Mathematics-in-Industry NZ 2019

24 - 28 June

Held at University of Auckland, Auckland

Organised by the University of Auckland, and KiwiNet

Co-Directors:	Dr Richard Clarke University of Auckland
	Dr Andreas Kempa-Liehr University of Auckland
Kiwinet Support:	Seumas McCroskery Kiwi Innovation Network
Invited Speaker:	Dr Stefan Schliebs Chief Data Scientist, Quantiful
Plenary Speaker:	Prof. Rosalind Archer Head of the Department of Engineering Science and Director of the Geothermal Institute

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Welcome

The Mathematics-in-Industry for NZ (MINZ) group is delighted to welcome you to the Mathematics-in-Industry for NZ workshop 2019. This is the fifth year the event has taken place, and the first time it has been held at the University of Auckland.

We are excited by the challenges put forward by four of New Zealand's leading companies**: Transpower, Sanford, Fonterra** and **Mercury**. The diversity of industry problems being brought to the workshop will no doubt cater to a range of interests and expertise. We are also very grateful to both Dr Stefan Schliebs and Professor Rosalind Archer for agreeing to speak at this year's event.

We warmly acknowledge the continued support for this event from KiwiNet, and in particular Seumas McCroskey. We would also like to acknowledge the help of Bernadette Ramos and Zoe Jamieson from the Faculty of Engineering Communications and Marketing team, for their help in organising the workshop.

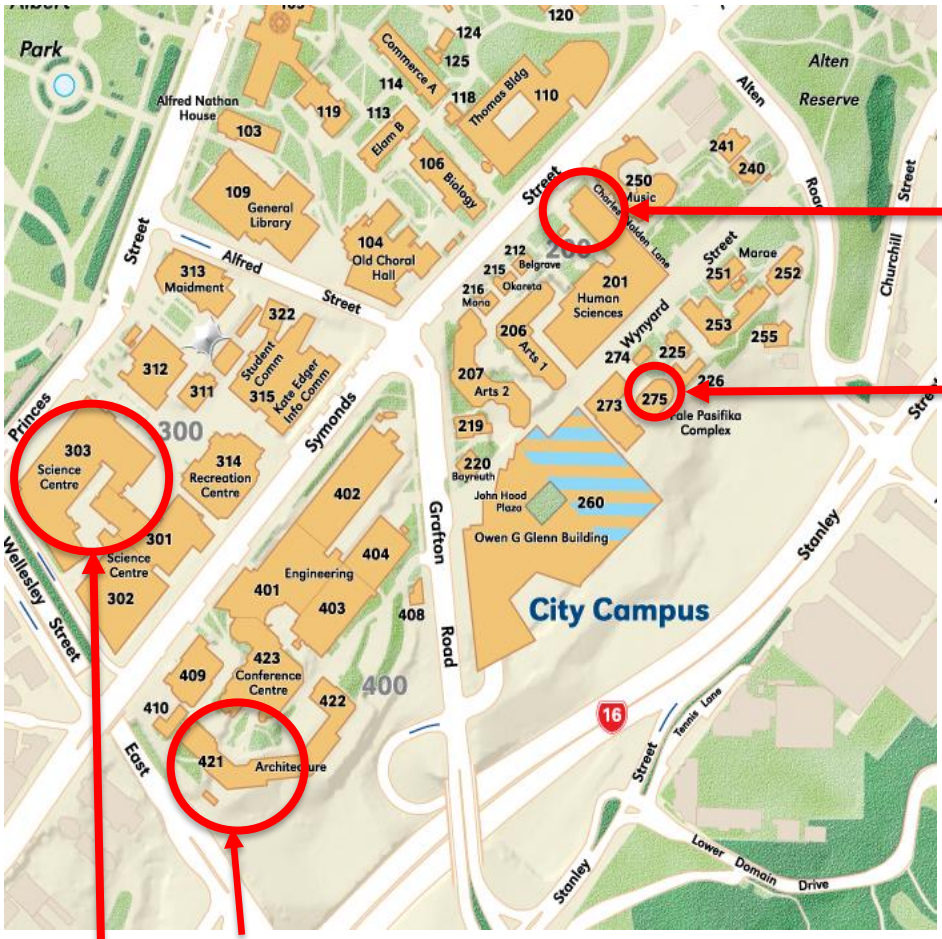
We would also like to recognise ANZIAM-NZ, who have provided travel support grants for a number of students attending this year's workshop

We hope that you will find the week ahead both enjoyable and fruitful.

