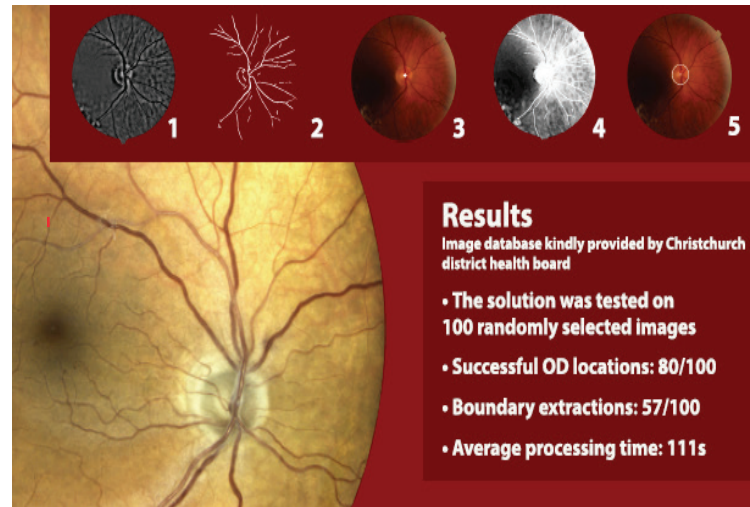
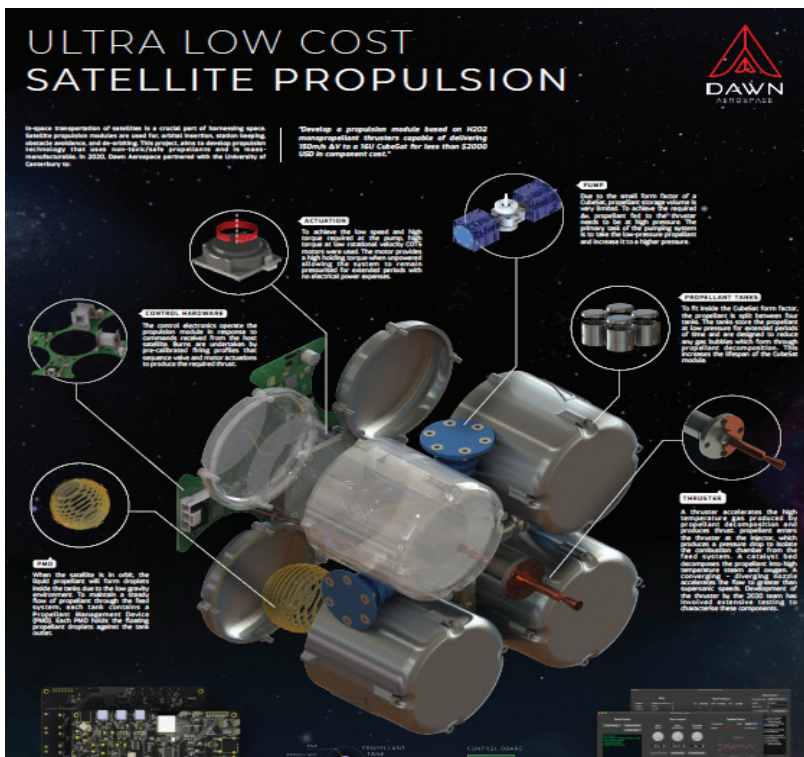


# Faculty of Engineering

## Engineering | Product Design

# Final Year Projects

# 2021



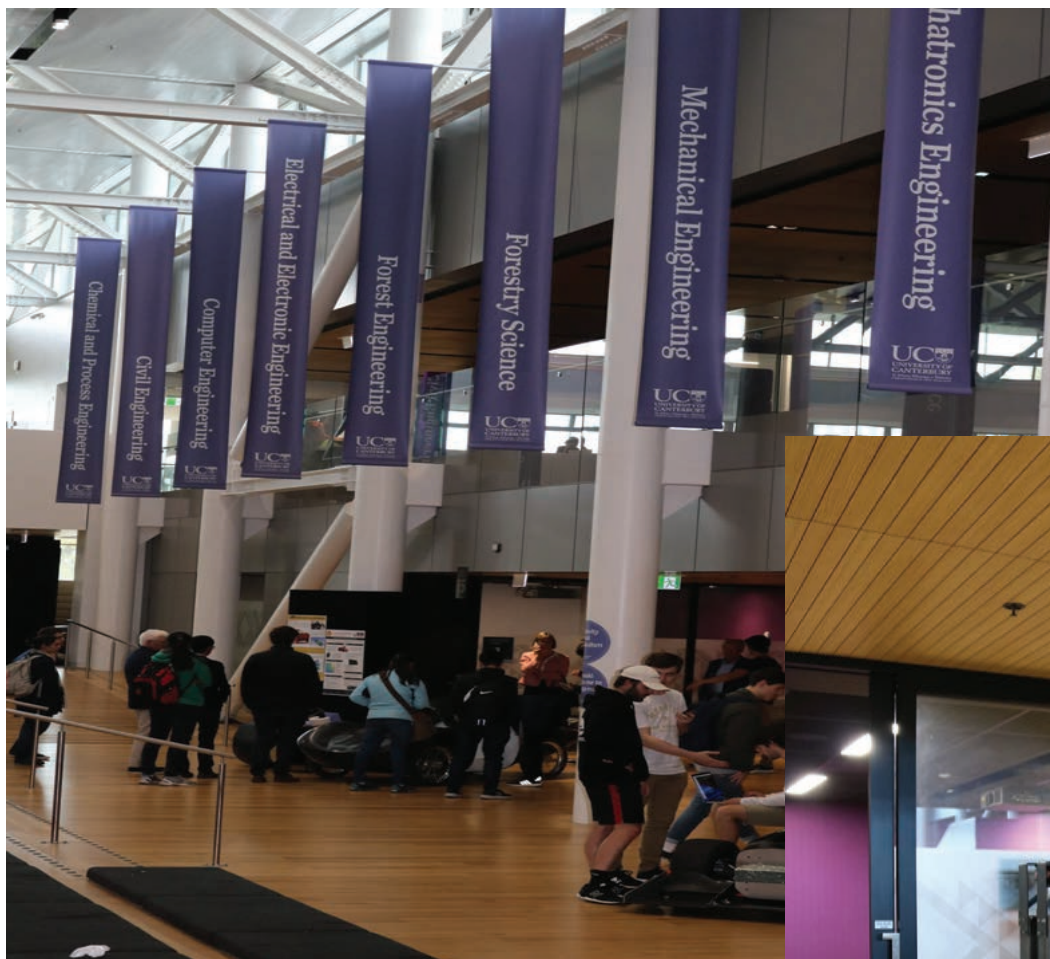


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# Thank you to all our 2021 Project Sponsors

All our industry Final Year Project sponsors and supporters are listed below. Your efforts to challenge and support our students last year were most appreciated. Without your support and encouragement, our students wouldn't be the amazing, well-rounded graduates they are now.

Note to new readers: Project sponsorship is a great way to participate in education, complete projects you wouldn't normally have time for, and get in-depth research or consultancy for your organisation. Students are available at many levels of study, in teams or as individuals and include all disciplines of Engineering including Forestry, Maths and Product Design. Projects and internships culminate in the production of a prototype, report or case study that is made available to the sponsor organisation. This brochure illustrates the majority of projects that were completed by Faculty of Engineering students with fantastic support from their sponsors, during 2021.

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## Special Thanks to all the Final Year Project Coordinators

Adrian Clark	Garrick Thorn
Bahareh Shahri	Rien Visser
Chin-Long Lee	Sarah Kessans
Digby Symons	Shayne Crimp
Fabian Gilson	



# The Peoples Choice Award 2021

Each year attendees at the Final Year Project Showcase are able to vote for their favourite project. This year due to the disruption caused by COVID-19, not all students were tasked with producing posters for their projects and as a consequence, the event was a more low key affair. For those that did produce posters, the standard was very high and fiercely competitive between some students.



