1 – 5 July 2024

Mathematics-in-Industry New Zealand 2024

University of Canterbury

People

Co-Directors	Dr Miguel A Moyers Gonzalez, University of Canterbury
	Dr James Williams, University of Canterbury
Administrators	Scott Collier, University of Canterbury
	Seumas McCroskery, KiwiNet
Plenary speakers	Professor Shaun Hendy MNZM FRSNZ
	Dr Rodelyn Jaksons

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Welcome

The Mathematics-In-Industry New Zealand (MINZ) workshop is a unique opportunity for industry and the academic community to collaborate on creative solutions to real world challenges, adding value to our community and providing opportunities for research and partnership. MINZ is finally back after a four year hiatus and we are excited to host the event at the University of Canterbury.

We have five exciting challenges to put forward to our attendees from a selection of companies and organisations, including **Fonterra**, **Orion Energy**, **Tait Communications**, the **New Zealand Police**, and **DairyNZ**. The diversity of these challenges will cater to a range of interests and expertise, and will enable out attendees to explore a variety of solutions. There will be a prize for the most promising solution as judged by our panel of experts from the MINZ reference group.

We also welcome **Professor Shaun Hendy MNZM FRSNZ**, Chief Scientist and Co-Founder of Toha, and **Dr Rodelyn Jaksons**, Head of Data and Insights at Whānau Āwhina Plunket, who are our plenary speakers for MINZ 2024.

We acknowledge the ongoing support for this event from KiwiNet, in particular Seumas McCroskey, and the contribution of the reference group to provide support and continuity over the years as MINZ is hosted by a different university each year.

We hope that you find the workshop simulating and enjoyable throughout the week ahead!

Co-Directors,

James Williams & Miguel A Moyers Gonzalez, University of Canterbury

MINZ 2024

Challenges

Challenge 1

Optimizing road policing to improve driver behavior and reduce incidents

Challenge 2

Critical communication network augmentation using broadband

Challenge 3

Online milk analysis for real time herd management and quality control

Challenge 4

Modeling daily energy demand profiles for hot water cylinders

Challenge 5

Dairy product ring lab trial stability and consistency over time

Plenary speakers

Professor Shaun Hendy MNZM FRSNZ is Chief Scientist and a Co-founder of Toha, a New Zealand company that builds and operates digital marketplaces for environmental action.

He has previously worked as an academic at both Te Herenga Waka - Victoria University of Wellington (2002-13) and Waipapa Taumata Rau - the University of Auckland (2013-22), as well as as a scientist at Callaghan Innovation (1998-2013), where he has been on the Board since 2018.

He has won many awards, including the Callaghan Medal for Science Communication, the Prime Minister's Science Media Communication Prize, and the E. O. Tuck medal for applied mathematics. He also led the team that won the 2021 Prime Minister's Science Prize for their COVID-19 modelling and communication.

Shaun is the co-author of Get Off the Grass with the late Sir Paul Callaghan, and author of Silencing Science and #NoFly.

Dr Rodelyn Jaksons gained her PhD in Bayesian spatio-temporal statistics from the University of Canterbury at the School of Mathematics and Statistics.

After completing her PhD, she worked in science research with a strong focus on biosecurity in the horticultural sciences. She then worked as a Data Scientist at NZ Police within the Evidenced Based Policing Centre, eventually becoming the senior manager.

Currently she is the Head of Data and Insights at Whānau Āwhina Plunket, the largest Well Child Tamariki Ora provider in New Zealand. Whānau Āwhina Plunket is a charitable organisation that provides healthcare services for children under five.

Her academic background gives her a different perspective on enterprise data challenges, bringing forward solutions that were often thought as purely academic into the operational sphere. She credits her statistics background as instrumental in transitioning between industries.

Programme

Day 1 – Monday, 1 July 2024

08:00 – 09:15	Registration	Erskine Building
09:15 – 09:30	Welcome	A2
09:30 – 10:15	Plenary speaker – Dr Rodelyn Jaksons	A2
10:15 – 10:45	Morning tea	A2
10:45 – 11:30	Plenary speaker – Professor Shaun Hendy	A2
11:30 – 12:00	Industry presentation 1 – New Zealand Police	A2
12:00 – 12:30	Industry presentation 2 – Tait Communications	A2
12:30 – 13:30	Lunch	A2
13:30 – 14:00	Industry presentation 3 – Dairy NZ	A2
14:00 – 14:30	Industry presentation 4 – Orion Energy	A2
14:30 – 15:00	Industry presentation 5 – Fonterra	A2
15:00 – 15:30	Afternoon tea	Erskine Building
15:30 – 17:00	Project breakouts	Erskine Building
18:00 – 19:00	Drinks and networking	UC Staff Club

