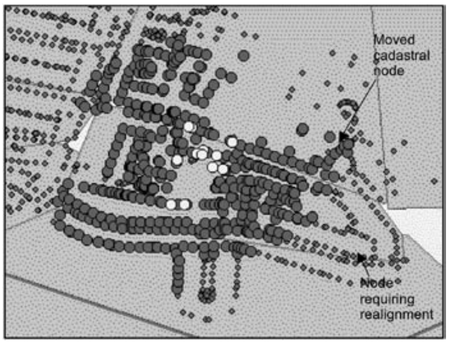

Figure 2. Effect of cadastral node movement on surrounding nodes. The light-coloured large circles highlight moved cadastral nodes; darker-coloured large circles represent adjacent cadastral marks that need to be realigned in order to maintain relative accuracy. Small circles represent unaffected nodes.

This was another scenario where real data could be analysed. An area was chosen where five new surveys had been lodged and 18 of the original geodetic coordinates had been updated. The data were extracted from Landonline and an adjustment run holding the geodetic nodes fixed. Cadastral coordinates that changed by more than 0.005 m were tested against the accuracy standard. This revealed that 2700 coordinates were to be updated. Figure 2 shows how changes to only a few cadastral coordinates can affect a large number of adjacent coordinates.

Table 2. Magnitude and frequency of typical adjustment scenarios

Scenario		Coordinates affected	Frequency
1	Datum re-adjustment	2 300 000	One off event
2	Geodetic control update	up to 25 000	Four per month
3	Large deformation event (eg earthquake)	1 200 000	One off event
4	Small deformation event (eg slow landslide)	up to 5 000	One per year
5	Cadastral area adjustment	up to 5 000	Four per month

Summary

Table 2 below summarises the results of the analyses of the scenarios:

FUTURE WORK: INVESTIGATION OF POTENTIAL SOLUTIONS

Based on the foregoing discussion, there are two major issues requiring resolution if the accuracy of the spatial layers in Landonline is to be maintained. The first is how updates of large numbers of coordinates may accurately and efficiently be carried out. The second is how the network accuracy standard should be applied to calculate the order of the updated coordinates.

Potential solutions can be split into two categories: those for which error information is a by-product of the adjustment method and those for which error estimates must be produced using some other method. A number of potential solutions have been identified, and are summarised in the table below. Future work will involve the detailed assessment of each option to

Table 3. Potential methods for resolving alignment issues

Method	Generates Coordinates?	Generates Error info?	**Description**
Step-By-Step Least Squares	Yes	Yes	A large adjustment is broken into a number of smaller blocks. These blocks are processed individually, with “junction stations” at block boundaries acting as the connection between blocks. The coordinates produced are identical to classical least squares. Relative error information is produced between coordinates within a block, but not between coordinates in different blocks. See Cross (1983).
Sequential Least Squares	Yes	Yes	When new surveys are integrated into the cadastre, the impact of the new data on existing coordinates is calculated and these are updated accordingly. The method is more efficient than classical least squares as it utilises information calculated in the previous adjustment of the underlying data. Thus changes to the underlying data can be calculated without needing to readjust all of the data (new and underlying) together. This method has the most relevance to Scenario 5. See Cross (1983).
Interpolation	Yes	No	Interpolation (or extrapolation) is used to estimate coordinate changes at cadastral nodes based on the coordinate changes at nearby geodetic nodes. This is sometimes referred to as “rubber-sheeting”, as the cadastral coordinates are moved in proportion to the movements at the geodetic nodes, as if they are on a rubber sheet being stretched.
Covariance Function	No	Yes	This may be used to calculate coordinate order. Rather than using the information output from a least squares adjustment, a covariance function looks at certain characteristics of the node (such as proximity to control) and assigns order based on these characteristics.
Least Squares Filtering	Yes	Yes	Similar to interpolation, but filters the coordinate changes at the geodetic node to remove any random errors. This means that the cadastral coordinate changes are derived from an analysis of the overall trend of the geodetic coordinate changes. See Mikhail (1976).

determine a preferred solution; one which will maintain spatial accuracy, enable compliance testing and be computationally simple enough to be practically carried out. The potential solutions identified at this stage are summarised below.

CONCLUSIONS

There are five main scenarios which require coordinates to be updated for extensive parts of the cadastre. The current least squares methodology implemented in Landonline is only efficient for adjustments of up to a few thousand nodes, so alternative methodologies need to be considered. The magnitude and frequency of occurrence of these scenarios has already resulted in the degradation of the relative accuracy of parts of the cadastral network.

Although this investigation has focussed principally on Landonline, the scenarios and compliance testing issues outlined would be relevant to any survey-accurate digital cadastral system.