## People's Choice Award Winner:

### Project Poster:

"Automated Forming of Reamer Teeth"

### Project Sponsor:

ENZTEC – Dr. Iain McMillan

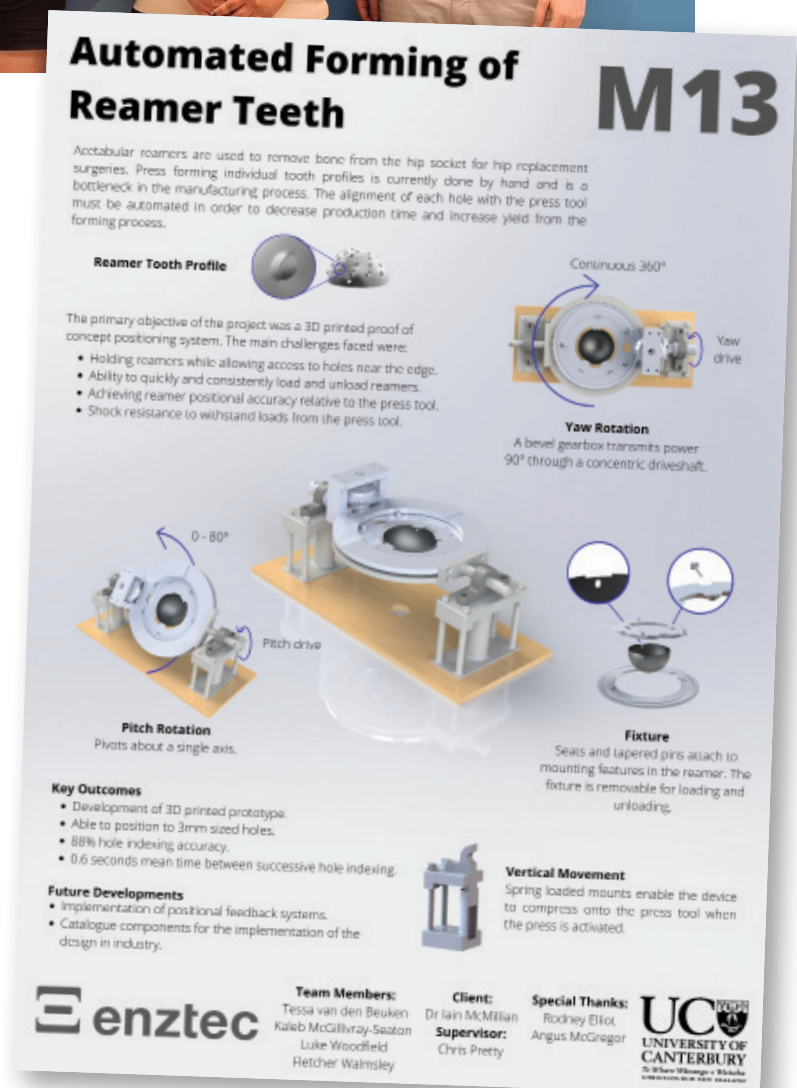
### Project Students:

Tessa van den Beuken,  
Kaleb McGillivray-Seaton,  
Luke Woodfield,  
Fletcher Walmsley.

### Academic Supervisor:

Professor Chris Pretty

See more on page 97.





## Student projects: Chemical and Process Engineering

L to R – Dr Brendon Miller, Kate Stoddart, Jack Scott, Indy Platt-Byrnes, Ben Trigg and Sophia White at the International Antarctic Centre in Christchurch.



A UC research project evaluating the feasibility of hydrogen production in Antarctica could help to reduce carbon emissions in the future by replacing fossil fuels with a zero-carbon alternative.

The research, in collaboration with Antarctica New Zealand and Callaghan Innovation, is looking at how hydrogen could be generated, used and stored at Scott Base and various remote field camps to reduce the reliance on carbon-based fuels currently used for transport, cooking and heating.

The project team of four UC Chemical and Process Engineering students: Indy Platt-Byrnes, Kate Stoddart, Jack Scott, and Ben Trigg, is being supervised by UC Adjunct Fellow and Jembec Consulting Principal Dr Brendon Miller.

Dr Miller says with the development of a new wind farm at Scott Base, the surplus electricity generated by wind turbines could be used to generate green hydrogen.

“Currently Antarctica New Zealand uses fossil fuels for transport to and operation of remote field camps but wants to investigate the feasibility of generating and using hydrogen as an alternative fuel. Turning excess energy from the turbines into hydrogen would help reduce emissions from burning fossil fuels and also transporting those fuels to Antarctica.

“Hydrogen is a step in the right direction – if not the eventual answer – to providing a zero-carbon alternative to fossil fuels in Antarctica.”

Ms Stoddart says the project provides an opportunity to explore a real-world solution involving unique design challenges.

“This project has the potential to help reduce carbon emissions in Antarctica, but there are a number of design challenges to consider, such as the geographic isolation, the pristine environment, extreme conditions and remote field camps. Being able to work with industry on a real-world application is providing valuable first-hand experience as to what a career in this field could look like.”

Mr Platt-Byrnes says the project has provided a valuable insight into the scientific work undertaken in Antarctica, as well as Antarctica New Zealand’s progress in reducing emissions.

“It has been fascinating learning about how operations at Scott Base are conducted by Antarctica New Zealand to support research, and how these can be modified within the unique set of considerations and constraints to optimise our proposed process economically.

“Antarctica New Zealand’s work over the last ten years and desire to further offset their carbon emissions sets a good precedent for the 29 countries that operate bases within Antarctica. Hopefully, this project will inspire similar initiatives to be undertaken at other permanent research stations.”

The project commenced in August and will be completed in November.

Antarctica New Zealand Environmental Advisor Sophia White says the outcomes of their research will be used by the organisation to inform futureproofing of their operations.

“We know burning fossil fuels has resulted in man-made climate change that is affecting the world today. The students’ project is important for us because, as kaitiaki of Antarctica, we want to move away from energy sources that are damaging our planet and this research shows us what could be possible.”



# Influence of Plants Morphology on Wildland Fires

## CONTEXT

Climate change has increased the frequency of fire risk weather, leading to a rise in wildland fires globally. As the human population increases, the interface between wildlands and urban areas merges, which poses a greater risk to people and property due to the effects of wildland fires. This paper studied the influence of plant geometry on flammability, focussing on the relationship between the fractal index and flame time, mass loss and visual flame spread. These findings can therefore be used to influence the types of trees people plant to reduce the chance of wildland fire spread.

## EXPERIMENTAL

Three repetitions of five different fire tests were conducted in the University of Canterbury Fire Laboratory. The independent variable was the angle at which each branch layer would expand from the previous layer (fractal index). The fixed variables were the mass of the flammable material, the ignition method and the thickness of each branch layer. The dependent variables were the time between ignition and extinction, the mass loss over time and the visual flame spread.

## CONSUMABILITY

Consumability is defined simply as how well the fire is able to consume the plant. The consumability of each plant case was tracked by logging the mass loss of the plants over the burn history. As shown in Figure 1, when the fractal dimension is low (10° and 30°) the plants were highly consumed. The rate of consumability (mass loss rate) varies significantly between plants and even within an individual plants experiment. This is shown by the timeline of the 30° experiment (Figure 2), where the flames vary significantly in each screenshot.

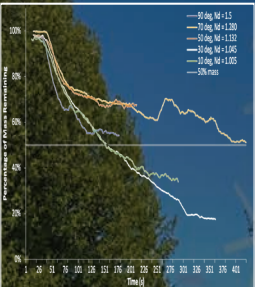


Figure 1 - The mass loss history of each plant



Figure 2 - The burn history of a 30° plant

## FRACTALS

A fractal is a shape that looks the same at any level of scale or magnification and are used to represent the geometry of different plant cases numerically. A fractal dimension of 1.0 is equal to a straight line or a trunk with no branches. This value increases as the branches of a plant spread out more and more. By altering the angle of each branch layer, the compactness, and therefore the fractal dimension of the plants was able to be generated.

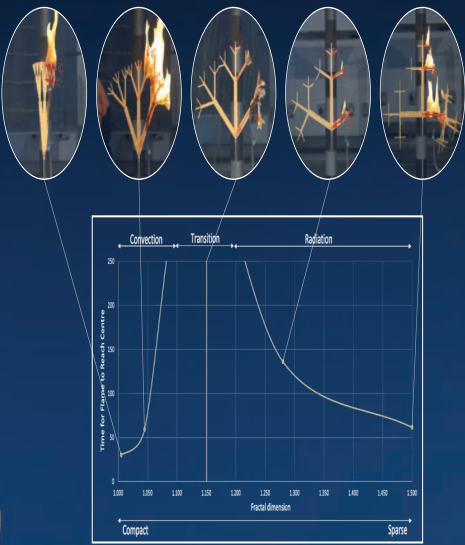


Figure 3 - Time for flame spread to reach halfway across each plant

Fire sustainability is the ability to sustain combustion once ignited. The sustainability was recorded as the flame spread from one edge of the plant to the centre of the plant. Figure 3 above shows the time taken for this flame spread to occur, with respect to the fractal dimension. It was found during the experiments, a lower fractal dimension increases the effects of the convection spread mechanism. A greater fractal dimension increases the effects of the radiation spread mechanism. This figure shows that plants with a lower fractal dimension and are therefore governed by convection, spread faster than those that are less compact and governed by radiation.