Day 2 – Tuesday, 2 July 2024

08:30 – 10:15	Project breakouts	Erskine Building
10:15 – 10:45	Morning tea	Erskine Building
10:45 – 12:30	Project breakouts	Erskine Building
12:30 – 13:30	Lunch	Erskine Building
13:30 – 15:00	Project breakouts	Erskine Building
15:00 – 15:30	Afternoon tea	Erskine Building
15:30 – 17:00	Project breakouts	Erskine Building

Programme

Day 3 – Wednesday, 3 July 2024

09:00 – 09:30	Address from the MINZ reference group	A2
09:30 – 09:40	Project update 1 – New Zealand Police	A2
09:40 – 09:50	Project update 2 – Tait Communications	A2
09:50 – 10:00	Project update 3 – Dairy NZ	A2
10:00 – 10:10	Project update 4 – Orion Energy	A2
10:10 – 10:20	Project update 5 – Fonterra	A2
10:20 – 10:40	Morning tea	A2
10:40 – 12:30	Project breakouts	Erskine Building
12:30 – 13:30	Lunch	Erskine Building
13:30 – 15:00	Project breakouts	Erskine Building
15:00 – 15:30	Afternoon tea	Erskine Building
15:30 – 17:00	Project breakouts	Erskine Building
18:00 – 22:00	Workshop dinner	UCSA

Day 4 – Thursday, 4 July 2024

08:30 – 10:15	Project breakouts	Erskine Building
10:15 – 10:45	Morning tea	Erskine Building
10:45 – 12:30	Project breakouts	Erskine Building
12:30 – 13:30	Lunch	Erskine Building
13:30 – 15:00	Project breakouts	Erskine Building
15:00 – 15:30	Afternoon tea	Erskine Building
15:30 – 17:00	Project breakouts	Erskine Building

Programme

Day 5 – Friday, 5 July 2024

09:00 – 09:20	Address from the University of Canterbury	A2
09:20 – 09:40	Project presentation 1 – New Zealand Police	A2
09:40 – 10:00	Project presentation 2 – Tait Communications	A2
10:00 – 10:20	Project presentation 3 – Dairy NZ	A2
10:20 – 10:40	Morning tea	A2
10:40 – 11:00	Project presentation 4 – Orion Energy	A2
11:00 – 11:20	Project presentation 5 – Fonterra	A2
11:20 – 11:30	Final remarks	A2
11:30 – 12:00	Workshop closing	A2

Challenge 1

Breakout room	Erskine 101
Industry representative	Mike Jones, Senior Sergeant, Road Policing
Student moderator	TBA
Moderators	TBA

Optimizing road policing to improve driver behavior and reduce incidents

Background

The New Zealand Police plays an important part in helping to make roads safer through rigorous enforcement of traffic laws including alcohol limits and speed regulations, promoting good driving practices, and road safety education in general. The Canterbury Police District is staffed with a road policing manager and a number of specialist road policing groups such as Strategic Traffic Units, Highway Patrol, Impairment Prevention Teams, Anti Social Road User Teams, Motorcycle Units and Serious Crash Units.

Checkpoints

Speed cameras

Road policing

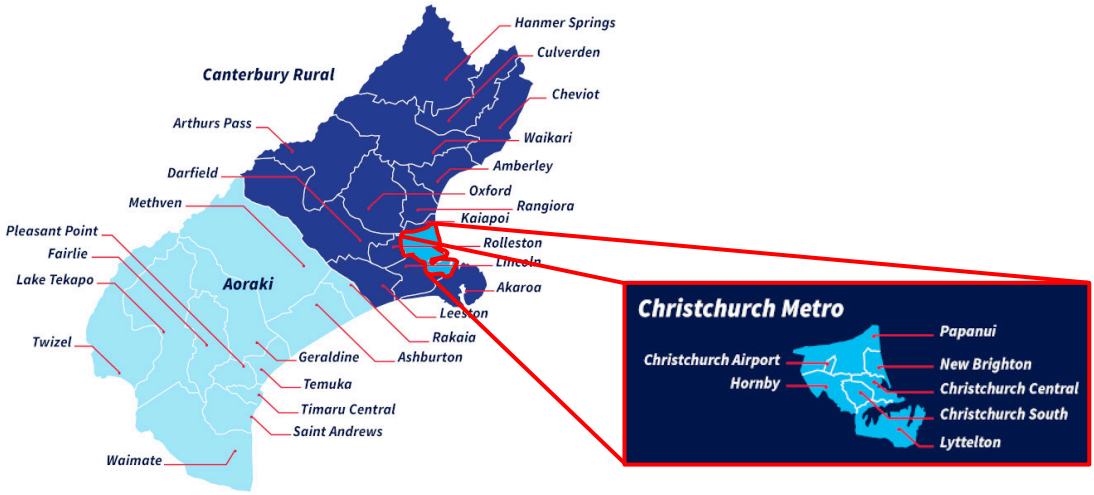
Road safety is about more than just enforcement, with a strong focus on community presence and prevention activities that target specific driver behaviour. The road policing resources are managed at a district level by the road policing manager and there is flexibility in how, when, and where those resources are deployed.

