SURVEYING + SPATIAL

March 2020
Issue 101

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Preparedness seems to be a hot topic in workplaces around the country at the moment with coronavirus (Covid-19) beginning to make its presence felt in New Zealand.

While there are certainly some people taking precautionary measures to extremes and toilet paper stockpiling seems to be taking on fairly desperate proportions, it is certainly a good opportunity for everyone to think about their general emergency plans that would be necessary for any kind of emergency or disaster scenario.

Civil Defence recommends making a personal emergency plan for you and your family and identifying the risks to your business by making a business continuity plan in the event your work can no longer operate in the usual way.

Your continuity plan should include all aspects of your business including staff, information, assets, clients, important contacts and suppliers. Understanding your business needs, back-up systems, outsourcing requirements and potential relocation options will help alleviate some of the 'what if' questions that may arise.

For more information on assessing the risks in your business, go to: *www.business.govt.nz/risks-and-operations/planning-for-the-unexpected-bcp/continuity-and-contingency-planning*.

This edition features a wide range of topics from across the survey and spatial sectors, from technological developments to surveying in hazard zones to personal perspectives.

Dunedin surveyor Toby Stoff presents his research report on the battle for the world's steepest street, between New Zealand's recently deposed record holder Baldwin Street and current Guinness world record holder Ffordd Pen Llech in Wales. Toby travelled to Wales in November last year to take his own measurements at Ffordd Pen Llech and discovered some interesting methodology flaws that could redefine the criteria, and with luck, bring the esteemed title back to Dunedin.

Soon-to-be-retired hydrographer Maurice Perwick looks back on a career in the hydrographic industry along with the many interesting challenges and experiences he has encountered while undertaking projects around the country.

After the tragic events that unfolded on White Island late last year, Peter Otway recalls the dangers and his own near-death experience while surveying in the hazardous environment of Ruapehu in the 1970s.

Duane Wilkins, of LINZ, presents another essential top 10 geospatial data highlights for geospatial practitioners this edition; and continuing our professional profile series, we profile West Coast cadastral surveyor and S+SNZ member Laura Coll McLaughlin who is making her mark on local governance.

Exciting Times With A Whole Lot Of 'New'

It's an exciting time for S+SNZ, with a whole lot of 'new'. In my first column as S+SNZ President, it's the start not just of a new year but also a new decade, and it is worth taking some time to consider what the next ten years will hold for us as an organisation and a profession. Survey and Spatial NZ has an important role to play in supporting our members to develop the networks, community, skills and experience they need to guarantee we are resilient and thrive in an uncertain world. By the time of this publication, we should have had our international panel webinar on "The Future of the Profession" which I'm sure will highlight some key considerations for us as we move into the '20s.

We also have a new CEO, and I'd like to extend a warm welcome to Ashley Church who has taken up this role. We are looking forward to a positive and collaborative relationship between National Office, the Board and Council, our Streams, Divisions and Branches, and our many stakeholders and partners. Part of this role will involve working with the organisation to set our new strategy for the next five years – building on the work from the previous strategy and guiding our direction to 2025.

We also have several new Councillors in the mix – bringing new perspectives and enthusiasm to our governance group. I'd like to welcome them, and I am very much looking forward to serving with them over the next few years. Our first face-to-face Council meeting for the year is in March and I encourage everyone to have a look on the S+SNZ website and get to know your Councillors.

The Council has been finalising the Letter of Expectation to the Board for this year with a renewed focus on delivering to members, raising our profile, and completing some of the reviews and initiatives started in previous years to provide some certainty to members. At the end of last year, the Council also refreshed our Vision, Mission, and Values. We will be working with the Board and National Office to ensure that we progress on our vision to be a globally respected organisation that sustains innovation and excellence for the benefit of our communities, as well as on our mission of providing a home which supports, develops and connects our diverse Survey and Spatial membership.

In terms of personal goals in this role, there are a few key themes that I aim to focus on over the next two years. The themes are about us being Respected, Resilient, Ready for the Future, Responsive, Relevant, and Recognised. I'd encourage members, branches and streams to think about what these themes might mean to you in your own context within our organisation and welcome any input on those themes from your perspective. Over the next few editions of this magazine, I will elaborate on each theme a bit more.

As well as the themes, some additional goals over the next two years is to see us moving from the establishment phase of the relatively recent changes into a performance phase. I'd like to see not just better visibility of our newer streams, but a more collaborative and integrated approach across streams so that we are operating as a connected organisation with strong member contributions. Together, I'd like to see us moving beyond talking about our role in measuring, managing and analysing data to our role in understanding and solving some of the big challenges both in New Zealand and globally. I'd also like to see the challenges and opportunities raised through our commitment to the Diversity Agenda being addressed and implemented so it becomes an integral part of who we are as an inclusive organisation.

Finally, I'd like to ensure we are connected more widely and openly to maintain a balanced and informed view of the trends impacting our communities and consider how we maintain our value in a rapidly and relentlessly changing world.

I look forward to engaging with you over the next two years.

Ngā mihi,

Kat Salm

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Simplifying The Complex

Survey and Spatial New Zealand Appoints New Chief Executive


Ashley Church

Survey and Spatial NZ (S+SNZ) Board Chair, Daniel Williams, was delighted to announce the appointment of Ashley Church as the new Chief Executive in early February.

Ashley comes to us with an extensive background in property – most recently as CEO of the Property Institute of New Zealand, a role he held from 2015 to 2019. Prior to this he has been CEO of the Newmarket Business Association and the Auckland Property Investors Association.

Ashley is a high-profile media commentator on the state of New Zealand's property market and currently writes a weekly column for One Roof and participates in a regular NewsTalk ZB radio show dealing with property matters.

"I am looking forward to working with Ashley," says Daniel, "he brings with him strong managerial and media focused skill-sets which will benefit S+SNZ going forward."

Ashley commenced his role at S+SNZ National Office in Wellington on Monday 3 February.

Cadastral Stream

The main focus for the stream at the moment is the draft Cadastral Survey Rules 2020 that LINZ has recently released.

LINZ has held presentations and is seeking feedback by the end of March.

Similar to the last round of consultation, the stream will be looking to make a submission on behalf of the membership and is keen to hear from members by Monday 16 March in order for us to get the stream submission completed by the closing date.

Late last year the stream was alerted to an issue where Auckland Council was requiring hydraulic modelling to be carried out in order to determine whether esplanade reserves or strips were required.

This requirement was being enforced in cases where stream banks were well defined and/or where streams were clearly not of sufficient width to qualify for strips or reserves.

The Cadastral Stream together with help from Kendall Reid made a submission against the requirement for hydraulic modelling.

As a result Auckland Council has reviewed its processes and confirmed that it will not require hydraulic modelling except for on the rare occasions where banks are not clearly defined and the profile of the riverbank necessitates it.

We expect this should indeed be a rare event, and if members are requested to provide hydraulic modelling in situations where it appears inappropriate, then please inform the Cadastral Stream so we can follow it up. Thank you to Kendall Reid for raising this issue and providing a valuable contribution to get a result.

Following completion of the rules review, we will be pushing on with getting a panel together to work with the Institute of Cadastral Surveying on the preparation of a good survey practice guide.

We also continue to contribute towards planning of this year's conference to be held in Rotorua.

If anyone has any feedback, please contact *cadastral@surveyspatialnz.org*.

Toni Hill, Cadastral Stream Chair

Engineering Surveying and Positioning & Measurement Streams

With the latest political announcement of the significant future infrastructure spend, a career in Engineering Surveying is looking very secure. To make sure you are aware of all the new surveying tools and methods for the coming frenzy of work, save the date for 31 July, which is when the next Engineering and Positioning Workshop will be held, this time returning to the Novotel at the Auckland Airport.

The Certification of Engineering Surveyors is still progressing. The aim is to have the process setup by the end of this year, so watch this space.

Michael Cutfield, Engineering Stream Chair
engineering@surveyspatialnz.org

Bruce Robinson, P&M Stream Chair

Hydrographic Professional Stream

Congratulations to members Andrew Price and Ryan Cantlon who were both awarded Level 2 certification by the Australian Hydrographic Surveyors Certification Panel (AHSCP) in 2019. They join a growing list of 12 Level 1 and 2 certified professional surveyors across New Zealand.

To commemorate Aotearoa New Zealand's history and 250 years of nation-building since James Cook's voyage to New Zealand, a special edition of the *NZ Surveyor* Journal has been published. HPS member Peter Knight provided the editorial, while Emily Tidey and two hydrographic students from the School of Surveying, Kara Jurgens and Jean-Louis Morrison, wrote two hydrography-related papers. A digital copy of the Special Edition is available on the S+SNZ website: *https://www.surveyspatialnz.org/members/Publications/Attachment?Action=Download&Attachment_id=5873*

The 9th International Shallow Survey Conference has been confirmed for 24-28 May 2021 in Wellington. The conference was last in New Zealand in 2011. The theme for 2021 is "Coastal Challenges: Innovative approaches to

mapping shallow coastal water environments". More information can be found on the *Shallow Survey website: https://confer.eventsair.com/shallowsurvey2021*

In late 2019, Declan Stubbing and Andrew Price joined the HPS leadership team. Stuart Caie is now the HPS chair. Thank you to past chair Emily Tidey for her two years of service.

HPS Team

Land Development and Urban Design Stream

This year's Survey and Spatial New Zealand Conference will be held in Rotorua from 2-4 November with a conference theme of *Unlocking New Zealand's Development*. Once again the LDUD stream have been assisting the National Technical Committee with the coordination of speakers. It will be a great event with something for everyone, so I strongly encourage you to book it in your calendar now.

The stream is also putting together several webinars that will run this year. The committee is working to nail down the focus of these webinars, however if anyone has specific suggestions for topics they would like to cover, please let me know.

Julia Glass, LDUD Chair

Spatial Professional Stream News

The Spatial Professional Stream new committee members had their first meeting on January 29. The new committee members are:

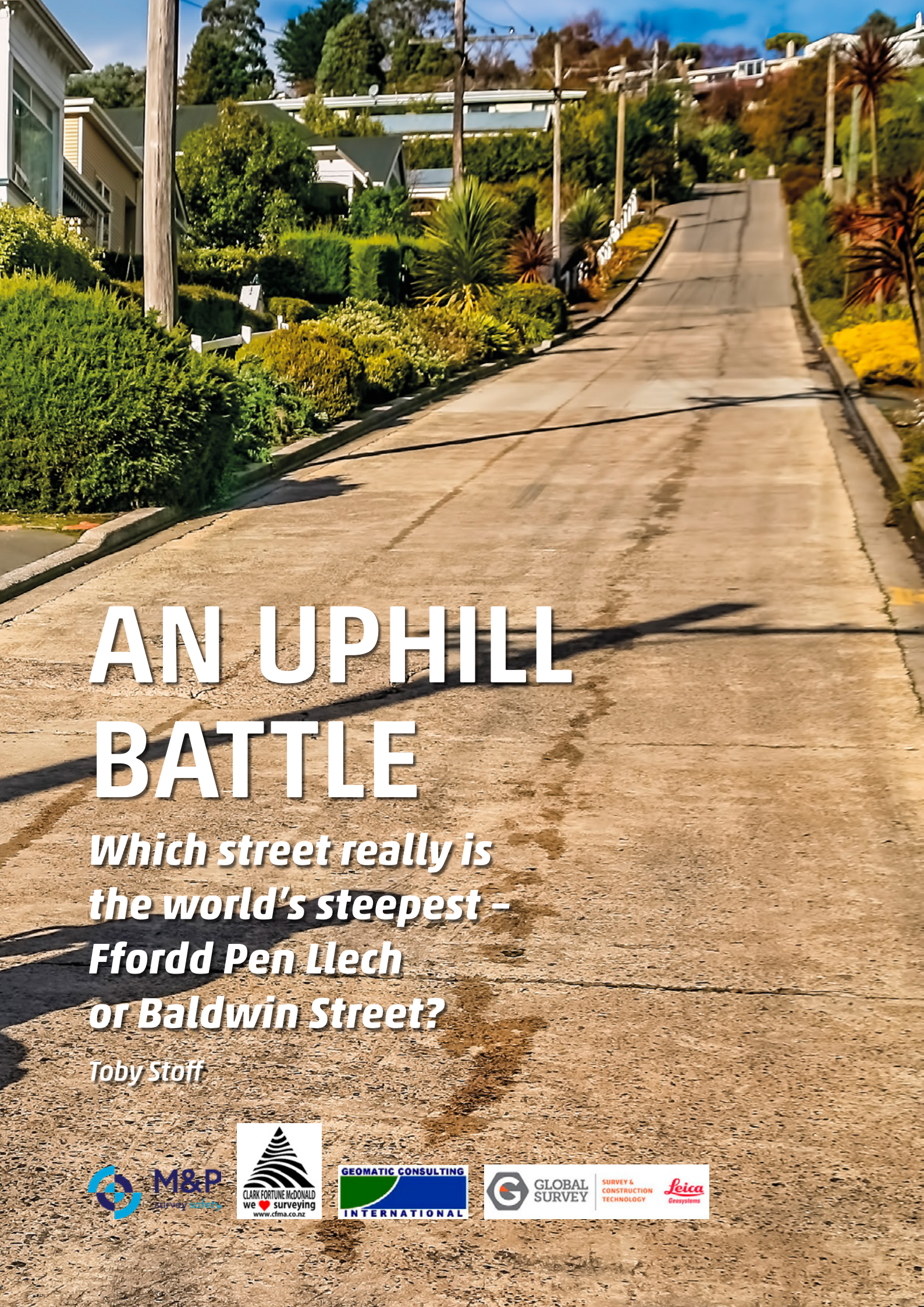
1. Mike Ladd – Committee Member, 4Sight Consulting
2. Tristan Murray – Committee Member, Harrison Grierson
3. Andrew Clouston – Council Representative, Critchlow
4. Jasmin Callosa-Tarr – Committee Chair, Jacobs Engineering

Due to the recent resignations of Elaine McAllister and Callum Smith from the team, we are looking in the wider spatial industry who are able to volunteer some hours and commitment to the stream. We would like to ensure that inclusion and diversity is also taken into account in getting people onto the committee.

In terms of events in the Spatial Industry the following are coming up:

1. Regional Conferences for the NZ Esri Users are happening soon. Link to the registration: *https://nzeug.org/home/rucs2020/*
2. FME World Tour 2019. Link to the registration: *https://locus.co.nz/product/fme-world-tour-2019/*
3. GeoCart 2020. August 26-28. Link to the registration: *https://cartography.org.nz/geocart2020/register/individual*

Jasmin Callosa-Tarr, Spatial Stream Chair



AN UPHILL BATTLE

Which street really is the world's steepest – Ffordd Pen Llech or Baldwin Street?

Toby Stoff

This report provides a comparison of the current world's steepest street: Ffordd Pen Llech in Harlech, Wales, with its predecessor: Baldwin Street in Dunedin, New Zealand. The analysis covers the three-dimensional shape of both streets, a review of the Guinness World Record parameters used to award the world record to Ffordd Pen Llech, and suggestions for future measurements of the world's steepest street.

This report finds that Baldwin Street is steeper than Ffordd Pen Llech by 5.2 per cent when the average of left-hand side, centreline and right-hand side gradients of the steepest 10-metre sections of both streets are compared. This report also finds that the centreline of Baldwin Street is 6.2 per cent steeper than Ffordd Pen Llech.