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Rodney Hope RPSurv ... CHRISTCHURCH
Simon Ironside RPSurv ... CHRISTCHURCH
Jeffrey Irving RPSurv ... CHRISTCHURCH
William Lawson RPSurv ... HANMER SPRINGS
Andrew Marr ... CHRISTCHURCH
Michael Martin RPSurv ... CHRISTCHURCH
Peter McAuley RPSurv ... CHRISTCHURCH
Warren McCall RPSurv ... CHRISTCHURCH
Craig McInnes RPSurv ... CHRISTCHURCH
Julie McMillan RPSurv ... CHRISTCHURCH
Keith Mills RPSurv ... CHRISTCHURCH
Ross Moulton ... CHRISTCHURCH
Mark Nichols ... CHRISTCHURCH
David Norman ... HANMER SPRINGS
Michael Peacock RPSurv ... CHRISTCHURCH
Maurice Perwick RPSurv ... CHRISTCHURCH
Stephan Rattray RPSurv ... CHRISTCHURCH
Michelle Reid RPSurv ... CHRISTCHURCH
Alexander Richardson RPSurv ... ASHBURTON
Vincent Ryan RPSurv ... CHRISTCHURCH
Murray Scandlyn RPSurv ... RD 2, RANGIORA
Bruce Sinclair RPSurv ... CHRISTCHURCH
Marton Sinclair RPSurv ... CHRISTCHURCH
David Smith RPSurv ... ASHBURTON
Malcolm Smith RPSurv ... CHRISTCHURCH
Mark C Smith RPSurv ... CHRISTCHURCH
Paul Stening RPSurv ... CHRISTCHURCH
Robin Sutherland ... CHRISTCHURCH

Lyndon Telfer RPSurv ..... CHRISTCHURCH
Craig Thompson ..... CHRISTCHURCH
Brent Toms RPSurv ..... CHRISTCHURCH
Willem van den Berg RPSurv ..... CHRISTCHURCH
Reuben Vos RPSurv ..... CHRISTCHURCH
David Wade ..... CHRISTCHURCH
Christopher Walker RPSurv ..... CHRISTCHURCH
Stephen Wardle ..... RANGIORA
William Wicks ..... CHRISTCHURCH
Scott Williams RPSurv ..... CHRISTCHURCH
Peter G Williams RPSurv ..... CHRISTCHURCH

NELSON/MARLBOROUGH

Members

Vernon Ayson RPSurv ..... BLENHEIM
John Batt RPSurv ..... NELSON
Vincent Belgrave RPSurv ..... PICTON
Michael Cotton RPSurv ..... NELSON
Errol Gilchrist ..... NELSON
Ian Gourdie ..... NELSON
Trevor Gowland RPSurv ..... GOLDEN BAY
Alexander Grigg RPSurv ..... NELSON
Anthony Hawke RPSurv ..... BLENHEIM
Graeme Haymes RPSurv ..... BLENHEIM
Robert Jones ..... NELSON
Simon Jones RPSurv ..... NELSON
Selwyn Light ..... MOTUEKA
Tony Lindbom RPSurv ..... NELSON
Ashley Macfarlane ..... NELSON
Alexander Martin RPSurv ..... NELSON
Grant McGillivray ..... NELSON
Terence McGrail RPSurv ..... BLENHEIM
Vicki Nalder RPSurv ..... BLENHEIM
Nigel Nalder RPSurv ..... NELSON
Peter Newbury RPSurv ..... NELSON
Julius Newman ..... BLENHEIM
Paul Newton RPSurv ..... NELSON
Anthony Nikkel RPSurv ..... MOTUEKA
Philip Norton RPSurv ..... BLENHEIM
Steven Odinot RPSurv ..... NELSON
Jayne Perrin RPSurv ..... BLENHEIM
Martin Potter RPSurv ..... TAKAKA
Michael Russell RPSurv ..... BLENHEIM
Ross Shirley RPSurv ..... NELSON
Andrew Stanger ..... NELSON
Matthew Straker RPSurv ..... BLENHEIM
Mike Verrall RPSurv ..... NELSON
Stuart Wallace RPSurv ..... MOTUEKA
David Ward RPSurv ..... NELSON
John West ..... NELSON
Frederick Wingate RPSurv ..... TAKAKA
Colin Wratt ..... NELSON

Retired Members

Anthony Alley ..... NELSON
Owen Amor ..... NELSON
Brian Bullivant ..... NELSON
Roger Chapple ..... NELSON
Graham Couldrey ..... PICTON
John Cross ..... NELSON
Hugh Gourdie ..... NELSON
Graham Henderson ..... BLENHEIM
Harold Jenks ..... NELSON
Prof John Mackie ..... NELSON
Robin Randle ..... NELSON
David Smythe ..... NELSON

Associate Members

Lennon Bedford ..... NELSON
John Cotton ..... NELSON
Brendon Cross ..... NELSON
Lisa-Maree Gibellini ..... NELSON
Perry Gilbert ..... BLENHEIM
Mark Holyoake ..... NELSON
Murray McGuire ..... NELSON
Philip Morton ..... BLENHEIM
Stephen Neal ..... BLENHEIM
Steven Parker ..... NELSON
Philippa Roberts ..... BLENHEIM
Lawrence Saunders ..... NELSON
Clifford Saxton ..... NELSON
Matthew Standish ..... NELSON
Liam Sullivan ..... NELSON
Arthur Taylor ..... NELSON
Jamie Thirkettle ..... NELSON
Christopher J Williams ..... BLENHEIM

