SURVEYING + SPATIAL

September 2018
Issue 95

Land administration – will technology supersede people?

City Rail Link – NZ's largest infrastructure project

Achieving superior survey data from drones

Survey and Spatial New Zealand
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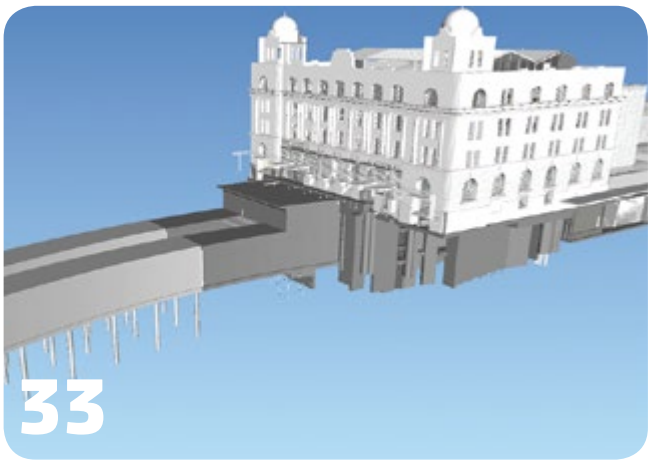

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Growing market for the industry

Rachel Harris

Survey and spatial professionals engaged in the construction and engineering industries will certainly be very active in the field right now with many major project developments coming to fruition in New Zealand's construction boom.

According to the Treasury, the forecast infrastructure spend from 2015-2025 is estimated at more than $110 billion, with several large-scale construction and infrastructure projects pending or currently under way, including Auckland's estimated $3.4 billion City Rail Link project (on which we have a engineering stream member's report this edition), Auckland Airport's 30-year growth plan, the Waikato Expressway, Wellington's Transmission Gully motorway project, and numerous Christchurch and Kaikōura rebuild projects, to name just a few.

The Ministry of Business, Innovation and Employment reports that career prospects for surveyors and geospatial professionals are very positive at present, particularly in the major-project cities of Auckland and Christchurch. A growing infrastructure market, along with an increasing demand for geospatial services and qualified professionals, is certainly ensuring a strong and optimistic future for the surveying and spatial industry.

This edition features a broad range of topics from across the surveying and spatial sectors, from a legal case study on equitable easements, to the essentials of a drone geo-referencing system, and a student perspective on supporting the future of GIS.

Daniel Wiederkehr, of Calibre Consulting Ltd, reports on the development of Auckland's City Rail Link project, currently the country's largest infrastructure project.

From the Hydrographic Stream, University of Otago Hydrographic Surveying lecturer Emily Tidey and students from the university have compiled an account of the annual Hydro Day event, held during the Survey and Spatial New Zealand conference in Nelson. The day's events included a tour of Port Nelson's operation and presentations ranging from hydrographic research through to technological advancements in the field.

Duane Wilkins, of LINZ, has provided another insightful 'top 10 interesting geospatial sites' article for our Spatial Stream this edition, with a look at some fascinating maps, imagery, virtual reality and tracks that can be discovered online.

And Claire Buxton and US-based Melissa Harrington present an analysis of the relationship between technological advancements and the human touch in land administration, examining current land trends, emerging technologies, artificial intelligence and the opportunities in the future of the geospatial industry.

Land Information New Zealand
Toitū te whenua

Tena koutou katoa,

In August Mark Dyer resigned his position as Surveyor-General to return to the private sector and pursue his interests in consulting and governance. I've been the Deputy Surveyor-General since 2005, first under Don Grant and since 2014 under Mark Dyer and will be acting in the role until a permanent replacement is found.

In taking up this acting role, I'm conscious of a number of issues and challenges facing surveyors and the cadastral survey system. On a recent visit to Auckland, I learnt of the massive amount of property development work that is required to address the housing shortage. The new Unitary Plan incentivises existing property owners to develop additional dwellings, often in conjunction with neighbours and often involving the removal of the existing house. While the survey work itself may not be complex, the huge number of such developments will place increasing demand on surveyors. This will require processes and standards that give certainty and confidence that developments can be completed in a timely manner. Recently we met with Auckland Council and NZIS representatives to consider the addressing requirements on such infill developments to ensure that they don't delay the project or unnecessarily upset neighbours.

I was also made aware of the need to improve the efficiency of unit title development through the use of digital data. Our architectural colleagues are producing 3D models of the developments that can provide the basis for production of 3D digital cadastral survey datasets. Our plans for Landonline under the Advanced Survey and Title Services programme address this need, although not in the early phases.

Surveyors have also made it very clear that the 2010 Rules are causing a lot of problems. We will certainly address those concerns, but also ensure that reviewed rules enable surveyors to better utilise digital technologies in both the field and office when undertaking their cadastral work.

We've really appreciated the contribution that surveyors have made to both ASaTS and the rules review through the Working Group and Reference Group respectively. We look forward to further liaison with surveyors on these intertwined projects as we look to develop the cadastral survey system to the next level.

Anselm Haanen
Acting Surveyor-General

THE INTRODUCTION OF A TRADING NAME MARKS AN IMPORTANT MILESTONE IN OUR HISTORY.

As an organisation that is very keen to grow its young professional and spatial membership, coupled with an external environment that is rapidly evolving, we needed to do something slightly radical to ensure our future success. 'Survey and Spatial New Zealand' is our way of opening our arms to the spatial profession, and showing potential members we are serious about offering them a home. It will ensure our profession remains highly relevant, without forgetting our traditional surveying origins.

Council acknowledges that not every member will have been comfortable with the outcome of our recent trading name vote. Please be assured that we do not underestimate the mana that our historic name has and the emotion attached to it. National Office is now implementing a marketing plan to ensure our stakeholders and the public know where we have come from and what we stand for.

Certification update

The working group is very close to having a completed paper for the consideration and approval by Council. We have simplified the structure, attempting to more clearly define requirements for each practise area and the application process. We are really looking forward to publishing this for members and moving the review process forward. It has been a long and arduous process, but we know it has to be right. Thank you for those who have provided input to date, and for your patience and understanding.

NZVD2016 Hawke's Bay Pilot update

The pilot is the start of a joint Survey and Spatial NZ and LINZ advocacy initiative to encourage Local Authorities to actively use NZVD2016. Terms of Reference have been drafted, and a working group assembled which is chaired by Guy Panckhurst. Other members are from the Positioning and Measurement Stream, LINZ, and the Hawke's Bay Branch, with National Office providing support. A presentation and workshop will be held

(continued page 11)

Cadastral

As you may be aware, there is currently a case before the Environment Court to determine if conversion of a cross lease to fee simple title is a subdivision under the RMA. The judge has heard the case and reserved the decision. At the time of writing, the judge is still deliberating and we will ensure that once the decision is released, we will forward it to all members.

We have also asked for members to help contribute to the submission that the stream is making on the Rules for Cadastral Survey review. By the time of publication, this submission will have been made with LINZ.

A project has been undertaken to re-establish an online version of the *Land Title Surveys in NZ* book that was first published in 2012. The new platform will give greater flexibility for members to interact with the content and allows posting of comments and suggested edits. It also has the flexibility to accommodate various levels of editing permissions. The book will be available to all members through a weblink.

A seminar is also planned for later this year. The topic this year is 'Good Survey Practice'. Like the GNSS seminar we hosted last year, this seminar will also be available via a live stream so members who cannot make the venue in person can still view and participate via a web link.

As usual, the Cadastral Stream exec welcomes feedback from members and can be contacted via National Office.

Matt Ryder, Cadastral Stream Chair

Engineering

For the first time, NZIS (now trading as Survey and Spatial New Zealand) had a presence at the annual Civil Contractors New Zealand (CCNZ) and Association of Consulting Engineers New Zealand (ACENZ) conference. The event was held at Claudelands Showgrounds in Hamilton, from August 1 to 3.

Max Will, NZIS's Marketing and Events Coordinator, flew up from National Office in Wellington and put together an excellent little stall, right at the entrance to the plenary room. There was a little competition to draw an artistic sketch of a tower bridge in 60 seconds, which gained the engagement of the delegates. From there we asked if they employed or contracted surveyors, which led on to an explanation of our organisation and the benefits we offer to our members such as CPD training and certification.

We were then able to paint a picture of why an organisation should look for our brand when engaging with surveyors. The objective of our presence there was visibility, which we feel we achieved. Most delegates were keen to get back to networking around lunch, but next time they pick up the phone to call a surveyor, they may at least remember that there is a professional organisation they can look to first to find the best.

Michael Cutfield, Engineering Surveying Stream Chair

Hydrography

Members of the HPS leadership team attended a national forum of the Port and Harbour Marine Safety Code on July 5, in Wellington. A number of guidelines associated with the code are being reviewed, including Good Practice for Hydrographic Surveys in New Zealand Ports and Harbours.

Originally produced in 2004, the document needs updating to reflect advances in technologies and the need to have qualified surveyors undertake the surveys. The review is being led by Maritime New Zealand and LINZ and will draw on the expertise of the HPS members.

We look forward to seeing many HPS members at HYDRO18 in Sydney from October 30 to November 2. The international conference theme is: 'The Climate for Change – Hydrography in the 21st Century', and will feature a wide range of presentations, workshops and exhibitions. Registration and further details can be found at: *www.hydro18.ahs.asn.au/home*.

The 76th International Multibeam Sonar Training Course will be held at the Australian Institute of Marine Science in Townsville, Australia from 19-24 November 2018. Register at: www.acousticimaging.com.

The LINZ survey supplier panel (DML and iXblue) will be surveying in Eastern Bay of Plenty (East Cape, Whakaari/White Island and Moutohora Island) and Fiordland (Doubtful, Thompson and Dusky Sounds) this coming year. These areas have been prioritised following the New Zealand Hydrographic Risk Assessment, which identified them as a 'heightened' risk based on the volume and type of traffic navigating the areas, as well as the quality of the underlying data.

Emily Tidey and Stuart Caie (HPS leadership team)

Land Development Urban Design

A key focus of the Land Development and Urban Design Stream Committee has recently been the Draft National

Planning Standards. This sets out the government's intention to introduce national standards that will require regional and district plans to be prepared in a standardised format with common terminology, layout and definitions. In essence, the draft standards lay out a structure as to how documents are laid out (parts, chapters, sections). It appears to be an exciting step towards more consistency in planning documents which should find favour with surveyors.

The Land Development and Urban Design Stream Committee, with the assistance of Karin Knedler, Advocacy and Policy Manager, National Office, has made a high-level submission generally supporting the proposed standards and providing some specific suggestions on definitions and a few other matters. We will keep members updated on progress as the process continues.

Julia Glass, LDUD Stream Chair

Positioning and Measurement

The Positioning and Measurement Stream has been working with the Engineering Survey Stream to prepare for the second annual Positioning & Measurement and Engineering Surveying Day Seminar, which will be held on Friday, October 26, 2018.

This year's event will again be held at Novotel Auckland Airport, a venue that is easily accessible to those both in and out of town. There is a great speaker line-up and we will cover topics such as construction intelligence, SBAS, NZVD2016 and evolving measurement technologies. There will also be plenty of opportunity for networking and getting more involved with Survey and Spatial New Zealand.

More information and tickets will be available on the Survey and Spatial New Zealand website closer to the 26 October.

Rachelle Winefield,
Positioning and Measurement Stream Chair

Spatial

The Spatial Professional Stream (SPS) has focused this quarter on RP Spatial certification. A working paper has been circulated to members and the wider industry for feedback, which is due at the end of August. We are encouraging feedback from all spatial professionals and employers – the working paper is available from the Survey and Spatial NZ website on the Spatial Stream group page.

The SPS has also been refreshing our Spatial Strategy and Work Plan, and we are working to further develop some of our key value areas for members. We are still working to grow our spatial membership, and have some exciting initiatives in place for the remainder of the financial year. We are looking to the support of the Board to action them, so keep an eye out for those. As always, feedback and suggestions from members really helps us to shape our goals, so we really appreciate your engagement.

The SPS has also been very pleased with the support for a name change to Survey and Spatial New Zealand. This change reflects the growing scope and membership of the institute and gives us further traction and visibility for our spatial members.

The applications for the 2018 NZ Spatial Excellence Awards have now closed and judging of the entries is under way. We are looking forward to the showcase of finalists, and the awards event on October 17 at Te Papa, Wellington.

The committee has met twice this quarter, and we continue with our support for selected spatial events, and representation on relevant external committees.

A reminder that the FIG Commission 3 Workshop and Annual Meeting will be held from December 3 to December 6 in Napoli. The theme for this meeting is: 'Spatial Information in the Era of Data Science: Challenges and Practical Solutions'.

As always, we encourage and welcome feedback and input from spatial members to the committee as we work to develop a stronger spatial professional representation and value proposition.

Dr Kat Salm, SPS Stream Chair

Note from last edition on 'Hochstetter's Lost Survey'

In regards to the *Hochstetter's Lost Survey of the Pink and White Terraces at Lake Rotomahana* article in June 2018's edition of *Surveying+Spatial:*

- The article was mostly Bunn's own work, with only limited technical assistance from the other authors named.
- Any conclusions are Bunn's own, and are not necessarily supported by Nick Davies, David Stewart, or Cheal Consultants.

David Stewart, Senior Surveyor,
Cheal Consultants Ltd.

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What it takes to get the best possible survey data from drones

(or everything you forgot in Photogrammetry 101)

Rob Klau

PHOTOGRAMMETRY IS THE NEW BLACK. WE PROBABLY ALL COVERED SOME SORT OF PHOTOGRAMMETRY AT UNI, BACK IN THE DAY, AND QUICKLY FORGOT IT, EXCEPT FOR THE SELECT FEW WHO ENDED UP WORKING IN MANNED AERIAL MAPPING. UNTIL A FEW YEARS AGO, IT WAS A DARK ART PRACTISED BY THIS HANDFUL OF SPECIALISTS IN THE COUNTRY.