This is largely due to the different shape of both streets. Baldwin Street is straight with uniform gradient across the width of the carriageway. Ffordd Pen Llech has many horizontal curves which all affect the road gradient.

Our view is that a minor rule change is necessary to enable straight streets and curved streets to be assessed fairly. This can be achieved by requiring steepness to be measured at the centreline of the street.

Measuring on the centreline:

- is standard practice in the surveying and engineering professions
- provides a reasonable approximation of average gradient over the full width
- allows straight and curved streets to be assessed equally without using overly sophisticated measurement and analysis techniques.

All calculations are in the appendices.

Introduction

This report is a comparison of the steepest 10m long sections of Ffordd Pen Llech and Baldwin streets. Its purpose is to compare the gradient of each street; a challenging task as they have very different shapes. The history, function, setting within the road hierarchy, and performance of each street is beyond the scope of this report. Suffice it to say they both satisfy the criteria of a "street" as it relates to the rules of Guinness World Records.

Description of Baldwin Street

Baldwin Street is located in Dunedin City, Otago, New Zealand. The road controlling authority is the Dunedin City Council.

It starts 1.4 kilometres north-east along North Road from the intersection of Bank Street, North Road, Opoho Road and Great King Street. Baldwin Street is 374m long and rises 69m from North Road to Buchanan Street. The horizontal alignment is entirely straight.

The first (lowest) 180m section of Baldwin Street is a flexible chip seal pavement. It is a two-way carriageway with parking on both sides. From there it steepens significantly and changes to a rigid concrete pavement with no parking on either side. Kerb and channel are provided on both sides over the full length. A footpath is provided over the full length of the south side. A footpath is provided over 80 per cent of the north side. The footpaths have long sections of steps owing to the steep topography.

Vehicular access is provided to houses on both sides of Baldwin Street over its full length.

Baldwin Street held the Guinness World Record for steepest street from 1987 until 2019 with a gradient of 35 per cent (1 in 2.86). There was some initial confusion over the gradient of Baldwin Street as its published value was 1 in 1.286 – an apparent typographical error.

Figure 1: Baldwin Street location diagram – satellite imagery courtesy of Google Earth

Figure 2: Baldwin Street steepest section – satellite imagery courtesy of Google Earth

Description of Ffordd Pen Llech

Ffordd Pen Llech is located in the town of Harlech, in the North Wales county of Gwynedd. The road controlling authority is the Gwynedd Council.

Ffordd Pen Llech starts in central Harlech, 80m southeast of Harlech Castle at the intersection of Twitl, Pen Dref, Ffordd Pen Llech and Stryd Fawr (B4573).

Ffordd Pen Llech is 343m long and falls 57m to Hwylfar Nant. The gradient is steep for the first (top) 240m until the end of the world record hairpin curve. The gradient reduces for the final 100m until it is moderately flat at the intersection with Hwylfar Nant. The alignment is complex and contains 12 horizontal curves up to 145 degrees deflection (at the world record corner).

It has a flexible chip seal pavement over its full length. Some sections of pavement rehabilitation are apparent with sections of new asphalt – around both sides of the steepest section in particular.

Figure 3: Ffordd pen Llech location diagram – satellite imagery courtesy of Google Earth

Figure 4: Ffordd Pen Llech steepest section – satellite imagery courtesy of Google Earth

The carriageway is entirely one way. There are occasional no-parking lines near the top of the street although parking for considerable portions is left to the discretion of road users. Long sections are too narrow to allow any parking on the carriageway. Short sections of concrete kerb and channel are provided, as required, to direct stormwater runoff into mud tanks. Ffordd Pen Llech is a shared space street. No footpaths are provided.

While relatively informal, the engineering is in keeping with its heritage setting. Its purpose is to provide vehicular access to a small number of residential properties and businesses, and to provide a pedestrian link to lower Harlech. Here amenity values predominate.

Ffordd Pen Llech was awarded the Guinness record of world's steepest street in July 2019 with a published steepness of 37.45 per cent.

The record is lost

Tuesday, 16 July 2019 – The *Otago Daily Times* published an article confirming that Baldwin Street lost the world's steepest street record to Ffordd Pen Llech in Wales.

This was disappointing, but no real surprise as there had been media reports in the preceding weeks and months advising that something was in the pipeline. It wasn't until later that morning, when photographs began circulating of the Welsh surveyors in action that it became apparent that things had gone aslant. The photographs showed the Welsh surveyors measuring the gradient on the inside of a hairpin curve.

Sharp hairpin curves are much steeper on the inside than the outside. It is not realistic to rely on measurements along one side of the road to gain a correct appreciation of the gradient of a road around a curve. Measurements on the centreline give a far better approximation of overall gradient. The average of left, centre and right is better still.

The photograph alone was not proof that the measurements used to award the world record were taken on the inside, but it did raise concerns.

Wednesday, 17 July 2019, we undertook a case study at Lancefield Street, Dunedin, as it was similar in nature to the world record corner and had the potential to challenge Ffordd Pen Llech. While the inside was not steep enough to lodge a claim for a new world record, it demonstrated the flattening effect of horizontal curvature from the inside toward the outside. We were confident that Ffordd Pen Llech would flatten off to a similar degree and that Baldwin Street was likely still steeper than Ffordd Pen Llech overall.

Our findings were discussed with RNZ National reporter Timothy Brown. He managed to contact Guinness which confirmed that the Welsh measurements were indeed

made on the inside of the curve. We recorded a radio interview for RNZ's *Checkpoint* that evening, discussing the issues.

Later that week we demonstrated our findings on television and suggested that straights and curves need to be assessed equally. To do so would involve nothing more complicated than to measure steepness on the centreline. This generated many weeks of media interest.

Work begins

We decided to submit our findings to Guinness World Records in the form of an assessment of the two streets.

The first item to be completed was a full survey of Baldwin Street. This would confirm its published maximum gradient of 35 per cent and would provide valuable graphical information to support our findings.

I discussed this with Ray Copeland of Global Survey who offered to send down a Leica P40 scanner and one of his scanning experts, Lennon Bedford. Lennon would scan Baldwin Street, produce reports and graphics.

Clark Fortune McDonald & Associates established some accurate benchmarks in Baldwin Street so that the scanned point cloud could be oriented into terms of recognised horizontal and vertical reference systems.

Sunday, 4 August 2019, I received a Facebook message from Mike Constable; a classmate from the Otago University School of Surveying, who suggested crowdfunding to send me from New Zealand to Wales. It was unexpected – however it would definitely raise the profile of our mission so I agreed. Mike Constable, Dave Mitchell and Andrew Bonallack set up a Gogetfunding page and began fundraising.

On Wednesday, 7 August 2019, we met Lennon Bedford on site and scanned 120 million points with the Leica P40 laser scanner. The P40 is an excellent piece of kit with the ability to gather a rich, accurate dataset very efficiently.

Meanwhile the crowdfunding had gathered a good head of steam and within a few weeks reached more than $8000. This was largely made up of very generous donations from the Class of '92, the public and other surveying firms in Dunedin.

The trip to Wales was announced, which sparked more media interest.

Another classmate, Sam Harman, volunteered to travel from his home in Aberdeen to Wales where he would provide technical and logistical support. We decided to rendezvous in Manchester as Air New Zealand flew there direct.

Organising traffic management from the other side of the world was a fun challenge especially given the time difference. For our proposed surveying activity, we needed a stop/go person plus half a dozen signs in English and Welsh. JTM Signs was engaged as it had resources in North Wales and plenty of local knowledge.

We also needed clearance from Gwynedd Council. They were taken slightly aback when they heard that a couple of New Zealanders were coming around the world to measure their street. We assured them that everything was totally legitimate; and once we provided our credentials, and a very thorough job safety analysis, they were most helpful.

The final item to square away was equipment hire. M&P Survey generously offered free total station hire for the project. Dave Langton also offered to travel down with a scanning total station and to scan the steepest section.

At 9am, Thursday, 7 November 2019, Sam and I carried our gear down to the steepest part of Ffordd Pen Llech, media in tow, to take our measurements.

JTM set up the traffic management and stopped the occasional car. Traffic volumes were very low.

Photo 1: Sam Harman selfie, with the author and New Zealand media behind

Although not absolutely necessary, our intention was to include the two survey points (nails in the edge of the seal) from the Welsh world record survey so that our work could be put in terms of the same coordinate reference system. Unfortunately, these had been destroyed in recent pavement repairs.

We were able to measure two circular manhole covers from the original survey. These had dimples in the precise centre of the lid. They were very good reference points and allowed us to put our work in terms of the Welsh survey with a high degree of confidence.

In total we measured 101 survey points around the steep corner which included:

Photo 2: David Langton of M&P Survey scanning Ffordd Pen Llech as a cyclist avoids the steepest side

- both seal edges at approximately 1m intervals
- centreline at approximately 1m intervals
- spot heights between the centreline and seal edge
- six nails to act as reference marks (to allow the scanning total station data to be oriented with ours).

We downloaded our modest (4kb) dataset and made the way clear for David Langton to begin scanning.

This left the rest of the morning free to do interviews. TV3 reporter Lloyd Burr had bought some Jaffas in London so that he could roll them downhill at the end of his interview. He was in the middle of telling us how staggeringly expensive they were when his bag split wide open and £10 worth went rattling into the undergrowth. Luckily most of them were recovered and, once the leaves were cleaned off, they were rebagged for the great rolling downhill.

Results

Methods of analysis included:

- resurveying both streets using conventional surveying methods
- laser scanning both streets as an independent check, for micro-level evaluation, and for graphical representations
- locating the steepest 10m section of Ffordd Pen Llech on the inside of the hairpin curve and confirming the world record gradient
- projecting this section onto a) the centreline; and b) the outside of the road; then determining the average gradient of the road base on left, centreline and right-hand side gradients
- demonstrating the amount of gradient reduction from the inside of the curve to the outside
- locating the steepest 10m section of Baldwin Street on the centreline and confirming the previous world record gradient
- projecting the 10m steepest section onto a) the left; and b) right hand sides of the road; then determining the average gradient of the road based on the left, centreline and right-hand side gradients
- comparing the centreline gradients of both streets.

Baldwin Street

Baldwin Street analysis was carried out on the P40 scan data from chainage 160.00 onwards. From chainage 0-00 to 160.00 the carriageway is quite flat and not worth analysing. The method of analysis is as follows:

- calculating the CL gradient between chainage 160.00 and 170.00
- calculating the gradient between chainage 160.20 and 170.20, then by moving up on the centreline in 200mm increments through to the gradient between 360.00 and 370.00 (approximately 1000 gradient values)
- ordering the results based on highest gradient to find the steepest 10m section of the centreline
- determining the corresponding gradient of the 10m section on the left-hand side
- determining the corresponding gradient of the right-hand side
- taking the average of the three gradients.

Baldwin Street	From (Chainage)	To (Chainage)	Gradient (%)
CL	289.8	299.8	**34.8**
LHS	289.8	299.8	34.5
RHS	289.8	299.8	35
Average			**34.8**

It is interesting to note that our maximum measured steepness on the centreline is 34.8 per cent, whereas 35 per cent was measured on the right-hand side.

The results show a small difference in left, centre and right-hand side gradients. For a straight street the centreline gives a good indication of overall steepness.

Ffordd Pen Llech

The world record is based on the inside seal edge over the steepest 10m section. This was located by analysing 10m long sections around the inside seal edge from the beginning of our survey data and moving up in 200mm increments per the Baldwin Street centreline. Refer below.

Once the steepest 10m long section had been found on the inside, the gradients of the adjacent 10m-long sections were found on the centreline and the outside seal edge.

The road outline in the study area is irregular and care was taken to achieve a best estimate of the centreline. The centreline is a critical to any road: it is the fundamental design string around which the three-dimensional shape of the road is built. The centreline of the study area comprises an approach straight, followed by a sharp curve to the left and a straight exit.

In residential situations, straights and circular horizontal curves are the most common element types. Spirals transition curves are generally used where operating speeds are higher than 50 km/h and where extreme gradients are unlikely to be present.

The centreline in the study area was determined by:

- plotting the midpoint between left and right-hand sides around the curve
- estimating a circular curve through these points using linear regression
- estimating the straights on either side using linear regression of the road midpoints along the straights
- offsetting these lines so they were tangential to the circular curve (maximum 6.6mm offset required).

The average of inside centre and outside was determined as follows:

Ffordd Pen Llech	From	To	Gradient (%)
Inside (LHS)	5.4	15.4	-38.6
CL	5.8	15.8	**-28.6**
RHS	10.2	20.2	-21.7
Average			**-29.6**

"From" and "to" relate to the distances from the start of each line as surveyed. Chainage is not used to avoid confusion – the inside line around a curve is shorter than the outside line. Refer to the plans and spreadsheets in the appendices.

Interestingly our study found the steepest 10m-long section around the inside (38.6%) to be steeper than the world record gradient by 1.1 per cent.

The study also demonstrates the significant difference in gradient between the inside and the outside (16.9%), such is the nature of steep curves.

Summary of results

	Ffordd Pen Llech	Baldwin Street
Centreline gradient	-28.6%	34.8%
Average gradient (left, centre & right)	-29.6%	34.8%

Although the steepest 10m section of Ffordd Pen Llech is steeper than Baldwin Street by 3.6 per cent, the centreline gradient of the steepest 10m section of Baldwin Street is 6.2 per cent steeper than Ffordd Pen Llech. The average gradient of Baldwin Street is 5.2 per cent steeper than Ffordd Pen Llech. This difference is significant and illustrates the effect that horizontal curvature has on the steepness of streets.

Recommendations

In addition to Guinness's existing rules for awarding the world record for steepest street, we recommend the following:

- Steepness to be determined on the centreline as this equalises straights and curves
- Steepness to be expressed as a per cent as this avoids confusion
- Steepness to be expressed to one decimal place of a per cent – two decimal places corresponds to 1mm over 10m which is an unrealistic degree of accuracy given the irregular nature of street carriageways.

Conclusion

Although steep on the inside of the curve, Ffordd Pen Llech is not steeper than Baldwin Street overall. The difference between the two gradients is significant. We recommend that future world records be decided on steepness at the centreline as this allows straights and curves to be assessed equally.

Report prepared by Toby Peter Stoff (B Surv, MNZIS, MCSNZ, RPSurv, Licensed Cadastral Surveyor), 9 January 2020.

ACKNOWLEDGMENTS

This report and the efforts to achieve it were made possible by donations of cash from members of the supportive community.

I would like to thank the following people and organisations: *All of the anonymous donors, David Somerville, Michelle Fletcher, Paterson Pitts Group Surveyors & Planners, Grant Hensman, Hayden (no surname provided), Trish Giles, Nigel Lattimer, Paul O'Connor, Mike Stott, Vanessa Leota, Darren Soo, Glenn Martin, Victor Shortland, Ben Zwartz, Grant McGillivray, Neil Cox, Paul Melville, Mark Madle, Paul Durkin, Stuart Wallace, Michael Constable, Andrew Bonallack, Sue Bevan, Jackie Stoff, Brent O'Meagher, Geomatic Consulting International, Dave Mitchell, the New Zealand media in particular the Otago Daily Times and Radio New Zealand National, Clark Fortune McDonald & Associates, Global Survey, M&P Survey Equipment, my family, and everybody who supported this venture.*

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Simplifying The Complex

Presentations from the P&M and Engineering Stream Workshop 2019 (Christchurch)

The annual P&M and Engineering Stream Workshop has proved to be a successful day of networking and shared learning. The 2019 workshop in Christchurch had 11 presentations across a varied set of topics ranging from monitoring to UAV to GNSS to scanning to immersive experiences; all the speakers' sessions were aimed to give thought-provoking and practical take-aways for the users.