There has been some work using general deterrence principles to optimise use of specific resources such as how checkpoints are deployed, focusing on parameters such as the number of checkpoints per month, how many checkpoints are run at the same time, and how long checkpoints should be in one place before being moved. These focused optimisations have been successful, but there is an opportunity for a more general analysis of the current deployment model which relies on coverage, dosage, and randomness to affect driver decision making.

There is a relationship between DSI locations and police events, and this has been used to increase dosage in high risk areas. A greater exploration of the relationship from a statistical modeling and simulation perspective could be used to further improve how police resources are deployed.

Objectives

How can the Canterbury Police District optimize road policing work to improve driver behaviour and to reduce incidents such as death or injury? Can you identify any specific relationships between how road policing resources are deployed and how incidents are reduced? Can the relationship between DSI crash and police events be modelled? Is there a halo effect in place?



Data

General deployment data, police event data, and crash analysis data is available.

- Police event database (deployment and crash locations with GPS, date, and time)
- Crash Analysis System (CAS)

Links

- Safe Roads Control Strategy
- Road Safety Partnership Programme 2021 – 2024
- Road to Zero
- The effect of police patrol on car accidents

Challenge 2

Breakout room	Erskine 121
Industry representative	James Collett, Software Engineering Manager
Student moderator	TBA
Moderators	TBA

Critical communication network augmentation using broadband

About Tait

For more than 50 years, Tait Communications has been designing, delivering and supporting critical communications networks for public safety, transportation and utility customers around the world. We support our customers from regional bases that cover the Americas, Asia Pacific, Europe, Middle East, and Africa. The hub of our global operations is in Christchurch, New Zealand and includes our principal design, engineering, and manufacturing facilities. Our campus sits at the hub of a network of suppliers and partners that fuels our local, regional and national economies. We believe we can make the world a safer, better, and more efficient place.

The problem

Create a real time, self adapting analytics system for determining the current health, performance and customer perception of our Broadband Voice Communications system.

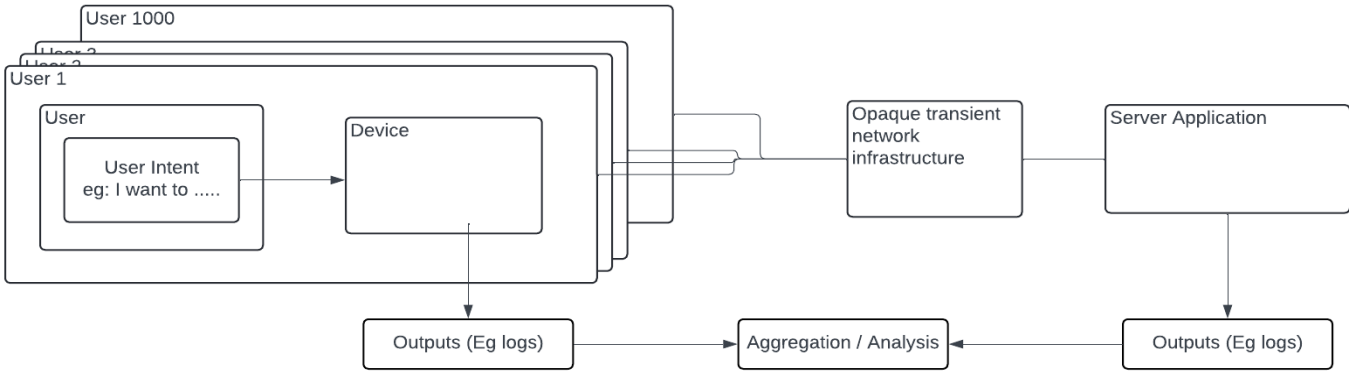
Background

In the last decade Tait has introduced a number of products and services that can operate on and utilise public cellular network infrastructure. The latest manifestation of this is a Push to Talk (PTT) voice service that is targeted at customers that want to have a PTT radio like experience while using a cellular network. The PTT over broadband solution Tait has developed offers many of the features that our customers have come to expect from our existing products. The feature that is most relevant for this project is the group call, a voice call that includes anywhere from 2 to 2000 devices.

With the introduction of these broadband devices Tait has less control over the end to end system, due to the reliance on public or customer hosted broadband infrastructure, but at the same time has significantly more access to diagnostic information from the end devices. The object of this project is to come up with a methodology for utilizing the increased access to data to provide a scalable,

adaptive and insightful analytics platform to monitor the status of the system in real time, while providing insights into feature usage, user behaviors, trends and general system performance.