Then along came drones. And photogrammetry is back on the map, so to speak. And with the drones come the drone guys, who now think they're surveyors ... but that's another story. Regardless of whether you're a drone guy or a professional surveyor, chances are there's a lot you need to catch up on with photogrammetry. Sure, you can capture some data with your drone and throw it at a cloud service or hit GO on your desktop software, but if you need to stand by your product as a professional, hang your hat on it, knowing that your results are right and are the best that can be achieved, then you need to go a little deeper.

This article highlights the essential details of a drone geo-referencing system to achieve accurate, reliable and repeatable 3D surveys.

How photogrammetry works

The simplest form of photogrammetry, two photos in a stereo viewer, effectively places each of your eyeballs in

the sky, where the photos were taken. A tower in a photo will tend to lean towards the nearest edge of the photo. That lateral displacement of the pixels of the top of the tower, as it matches up with the similar effect in the next photo, determines the height of the tower.

This process is managed digitally in your photogrammetry software, with any point in a project typically appearing in five or six photos. A typical small mission may have 500 photos at 20 million pixels each, or 10 billion pixels to smash together and make sense of. No wonder it takes hours of your best computer.

Errors

Achieving the best possible absolute accuracy with UAVs and photogrammetry requires an understanding of a wide range of errors and how they propagate in the system. Aerial data capture is just that, aerial or remotely sensed, and it needs to be tied to the ground in some way if you want to consider it to be a survey product.

Photogrammetry, with any data, may create a DSM (digital surface model), orthophoto or 3D mesh model that looks great to the eye, but is it a 'survey' product? Can you measure and digitise on that digital version of reality? Is it in a real survey coordinate system or frame of reference. How accurate is it in both a relative and absolute sense?

GSD

Aerial imagery may be captured with a very small GSD (ground sampling distance or pixel size on the ground) but it doesn't make it accurate. Obviously, the GSD in a drone photo will be much smaller than that from a manned aircraft or satellite, and though this does achieve a higher level of detail in the resultant model, it doesn't necessarily mean higher accuracy.

Accuracy, relative and absolute

Without accuracy, your model will have warps and wobbles or gross spatial shifts that can be very significant as we try to use this mapping for survey grade measurements.

Some may consider a project to have good 'relative' accuracy, which would work to measure a stockpile relative to the surrounding terrain, but does it have 'absolute' accuracy? Can you digitise on it and merge it with your engineering design? Can you fly it again, at a later date, to compare surfaces or inspect the same asset detail? Absolute accuracy means every part of that model corresponds to the real world, in a real-world coordinate system.

So where do these errors come from? What do we need to do to tie a 3D virtual world from aerial photos to the real world we survey on the ground every day. Now we delve into the secrets of the dark art of photogrammetry!

GCPs

GCPs (ground control points) are the obvious traditional way of tying a photogrammetry model to the ground.

The limitations of surveying a network of ground targets across an entire project quickly become evident. Though a drone mission may only take minutes, travelling around a site to place GCPs can be time consuming and costly. On a mine site, this may take days for inductions and vehicle compliance. On a corridor survey, the distances to be covered are huge. Some sites may be totally inaccessible or hazardous to walk over to place GCPs. Smart GCPs may save you the time of taking an RTK shot, but you then have to travel around the site again to retrieve them, if they're still there.

Even if access is possible, and the time is spent to place GCPs, errors creep in to the model between the GCPs as the matching process does its best to create a 3D model from the errors in less than perfect photos. So, what are these errors and what makes a great mapping system?

Photo distortion

Cameras often used on UAVs may have great specs if you're a media photographer, but to capture photos for creating models for virtual surveying, measurement and digitising, the criteria is totally different. It's not all about pixel count.

The placement of each pixel in each photo determines the accuracy achieved on the ground. Each photo has errors due to many variable factors such as geometric pixel distortion caused by aircraft motion and vibration, lens distortions, image blur and many other small factors which combine to contribute significantly to the errors in the results.

Shutter type

Stay away from cameras with an electronic or rolling shutter. These shutters effectively scan the pixels into the photo from one end to the other, so any movement during the exposure will skew the images. A leaf shutter, or mechanical shutter, will capture every pixel at the same instant.

Focal length

The lens in the camera on your drone will have a certain focal length defined by the manufacturer. When we're trying to place pixels to measure centimetres from 100 metres away, the actual focal length is critical. Cameras with fixed lenses, such as aerial cameras in manned aircraft or the small DJI cameras in the Phantom 4, can be calibrated as they have no moving parts. If you don't have a calibrated lens, your photogrammetry software will use GCPs to determine this unknown through many processing iterations.

Camera calibration

Errors in the lens focal length effectively zoom the terrain up and down in photogrammetry. Distortions push pixels out of place randomly, introducing additional processing complexity and errors.

Typical photogrammetry processing software normally does a camera self-calibration for each project and estimates the camera distortion parameters. A camera that has been professionally pre-calibrated will have stronger lens parameters and produce better results than an on-project calibration.

PPK

Putting the survey control in the air, rather than on GCPs, is a great step towards increasing efficiency and absolute accuracy. A blanket of control over the whole site, hundreds of control points at each click of the camera, using RTK or PPK in the drone or aircraft.

PPK overcomes many of the limitations of RTK. The processing algorithm is similar, but PPK uses all of the data collected at the base and rover to process after the mission. RTK sends base data to the rover via a radio link, which can be unreliable around obstructions and over distance. As we don't need to produce real-time coordinates, PPK data processing is more robust, with no gaps in the data, and solid reliable processing.

Centre of exposure timing

The main criteria in achieving accurate PPK positioning is capturing accurate centre of exposure timing. This must be done at the shutter or via a calibrated flash output that is set up to give consistent synchronisation. If your drone is travelling at 10m/s and you have a 20 millisecond error in timing, then you are introducing a 200mm error in position.

Reliable GNSS positioning technology

There are many positioning systems on the market, from very cheap L1 RTK systems to sophisticated and robust PPK systems, with various levels of accuracy, range, reliability and cost. High-end GNSS boards have advanced interference mitigation, coping with high or low temperatures and humidity without loss of data. L1/L2 is essential over longer distances, and additional bands and satellite constellations extend the operation into difficult environments with low satellite visibility.

Lever arm corrections

So, with your accurate post-processed GNSS measurements, you'll know where the antenna was for each camera event. But with that howling Wellington wind, the drone is pitched to the south for the entire mission.

The roll pitch and yaw of the drone are applied, with lever arm measurements (distances from the antenna to the camera in X, Y and Z of the aircraft) to correct the positions to the camera centre, no matter how the drone is tilted.

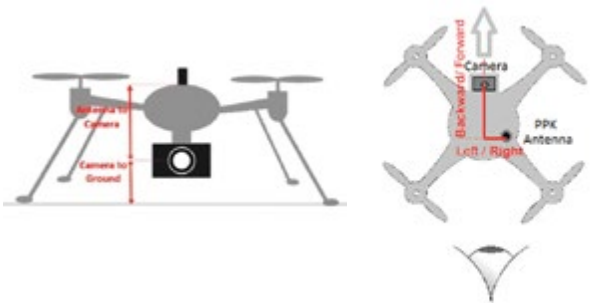

Figure1. 3D lever arm correction settings. The left image shows the vertical offset and right image shows the horizontal antenna/camera offset.

Camera attitude

No, it's not about your camera talking back, this is the direction the camera is pointed when each photo is taken. This is captured from another IMU, on the camera gimbal. Though this data is quickly updated in the photogramme-

try processing, it does give the processing a good starting point to project the overlapping photos onto each other in the matching process.

Direct georeferencing

Combining accurate camera positions, with lever arm corrections, lens calibration and camera attitude data is called direct georeferencing.

To gain real efficiency in aerial mapping, manned or unmanned, direct georeferencing is the solution. This combination of methods reduces or removes the need for GCPs, greatly improves photogrammetry processing time and increases the accuracy of the resultant 3D models.

Direct georeferencing requires more inputs than traditional photogrammetry, including accurate camera positions, determined using aircraft IMU data to apply lever arm corrections, applying lens calibration and camera IMU orientation data. With more inputs, your photogrammetry processing has fewer unknowns, so it will achieve better results much faster. You are telling your software exactly where the photos were taken, with the exact focal length and direction that the camera was pointing for each photo.

Now, let's think back to how we used to do it. The camera positioning accuracy was around 3m to 5m, no idea where it was looking, and with an error in the lens, zooming the images closer or further than they should. Your photogrammetry software would start with some GCP coordinates picked in photos and then run through iteration after iteration, with billions of pixels, matching photos and trying to reverse engineer the camera coordinates and the actual lens calibration. Give your photogrammetry software these variables up front and it's already most of the way through the processing, cutting hours of compute time while increasing accuracy.

Attention to detail is what makes great photogrammetry. Best data in means best results out, in terms of quality, accuracy, time efficiency and cost efficiency.

Coordinate system and geodetic corrections

Getting your geodesy right. Many surveyors get used to working in grid coordinates on orthometric heights, in typical local grid coordinate systems. Now we're working with GNSS, in a global reference frame, and though many of the processes are simplified or automated, it pays to understand what's going on. You remember studying all about ellipsoids, geoids, datums and projections, scale factors, convergence and corrections… Well, now it's time to brush up.

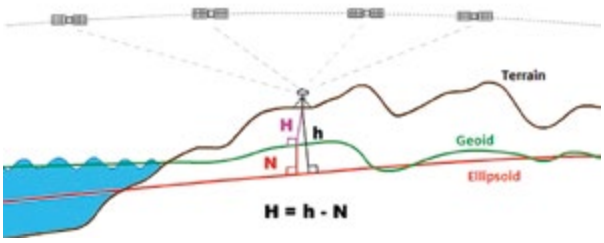

Figure 2. Ellipsoid and geoid separation. H is the orthometric height used in engineering and survey applications, h is the ellipsoidal height measured by a GNSS receiver and N is the geoid separation.

Another important factor to consider is the conversion between geographic latitude and longitude to a planimetric projection system. This could be a published coordinate system defined by national geoscience organisations, or a localised site coordinate system and datum.

The basic PPK and RTK GNSS positioning products on the market will capture global geographic WGS84 coordinates; latitude, longitude and height above the ellipsoid. For real-world surveying applications, these positions will need to be converted to the local coordinate system using published parameters and applying the local geoid model to best estimate the orthometric heights on the project.

Site localisation is often required for building site or projects on an arbitrary system. Surveyors will need to apply localisation files from their RTK survey system to transform the drone photos to this local system, or capture a set of control points with coordinates in both the local and global systems to perform the transformation and confirm the accuracy of the transformation with residuals on each point.

With a basic RTK/PPK system you will need to manage this using external software. More sophisticated PPK systems will have the capability to manage coordinate systems and site localisation.

And CHECKS!

Check your work! Don't trust any salesman or manufacturer, be able to prove your work, to stand by it with your professional reputation and your survey licence. Have some checks on the ground, targets that you've independently surveyed or objects you can compare to in some way to previous survey or existing data. Like any survey, you need to measure just how accurate your survey is.

The timing is good now to consider drones for your surveying applications. The drone hype has passed and serious professional products are available now for surveyors.

Contributed by Rob Klau, BSurv (UNSW), ESP-AP SSSI, Director of Klau Geomatics Pty Ltd, manufacturer of KlauPPK: www.klauppk.com. KlauPPK addresses all of the details raised in this article.

Meet Survey and Spatial New Zealand – formerly known as NZIS.

Voting members agreed to the new name in a recent ballot. The legal name New Zealand Institute of Surveyors Inc. remains in place.

Survey and Spatial New Zealand President, Rebecca Strang, says "the new name reflects an important milestone in our history. It builds on our proud history and encourages better collaboration, diversity and engagement in the future."

"As an organisation, we must acknowledge our heritage and our current strengths. We also need to consider how we move forward in an external environment that is rapidly evolving. We are serious about ensuring everyone – current members, potential members, central and local government, all arms of the sector and our communities – understand how we are positioning ourselves for the future" says Rebecca.

"Our members are very diverse and make important contributions to the built environment. Working together helps us all remain at the cutting-edge of technology and retain relevance. There are outstanding opportunities ahead," says Rebecca, "as we continue to celebrate our role as professionals that create better communities throughout New Zealand".

Work is underway to implement the new name and to apply it across all communication platforms. The new website URL, **surveyspatialnz.org** will be rolled out and @surveyspatialnz.org emails will appear in people's inboxes.

Rebecca Strang, Survey and Spatial NZ President

(continued from p3)

with Local Authority officers and other interested parties to explain the benefits of NZVD2016, and the issues around using the present local datum. The results of the pilot will be reported to the stakeholder workshop in November.

Spatial stream strategy and work plan

The spatial stream committee recently shared their draft strategy and work plan for FY19. I won't steal their thunder by elaborating on the details, but can say there has been some serious thought put into this and impressive goals set for the year. I encourage all members to read and digest once it is made available to the membership.

Professional entrance exams

The examination panel members put an extraordinary number of hours into preparing and marking the law exam, reviewing projects and interviewing professional candidates. The recent law exam had 74 examinees creating a significant marking burden. We are looking into ways of making the process more efficient and less onerous on our volunteers. We are also looking to develop policy to provide more structure around processes and expectations for the law and professional exams.

Councillors' attendance at local branch meetings

Several branches are holding meetings over the next month or two. Councillors will be in attendance and available to update the membership on their particular Streams' plans as well as Council activities. I am looking forward to attending the Rotorua/BoP meeting later this month.

Rebecca Strang & Guy Panckhurst

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LAND RIGHTS – WILL TECHNOLOGY EVER REPLACE THE HUMAN TOUCH? FROM THE PERSPECTIVE OF MILLENNIALS

The Relationship between Technology and People in Land Tenure

Claire Buxton, New Zealand, and Melissa Harrington, New Zealand/USA

IT IS THE YEAR 2017, AND AN ARTIFICIALLY INTELLIGENT 'WOMAN' IS SAYING SHE WANTS TO HAVE A CHILD ON HER OWN ACCORD IN SAUDI ARABIA. IN THE SAME YEAR, TWO SMART MACHINES FROM MICROSOFT START TO COMMUNICATE IN THEIR OWN LANGUAGE THAT THEIR CREATORS DO NOT UNDERSTAND. IN GERMANY A DRIVERLESS BUS HAS TAKEN ITS FIRST PASSENGERS TO THE TRAIN STATION.[1] MEANWHILE, RESIDENTS OF SLUMS IN HARARE, ZIMBABWE, ARE STILL STRUGGLING TO BUILD HOUSES AND SAFE, SANITARY INFRASTRUCTURE.