Due to the success of the event, the range of topics and interest in sharing this information widely, *Surveying+Spatial* magazine will focus on one of the presentations in each magazine up until the 2020 workshop.

The 2020 workshop is planned to be held in Auckland in November.

GNSS STATIC PROCESSING

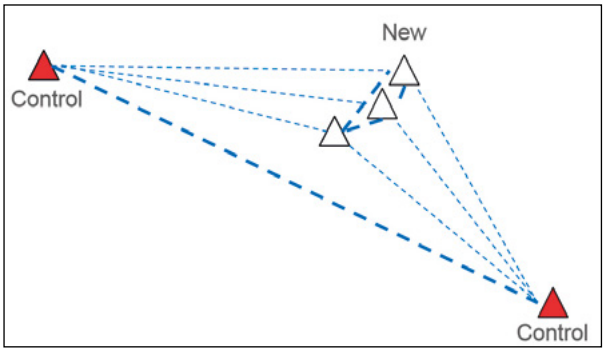
A 10-step practical guide

Bruce Robinson – Global Survey

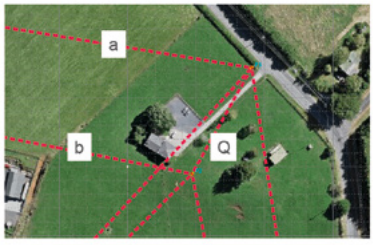
Static GNSS processing is an extremely efficient way to set up site control or fix points that are not able to be fixed by RTK (or that moving the base makes the job inefficient).

The following is a list of key elements to ensuring a successful static GNSS survey is run.

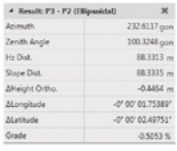
1. Close your own network – make sure that if you are using multiple control points that there is overlapping data (for post processing) between your own control points.



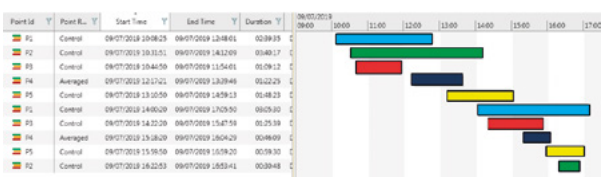
2. Observe the short lines – the error between two points is based on the observational distance, not the calculated distance between these two points. In the following image if the line Q was not observed, the error in Q would be based on the error in a & b.



$$\delta Q = \sqrt{(\delta a)^2 + (\delta b)^2}$$



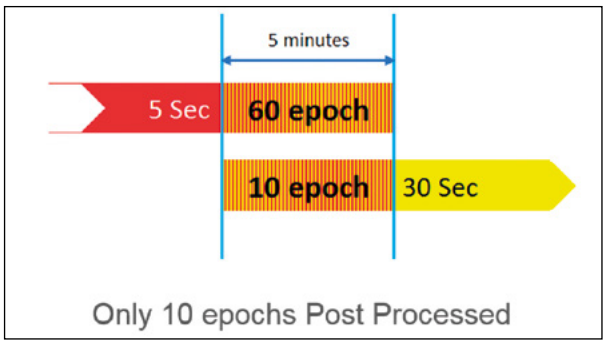
3. Redundancy comes from a minimum of observing at every point twice (this gives redundancy in the set-up over the mark and the measured height). This **does not** mean every vector needs to be measured twice. Rule of thumb – Every mark twice, every vector at least once.



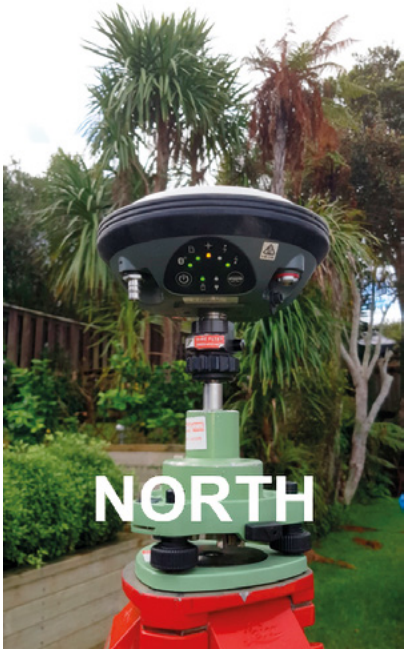
4. In order to obtain a successful result, you need to plan well, before you head to field, have a plan

that enables every mark twice, every vector at least once and, observe the short lines.

5. When in the field it is important to have a good mark naming convention and stick to that convention, this will speed up the office post-processing time, and remove confusion.
6. It is important to understand the purpose of the survey, and therefore understand the accuracy requirements. Only once the purpose and accuracy has been determined can the observational routine be determined. A very good place to start when determining the purpose is to look at the LINZ description of classes and orders. (*www.linz.govt.nz/data/geodetic-system/datums-projections-heights/coordinate-height-accuracy/accuracy-terms*)
7. Observational time versus logging rate – or how long you are at the point versus how often the positional information is stored.
   Note: 5 minutes of 5-second logging will store 60 epochs. This is better than 1min of 1sec logging (60 epochs) as this allows the satellites to move further and across the sky.



8. GNSS work is about minimising risk and maximising potential – personal testing has given me the following rule of thumb at 95 per cent confidence for occupation. This of course does change with the environment you are working in, the number of SUVs tracked and the antennas you use. The "5 to 3" rule: 5min of 5sec logging will give class V (see 6 above) @ 95 per cent up to 2km then you require an additional 3min of 5sec data per additional kilometre over 2km (works up to 20km).
9. Antennas are extremely important. Best practice is to orient them correctly, all antennas have a north point (may not be marked on the antenna). Even more important than the alignment is to ensure that when post-processing, you select the right antenna as each antenna has different characteristic and the post-processing software will be applying corrections based on the antenna type.



10. Remember the accuracy results you get are precisions – not accuracies. It is quite possible to see sub-millimetre precisions in your results, which means points that fix well do not mean the survey is accurate.

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The very start of the big blast tearing through the steam cloud, fortuitously captured by my camera seconds before it was hit by a wave of hot acid water and ash. Paretetaitonga Pk in background. John Latter & Chris Hewson would have been well to the right of frame.

RUAPEHU ERUPTION, 8 MAY 1971

Peter Otway

During my surveying career, starting as a survey cadet way back in 1955, I often found myself working in potentially hazardous situations, but there were only three occasions when I truly thought I was only seconds away from meeting my maker. I had survived prolonged blizzards and been threatened with exposure and frostbite while surveying in Antarctica but it was gun-toting bandits in Iran in 1964 and two volcanoes, in 1971 and 1984, that brought about my closest encounters with the Almighty.

The recent tragedy of the 50-strong tourist group on White Island caught, during their brief walk, in a rare explosive blast and super-heated pyroclastic flow, killing or severely burning nearly all of them, brought home to me how lucky I had been to escape injury, or worse, during at least 500 hours spent over 23 years surveying on the same crater, and many more hours spent working in the craters of other unpredictable active volcanoes.

I began my career in the NZ Geological Survey, DSIR, (later morphing into GNS Science) in the new Earth Deformation Studies group in Lower Hutt, set up to detect and research the very small tectonic and volcanic earth movements thought to precede and accompany earthquakes and eruptions. My main mission at first was to organize and carry out precise surveys in actively faulting, earthquake prone regions – eg Wellington and across Cook Strait, Marlborough and down the full length of the Alpine Fault to Lake McKerrow.

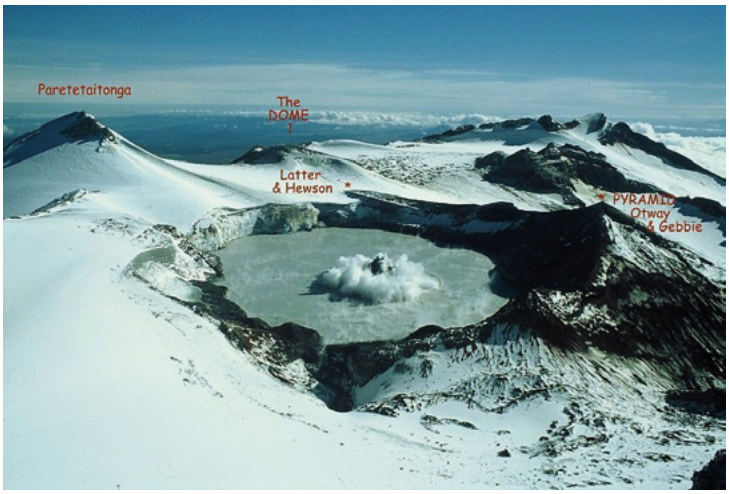
Monitoring volcanic deformation began almost as a sideline for me but steadily increased after 1973 when I managed to transfer to DSIR's Wairakei Geothermal office, later joining the Volcanology Group. Being in pre-GPS days, this meant carrying out levelling, triangulation and EDM surveys in and around the craters of at least six active volcanoes between Ruapehu and White island, later also including Mt Erebus, Antarctica, and Mt St Helens and Kilauea volcano in USA. Over 30 years, I witnessed many eruptions at close quarters – relatively small events

A small prheatic eruption taken in summer a decade later, similar in style and size to the one that occurred seconds before the big eruption (photo on previous page) that almost knocked us flat. Our survey station on the Pyramid (extreme left) was a great viewpoint, albeit a little too close!

with just two exceptions: an explosive eruption of Mt Ruapehu in 1971 and a spectacular fire-fountaining eruption of Kilauea in 1984.

It was on Ruapehu that I came closest to eternity. The story begins in April 1970 – the year after a major eruption sent destructive lahars through Whakapapa ski-field – when I joined forces for the day with Bob Tremaine, surveyor with Ministry of Works, Turangi, using their Geodimeter to make the initial survey of a small pattern I had earlier installed – 3 stations on the crater rim connected to 3 others further back in more stable ground. The following summer, in March 1971, I returned with my newly recruited keen, young assistant, Graeme Blick, to add further stations and to concrete them all in for better stability – a lucky move, as it transpired! We carried out this second survey by triangulation only with our office's new Wild T3 precision theodolite, but detected no significant movement, beyond the estimated error of about 10mm.

The real action began a month later, in April 1971, when increasing volcanic tremor was detected by the Chateau seismograph as the crater lake temperature began to rise, followed by reports of small phreatic (ie "hydrothermal") eruptions. The increasing activity was being monitored by volcanologist, Dr John Latter of Geophysics Division, DSIR, who proposed to set up portable seismographs on the summit plateau to better identifying the source and nature of the earthquakes. He phoned me to see if I would be interested in also trying to detect any pre-eruption inflation. Not wishing to miss such a golden opportunity, I picked up the theodolite from our Lower Hutt office and drove up to the Skotel at Whakapapa alone. The rest of my survey team



The crater lake viewed from the summit, Tahurangi, in 1982, looking north towards the Dome during a small phreatic eruption. The Pyramid is the sharp black peak on the crater rim, to the right of the lake. The position of the four DSIR party during the 1971 eruption as marked. For scale, the lake is 450 metres wide, west-east, and Pyramid stands 120m above the lake.

The eruption photographed by a member of a ski club working party at Tukino, taken probably less than a minute after the blast.

had just left to drive south and monitor the Alpine Fault, and I had planned to fly down and join them the following day. As I drove north instead, after notifying them of my change of plan, I was trying to estimate the odds of being struck by a serious eruption, such as the major one two years earlier – the only potentially deadly one since the 1945 series of spectacular eruptions. By my reckoning, that meant a roughly 1 in 40,000 chance of a deadly hit during a 6-hour period for anyone working close to the crater – surely a small risk well worth taking for the scientific opportunity it presented? After all, I would never win a lottery even with those odds, and actually working on the volcano was probably no more hazardous than driving to it!

While enjoying an after dinner drink at the Skotel (having survived the road trip as I mentally calculated the odds), I mentioned to the barman that I would be doing a crater survey next morning, travelling by helicopter, but needed a field assistant. Needless to say, the "barman" – who turned out to be the manager, Marshal Gebbie – jumped at the opportunity as he had never visited the crater before. At this stage of the narrative, I should explain to the modern generation that monitoring live volcanoes in the early 1970s was extremely basic, being carried out in typical DSIR fashion on a shoestring, with little funding and equipment but plenty of flexibility, innovation and willing unpaid volunteers – luckily all in the pre Roger Douglas and OSH era!

The following morning, Saturday 8 May 1971, our party of four was lifted in two flights and landed on the snow-covered Dome (2,672m elevation and 600m north of the centre of the crater lake) by legendary Ruapehu helicopter pilot, Otto Gram, flying his under-powered little Hiller, riding the updrafts like a seagull. John Latter was accompanied by his technician, Chris Hewson, while Marshal Gebbie was my enthusiastic assistant for the day. Shortly afterwards, as I was about to set up the theodolite at our station on the Dome, an NZBC news team arrived and was soon interviewing John and filming the occasional small upwellings and bursts of steam from the lake. Unfortunately, they were becoming so nervous, especially as they filmed a small geyser-like phreatic eruption at 2pm, that they requested Otto to fly them down again, then headed back to their newsroom – a unique opportunity lost, as later events proved! Or were they the only sensible volcano watchers that day?

Meanwhile, John and Chris had set up a portable seismograph and established radio contact with their technician, Maria Meyer, down at the DSIR Volcano Observatory monitoring the Chateau seismograph to sound the alert if seismicity suddenly increased. At the same time, I had been carrying out rounds of horizontal and vertical angles to the other 7 stations (galvanised iron tubes now set in concrete, standing 30cm proud of the surface) with Marshal booking the numbers. At about 1.30pm, we called for Otto to lift the two of us to our next planned station,

on the Pyramid (Pyramid Peak) – the highest point on the eastern section of the crater rim, with difficult access, 350m east of the centre of the crater lake and 120m above it. The ridge was so sharp and narrow on top that, as we jumped out of the hovering helicopter, there was barely room to stand, with a precipitous drop to the angrily steaming lake on one side and a long, steep icy slope into the deep Whangaehu Gorge on the other.