WELLINGTON

Members

Robert Adam ..... WELLINGTON
Phillip Adamson RPSurv ..... MASTERTON
Matt Amos ..... WELLINGTON
Gerald Arthur ..... UPPER HUTT
Ian Ayson ..... PARAPARAUMU
John Baldwin RPSurv ..... WELLINGTON
Daryl Baynes ..... LOWER HUTT
Graeme Blick ..... WELLINGTON
Michael Brownie RPSurv ..... WELLINGTON
Trevor Burrows ..... WELLINGTON
John Carruthers RPSurv ..... MASTERTON
Neville Ching ..... WELLINGTON
Andrew Clouston RPSurv ..... WELLINGTON
Stephen Critchlow RPSurv ..... WELLINGTON
Eric Dodd RPSurv ..... MASTERTON
Mark Edgar RPSurv ..... PARAPARAUMU
Michael Foster RPSurv ..... WELLINGTON
Wayne Gair RPSurv ..... WELLINGTON
Christopher Galbreath ..... MASTERTON
Trevor Garnett RPSurv ..... WAIKANAE
Brett Gawn RPSurv ..... WELLINGTON
Daniel Geeves ..... WELLINGTON
Mark Goodin RPSurv ..... WELLINGTON
Richard Graham RPSurv ..... WELLINGTON
Donald Grant ..... WELLINGTON
Anselm Haanen ..... WELLINGTON
Andrew Han ..... WELLINGTON
Bruce Hanify ..... LOWER HUTT
Joanne Head RPSurv ..... WELLINGTON
Ashley Houghton RPSurv ..... UPPER HUTT
Simon Jellie ..... WELLINGTON
Robert Jennings RPSurv ..... WELLINGTON
Ralph Jorgensen RPSurv ..... WELLINGTON
Tim Kenning ..... WAIKANAE
Bruce Kiddle RPSurv ..... WELLINGTON
Peter Kiernan RPSurv ..... WELLINGTON
Stuart Kinnear RPSurv ..... UPPER HUTT
Stefan Kiss RPSurv ..... WELLINGTON
Ian Leary ..... WELLINGTON
Robert Lendrum RPSurv ..... UPPER HUTT
Rebecca Lowe ..... WELLINGTON
Ronald Lucas ..... LOWER HUTT
James Lynch ..... WELLINGTON
Bruce Manners ..... WELLINGTON
Peter Maunder RPSurv ..... WELLINGTON
Colin McElwain RPSurv ..... LOWER HUTT
John McKechnie RPSurv ..... UPPER HUTT
Dion Mead RPSurv ..... WELLINGTON
Edward Meldrum ..... WAIKANAE
Hudson Moody RPSurv ..... WELLINGTON
Michael Morris RPSurv ..... WELLINGTON
Jeffrey Needham RPSurv ..... WELLINGTON
Hugh Norton RPSurv ..... WELLINGTON
Clinton O'Leary RPSurv ..... WELLINGTON
Geoffrey O'Malley ..... WELLINGTON
Neville Palmer RPSurv ..... LOWER HUTT
Russell Paterson RPSurv ..... PORIRUA
Ryan Patterson ..... PETONE
Dr Merrin Pearse RPSurv ..... WELLINGTON
Scot Plunkett RPSurv ..... LOWER HUTT
Ian Prentice RPSurv ..... WELLINGTON
Neil Pullar RPSurv ..... UPPER HUTT
Gary Rawson ..... LOWER HUTT
Ian Redward ..... PARAPARAUMU
Mark Roberts RPSurv ..... LOWER HUTT
Derek Roberts RPSurv ..... MASTERTON
Dr William Robertson RPSurv ..... WELLINGTON
Glen Rowe RPSurv ..... LOWER HUTT
Anthony Sarniak-Thomson RPSurv ..... PORIRUA
Barry Sayer RPSurv ..... WELLINGTON
Alastair Seyb RPSurv ..... WELLINGTON
Michael Shaw ..... MASTERTON
Barrie Shute ..... LOWER HUTT
Barry Silvester ..... GREYTOWN
Devendra Singh ..... WELLINGTON
Kevin Smith RPSurv ..... UPPER HUTT
Michael Snow RPSurv ..... WELLINGTON
Mack Thompson RPSurv ..... WELLINGTON
J Stuart Thomson ..... WELLINGTON
Nicola Todd ..... PARAPARUMU
Peter Tong RPSurv ..... WELLINGTON
Ross Topham RPSurv ..... WELLINGTON
Peter Trotman RPSurv ..... LOWER HUTT
Paul Turner RPSurv ..... WAIKANAE
Brian Warburton ..... PORIRUA
Stu Watson RPSurv ..... LOWER HUTT
Graham Wigley RPSurv ..... LOWER HUTT
Ralph Winmill RPSurv ..... WELLINGTON
W Daniel Wood RPSurv ..... UPPER HUTT
Warwick Wyatt ..... WAIKANAE
Ben Zwartz RPSurv ..... WELLINGTON