## COMBUSTIBILITY

Combustibility is the rapidity of the combustion after ignition. The governing combustion mechanisms were convection (q<sub>c</sub>) and radiation (q<sub>r</sub>), which therefore determined the sustainability and combustibility of the different plant cases (Figure 4). Convection flame spread occurs when the heating of neighbouring branches causes pyrolysis and eventual ignition of this material. Radiation is where the flame directly heats the unburnt material that the burning material is attached to. The angle of the direction of flame spread controls this mechanism.

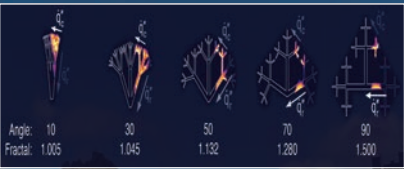


Figure 4 - Flame spread mechanisms as seen through infrared camera

## CONCLUSION

The plant cases tested in this study were chosen as the general shapes roughly represent the trees we see in the environment around us. Figure 5 shows examples of trees that the tested cases drew influence from. Further studies into the comparisons of real trees and flame spread could support the findings in this report and therefore influence the types of trees people plant to reduce the chance of wildland fire spread.

These results have concluded that the fractal dimension of a plant has an influence on its flammability characteristics.

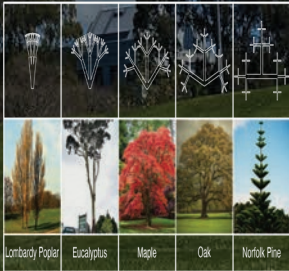


Figure 5 - Comparison between plant cases and real trees



## Developing Design Fires for Performance Based Building Design

Jiayi LI & Xiaolan LU Project supervisor: Charles Fleischmann



### Background

The damage of fire must be serious and unacceptable because of the huge loss of lives and economics. During the current days, the International Society of Fire Protection Engineers needs assistance to the Design Fire Scenarios of Performance-Based Design on a new standard, the development of design fires for use in the standard. The design fire is clearly the single most parameter in fire engineering design.

However, the design values like Heat Release Rates the industry uses are often poorly justified data. The cause is that the available data could have not been well collected nor analyzed. In this project, the purpose is mainly to search the literature to find and analyse as much experimental data as possible in order to develop effective design fire guidance for use in a new standard.

### Objectives

- The purpose of browsing Campbell's report is to identify the locations of the fire occurs.
- Use fatality rate, injury rate and property loss rates to find out high-risk fire sites
- Make decisions about what the design fire in both hotels and also hospitals should be, which item should be focused
- See how severe are these fires that find on the sites by experimental data

### Hotels and Motels

Hotel occupants include staff, guests, and event participants. According to statistics by the U.S fire department, the highest rates of death and property loss occurred between midnight and 6 a.m. The bar chart summarized the results of previous studies. Although the main ignition source was the kitchen, the highest fatality rate occurred in the bedroom.

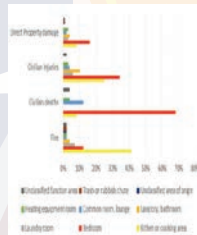


Figure 1. The origin and consequences of the fire (Hotels and Motels).

### Hospitals

According to the Table 1 (Campbell 2017), United States fire departments reported to about 5750 fires occurred annually in four types of health care facilities from 2011 to 2015. The nursing home occupied about half of them. And an estimated average of 1,130 fires were in hospitals or hospices each year but the hospices only occupied 2% of them. The events caused an average of 32 injuries and about \$8.8 million in direct property loss per year. There was less than one death in fires annually in the hospitals.

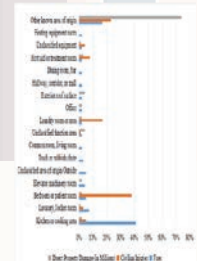


Figure 2. The origin and consequences of the fire (Hospitals and Hospices).

### Methodology

The literature review of data collection needed to integrate a large number of articles, summarizing and integrating the results of each article.

First of all, hotels and hospitals should be determined as the research objects of fire occurrence. Literature collected about them, the background was known and fire scenes were listed. The summary, introduction and conclusion overviewed of each article was a crucial step. A bar chart was used to represent the fatality rate and property loss rate caused by a fire in various places. According to the extremely high value, found out the area with the highest fire risk.

Secondly, after determining the area, literature data collected on the items that may be contained in the area and searched for keyword extraction data. Websites related to the topic of the project could also be used for data collection, where the original article needed to be identified by the source of the data. The extreme value could also be found by bar chart to determine the flammable items in this area.

Thirdly, subsequent data collection would focus on combustible materials. It included counting the heat release rate, mass loss rate and combustion products of each item with line charts or tables.

### Conclusions and Recommendations

Design fire is the most important variable in fire engineering. However, because the existing data are not well organized and analyzed, unreasonable design values are used in the industry.

The purpose of this project aims to find out as much data as possible through a literature review. Summarize and analyze data from the literature to help formulate design suggestions for new standards. Hotels and hospitals are selected as scenarios. Because of the high injury rate, death rate and property loss rate, burning items in the bedrooms need to be collected.

According to the data collected at present, the flame propagation speed, smoke generation and carbon monoxide gas flow rate of particleboard wardrobe and metal are all low. Compared with plywood, they have higher safety in a fire. Even so, wardrobes may cause big fires, and high concentrations of carbon monoxide and smoke can seriously prevent people from escaping. According to the collected heat release rates of mattress, polyurethane foam and cotton mattresses with high peak HRR should not be used in the hospital.

# Modelling lateral placement of vehicles on horizontal curves

Sam Conley and Oliver Munan



## Background

Most of New Zealand's road network is constructed using flexible chip seal. During resurfacing, a variable rate spray bar is used to apply the binder (bitumen) at lower volumes in the wheel paths. This minimises the issues caused by flushing, a condition where the binder pushes through the aggregate. This To better calibrate the spray bar for resurfacing sections of pavement featuring horizontal curves, more data needs to be collected to model the lateral placement of vehicles on curves.



Figure 1. Bitumen spray bar in action.



Figure 2. Example of Flushed Pavement. Most common on heavy vehicle traffic routes.

Over \$300m is spent on pavement maintenance and rehabilitation annually. By better charactering the wheel paths, resurfacing procedures can be optimised by saving material and improving road user safety.

## Objectives

The objectives of this study were to:

1. Determine the suitability of ultrasonic sensors for measuring the distances of vehicles from the roadside
2. Distinguish between light and heavy vehicles using the ultrasonic sensors.
3. Develop a model to quantify the lateral wheel paths of vehicles travelling around horizontal curves

## Methodology

To create a lateral wheel path distribution, the distance between each vehicle and the roadside was measured using ultrasonic distance sensors. Data was processed using python code, which used the number of data points to predict vehicle type.

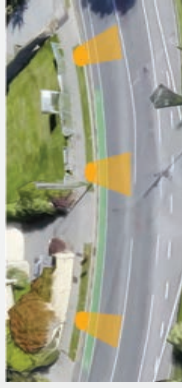


Figure 3. Position of Arduino modules on Kahu Road Location 1. Arduinos were positioned at entry, midpoint and exit of the curve or as close to as possible.



Figure 4. Arduino in position. Stakes were used to raise the boxes to increase recording reliability.



To ensure accuracy, the curves chosen for testing had to fit these criteria:

- Painted cycle lanes on both sides
- At least 100 m from major intersections (to minimise effect of turning traffic)
- 50 km/hr speed limit

A detailed health and safety plan was followed to ensure safety of all testers. This involved not crossing roads unless necessary and wearing hi-vis clothing when setting up the modules.

## Results

Across all sites, there was a trend of curve cutting as opposed to idealised curve following behaviour. Overall, the data shows that vehicles approach the curve with an average distance to the edge line of 22 cm, and upon reaching the midpoint of the curve, vehicles tend to cross over the edge line by an average of 15 cm. Following this, drivers tend to drift out towards the centerline, generally crossing back into the lane with a lateral distance of 5cm to the edge line. This trend was found to be more prevalent with sharper curves (radius less than 100 m). Moreover, the distribution of wheel paths was found to increase at the mid-point of the curve.

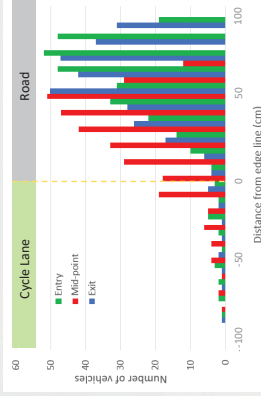


Figure 5. Histogram showing that as a car travels around the curve it drifts closer to the curb. Negative values are in cycle lane.

## Conclusion

The results show that curve cutting behaviour is the most common driver trend while negotiating horizontal curves in urban roads. This behaviour is most prevalent at sharper bends, where drivers decrease their driven radius to minimise lateral acceleration. Furthermore, the spread of wheel paths was observed to increase at the mid-point of the curve.