The world is full of innovation, rapid technological change and economic disruption. But it is also a world of great disparity. In asking the question, will technology ever replace the human touch, we refer to the people side of land administration. It is a question that has been asked for many generations. The way people engage with technology is constantly changing. One example is the Luddites, who feared that knitting machines would replace their jobs in the textile industry. However, the textile industry still exists today and people work with these machines to create masterpieces. So, too, will the geospatial industry continue to exist alongside artificial intelligence (AI).

AI and automation are proof that technological advancement is not slowing down. But neither is poverty. This disparity and the digital divide is concerning. Geospatial professionals have a global responsibility to use their skills to help narrow the divide. However, as professionals we must tread with care and wisdom so as not to exacerbate the very same thing we are trying to combat. After all, technology only enables us to use our skills.

1. INTRODUCTION

Land administration is an evolving discipline. It generates discussion, debate and different perspectives on how things should be done. Combine this with emerging tech-

nologies and varying cultures, and land administration systems (LASs) can get very complicated.

First off, we dive into a discussion on how technology may go wrong if it is implemented incorrectly. Being millennials, we've written this in plain English so our message is not lost in unnecessary words. We encourage you, the reader, to think about the impact that changes in technology could have on people and their security of tenure.

In the second half, we summarise the following with reference to our research:

- Fundamental technologies for human survival
- Current land administration trends
- Emerging technologies that will influence the geospatial profession.

2. SETTING THE SCENE

The term millennial refers to the generation of people born between the early 1980s and early 2000s. Millennials like us have grown up during a time of rapid technological change, globalisation, and economic disruption. Our view is socio-technical. We respect social structures, roles and rights. But we also recognise that technology has its place in a spatially enabled society.

Technology is a common word used throughout this article. It is a broad term and we cannot use it without defining the type of technology we refer to. As Srinivasan puts it in his book, *Whose Global Village?: Rethinking how Technology Shapes Our World:* "Communities across the world, past and present, have always developed and crafted innovative tools, systems, and networks that shape social and cultural life".[2] Throughout this article, we have used the word technology when referring to these innovations: from basic tools for human survival through to the most advanced 'blue sky' technologies, which have come about rapidly in our lifetimes.

3. DISCUSSION

LASs vary in each country. Whether a country is economically successful or not, the improvement of existing systems is essential to ensure that they can adapt to change and meet global challenges.

Though the technical method of data capture may evolve from measuring angles and distances to high accuracy, GNSS software attached to a smartphone, the human involvement remains the same. We are "working with community members to identify boundaries, settle disputes, and register the rights of all land holders – women and men".[3] Below, we encourage you to think about the impact that these changes will have on our society and how to prepare for future challenges.

3.1 The digital divide

The digital divide is present in both developed and emerging nations. Not only does this divide exist due to economic reasons but it is also due to computer literacy and empowerment. The digital divide will continue to widen as the use of technology becomes commonplace in basic services.

3.1.1 Mobile Phones

One of the most significant technological advancements for land administration has been the use of mobile technology.

Globally, approximately 5 billion people have mobile phones.[4] Smartphone subscribers are expected to total 3.5 billion by 2019.[5] Of a global population of 7.6 billion, these numbers are impressive. But it must be remembered that those mobile phones and smartphones are of differing types. Most emerging nations' citizens who own a mobile phone have one that lacks access to the internet and multimedia. In fact, many mobile devices and applications are not even used for the intended purpose (a common theme also found in land administration trends). For example, a mobile phone is used for spotting crocodiles while hunting in New Guinea more than it is used to speak to another person.[6] Once a person has a mobile phone, they must pay to use it. The mobile charges may keep people in relative economic poverty. The rich/poor gap remains.[7]

There is a bit of a chicken and egg situation with basic needs infrastructure. In 2013, more people on earth had access to cellphones than toilets.[8] This is shocking. The residents of slums near Harare may not have running water, sewage reticulation or electricity, but they do have the opportunity to access mobile phones. In Harare South and Magada, Epworth, there are three mobile phone service providers that are accessible to residents.[9]

Can this be flipped around to be a positive thing? In embracing mobile technologies, those residents of Magada could bring themselves into a position where they can afford to buy basic needs materials. If they are able to accept that a right to their stand in a slum can be registered using a mobile LAS, they may see the benefit of investing and improving these basic needs infrastructures.

3.1.2 Internet

The internet is also commonly known as the world wide web. Is access to the 'web' actually worldwide? It is estimated that only 3 to 4 billion people have access to the internet.[10] Other sources suggest 3.58 billion[11] and 4.05 billion.[12] When looking at all these numbers "... it is far too easy to assume that we live in the democratic 'global village'".[13]

To most people in developed countries, the word internet portrays an open source of knowledge, communication and entertainment. To many other people in both developed and emerging nations, the internet has a different meaning depending on their type of access. Warschauer (2004) writes that the most important thing is not so much the physical availability of computers and the internet but rather people's ability to make use of those technologies to engage in meaningful social practices. As such, we have separated access to the internet into two components, physical and public, below.

Physical access to the internet is the ability to access it through appropriate infrastructure and through a device. Just because a community has the fibre optic cable infrastructure, it does not mean every person within that community has direct access to the internet. They may not be able to afford a device to use the internet.

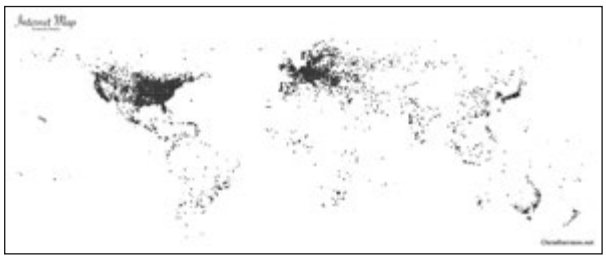

Figure 1: Chris Harrison Internet Connectivity (*www.chrisharrison.net/index.php/Visualizations/InternetMap*)

Public access relates to the constraints put on internet either through a government policy, through the person's IT literacy, a lack of economic resources, or through a filtered down version of internet supplied by certain companies.

The point here is that access alone to the internet and mobile phones cannot help people in need of assistance. This is why philanthropic initiatives like One Laptop per Child and Hole in the Wall are met with doubt.

Figure 2: Network Affect, Hole in the Wall (New Delhi, India): *www.networkaffect.org/blog-intro-india/*

What does this mean for us as geospatial professionals? It means we must recognise the digital divide and exercise digital responsibility when implementing a LAS. Developers must understand users and their relationship with land. We must all recognise that systems are used by a diverse audience with differing levels of empowerment and varying levels of access to information.[14]

3.2 Grass-roots design

"Land tenure is directly embedded in social identities and relations" – Cousins, 2017.

In our opinion, LASs that benefit people of emerging nations will only be sustainable when implemented by people who are members of the community, or else 'outsiders' who can remove themselves from their own unconscious bias. Tuhiwai-Smith, a Māori ethnographer says "researchers must let go of their attachments and embrace beliefs, values, and practices that differ from their own".[15] Although relating to ethnographic research, this is applicable to all those in the land administration sector who collaborate with communities outside of their own.

This is where free prior and informed consent (FPIC) comes in. Before implementing a fit-for-purpose LAS, the community should be given as much information as possible. It should be presented in their own language and their own customs without time constraints. Consent is not always given during the FPIC process, nor is it a one-off thing. It is an agreement between the agency and the community on how the project will be implemented. The agreement requires continuous participatory monitoring and evaluation.[16] We elaborate our discussion on evaluations further below.

During the FPIC process, the technology that is 'fit-for-purpose' should become clear. When taking a bottom-up approach, the focus is on the challenges trying to be solved and the information required. Only when these factors are identified, is it decided which technology to use (if any).[17]

Often systems are pushed upon nations by outsiders as they are seen to be the best solution. However, history suggests otherwise. Look at New Zealand, Aotearoa, for example. British settlers came in during a time when informal settling was happening by the French. In order to prevent the French taking advantage of the Māori, the British initiated a Western tenure system as was the

case with other British colonies. They thought they were doing Māori a favour in blessing them with this rigid system of recognising individual land rights. Now, it is clear that Aotearoa would not be what it is today without colonisation. But Aotearoa would be a different place altogether if the New Zealand Company had been open to a concept like FPIC. As land rights professionals, we must be careful not to rush in and recreate the same issues for communities we work in today. Otherwise we risk inflicting long-term conflict and cultural dilution on future generations.

Fit-for-purpose technology combined with FPIC methodologies will allow for transparency in land administration. Through making the community an active user and creator rather than a passive user of the systems, there is more chance of a sustainable solution.

3.3 Education – socialising our surveyors

"If you think education is expensive, try ignorance" – Derek Bok, 1975.

We recognise the importance of education and socialising. But do others in our profession? Having the right connections can not only help professionals improve individual job performance but also improve the solutions we provide for customers. We should network and advocate among all other professions, government agencies and communities. This will result in better collaboration with key stakeholders on land, spatial and governance issues.

Fit-for-purpose technology combined with FPIC methodologies will allow for transparency in land administration. Through making the community an active user and creator rather than a passive user of the systems, there is more chance of a sustainable solution.

We need to educate our profession and we need to educate the public. The surveying profession in New Zealand struggles to attract diversity. This could be due to the perceived persona of a surveyor: someone who is good at maths and likes the outdoors. But what about the person who had English as their strength at school? Could they not provide an element of diversity to the profession through being a good communicator? The programmes that we are aware of do not offer enough opportunity to socialise our young professionals into communities. Earlier this year, two engineering students approached Claire Buxton during her lunch break to ask if they could survey her about sea-level rise. Those students were required to do this questionnaire in order to learn how to communicate with the public. The benefits are twofold with a programme like this:

- The students gain social skills which are vital in the 'real world'
- The public learns more about the profession through exposure to the students.

3.4 Evaluation of effects (whose success criteria?)

Most communities have developed land tenure systems to suit their own specific needs and circumstances. The tenure systems differ within, and between, countries. They vary in terms of complexity which makes evaluating the effects of a LAS difficult.

"One third of the people on the planet … have no documented rights to the land they rely on".[18] There is a clear trend in land administration towards modern, socio-technical LASs that support spatially enabled societies and sustainable development. So, how does one measure the success of a modern LAS? Well, it depends on who is measuring it. This introduces the concept of unconscious bias. Your personal experiences and cultural background can have an impact on your decisions and actions without you realising it.[19]

Most aid programmes have an evaluation process. There have been many assessments of the technical applications, but what of a programme's effect on the community. Examples of recent evaluations we found were completed by USAID and Land Equity International. After the first pilot of the Mobile Application to Secure Tenure (MAST) in Tan-

zania, USAID developed a "rigorous impact evaluation" to evaluate the impact of MAST "on food security/livelihoods and perceptions of tenure security".[20] Land Equity International was engaged to do an independent evaluation of Solutions for Open Land Administration (SOLA) after it was piloted between 2010 and 2013 in Ghana, Nepal, and Samoa. The review was to focus "on the SOLA pilots from a user perspective rather than a technology perspective".[21] This is positive to read that the user was put first when evaluating these pilots but the question is: Were these evaluations themselves done in a participatory way?

This FAO FPIC Manual recommends a repeating continuous participatory monitoring and evaluation of the agreement during implementation.[22] Note the use of the word participatory. Both examples of evaluation above are not participatory: Land Equity's is independent and USAID's is rigorous, but neither are participatory. An even better approach to evaluation may be to employ a member of the community who was involved in the implementation of a LAS and stay in contact with them. Then, get them to evaluate the effects with their own social tests or success criteria to compare against every year. This can link into the agreement reached through FPIC.

4. FUNDAMENTAL TECHNOLOGIES

Not everything has to be brand spanking new, high spec and hi-tech when discussing technology. We have written this section in an attempt to make you think about what technology means to the people you work with.

4.1 Essential technologies

Chirisa looks into the vital role that appropriate technology can play in the transformation of peri-urban residential spaces near Harare, Zimbabwe. To Harare slum residents, new technology is building tools like farm bricks and ash toilets. Technology like this allows the communities to avoid typhoid caused by poorly located wells next to Blair toilets: shallow holes in the ground.[23]

There are always social pressures that add complexity to adoption of new technologies. Some houses are shunning the new technologies of farm bricks and ash toilets in the Nehanda Housing Cooperative in Dzivaresekwa. This is due to the derogatory names given to them by neighbours.[24] If this is the result when essential technologies are introduced, it doesn't look good for a LAS that can be accessed by a mobile phone. Unless, as we suggested above, the community embraces the mobile technology.

Becedas, a small peasant village in Spain, is thriving despite technological stagnation. This stagnation is due to the village topography. The technology referred to here is farm machinery. Similar villages have dissolved under the same pressures because they have lost too many residents to emigration and lost the cultural and social ties that made them a community. Becedas is an exception because it was able to merge old customs with new.[25]

Our point being, whether it is pipes in the ground or a tractor, without low-cost technology, most communities simply struggle to survive. The adoption of new technologies is tied up with social and cultural pressures.

4.2 Earth observations

It is widely acknowledged that the use of large-scale aerial imagery and remote sensing makes increased tenure security more achievable.[26] Although accessibility is still an issue in Harare, satellite imagery quality is improving. Chirisa and Munyaradzi recognise the solution to building sustainably is combining earth observations with GIS, the cost of this method far outweighing the cost of conventional ground methods.[27] Good governance and planning are required to implement, and fully benefit from, aerial imagery and remote sensing products.