The diagram below breaks down the problem into a number of components. The most important actor in the system is the end user and specifically their actions or intent. It is however hard to collect data from the user directly, which is discussed more below in the analysis outputs. The diagram also highlights the components in the system that data can be collected from.



The following is a list of possible analysis outputs which could be extracted using the data provided.

Detecting user expectation anomalies: The user pushed a button on the device, given the current context this probably means they want to make a call to other devices. If this call doesn't proceed for any reason the user would be surprised, representing a user expectation anomaly.

Call behavior anomalies: During a call a user expects to be able to transmit uninterrupted audio to everyone else in the call (maybe 1000's of other devices). If another device doesn't receive all of this audio then this would be a call behavior anomaly.

System Performance: Radio networks have a very deterministic performance profile for metrics like call setup time, audio delay, jitter etc. Due to the transient nature of the broadband network, that the new system relies on, tracking system performance, from the user perspective, is highly valuable.

Trends: Over time trends may emerge, for examples Anomalies or performance issues may occur at specific locations, certain times of day, particular devices, or particular users. Identifying these trends help with the identification of the root cause of the anomalies or performance issues.

System health: There are many systems around the world being operated concurrently by a number of different customers, and anomalies and performance issues need to be aggregated into a single entity that represents the health of the system overall. This likely requires a weighting system to determine the severity of any given issue while taking into account user impact and occurrence rate.

Insights: Detecting trends around user expectations and behaviors, both positive and negative. A possible insight output could be a weighted summary of severity of anomaly versus occurrence rate vs global usage of the feature.

Challenge 3

Breakout room	Erskine 443
Industry representative	Mark Neal, Head of Data Science
Student moderator	TBA
Moderators	TBA

Online milk analysis for real time herd management and quality control

Background

New Zealand's largest export industry is dairy produce, which comes from about 11,000 farms, with about 400 cows each. Most cows calve in July, August, September, and are milked for about 270 days on average. Over this time, they produce on average 4,300 litres per year per cow, with the most valuable components being milk fat (~220kg/yr.cow) and milk protein (~170 kg/yr.cow). Together, milk fat and protein make up milksolids (fat plus protein), not to be confused with milk solids (two words) which is all non-water components of milk, primarily the fat protein, lactose and minerals.

Herd testing

Milking parlour

Samples being tested

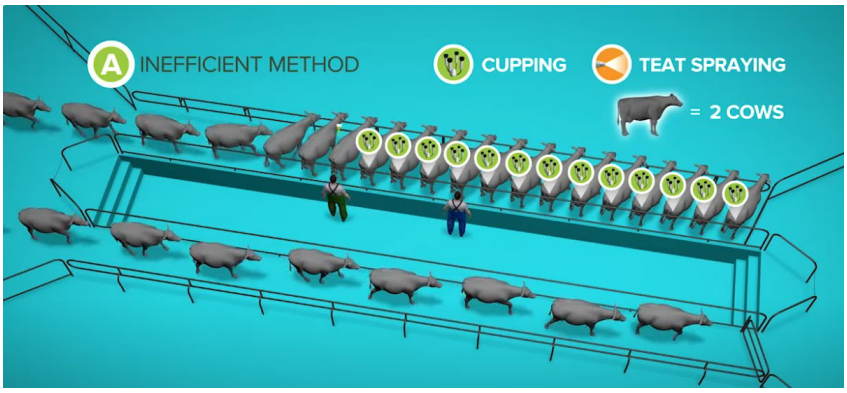
Knowing milk production at an individual cow level is useful for two main reasons; farmer decisions (e.g. do I keep this cow? is there a health issue?), and for industry animal evaluation (e.g. how well are the genetics of this animal performing?). Traditionally, most milk production information is gathered through a herd testing process, where companies like LIC and CRV provide devices to the

farm for 24 hours to measure volumes and components at the milking events (mostly once or twice in a 24 hour period). This is usually repeated 3 or 4 times per year across 80% of dairy farms in NZ. The timing of these tests is carefully spaced to cover the lactation period.

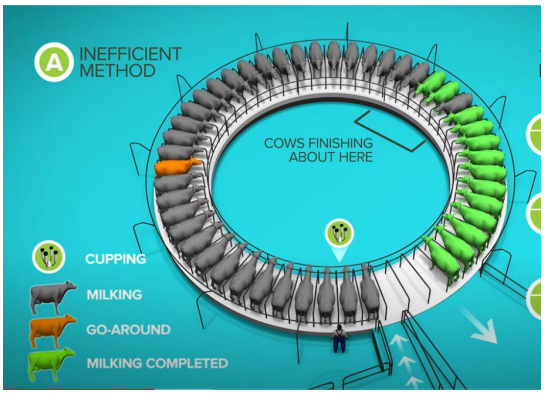
An alternative to measure milk production is to use milk meter technologies that can be permanently installed in a dairy milking parlour (Online Milk Analysers - OMA). However, these technologies come at a cost, and so farmers often consider having less milk meters than there are milking points.

