Mathematics-in-Industry NZ

2018

25 - 29 June
Held at Auckland University of Technology, Auckland

Organised by AUT, MINZ and KiwiNet

Organisation Director:	Dr Hyuck Chung, AUT
MINZ Director:	Prof Mark McGuiness, Victoria University of Wellington
Administrators:	Seumas McCroskery, Kiwi Innovation Network Wenjun Zhang , AUT
Plenary Speaker:	Prof. Troy Farrell

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Welcome

The MINZ (Mathematics-in-Industry for NZ) group is delighted to welcome you to the fourth Mathematics-in-Industry for NZ Study Group being held at Auckland University of Technology in Auckland CBD. MINZ is a event established to add value to our community and our industry as well as provide academic opportunities for many of us. We warmly acknowledge support from all our sponsors, but especially KiwiNet: a consortium established to foster industry links with experts such as those in the mathematics community. KiwiNet continues to provide the administrative structure to make this event happen.

We have six exciting challenges put forward to the mathematical group from six dynamic and significant companies**: Fonterra, Transpower, International Cable Protection Committee, Sanford, Methanex,** and **Fisher and Paykel Appliances,** it is a pleasing mix of those that have taken part in similar events and those new to the study group concept. Thank you all.

We are very pleased to welcome many participants from around New Zealand and further afield. One such guest is Prof. Troy Farrell, an applied mathematician working at QUT, we are delighted to have him here and look forward to the plenary talk, and other contributions both formal and informal throughout the week ahead.

It is a great honor to also welcome Head of Department Prof. Jiling Cao, and MINZ Director Prof. Mark McGuiness and who has graciously accepted our invitation to open MINZ 2018.

We trust that you will find the week ahead both stimulating and enjoyable and wish you all the very best.

MINZ2018 Organizing Director:
Hyuck Chung
AUT
June 2018

Maps

The Key note is held in the WA building (Teal colour on Map) in Lecture Theatre WA220. The majority of the time we will be in the 6/7thth Floor of the WG building (In orange on the map) at AUT CBD campus, 25 – 29 June 2018. There will be MINZ signage.

We will point out other place such as the conference dinner will be- as it is all close by.

Challenges

Challenge 1: Sanford

Logistical aspects of mussel farming, harvesting and processing

Full Challenge Details

Challenge 2: Methanex

Heat exchanger tube inspection

Full Challenge Details

Challenge 3: Transpower

How can you accurately incorporate battery energy storage systems into national grid

Full Challenge Details

Challenge 4: International Cable Protection Committee

Better utilization of the submarine cable faults database

Full Challenge Details

Challenge 5: Fisher and Paykel Appliances

Modelling the performance of a front loading washing machine

Full Challenge Details

Challenge 6: Fonterra

Tribology & Dairy Beverages

Full Challenge Details

MINZ- Study Group Agenda

Monday 25th June

8:00 – 9:00am	Greeting/Registration WA224A

Welcoming address in Lecture theatre WA220

9.00 – 9.25am	MINZ Director Prof. Mark McGuiness and HoD Prof. Jiling Cao
9.30 – 9:50am	Invited Speaker Prof. Troy Farrell
9:50 – 10:00am	What's coming up next, Hyuck Chung MINZ 2018

Industry presentations

10:00 – 10:30am	Sanford
10:30 – 11:00am	Morning Tea
11:00 – 11:30am	Methanex
11:30 – 12:00am	Transpower
12:00 – 12:30pm	International Cable Protection Committee
12:30 – 1:30 pm	Lunch (not provided)
1:30 – 2:00pm	Fisher and Paykel Appliances
2:00 – 2:30pm	Fonterra
2.30 – 2.35pm	Group sorting (Rooms for Challenges- WG608-609 & WG701-703 & WA224B)
2:30 – 3:00pm	Afternoon Tea
3:00 – 5.00pm	Initial project Meetings (Led by moderators and Industry Reps).