This data can be used to improve road surfacing by programming the variable rate sprayer.

DVA-05



# Microplastic & metal accumulation in urban road dust

Final Year Project, 2021

Students: Bethany O'Connor and Melissa Halligan

Project supervisors: Simone Larcher and Sally Gaw



## OBJECTIVES

This study aimed to discover if microplastics (MPs) are present in urban Christchurch road dust, and if there is any correlation between heavy metals and the presence of MPs in road dust. This will be the first study of MPs in road dust in New Zealand.

## BACKGROUND

Plastic has become a part of everyday human life. Plastics' poor degradation properties result in small pieces of plastic that remain in the environment known as MPs. MPs are classified as plastics < 5 mm.

MPs in road dust often end up in waterways. To date, there is a considerable lack of knowledge on the damage caused to human and ecological health due to a lack of data.

Because testing for MPs is a relatively new field of research, there is yet to be a standardised method of analysis or unit of concentration.



Figure 1. Schematic showing how metals and MPs enter waterways

## METHODOLOGY

Samples were taken from the road curb of 12 high traffic density areas (see Figure 3) and were classed into three different land uses as seen in Figure 2.

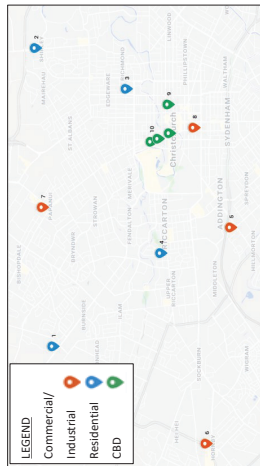


Figure 2. Map of sample locations

### Metals identification method:

Acid digestion followed by inductively coupled plasma mass spectrometry (ICPMS) analysis was used to measure Cu, Pb, and Zn in the road dust.

### Microplastics identification method:

Density separation of MPs followed by visual identification of MPs using a microscope (see Figure 4). We would like to acknowledge Hayden Masterton for his help and expertise during the MP identification.

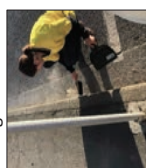


Figure 3. Collecting road dust samples



Figure 4. Visual identification of MPs

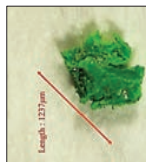


Figure 5. Green fragment from sample

## RESULTS

MP data for each site was converted into units of "pieces per kg" of road dust. The data was broken down into colour and type (fibre = thread-like, fragment = pieces broken down from larger plastic debris) as shown in Figures 6 and 7 respectively.

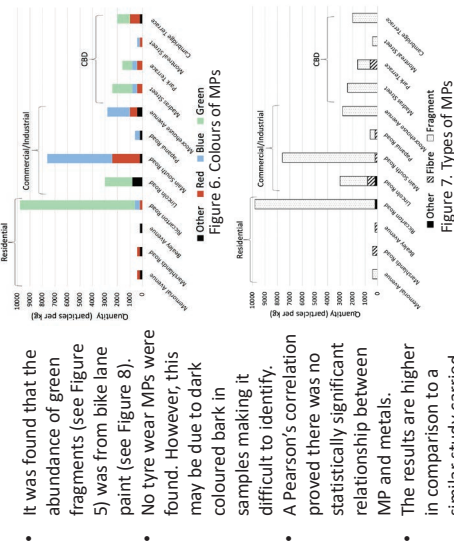


Figure 8. Christchurch bicycle lane

## CONCLUSIONS

- There is an abundance of MPs present in Christchurch urban road dust. The concentration ranges from 200 pieces/kg to 9200 pieces/kg for the sites tested.
- Further testing such as Fourier Transform Infrared Spectroscopy (FTIR) is required for all samples to confirm the presence and type of MPs, as visual identification has many limitations.

# Risk of Lead Contamination in Christchurch's Drinking Water

Kate Fouche & Elsa Hegarty

## Project Supervisor: Simone Larcher

## Summary

Lead has been shown to leach into drinking water through lead pipes when there is prolonged contact to water with no or little movement.

Among the 572 water samples taken since 2019 within Christchurch, Lyttelton and Akaroa, 11 have exceeded the Ministry of Health's maximum acceptable value (MAV) for lead of 0.01 mg/L.

This study investigates the rate of lead leaching into drinking water with a changing retention time. Our research found longer pipe retention time resulted in higher rates of lead leaching.

## Background

Lead is a known toxin that can lead to serious health risks when consumed. The public water supply networks in the Christchurch district contain 170.9 km of cast iron pipes. 28% of these pipes are assumed to contain lead.

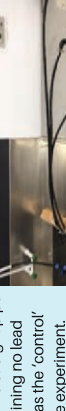
**Fig 1.** Red lines indicate the current scope of lead-jointed pipes in yellow.

## Objectives

- Assess how the retention times in lead-jointed pipes affects the amount of lead leaching into the water.
- Determine the effects of flow on the lead leaching rate
- Consider other water quality parameters that could increase the rate of lead leaching.

## Experimental Procedure

The samples in the experiment were taken from two taps in the university laboratory and the water was flushed through:

- 
- **Pipe 1** - a straight pipe containing no lead used as the 'control' for the experiment.
  - **Pipe 2** - lead-jointed pipe approximately 800 mm in length and 80 mm in diameter.
  - **Pipe 3** - same as pipe 2 with a lump of lead inserted to represent a common joint defect.

**Fig 2. Complete Experimental Set up**

Inductively coupled plasma mass spectrometry (ICPMS) analysis was used to measure total and dissolved lead. Other water parameters were tested using standard methods to form more conclusive results.

- Total Dissolved Solids (TDS)
- pH & Alkalinity
- Calcium Hardness
- Free Chlorine
- Lagelier Saturation Index (LSI)

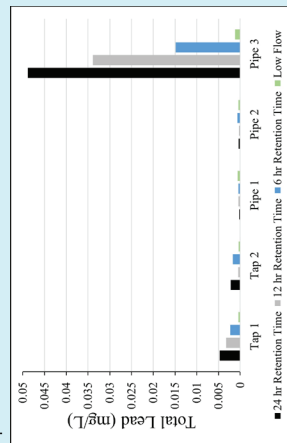
## Results

The total lead concentration consistently increased with retention time for all water samples. However, only pipe 3 had levels > MAV for all retention times. The results show a higher LSI resulted in a larger total lead concentration in the samples.



**Fig 3. Samples Collected**

The total lead release rates within the flow scenario were lower compared to the retention samples, as seen in Fig 4. This can be explained by the lower contact period with the lead joints within the pipe.



#### Fig 4. Total Lead Results

Contrary to expectations, the university's tap sample results had a higher total lead value than pipe 2, which contained a lead-joint. This result could be due to the scale inside pipe 2, formed from corrosive processes, providing a diffusion barrier.



**Fig 5. Interior of Pipe 2**

## Conclusions

**The analysis of the results indicate:**

- A longer retention time attributes to higher rates of lead leaching into drinking water samples.
- Sealing inside the pipe provided a physical barrier, preventing lead leaching in pipe 2 samples.
- Further investigation is suggested to more comprehensively understand the relationship between flow and lead contamination.

SLA05



# Comparing the seismic performance of frame structures proportioned according to traditions from The U.S. and New Zealand

Project Team: Ben Dang and Caleb Rust  
Academic Supervisor: Professor Santiago Pujol



## BACKGROUND

The largest earthquake recorded in NZ was a magnitude 8.2 earthquake in Wairarapa in 1855. About 100 years later, a magnitude 9.2 earthquake struck the U.S. in Alaska, being the largest ever recorded earthquake in U.S. history. These earthquakes caused many concrete buildings to collapse and left many more uninhabitable. This led to the development and modification of reinforced concrete design codes to minimise building failure. Since then, many reinforced concrete structures have been constructed, with the intent of acceptable seismic performance.

## OBJECTIVES

This study was carried out to compare the seismic performance of reinforced concrete frame structures designed and detailed according to The U.S. and NZ design codes. The methods used in the two design codes are drastically different, so the differences will be judged to see which codes produce better buildings.

The effects of the following cases were investigated.

- a) Differences in the amounts of longitudinal reinforcement related to code requirements
- b) Differences in the amounts of longitudinal reinforcement beyond what the codes require
- c) The addition of shear walls

## METHODOLOGY

- A five-storey and a nine-storey hypothetical reinforced concrete frame were constructed according to each standard. The resulting hypothetical building configurations were named accordingly NZS5, NZS9, and ASCE5, ASCE9.
- Standards NZS1170.5 (2004) and ASCE7 (2016) were used to define the respective frame earthquake demands.
- Structural analysis and design software SAP2000 was used to determine the required seismic design demands.
- Standards NZS3101 (2006) and ACI318 (2019) were used to design and detail the respective beams, columns, and beam-column joints of the reinforced concrete frames
- Non-linear analysis software Siera3D was used to model the seismic response of the hypothetical frames according to selected ground motions from the 2010-2011 Canterbury earthquakes.