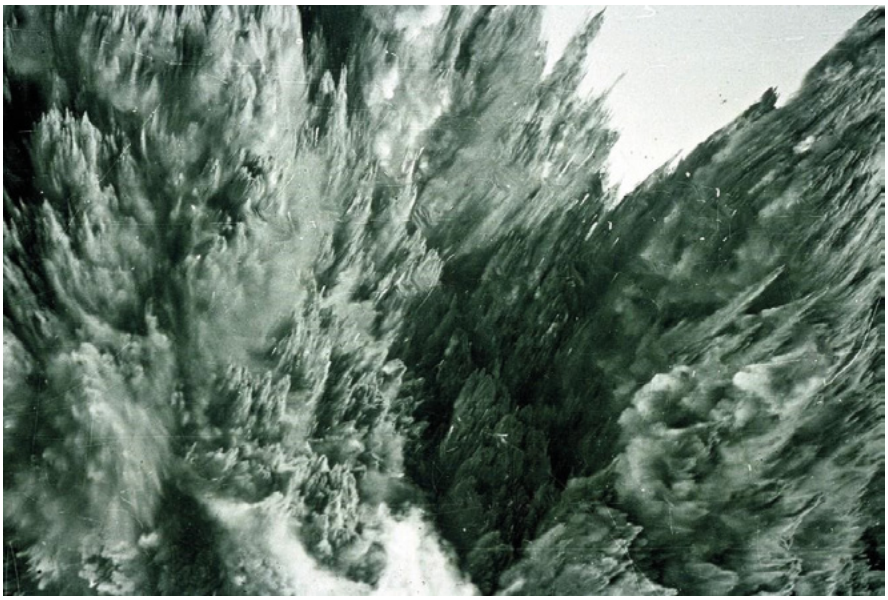
As the chopper departed, I mentioned to Marshal: "In the highly unlikely event of a big eruption we've got nowhere to run. Just dig in your ice axe and cover your head with your pack." Advice delivered light-heartily but a life saver in the event. During the following 3 hours I was observing, making sure I didn't step off the edge as I moved around the theodolite, Marshal was keeping his eye on the lake, watching for any sudden upwelling with the greatest suspicion, breaking off briefly only to write down the numbers I called out. He was rewarded with the small eruption at 2pm that frightened off the film crew from the Dome, and a sudden upwelling in the same spot an hour later. Between these two events, we both watched with a sense of awe as Otto flew down to the lake and hovered below us, so low that the skids were breaking through the scum on the surface of the water right over the source of the upwelling (the active vent) to enable Chris, sitting on the luggage rack, to take a water sample and record the temperature by hand: 55 degrees C.

Just as I finished stashing away the field book into my pack and fastening the T3 into its bomb-proof case in preparation for Otto to pick us up as scheduled at 4pm, Marshal called out to me as the lake suddenly welled up forming a dome of steaming, turbulent water. Seconds later, there was a big "whoosh", as the dome burst open with a mass of black water shooting out big jets in all directions, almost up to our level, before falling back into the lake, leaving a billowing cloud of steam in its place. I grabbed my camera to at least catch the steam cloud but, as I pressed the button and removed the viewfinder from my eye, I was shocked by the sight of great fingers of black water exploding out of the steam and soaring straight up into the sky. I remember looking up and seeing hot volcanic "bombs" exploding out of the black jets high overhead, streaming curved vapour trails across the blue sky. A split second later, I was hit by the sonic shock wave and booming, echoing reverberations from all around.

Suddenly, my whole world turned pitch black as I dropped to the ground and was immediately hit by a tsunami of ash and water, cold at first but becoming rapidly hotter, threatening to scald me. I felt the size of an ant and utterly overwhelmed by this gigantic force, immersed in the thunderous noise. In a split second I knew the volcano had cheated me by ignoring my calculated I in 40,000 odds of death because I had forgotten to factor in its recent resurgence of activity – the very reason I was there. Buggar! Ruapehu was about to win my gamble. It had probably killed my camera and I would be next – but I was going to fight it to the bitter end.

Now the water was hitting me like a horizontal waterfall, starting to push me down the steep slope, but I just managed to grab my sturdy station pipe with one hand and hold fast. As I was now below the crest, the full blast was shooting over my head but I was being asphyxiated by the waves of gritty ash and drowned in the acidic water – uncomfortably hot but still just bearable. Luckily, I was able to bury my face inside my parka and drag my pack over my head with the other hand – and just breathe for a little bit longer. Amid all this battering I became aware of the ground thudding around me as the large bombs and ballistics came whistling down out of the sky. I was just waiting for the big one to strike my back: in fact I was beginning to hope the end would be quick!

Finally it slackened off, then all was silent for a few moments. I was incredibly relieved to hear Marshal call out to see if I was still alive. Just as I answered, there was another deafening boom, followed by another tsunami and falling



A black & white photo taken by John Latter, standing beyond the northern side of the crater rim, several seconds later – photo not enlarged! Marshal Gebbie and I would have been just out of frame to the left and were already engulfed.

missiles, although miraculously, there were still only pebbles and small rocks bouncing off my parka and the pack over my head. Again, I was rapidly running out of breath and choking on the ash. How many times can I go through all this before it finishes me off? Another 2-minute eternity, and then the battering suddenly stopped again, this time as a cold gale blew in from the opposite direction, presumably drawn in to replace the rapidly rising eruption column. Wonderful, delicious, clear air. I could breathe again! Then silence broken only by the sound of rushing water as a small muddy lahar tore down the outer side of the crater rim below me towards the Whangaehu Stream. *My* lahar! Coughing and spluttering, I was able to scrape enough grit out of my eyes, only to see white impact craters all around through the thick ash blanketing the snow and, behold, an almost metre-long solid hot block sizzling its way into the ice just beyond my feet. The one that had been aiming for me had only just missed its target! I had won my gamble with Ruapehu after all – as long as I could get to safety before it exploded again.

Surely no-one else in our party could have shared my incredible luck in surviving so many simultaneous attacks – the explosion, scalding, drowning, sliding off the peak, asphyxiation and burial, and bombing by red hot missiles – twice? Was Marshal *still* there, alive? In trepidation, I managed to screw around, convinced this time I would find him either dead or gone – but he called out again, and there he was, almost buried in wet ash but with a grin of relief from ear to ear as he scraped the ash off his face and pointed to a his own "breadcrust bomb" sizzling into the ice beside him. We were *both* still alive and apparently undamaged! We even managed a bear hug – a rare event in those days! He had hung on desperately to his ice axe as he was pushed downhill until the hot water turned the icy snow to mush, allowing his axe to dig in and anchor him. He even followed my advice, managing to cover his head with his pack. Then we looked out to the north of the crater, towards the foot of the Dome, expecting to see the bodies of John and Chris, but there they were, standing at the very edge of the blanket of black ash with the clean snow beyond, but with impact craters all around. The westerly wind had pushed the main eruption column and fallout right over us instead. The four of us were still alive – for now. All we needed was our guardian angel, Otto Gram.

Meanwhile, down at the Volcano Observatory, Maria was alarmed to see the needle of the seismograph go berserk, flicking its red ink over the chart, and rang Park HQ to shout: "Eruption!" knowing that Otto's helicopter had just landed outside on the lawn to refuel before picking us up. Otto was characteristically running about 10 minutes late, but – by incredible luck once more – this meant he hadn't been picking us up as the crater lake exploded! Without hesitation, he jumped in, fired it up and took off for the Dome, but was horrified as the view of the blackened mountaintop unfolded beneath him. He radioed back: "My God, I've just lost four scientists in a colossal eruption. I'm going back to flying tourists!" Fortunately he carried on and was amazed to finally spot all four standing up, waving vigorously. He headed straight for Pyramid and hovered beside us while we threw our gear onto the luggage racks each side and stood on the skids, clinging on as he took off for the clean snow on the far side of the summit plateau. There, we landed to secure our gear, climb right in and belt up.

For the first time, were able to converse with Otto and express our extreme gratitude as he flew us down, landing us at the Park HQ. As we stood on the grass dripping acid ash, he flew back for John and Chris who, meanwhile, had been busy collecting ash, samples of ejecta including some of the plentiful breadcrust bombs (formed from blobs of lava rapidly solidifying and forming a cracked crust as they spun through the air). Before we knew it, someone came out unravelling a firehose, turning it on full and drenching us down, and our packs, as we just stood there savoring the taste of the lovely sweet water, and at last washing away the stinging ash from our eyes. (Otto later informed me the acid dripping off our clothes in the chopper had eaten into his aluminum floor, leaving small holes.) Powerful stuff, that crater lake water!

Back in the Skotel, I rang my wife, Rosemary, staying with my mother (together with our 18-month old daughter) while I was ostensibly in the South Island, to wish them both "Happy Mothers' Day for tomorrow and, by the way, if you see anything about an eruption on the TV news – don't worry, we're all just fine". (They did – and felt quite relaxed during the whole dramatic news item!) After dinner, all cleaned up and in fresh clothes, suffering only sore eyes and throats and a few minor rock bruises, the five us (including Maria) sat around a tape recorder to give our individual accounts of the experience before they became lost or embellished over time. We had each experienced a unique scientific situation – witnessing a "significant" phreato-magmatic eruption (ie ejecting fresh, hot lava as well as dense old rock) from uncomfortably close quarters – especially Marshal and me who felt we had experienced it from the *inside*. (Our conversation was later transcribed word for word, and it is sitting in front of me right now as I tell this story to make sure I get it right!)

Looking back, it seems as though at least three of us must have been slow learners: we were sitting there also planning how we would return the following day and follow up our observations – but I did agree to give Pyramid a miss! Marshal, though, had learned his lesson

more convincingly: he promised to never return to any part of the crater again but he was later able to make the most of his experience in another way. As manager of the Skotel, this big-hearted, burly ex-Australian was a natural story teller. He had already established a tradition of seating his guests around the barbeque every Saturday evening while he recounted his wild travelling experiences. Now he was able to add the most dramatic story of his life! From later accounts, the guests absolutely lapped it up.

The following clear, cold morning, the three of us were deposited again on the still-clean snow of the Dome by Otto, overlooking the blackened crater basin and its now-malevolent looking lake. While John and Chris deployed their seismograph, I set up the theodolite at the Dome station once more and repeated yesterday's observations, alone this time. I later occupied two other stations upwind of the crater rim, giving my Pyramid station a wide berth. At least I had learned something from yesterday's experience. My aim now was to determine whether or not there had been any movement since my previous observations completed just 5 minutes before the eruption. Several other DSIR geologists also arrived to study the eruption fallout and recover samples of ejecta to determine its composition and origin. The crater lake temperature and water samples were also taken for chemical analysis. We completed our day's work with no sign of further eruptions and I returned to Lower Hutt that evening to prepare to fly south, after my unplanned two day delay, and catch up with our team on the Alpine Fault. First, however, I was determined to find out if my latest surveys had detected any volcanic inflation before the eruption, or perhaps deflation afterwards.

After computing the 8 and 9 May surveys, and recomputing the mid-March survey just to be sure, I had the results. By comparing the surveys I could see that the only change exceeding the estimated 10mm error was a 25mm east-west widening of the crater between Pyramid and its opposing station across the lake, sometime during the 6 week period leading up to the eruption, with no significant further change observed 24 hours later. In other words, this indicated minor inflation preceding the eruption, but with no further inflation or deflation occurring either during or immediately following it. Considering the fortuitously close timing of the survey and eruption (never to be deliberately repeated!), this was a lucky strike – evidence that large Ruapehu eruptions are sometimes, at least, preceded by inflation.

Some of the newspaper headlines

This was confirmed over the following 26 years that I continued carrying out at least 230 further surveys), mainly on foot, later combining them with each regular monthly crater lake inspection. During the same period, my White Island levelling surveys made every three months of a network of pegs on the crater floor, detected convincing pre-eruption inflation on a number of occasions, helping the monitoring team make more accurate assessments of the level of volcanic risk. However, no specific indicator was ever detected for the fortunately rare eruptions producing pyroclastic flows, like the one exploding with such tragic consequnces in December2019.

In discussions following our Ruapehu eruption, I learned that John Latter, together with a number of other scientists, had managed to obtain unique seismic recordings of the eruption (which gave only a few seconds of warning), together with gas chemistry and petrological data to help model the explosive eruption processes. Intriguingly, Chris Hewson had taken an 8mm movie of the whole sequence, until he was knocked flat. From that, John was able to calculate the speed of the ejecta as it exploded from the lake – far exceeding the speed of sound. Hardly surprising we were all just about stunned by the shock wave. Several weeks later, I received a small reward: my processed slide film, recovered from my ash-filled camera, arrived in the post. Not only had I accidentally captured the big blast just a second or two after it burst out of the lake, but a photo I tried to take immediately afterwards of the angry lake with hot pumice pieces fizzing around had also come out well. But the camera had then seized up – for good. After years of faithful service in Antarctica, Iran and around the world, it had sacrificed its own life for those unique last shots! Perhaps Ruapehu had regarded that as sufficient retribution and decided to spare my life after all!

5 differences between a good recruiter — and a cowboy...

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1. Good recruiters will meet you face to face
Clever recruiters have deep insights of the companies they represent so they'll meet you In real life to get an understanding of your personality. This will help them decide whether you'll be a good cultural fit for a business or not, which contributes massively to how much you'll enjoy working at your new company.

2. Good recruiters have in-depth knowledge of the industry
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3. Good recruiters keep you updated
If you find yourself desperately emailing your recruiter, pleading for progress, move on. A good recruiter will happily (but metaphorically) hold your hand through the process — they won't leave you feeling needy, like a bad recruiter will.

4. Good recruiters respect your career goals
If you're ever involved in a conversation where the recruiter's trying to persuade you to accept a role that you're not really interested in and it makes you feel undervalued, despite you being clear about what you want? Hang up as soon as you can.

5. Good recruiters focus on long-term relationships, bad recruiters on one-night stands
Bad recruiters dump your CV into the recruitment pipeline and only contact you if there's good news. Maybe they hate to be the bearers of bad news, or maybe they're just emotionless pimps. Either way, it's no good for a candidate or a business. A good recruiter walks the extra mile to ensure their clients and candidates achieve what they want.

EIGHTY4 ONLY HAS RECRUITERS OF THE GOOD SORT.
We have multiple job opportunities NZ-wide. Contact us now for a confidential chat and FREE salary check.

CONTACT:
Mark Fisher
021 347 445
mark@eighty4recruitment.com

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Eighty4 — RECRUITMENT —

Survey and Spatial New Zealand Diamond Partner

MOBILE MAPPING TECHNOLOGY

Pegasus 2 Ultimate Mobile Mapping System

Graham Watson: graham.watson@roadscience.co.nz
Rhys O'Cain: rhys.ocain@downer.co.nz

Leica Pegasus 2 Ultimate mapping 128km of road network between Te Anau and Milford Sound for Downer. (November 2019).

In April 2019 Road Science added mobile mapping technology to the fleet, helping to improve the real time data available to customers.

The purchase of a Leica Pegasus 2 Ultimate system came after 18 months of investigation into the technology. Cornerstones of this investigation included asking what the benefits were to our current and future workloads. Is there a point of difference in the technology? Does it make what we do safer?

The P2U does all of the above and has proven to be an integral part of Road Science's advanced road condition test vehicles used by our teams. To this date, the P2U is the only system of its type in the country.

This technology has seen a remarkable improvement in data capture, which, in turn, can produce solutions that were historically difficult and time consuming without the Leica Pegasus 2 Ultimate system.

The P2U is an advanced highly configurable system for high speed capture of 3D scan data and high resolution imagery including 360° spherical and targeted detailed orthometric images. Road Science has built the system onto a custom mount in the back of a 4WD for normal use.

Recently it was on display at the S+SNZ 130th Annual Conference in Auckland.

If you do see the P2U around, make sure you come over and have a chat and we will be happy to show you how it works!

The 4WD is by no means the only vehicle we can mount the system on. Utilising the mounting rack system it can be placed on numerous other vehicles. Road Science also has a set up for Hi-Rail vehicles when doing railway surveys.

To date the system has worked extensively across Downer's Network Outcome Contracts (NOC), surveying roads from Auckland to Fiordland. One of the key benefits is that the system can work without disturbing any stakeholders, keeping the roads open and operating at the posted speed limits. This also means the team no longer need to operate in the live traffic lane to collect the data which helps to ensure a safer road network for everyone.