Breakout Area 1	Sanford Ltd
Breakout Area 2	Methanex
Breakout Area 3	Transpower
Breakout Area 4	International Cable Protection Committee
Breakout Area 5	Fisher & Paykel
Breakout Area 6	Fonterra Ltd

Tuesday 26th June

Rooms WG608-609 & WG701-703 & WA224B

Project working sessions as determined by the moderators and posted on noticeboards etc
9.00 – 5.00 pm

Breakout Area 1	Sanford Ltd
Breakout Area 2	Methanex
Breakout Area 3	Transpower
Breakout Area 4	International Cable Protection Committee
Breakout Area 5	Fisher & Paykel
Breakout Area 6	Fonterra Ltd

10:30 – 11.00 Morning Tea
12.00 – 1.00 pm Lunch *(not provided)*
2.30 – 3.00 pm Afternoon tea
5:15pm – 7pm Student get-together @ WG201 (*Pizza and drinks provided*)
Informal talk by Prof. Troy Farrell & Friends

Wednesday 27th June

9:15 – 10.10am Plenary Speaker – Lecture theatre WA220
10.10 – 10.30 Feedback from Moderators on progress, looking for support
10:30 – 11.00 Morning Tea

Project working sessions as determined by the moderators and posted on noticeboards etc
11.00-

Breakout Area 1	Sanford Ltd
Breakout Area 2	Methanex
Breakout Area 3	Transpower
Breakout Area 4	International Cable Protection Committee
Breakout Area 5	Fisher & Paykel
Breakout Area 6	Fonterra Ltd

12.00 – 1.00 pm Lunch (*not provided)*

2.30 – 3.00 pm Afternoon tea

6:00 – 8.00 pm Informal Dinner at AUT WG201

Thursday 28th June
Rooms WG608-609 & WG701-703 & WA224B

Project working sessions as determined by the moderators and posted on noticeboards etc
9.00 – 5.00 pm

Breakout Area 1	Sanford Ltd
Breakout Area 2	Methanex
Breakout Area 3	Transpower
Breakout Area 4	International Cable Protection Committee
Breakout Area 5	Fisher & Paykel
Breakout Area 6	Fonterra Ltd

10:30 – 11.00 Morning Tea
12.00 – 1.00 pm Lunch (*not provided)*
2.30 – 3.00 pm Afternoon Tea

Friday 29th Lecture theatre WA220

Project moderators reports on progress and recommendations followed by comments from Industrial representatives

8:50 – 9:00 am	Short address MINZ2018 Organising Director Dr Hyuck Chung
9:00 – 9:10 am	Short address by KiwiNet

Challenge Summaries

9:10 – 9:35 am	Sanford Ltd (Moderator/Group + Industry rep)
9:35 – 10:00 am	Fisher & Paykel (Moderator/Group + Industry rep)
10:00 – 10:25 am	Transpower (Moderator/Group + Industry rep)
10:25 – 10:50 am	Morning Tea
10:50 – 11:15 am	International Cable Protection Committee (Moderator/Group + Industry rep)

11:15 – 11:40 am	Fisher and Paykel (Moderator/Group + Industry rep)
11:40 – 12:05 pm	Fonterra Ltd (Moderator/Group + Industry rep)
12:05 – 12:10 pm	Closing remarks Prof. Mark McGuinness
12:10pm	Conclude

Other Information

Student Pizza Evening

A casual student get-together will be held @ WG201 on Tuesday evening from 5:15pm (free pizza!)

Conference Dinner

The MINZ dinner is being held at WG201 on campus from 6pm, Wednesday 27th June.

On-campus Internet Access

Look to the white board in break out rooms for internet access.

Challenge Outlines

Challenge 1 – Sanford Ltd.

Moderators: Kate Lee, AUT & Richard Clarke (UoA)

Student Moderator: Jason Pang

Industry Representatives: Andrew Stanley

Title: Logistical Aspects of Mussel Farming, Harvesting and Processing

Background

Sanford Ltd is New Zealand's largest and most diverse seafood Company. The Company is vertically integrated from wild fish quota ownership and marine farm ownership to marketing of quality seafood 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 in nutraceutical formats.