## FRAME LAYOUTS

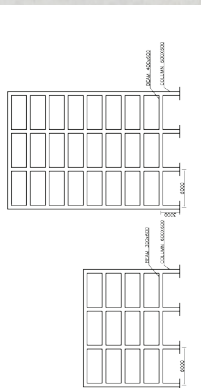


Figure 1. Five-storey and nine-storey frame configurations

## RESULTS

Case A results are shown below in Figures 2-5. The roof and max storey drifts are plotted against the respective peak ground velocities (PGV). A conservative approximation of roof and max storey drifts (the product of peak ground velocity and the initial building period divided by building height) is also plotted.

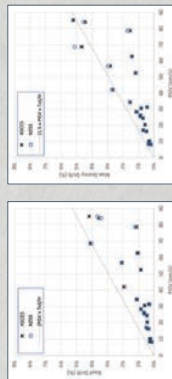


Figure 2. RDR vs PGV for the hypothetical five-storey frames

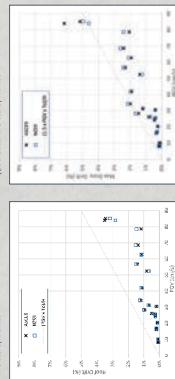


Figure 3. Max storey drift vs PGV for the hypothetical five-storey frames

Cases B and C results are shown below in Figure 6. The roof drift ratio (RDR) for differing amounts of longitudinal reinforcement beyond what the code requires is divided by the RDR for the code reinforcement. A decrease of 50% is shown in the first column, the code reinforcement reference value is shown in the second column and an increase of 50% is shown in the third column. The fourth and final column shows the effect on the RDR from adding a shear wall.

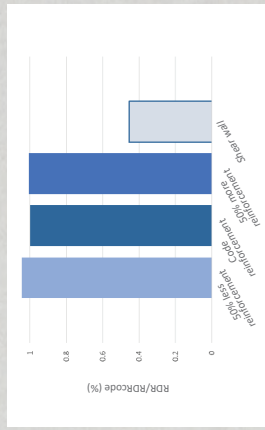


Figure 6. Changes in reinforcement and addition of a shear wall vs RDR for changes in reinforcement divided by RDR for code reinforcement for the NZS9 frame

## CONCLUSIONS

- The responses are comparable as the results did not differ drastically. Even though the code provisions in NZ and U.S. are quite different, the estimated roof drift ratio did not change by more than 10%.
- However, the introduction of shear walls showed a radical difference in the response seen in the structure. The increase in stiffness saw the roof drift ratios reduce by more than 50% compared to frame scenarios investigated according to cases (a) and (b).
- From the roof drift values, a value for roof drift can be conservatively approximated with the product of peak ground velocity (PGV) and the initial building period considering gross cross sections.
- The frames were designed for values of PGV not exceeding 35 m/s. For ground motions with PGV values not exceeding 35 m/s, the drift ratios were smaller than 1.5%. Nevertheless, for the ground motions that exceeded a PGV of 35 m/s, the drift ratios reached values as high as 5%. This is dangerous as these earthquakes have already happened which means they could happen again.

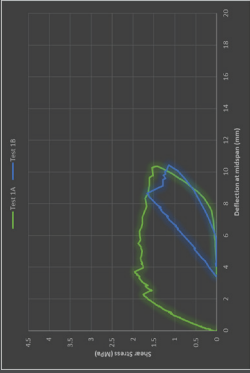
# Pre-stressed clamps to strengthen reinforced concrete (RC)

## TESTS



NO CLAMPS, BARE BEAM

## LOAD - DEFLECTION GRAPHS



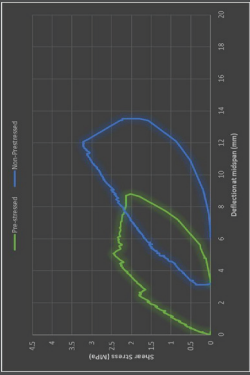
Strength versus Deflection at the midspan of the bare beam.

## RELATIVE STRENGTH OF CONCRETE CONTRIBUTION

1 x



CLAMPING IN 2 DIRECTIONS\*

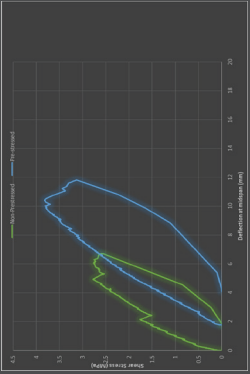


Strength versus Deflection\* for clamping in 2 directions

1.36x prestressed  
1.0x non-prestressed



CLAMPING IN 1 DIRECTION



Strength versus Deflection for clamping in 1 direction

1.30x prestressed  
1.0x non-prestressed

## CONCLUSIONS

- Pre-stressing clamps increase effectively the shear strength of RC
- Prestressing in 1 direction was as effective as prestressing in 2 directions
- Quick, easy, and low skill required to install. Only a torque wrench required



Take a picture to download the full paper for more information



## What is the probability of different failure modes in RC columns?

Timothy Sullivan

Alaska Upton-Gill & Dongyi Ruan



### CONTEXT & OBJECTIVES

Reinforced Concrete (RC) is commonly used in multi-storey buildings in New Zealand. As a seismically active nation, we must understand the probability of RC members, namely columns, suffering different failure modes when pushed to their lateral displacement limits during an earthquake.

RC columns can fail in a brittle or ductile manner. Brittle failure is undesirable as it occurs suddenly, with a dramatic loss of strength, and can lead to the entire structure failing. Brittle failures can occur when insufficient transverse reinforcement is provided. Ductile failures, on the other hand, involve a slower loss in strength and occur at much higher deformation demands, which reduces the chance of injury and collapse.

### COLUMN CONSTRUCTION

To obtain data on the probability of different failure modes in RC columns, 10 columns were produced and tested, with a variety of specifications and loading parameters as follows:

1. Longitudinal bar diameter
  - a. 16 mm
  - b. 10 mm
2. Transverse reinforcement spacing (hinge, central)
  - a. 50 mm, 100 mm
  - b. 150 mm, 150 mm
3. Span (clear, total)
  - a. 1200 mm, 2000 mm
  - b. 800 mm, 1600 mm
4. Axial load
  - a. 480 kN
  - b. 180 kN

A cross-section can be seen in Figure 1. The columns are half-scale models of bottom floor columns in a multi-storey structure, shown in Figure 2.

Columns with a shorter clear span and higher reinforcement spacing are reminiscent of older, pre-1970s RC columns in New Zealand, before modern transverse reinforcement requirements were introduced. These types of columns still exist in many buildings in New Zealand today.

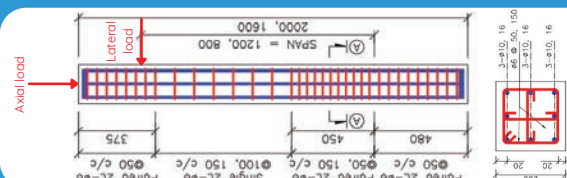


Figure 1. Exemplar column cross-section (Milap Dhakal, 2020)



Figure 2. Test setup & simulated conditions (Milap Dhakal, 2020)

### TESTING PROCEDURE

- Column clamped at base to simulate fixed foundation connection (Shown in Figure 2).
- Loading beam provides force to simulate weight of upper floors on column using vertical actuator.
- Horizontal actuator applies incremental cyclic displacements to simulate earthquake motion.
- Horizontal displacement and resistance logged at each increment.

### ANALYTICAL METHODS

To carry out seismic analysis of concrete buildings in New Zealand, engineers use Section C5 of the 2017 Engineering Assessment Guidelines. C5 includes expressions for predicting:

- Force displacement response of the columns
- Displacements at which longitudinal bars buckle
- Displacements where flexural-shear failure occurs

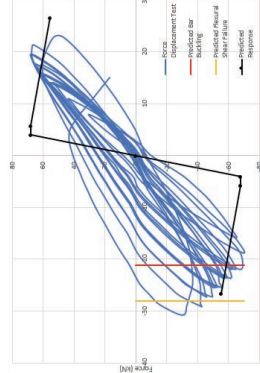


Figure 3. Test results versus predicted results

The predictions can then be compared with the column test results to gauge the accuracy of the predictions. The results from a column failing in flexure-shear as shown in Figure 3.