Projects have been varied and interesting, taking the team all over the country, including mapping the Milford Road where we surveyed 128km in three days and completed a detailed topographical survey of George Street for the Dunedin city centre upgrade and the capture and catalogue of rail corridor assets from Trentham to Upper Hutt.

Like the system, deliverables can be configured to meet the end-user's requirements. It could be as simple as an area calculation, clearances, or detail topographical survey dataset. This can also include regular infrastructure monitoring or road inspection/pavement analysis. Regular deliverables are point clouds, shape files, photogrammetry, 2d/3d cad files including TINs and sections.

The Road Science team is happy to be contacted about the system and how it could be used on your upcoming projects. Sample datasets are available for viewing as well. In future issues of S+S magazine we will highlight some of our interesting projects.

HYDROGRAPHER – IN RETIREMENT

'A Conversation'

Maurice Perwick, RPSurv CPH1 Dip Surv

I CAME INTO HYDRO A FEW EONS AGO AND FOR ME IT COMBINED A WHOLE SUITE OF LATENT SKILLS JUST BURSTING TO GET OUT.

We all know surveyors enjoy the outdoors and the need to balance that with office-bound activities but I've found hydro released me from the Cadastral 01s even though I was often referred to as 'Millimetre Man' by those ungracious enough to not see that by understanding the process of measurement one could discern and opt for what was practical and meet the spec.

That's not to say I gave up the quest for getting things right, that is always a given but I became mature enough to realise that a similar answer could be obtained in different ways.

I see CSNZ is presenting 'mentoring for the oldies' at its workshop and having been a mentor in the SSSI post and undergraduate programme last year, I can see that youthful skills can be useful to us oldies too.

Of course, I've been using the 'spirit of empowerment' on my graduates and staff to share their knowledge and skills with me and their fellows all my professional life.

The benefit is seen in their ownership of their work and the pride they have in it and being able to share. It creates a culture of wellbeing and confidence that would otherwise not be freed.

Hydro is a world of dynamics, quite different to static measurement although if you took a moment to realise that GPS satellites move at 4km/sec, then you would see that time measured to 10-9 and latency are very relevant in our day-to-day use, which could include navigation (read set-out) mapping and 3D measurement including tide levels and ship and wave dynamics.

Before having GPS we used radio distance-finding (similar to the way GPS works) and total station tracking or even sextants though this is mixing the commencement of the new digital age with hand plotting of position.

Depth was and still can be measured using a pole, lead line or echosounder, and now we can add multibeam echosounders to the mix. A sound velocity probe is used to correct 'measured depth in water' due to changes in water temperature and salinity. A static 'bar check' is used to determine the draft or offset of the echosounder transducer below the water level and can be used to determine or compensate for apparent sound velocity.

Of course, a tidal datum should be established to provide a height datum relative to LAT (lowest astronomical tide) and chart datum in order to correct for the rise and fall of tides.

Ship dynamics and sea state then provide the last set of corrections for the ship's motion through the sea.

Rivers and lakes may have a hydraulic gradient depending on the topography and impoundment.

I grew up on the banks of the Mataura River and learnt to my detriment the dangers inherent in travel on the river though shoaling, currents, debris, wind and minimal boat skills, but I did survive and am very wary when working in a boat. I'm not scared but aware of what can cause accidents.

I arrived in Dunedin when I was 16 and enrolled in the survey systems courses but was not accepted until partway through my alternative pursuit of a mathematics and chemistry degree (not completed). I enjoyed hostel living and later mixed flatting and essentially a 'free education' though had to work all my holidays to fund my study there, to finish owing my dad $50 (10 weeks' rent).

The survey course included sextant work and depth measurement on Otago Harbour.

Hydrographic training was either in the realm of the navy or available at overseas universities or maritime colleges which made it prohibitive to most New Zealand land surveyors.

The digital age came to the survey profession by way of electric adding machines and programmable calculators, eg Monroe 1880 or HP25C in the 70s, and then in the 80s electronic field equipment appeared and PC survey software.

Hydro work started for us in the mid-80s and cost a lot of money and didn't initially include a motion sensor to measure heave (swell heights). The power of the PC and algorithms.

By the 90s we were using American differential GPS and the first of the OTF-Kinematic GPS receiver systems and echo sounders and our own dedicated telemetry systems from Beech in our coastal, river, lake and harbour surveys.

Hydro opened up a whole new world of experiences and distinct challenges when working remotely and essentially alone. The use of a cellphone (not a brick) proved very advantageous when equipment or software malfunctioned. We take all this for granted now with the interoperability of systems.

Working with boats of convenience necessitated fabricating an OTS bracket for mounting the GPS and echosounder transducer on the side of the vessel. We still have the Mark I, though it is wearing out from seawater corrosion.

We have built or modified three launches for our coastal and harbour work along with the use of a 3m RIB for shallow work or where logistics prohibit the use of 6-8m vessels. We developed 'Bubbler systems' for measuring the depth of underwater dredging equipment. Recently our use of a drone for profiling the near-shore Kaikoura coast was named a NZSEA finalist.

We had three major projects on the go in the early 90s, the Clutha River tailrace dredging, the Westport real-time

mapping of the Buller Bar and establishing an independent hydrographic surveying practice in Hong Kong. These were all advanced uses of the available technology at the time and required innovation and customising of the hydro-DOS software.

The Westport system is still going but the daily need to survey the bar for the cement ships has gone with Holcim importing and distributing the cement from East Coast hubs. We customised the hydro software to facilitate the dredging of the bar, river and berths and later supported the 'out of port' dredging in Nelson, Gisborne and Wellington.

The Hong Kong operation supported the building of the Chek Lap Kok Airport platform (reclamation) and infrastructure and other projects for four years. The survey gear was later repatriated back to New Zealand and enabled the building of our own CORS GPS Base Station network for our land development operations around Christchurch.

The Clutha River dredging was a four-year construction project using self-tracking total stations for positioning floating back-hoe diggers and a survey jetboat in a very constrained river environment where temperatures ranged from -6 to 35 degrees C on a good day.

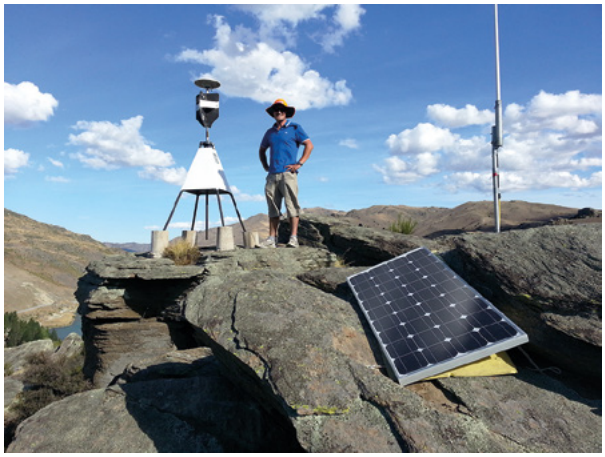
Our use of Trimble GPS processing software, separate from our land development software, allowed us to carry out geodetic surveys and determine transformations or site calibrations which could be integrated into our field controllers and hydro software. Site surveys could be expanded and adopt previously measured baselines and connections to control marks for locating, coordinating and heighting new marks and re-establishing chart datum in remote or earthquake damaged ports.

We now take for granted the Datum 2000 network and VD16 height datum which require minimal connections to control. All this is possible through cellular networks to the real-time internet CORS systems around New Zealand.

The geodetic and tidal work that LINZ initiates around New Zealand leads to a better understanding of tectonic crustal movements, tidal changes and sea level rise. Once the domain of our most senior geodesists, we now have this information available at our fingertips where it can be integrated into our daily surveys.

Nelson has been subsiding about 5cm over the past few years and required adjustment of the tide pole and tide gauge systems to reflect the changed relationship of chart datum and the landward reference marks. This affects the surveys relating to dredging the harbour and the amount of material to be removed as the harbour has become naturally deeper. Note, the tide levels haven't changed significantly to that extent.

The opposite action occurred in Kaikoura and Lyttelton following the Dec 2016 and 2010-11 earthquakes where the land rose out of the sea. In Lyttelton the tide gauge initially showed the sea level had dropped after the earthquake but we all know about equipotential surfaces so we immediately deduced the land and tide gauge structure had lifted to a new higher reduced level. Our CORS system confirmed this after being referenced to other LINZ CORS away from Christchurch and new coordinates and heights established.



Our understanding of geoid correction models and sea level rise has stood us in good stead when advising clients of the construction levels for coastal structures and berths. Atmospheric pressure can also have a significant effect on sea levels and could require a jetty to be built higher or a channel or berth to be dredged deeper to compensate especially when heights of structures and channel depths are critical. The rule of thumb is 1hPa= 1mbar = 1cm – known as the inverse barometer effect.

Maritime New Zealand has just released another draft of *Good Practice Guidelines for Hydrographic Surveys in NZ Ports and Harbours* for consultation. Ports have relied on their surveyors to reliably report the available draft for ship movement and berthage but with the increased pressure to increase tonnage through a port, the under-keel clearance or tolerance has been greatly reduced to the point where every decimetre counts and full seabed coverage is warranted. Surveyors are but one important part of ship handling but I've always been amazed how well the harbour pilots and harbourmasters know my plans and the depths shown on them. A lot of experienced judgment goes into the cleaning and post-processing before depths are finally accepted for the chart. Being able to create surface models and produce comparisons between surfaces can aid greatly and give confidence that outliers or anomalies are just that but there is always the risk of that anomaly being significant. Looking at the echo trace, whether paper or digital, can often highlight the validity of the sounding as there can be many conditions in the water column to obscure the real depth. I work on the precept, 'If in doubt show it'.

The Australasian Hydrographic Society has been instrumental in promoting the use of certified hydrographic surveyors for hydro work though the SSSI and S+SNZ. The Accreditation Panel is like our Cadastral Licensing Board and requires candidates to show sufficient experience, academic qualification and skill to meet their criteria. This professional standing is seen as a way of mitigating risk in port management and raising the profile of hydrographers.

In a similar vein, Maritime New Zealand requires users of boats for commercial gain to have their operational documents prepared and approved under the MOSS system and the skippers appropriately qualified and the vessels surveyed and equipped.

Preparation is the key to success, not luck, as this process allows us to assess the options and how a project will be executed. Experience allows you to look at various scenarios and backup options when planning and costing a project. The execution relies on the preparedness of the surveyor, his gear and the methods deployed. However, field conditions can often be found to be quite different after arriving on site and needs a serious approach to bring work to a conclusion.

One thing I've learnt to do, is to stand back and let the mind and body appreciate a site's dynamics, whether that be a river, an ocean, a worksite or an office meeting. This gives you a feel for the forces at play and how you are going to mitigate the risks or take advantage of the situation. A shallow river can be more dangerous for boating that one in full flow but not in flood.

I've always wanted to build on things rather than reinvent the wheel each time but this can lead to compla-

cency when systems are either taken for granted or not fully understood. Of course, systems need to be reliable and simple to operate and much has been done by equipment and software manufacturers to ensure compatibility and interoperability. Familiarity and training can ensure proper execution.

Another is to be discerning in your use and understanding of methods, gear and software. Check the solution is fitting the reality check and devise critical tests to validate your result or methodology. It does take time and costs money but it gives you confidence in your results – water up to your knees is 0.5m deep, not what the software is suggesting.

Hydro operations require a plethora of equipment and knowledge of their operation and constraints. Even single beam surveys can involve a number of different frequency echosounders and methods of calibration, side-scan for visualisation, heading devices for equipment to be offset and logged correctly and to assist the helmsmen with visualisation and orientation, sound velocity probes, laptops and tablets for field processing and navigation, RTK-GNSS receivers for 3D positioning, telemetry or the internet, wireless or cellular, bar check, graphics and logging sheets. Choosing the correct watercraft and skipper can be very important.

In conclusion, hydrographers will tell you it's an amazing but demanding job, the opportunities it offers by way of experiences, skills, environments both physical and cultural, technical, managerial, and professional are second to none. Your surveys have a huge impact on people's lives albeit often through a third party.

Flood management and mitigation, highway and rail corridor protection, navigable channels and oceans, ocean outfalls, power generation, reclamations, dredging and port management, navigation aids, transport and construction projects, Pacific Island support, marine farming, recreation, military support and border protection, science and research, export-imports, fishing and the blue economy.

Surveyors and hydrographers are there!

TOP 10 Geospatial Things
AUTUMN EDITION

Land Information New Zealand
Toitū te whenua

INTERESTING GEOSPATIAL DATA LAYERS

Useful datasets and sites of interest for GIS users

Duane Wilkins, LINZ

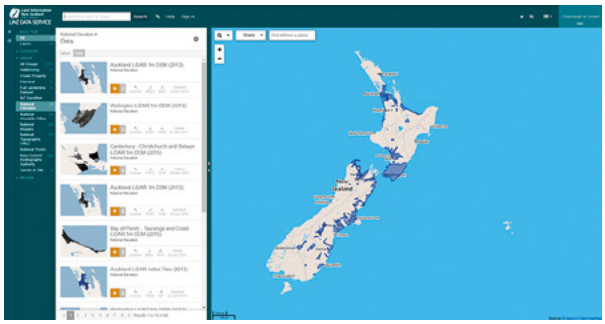
The last decade of open GIS data has been fantastic for geospatial practitioners who now have access to an ever-growing range of datasets and imagery for use in GIS projects.

The catalogue of open data at *data.govt.nz* now has several thousand datasets available in an array of data formats, including types that we can live stream without downloading. Data.govt.nz is also a great way to browse and discover interesting datasets like footpath renewals, airport air noise contours, and national grid transmission corridors.

At Land Information New Zealand (LINZ) we thought it would be useful to share a few of our geospatial data highlights to kick off the first edition of S+S in 2020.

LiDAR[1] Elevation Data

go: *gis.ai/lidar*



Lidar coverage available from *data.linz.govt.nz*

Large areas of data now available from *data.linz.govt.nz* including DSMs,[2] DEMs,[3] and Point Cloud Data can be accessed online and downloaded in its native format from *opentopography.org*.

Large scale LiDAR capture is underway for much of New Zealand, and significant areas of derived 1m resolution elevation data are already available at *data.linz.govt.nz* including these areas: Auckland, Tauranga, parts of the Waikato and Hauraki, Manawatū, Wellington, Nelson, Tasman, Marlborough, Kaikōura, Rangiora, Canterbury, Timaru and quite a few other areas. View full coverage at *gis.ai/coverage*.

Most datasets are available as clear DEMs, as well as DSMs that retain trees, buildings, cars and other features.

You can access elevation data from *data.linz.govt.nz* by searching for DEM or DSM or browse to the National Elevation group. Once you've found the data you are looking for, add it to your downloads and crop to your area of interest.

Once you have downloaded the data, you'll want to merge the tiles to a new mosaic dataset before re-projecting, and then build a cache or pyramid layers for faster access and viewing. Don't forget to set the coordinate system and vertical datum (more information about NZVD2016 below).

If you're creating a hill shade, try out a multi-aspect option if available. If you're working with WGS84 or Web Mercator projections, you might want to be aware of setting the Z- factor correctly based on the latitude of your map extent. Most of the time you'll be using this data in NZTM[4] and will not be affected, but you'll know it when your hill shades are too dark when using non-linear projections.