Challenge Overview

The supply chain for GSM is complex with multiple variables that result in significant challenges for management and financial forecasting.

From spat catching (finding babies on the beach) to at-sea survival, to growing rates, harvest losses and production yields, the weather and environmental variables create significant uncertainty and variability in the value chain outputs.

The challenge involves developing and trialling a suite of tools and solutions to assist in explaining and managing a complex and challenging industry.

The event will be supported by a team of Sanford representatives to provide information, data and support

Ideas

- Opportunity and value loss, quantification
- Modelling the financial implications of weather, biological and other events
- Probability models and predicting outcomes
- Factor prioritisation to focus investment in solutions
- Economic model from seed to market
- Visual supply chain maps
- Information analysis to assist operational and strategic decisions
- Hypotheses vs historical activities
- Water space vs export sales
- Farm lifecycle models
- Product lifecycle
- Biofouling event management
- Farming and harvesting models to maximise efficiency
- Spat to harvest

Challenge 2 – Methanex

Moderators:	Graeme Wake (Massey), Boris Baeumer (Otago) & Barry McDonald (Massey)
Student Moderator:	TBF
Industry Representatives:	Peter Tait

Title: Heat Exchanger Tube Inspection

Background

Heat exchangers in chemical plants contain up to a thousand small bore tubes that may be subject to corrosion. It is important to know the condition of the tubes in order to manage the life of the exchanger and to repair or replace it before the corrosion causes unacceptable leakage.

Existing internal systems have identified the risk, that is likelihood and consequence of tube leaks which can be reinterpreted as the level of confidence required in the results of the exchanger periodic testing.

There are a variety of test methods available, each with a different level of uncertainty and speed of inspection, typically the faster the inspection the less precision the method offers.

Exchanger testing is performed only every five years during a short timeframe plant outage. It is not possible to test all the tubes, so a sampling regime is adopted. There is no consensus as to how many tubes, or what pattern, should be tested.

Challenge Overview

The first stage of the challenge is to provide an algorithm that will take the established risk factor for the exchanger and the known uncertainties of the inspection methods to calculate the minimum number of tubes that need to be inspected.

The second stage of the challenge is to take into account the results of previous inspections, that is the number of tubes inspected with various degrees of damage and confidence, and to provide the number of tubes to be inspected at the next outage.

The final stage of the challenge is to provide a software model that can take the data from the inspections in real time and determine if more, or indeed fewer, tubes need to be inspected in order to meet the confidence level required.

The historical data is often messy with varying quality of reporting and actual inspections. The initial models can be idealised but ultimately need to factor in the quality of the input data, even if this is a qualitative judgement.

Challenge 3 – Transpower

Moderators:	Catherine Sweatman (AUT) & Nuttanan Wichitaksorn (AUT)
Student Moderator:	Aaron Jiang
Industry Representatives:	Vong (Nyuk-Min) Vong, Gareth Robinson & Charles Chrystall

Title: In order to maintain an accurate load, forecast how can Transpower accurately incorporate the increasingly abundant battery energy storage systems

Challenge Overview

The system operator (SO), Transpower, is responsible for managing the power system and operating the wholesale electricity market.

Managing the power system requires balancing load and generation in real-time, as well as ensuring the network is operated securely.

To achieve this balance, the SO prepares a forecast of demand at conforming grid exit points (GXPs) for each trading period. This information is a key input into the market schedules.

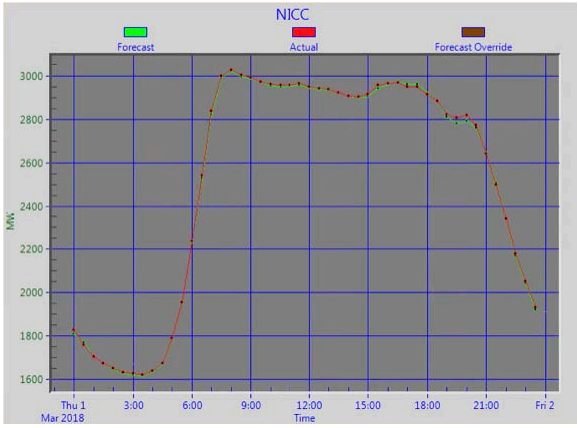

Figure 1: North Island Load Forecast vs Actual Load for Thursday 1st March 2018

A recently published Transpower report, Battery Storage in New Zealand, indicates that batteries can offer the greatest value when located as close to the customer. Pricing and commercial arrangements to realise all benefits have yet to emerge.