Benefits of using aerial imagery, both from photogrammetry or satellites, either on a device or in paper form, include:

- Real-time capture during adjudication[28]
- Faster processing times[29]
- The ability to communicate in a common language with a common, unbiased base map.

The result is less room for conflict and higher chance of increasing tenure security. These benefits are recognised by most technology-based LAS. Most use aerial photography heavily, for example Cadasta, Open Tenure and the Social Tenure Domain Model (STDM).

Whatever the boundary type, whatever the land right being captured, and whatever the community wants, aerial photography in all forms provides a foundation for flexible land administration.

5. LAND ADMINISTRATION TRENDS

We have come across several names and acronyms when reading about current land administration. To make sense of these we have broken them down in our full paper. This is not a critical comparison. Nor is it an exhaustive list: it is merely there to provide context to you, the reader. This topic is also more widely covered by other authors.[30]

5.1 Global Land Tool Network (GLTN)

GLTN is a network of experts, researchers, and organisations. It is facilitated by UN-Habitat and supported by the UN Food and Agricultural Organisation (FAO) among many others. Kadaster and FIG are part of the GLTN. The network's goal is to alleviate poverty through access to

land and tenure security.[31] There are 18 GLTN tools in development: one of which is STDM.

5.2 Social Tenure Domain Model (STDM)

STDM is technically a specialisation of the LADM ISO Standard. It is often referenced as being the base of other tools. For example, Cadasta took its inspiration from STDM and Talking Titler can be combined with it. STDM was developed in parallel with LADM in the year 2000. It stemmed from the GLTN emphasising that there was a technical gap. It says "conventional land administration approach cannot support the continuum of land rights approach and will not deliver security of tenure at scale".[32] STDM is designed to plug that technical gap.

The partners who developed STDM are GLTN, UN-Habitat and the University of Twente (as it is now known). The STDM concept is to represent people-land relationships regardless of formality, legality and technical accuracy. It is meant to accommodate communally held land. The STDM was field tested in some parts of the Caribbean in 2013. The software was at version 0.9.5 and was generally well received technically. But middle and lower incomes were resistant to the concept of recognising informality because they perceived "difficulties in differentiating between legitimate land tenure rights and illegal occupation and use".[33]

The STDM software is now at version 1.7 and includes mobile data collection capability and has added language translations. Due to the nature of this tool, there are different spatial types and ownership types. There is also an option to link a fingerprint to a coordinated point within a tenancy.[34] Kadaster, FIG, GLTN, and UN-Habitat combined forces in late 2017 to pilot a volunteering initiative for young surveyors in Nepal. The outcomes are yet to be published.

5.3 Solutions for Open Land Administration (SOLA) and Open Tenure

SOLA and Open Tenure are offered by the same group: FAO. SOLA is an open source suite of software. It is designed for regional/national land rights administration and uses multi-tier web services to support larger user numbers.[35] Open Tenure was released in 2014 and fills a similar space to that of STDM. Both Open Tenure and STDM are trying to support for social/community tenure.

SOLA has been piloted in three countries: Ghana, Nepal, and Samoa. The pilots had mixed success. Samoa adopted the system and rolled it out to all other ministries concerned but Nepal and Ghana had the common issue of weak governance.[36] The lessons learnt from the pilots have been applied to further implementations of SOLA since. There are now seven working implementations of SOLA around the world in varying extensions and language translations.[37]

Open Tenure uses mobile devices for field data capture. It has been field tested in Cambodia and Myanmar in combination with the net-based SOLA Community Server software. In Cambodia it has appeared to dwindle due to the internal governance issues within the monk community implementing it. More recently, Myanmar has had a much more positive experience. It involved positive collaboration between NGO Partners Asia, an Open Tenure representative, a group of dedicated non-government people, and some local villagers from across Myanmar. These dedicated people are reportedly still using Open Tenure and are trying different sources of satellite imagery and attempting to capture their own imagery using drones.[38]

5.4 Mobile Application to Secure Tenure (MAST)

MAST is a package that uses a mobile application and web-based data management for capturing rights and preparing land certificates in order to secure tenure. Data capture is completed through filling in standardised entry forms on Android smart devices. The app is not an off-the-shelf application, it requires customisation.[39] When a connection to wifi or a mobile network is available, data is sent to the web-based data management platform. There, it is processed for preparation of land certificates.[40]

MAST is most appropriate for use by local organisations that deal with land management information like local government and non-government organisations. It is currently being tested for its potential use by community-based organisations. At present, the MAST suite is being used in rural parts or Tanzania, Zambia and Burkina Faso to help smallholder farmers increase their land tenure security.[41]

Figure 3: Mobile Application to Secure Tenure (*land-links.org/tool-resource/mobile-applications-to-secure-tenure-mast*)

If you want to read more, we also summarise the following in our full paper:

- Land Administration Domain Model (LADM)
- Cadasta
- Kadaster
- UN-Habitat and Food and Agricultural Organisation (FAO)
- United States Agency for International Development (USAID)
- Talking Titler.

6. FUTURE TECHNOLOGIES

As a profession, we do not need to sit in fear of a technology take over. Instead, we need to utilise our global community, embrace changes in technology and solve challenges. Technology is an enabler so long as we are wise in its application. It helps us to be better informed and focus on our skill sets. In this section, we identify emerging technologies that will influence our industry and land administration solutions.

6.1 Spatial Data Infrastructure (SDI)

An SDI is a platform that links people to information. Another name for SDI is a multi-purpose cadastre. At its core is the cadastre and accurate geospatial information. It supports the integration and sharing of spatial data from the natural and built environment. It is intended for use by multiple stakeholders for decision making and resource management.[42] An SDI provides important information about the places that people create and use, and is the foundation for supporting a spatially enabled society.

6.2 E-commerce subscription/the subscription economy

An e-commerce subscription model is used by businesses that charge for services rather than physical products. Netflix is a perfect example, where you pay per month to watch television series and movies, and you as the consumer can unsubscribe at any point. Selling products is quickly becoming a thing of the past, as consumers increasingly opt for subscription services.[43]

One recent example in the geospatial industry is Trimble Catalyst. This solution incorporates Trimble's core GNSS technology into a subscription-based software service for your mobile device, where you select the accuracy you wish to obtain and pay per month. This reduces the overall upfront cost allowing more users to access the technology and the information it can provide.

6.3 Blockchain

A blockchain is a digital ledger or a record of transactions.[44] Think of it as DNA, where genetics and mutations have been recorded since the beginning of time providing information about the origins of life. Blockchain does the same. Blockchain technology also facilitates secure online transactions. A network of computers must approve a transaction before it can be verified and recorded. Basically, it is harder to hack, because there is more to hack.[45]

Bitcoin is a well-known use of blockchain technology, but it is not the only one. Blockchain has the potential to create new opportunities for modern LASs. Every agreement, process, task, and payment would have a digital record and signature. It could then be identified, validated, stored, and shared.[46] This information would also be protected from deletion and tampering by others.

6.4 Artificial intelligence

Artificial intelligence (AI) is the ability of a computer program or machine to think and learn.[47] We are already seeing this today, through insights and recommendations on websites and social media such as Google, Amazon and Facebook.[48]

Many people are concerned that AI will replace humans in the workforce. The PWC Global Economic Outlook Report for 2017 summarised that "by the year 2030 it is expected that AI will replace 40% of jobs" with the most vulnerable being "retail, manufacturing and administration".

As a profession, we do not need to sit in fear of a technology take over. Instead, we need to utilise our global community, embrace changes in technology and solve challenges.

AI will replace simple jobs and processes; for other more complex processes, AI will collaborate with and learn from humans.[49]

Geospatial technology providers are already incorporating AI into solutions. Trimble Ecognition is one example, where AI is used for object-based image analysis. In Ecognition, a rule engine is developed, with the initial assistance of professionals or experts in the field, to create maps from aerial imagery and old cadastral survey plans.

Figure 4 Trimble eCognition (*www.ecognition.com/suite*)

6.5 Integrated technologies

6.5.1 Mobile

As we have already discussed, mobile technology such as smartphones are placing geospatial technology in the hands of many. Today there are thousands of smartphone applications that use location data supplied by a device's built-in GPS receiver.[50] Examples include Google Maps, Uber and Pokemon Go. The rise in the use of smartphones has seen an increased demand for accurate geospatial data. This is not only for mobile application developers, but also for users who seek to obtain reliability and accuracy from their location-based services.

In 2016, Trimble introduced a software-defined GNSS receiver, Trimble Catalyst, that works with selected Android smartphones and tablets. The software-defined GNSS solution includes software running on a handheld device, a small digital antenna and a subscription to the Catalyst service. With Catalyst, users can obtain positions in real time with accuracy ranging from metres down to centimetres.[51]

Catalyst represents a convergence and evolution of multiple technologies. This includes processing power on small devices, computing algorithms and cloud-based correction services.[52] Catalyst also allows for mobile application developers to link precise positions to any application running on a smartphone or tablet.

If you want to read more, we also summarise the following in our full paper:

- Electronic commerce (e-commerce)
- Cloud computing
- Crowdsourcing.

7. NEXT STEPS

A common theme throughout our article is understanding and collaborating with end users of technology to understand the challenges that they are trying to solve. We think there is room for additional research. We suggest outlining the various types of technology available in a matrix, then comparing them to a set of social tests or success criteria. The goal would be to determine if the technology is truly benefiting the communities and the people within them.

8. CONCLUSION

The human touch will never be replaced in the people side of land administration. But it will replace humans when it comes to capturing data. As a profession, we need not sit in fear of a technology takeover. Instead, we need to utilise our global community, embrace change and use technology wisely.

Technology is an enabler and we cannot disregard the opportunities it may provide geospatial professionals in the future. Whatever the technological innovation, humans will always need to exercise their emotional intelligence in land administration and ensure decisions are being made based on spatial data, collaboration and empathy. Get to know the people and their customs before choosing the right technology. Then you will create a sustainable solution that secures land tenure for all.

This article has been edited from our full paper. Please refer to: www.fig.net/resources/proceedings/fig_proceedings/fig2018/papers/ts08g/TS08G_buxton_harrington_9480.pdf

REFERENCES

A full list of references can be downloaded from: *https://www.surveyors.org.nz/members/Article?Action=View&Article_id=107*

ABOUT THE AUTHORS

Claire Buxton and Melissa Harrington are Bachelor of Surveying graduates from the University of Otago. Both received the Bogle Young Surveyor of the Year Award, joining a group of dedicated New Zealand surveyors who volunteer to advocate and support the industry.

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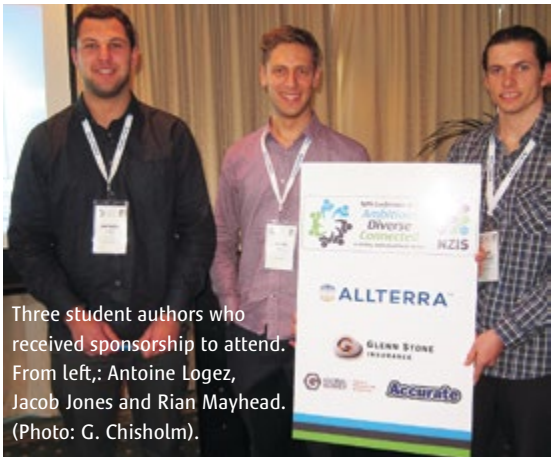
'HYDRO DAY'

at the 2018 NZIS Conference in Nelson

Jacob Jones, Antoine Logez, Rian Mayhead and Emily Tidey –
School of Surveying/Te Kura Kairūri, University of Otago/Te Whare Wananga o Otāgo

This year, the Hydrography Professional Stream (HPS) ran a successful one-day event as part of the annual NZIS Conference. We were well supported by the NZIS organising committee and representatives from the New Zealand hydrographic industry. Three university students were generously sponsored by the Australasian Hydrographic Society (AHS) and the New Zealand Region of the AHS and to attend and report on the day.



Three student authors who received sponsorship to attend. From left,: Antoine Logez, Jacob Jones and Rian Mayhead. (Photo: G. Chisholm).

Port Nelson

After attending the conference opening and keynote address, 'Hydro Day' started with a tour of Port Nelson. John Hart gave attendees insight into the port's operation, including a discussion about the type of, and demand for, various goods shipped in and out of the region. Maurice Perwick, of Eliot Sinclair, spoke about the dredging programme at the port. The port has an 8-metre dredged channel that is maintained using a target dredging procedure. Annual surveys identify areas of interest and Trimble hydroPRO software is used to show, in real time, whether the dredge is above or below the target depth. An interesting part of the tour was seeing the containment solution for dredged contaminated sediments. Contaminants that had entered the water after years of vessel sandblasting in the port are now contained by mixing with cement to produce more reclaimed wharf space.

Fig 1a: Port Nelson (Photo: J. Jones)

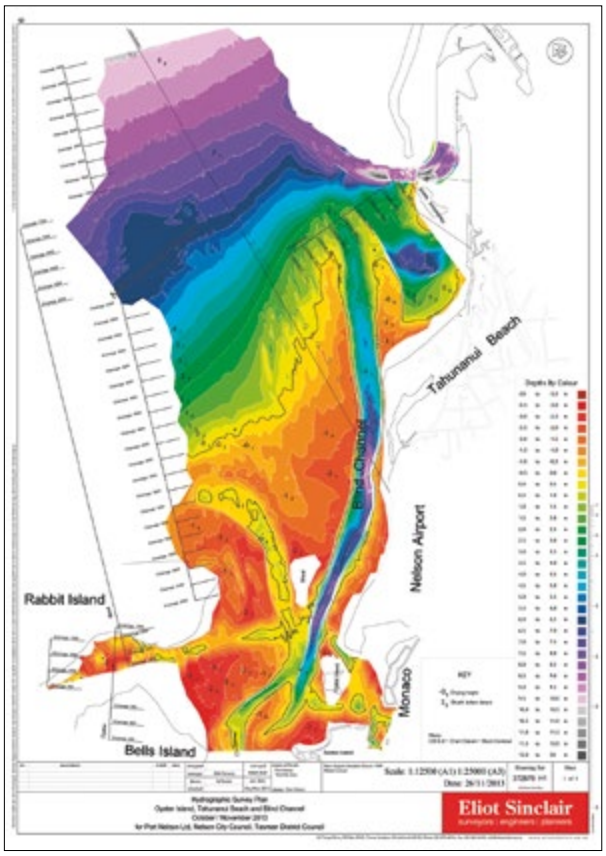


Fig 1b: Eliot Sinclair survey plan in Port Nelson (Source: Eliot Sinclair)

On return from our port tour, NZIS CEO Hadyn Smith welcomed attendees, noting the range of upcoming presentations and congratulated the hydro stream on their

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proactive work within NZIS. Emily Tidey (HPS Chair) thanked Hadyn and the conference team for the support given to the day and welcomed the range of personnel in attendance.