### FLEXURAL FAILURE

Flexural failure (shown left) is a ductile failure mode, characterised by a gradual loss in column load bearing capacity and lateral strength. This is as the concrete core remains intact, allowing the column to carry load till displacements up to twice as high as achieved in brittle failures

### BAR BUCKLING

Bar buckling (shown right) results from high axial load and inadequate bracing provided by transverse ties. This failure mode noticeably results in the loss of cover concrete due to the longitudinal bars bulging outwards. Once buckling is initiated, the column quickly loses strength.



### FLEXURAL-SHEAR FAILURE

Flexural-shear failure (shown left) is a brittle failure mode, characterised by a sudden angled rupture in the concrete core, resulting in a swift loss in column load bearing capacity and lateral strength. This is usually accompanied by sudden longitudinal bar buckling.



### OBSERVATIONS & CONCLUSIONS THUS FAR

- Flexural failures reached much higher lateral displacements than brittle failure modes.
- Buckling and flexural-shear failures occurred suddenly, with dramatic loss of axial and lateral strength.
- All columns with transverse reinforcement meeting modern New Zealand standards failed in a ductile manner.
- For the columns tested, the C5 guideline expressions accurately predict the maximum lateral strength.
- For the columns tested, the C5 expression for bar buckling predicts failure at a lower displacement than what is achieved.

TSU04

## Achieving the Accessible City Using X-Minute Cities as a Tool for Urban Vitality and Renewal

### Objectives

- Evaluate the best method to measure the concept of a 5, 10 or 15 minute city (the X-Minute City)
- Evaluate the proximity of residents to amenities in Aotearoa New Zealand
- Enable the design of sustainable, healthy, and equitable neighbourhoods



### Applicability

Do you live in a 5, 10 or 15 minute neighbourhood? Check out our interactive dashboard

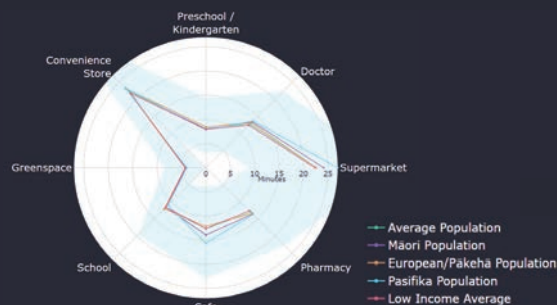


Figure 1: Walking accessibility in Tāmaki Makaurau Auckland

### Background

We must densify and advocate for hyper-proximity to amenities. Living locally improves community health, reduces carbon emissions, increases wellbeing, and is an urban planning response to the pandemic. Globally, there has been a surge in interest in ideas such as the 15-minute city, the superblock, and the circle of daily life. The goal of the X-minute city is to create neighbourhoods where all amenities are within easy reach by walking. To achieve this concept, we must first be able to evaluate our current situation.



Figure 2: Maximum, average and weighted average method to evaluate the X-Minute City

### Method

**Quantifying proximity:** The travel time from each neighbourhood block to a range of daily amenities for urban areas in Aotearoa New Zealand was calculated.

**Evaluating methods:** The maximum, average and weighted average of all of the amenities in each neighbourhood contributed to an overall time of access in each city, the 'X-Minutes'.

Figure 3: X-Minute walking access to eight key amenities using the maximum method

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# Design for Sustainability: Exploring Low-Carbon Building Concepts Through Parametric Design



Lewis Raumati & Rene Conradie; Project Supervisor Giuseppe Loporcaro

## BACKGROUND

The New Zealand Whole-of-Life Embodied Carbon Emissions Reduction Framework has introduced a need to reduce the embodied carbon emissions from the building sector. As a result of signing the Paris Agreement, there is a global initiative to mitigate the effects of climate change. The New Zealand Government has set the goal of reducing the net emissions of all houses to zero by 2050. The building sector contributes 38% of the GHG emissions, with 28% of this portion coming from embodied carbon. Currently, there is a demand for more affordable housing in New Zealand. As of March 2021, there are over 23,000 applicants on the social housing register who are waiting to be matched with a suitable property. This has risen due to population growth, lack of supply in the market, and difficulties in obtaining building consents.

## METHODOLOGY

The development of the interactive LCA tool consists of programming geometries and associating materials to these geometries using Grasshopper in Rhinoceros. The algorithm developed is captured in Figure 2 below. It features 4 major groups. The primary being the formation of geometry components that translate into Rhinoceros. This is a complex group within the Grasshopper canvas, that works together to form the desired size, height, rooms and openings. It outputs the relevant element parameters required to calculate the embodied carbon emissions. The other components consist of the calculations for embodied carbon emissions, calculation of transportation materials and exporting the results to an excel file for viewing.

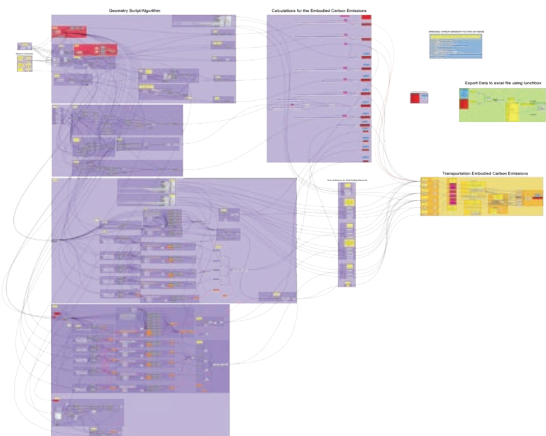


Figure 3: Grasshopper algorithm.



Figure 1: Rhino render of residential model.

## RESEARCH OBJECTIVES

The objective of this research is to develop a tool that accurately provides immediate feedback on the embodied carbon emissions for a typical medium density house. The tool will allow users to alter the size, quantity of rooms and choice of materials. This will be used to inform designers on the environmental impact their structure will have during the earliest design stages of the structure.



Figure 2: Wall composition in Grasshopper algorithm.

## RESULTS

The major output of the project is an interactive algorithm that allows users to form a preliminary stage design of their house. It provides the ability to adjust the size of the building, move rooms, openings and change materials. Once their design is complete, the algorithm will provide a measure of the embodied carbon emissions from the product and transportation stage. To compare the validity and accuracy of the results, quantity take-offs were performed by hand and in Revit. Iterative checks of the algorithm were done in order to avoid any errors in the geometry.

With complexity in design, there are limitations to capacity of the tool. Estimations for the embodied carbon emissions must be taken as preliminary and do not include the construction phase, operational or end-of-life emissions.

Table 1: Final results from a 162 m<sup>2</sup> timber house.

Category	Family and Type	Embodied Carbon Emissions (kg CO <sub>2</sub> -eq)
Roof	Roofing	2643.44
	Insulation	N/A
	Purlins	-2004.55
Ceiling	Rafters	-1571.14
	Framing	-1619.77
	Plywood	-647.35
	Plasterboard	195.37
Walls (Interior + Exterior)	Insulation	299.57
	Framing	-1828.09
	Insulation	136.14
	Plasterboard	359.48
Floor	Fibre cement Cladding	1070.17
	Framing	-1619.77
	Plywood	-647.35
	Plasterboard	195.37
Foundation	Insulation	299.57
	Concrete Slab	15621.62
Total	Timber Piles	-1086.91
		9795.80

## CONCLUSION

There is a strong potential to incorporating low carbon building concepts and parametric design. With the need for a significant reduction in the embodied carbon emissions and growing impact of global warming, this tool can be further developed. There is a need for a more streamlined and regulated way of measuring the carbon footprint of residential structures. A large outcome of this project includes the need for a detailed and complete database that individuals can use to measure their footprint.



Figure 4: Final render of the model.

GLO01

# The Climate Migration Impact on Aotearoa's Potable Water Supply



By W.M. Conibear and A.G.M. Lysaght | Dr R.A.M. Peer

## Why do we need to assess the impact of climate migrants on infrastructure?

- Aotearoa's population is projected to increase to 6,215,800 people by 2050 and **climate migration is expected to contribute 1.6% to this increase.**
- Although they account for climate change and population increases, nationwide water resource management forecasting techniques currently **exclude the impacts of climate migrants on water supply.**
- Water New Zealand's Insights and Sustainability Advisor noted that "our [Aotearoa] **water source capacity and climate preparedness** is a really tricky one that **is not yet well understood**." (Direct correspondence)
- There is a **need to understand the impact of climate migration** on Aotearoa's potable water supply.

## How do we estimate the impacts?

- Available data from Stats NZ (population estimates to 2050) and New Zealand's Drinking Water Register (available water capacity) and data of insurance home losses (to assume internal migration) in 2050 were leveraged to build a model with Aotearoa's **first estimate of regional available potable water supply for a 2050 population including climate migrants** (Figure 1).
- A qualitative scale was built to describe the **Level of Impact (LoI)** a region is predicted to face in 2050, considering both the impacts of climate-induced changes in available water capacity and population changes due to climate migration.