Objectives

There are two main types of milking parlour, a herringbone and a rotary. Common sizes for a herringbone are between 20 and 40 cows per side, and rotary dairies between 40 and 60 cows on the platform.



Herringbone parlour



Rotary parlour

Assuming the OMA is as accurate as traditional measurement devices for a single measurement, how few devices could be installed in a rotary and herringbone milking parlour, to generate animal level estimates for the last week, month, or year of similar accuracy to the traditional herd test? How would the number of devices change if the OM had half the accuracy of the traditional milk meter?

Data

- Cow unique identifier and milking order – Herringbone parlour
- Cow unique identifier and milking order – Rotary parlour
- Cow unique identifier and milking level milk components data, two production seasons (Herd Testing Regime Report AB Dataset)

Challenge 4

Breakout room	Erskine 445
Industry representatives	Peter Jaksons, Head of Data Intelligence
Student moderator	TBA
Moderators	TBA

Modeling daily energy demand profiles for hot water cylinders

Background

Orion Energy, a Christchurch based energy distributor, services approximately 190,000 residential customers, accounting for about half of its network's energy demand. Heating hot water constitutes roughly one-third of daily household energy consumption. Most residential customers use hot water cylinders, which offer a controllable energy store that can be managed to optimize overall energy demand.

However, there is a lack of comprehensive understanding of the daily energy demand profiles of these hot water cylinders, both individually and collectively, under various control regimes. These regimes include fixed time control, interruptible control, and uncontrolled usage. By modeling and simulating different control regimes, Orion will be able to identify the most effective methods to manage residential energy demand, enhancing overall network efficiency and reducing peak loads.

Objectives

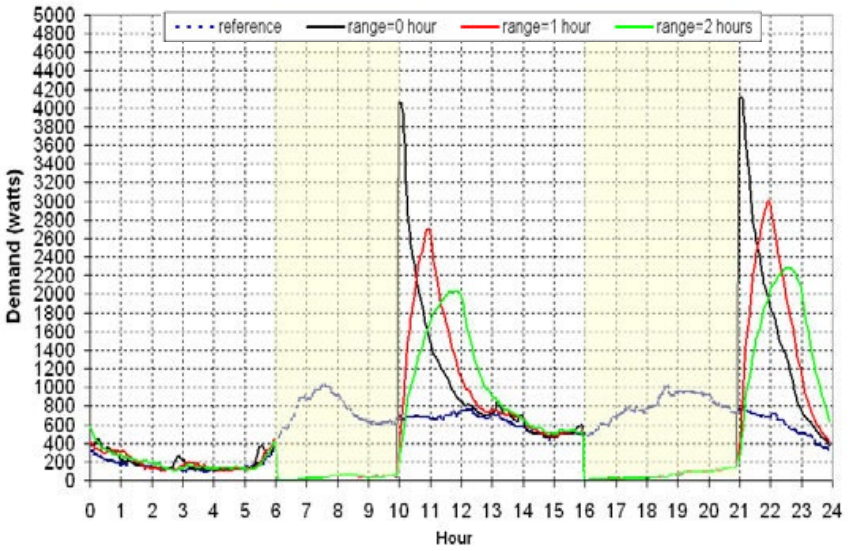
The primary objectives are to develop detailed daily energy demand profiles for individual and aggregated hot water cylinders, compare these profiles under different control regimes (fixed time, interruptible, and uncontrolled), and model the impact of changes in control strategies on the aggregate demand profiles.

Methodology

The solution might utilize a top-down or bottom-up approach. The top-down approach involves collecting overall energy demand data from various network levels such as substations and transformers, as well as household-level demand profiles that include all energy consumption to disaggregate the hot water demand from overall demand. The bottom-up approach will synthesize

individual hot water cylinder demand profiles based on typical usage patterns and simulate these profiles under different control regimes to understand their impact on aggregated demand.

Hot water cylinder



Fixed time control diversified energy demand profile

Data synthesis and analysis will involve creating synthetic individual demand profiles using existing data on hot water usage, modeling the energy consumption of individual hot water cylinders under fixed time, interruptible, and uncontrolled regimes, and aggregating these profiles to understand overall demand under each control regime. These synthesized aggregated profiles will be compared with measured network-level data to validate the models. Scenario modeling will then be conducted to simulate the impact of various control strategies on overall demand, analyzing potential benefits in terms of peak demand reduction and energy savings.

Data

- **Network data:** Measured in 5 and 30 minute increments, this data captures the dynamic behaviour of the network as a whole and can be used to check aggregated load profile assumptions or disaggregate hot water load profile changes.
- **Household data:** Measured in 5 minute increments, this data reflects individual household behaviours, which can be used to disaggregate hot water profiles, understand the diversity of demand between households, and check aggregate assumptions about hot water load.