Retired Members

George Andrews ..... WELLINGTON
William Arnold ..... WELLINGTON
Anthony Bevin ..... WELLINGTON
Peter Chambers ..... LOWER HUTT
Mairi Clark ..... WELLINGTON
Graeme Crocker ..... WELLINGTON
Barry Davidson ..... UPPER HUTT
David Dyett ..... WELLINGTON
Lawrence Harding ..... UPPER HUTT
Peter Hughes ..... WELLINGTON
Howard Hunter ..... JOHNSONVILLE
Wilson Lattey ..... PARAPARAUMU
Ian MacLean ..... WELLINGTON
Dr Bruce McFadgen ..... WELLINGTON
Roger McLeod ..... UPPER HUTT
Alan Milne ..... PARAPARAUMU
Bruce Purdie ..... WELLINGTON
Evan Rait ..... WELLINGTON
Dirk Rinckes ..... WAIKANAE
Brian Shearer ..... LOWER HUTT
Kaye Soutar ..... LOWER HUTT

Associate Members

Robert Batt ..... WELLINGTON
Grant Beattie ..... WELLINGTON
Stuart Caie ..... WELLINGTON
Scott Carley ..... JOHNSONVILLE
Lance Chisman ..... WELLINGTON
Henry Coll ..... WELLINGTON
David Collett ..... WELLINGTON
Joanna Cushen ..... WELLINGTON
Roy Dale ..... WELLINGTON
Nic Donnelly ..... WELLINGTON
Peter Drown ..... LOWER HUTT
Daniel Fraser ..... WELLINGTON
David Gibson ..... WELLINGTON
Shepherd Gweshe ..... WELLINGTON
Toni Hill ..... LOWER HUTT
Brett Horne ..... WELLINGTON
Barry Hughes ..... WELLINGTON
Paul Hughes ..... WELLINGTON
Paul James ..... WELLINGTON
Geoffrey Linnell ..... WELLINGTON
Bradley Monaghan ..... WELLINGTON
Terry Mueller ..... LOWER HUTT
Andy Muir ..... WELLINGTON
Nathan Nadan ..... LOWER HUTT
David Pearson ..... WAIKANAE
Andrew Perry ..... WELLINGTON
Andrew Rivers ..... WELLINGTON
Daniel Rodie ..... WELLINGTON
Brett Smith ..... WELLINGTON
Phillip Stroud ..... WAIKANAE
Ann-Maree Wallace ..... PARAPARAUMU

MANAWATU/WANGANUI

Members

Steven Archer RPSurv ..... WANGANUI
Trevor Attrill ..... WANGANUI
Christopher Bone ..... DANNEVIRKE
Iain Ferguson ..... WANGANUI
Colin Fink RPSurv ..... PALMERSTON NORTH
Hugh Gilberd RPSurv ..... WANGANUI
John Harrison RPSurv ..... WANGANUI
Kevin Judd RPSurv ..... PALMERSTON NORTH
Robert Longley RPSurv ..... LEVIN
Patrick Manson ..... PALMERSTON NORTH
Michael O'Sullivan RPSurv ..... WANGANUI
Philip Pirie RPSurv ..... PALMERSTON NORTH
Grant Pope RPSurv ..... RAETIHI
William Riordan RPSurv ..... FEILDING
Thomas Robinson RPSurv ..... FOXTON
Mervyn Shand ..... LEVIN
Dean Sherrit RPSurv ..... OHAKUNE
Bruce Stern ..... FEILDING
Roger Truebridge RPSurv ..... LEVIN
I G Peter Wilde RPSurv ..... PALMERSTON NORTH
Glenn Young ..... PALMERSTON NORTH

Retired Members
Ronald Beadle .... OTAKI
Hugh Farquhar .... PALMERSTON NORTH
Graeme Hartnell .... MARTON
Henry Payne .... WANGANUI
Bill Sawers .... PALMERSTON NORTH
Associate Members
Nigel Beedell .... PALMERSTON NORTH
Lawrie Cairns .... PALMERSTON NORTH
Karl Carew .... PALMERSTON NORTH
Colin Gates .... WANGANUI
Kate Gwilliam .... PALMERSTON NORTH
Vaomu Ioane .... PALMERSTON NORTH
Andrew Jones .... WANGANUI
Victoria Loughlin .... WANGANUI
Peter McConnell .... WANGANUI
Hamish Pirie .... PALMERSTON NORTH
Michael Proude .... RAETIHI