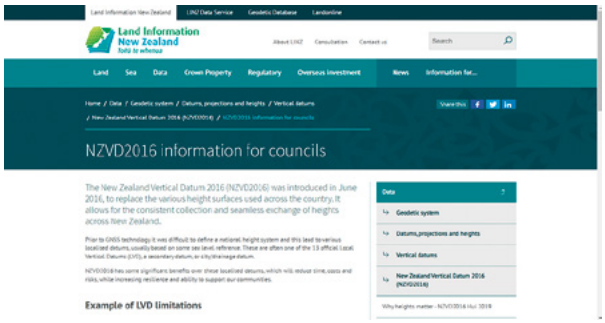
If you're intending to do further hydrological modelling you'll need to research filling sinks, smoothing spikes, and gain an understanding which method has been used to interpolate the raster from its point cloud origin. Before you download and process a large area, start with a sample area first.

For more information about creating DEMs from LiDAR, check out this post from the Topographic team at LINZ *gis.ai/dems*.

You can also access and preview on *opentopography.org*. The first thing to do is to create a login, and then log in. This increases your workspace from 50 million to 250million points and you can also request access for up to a cool half a billion points. You can preview the data in 3D online or download for local use.

X, Y and Z Datums

go: *gis.ai/nzvd2016*



Vertical Datum information on the *linz.govt.nz* website.

Now that you have some detailed LiDAR, Z values for other datasets like pipes, drains, streams and shorelines will feature in data management discussions. GNSS[5] GPS[6] receivers can measure height more accurately so its timely to look at the implications for GIS data and projects such as ensuring pipes remain under the ground.

There is nothing worse than finding out your flood model won't work because water refuses to flow upwards into a 35m high polygon representing the sea as can be the case.

Long story short: Set the New Zealand Vertical Datum 2016 (NZVD2016) as a vertical datum when working with elevation data and water modelling.

Most GIS users will not have come across a vertical datum before, and it's worth spending some time carefully reading through the LINZ Vertical Datum pages at *gis.ai/nzvd2016*. Most of the time you'll be able to set NZVD2016 and forget about it. You'll find the Z spatial reference settings near the XY coordinate system dialogue boxes in most desktop GIS apps.

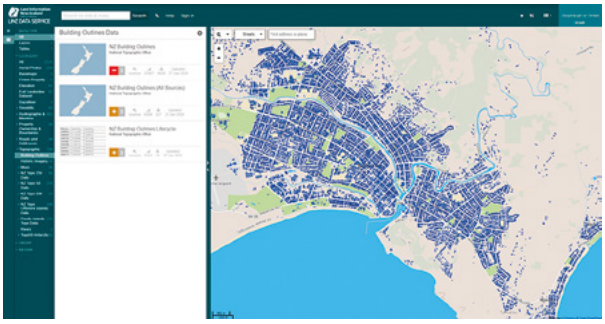
NZ Building Outlines

go: *gis.ai/buildings*

NZ Building Outlines is a recently released new dataset of 3.11 million features captured using the latest in machine learning technology and represents the outline or roofline of a building ("footprints" are difficult to capture using 2D aerial imagery due to eaves and other roof related structures).

Coverage is available for most of New Zealand, and the few remaining areas should be completed by June 2020, and a building use type attribute is in the works.

The outlines data are a great reference addition to any



Building outlines for Gisborne from *data.linz.govt.nz*

neighbourhood scale maps, and a variety of other indicative analysis like solar potential and water runoff modelling. If you're using them in 3D visualisations you can add a generic height field which makes them useful as background context for a study area where you may already have 3D building models.

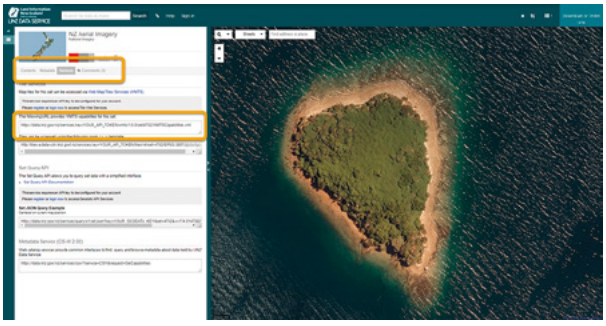
Other uses for the data could include developing evacuation plans during an emergency, monitoring building inspections, and exploratory analysis of building size for real estate and subdivision or urban development potential using council zoning or residential area selections.

The Building ID field is extremely important during an emergency response to record Damage Assessments. This field can become a proxy ID to tie together information about a person, building, address, property - records, images, registration forms, and insurance claims for example.

Because this is a countrywide layer it's useful to think of it as a "national single source of the truth" as multiple agencies and organisations will use it.

Avoid Downloading 20TB of Urban and Rural Aerial Photography

go: *gis.ai/aerials*



Can you guess the name of this heart shaped island near Picton?

There are more than 20 terabytes (20,000GB) of aerial photography hosted and available to everyone from *data.linz.govt.nz*. Best of all you can livestream *all* of these as services directly in your web maps and desktop applications in a variety of projections without downloading the data.

If you're printing a high quality and high-resolution map it may still be better to download the data as this

reduces any compression artefacts, and gives you more control over colour matching and other settings including scale as webservices are cached for use at 15 or so set scales in web maps.

The webservices are provided as a WMTS[7] service (not WMS)[8] and supports NZTM, Web Mercator and others. To use the webservices you'll need to login and under your profile, specify an API[9] key. Avoid making these public in the event they are over-used which may create issues.

Within the imagery category of *data.linz.govt.nz* under each layer you'll find a "Services" tab, and you're after the WMTS Capabilities section. One you've logged in, copy the URL[10] for the imagery you need, and then within your mapping software, add "webservice from URL" or add WMTS server.

If you do download the imagery, you'll want to create an index or mosaic the imagery into a single layer for ease of use, build the cache/pyramids for speed and adjust colour matching.

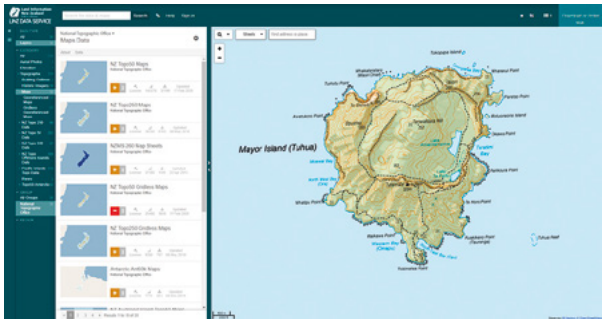
In the future new imagery will be added all the time as soon as it's processed, and there is an increasing availability of imagery for more than one time period for much of the country. Coming soon is new Waikato Region 0.3m imagery. Great imagery for Otago and Chatham Island has been recently released.

Sentinel satellite imagery is another useful national base map layer, there are two periods of cloud free cover at 10m resolution, visual spectrum only.

Access the Sentinel images at *gis.ai/esa*

Getting Lost with NZ Topo50 and Topo250!

go: *gis.ai/topo*



An example of the NZTopo50 Gridless map for Mayor Island (Tuhua)

We're all well familiar with the NZ Topo maps, and the team at LINZ is updating them often, and the maps published to *data.linz.govt.nz* are always the most recent version.

You can also access these maps as streaming webservices, once you've logged into the LDS and generated an API key, go to the Topo layer you're interested in and copy the WMTS capabilities URL, add it into your web map as a WMTS service and it should appear within a moment or two.

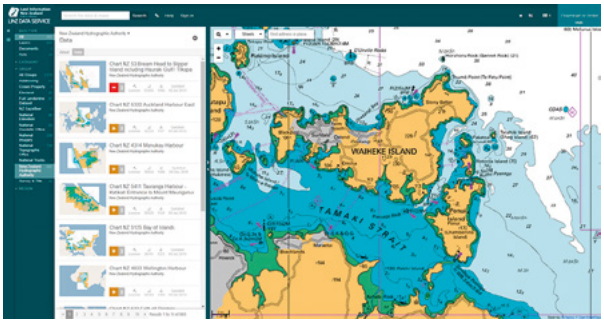
If you are printing, exporting or using the Topo maps in 3D you may want to download them all as image tiles. For the NZ Topo50, you'll need to download them in zipped chunks of 3.5GB (it's limited to help manage cloud processing costs and share resources fairly across all users) and then build a mosaic after downloading.

If you can wait a week, a better option is to ask your manager to have the LINZ Data Service team put this data and (several other large datasets at the same time) on a USB or portable hard drive and courier it to you overnight for a fee. You'll get to keep the drive or pass it on to a client, upgrade your media server, or create a backup image of your workstation or routine data backup for emergency purposes, easily justified as it mitigates data loss and backup risks as well.

If you're looking for the individual NZTopo50 vector datasets they're all there as well, and you can access them as "sets" which avoids the need to find them one by one, which is a real time saver. Check them out at *gis.ai/sets*. For advanced technical users there are changesets for most datasets that can be scripted to run automatically, try *gis.ai/changesets*.

Water Wonderful World

go: *gis.ai/hydro*



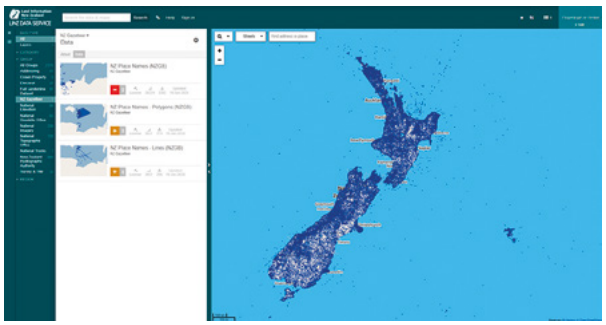
An example of a marine chart found on *data.linz.govt.nz*

While for many of us our work is focused on the land, marine geospatial information can be useful for many projects. This information includes bathymetric surfaces (the topography of the seafloor), vector data and raster images of the marine navigational charts. All are available on *data.linz.govt.nz* and can be downloaded in a variety of formats or streamed using WMTS web services for including in web maps and online applications. Just search for "depth contours" or "bathymetric" to discover the wonders of the undersea world.

If you are looking for a good image of New Zealand's bathymetry, the data from NIWA could also be useful as well: *gis.ai/niwa*

Official NZ Place Names

go: *gis.ai/places*



NZ Place Names data available on *data.linz.govt.nz*

Ever wondered if there was an official or given name for a place? This data has every official and many unofficial place names for all areas managed by the NZ Geographic Board. Over the past few months, about 700 place names were made official and 550+ Antarctic places have improved positions, so it's worth downloading an updated copy for your reference data. The data has a reasonably comprehensive attribute table, including NZTM and Lat Long coordinates.

If you're wanting to filter or adjust the symbology hierarchy for this layer, it's possible to use the **feat_type** field as a way to categorise both icons and labelling styles at different scales, so that you can avoid a large number of labels drawing.

You can also use this data to select or filter for different types of map themes, for example all of the named Glaciers (1149), Waterfalls (300), Rock (500), or place names referencing other keywords of specific interest.

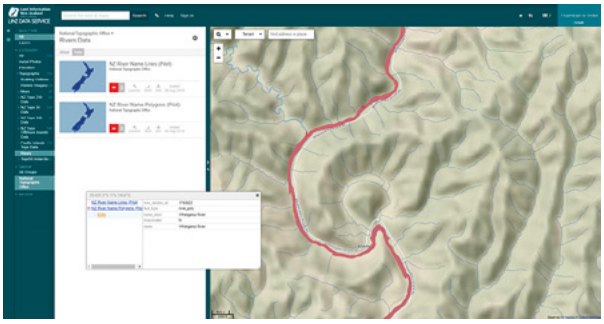
If you know of a place spelled incorrectly or a naming error, you can also make a proposal for a place name change on the NZGB page *gis.ai/propose* and there is the recently updated online Gazetteer at *gazetteer.linz.govt.nz* and at the bottom of that page, you can download a csv file of Māori place names which include macrons. Unfortunately, most mapping tools do not support macrons, or they can become lost in the data editing, encoding, data translation, publishing or printing process.

A named river dataset at last!

go: *gis.ai/rivers*

The Topographic team has been carefully adding river names to the river lines used to create the NZ Topo50 maps. They need to be used in conjunction with the coastlines, islands, lagoons, lakes, ponds and swamp polygon areas, but they do make a very nice cartographic representation – with labels and this works very well with other NZ Topo50 vector layers.

If you're wanting to display river orders and catchments, you could try using the "River Environment Classification



A closeup of the named river datasets available on *data.linz.govt.nz*

(2010)" from *data.mfe.govt.nz*, and the "Sea Draining Catchments" which are based on a coarse nationwide raster grid, which will become readily apparent at local scales. You can run a smoothing algorithm to improve their appearance. Note that the catchments and some rivers may flow up and over some ridgelines visible in any underlying hill shades.

A Realtime Group Selfie from Space!

Here's a fun site for geospatial enthusiasts. Last summer, the Japanese Himawari satellite made the headlines by providing real time imagery of smoke from the Australian bushfires, and recently a rare cloud free image of New Zealand again made the headlines.

Remember the Smokey skies in January?

gis.ai/himawari8

Or try this rare cloud free day back in February:

gis.ai/cloudfree

Or for a real time, whole of Pacific selfie from space taken in real time while you were reading this! *himawari.asia*

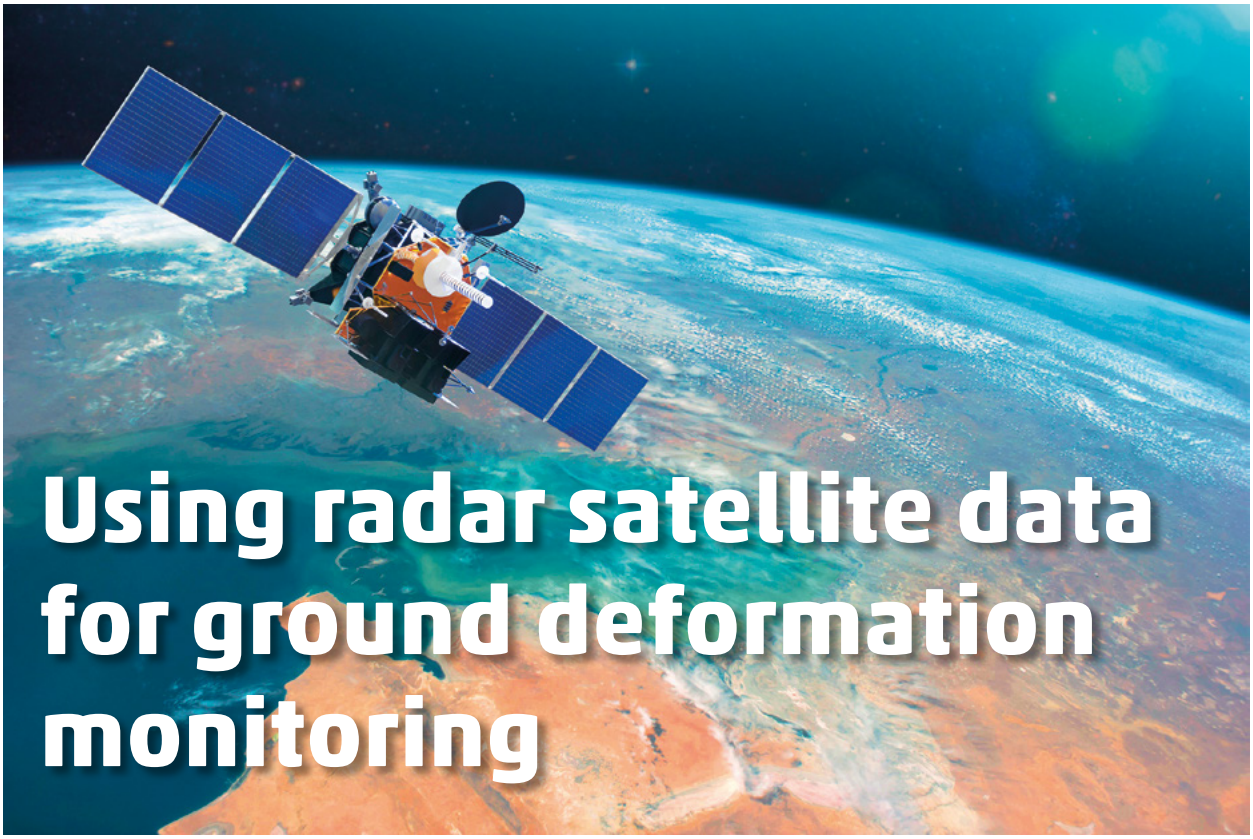
Geospatial Webinars

Keep an eye out for the LINZ Webinar series coming up that will include sessions focused on taking a more detailed look at some of these and other open datasets, their creation, maintenance, and demonstrations of how to access, and apply some of the processes described above including downloading, processing and using web services in live web maps and applications. If you have ideas for webinar themes and topics, please do get in touch.