Expected Outcomes

The research is expected to produce detailed energy demand profiles for hot water cylinders under different control regimes, providing an improved understanding of how different control strategies impact aggregated energy demand. This will lead to recommendations for optimizing hot water cylinder control to manage peak demand effectively.

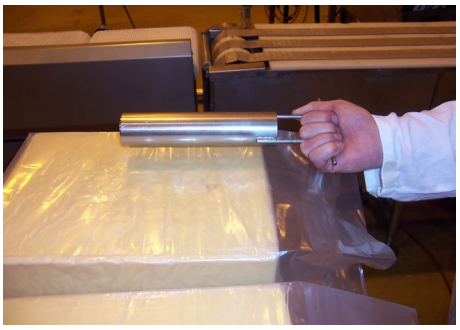
Challenge 5

Breakout room	Erskine 446
Industry representatives	Jo Simpson, Calibration Technologist
Student moderator	TBA
Moderators	TBA

Dairy product ring lab trial stability and consistency over time

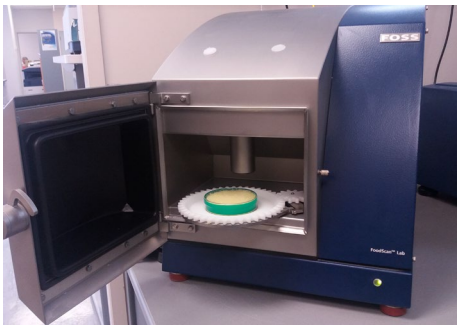
Background

Fonterra measures composition (fat, moisture, protein) of most of its products with a secondary method, near infrared (NIR) spectroscopy that is calibrated against reference laboratory results (the primary method). These instruments are networked and share a calibration across product classes that allows them to predict product composition. The stability of the instruments is monitored via regular ring lab trials where a representative bulk sample of product is subdivided, and a subsample is put through all the NIR instruments along with the reference labs and the results are compared.