TARANAKI
Members
Kathryn Barrett .... NEW PLYMOUTH
Geoffrey Bland RPSurv .... NEW PLYMOUTH
James Christie RPSurv .... NEW PLYMOUTH
Philip Dickey RPSurv .... NEW PLYMOUTH
Alan Doy RPSurv .... NEW PLYMOUTH
Michael Gibson .... NEW PLYMOUTH
John Hermann .... NEW PLYMOUTH
Graeme Howarth RPSurv .... NEW PLYMOUTH
Colin Jackson RPSurv .... NEW PLYMOUTH
Allen Juffermans RPSurv .... NEW PLYMOUTH
Stephen Koning RPSurv .... NEW PLYMOUTH
Stephen Lumb RPSurv .... NEW PLYMOUTH
John Robertson .... NEW PLYMOUTH
Patrick Sole RPSurv .... NEW PLYMOUTH
Robert Waugh RPSurv .... NEW PLYMOUTH
Anthony Wey .... NEW PLYMOUTH
Belinda Willis RPSurv .... NEW PLYMOUTH
Retired Members
Trevor Bright .... NEW PLYMOUTH
Paul Catchpole .... NEW PLYMOUTH
Ian Dudding .... NEW PLYMOUTH
Colin McKinlay .... NEW PLYMOUTH
Christopher Stayt .... NEW PLYMOUTH
Associate Members
David Armstrong .... WAITARA
Paul Cracroft-Wilson .... NEW PLYMOUTH
Ian Dickey .... NEW PLYMOUTH
Mel Harper .... NEW PLYMOUTH
Graham Hills .... NEW PLYMOUTH
Keith Holswich .... NEW PLYMOUTH
Duncan McRae .... NEW PLYMOUTH
Bradley Moller .... NEW PLYMOUTH
Vaughan Redshaw .... NEW PLYMOUTH
Christopher Smith .... NEW PLYMOUTH

HAWKES BAY
Members
Murray Arnold RPSurv .... NAPIER
John Craven RPSurv .... NAPIER
Andrew Dagg .... NAPIER
Brian Daly RPSurv .... HASTINGS
David Devine .... NAPIER
Brian Foote RPSurv .... HASTINGS
Jamie Goodsir RPSurv .... HASTINGS
Warren Gunn RPSurv .... HASTINGS
Warwick Marshall RPSurv .... NAPIER
Guy Panckhurst RPSurv .... HASTINGS
Colin Shanley .... HASTINGS
Peter Smidt RPSurv .... NAPIER
Andrew J Taylor RPSurv .... HASTINGS
Kenneth Thorn .... NAPIER
Retired Members
Ralph Duley .... NAPIER
Jim Tobin .... NAPIER
Cyril Whitaker .... HASTINGS
Norman Eathorne .... TARADALE
Associate Members
Caleb Baildon .... NAPIER
Blair Duckett .... HASTINGS
Clare Foote .... HASTINGS
Peter Frizzell .... HASTINGS
Keith Gore .... NAPIER
Aaron Hick .... HASTINGS
Alan Martin-Smith .... NAPIER
Gareth Mitchell .... NAPIER
Niels Nikolaison .... NAPIER
Stephen Oldfield .... HAWKES BAY
Christopher Rodgers .... HASTINGS
Stuart Whiterod .... NAPIER

GISBORNE
Members
Adrian Besseling RPSurv .... GISBORNE
Mark Clapham RPSurv .... GISBORNE
Stephen Coombes RPSurv .... GISBORNE
Paul Ericson RPSurv .... GISBORNE
Alan Radcliffe RPSurv .... GISBORNE
Kevin Taylor RPSurv .... GISBORNE
Retired Members
Bennick Hudson .... GISBORNE
Campbell Taylor .... GISBORNE
Associate Members
Roger Bell .... GISBORNE
Lloyd Dickinson .... GISBORNE
Mark Stenning .... GISBORNE