Initially, battery energy storage systems (BESS) are expected to see largest uptake at a residential level, so called behind-the-meter (BTM) installations, with the primary drivers being to maximise self-consumption of residential PV generation, for back-up power, and Time of Use (TOU) bill management.
As ancillary service procurement arrangements are adapted to facilitate access to capabilities afforded by batteries, and battery uptake increases the diversity of electricity consumer behaviour may become increasingly difficult to predict. This will have a direct impact on Transpower's ability to accurately forecast load and manage the balance between load and generation in real-time.
The impact of not producing an accurate load forecast may impact on the quality of forecast schedules (including price and generation quantities) leading to sub-optimal purchase and generation availability.

The question presented to the group is:

Based on historical information of system loads but limited data beyond the GXP level, how can Transpower determine the update of battery energy storage systems, along with their capacity and behaviour, in order to maintain an accurate load forecast?

Challenge 4 – International Cable Protection Committee

Moderators: Alona Ben-Tal (Massey) & Jamas Enright (STATS NZ)

Student Moderator: Emma Greenbank

Industry Representatives: Lionel Carter (Emeritus Prof at VUW) & Prof. Mark McGuinness (VUW)

International Cable Protection Committee
Sharing the seabed in harmony with others

Title: Better Utilization of the Submarine Cable Faults Database

Background

ICPC is the International Cable Protection Committee. It maintains a database on all of the submarine cables in the world.

These were originally telephony cables, and now they are millions of kilometres of fibre optic cables for telecommunications, carrying global internet traffic.

They cross (under) the oceans of the world. They carry 95% of internet traffic across oceans; satellites carry the other 5% and they do it slower and more expensively.

There are about 200 serious faults a year. It is quite clear that the fibre-optic cable network has strong socio-economic and security implications. Hence, improving knowledge of the factors affecting the integrity of the cables is high on the agenda.

Database

The database proposed for analysis is held on a strictly confidential basis by the ICPC (https://www.iscpc.org/) It is based on reports of cable repairs undertaken by Maintenance Authorities, which carry out this work for various owners and operators of cables. This raises an important point in that the so called global submarine fibre-optic network is in fact a collection of individually owned, fibre-optic systems in much

the same way that the international air travel network is a group of individually owned airlines.

Currently, the database contains information on ~1400 cable faults that goes back around 7 years.
The database grows by ~ 200 faults per year worldwide.

There is a range of information for each fault that includes time and date fault occurred; time taken for repair; potential cause of the fault etc.
In all, approximately 9 variables are recorded, some of it textual.

Challenge Overview

The over-arching question that the Study Group should tackle is: has the database been used to its full potential and what can be done to realise that potential.

Are there any useful patterns in faults and repairs that can be extracted from the database, and leveraged to help with future planning and strategies for the structural health of the cable network?

Challenge 5 – Fisher and Paykel Appliances

Moderators: Hyuck Chung (AUT) & Wenjun Zhang (AUT)

Student Moderator: TBF

Industry Representative: Jennifer Trittschuh & Ian McGill

Title: Modelling the performance of a front-loading washing machine. Analysis and Modelling of Soil Removal and Gentleness of Wash Performance.

Challenge Overview

The clothes washing process removes dirt particles and grease-like products by a synergistic combination of chemical action, thermal action and mechanical action. More action of one type can compensate, at least to some degree, for less action of another type (ex: if detergent is increased, wash time can be decreased.).