Richard Clarke and Andreas Kempa-Liehr

Workshop Information

Map



Mon & Fri AM

Workshop dinner

Weds AM Plenary

Breakout session:
Mon-Thu

Internet Access:

Select the wireless: UoA-Guest-WiFi
Enter the username: math@wifi.com
Enter the password: qzp2JzuQ

Programme

Monday 24th June

Human Sciences building (Building 201N, Room 352)

8:00 – 9:15am	Registration
9.15 – 9.30am	Welcome from MINZ 2019 Co-directors
9:30 – 10:00am	Transpower - Industry presentation
10:00 – 10:30am	Sanford - Industry presentation
10:30 – 11:00am	Morning Tea
11:00 – 11:30am	Fonterra - Industry presentation
11:30 – 12:00pm	Mercury - Industry presentation
12:00 – 1:00pm	Lunch (not provided)
1.00 – 2.00pm	Invited Talk: Dr Stefan Schliebs - Quantiful

Science Center (Building 303, Rooms B05, B07, B09, B11)

2:00 – 3.00pm	Initial project meetings
3:00 – 3:30pm	Afternoon Tea
3:30 – 5.00pm	Project breakouts

Tuesday 25th June

Science Center (Building 303, Rooms B05, B07, B09, B11)

8.30 – 10.15am	Project breakouts
10:15 – 10.45am	Morning Tea
10.45 – 12.00pm	Project breakouts
12.00 – 1.00pm	Lunch (not provided)
1.00 – 2.00pm	NZMS curriculum workshop
2.00 – 3.00pm	Project breakouts
3.00 – 3.30pm	Afternoon tea
3.30 – 5.00pm	Project breakouts

Wednesday 26th June

Architecture Building (Building 421W, Room 301)

9:00 – 10.00am	Plenary Speaker: Professor Rosalind Archer
10:00 – 10.30am	Mid-week challenge updates

Science Center (Building 303, Rooms B05, B07, B09, B11)

10:30 – 10.50am	Morning Tea
10:50 - 12:30pm	Project breakouts
12.30 – 1.30pm	Lunch (not provided)
1:30 - 3:00pm	Project breakouts
3:00 – 3.30 pm	Afternoon tea
3:30 - 6:00pm	Project breakouts
6:30 – 10.00 pm	Workshop dinner @ Fale Pasifika

Thursday 27th June

Science Center (Building 303, Rooms B05, B07, B09, B11)

8.30 – 10.30am	Project breakouts
10:30 – 11.00am	Morning Tea
11.00 – 12.30pm	Project breakouts
12.30 – 1.30pm	Lunch (not provided)
1.30 – 3.00pm	Project breakouts
3.00 – 3.30pm	Afternoon Tea
3.30 – 5.00pm	Project breakouts

Friday 28th June

Human Sciences Building (Building 201N, Room 352)

9:00 – 9:10am	Short address: MINZ Co-Directors
9:10 – 9:20am	Short address: KiwiNet
9:20 – 9:45am	Mercury - Challenge Summaries
9:45 – 10:10am	Fonterra- Challenge Summaries
10:10 – 10:35am	Morning Tea
10:35 – 11:00am	Sanford- Challenge Summaries
11:00 – 11:25am	Transpower- Challenge Summaries
11:25 – 11:30am	Final remarks
11:30am	Workshop Closes

Challenge Outlines

Challenge 1 – Transpower (Room B05)

Moderators: Geoff Pritchard, University of Auckland
Mark McGuinness, Victoria University of Wellington
Student Moderator Julie Mugford, University of Canterbury
Industry Representatives: Charles Chrystall, Market Insights Analyst

Decompose aggregate energy consumption data into various load types to increase power system efficiency and reliability

Background

Transpower owns and operates the core power system for New Zealand. This system delivers energy generation to energy consumption via a high voltage AC transmission network (a.k.a. the grid). Ensuring efficient and reliable delivery is a complex task, requiring contingency planning to maintain system frequency and voltage. Doing this well means being able to run more low carbon, renewable, generation which is intermittent in nature compared to coal or gas fired plant. It also means preventing cascade asset failure leading to widespread blackouts. Transpower can increase efficiency and reliability by increasing their understanding of what comprises the energy consumption at a point of offtake from the grid. This will be especially important in the future with expected uptake of household solar generation, batteries, electric vehicles and home energy management systems.