ROTORUA – BAY OF PLENTY
Members
Antony Aldersley RPSurv .... TAURANGA
Paul Andrews RPSurv .... ROTORUA
John Barnes RPSurv .... TAURANGA
Philip Battersby RPSurv .... TAUPO
Georgina Beattie RPSurv .... TAURANGA
Stephen Bowden .... TAUPO
Ian Boyd RPSurv .... TAURANGA
Robin Brill RPSurv .... TAURANGA
John Collie RPSurv .... TAURANGA
Grant Cowles RPSurv .... TAURANGA
Peter Crane RPSurv .... MT MAUNGANUI
Hamish Crawford .... TAUPO
Fergus Cumming RPSurv .... ROTORUA
Stephen Currie RPSurv .... TAUPO
Peter Daffurn RPSurv .... TE AROHA
Trevor Davey RPSurv .... TAURANGA
Godfrey Day RPSurv .... TAURANGA
Ross Dean RPSurv .... TAURANGA
Michael Dewhirst RPSurv .... TAURANGA
Terence Doherty RPSurv .... TAURANGA
John Downey RPSurv .... TAURANGA
Grant Downing RPSurv .... FRASER COVE
Mark Dyer RPSurv .... ROTORUA
Paul Ellison RPSurv .... TAURANGA
Michal Falis RPSurv .... THAMES
Garth Falloon RPSurv .... TOKOROA
Michael Flaherty .... ROTORUA
David Forsyth RPSurv .... TAUPO
Paul Francis RPSurv .... TAURANGA
Michael Hallam .... TAURANGA
Deborah Hallam .... TAURANGA
Graeme Harder .... KATIKATI
Campbell Harvey .... TAURANGA
Rupert Hastings RPSurv .... ROTORUA
Josette Hastings RPSurv .... ROTORUA
Peter Hawley RPSurv .... WHITIANGA
David Holland RPSurv .... MT MAUNGANUI
Christopher Hopper RPSurv .... ROTORUA
Raymond Houghton RPSurv .... KATI KATI
Brendan Hurring RPSurv .... TAURANGA
John Hurst RPSurv .... ROTORUA
Blair Jackson RPSurv .... MT MAUNGANUI
Stephen Jolly .... TAUPO
Chadley Keir RPSurv .... TAUPO
Gerald Kelly .... TAURANGA
Colin Kemeys RPSurv .... TAURANGA
Raymond Ladyman RPSurv .... TAURANGA
David Laing RPSurv .... TAURANGA
Richard Lawton RPSurv .... ROTORUA
John Lewis RPSurv .... TE PUKE
Bruce Lysaght RPSurv .... TAURANGA
Craig Madsen .... TAURANGA
Luke Martin RPSurv .... ROTORUA
Cameron Martin RPSurv .... TAURANGA
Andrew Martin RPSurv .... TAURANGA
Simon Maxwell .... TAURANGA
Timothy McBride RPSurv .... TAURANGA
Denis McDonald RPSurv .... TAURANGA
Ross McDowell .... TAURANGA
Gregory McKeever .... MT.MAUNGANUI
Claire McKeever .... TAURANGA
Dallas Miller RPSurv .... TE PUKE
Brian Mollard .... TAURANGA
Bruce M Morrison RPSurv .... WAIHI
Albie Mulder RPSurv .... TAURANGA
Ross Overington RPSurv .... WHAKATANE
John Patterson RPSurv .... WHAKATANE
Michael Poppelwell .... TAUPO
John Rainford RPSurv .... WHAKATANE
David Rankilor RPSurv .... TAUPO
Ian Reynolds RPSurv .... TAURANGA
Kevin Sewell RPSurv .... ROTORUA
Jock Speedy RPSurv .... TAURANGA
Stacey Spooner .... WHAKATANE
Symon Stamm RPSurv .... ROTORUA
Callum Stewart .... WHANGAMATA
Ross Stewart RPSurv .... WHANGAMATA
Michael Stott RPSurv .... TAURANGA
K Grant Sutherland RPSurv .... KATIKATI
David Thompson RPSurv .... TAURANGA
Brent Trail .... TAURANGA
Bradley Welsh .... TAURANGA
Alan Wilkinson .... TAURANGA
Derek Wood RPSurv .... TAUPO
Russell Wright .... TAURANGA
Andrew Wylie RPSurv .... TE PUKE
Bart Yetsenga RPSurv .... ROTORUA
Retired Members
Brian Askin .... TAURANGA
Vaughan Baker .... PAEROA
Adam Blair .... TAUPO
William Burns .... TAURANGA
Gordon Elliston .... BAY OF PLENTY
Barry Fordyce .... TAURANGA
Desmond Grace .... TURANGI
John Hindess .... TAUPO
Douglas Jeffery .... ROTORUA
Keven Locke .... ROTORUA
Alan McCaulay .... ROTORUA
Curtis Moxham .... TAURANGA
Dennis O'Hagan .... ROTORUA
Peter Otway .... TAURANGA
John Stephenson .... TAURANGA
Brian Taylor .... TAURANGA
Associate Members
Geoffrey Baume .... ROTORUA
Trent Gulliver .... TAURANGA
Matthew Hayward .... TAURANGA
John Hesseling .... TAUPO
Michael Kemeys .... TE PUKE
Kevin List .... TAURANGA
Anthony Moss .... TAUPO
Dean Nettlingham .... TAURANGA
Brent Nijssen .... TAUPO
Jeffry Oldman .... TAURANGA
Neil Parkinson .... TAUGANGA
Karl Rendall .... ROTORUA
Stuart Roberts .... TAURANGA
Charlotte Ronaldson .... TAUPO
Jodi Rook .... TAURANGA
Anthony Smith .... TAURANGA
Stephen Smith .... TE AROHA
Duncan B Stewart .... TAUPO
Scott Walker .... ROTORUA
Vicki Webster .... TAUPO

WAIKATO
Members
Noel Armstrong RPSurv .... CAMBRIDGE
Errol Balks RPSurv .... TE AWAMUTU
Nicol Beeby .... HAMILTON
Albion Bell .... TAUMARANUI
Ian Blance .... TAUMARUNUI
John Blue .... HAMILTON
Kelly Bosgra RPSurv .... TE AROHA
Jason Cargo RPSurv .... HAMILTON
Phillip Cogswell RPSurv .... CAMBRIDGE
Ronald Cogswell RPSurv .... CAMBRIDGE
Kenneth Collier .... HAMILTON
Rex Cunningham RPSurv .... HAMILTON
John Curtis RPSurv .... HAMILTON
Morrison Dunwoodie RPSurv .... THAMES
Mark Gilberd RPSurv .... HAMILTON
Graeme Goodwin RPSurv .... HAMILTON
Philip Green RPSurv .... THAMES
Jonathan Gwyn .... HAMILTON
Gavin Harris RPSurv .... MATAMATA
Richard Hewison .... HAMILTON
Murray Hislop RPSurv .... TE AWAMUTU
Christopher Irvine .... HAMILTON