Sampling

Prep



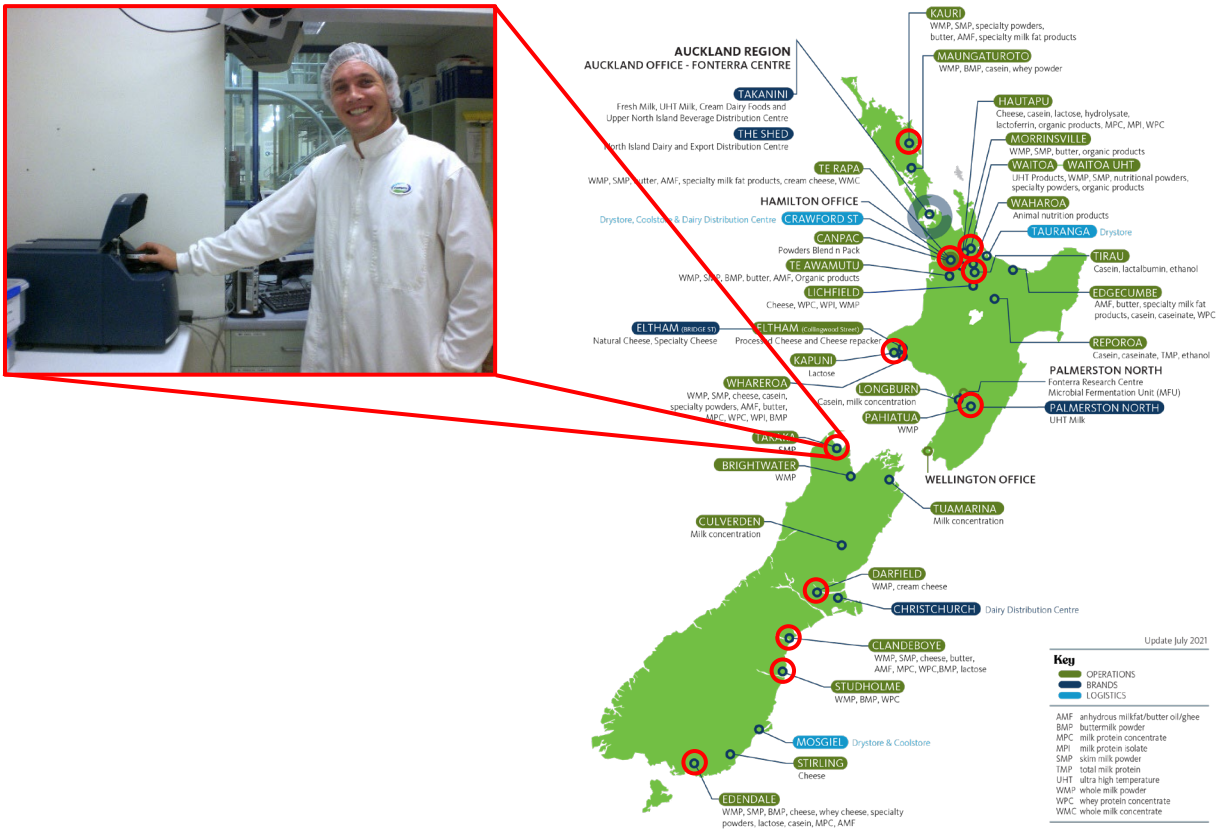
Testing

Fonterra is interested in understanding the differences in performance between the NIR instruments (both raw spectral data and predicted results) for each ring lab trial, for multiple ring lab trials when compared to each other as well as the performance over time. We seek better definition of the

source of errors and also assess the relative stability of the NIRs and effectiveness of our monitoring programme.

Details

Fonterra will provide data that includes NIR predictions, raw NIR spectral data, and reference lab info from a number of ring lab trials from a specific period with results for whole milk powder, protein powders and cheese from a single class of instruments. We'd like to understand the relative variation from the results (both predictions and raw spectral data, do we go to lab results too?) from a single ring lab trial, and then compare a number of ring lab trials across the three products groups and determine if there are any trends over time and between product groups.



To extend we'd also like to see if there are broader trends across time with the ring lab trial results, although we acknowledge that each week a different group of products is used in the ring trial. We will also present a second data set derived from a different newer group of NIR instruments with a different calibration to validate the findings from the previous work.