Transpower sees one value for energy consumption per offtake point, but this represents a net value of various consumption types - e.g. air conditioning, dryers, lights, LED lights, small industrial – and generation types – e.g. small wind farms or hydro plant. By utilising highly frequent offtake data, Transpower wants to estimate the amount of each component, in particular the typical range of variation. This will help them determine requirements for reliable supply. For instance, because different offtake types have different impacts on an AC power system, e.g. how much inductance they create, or whether they provide reactive support, knowing how much of one component exists in a given location will allow planning of what reactive power is required from generation or reactive plant such as Static Var Compensators.

Challenge 2 – Sanford Ltd (Room B07)

Moderators:	Richard Clarke, University of Auckland Stephen Waite, University of Auckland
Student Moderator:	Behdad Shaarbaf Ebrahimi, University of Auckland
Industry Representative:	Andrew Stanley – GM Innovation Matthew MacDonald – Innovative Products and Processes Design Engineer James Higgins – Farming Support Services Manage Mike Mandeno – Manager Mussel Farming

Optimising float design and performance

Background

Sanford Ltd is New Zealand's largest and most diverse seafood Company. The Company is vertically integrated from quota and marine farm ownership to marketing of quality seafood and other marine products.

The largest aquaculture species is NZ's endemic Green Shell Mussel ("GSM", also referred to as green-lipped mussels) which Sanford exports to the world in fresh and frozen food formats and now in nutraceutical formats. It is been recognised that there is a significant opportunity for aquaculture in NZ and globally in the development of techniques for off-shore farming.\

The Challenge

Plastic buoys (floats) are used to keep mussel farms from sinking to the sea floor, often at or near the surface of the water. The buoys used by Sanford and other marine farmers have remained largely unchanged for decades and recent attempts to apply the aging buoy and farming technology to new growing areas has resulted in new challenges and sometimes system failure.

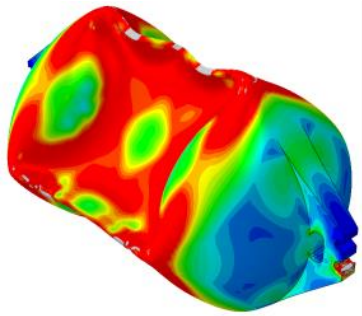
Farms located in deeper waters face significantly more challenging conditions than those in enclosed and protected waters such as harbours . Application of traditional buoys in off-shore environments is resulting in those buoys collapsing and/or failing under the strains and pressures observed on those sites. It is evident that the design of the float is not optimised for these conditions and preliminary data is suggesting shape and handle design are key elements to redesign. There are many factors that need to be considered and incorporated into the redesign process.

This challenge will seek to quantify the mechanical loadings on these buoys under different conditions, and inform ways in which their design can be optimised to provide the best overall performance.

Some of the factors to be considered include:

i) Stress-Strain relationships
ii) Hydrodynamic Loadings
iii) Transport and storage safety
iv) Cost and production
v) Biofouling
vi) Safety
vii) Structure, longevity and robustness

It is exciting times for the aquaculture industry with increasing demand for quality products, opportunities to apply IOT and other technologies at sea, lot of opportunities for additional value through species and product diversification including multitrophic farming and many other innovations. NZ has always led the innovation around mussel aquaculture and we want to maintain that position. The redesign of the humble mussel float is seen as an important development to secure the future of the industry in New Zealand.



Challenge 3 – Fonterra (Room B09)

Moderators:	Luke Fullard, Massey University
	Oliver Maclaren, University of Auckland
Student Moderator:	Valerie Chopovda, Massey University
Industry Representatives:	Lisa Thomasen – Research Scientist, Statistics
	Liz Nickless - Associate Research Scientist

Using Raman Spectroscopy to Develop New Dairy Products: The Mathematics of Shining Lasers Through Cheese

Background

Inside the Fonterra Research & Development Centre in Palmerston North, there are teams working to create new innovative dairy products to share with the world. One of these teams is working on mozzarella cheese for pizza, cheese slices for burgers and other delicious cheeses. Cheese making has been around for centuries, but we're working on making cheese bigger and better.