Mechanical action is composed of soil removal through friction within and between garments, friction between garments and the machine and fluid flow through fibres and garments. Chemical action is soil removal performed by the detergent and thermal action accounts for the effects that temperature introduces (ex: increased detergent chemical action and fibre diameter with higher temperatures; garment stiffening with cold temperatures.)

In the washing process customers are primarily concerned with soil removal1 from their garments, but they are also concerned with the "wear and tear" that the garments are subjected to. This is referred to as gentleness of action2. Gentleness of action results from the rubbing actions described above.

Wash Performance (WP) is the combination of the soil removal and gentleness of action. Many wash parameters can be changed to increase soil removal but will simultaneously decrease gentleness of action. Trade-offs need to be made and balances struck so that the overall wash performance will be acceptable to the user.

Wash performance testing of a particular washing machine is performed under controlled conditions, including: Machine dimensions, water temperature and volumes, detergent concentration, load size, wash program parameters (tumble pattern; time; tumble speed).

Swatches of special fabrics are attached to garments to provide estimates of soil removal and gentleness of action. Test results are used by F&P designers and developers to make design decisions. Parameters may be changed, and testing repeated until acceptable performance is achieved.

There are many variables involved in the washing machine (see a basic list in table 1, below).

Table 1: Some variables affecting wash performance

Name	**Unit**	**Description**
Drum radius	mm	
Load size	kg	mass of load (dry)
Load size fraction		= {mass of test load [kg])1 (Maximum volume capacity of drum[kg])
Total wash time	mm:ss	time during wash portion of cycle during which the drum is rotating
tumble speed	rpm	speed at which drum rotates
Wash water volume	Litre	total amount of water added to machine to wash the clothes (excludes rinse water)
Wash liquor concentration	ml/l or g/l	= {detergent amount [ml or g]) / (wash water volume [l])

number of drum revolutions		sum of drum revolutions in clockwise and anti-clockwise directions during wash portion of cycle (excludes any sensing)
pause time	mm:ss	time the drum spends stationary between clockwise and anti-clockwise movement
running time	mm:ss	time the drum spends rotating in either clockwise or anti-clockwise directions between two pauses
tumble pattern		(x_y_z) where x = running time clockwise, y= pause time, z= running time anti-clockwise. **NOTE:** it would be more complete to state it as (x_y_z_y)

Desired Outcomes:

While physical testing will always be part of our development regime, we would like to improve our designs and reduce our development time by utilizing mathematical modelling. We would thus like to have a mathematical model that quantitatively estimates the effect on soil removal and gentleness of action that a parameter change would have. The model could be based on fundamental physics, empirical statistics, dimensional analysis or some other method.

Glossary of Terms:

- **Soil type:** Description of the dirt present that the washing process is expected to remove. Ex: body oil and skin; charcoal; protein; wine;

- **Gentleness of action:** How much wear and tear a load is subjected to in a wash cycle. Quantified by the surface area of fabric swatches that has disturbed thread weaves at the end of a cycle. Commonly referred to as "fray".

- **Soil removal**: how much dirt is taken away from a load during a wash cycle. Quantified by the colour change in commercially-prepared pre-soiled fabric swatches from a wash cycle.

[1]Soil Removal

This is measured by the colour change of “standardised dirt” cloth swatches after a wash cycle when compared to a “clean” standard swatch. The Soil Removal is defined as two standard deviations less than the average colour change.

SR= Cmean – 2s

[2]Gentleness of Action

This is measured by the amount of fray seen on 20 or so, 1dm squares of coarse-weave cloth after the wash cycle.