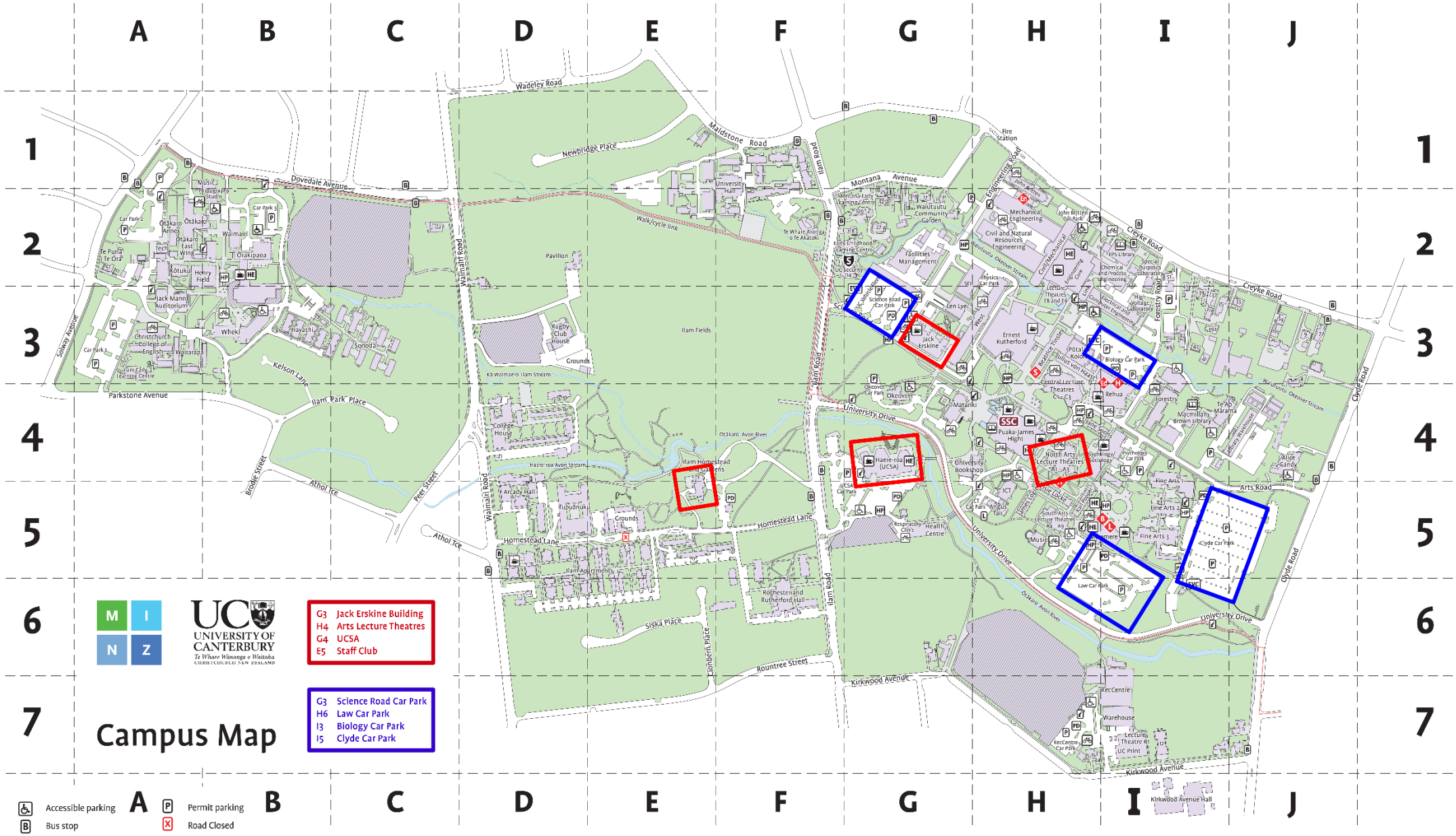
Outcomes

The outcomes for Fonterra could include an assessment of the relative stability of our NIRs over time and across different products, recommendations regards the frequency and nature of our ring lab trials and an understanding of the error sources in our compositional testing process.

Campus

MINZ is being hosted by the School of Mathematics and Statistics at the University of Canterbury, in the award-winning Jack Erskine Building. This building received a number of architectural awards when it was built in 1998 and more recently two Enduring Architecture awards in 2023.

Jack Erskine Building	Erskine 101	Project breakout 1 – New Zealand Police
	Erskine 121	Project breakout 2 – Tait Communications
	Erskine 443	Project breakout 3 – Dairy NZ
	Erskine 445	Project breakout 4 – Orion Energy
	Erskine 446	Project breakout 5 – Fonterra
	Atrium	Breaks
Arts Lecture Theatres	A2	Welcome, speakers, presentations, and closing
	Atrium	Breaks
Staff Club	Homestead	Drinks
UCSA	Ti Kouka	Workshop dinner



M I N Z

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

G3 Jack Erskine Building
H4 Arts Lecture Theatres
G4 UCSA
E5 Staff Club

G3 Science Road Car Park
H6 Law Car Park
I3 Biology Car Park
I5 Clyde Car Park

Campus Map

- Accessible parking
- Bus stop
- Café or Bar
- Closed temporarily
- Cycle stand
- Directory
- Electric Vehicle Charger
- Library
- Link parking
- Heat and Eat
- Help Point
- Pay by Plate parking
- Permit parking
- Road Closed
- Security
- Student Services Centre | Te Pātaka
- Uni-Cycle Route
- Faculty of Arts
- Faculty of Education
- Faculty of Engineering
- Faculty of Health
- Faculty of Law
- Faculty of Science
- UC Business School

Cafés, bars and galleries

H3 Ancestral — *Ernest Rutherford*
H4 Café 101 — Psychology/Sociology
H4 Café 1894 — Puaka-James Hight
I4 Café Therapy — Rehua
H4 Chiltons — Puaka-James Hight
B2 Collective — Dovedale
I5 Ilam Campus Gallery — Fine Arts 2
I5 Mix Café UC — Meremere
H2 Nuts & Bolts — Engineering Core
H4 Oishii Sushi — Puaka-James Hight
H4 Otto — Puaka-James Hight
G3 Reboot — Jack Erskine
D5 Shirley's — Ilam Apartments
G4 The Foundry and Bentley's lounge — Haere-roa
H4 Undercroft Food Hall — Puaka-James Hight

Computer workrooms (24/7)

A2 Kōtuku
G3 Jack Erskine

Halls of residence

D5 Arcady Hall
D4 College House
B3 Hayashi
D5 Ilam Apartments
I8 Kirkwood Avenue Hall
F6 Rochester and Rutherford
C3 Sonoda
D5 Tupuānuku
F1 University Hall

Lecture theatres

A3 Jack Mann Auditorium
H4 A1 –A3 North Arts lecture theatres
H5 A4 – A9 South Arts lecture theatres
H3 C1 – C3 Central lecture theatres
H2 E5 – E16 Engineering lecture theatres
I4 F1 and F3 Forestry lecture theatres
A2 L1 – L2 Ōtākaro lecture theatres
I7 K1 – Warehouse lecture theatre

Libraries

H4 Central Library — Puaka-James Hight
I2 Engineering and Physical Sciences Library
I4 Macmillan Brown Library — Te Ao Mārama

Services

H4 ATM, ANZ — Puaka-James Hight
G5 Health Centre
G4 IT Service Desk — Matariki
H4 Pharmacy — Puaka-James Hight
H4 Postal Services — Puaka-James Hight
I7 Recreation Services — RecCentre
G4 Students' Association (UCSA) — Haere-roa (UCSA)
I7 UC Print
G4 University Bookshop
G4 Vice-Chancellor's Office — Matariki

Whare

A2 Te Puna i Te Ora — Dovedale
F2 Te Whare Akonga o Te Akatoki — Ilam

1 - 5 July 2024