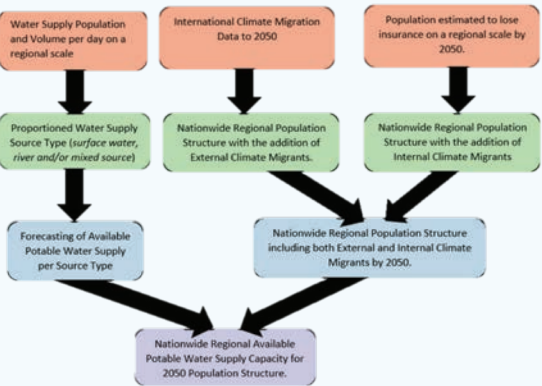


Figure 1 - Schematic outlining model construction; accounting for climate, migration and water supply data.

- Because of limited data availability on climate migrants and water source capacity, the following assumptions were required:
  - The relative proportional of water supply type (surface water, ground water, mixed source) would remain constant from 2018 to 2050.
  - Based on the Asia-Pacific migration prediction, 2.5% of Pacific Islands population would migrate to Aotearoa.
  - The most recent data for the location where Pacific Island migrants settled across Aotearoa was valid for 2050.
  - No new immigration policies would impact the forecasted migration data beyond 2020.

## What are the predicted impacts?

### Data simulation

- The regional available daily water supply per person for 2018 and 2050 was determined from the model output (Figure 2). The incorporation of climate migrants for 2050 population estimates shows that **water supply will need to be better managed to avoid demand exceeding available capacity (of 162.8 L/person/day).**
- The regional population distribution of predicted internal migrants and external migrants were different. **Water resource management planning must account for these regional differences**
- Regions supplied by a high proportion of surface water were found to be vulnerable** to a decrease supply capacity in 2050.

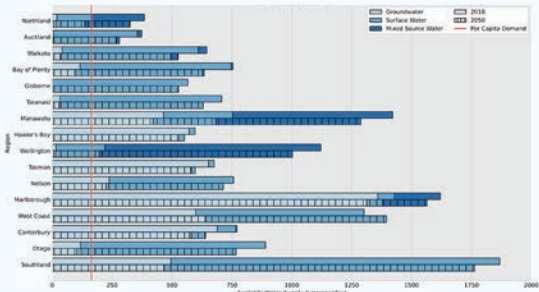


Figure 2 - The available daily water supply per capita in 2018 and projected to 2050 incorporating climate migrants on a regional basis.

### Level of Impact (LoI)

- A qualitative scale of impact of climate migrants on water supply was used to classify the regional outcomes of our assessment (Figure 3).
- Auckland** was estimated to **receive the majority of climate migrants by 2050 (38%)** and is **supplied mostly by surface water**. This **classifies the Auckland region at a LoI of 5.**
- Auckland's water demand will increase more than any other region** and surface water source supply will experience the greatest pressure from increased severity and frequency of drought due to climate change.
- Manawatu, Marlborough and Hawke's Bay regions** were each estimated to **receive less than 2.5% of the total climate migrants by 2050**. Regional water supply is largely sourced from **groundwater**. Comparatively, the potable water supply in these regions will not be as greatly impacted by climate migrants.

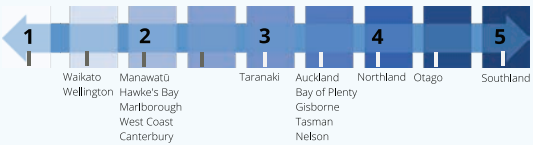


Figure 3 - Level of Impact Indicative scale across regions.

## Where do we go from here?

- This model shows that the **climate migrants are likely to impact available water supply over time** and therefore **regional water plans should account for climate migrants in the future to avoid water demand exceeding supply capacity.**
- More specific quantification of climate change impacts on water supply will improve data quality and overall assessment. In this analysis, the impact of climatic changes were considered only for surface water; the impact of increased flooding on groundwater was ignored.
- The migrants from each Pacific Island country must be quantified to improve the quality of migration data for 2050. This assessment assumed a uniform proportion (2.5%) of the 2050 Pacific Islands population will migrate to Aotearoa.



# Subannual water consumption at hydroelectric dams



## Introduction

Hydroelectricity is not often thought of as a water consumer, but, perhaps surprisingly, it often is. Hydroelectric dams consume a significant amount of water, known as a water footprint, through evaporation. This is driven by the local climate. Limiting evaporation losses can improve a dam's efficiency, and minimise impacts on surrounding areas. In the face of increasing frequency and severity of water scarcity, understanding water footprints is important. Previous research has focused on the annual average gross or net evaporation from the reservoirs behind each dam. The dynamic and seasonal nature of the climatic variables creates the need for a sub-annual analysis to understand how evaporation changes throughout the year and across New Zealand.

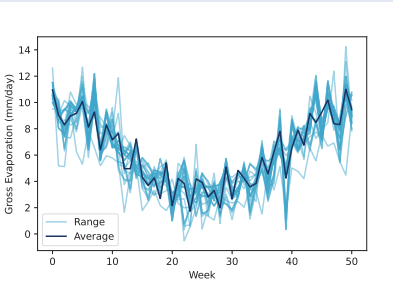


Figure 1. Gross Evaporation

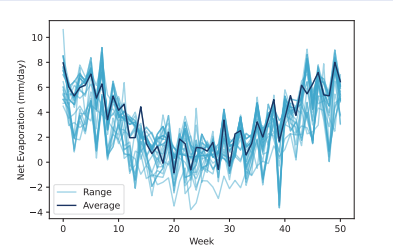


Figure 2. Net Evaporation

— NZ Coastlines

Reservoirs Capacity (MW)

- 1.3 - 5.2
- 5.2 - 24.8
- 24.8 - 73.2
- 73.2 - 119.2
- 119.2 - 540

Western South Island

Inland South Island

Southern New Zealand

Northern New Zealand

South-West North Island

Central North Island

Eastern North Island

Northern South Island

Eastern South Island

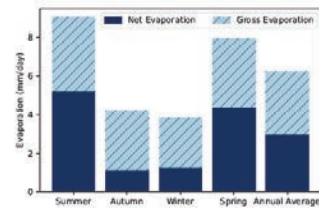


Figure 3. Net and Gross Evaporation comparison for seasons

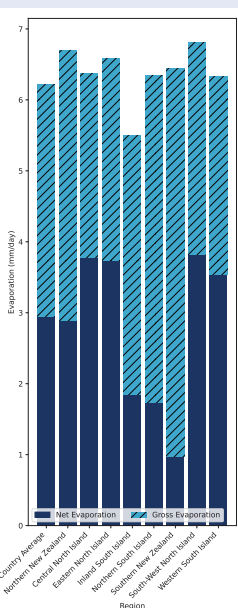


Figure 4. Net and Gross Comparison for Climate Regions

## Method

- Water consumption of hydroelectric dams is assumed to be approximately equivalent to the net evaporative losses resulting from the construction and operation of the dam and reservoir.
- Daily evaporative losses at each dam site are calculated using the Penman-Monteith equation, which describes the gross evaporation from a body of water.
- Data on minimum temperature ( $^{\circ}\text{C}$ ), maximum temperature ( $^{\circ}\text{C}$ ), hours of bright sunlight (hours), wind speed (m/s), global radiation ( $\text{MJ}/\text{m}^2$ ), maximum lake depth (m), sunrise time (hours), sunset time (hours), and lake area ( $\text{m}^2$ ) were sourced to calculate gross evaporation.
- Net evaporation was calculated by subtracting the gross evaporation value by assumed regional evapotranspiration.
- All hydroelectric dams with constructed reservoirs and capacities greater than 1 MW were analysed. Hydroelectric facilities that were built on a natural lake have been excluded from this analysis.
- To give a better understanding of how the seasonal climate impacts evaporation, results are aggregated by climate regions.

## Results and Discussion

- There is significant seasonal variability in gross and net evaporation of lakes (Figure 1 and Figure 2). Yearly averages are an incomplete way of representing values that vary significantly based on climatic conditions.
- There is a difference in annual evaporation across New Zealand. If the analysis was undertaken using average data for the year, the gross evaporation would be underestimated by 60 million  $\text{m}^3$ , or 15%.
- Drier climates have lower net evaporation than more humid climates (Figure 4). This is a result of higher evaporation values for land use prior to dam construction.
- There is a visible seasonal variation in evaporation (Figure 3). Evaporation in spring is significantly closer to summer and autumn closer to winter.
- Net evaporation can be negative in winter and autumn due to the higher evaporation from plants surrounding the reservoir. This occurs across the whole season for the southern South Island in both winter and autumn.