Geospatial capability queries: dwilkins@linz.govt.nz
Open data and reuse queries: jball@linz.govt.nz

NOTES

1 Light detection and ranging
2 Digital Surface Model
3 Digital Elevation Model
4 New Zealand Transverse Mercator
5 Global Navigation Satellite System
6 Global Positioning System
7 Web Map Tile Service
8 Web Map Serve
9 Application Programming Interface
10 Uniform Resource Locator



Using radar satellite data for ground deformation monitoring

M Camafort, N Devanthéry and B Payas, SIXENSE Satellite & Data Solutions, Barcelona
E Audigé, C Fagan and V Aguado, SIXENSE Oceanía

In many construction projects, one of the major challenges is to guarantee that the different infrastructure assets crossing or adjacent to the site works are not affected by the construction activity.

To some extent, interpreting the deformation patterns might be complex, but it becomes even more problematic if the geotechnical team is unaware of ground deformation in situations such as:

- Before the start of the groundworks, **unidentified pre-existing ground movements** away from the main area of interest may eventually affect the stability of the site groundworks.
- During the construction activity, the **unknown extent of the deformation** induced by groundworks may result in the installation of an unoptimized network of instruments, or worse, a costly and oversized instrument network.

Additionally, using traditional, in-situ instrumentation to monitor the long-term stabilisation of ground movements following the completion of works can be financially inefficient.

These limitations can be overcome by using remote sensing techniques. In particular, radar satellite technology (InSAR), which has been broadly implemented for these purposes thanks to the availability of historical data and the large coverage of satellite images that allows detecting measurements over very large areas, up to 200 x 100 kilometres.

Also, the possibility of monitoring without physically accessing site allows for lower costs, as a result of:

- **Setting up a more optimised** and efficient network of in-situ instruments that might be initially placed before the initiation of the works.
- If necessary, the **re-adjustment of instrument locations**, as the work progresses, based on the adjacent ground deformation detected through satellite ground deformation data.

Satellite ground deformation monitoring has now become a reality for most of the major underground construction projects. It has proven a useful and complementary source of information to the traditional monitoring instrumentation.

1. InSAR technology: How does it works?

Interferometric synthetic aperture radar technology, or InSAR, is a technique to derive millimetric measurements of individual terrain structures over wide areas in both urban and non-urban environments.

This technique is based on the exploitation of a set of radar satellite images acquired from space (SAR images). The large size of SAR images and the availability of high-resolution sensors, such as TerraSAR-X (up to 3x3m pixel resolution) enable to retrieve detailed information on target structures.

Figure 1. SAR amplitude image taken over an urban area

The synthetic aperture radar (SAR) is an imaging radar system mounted on satellites whereas interferometry refers to the superimposition of waves to detect differences over time in fractions of wavelength.

These satellites capture radar images by precisely recording the travel phase between ground surface and the sensor. When several measurements are compared over time, the difference indicates ground deformation over time.

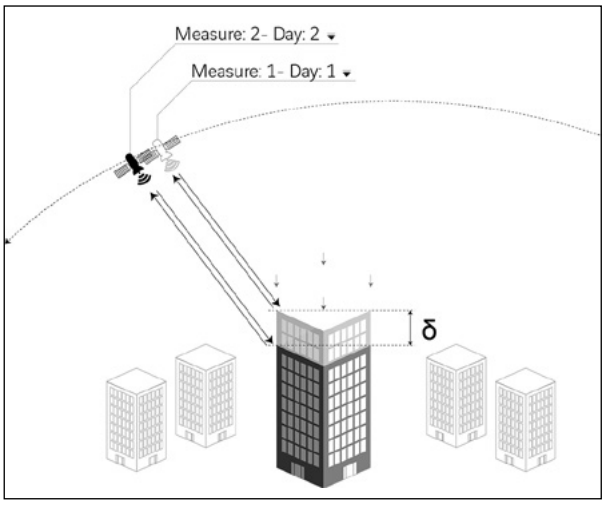


Figure 2. Schema showing the measurement of ground deformation between two consecutive satellite passes.

The satellites that capture these SAR images continuously orbit the earth on a fixed polar orbiting track, taking 100 minutes to complete one full orbit. Because of the earth's rotation, the satellite revisits the same area on the globe at regular intervals. For example, high resolution satellites, such as TerraSAR-X and PAZ, specially designed for urban areas, provide revisit times of 4 and 7 days.

For any measurement point, satellite time-series data allows the follow-up of movement phenomena every few days during the monitoring period.

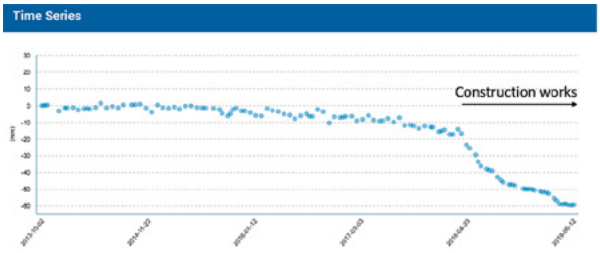


Figure 3. InSAR time series of a measurement point. A strong non-linear component has been detected subsequent to dewatering activities.

Not to mention, InSAR monitoring comes with no installation on the field nor safety hazards, and yields millimetric monitoring accuracy similar to other traditional systems.

Furthermore, while precise levelling is carried out in one specific area at a rate of around 100 points monitored per day, InSAR can provide more than 20,000 measurements points per km^2 in urban environments. Precise levelling, automatic total station and InSAR are complementary technologies and if properly deployed, the combination of the three can significantly lower the cost of ground deformation monitoring.

2. ATLAS™: SIXENSE's InSAR solution

ATLAS™ is SIXENSE's InSAR solution, which has been developed with the aim of monitoring geotechnical and structural deformations linked to urban or peripheral construction activities, with an emphasis on tunnel monitoring. SIXENSE's InSAR capabilities can be summarised as follows:

- A **dedicated satellite department** (SIXENSE Satellite & Data Solutions) with more than 10 years of expertise in processing radar data on many projects.
- Our own **radar satellite interferometry (InSAR) processing chain, ATLAS™**. A continuous focus on R&D allowing for developing features linked to new satellite capabilities.
- A value-added service with its advanced web platform, **BEYOND Satellite**, able to transform data into actionable and customised information.

3. ATLAS™ applications for civil engineering

ATLAS™ InSAR data is a tool suited for monitoring, inspection and management of infrastructures. SIXENSE's solution has been applied to monitor urban areas to assess settlement caused by tunnel constructions; dewatering effects; subsidence and landslide activity in dams and surrounding areas; land reclaimed areas and related critical assets; dikes, piers, embankments and pipelines; airport terminals and runways; geothermal effects on land; subsidence and landslide monitoring along linear infrastructures such as road networks, highways or railways; bridges, elevated roads and viaducts, among others.

ATLAS™ InSAR has proven to be a powerful tool not only to monitor classic patterns of deformation but for monitoring seasonal patterns of deformation. Figure 4 shows a time series from a rural area in northern France, where seasonal patterns of deformation related to the shrink and swell of expansive soils were monitored.

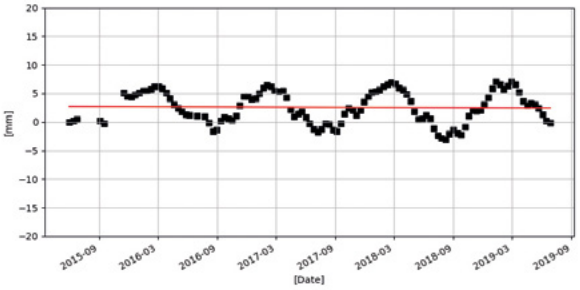


Figure 4. Time series showing a seasonal pattern of deformation related to expansive soils in a rural area of northern France.

These expansive soils are made up of plate-like clay minerals, which absorb moisture between the plates and can expand to more than 100 per cent of the original volume when wet. This is the reason why during northern winters (from January to March), due to the rainy weather, the time series (Figure 4) shows the maximum soil heights, as expansive soils are swollen.

On the contrary, during northern summers (from July to September), due to the lack of rains and water pumping of farmers, the time series (Figure 4) shows the maximum settlement as expansive soils are shrunk.

Apart from these applications, InSAR is also used to monitor hard rock open pit and underground mining activities, to capture the subsidence caused by oil extraction from underground reservoirs, tectonic deformation or ground deformation related to volcanic activity.

4. ATLAS™ for tunnelling monitoring: The Crossrail project (London, UK)

The Crossrail project is a 117km new railway line that has been built in London (UK) crossing the city from west to east. Up to 21km of the rail network runs underground along "twin-bore" TBM tunnels (i.e. 42km of tunnels) of 6.2m internal diameter and up to 40m deep.

The civil work of the tunnels began in May 2012, with completion in May 2015. The new railway line, named the Elizabeth Line, is expected to be put into service in 2021.

ATLAS™ is being applied in London to monitor the tunnelling construction works since August 2013 and it has provided very useful information at the different construction phases of the Crossrail project.

Pre-construction phase: Access shaft, station excavation works and dewatering works

As is similar for many tunnelling projects, a dewatering process was carried out as part of the pre-construction phase. These activities preceding tunnelling works usually result in settlement as porewater pressure in the soil is

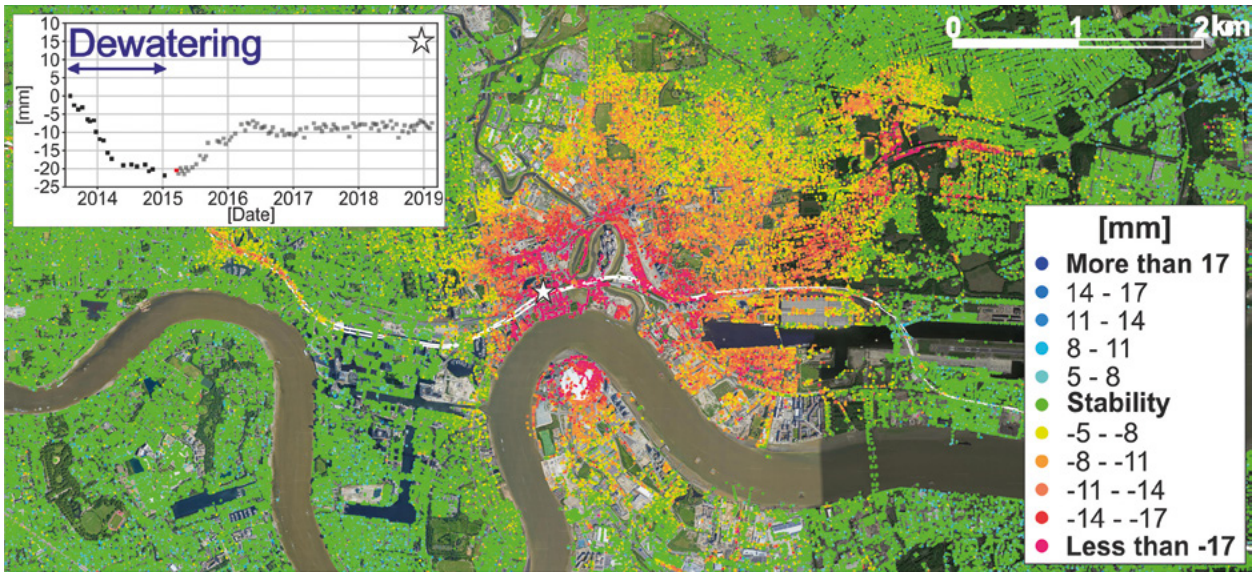


Figure 5. Accumulated deformation map over Limmo area (London) – subsidence colours ranging from yellow to red whereas uplift is plotted in the blue palette.

reduced. ATLAS™ has been a fundamental tool to measure the magnitude and total extent of the settlement due to dewatering works in London.

An example of one of the dewatering activities at the Crossrail project is that carried out in the Limmo area (Figure 5). InSAR was crucial to determine the total extension of the settlement, up to 2.5km from the dewatering well, that reached a wider extension than the area estimated at the design phase.

Construction phase: Tunnelling works

One of the most important control measures, during the tunnel construction phase, is the 'ground loss', i.e. the volume loss. It depends on the depth of the tunnel, ground conditions, machine characteristics, workmanship, among other parameters.

InSAR has been successfully used as a complementary source of settlement data, which could be considered as 'absolute' and in the same grid for the entire project. Satellite measurements were also used to check for any widening of the settlement trough along the tunnel route, and outside the planned area of interest.

Post-construction phase: After the end of the tunnelling works

Upon termination of the civil works, satellite measurements provided a technically and financially efficient way of monitoring long term stabilisation of movements.

InSAR is a suitable tool to measure the long-term movements, immediately following the end of the construction activity, or many years later, if adverse claims are raised. In the case of the Crossrail project, ATLAS™ results were used to combat adverse claims, and to monitor the stabilisation of the settlements long after the end of tunnelling, when in-situ monitoring instrumentation, such as levelling points or prisms, had been removed. As observed in Figure 6, InSAR measurements are comparable to the manual/automatic monitoring put in place during the construction activity. Additionally, both techniques confirmed that the stabilisation period started in late 2017.