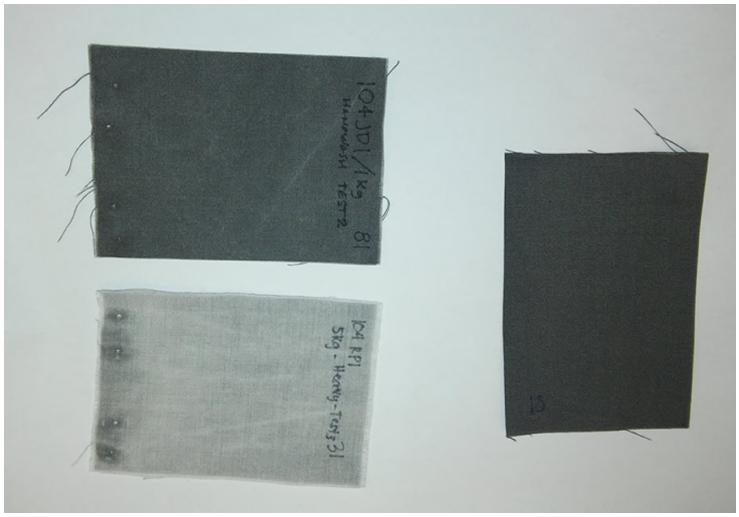

Figure 1: Soil removal swatches, before and after wash cycle (top was heavy cycle; bottom was delicate cycle)

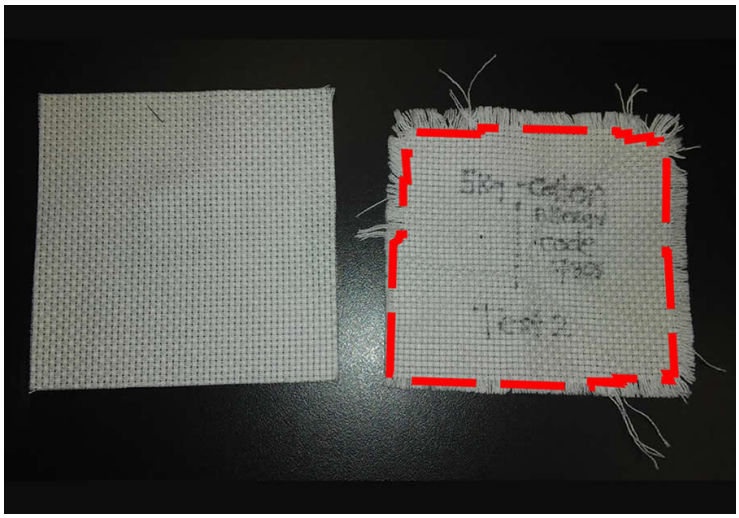

Figure 2: Gentleness of action (fray) swatches- before and after wash cycle

Challenge 6 – Fonterra Ltd.

Moderators:	Stephen Taylor (UoA) & Winston Sweatman (Massey)
Student Moderator	Alan Chen
Industry Representatives:	Lisa Thomasen

Title: Tribology & Dairy Beverages

Challenge Overview

Flavour and texture are both drivers of food acceptance and the perception of one of these factors can change the perception of the other. Texture is harder to define than flavour from a sensory perspective as people often have a default texture in their head for a product category – compare a CalciYum chocolate flavoured milk to a chocolate CalciYum dairy food.

Tribology is the science and engineering of interacting surfaces in relative motion and includes the principles of friction, lubrication and wear. When it comes to food and beverages, tribology is used to mimic oral processing (eating) and can be used to provide insights into the sensory perception of food texture. Oral processing includes the breakdown of food particles (via chewing), the incorporation of saliva and the roles of the teeth and tongue as food is eaten.

A large part of Fonterra's business is the manufacture and sale of ready-to-consume dairy products including plain and flavoured milks, yoghurts and cheeses. Before a product makes it to the supermarket shelves, we want to have a reliable understanding of the in-mouth texture of the product to ensure that it meets consumer expectations. Trained sensory panels are an option for gaining this information but require extensive time and people resourcing to deliver good quality data.

Fonterra has recently started measuring tribology as part of our new product development process. This technique is relatively new to us and we believe that we are not utilising the data to its full potential. We are keen to move beyond using a

single point tribology measure for comparisons to sensory perception, to a more sophisticated tribology to sensory model.

We have sensory and tribology data for a selection of powder samples and we are keen to better understand the relationship between the sensory perception of texture and the tribology measurement data. We want to know whether in-depth exploration of the tribology data can fill in another piece of the puzzle when it comes to understanding the complexity of the sensory experience when a consumer interacts with one of our dairy products.