As part of the cheese making process, we have a team that shines lasers through cheese and gathers spectral data to generate microstructural images of the cheese. We use our Raman Spectrometer to shine lasers through shreds of mozzarella and slices of processed cheese to help us to understand the cheese composition on a microscopic level. Raman spectroscopy is used in food manufacture to identify molecules and study chemical bonding. In dairy products such as cheese, this allows us to understand the composition of the cheese with respect to fat, protein and moisture content.

As fun as it sounds, shining lasers through cheese is actually quite time consuming. We are keen to understand how many samples we need to take from a given product to be confident that the results are representative of the product as a whole. Some cheeses are homogenous in composition, while others are non-homogenous. It suffices to say that whether you're eating it, or shining lasers through it, one slice of cheese is never enough!

Once we've shined lasers through two different batches of cheese, it can be challenging to determine whether the differences between them are big enough to be significant. The multi-dimensionality of the Raman spectral data makes this especially difficult. We're hoping the MINZ team can work with us to define some metrics from the Raman spectral data to give us a reproducible way of detecting real differences between samples.

Join our team for some cheesy discussions that will change the way you think about cheese and the way we do R&D on it.

Challenge 4 – Mercury (Room B11)

Moderators:	Tony Downward, University of Auckland
	Andreas Kempa-Liehr, University of Auckland
Student Moderator:	David Wu, University of Auckland
Industry Representatives:	Nick Waddington - Wholesale Markets Analyst

How can Mercury improve the generation efficiency of the Waikato hydro scheme?

Background

Mercury is an electricity generator and retailer with a long heritage in renewable electricity generation. Our Waikato Hydro Scheme is a chain of nine hydroelectric dams along the Waikato River. The gravitational energy of the water that runs down the river from Lake Taupo and through our power stations generates around 10% of New Zealand's annual electricity generation. Mercury continues to invest in maintaining our hydro assets, building on the legacy of those who created them over the course of nearly a century so that they contribute to the future of local communities and to New Zealand for many decades to come.
Our team of Hydro Controllers work 24/7, running 39 generating units across the nine power stations on the River to generate electricity, responding to real-time national demand for power. This is a complex process requiring Hydro Controllers to draw on years of experience as well as input and support from other teams, to do this effectively.

Mercury is interested in investigating whether using mathematical models and optimisation algorithms can provide incremental gains in the generation efficiency of the Waikato Hydro Scheme. There are several factors that influence generation efficiency, including:

- Mercury's electricity generation forecast
- The water levels in each of the dams along the river
- Rainfall and tributary flows feeding the river
- Design of the hydro turbines
- Generation unit outages at power stations

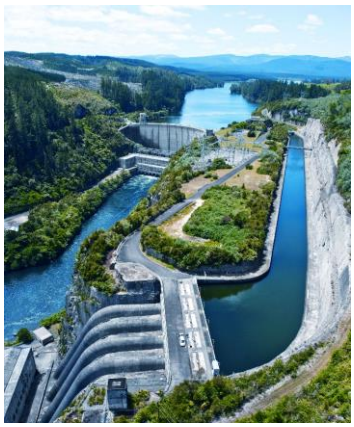


Figure 1Maraetai 1 and Maraetai 2

The Challenge

How can Mercury improve the generation efficiency of the Waikato Hydro Scheme? How does altering the electricity generation plan affect this efficiency?

NZMS Curriculum Workshop:

What could Mathematical Modelling look like in the classroom?

Kerri Spooner, Auckland University of Technology

This workshop is a self-initiated consultation process with Mathematical Modellers (both academic and industry based) concerning what they think are important aspects of mathematical modelling that could or should be taught at school level. To start the discussion the modelling behaviours of a New Zealand real world modelling team and the potential authentic mathematical modelling behaviours of a secondary school student will be presented. The rest of the workshop will be a discussion session seeking feedback from you concerning what you think is important to teach at school level, why it is important and if you think it is possible to teach at school level. Discussion questions will focus on: what does mathematical modelling look like for you? What aspects of mathematical modelling do you think should be taught at school? What aspects do you think should be taught at Universities? What activities are possible to develop authentic modelling behaviour in a classroom? What do you see as the challenges? What support do you envisage would be needed? Your participation will be used to inform submissions I make to the NZMS education group around mathematical modelling in the New Zealand curriculum. I am also hoping to build research around this project.