Rodney Janes........HAMILTON
Rodney Keucke RPSurv........HAMILTON
Mark Lai........HAMILTON
David Latham RPSurv........TE AWAMUTU
Stuart Lennox RPSurv........TE AWAMUTU
Edward Letford RPSurv........HAMILTON
Warren Lovegrove RPSurv........HAMILTON
Kewwa Low RPSurv........HAMILTON
Jeremy Maseyk RPSurv........HAMILTON
David McCracken RPSurv........HAMILTON
Daniel McDaid RPSurv........HAMILTON
Russell McQuoid........HAMILTON
Bruce Millar RPSurv........THAMES
Frank Millington RPSurv........THAMES
Timothy Nicholson RPSurv........TOKOROA
Grant Nicklin RPSurv........CAMBRIDGE
Maurice O'Neill RPSurv........NGARUAWAHIA
Shaun P O'Neill RPSurv........TE AROHA
Vernon Pickett RPSurv........HAMILTON
John Ravenscroft RPSurv........TE KUITI
Alan Ridge RPSurv........HAMILTON
Peter Rogers RPSurv........WAIHI BEACH
Grant Ruffell RPSurv........HAMILTON
Donald Sangster RPSurv........THAMES
Antony Tynan RPSurv........HAMILTON
Murray Wallace RPSurv........HAMILTON
Rodney Young RPSurv........TE AROHA

Retired Members

Robert Eyeington........HAMILTON
Gordon Matheson........HAMILTON
Peter McPherson........HAMILTON
Alfred Palleson........HAMILTON
Brent Player........TAUPO
Paul Spence........HAMILTON
Warren Stace........HAMILTON
Kevin Walsh........HAMILTON
Jeff Warner........HAMILTON

Associate Members

Wayne Beere........HAMILTON
Brendan Carroll........HAMILTON
Charles Gosling........CAMBRIDGE
Guy Halewood........CAMBRIDGE
Gregory I Harris........THAMES
John Marsden........HAMILTON
Bernard Milne........HAMILTON
Stuart W O'Neill........WAIKATO
David Prasad........HAMILTON
Clive Robinson........HAMILTON
Hamish Ross........TE AWAMUTU
Noel Sanderson........WHANGAMATA
Steven Thomas........MATAMATA
Graham Walder........TE AROHA
Andrew Watts........CAMBRIDGE
Wendy Wickens........HAMILTON
Angus C Wright........TE AWAMUTU