Emily Tidey: Hydro 101

Emily Tidey, from the University of Otago's School of Surveying, discussed the many differences between hydrographic and conventional land surveying. Possibly the most fundamental difference is in planning because we often do not know what lies beneath the water surface. Constant movement in both the horizontal and vertical dimensions are another significant difference and are reduced by ensuring correct interfacing between different instruments. The complexity of undertaking a hydrographic survey contributes to the accuracy standard requirement. It is therefore important to calculate the total propagated uncertainty that can be expected from the equipment set-up and anticipated environment. Vessels and survey equipment also need to be checked and calibrated, with speed of sound in the water accounted for. This is becoming especially important in the modern day because of the continuous advancements in technology that are pushing equipment to become 'blackbox systems'. There is a need to ensure that the correct data is being collected and an in-depth understanding of the theory behind hydrographic surveying equipment is therefore essential.

Fig 3: In a terrestrial survey you can make survey plans based on the stable, visible terrain. (Source: E. Tidey).

Maurice Perwick: Rivers, Lakes, Coast, Industrial Surveys

Maurice Perwick, of Eliot Sinclair, presented on river, lake, pond, coastal and industrial surveys. These diverse environments and locations require the use of different planning, equipment and methods in order to complete the survey because of various factors that each employ, which will have an effect on the data being captured. Examples include changes in temperature and salinity that alter the speed of sound through the water column, different seabed types that affect the intensity of returning signals, and tides that continuously change the depth of the water. Positioning system limitations were also discussed with an example of a survey done on a canyon-like section of the Clutha River. However, he noted that these challenges are all part of the fun and do create opportunities for new technology and processes to be invented. One such invention was created and used by Maurice in a survey of Kaikoura following the November 2016 earthquake. A leadline attached to a drone allowed the surveyor to collect infill data around rocks, reefs and shoals that were too dangerous to access by boat. A 3D printed device known as 'Blink' indicated that the leadline was on the bottom and a fix was taken using a GPS receiver on the drone.

Fig 4: Hydrographic drone work in Kaikoura (Photo: M. Perwick).

Rhys Davies: The iXblue DRIX

More exciting technological advancements were presented by Rhys Davies, of iXBlue. The iXblue DRIX is an autonomous surface vehicle that was created to improve the safety, efficiency, cost and accessibility of hydrographic surveys. DRIX allows for the mapping of seafloor features that may otherwise pose a hazard to vessels, and significantly reduces the amount of resources that are required for a job, including the number of vessels and crew members, and also allows the job to be undertaken faster. When finalised, the state-of-the-art system will have a survey speed of 10 knots, a range of up to 10 days and will be able to broadcast data in real time. The vehicle is suitable for running alongside a mother ship while effectively widening the swath of data collected and reducing the number of lines to be surveyed. Once the system is made fully autonomous, there will also be scope for it to operate in sea conditions exceeding those that are normally worked in or to survey infill lines while the mother ship carries on in another area. To be fully autonomous, the DRIX still requires a sophisticated obstacle avoidance system, which uses a combination of LIDAR, IR and AIS (Automatic Identification System). Conditions in New Zealand are unique and unpredictable, presenting a challenge but

also meaning that the hydrographer is still required for navigation and surveying decisions in all but easy surveys.

Fig 5: The iXblue DRIX in action (Photo: iXblue).

Bruce Wallen: Queen Charlotte Sounds Survey

Bruce Wallen, of Discovery Marine Ltd (DML), used DML's Survey of Queen Charlotte Sound as an example to explain some of the challenges involved in surveying for hydrography and science simultaneously. A significant amount of auxiliary data was required for the science components of this survey and due to the size of the project and the challenges that it entailed, much problem solving was required. Not only did the terrain mean linear tide models could not be used, but the Kaikoura earthquake and subsequent aftershocks produced uncertainty in the tide gauge data, and required determination of whether there had been any significant resulting seabed movement in areas that has been already surveyed. Depth variations from 30 metres to 150 metres meant that swath width had to be constantly changed throughout the survey with resulting ping rate changes and therefore vessel speed adaptations. The result of the survey was eight different datasets for the Marlborough District Council to use for monitoring and management of their marine ecosystems, as well as to LINZ for nautical chart updates.

Fig 6: Bruce Wallen presenting (Photo: J. Jones)

Helen Neil: Queen Charlotte Sounds Survey

Helen Neil, from NIWA, discussed being on the receiving end of DML's Queen Charlotte Sounds Survey – and noted this work was also discussed in a recent *International Hydrographic Review* article.

The Resource Management Act 1991 requires Marlborough District Council to monitor and manage ecosystems, of which a modern snapshot was achieved from the resulting benthic terrain maps. As discussed by Bruce Wallen, the project was a combination of hydro bathymetry modelling and science, which required much auxiliary data. This includes information about blue cod juvenile recruit habitats within the sound and what lies on the seabed or in the water column. Mussel farms were also surveyed because 43 per cent of these habitats fall within marine farm licences. The data therefore also shows the location of spat and anchor lines within these farms, and mapping these produced important data on current use which is required for re-consenting. Acoustic noise profiles were obtained through the use of passive acoustic hydrophones. Materials of gravels, sands and muds made up the seabed composition, and dolphins and other marine mammals were also present in the sound with more than 200 sightings and recordings of several pods and individuals. The project was undertaken with significant consultation with iwi, DOC and residents. It will aid ecotourism in the region and significantly improve understanding of the local resources and coastal marine ecosystems.

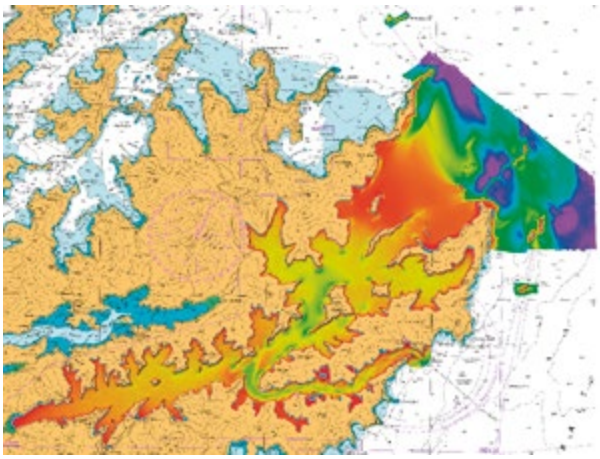

Fig 7: The Queen Charlotte Sound survey area HS59 overlaid chart NZ615 © LINZ. Not to be used for navigation (Source: B. Wallen).

Emily Tidey and Antoine Logez: Hydro Research at the University of Otago

University of Otago student Antoine Logez and lecturer Emily Tidey went on to discuss hydrographic research being undertaken at the University. The talk covered some of the equipment available for such as the R2Sonic MBES

and Starfish SSS. Vessels at the University of Otago range from the 21-metre *RV Polaris II* to smaller, specialised crafts. An engineered towable creation that allows for the MBES to be used from smaller vessels has been developed. Current research projects such as habitat mapping in areas where hoiho (yellow-eyed penguins) have been tracked, geophysical studies in deep canyons and glacial investigations in the Auckland Islands were outlined. Recently, Otago's MBES was also used for a project in Fiordland, which was a challenging environment because of issues such as a significant freshwater layer and rapidly changing seafloor types. Future projects using multi-frequency multibeam, water column measurements and protocol development to support marine scientific mapping were then covered.

Fig 8: University of Otago survey vessel and seabed imagery collected with the R2 Sonic 2026 multibeam (Source: School of Surveying & E. Tidey).

Geoffroy Lamarche: Seabed 2030

Dr Geoffroy Lamarche spoke about his role with the global Nippon Foundation-GEBCO Seabed 2030 project. He is the coordinator of the South and West Pacific Centre (along with NIWA, LINZ and GNS Science), responsible for an area of a modest 127 million square kilometres, which will be mapped to produce a global terrain model at 30 arc-second intervals (~926m at the equator). Currently 18 per cent of the oceans is mapped at this – 82 per cent of what you see on global images is interpolated. Lamarche discussed the importance of finding open access to existing data, but noted this is a difficult task because of the competitive nature of the market and because scientists are often only interested in areas of ecosystems and interesting submarine terrain, rather than the vast oceanic deserts, for example. Crowdsourcing for data has been requested, and through this, companies such as Fugro have provided transit data to the cause. A number of cruise ships have also agreed to participate.

An interesting technique that is being explored for areas of data gaps is satellite inversion. An issue that is created due to the sheer scale of the project is convincing countries to allow surveying to take place, due to the network of political boundaries that the region encompasses. More information is available at *seabed2030.gebco.net*.

Fig 9a: Dr Lamarche presenting (Photo: J. Jones).

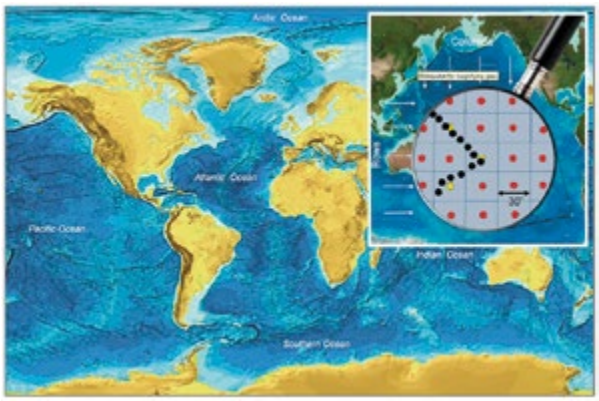

Fig 9b: The Nippon Foundation GEBCO Seabed 2030 project aims to generate a complete map of the world ocean floor by 2030 at a resolution of 400m in water depth greater than 3000m. Presently, about. 6 per cent of the grid cells of the new Seabed 2030 grid contain true soundings measurements. Other cells are interpolated or derived from satellite altimetry. (Source: G. Lamarche and *seabed2030.gebco.net*).

Stuart Caie and Anja Boehme: LINZ hydro update

An update from LINZ with a focus on safe navigation was presented by Stuart Caie and Anja Boehme.

It is important that charts are continuously updated with accurate soundings and the HYPLAN (available at *www.linz.govt.nz/sea/charts/annual-work-programme*) shows a hierarchy of certain areas of interest determined by the increased traffic in these places or the time since the last survey was completed. As well as bathymetric data, there is an emphasis on science, so surveys that include habitat maps or data collection for more than one purpose are being encouraged. The new update also includes filters used to search for certain charts with all the metadata about them being displayed. Searching allows all the charts available in a specified area to be viewed as either electronic or paper charts. It is interesting that currently the Cook Islands charts are in fathoms, so they

are unable to be uploaded as electronic charts. LINZ is also looking towards releasing bathymetric surfaces and having a database where raw or processed survey data can be requested.

Dave Field and Emily Tidey: Hydro certification

Hydrography stream chair Emily Tidey gave an update on the RPSurv process and noted that the HPS leadership team is working to ensure this will link smoothly with the existing Australasian Hydrographic Surveyors Certification Panel (AHSCP) certification as this is supported by NZIS and SSSI.

Dave Field who is on the AHSCP gave a rundown on the application process and tips for successful submissions.

NMIT Maritime Simulator

The final activity of the day was a visit to the Nelson Marlborough Institute of Technology (NMIT), where attendees were given a tour by Stuart Whitehouse and tried out their skills in the Maritime Simulator. The world-class system consisted of a main bridge with connected rooms allowing for the integration of other vessels all in the same simulation. This allowed those involved to test their navigation skills (with varying degrees of success), when bringing large vessels into a series of ports from around the world in a range of wind speeds, tides and currents. After the serious testing was complete, the evening escalated into a war as the three simulation rooms battled for victory in Sydney Harbour.

A delicious Italian meal with limoncello and some great catching-up followed.

Student attendees would like to thank the AHS and the New Zealand Region of the AHS for their generous sponsorship which allowed them to join in with professionals whom they hope to work alongside one day.

Figure 11: Hydro Day attendees try out the NMIT marine simulator (Photos: J. Jones) + NMIT logo.

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TOP 10 Geospatial Things

SPRING EDITION

Duane Wilkins

If it weren't for your gumboots, where would you be, you'd be in the hospital or ... well, most likely sitting at a desk with mild hay fever at this time of year.

The team at *Surveying + Spatial* mag asked if we could share another geospatial 'top 10', so with spring in the air we thought it might be useful to share a few interesting 'geospatial things' that we've come across over the past few months.

In this article, we've used a URL shortening service called Tinyurl.com – if you type in these shortcuts, they'll take you directly to the resource.

You'll thank me later today for putting the gumboot song in your ear... so in no particular order, let's go!

1. Aerial Imagery | *tinyurl.com/Spring18-Aerials*

Recent imagery releases on the LINZ Data Service have added to the growing collection of ultra high resolution imagery (10cm). This is a much higher level of detail than you'll see in most online map services. The areas now covered include Thames Coromandel, Hastings, Napier, Kapiti, New Plymouth, Wellington, Hutt Valley, and Auckland. These are available free to download and in a variety of formats and projections, just remember to reference your source.

Did you know: Using web services, you may not even need to download the imagery to use it in your mapping software?