Attendees

As at 15th June 2018

Boris	Bacic	Auckland University of Technology
Hamid	Abbasi	University of Auckland
Hamed	Amirinezhad	Victoria University of Wellington
Jacek	Andrzejczak	Albany Senior High School
Harold	Atkinson	Te Wananga o Aotearoa
Boris	Baeumer	University of Otago
Timothy	Bilton	University of Otago/AgResearch
Penelope	Bilton	ex Massey
Christian	Blasche	Massey University
Niall	Bootland	University of Oxford
Calum	Braham	The University of Western Australia
Bruce van	Brunt	Massey University
Nadeem	Caco	Massey University
Lionel	Cartner	International Cable Protection Committee
Alan	Chen	University of Auckland
Yan	Chen	University of Auckland
Irvin	Chew	Self-employed
Renu	Choudhary	Auckland University of Technology
Hyuck	Chung	Auckland University of Technology
Alys	Clark	University of Auckland
Richard	Clarke	University of Auckland
John	Crequer	Statistics NZ
Jamas	Enright	Statistics New Zealand
Hammed	Fatoyinbo	Institute of Fundamental Sciences, Massey University
Albert	Feng	New Zealand Institute of studies
Brendan Florio	Florio	CSIRO/UWA
Luke	Fullard	Massey University
Tony	Gibb	Adelaide Advanced Engineering
Alexander	Gibbs	Massey University
Minjung	Gim	National Institute for Mathematical Sciences
Emma	Greenbank	Victoria University Wellington
Hongbin	Guo	University of Auckland
Mahrita	Harahap	University of Technology Sydney
Jack	Houston	Victoria University of Wellington
Ali Abdul	Hussain	Massey University
Corvin	Idler	Massey University

Rodelyn	Jaksons	ESR and University of Canterbury
Gareth	Jardine	Demand generator
Daniel	Jeong	University of Otago
Deepak	Karunakaran	Victoria University of Wellington
Jeong-Hoon	Kim	Yonsei University, Korea
Sungwoon	Kim	National Institute for Mathematical Sciences, Korea
Lucien	Koefoed	KEDRI (Knowledge Engineering and Discovery Research Institute - AUT)
Celia	Kueh	Massey University
Tianli	Liu	University of Auckland
Oliver	Maclaren	University of Auckland
Barry	McDonald	Massey University
Ian	McGill	Fisher and Paykel
Mark	McGuinness	Victoria University of Wellington
Shawn	Means	Massey University
Georgia	Miskell	University of Auckland
Julie	Mugford	University of Canterbury
Rua	Murray	University of Canterbury
Sweety	Naik	Albany Junior High School
Haniffa Mohamed	Nasir	Sultan Qaboos University
Zijian	Pang	Auckland University of Technology
Samuel	Park	University of Auckland
Nasca	Peng	Statistics New Zealand
Peiran	Quan	University of Auckland
Aleksei	Rasskazov	Auckland University of Technology
Gopesh Shivaji	Reddy	Auckland University of Technology
Annette	Sharp	Self-employed
Navdeep	Singh	Auckland University of Technology
Andrew	Stanley	Sandford
Catherine Hassell	Sweatman	Auckland University of Technology
Winston	Sweatman	Massey University (Auckland)
Peter	Tait	Methanex
Jason	Tam	University of Auckland
Frederick	Tan	Massey University
Steve	Taylor	University of Auckland
Lisa	Thomasen	Fonterra
Alexander	Ton	University of Auckland
Jennider	Trittchuh	Fisher and Paykel

Mirian Tsulaia	Tsulaia	
badrinath	Venkata	JB associates and Consulting
Vong (Nyuk-Min)	Vong	Transpower
Graeme	Wake	Massey University
Lijun	Wang	University of Auckland
Alan	Williams	Isogonal
James	Williams	Isogonal
Alex	White	Massey University
Henry	Wu	University of Auckland
Jade	Xiao	University of Auckland
Wenjun	Zhang	AUT
Di	Zhu	Auckland University of Technology
Devansh		Auckland University of Technology
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