AUCKLAND

Members

Matthew Adams RPSurv........AUCKLAND
Jeremy Adams RPSurv........AUCKLAND
Hazim Ali........AUCKLAND
Michael Allan........MANUKAU
David Allen RPSurv........HIBISCUS COAST
Robert Anderson........AUCKLAND
Malcolm Archbold RPSurv........AUCKLAND
Carswell Bain RPSurv........AUCKLAND
Michelle Bain RPSurv........AUCKLAND
Peter Baker........AUCKLAND
Leslie Barker RPSurv........AUCKLAND
Anthony Bates........NORTH SHORE
Diane Beggs........AUCKLAND
Michael Benning RPSurv........AUCKLAND
Keith Benton RPSurv........NORTH SHORE
Sir William Birch RPSurv........PUKEKOHE
Kevin Birch RPSurv........PUKEKOHE
Andrew Blackman RPSurv........MANUKAU
Gary Blyth RPSurv........AUCKLAND
Denis Boak........AUCKLAND
John Bolam RPSurv........NORTH SHORE
Craig Bond........AUCKLAND
John Bould RPSurv........AUCKLAND
Dene Bowmar RPSurv........AUCKLAND
Grant Brebner RPSurv........MANUKAU
Thomas Bretherton RPSurv........AUCKLAND
Richard Bromley RPSurv........OREWA
Bevan Brown........NORTH SHORE
Murray Browne RPSurv........AUCKLAND
Ronald Buckton........WARKWORTH
Rick Bull RPSurv........AUCKLAND
Peter Burrows........AUCKLAND
John Carter RPSurv........AUCKLAND
Graham Cato RPSurv........AUCKLAND
William Cheung RPSurv........AUCKLAND
David Churchill RPSurv........AUCKLAND
John Clapperton........AUCKLAND
Kathryn Clark RPSurv........AUCKLAND
Gary Clark RPSurv........NORTH SHORE
Louis Clements RPSurv........East Tamaki
Mark Cochran RPSurv........AUCKLAND
Martyn Compton RPSurv........AUCKLAND
Andre Conradie RPSurv........AUCKLAND
Clifford Corbett RPSurv........AUCKLAND
Peter Cotter RPSurv........NORTH SHORE
David Crerar RPSurv........AUCKLAND
Richard Crowsen........MANUKAU
Trevor Cullen........NORTH SHORE
Nicholas Davies RPSurv........AUCKLAND
Sumith Dharmawardana........AUCKLAND
Stephen Dobbie........MANUKAU
Graham Donald RPSurv........AUCKLAND
Gerald Donn RPSurv........AUCKLAND
Spencer Drinkwater RPSurv........AUCKLAND
Brian Duncan........AUCKLAND
Neill Dwyer RPSurv........AUCKLAND
Don Eagleson........AUCKLAND
Lyndon Endicott-Davies RPSurv........AUCKLAND
Neale Faulkner RPSurv........AUCKLAND
Donald Finlay........AUCKLAND
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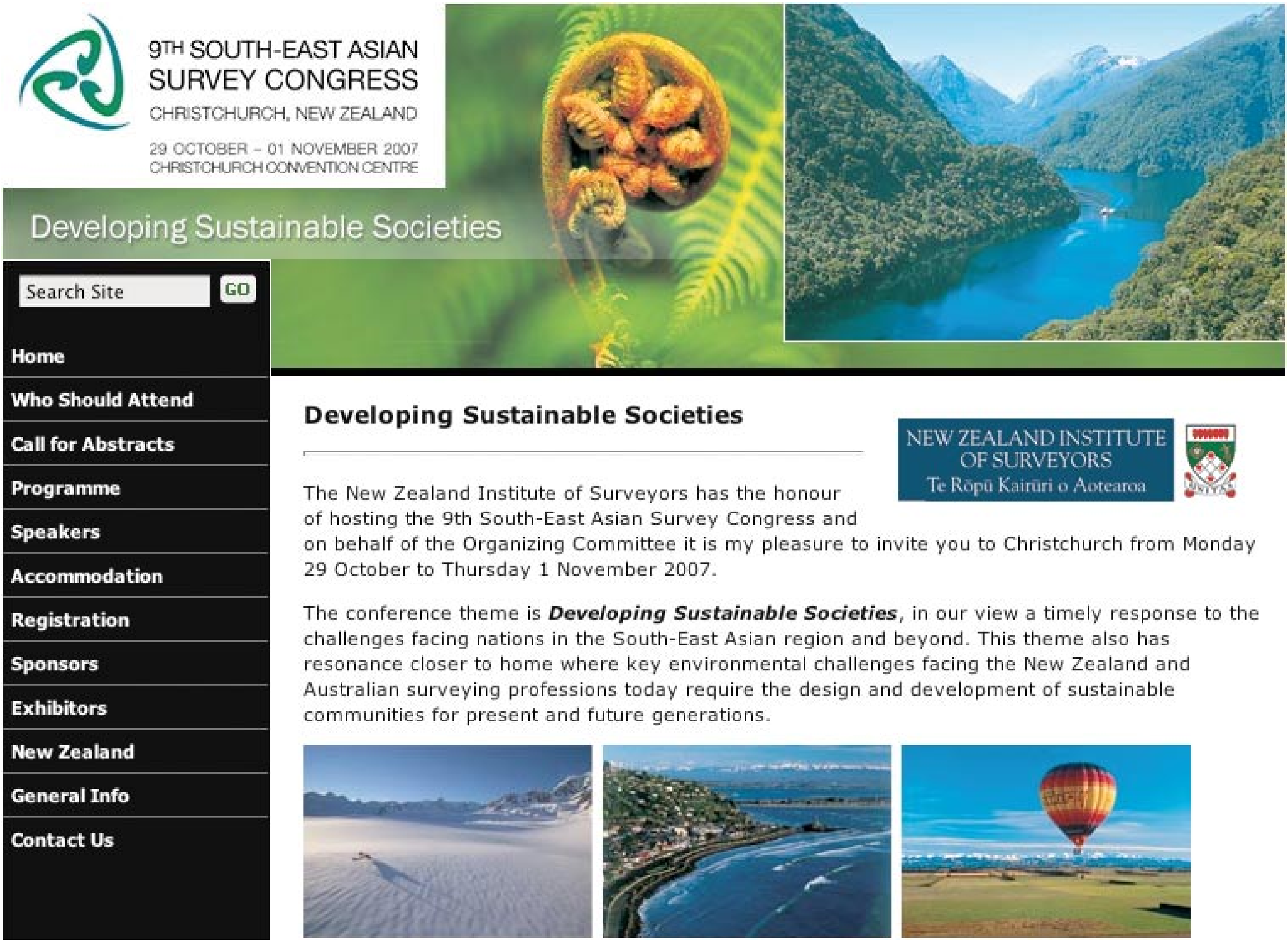
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Developing Sustainable Societies

NEW ZEALAND INSTITUTE OF SURVEYORS
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The New Zealand Institute of Surveyors has the honour of hosting the 9th South-East Asian Survey Congress and on behalf of the Organizing Committee it is my pleasure to invite you to Christchurch from Monday 29 October to Thursday 1 November 2007.

The conference theme is ***Developing Sustainable Societies***, in our view a timely response to the challenges facing nations in the South-East Asian region and beyond. This theme also has resonance closer to home where key environmental challenges facing the New Zealand and Australian surveying professions today require the design and development of sustainable communities for present and future generations.

Build
create societies

Developing sustainable societies will require a different way of thinking and working. It will require that we manage our developments in a manner that will improve our collective quality of life by delivering better social, environmental and economic outcomes for all people, now and in the future.

The 9th South-East Asian Survey Congress will therefore be of interest to professional surveyors, the wider surveying profession and associated professionals who are involved in the development and maintenance of cities and settlements and who are seeking to make real progress towards the development of sustainable societies.

Developing Sustainable Societies

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