Most of the LINZ image sources are available as Web Map Tile Services (WMTS) which are a type of data livestreaming format which downloads just for the area you need on screen – similar to YouTube where you don't need to download the whole video before you can view it or skip ahead to the middle; it also means you don't need to store and manage several gigabytes of data that you might only use occasionally.

To access this web service, look for the 'Services' tab once you've logged into the site and created an API key (you can do this in your LDS profile) then copy the URL and add it as a 'WMTS layer' within your software. Most mapping applications will identify which projection the services provide, and will align to your current map projection. Try searching for 'LDS URL endpoints help' or use this link to view a tutorial showing how to do this in more detail: *tinyurl.com/lds18*.

2. NZ Topo50 Gridless Maps | *tinyurl.com/Spring18-Topo50*

Over the past few months, I've been sitting next to the team responsible for updating the NZ Topo50 maps and it's been interesting to see how the topographic maps are updated. The standard 1km grid lines on topo maps provide a useful scale reference, but all those lines can be distracting if you're using a mobile device that plots your location and calculates the scale automatically.

You can download the tiles in a variety of file formats and projections, or add them directly to your mapping software as a WMTS web service just like Aerial Imagery and always have the latest and greatest map tile sheets.

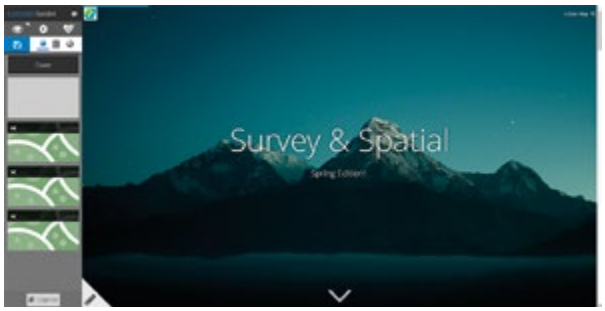
3. NZ Topo50 maps in Google Earth 3D | *gelib.com*

If you are a regular user of Google Earth, *gelib.com* has developed a free streaming service that lets you overlay NZ Topo50 directly within Google Earth without any need to download. This is a great trick to see what a topographic map is representing, particularly in areas of steep topography.

While the lower resolution service is free, if you find yourself using it often, you may want to invest in the higher resolution service. Another trick is to adjust the transparency of the layer, allowing some of the satellite imagery to come through giving a rather interesting terrain effect.

You can also download the full resolution map tiles from *data.linz.govt.nz* and add them directly to Google Earth – just keep an eye on how many you load up as too many will cause your system to become slow and unresponsive.

4. Storymaps | *storymaps.arcgis.com*



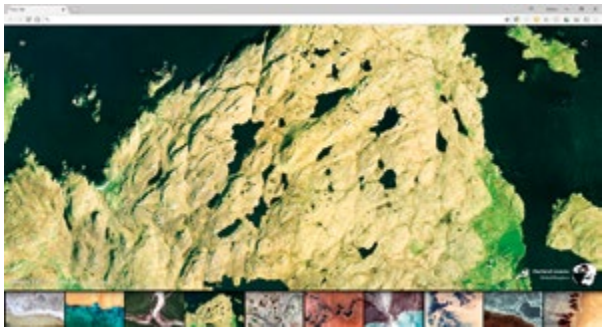
I really like the way Esri Storymaps can be used to 'spoon-feed' an audience, or tell a map-based story in exactly the order and style that you want it to be told, similar to a featured article in the news media like *Stuff.co.nz*. A storymap is an online presentation, similar to a long-form scrolling PowerPoint with images, text, video and, of course, maps that can be linked to featured content, or you can introduce and describe themes of a web map to reduce the effort needed to interpret data.

Did you know: Anyone can create a storymap for free without an ArcGIS licence?

Try a Google search for 'Storymaps Gallery' and scroll down to check out some of the contest winners for inspiration; you can combine static maps, 3D interactive maps, video, images and even embed other webpages. One of my favourites is the Anacostia 'Rivers of Resilience': *tinyurl.com/StoryMapA*.

To create your own storymap, create a free Esri ArcGIS Online account or use Gmail or Facebook to sign up, then select 'create a new map' and try the 'Cascade' option – next add a heading and a 'Hero' background image of your own. Scroll down and use the + to add titles, text, video or maps. The Immersive section will allow you to use one map, but provide multiple custom views, zooms, or 3D perspectives.

5. EarthView Chrome Extension | *g.co/ev*



This one's a little bit of geospatial air freshening eye candy for your browser, providing you with a new curated satellite image collection each time you open a new tab in Chrome.

You can download any of the views and set them as your desktop wallpaper or open and view its location in Google Earth. Access this from *g.co/ev*

6. Historical Survey Plans in Landonline | *linz.govt.nz/land/landonline*

ML700A Crown Copyright.

For those of you with access to Landonline (or know someone with access), next time you need a coffee break, look up some of the historical survey and Māori land survey and sketch plans, they're a fascinating view into our history and the connections that iwi groups have with geography.

Here is an example on ML700A from Ngamoe block near Ruatoria, with detailed information describing the names of rivers, fishing reefs, historical pa and other locations of interest to Māori.

LINZ also has a programme under way to scan and make the associated survey notebooks available as they too are a rich source of contextual information. Keep an eye out on the 'Our Changing World' pages of National Radio: *tinyurl.com/Spring18-RNZ*

7. 360 Imagery & Virtual Reality | *vr.google.com/tourcreator*

If you've never looked up your address on Google Maps and looked at your letterbox in Streetview 360 imagery, here is your chance. 360 imagery and virtual reality are now very easy to capture, and string together to create a virtual tour. Just open Google Maps and look for the yellowish 'Pegman' and click it or drag and drop onto your area of interest where blue lines and dots appear.

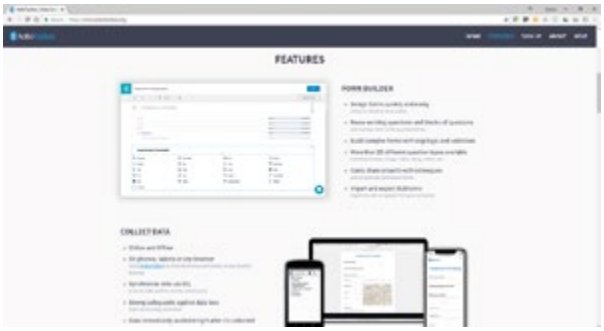
To capture a 360 image, you can use any recent smartphone with the Google Streetview 360 Camera App. While you can upload and add them to Google Maps, you don't need to publish these images on Google Streetview and can keep them private to you and your client/customer using Google Photos or any other application that supports 360 photospheres. They are stored as a rectangular image, and projected into a sphere when viewed.

You don't need to view them with a special VR viewer either, you can use your phone and a cardboard VR viewer, you can pick one up for less than $5 on Trade Me. VR apps like Streetview for a mobile phone will split the screen in two, giving you a stereo pair of images.

One free and nifty and easy to use tool to create virtual tours is called 'Tour Creator' which allows anyone to build a guided VR tour within their browser, no special tools needed. You can use Google Streetview or your own 360 photos (capture method outlined above).

Check out some of the examples and create your own tour at *https://poly.google.com/creator/tours/*.

8. Open Data Kit | *opendatakit.org*

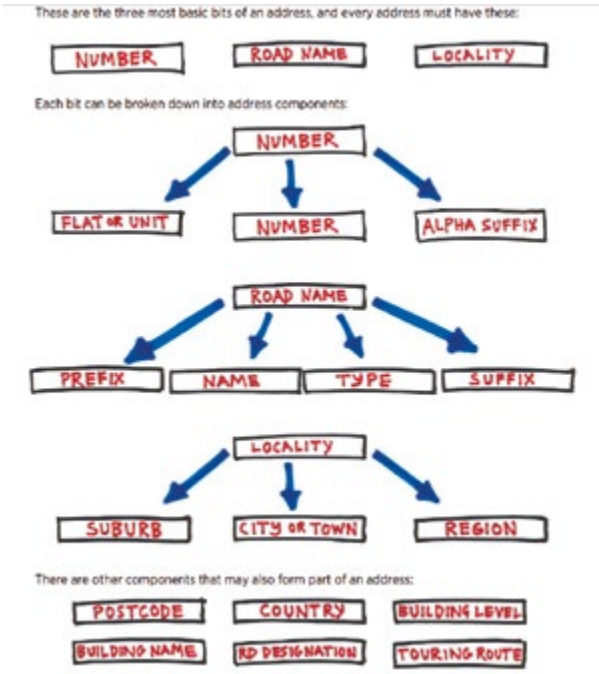


If you're looking for a free mobile phone field data capture tool, ODK is a free and open-source option to enable collecting and managing data in 'resource constrained' situations. ODK allows you to capture text, build forms, include complex branching (if this is the answer, then

here is the follow up question) answer validation and includes mobile, service and desktop tools.

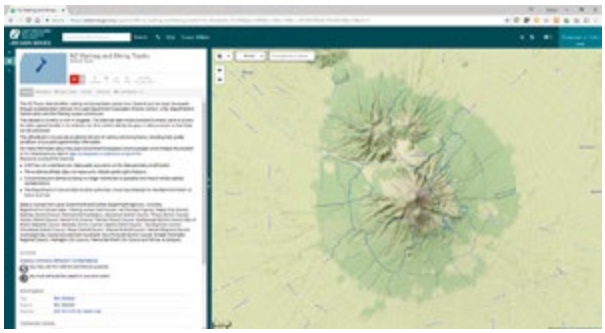
If you're wanting to try it out, check out a free hosted option called KoboToolbox, and open the sample form on your mobile with your login details. You can capture points, lines and polygons, as well as audio, photos and video and have many people working in teams contributing to the same map source.

9. Addressing Guidance | *tinyurl.com/Spring18-Addressing*



The Integrated Property Services team at Land Information New Zealand has prepared some useful information for people working with addresses. Some work done in 2016 after consultation with other government agencies found that many people capturing addresses from customers, and many IT professionals designing systems that contain addresses, do not have a clear understanding of what makes a good address, and in particular, how concepts like validation help improve the addresses in their systems. Download and have a look at this material or share it around the office. I particularly like the hand-drawn illustrations, I think they're much easier to understand than the horrific diagrams we're all guilty of creating.

10. NZ Walking and Biking Tracks | *tinyurl.com/Spring18-Tracks*



The NZ Tracks data identifies walking and biking tracks across New Zealand and has been developed through a collaboration between the Local Government Geospatial Alliance (LGGA), LINZ, Department of Conservation and the Walking Access Commission.

This is a fantastic resource for cyclists, walkers and trampers and is the same data used by the Walking Access Commission's popular mapping website, *walkingaccess.govt.nz/*.

We hope you'll find some of these useful and we'll start collecting another 'Top 10 interesting geospatial things' for summer. If you have any suggestions for future interesting top 10 geospatial things or any queries, send them to *dwilkins@linz.govt.nz*.

Complaint to Ethics Committee upheld by Survey and Spatial New Zealand (S+SNZ) council

In accordance with the rules governing conduct of a member, Council has upheld a complaint against a member relating to plagiarism and misrepresentation of competency.

The complaint was investigated by the S+SNZ Ethics Committee. It found that a prima facie case had been established which required an enquiry to be held under section 24.2 of the NZIS Policy Statement A19-24 Conduct of Members. As the member did not wish to contest the complaint a hearing was not held. Council approved the Ethics Committee's recommendations on appropriate penalties for serious breaches of the rules of conduct. The penalties included a 6-12 month suspension of membership, completion of an approved professional ethics course, provision for application for readmission by way of Council interview, associated costs and publication of complaint details, and a fine to be waived if the application for readmission is successful. In the event that an application for readmission is not made within 12 months or is not successful, the member will be expelled from NZIS with publication of name and complaint details.

The Conduct of Members policy can be viewed at: *https://www.surveyors.org.nz/Attachment?Action=Download&Attachment_id=3183*

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CITY RAIL LINK

New Zealand's largest infrastructure project

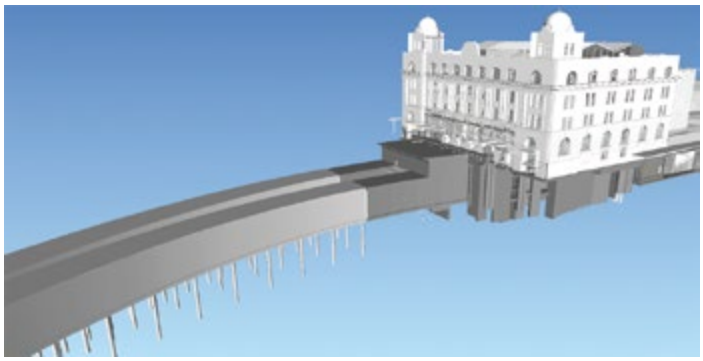
Daniel Wiederkehr, Business Unit Leader, Survey and Geospatial at Calibre Consulting Ltd

Outside the CPO building on Queen Street

The City Rail Link project will cost more than $3.4 billion and will be able to transport 54,000 passengers an hour at peak. The target project completion is 2024.

Background

The City Rail Link (CRL) is the largest infrastructure project undertaken in New Zealand. The CRL is a 3.45km twin-tunnel underground rail link up to 42 metres below Auckland city centre, transforming the downtown Britomart Transport Centre into a two-way through-station that will better connect the Auckland rail network.


The CPO (Chief Post Office) viewed from the southwest

It includes a redeveloped Mount Eden Station, where the CRL connects with the North Auckland (Western Line) and two new underground stations – one mid-town at Wellesley and Victoria streets, provisionally named 'Aotea Station', and one at Mercury Lane and Beresford Square, off Karangahape Road, provisionally named 'Karangahape Station'. The depth of the two new underground stations are 11m and 33m deep respectively. The section from Britomart to Aotea Station is cut and cover (surface) construction, whereas from Aotea to Mt Eden Station, a tunnel boring machine (TBM) (underground) will be used.

Britomart will no longer be a 'dead end' station but a through station. The CRL is jointly funded by the Government and Auckland City Council. City

Rail Link Ltd, which came into being on 1 July 2017, has full governance, operational and financial responsibility for the CRL, with clear delivery targets and performance expectations. The project's total cost will be within a funding envelope of more than $3.4 billion.