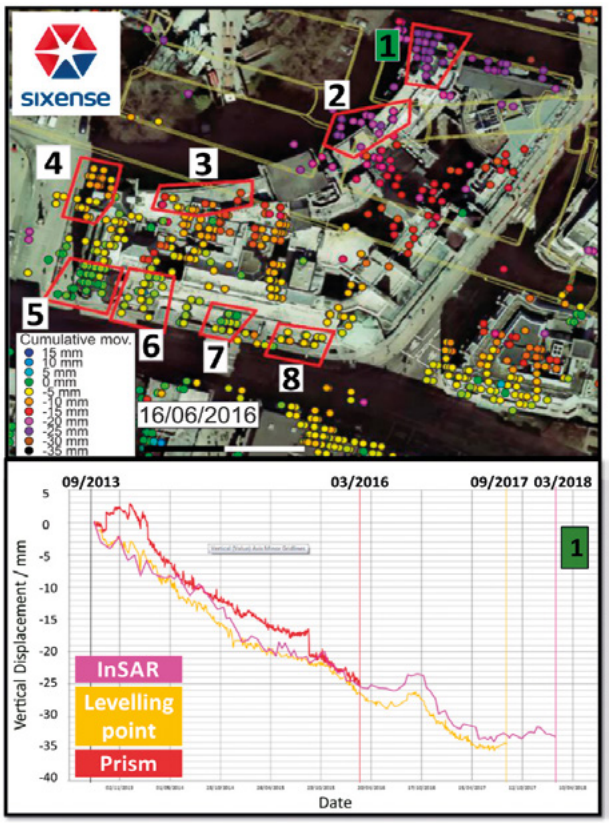


Figure 6. Time series comparison over a critical area from the Crossrail project.

5. Conclusions

ATLAS™ InSAR data is a cost-effective solution used to monitor a large zone, extending beyond the area of settlement induced by construction works.

The high density of measurement points obtained by this remote sensing solution offers the possibility to measure surface deformation where in-situ instrumentation is not installed, providing complementary data to the traditional instruments used to monitor the safety of underground works.

The temporal and spatial coverage offered by InSAR provides both historical data on the natural movements of buildings and surrounding ground, as well as an ongoing check of the stability of instrumentation reference points, which is crucial when sub-millimetric accuracy measurements are required.

The increasing number of underground infrastructure projects that combine both terrestrial and remote sensing spatial solutions demonstrates that InSAR is now a full endorsed and utilised technology for the monitoring of construction works.

Eric Audige was one of the interesting and thought-provoking presenters at last year's S+SNZ Engineering and Positions Workshop held at the Sudima Hotel in Christchurch. His passion for this topic is contagious. Don't miss this year's S+SNZ Engineering and Positioning workshop on 31 July at the Novotel Auckland Airport.

Laura Coll McLaughlin

This edition we are continuing our professional profile series with West Coast-based S+SNZ member Laura Coll McLaughlin.

Laura is a licensed cadastral surveyor and planning consultant with Chris J Coll Surveying Ltd in Westport. She is an associate member of Survey and Spatial New Zealand and the New Zealand Planning Institute and holds a Bachelor of Surveying with first class honours.

In October 2019, Laura was elected to the West Coast Regional Council to represent the Buller constituency. She is the chair of the Homebuilders West Coast Trust board, an adult literacy and numeracy tutor and a member of Buller Surf Rescue. In 2015, she completed Development West Coast's Leadership and Governance Programme.

Laura has served as the education representative for S+SNZ, and as the secretary-treasurer and Young Surveyors Group representative for the Westland Branch. She lives with her husband and son on their drystock farm outside of Westport. Laura is a sixth-generation West Coaster.

What does your role as a West Coast Regional councillor involve?

It has been a bit of a baptism of fire so far. We have regular council meetings and workshops. There is a lot of reading – luckily, I love reading. I also attend community meetings and hold drop-in sessions. I meet with ratepayers over matters of concern to them and also communicate with them via email, telephone, social media and my website. My regular column for our local newspaper has been well received.

I have also been appointed to a number of additional roles. In 2019, the Local Government Commission determined that the obligation to create a new West Coast one district plan (Te Tai o Poutini Plan) would transfer to the West Coast Regional Council. The plan committee is composed of the mayors of the Buller, Grey and Westland districts, the chair of the West Coast Regional Council, representatives appointed by Te Rūnanga o Ngāti Waewae and Te Rūnanga o Makaawhio, one additional appointment from each council and an independent chair. I was over the moon to be appointed to this committee.

The Te Tai o Poutini Plan was a catalyst for my standing for election. I actually submitted in opposition during consultation. However, given that we must now create it, I want us to secure the full benefit. My focus is that the plan reflects local needs, voices and values. I am fairly fervent about grassroots democracy. I believe that devolved and decentralised decision-making empowers people to live responsibly and sustainably. Anything that disempowers communities, encourages apathy or "checking out" is not OK with me.

I will be undergoing commissioner training so that I am able to sit on hearing panels for resource consent applications. This will support my district plan work, but it is also important to have councillors trained as commissioners. Independent commissioners are typically more expensive than elected members and it is important to keep costs down for applicants.

I have also been appointed to the Westport 2100 Working Group. This group looked at hazard planning for future generations with a particular focus on flooding risk from the Buller River. In February, I was appointed to Local Gov-

ernment New Zealand's national Policy Advisory Group. I am excited to bring a West Coast voice to the table and to create strong networks with other regions. I'm very passionate about doing what I can to bridge the city-country divide and facilitating more positive and optimistic conversations between urban and provincial New Zealand.

What are your key priorities as an elected member?

My three key priorities are encouraging community engagement, direct reporting to ratepayers and responsible fiscal decision making.

In terms of voter turnout for local body elections, the West Coast actually fares really well. I think it is the role of councillors to maintain engagement. For most people, local government is something they only think about when they are required to have direct interaction such as when they pay their rates or need a building consent. I'm working hard to report directly to my community via a number of different channels. I think this is all part of a critical feedback loop. Local governance needs to be a two-way conversation. Everyone stops listening when they feel the other party is doing all the talking.

I think that most West Coasters live where we do because we value community and we love our natural environment. However, a reality of life here is that we have a small population and relatively little freehold land to leverage for economic growth. Consequently, we need to be prudent with our spending and wise with our investing. Councils throughout the country are being faced with a deluge of central government legislation and policy at present. Much of what is proposed will have particularly significant but as yet unknown effects on the work of regional councils. Small councils, like ours, are especially anxious. The cost of implementing these new obligations is of great concern to me.

What does your surveying role entail?

Our firm provides many services such as cadastral surveying, hydrographic and river monitoring surveys, engineering and construction surveying, UAV surveying and photography, photogrammetry, topographical surveying, mine surveying (underground and opencast) and land development engineering inspections. I am involved with virtually all of this work. I have also been doing a lot more resource management planning in recent times and, in addition to the usual subdivision consenting, have being working on land use consents and plan changes.

An unexpected benefit of being a surveyor is the amount of community respect that I feel that I receive. I don't know if this is related to the West Coast community being a relatively small one, but I really feel that my being a "professional" carries weight. This became clear during my campaign. I was quite chuffed.

How long have you been surveying?

I finished Survey School at the end of 2008 and started working for the company then. I became licensed in 2012. However, I guess you could say that I have been surveying in an "unpaid capacity" a lot longer than that. My first, clear "surveying memory" is holding the levelling staff for Dad at the Waiuta gold mine near Reefton when I was about six (this was well and truly before JHAs were mandatory!). I also have a vague memory of climbing over the baby gate when I was still in nappies and letting myself into the office adjoining our old house. Mum heard me scream and rushed out to find me with a very grumpy face and very black teeth after I had bitten through the ink cartridge of one of her draughting pens. I can still remember what the ink tasted like.

What are some of the challenges and opportunities you've had in balancing work, volunteering and family in your professional career?

Despite being a surveyor, I don't have very good boundaries between my work, political, volunteering and home lives (excuse the terrible pun). I think this dilemma can be particularly acute with a family business. It is typical for me to discuss surveying and council work at any hour of the day (or night). My husband grew up in a family business, so he is very tolerant, thankfully. My three-year-old son has already been out in the field with me, so it is probably going to be too normal for him as well.

At present, the biggest challenge that I am facing is saying "no" and not taking too much on. I know that a lot of people look at somewhere like the West Coast and think there are too few opportunities for professional or personal advancement. However, in my experience, the exact opposite has been true. I do not know if I would have been able to experience the same range of projects elsewhere. I have also had a lot of leadership and governance opportunities that I am grateful for.

Having been back on the Coast for just over a decade after being at boarding school and university, I now have strong networks within my community and a lot of wonderful people who are willing to give me advice and offer mentoring. Also, luckily for me, my entire family has a problem with volunteering too much, so they are all very supportive of me when I take on new roles or tasks.

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3 ISSUES
facing Professional Services firms *and how to overcome them*

Edward O'Leary, Abtrac Time Management & Invoicing Software

IT'S EASY TO COUNT INVENTORY AND TRACK SALES WHEN YOU'RE MAKING OR SELLING ITEMS OF STOCK. HOW DO YOU MANAGE SELLING TIME AND EXPERTISE IN A PROFESSIONAL SERVICES FIRM?

The thing with professional services firms is they don't make stuff. They don't sell stuff either. They sell expertise. That's their business, trying month by month like all businesses, to survive in the margin between total outgoings and total receipts. Working in this ecosystem requires business practices that inventory based systems simply don't support. They're not built for it.

Issue One:

When I left one of the big accounting firms to start Abtrac, I was adamant I'd never fill out another timesheet. "That's too corporate for me. I don't need all that palaver." But by the time we had 12 staff I realised at each month end I was lacking the details of what staff had actually done, and thus what to invoice was at times a 'best guess'. I realised if anyone queried an invoice, this particular business weakness could have been exposed.

Even though a lot of our work was on fixed fee contracts, I had to swallow my self-righteous pride and concede that having everyone keep up-to-date timesheets was the only way forward. I needed to know more about what was happening.

I then realised "If you measure it, you can manage it", was a real pearl of wisdom. It might not always be true in all facets of management. Sometimes you have to rely on intuition, comparatives, and broad ranging 'assessment tests' or personal feedback and opinion. But if you want

to justify why you're invoicing a client a certain fee value, you need some hard data to back it up. If you need to know how far through a project stage you've come and how far you still have to go, you also need hard data.

Confidence is not enough.

The biggest issue facing professional services firms of all sizes comes from not correctly measuring what has been done. In my former employment, we'd all joke about doing our weekly lie-sheet. It's no joke to me now. Every week I hear from others who've started a business or taken over the management of a business to realise they simply aren't on top of what is happening day by day and from one month to the next. They call us when they realise that keeping up-to-date timesheets is the only way forward.

Issue Two:

"Second verse, same as the first!" A fee of $50,000 is earned by putting in hundreds of hours of work in a typical professional services business. Nobody can manage a fee of that size unless they break it up into smaller chunks. Converting each chunk into 'things to be done' also means converting dollars into hours per chunk. Without being obsessive about it, (OK maybe I am, but it's from experience), you don't suddenly run over budget on a fee of $50,000. It happens gradually, literally hour by hour. You want to come in pretty close to your $50,000. That's the budget. To achieve that you have to measure how each person on the team is performing vis-à-vis who is supposed to be doing what and when. Few chunks of work should be 40 hours or more. Much more than that and you'll lose it. Many might be less than 4 hours.

Every day imagine you're climbing Everest. Every step has to be planned, because every step counts towards the end goal. The success of the outcome is in the planning, and then keeping on top of how you're going versus your budget for each bit of work. Planned time is as important as actual time.

Honestly, the quality doesn't cost any more. In fact it doesn't cost at all. It saves! It could save you thousands of dollars on one job alone, and it'll make a huge difference across all the jobs in your office.

Issue Three:

As projects progress, sometimes the client changes their mind. And sometimes other parties or external factors force a change to the scope of work. The result is often "extras" or "variations". You have an agreement and a planned fee for service. As the scope of work changes, signal this to the client ASAP. Agree on how each change affects the original fee. Changes are a fact of life and while the client may have relied on your professional knowledge to foresee the unforeseen, the longer you leave each variation as it arises, the more difficult it is to raise the topic and discuss the additional costs involved. I'm a bit of a sucker myself and we try to keep our clients as happy as possible. But a hard-nosed friend once told me "generosity breeds greed, not gratitude". Whether that's correct or not I'm never sure. Either way, there's never any harm in raising the issue of 'extras' with a client and asking the question about payment.

Forget Your Spreadsheets!

To support all of this you need a quality business support system. It doesn't have to be the most expensive, but it should tick all of the boxes above. I love Excel. But running a project on it is asking for trouble and running your whole business on it and then also invoicing from it is not only risky, but it's **totally unnecessary**.

A good software package will enable significantly more sharing of information. The data in it will be up to date and everyone has access to whatever they need to access, be it simply entering their **timesheet** for the morning's work, adjusting forward their **schedule** of planned time, or running their favourite **project management report**. You don't want to find out at month end that you blew your budget three weeks ago. And you don't want to spend hours of your time nursing custom spreadsheets to figure out what to invoice when a **commercial system** brings the value of input from thousands of people in businesses like yours.

'FRESH FACES'

Richard Hemi

The new year at Survey School sees a number of new faces in the staff room with recent retirements and people moving on. In 2019 both Alastair Neaves and Ray McLennan retired from the technical support section after more than 50 cumulative years of service to the school.

Alastair attended his first surveying camp on the Taieri in 1986 and has worked continuously since that time until last year. His retirement caps off a significant contribution to the school spanning 34 years, with about 1500 surveying students having enjoyed Alastair's tutelage at practicals, camps and Scrum Room events.

Ray McLennan has also provided a long and valued contribution to the school over an extended period of time. He started at the school in the late 1970s, left in 1992 for work in Bahrain and back in New Zealand at LINZ, but returned to the university in 2010.

While their faces may be fresh, the new appointments to replace Alastair and Ray both have an existing association with the school. Craig Tidey has been appointed the new senior technical officer and has already enjoyed a return to the survey camp at Otematata, which he attended as a student in the 2000s.

Craig joins wife Emily Tidey, our current hydrographic lecturer on staff, highlighting the fact that the school is indeed one happy family.

Judy Rodda has been a postgraduate of the school and has also been employed in various research assistant roles. She now joins the staff in the other vacated technical position.

In 2019 we welcomed Amber West to the school office and she joins Fiona Webster in a departmental administration role. Amber's appointment, in part, fills the space that was created by the retirement of long-serving staff member Marg Newall. Marg was another person who has made a major contribution to the running of the school, and she was a very friendly and helpful person to both staff and students alike.

Her broad knowledge of the survey industry, employer relationships, and student issues was an invaluable asset to the school for 21 years.

The academic teaching staff have been joined this year by James Berghan, who takes over the urban design role vacated by Dr Crystal Filep. While only here for a relatively short period, Crystal had a very positive effect on the teaching of urban design within the school.

In mid-2019 however, she took up a position as an urban designer with Wellington City Council and has already been promoted to a more senior role. Crystal remains a member of the S+SNZ conference technical committee.

James was a BSurv graduate of the school and worked for CKL in Hamilton where he became a licensed cadastral surveyor. In 2017 James returned to the school to complete a PhD on urban papakainga and co-housing. We are very excited to welcome James back to the school in a teaching role.

It is the start of a new university semester and at this time of year we are also welcoming the fresh faces of new students arriving to start their surveying and spatial studies. We are pleased to see an increase in the size of our first-year intake which bodes well for the years ahead.

Furthermore, there is also a small increase in enrolments in the alternative surveying and spatial degrees offered – BSc degrees in land planning and development, measurement and GIS – some of which can be taken as majors or minors in combination with other Otago degrees.

While there is always room for improvement and growth – particularly in under-represented groups – the numbers represent a moderate but welcome increase in new student numbers.

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