List of Registrants:

Abigail Pascal	University of Auckland
Alan Chen	University of Auckland
Alan Williams	Isogonal
Aloys Nghiem	Mercury
Andreas-Kempa Liehr	University of Auckland
Andrew Stanley	Sanford
Asma Khan	University of Auckland
Athira Nair	University of Canterbury
Barry McDonald	Massey University
Behdad Shaarbaf Ebrahimi	Auckland Bioengineering Institute
Benjamin Liu	Business School, Auckland University
Bernd Krauskopf	University of Auckland
Bogdan Toader	University of Oxford
Caroline Jagtenberg	University of Auckland
Catherine Hassell Sweatman	Auckland University of Technology
Celia Kueh	Massey University
Charles Chrystall	Transpower
Clever Gama Alves	University of Auckland
Colin Whittaker	University of Auckland
Darren Thomson	Devcon Holdings Ltd
David Wu	University of Auckland
Deepak Cosmos	Victoria University of Wellington
Devendra Oak	Fonterra
Devi Uday Bhan Singh Garandal	University of Canterbury
Ehsan Izadpanahi	University of Auckland
Florian Wechsung	University of Oxford
Gemma Mason	University of Auckland
Geoff Pritchard	University of Auckland
Giorgia Vattiato	University of Canterbury
Gislain Uhl	Mercury
Golbon Zakeri	University of Auckland
Graeme Wake	Massey University
Hamid Abbasi	University of Auckland
Hammed Olawale Fatoyinbo	Massey University
Haniffa Mohamed nasir	Sultan Qaboos University
Hinke Osinga	University of Auckland
Hongbin Guo	University of Auckland
Ishmita Bedi	Auckland University of Technology
James Higgins	Sanford
James Ramsay	Universisty of Canterbury
James Sneyd	University of Auckland
James Williams	Isogonal
Jason Tam	University of Auckland
Joaquin Pablo Aguilera Bustos	University of Auckland
Julie Mugford	University of Canterbury
Kanchan Joshi	Auckland University of Technology

Kerri Spooner	Auckland University of Technology
Khushboo Breja	University of Canterbury
Lisa Thomasen	Fonterra
Luke Fullard	Massey University
Marie Graff	University of Auckland
Mark McGuinness	Victoria University of Wellington
Martin Ai	University of Auckland
Mathilda Zhang	University of Auckland
Matthew MacDonald	Sanford
Meital Bar	University of Canterbury
Michael LockyerAuckland	University of Technology
Mike Mandeno	Sanford
Misagh Ebrahimpour	University of Auckland
Muhammad Nadeem	University of Auckland
Nate Wichitaksorn	Auckland University of Technology
Nathan Moore	Mercury
Nathan Pages	University of Auckland
Navdeep	Ricoh
Neelum Bashir	Massey University
Nhi Nguyen-Smith	Fisher & Paykel Healthcare
Nick Waddington	Mercury
Oliver Maclaren	University of Auckland
Olivia Dilek Celik	University of Auckland
Piyush Rastogi	University of Canterbury
Prashant Islur	University of Canterbury
Ramin Razmi	University of Auckland
Richard Clarke	University of Auckland
Rosalind Archer	University of Auckland
Rua Murray	Universisty of Canterbury
Ruanui (Ru) Nicholson	University of Auckland
Saima Gul	Massey University
Samuel Kyle Irvine	Massey University
Sedigheh Abbasasab	University of Auckland
Shan Su	University of Auckland
Sidra Zafar	Massey University
Sione Mau	University of Auckland
Sishu Shankar Muni	Massey University
Speedy(Weichen) Jiang	University of Canterbury
Sreekanth Damodaran	University of Auckland
Stefan Schliebs	Quantiful
Stephen Waite	University of Auckland
Steve Taylor	University of Auckland
Thao Tran	Victoria University of Wellington
Thiwanka Jayasiri	University of Canterbury
Tony Downward	University of Auckland
Tony Gibb	Adelaide Advanced Engineering
Valerie Chopovda	Massey University
Victoria Pereira	University of Oxford

Winston Sweatman	Massey University
Xiao Lin Kee	University of Auckland
Xun Xiao	Massey University
Yordan Nedkov	University of Auckland
You Chen	Auckland University of Technology
Yourong Wang	University of Auckland
Zachary Todd	University of Canterbury