A Downer NZ and Soletanche Bachy joint venture (DSBJV) was chosen to progress the CRL work through and under Britomart Station and Queen Street to the site of the former Downtown Shopping Centre, now the Precinct Properties Commercial Bay development. A McConnell Dowell and Downer NZ joint venture (Connectus) was chosen to construct the cut and cover tunnels under and along Albert Street from Customs Street to Wyndham Street.

Introduction

A few years ago, in April 2015, when I was working on a large road rehabilitation and widening from New Lynn to New Windsor Auckland, the *New Zealand Herald* reported that the Downer NZ and Soletanche Bachy Joint Venture (DSBJV) had won Contract 1 (C1). At the time, I was the Regional Survey Team Leader of the Downer Northland Survey Team, and naturally was excited at the prospect of being part of this historic infrastructure project. Today, some years later, working with Calibre and having a team of five young and keen survey professionals supporting me, I have the privilege to tell you about the project's progress and the survey technical achievements and challenges we have faced in the past two years of construction.

Preparation – Survey Control

Initially, we set up a Survey Control network on ground level via conventional survey methods, enabling us to set out all structures and assets relating to the new but temporary railway station at the rear of the Chief Post Office (CPO) building, as well as minor works in front of the CPO building on Queen Street. The first test was to check whether the new adjacent designs fitted well against the existing building, which proved to be spot on.

Due to the ground having been more or less completely excavated for the new build and services, any ground marks we had placed were lost, sooner or later. We therefore opted to place reflective targets on the surrounding buildings, as well as on and within the CPO building. Once that was established, a totalstation could be set up at any desired location which is practical for the work at hand to achieve repetitive millimetre accuracies.

Subsequent work within the CPO building and the existing underground Britomart Railway Station required us to adopt and build on this initial established network. Cross checks throughout the 105-year-old building and as-built surveys of known features, such as existing floor levels, were used to confirm our values once we went below ground level. The average RL around the CPO building is 3.6 metres. The ultimate check was performed when we surveyed the two tracks, 1 and 5 at B2 level with an RL of minus 7.26 metres. The height of the platforms either side were within 1mm to 3mm and the centrelines of both tracks were observed perfectly in position, confirming that any future designs coming off the two tunnel design centreline alignments, MC20 and MC30, would conform well with the existing structures.

Chasing the millimetres

Simultaneously, as the work was progressing well within the C1 site, we established a dialogue with our next-door neighbours, who are building the mid-section of the tunnels going under the Commercial Bay development.

Work inside the CPO building

Work inside the CPO building

These tunnels will be completed well before we join them, roughly 1½ years later. It was at this time that we discovered that both project survey teams were using different origin marks as provided by the principal technical adviser (PTA). This was not an issue in theory, but potentially a challenge or risk, should the origins be different by an amount that exceeded the construction tolerance of the tunnels, which is only +/- 15mm. A few weeks of discussions and repeat confirmation surveys were required for survey alignment to be reached.

Sites like these, where risk with detail and accuracy is highly critical, demand constant and precise communications among all teams. On this relatively small site, we have up to 80 workers performing their tasks on different levels inside the CPO building, beside the building, and below ground level every day. The onsite survey team, up to three at a time, are having to make sure that the survey control network is maintained, with the ever-changing demands and the uninterrupted build of temporary and new structures. Needless to say that survey control points are regularly destroyed and new ones have to be re-established.

All this demolishing and building of temporary and permanent structures may potentially have some impact on the existing CPO building and infrastructure surrounding it. Sixense, a French engineering and monitoring specialist company, has been contracted to monitor our site, using seven totalstations constantly measuring dozens of reflectors, observing 1mm accuracies in x, y and z, sending off alarms if prisms move by 3mm or more. Four totalstations are located outside the CPO building and three are inside. They are constantly correlating the measurements captured. This relieves us from having to worry about most of the monitoring surveys; we are still required to complete some monitoring work, but only when instant findings are required – for example, while load transfers are performed.

We recently reached the halfway mark on the C1 project and have started the excavation between the diaphragm walls (D-Walls).

A diaphragm wall is a reinforced concrete wall that is made in situ. The trench is prevented from collapsing during excavation, reinforcing and casting by the use of supporting bentonite slurry. The slurry forms a thick deposit (the cake) on the walls of the trench which balances the inward hydraulic forces and prevents water flow into the trench.

The excavation will take about three months before we reach the bottom (underside of the tunnel floors). At this point, we will begin to construct the two tunnel envelopes. After their completion, the trenches will be backfilled, including the inside of the CPO building, as well as reinstating the surrounding areas. Newly designed pedestrian-only areas and shared areas will also be built, further enhancing the inner city's quality of life for work and enjoyment.

Conclusion

With still a long way to go, I am confident that we will complete this project within budget and on time. The DS-BJV teams are the most enjoyable bunch of people I have ever worked with. No matter how tough it gets at times, working long days and night shifts, or elaborating complex tasks, everybody always keeps a cool head and no compromises have ever been made in regard to health and safety. I am proud to be part of the CRL C1 project and look forward to its completion in 2020.

Equitable easements

Mick Strack

Butterworths Conveyancing Bulletin (2018) 18 BCB has recently highlighted the comparison between two cases about equitable easements. I review these cases from a perspective relevant to surveyors.

Kiwi Trustee Ltd v Lin [2016] NZHC 595

An equitable easement is a right over land that is asserted by use and consent of both parties and such right is capable of being registered as an easement. It is, however, unregistered so it does not directly run with the land. A licence, on the other hand, is an agreement to allow someone to use or access land, but it "does no more that confer a defence to a claim for trespass" (*Kiwi Trustee* at 25).

Kiwi Trustee Ltd had two registered easements over Ms Lin's adjoining land for the purpose of pumping and piping irrigation water from a stream on Lin's land. Previous proprietors had accessed these easements through Lin's land beyond the defined easement area, a concession that had been accepted by previous owners, and which may have given rise to an equitable easement to continue such access and use.

When Ms Lin acquired her land, she established the boundaries between the land parcels and the extent of the registered easement. She found that the water pipeline was outside the easement boundaries so she moved the pipeline onto the defined easement area. She objected to her neighbour's access and sought to deny continued access by these other routes. It was claimed by Kiwi Trustee Ltd that the accepted use and access amounted to an equitable easement in their favour, and they lodged a caveat to uphold that claim, and that Lin was acting fraudulently in denying the equitable easements.

Ms Lin had purchased her property by way of a mortgagee sale and s105 of the Land Transfer Act 1952 provides for such a sale to be "freed and discharged from all liability … of any estate or interest except an estate or interest created by any instrument which has priority over the mortgage …".

The registered easements had priority but the equitable easement (if in fact it had existed for previous proprietors) did not. Therefore, Ms Lin was entitled to rely on her indefeasible title and was not acting fraudulently in denying access and use of her land beyond the extent of the registered easement. Ms Lin also pointed out that Kiwi Trustee Ltd had exercised its right to the water for several years to successfully reticulate water onto its property without needing to use the alternative access, so the access right was certainly not a functional component of exercising the rights of the easement.

The result was that the caveat was removed, the equitable easement did not exist, Ms Lin was not fraudulent in asserting her indefeasible (registered) rights, and this decision supports the expectation that anyone can rely on the register to know what the proprietor can convey.

Street v Fountaine [2018] NZCA 55

This case concerns a rural water reticulation scheme first established in the 1970s by a group of adjoining landowners providing for stock water to be extracted and piped from a stream to various properties that did not have riparian access. It was part of a larger scheme: upstream users proposed the initial water scheme that prompted downstream users to object, fearing that their access to the water would be compromised by the upstream users. The scheme was agreed to by downstream users when they agreed to share and regulate the water take and to establish relevant and appropriate easements. An easement plan was prepared, but only the upstream users registered their easements. The downstream users may have delayed registration because the route of the easement was apparently realigned to allow for gravity flow piping. The scheme was altered and upgraded in the

1990s, such that the intake works and the pipeline route were moved.

The dispute arose with current proprietors about the nature of their rights to use the water and to gain access to the intake; whether their rights were in the nature of an equitable easement that therefore passed with the land, or if they were "gentlemen's agreements" that were terminable at will, or at least did not pass directly with the land without being renegotiated on every transfer of title.

The trial decision was that there was no easement, but at the Court of Appeal, that decision was reversed. An equitable easement had been created by:

- an initial intention to create an easement
- an acceptance that use of the water pipelines would pass to subsequent owners (access to water contributing significantly to the properties' value) without renegotiation
- the right to use the water has the essential characteristics of an easement
- all parties benefiting from valuable consideration
- there had been considerable investment in the infrastructure in part performance of a contract (both the initial scheme and the later upgrade).

There is useful legal argument about easements and licences. "A registered easement is a legal easement. An equitable easement creates an interest in land which is registerable (but not registered), but can nevertheless be protected by a caveat" (*Street* at 45).

"In contrast, a licence does not grant any interest in land. The benefit of a licence does not pass to successors in title of the licence, nor bind successors in title to the land. A licence is a personal, contractual arrangement which provides permission to do an act on land that would otherwise be a trespass...

"Licences are revocable as the parties agree but otherwise by will. For all these reasons, licences are not generally suitable for multi-party arrangements as they create difficulties when there is a change of ownership in either the licensee or the licensor. Easements are the usual mechanism where there are to be multiple parties to one arrangement, including initial and subsequent owners of land" (at 47).

As "this was a community water scheme. It is unlikely that the farmers would have proceeded without long term security for the scheme's operation, or an ability to pass on the benefit of the scheme when and if they came to sell the land" (at 78). The rights to use the infrastructure "were not seen as personal to the parties to the agreement but rather rights which affected the use, enjoyment and inevitably the value of the land" (at 80).

Several of the parcels of land involved had passed down to the next generation of the families and no party to the original scheme remained alive. The trial court heard evidence from two such second-generation proprietors who were denying the existence of any easement beyond a "gentleman's agreement". The trial judge considered them credible and reliable witnesses. But the Court of Appeal considered their evidence to be "unsubstantiated assertion … properly characterised as hearsay" (at 88). The Court of Appeal also comments on such evidence based on memory: that "it is shaped by the fact that there is conflict between the parties" (at 128) and follows this comment with an interesting extract from a UK case about how a testimony based on memory may be manipulated or 'refreshed' by the preparation of statements required to defend a particular position. The appeal court therefore dismissed much of the evidence from the "credible and reliable" witnesses in favour of a reliance on documentary records or perhaps circumstantial evidence of these.

The result was that an equitable easement was confirmed on the basis that proprietors had relied on the water for the value and use of their farms, had invested in the infrastructure and had an intention to bind successors in title. The court ordered that easement to be registered.

These cases touch on several issues of relevance: the importance of registering any right exercised over another's land; the importance of accurate and complete drafting of the easement documents (for example, whether an easement to convey water might also allow for access for maintenance); the extent of a reliance on indefeasible title (for example, whether any purchaser needs to consider unregistered interests); and the difference between a personal licence and an equitable easement which runs with the land.

Easement order appealed and reversed *Guo v Bourke* [2017] NZCA 609

In *Surveying + Spatial* issue 91, September 2017, I reported on an easement case that I suggested was decided rather surprisingly and unfairly. That case was appealed to the Court of Appeal and the judgment was, in most respects, reversed.

To summarise again, a reciprocal right of way gave access to both a front lot and a rear lot. The rear owner had built a gate across the back of the RoW but about 6m into the RoW where it was about 5.5m wide. Beyond that point, the RoW widens to about 9.7m to allow for turning convenience from the RoW to the side of the rear section. The driveway formation, nevertheless rounded the corner off even more such that part of the driveway, now within the gated area of the rear lot, encroached significantly

(continued page 39)

Construction Industry Risks in New Zealand and Mitigation

Stephanie Harris

Risk and contracts

Limiting liability and risk is an ongoing challenge. While it can seem like a daunting and complex task, it must be undertaken to protect your construction company client from liabilities that should not be their responsibility.

Further, given the nature of the risk and reward in a construction contract, where there is a shifting of risk, there should be a counterbalancing advantage of price to balance that risk. It is important to analyse and understand the types of risk and match them and consider them in the context of the specific contract and project. It can be assumed of course that the common aim of all of the significant parties to a contract is to reduce claims and equitably distribute risk to diminish overall risk to the project.

To that end, well-drawn contracts are a powerful and effective method of transferring risk and equally should be so in reducing costly disputes and claims.

Contracts define the relationship and govern the interaction at every level and stage of a project, and therefore are a strong tool to address issues, disputes and risk at the outset.

We see many contractors/developers who consider that they have assessed the risks or have undertaken a risk analysis of the particular project. However, in our experience it is not common for all of the elements of risks to be identified particularly as between design, ground risk and construction risk. We generally see it all pushed to the contractor in the current market, irrespective of whether the contractor can actually assess or influence those risks.

We consider that different contractual provisions are needed to deal with risk profiles and responsibilities. Proper or improper risk allocation translates into financial consequences for the contractor; not just the risk of problems and disputes but the cost of the project, particularly given if the methods employed are not successful in completing the project.

More and more frequently we see risks allocated based on power in the relationship, rather than equity. This generally translates to the contractor being apportioned all substantial project risk in the current market, irrespective of the negative impact on project costs. The outcome of this is increasingly evident in the media reporting on the failure of some construction companies.

Risk analysis

Risk is a complex issue from the contractor's perspective. Frequently to a contractor's disadvantage, these are couched in due diligence terms. The due diligence provision generally requires the contractor to assess and analyse the site and conditions, and price the contract on the basis of what they perceive to be the relevant risks. This is often in the face of incomplete design work, which means variations are inevitable to accommodate changes, which equate to risk to the project (time and costs). This has allowed parties to develop the thinking and belief that any loss and expense incurred by the contractors as a result of unexpected risks are in fact a result of a lack of due diligence by that contractor and therefore they are not entitled to a variation or any kind of reimbursement for the unexpected costs.

However, frequently given the nature of how these risks are assessed, understanding the risk can be beyond the experience of even a diligent contractor at the time of contract. Overall, I think New Zealand contractors address poorly formalised risk analysis and generally apply a contingency margin to price out the risk which seems to be reliant largely on experience. Sometimes that is all there is because there are of course usually limited resources available to contractors to either assess the risk or get the relevant risk information.

This issue coupled with the fact that New Zealand construction industry is extremely competitive and most contractors understand and seem to accept high-risk and

low-profit margins. This is further exacerbated because the lowest price is generally the one accepted in a competitive tender process. With contractors incentivised effectively to deliver as low a bid as possible to win the contract, this has an unintended consequence on the treatment of risk and how they price it (or more often, don't price it appropriately). This is because I think it is endemic in our system that parties undercut each other so there is an equal undercutting or underrating of risks to remain competitive to win the job and outbid competitors.

There are other risks that we tend to see not being considered which is related to the current workload of the contractor and the need for more work to fill the pipeline represented by their staff and other resourcing.

A greater analysis of the risk is required; it can be summarised by addressing the following issues:

- Who can control the risk?
- Can the risk be mitigated, e.g. by methodology or insurance etc?
- Where and by whom is it most economic to deal with the risk?
- Who gets the most benefit from controlling the risk?
- Is it the most efficient way of dealing with the risk?

In summary, who can manage it best and who benefits most? Whereas in my experience, risk is allocated on the basis of negotiating power, that is, the strong party allocates the risk to the weak, generally the contractor. The

(continued from page 37)

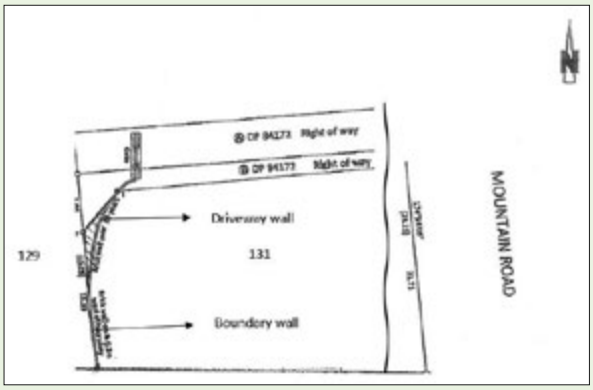
on the front lot land, although that is not what the appellant was particularly concerned about. The gate had been there for some time and had been accepted by all previous owners, although it was a barrier to the front lot using the RoW for access to its rear yard.

The front lot owner, Mrs Guo objected when a replacement steel gate was installed. The High Court found that Mrs Guo had consented to the gate being replaced over her land, so decided against her, allowing the gate to remain. Furthermore, the court ordered that she remove the landscaping that was encroaching on the RoW which apparently restricted access to the back lot. The High Court also denied its jurisdiction to consider a misplaced structure under the Property Law Act because it considered that the gate and wall were fences so could be considered under the Fencing Act.

The Court of Appeal accepted that Mrs Guo's 'consent' was given without any knowledge of where the actual boundary was so her consent was meaningless. The Court of Appeal also considered that Mrs Guo had a right to protect her indefeasible title by having the gates removed from her servient land and the area of the RoW where she was dominant tenement.

The situation in relation to the survey plans of the easement, was poorly illustrated and described, such that the appeal court decided that the High Court judge was 'clearly confused' about where the wall was and where the boundary was – an incorrectly labelled aerial photo was used in this case. The suggestion is that this confusion led to the wrong decision.

It is worth noting here that surveyors should insist on being part of proceedings such as this to clarify, both by description and by illustration, the lay of the land, such that confusion does not occur.



The decision against Mrs Guo was reversed and the court ordered the gates to be removed, in exchange for a new survey and definition of an extended easement area to incorporate the drive as formed. The other part of the decision which required Mrs Guo to remove landscaping encroaching on the RoW was unchanged, apparently on the basis that the landscaping took up over 50 per cent of the RoW strip over which Mrs Guo was the servient tenement. I would suggest that this decision may also be misconceived: the landscaping and the less than full 5.5m existing formation have not been an impediment to access, and are unlikely to be so in future. Reciprocal RoWs are very common and some are created in multiple narrow strips, some of which are not used at all for formation, but exist to satisfy other width and frontage requirements. It is certainly common practice to landscape easements and not to form the full easement area. If such precedent was to hold, there is potential for all easements to be contested. This would serve nobody's interests.

The end result restores some level of fairness to Mrs Guo, but is still a partly unsatisfactory result in terms of the concessions she had to make to the adjoining proprietor.

stronger party generally attributes no risk to themselves by passing on inappropriate risk, although it significantly increases the likelihood of not getting the project outcome they desire because the weaker party inevitably perceives the risk as onerous and either charges more or if it ends up very one-sided. It is simply placing a greater pressure on the stronger party's balance sheet and their ability to complete if significant risks are realised.

Frequently, there is little financial capacity to absorb risks and the asset base of the contractor (while they might have a significant intellectual property in terms of experience and ability to physically undertake the project and manage it), their balance sheet is not so robust. This also has a negative impact on their ability to monitor and manage risks as they move through the project. Lack of monitoring heightens all risk factors in my view.

This also ignores lender requirements/covenants and the general ability to manage financial obligations where there are potentially significant contingent liabilities being carried by the contractor.

There is also often difficulty in that there is only a perceived sharing of risk. For example, where there is an independent engineer or architect as a designer and administrator, although they are obliged by the contract to behave in an independent manner and certainly most that I have come across use every endeavour to behave appropriately and in good faith, they are frequently not independent when it comes to issues where the determination may well have potential to impact on their own liability and responsibility. This is particularly so in New Zealand with its complex consenting environment.

Common issues of dispute arise out of the key areas that are considered when drafting a contract such as scope, contract typology, communications and expectations such as milestones and completion dates. Thus, the contract equals an early opportunity to define the project and address these issues by agreeing equitable project delivery mechanisms. The natural tension between the owner who wants a quality outcome for a minimum cost and the contractor who wants minimum resource to meet minimum scope is not going to go away. However, a realistic and fair sharing of responsibility can be considered by addressing both positive and negative risk management drivers or incentives. It is frequently overlooked but critical to address the fact that risks change throughout the life cycle of a project and the control mechanisms need to have some flexibility to address that change.

Mitigating risk

There are different ways of contracting that make parties consider risk more clearly. There are a number of issues and methodologies that can be considered as part of a risk analysis and for a better sharing of risk and reward. I list these below really only as headlines; once negotiations commence for a specific contract, appropriate issues can be more closely considered.

- Partnering provisions with agreements to act in good faith and in the best interests of the project can be a powerful tool, particularly when getting parties to the table to resolve disputes early on.
- Early contractor involvement (ECI) documents have been argued to deliver consistent outcomes because the owner and contractor are forced together in the project planning stage on an open-book basis before entering into the contract. However, in my opinion, although it is useful to allow parties to initially engage, it is still intended to be an analysis of risk. Thus, that analysis should acknowledge that both parties have a vested interest in avoiding or mitigating their risk, and that analysis is required to appropriately apportion it to obtain the appropriate outcome. The ECI can therefore be a very useful risk identification tool.
- Note that I am not suggesting that the liability of risk is shared as this can negatively muddy contractual obligations and responsibilities. It is the costs of risks that can be appropriately shared. I have done this a number of times, particularly in respect of geo-tech issues. The contractor is effectively obliged up to an agreed maximum figure, and should there be something unexpected in the ground, then the ultimate land owner, subject to agreement as to the type of risks in question, pays for everything over and above that figure. Often, such contracts are subject to both partnering obligations and ECI requirements.
- Adopting the common alliance pain-share/gain-share approach can also be useful, but I still consider that

steps should be taken to appropriately allocate risk in the first place.

- Alliance performance bonuses are effective.
- Liquidated damages (as a negative motivator).
- Acceleration provisions (again as a negative motivator).
- Price escalation during the life of the project can be a sharing of risk as fixed-price contracts tend to be subject to the most variation claims, and so a formula to compensate the contractor for agreed costs could incentivise the parties appropriately.
- Staged bidding; where you first qualify interested contractors and thus ensure that you are only dealing with parties that are financially and operationally competent to undertake the project. Those parties can then undertake appropriate due diligence and present a further bid based on the criteria agreed at that point. The intent being that staged bidding allows the contractor to understand more clearly the project risks and should for the owner limit problems arising from resourcing and productivity, meaning milestones and completion dates are more likely to be met.
- There should also be recognition of the role of procurement and the role that major suppliers of materials play in the construction process in New Zealand. Significant and sophisticated procurement strategies should be more and more to the fore so that those critical materials are agreed before works take place and form part of the owner's specifications. This would mean the contractors did not take the risk on the agreed systems and materials because design and performance of materials as adopted through the procurement process could be more easily and appropriately undertaken by the material supplier (who should be carrying the risk for that aspect in any event).
- Value engineering is also becoming increasingly to the fore to address errors and problematic design in the hope that it can be identified early enough to avoid any additional costs and delays for the project.
- Ongoing monitoring and reporting. This is often imposed by the financiers to a project, but reporting of work completed each month, and payment being against that report, forces parties to address outstanding issues.
- I think it is frequently overlooked that the adequacy of the funding for the project is understated and reasonable contingencies should be incorporated into the budget from the start to deal with inevitable increased costs.
- Well-managed realistic milestones, particularly given complexity of compliance with regulatory obligations are also key to ensure contractors do not inadvertently suffer negative penalties such as liquidated damages or acceleration provisions in relation to obligations outside their control.
- Joint ventures can bring together skills, assets and funding for the benefit of a project. JVs tend to spread risk (albeit project management issues are more to the fore).
- Finally clear, fast and efficient dispute resolution mechanisms are required that are for the benefit of all parties to the contract and should include initial informal resolution by escalation through relevant managers to CEOs before any formal process.

Role of the owner

Owners have via traditional construction contracts in New Zealand increasingly been able (largely due to market forces in terms of competitive tendering for the work) to place significant emphasis on self-protective behaviour, i.e. what are the consequences of failure and that under traditional contracting models, each party can only profit at the expense of the other. The end result is the pushing of more and more risk onto the contractor in the view that this drives performance to obtain the desired outcome without risk to the owner. This has resulted in failures of contractors because generally contractors have not been paid a premium for the transfer of such risk and nor have they made an allowance that covers the consequences of the risk occurring. Owners need to be an integral part of appropriate mechanisms to drive their desired outcomes without maximum risk transfer to contractors in the mistaken belief that this contractual power equates to desired outcomes.

Conclusion

Risk exists because there is uncertainty both in the nature of the risk and how it can be avoided or mitigated. The competitive tender process to obtain work, the strength of the owner party and the relative lack of sophistication in risk analysis methodologies in our current market largely means that contractors tend to simply accept all risk to their detriment to win a tender. Owners need to reconsider better mechanisms to achieve their outcomes because standard adoption of risk transfer and acceptance largely under pressure during the tender process often means an inevitable loss to the project, whether it is to time, quality or the entire project.

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Christina Hulbe

When I first arrived at Otago, people described the School of Surveying as a family. Nearly six years on, I agree with that sentiment but with an important addition: this is a family we choose and a family we work to remain a part of, rather than a family we happen to have. The work we share – among staff, with students and with our past graduates – supports a sense of common purpose and that's what binds us together. We work together to deliver excellent educational experiences, to conduct research that matters nationally and internationally, and to engage with the community in which we live and work.

The school wouldn't be the same without our strong ongoing connections with the professional community. Every year, dozens of you return to Dunedin (or walk across town) to talk to surveying students about your projects and their prospects. Earlier this year, Kurt Bowen took time out of his busy schedule to help us select our new Lecturer in Urban Design, Dr Crystal Filep. The Phantom Pro drone donated by Mark Fisher and Eighty4 Recruitment at the NZIS National Technical Conference this year is already in use for student projects. And in the heart of recruiting season, a team from Trimble Christchurch, including recent BSurv (Hons) graduate Luke Johnson, gave a next-generation presentation featuring progress in lightweight, low-cost, high-accuracy GNSS solutions, as well as virtual and augmented reality solutions. These partnerships and others like them, built through shared experiences in the surveying family, ensure that the next generation of surveying graduates will be as strong as the previous generation.

Sometimes we are fortunate enough (or clever enough) that our teaching, research and community connections align. Certainly, research-informed teaching is part of the Otago way and strong connections between education and community partners should be the norm in a professional school. But connecting all three is harder to achieve. Pascal Sirguey, who is very active in this space, was recently invited to attend the Trimble Dimensions 2018 User Conference on behalf of the school and Otago. We will be one of a dozen international institutions to participate in their formal university outreach effort. The invitation builds on a history of partnerships and high-profile projects such as the re-survey of Aoraki/Mt Cook and laser scanning of WWI tunnels in northern France (the LiDARRAS project, with Richard Hemi, colleagues in France, and both French and New Zealand students). Another excellent example is the collaborative work Paul Denys, Robert Odolinski, Chris Pearson and surveying students have been undertaking in partnership with LINZ, to consider how satellite-based augmentation systems can benefit New Zealand.

This column is too short to include all of the activities and projects that make the School of Surveying family what it is. (So my apologies to everybody I didn't cite as an example.) The point is this: we value our extended family and we see very clearly how and why its net of interconnections benefits the work we do here.

There are two important news items to share. First, we welcomed Dr Crystal Filep as Lecturer in Urban Design at the start of the second semester. Crystal is an Otago PhD who was the Dunedin City Council Urban Design Team Leader before joining the surveying family. Her background is in both architecture and urban design and if you have found yourself using the term 'urban typology' lately, you two should start up a conversation. Second, Robert Odolinski was awarded a University of Otago Early Career Award for Distinction in Research. The highly competitive award recognises Robert's groundbreaking contributions to the theory and application of multi-constellation GNSS solutions and his recent innovations on low-cost, high-accuracy. You can read more about this in the July 2017 issue of *GPS Solutions*.

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