## Future work

- A better estimate of land evaporation values and use types prior to dam construction would significantly improve the net evaporation estimates.
- A water balance on the lakes and total catchments would provide a better insight into the environmental impacts.
- Editing the model so that climate estimates can be used could allow for estimates to be projected into the future.
- Adjusting the method to incorporate climate models and forecasts could enable analysis at a global scale as well as projections under different climate scenarios.

RPE02  
Seb Daellenbach  
Tylan Collins

# Secret Contracts for Decentralized Location-Based Applications

## The Motivations

Location Data has a variety of uses in software for things like device tracking, destination reviews etc. However, this data can be sensitive for user privacy, and many of these uses involve the data being stored on cloud servers of companies which can be at risk of leaks, loss, or being put up for sale. So how can we store and use this data in a way that's secure for users?

## Problems and Solutions

### Blockchains

Blockchain technologies offer the tools for decentralized data storage that cannot be altered or lost due to cryptographic hash verification. However, the data is publicly visible. How can we have our data be private?

### Secret Network

Secret Network is a privacy-focused blockchain where all data is natively encrypted and only decrypted in special hardware-based private environments. So how can we make use of Secret Network for our programs?

### Rust


Secret Contracts are the programs that run on the Secret Network, and are developed in the programming language Rust. But Rust doesn't support floating points that would be needed to store coordinates. How can we solve this?

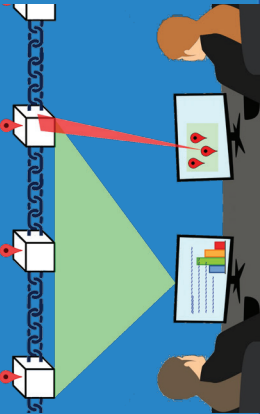
### Libraries

Community Libraries for Rust offer tools for things like fixed point numbers and efficient editable storage arrays that allow us to store and operate on location datapoints within the restrictions of Rust and Secret Contracts and create useful programs with them as a result.

## The Results

By combining these technologies and libraries, we have created a proof-of-concept secret contract that demonstrates how location data can be privately stored on the Secret Network, accessed by its original owner for use, and used for public statistical analysis without exposing individual records. This can now be shared with the Secret Network community as an example to aid further development by others.





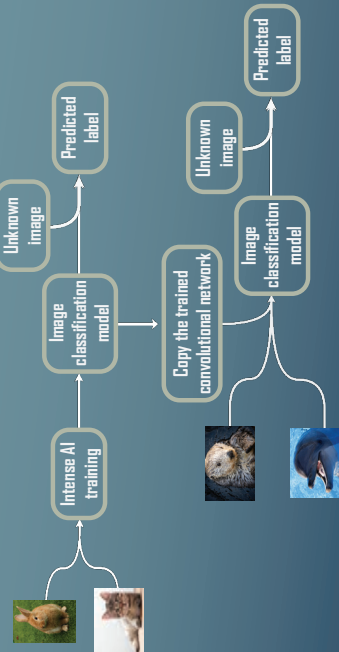
Student: Cameron Arnold | Supervisor: Benjamin Adams UC Computer Science & Software Engineering



# Teaching the Concept of Intelligence in Pre-tertiary Education

## Why?

Everyday technologies utilize more Artificial Intelligence for automation and acceleration of previously slow or complex tasks. However, AI education is critically sparse outside of specialised tertiary education.



## Solution

This project developed an online interactive activity to teach the generality of intelligence without requiring advanced education on AI.

- Computer Science Field Guide 
- TensorFlow JS 
- Image Classification    
- Feature knowledge learned in one domain can transfer to another domain

## How it works

1. Train an image classifier to differentiate between two classes of images
2. Generalize the trained model by reusing it to classify different classes (skips the high computation of training)
3. Experiment with configurations of the convolutional network model to gain insight into differences in how well each model generalizes

# GitAnalyser

## Tracking a Student's Code Contribution in a Repository

Martin Lopez - Moffat Mathews (Supervisor)

### The Problem

University students complete group projects. These projects are difficult to grade because of how repository tools fail to persistently track code contributions.

Commit 1

Commit 2

Commit 3

Actual

Tools

We wanted to create a solution that gives a better representation of code contributions and to keep these contributions over time.

### Abstract Syntax Trees

To analyse code deeper than line level we used Gumptree and Grafast tools. They represent code as **Abstract Syntax Trees**. They can also do diffs on two trees to match nodes. We used these diffs to compare code before and after changes, here is an example of that diff.

```
5 if (age >= 18) {
4   return true
6 }
```

```
5 if (age) {
4   return current + 10
6 }
```

### The Solution

We keep track of how many commits each node has survived (we define this as their **value**) to credit nodes which last large amounts of commits. **GitAnalyser** does this because nodes that survive a lot of commits are seen as having good quality. An example of the GitAnalyser process when traversing commits is shown below

Commit 1

Commit 2

Commit 3

Node	Value
A	1
B	1
C	1
D	1

Not only can we keep track of how long nodes have survived but we can also see what type of nodes and how much of each type they have contributed.

### Evaluation

To evaluate, we created a simple repository with 3 developers. We used the following table to manually record contributions and then compared the developer percentages against **GitAnalyser** results.

Weight	Contribution	Dev Pink	Dev Blue	Dev Yellow
5	Re-engineer		2	
4	Features or Class	9	5	4
3	Improvement or Method	30	11	27
2	Fix or Variable Initialisation	65	43	41
2	Maintenance	4	5	22
1	Documentation or Clean up	28	24	18
	Total	292	183	241

#### Manual Analysis

#### GitAnalyser

##### Node Count

##### Node Contributions

	Dev Pink	Dev Blue	Dev Yellow
Node Count	1969	832	1380
Node Contributions (value)	55430	27678	42109

**GitAnalyser** gave a **93%** agreement with our manual analysis. The slight inaccuracy was caused to a limitation where it is difficult to consistently quantify code in our manual analysis. Overall **GitAnalyser** gave a good representation of contributions. It can also be used to get a deeper understanding of the type of contributions that developers are making. This will enable markers to identify areas than need improvement.

University of Canterbury  
Computer Science & Software Engineering



## Gamifying Peer-Feedback and Self-Reflection in a Software Engineering Course

The use of game elements in an educational context is an area that has been rapidly growing in popularity. There is substantial evidence to show that when utilised correctly gamification can help to improve motivation, effort, and learning outcomes. This research aimed to investigate how gamification can improve the self-reflection and peer-feedback processes in Software Engineering. For this purpose, a web application that implements game elements such as points and badges was created.



### Background

- Peer-Feedback and Self-Reflection provide an opportunity for students to learn vital non-technical skills.
- A lack of motivation and effort reduces the value these processes provide.
- Previous studies have seen promising results using gamification to improve these processes.

### Survey

An investigative survey was carried out to gather information around students feelings towards current peer-feedback and self-reflection processes. As well as to help gather information to help decide on features to include in the tool being designed.

How long students said they spend writing giving peer-feedback.



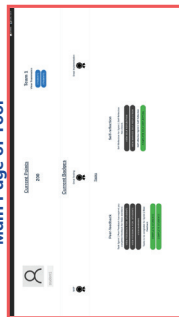
### Tool Design

A tool for students to complete peer-feedback and self-reflections was designed with game elements integrated.

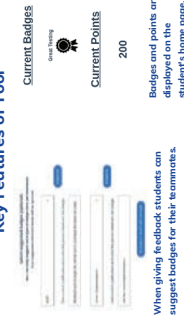
#### Key Features

- Points are calculated by the system and awarded automatically based on the quality of feedback and reflections.
- Students can suggest badges they think their teammates deserve.
- Badges are awarded to students by the teaching team based on these suggestions.

#### Main Page of Tool



#### Key Features of Tool



### Results

- Assessing the tool using the System Usability Scale gave an average score of 87.5/100 which suggests the tool has been well designed.
  - "The design is very simple and not cluttered which made it easy to find what I wanted to do."
  - "Centralization of information on the home page made navigation very easy."
- Initial assessment of the tool also shows students expect the tool will increase their motivation and effort.
  - "The badge element(s) would encourage people to try better and improve, it provided an easy way to remember what I should improve"
  - "Yes I thought they (the game elements) made it more fun and it would be really rewarding to receive the badges from your team members."
  - "I liked them (the game elements) because I'm a competitive person..."

How the tool will increase student motivation.



How the tool will increase student effort.



### Conclusion

This research aimed to investigate the use of gamification to improve the peer-feedback and self-reflection processes of a Software Engineering course. The tool developed implemented game elements into these processes. Assessment of the tool suggests that these game elements will have a positive impact on students' motivation and effort as was intended.

# SLAM AND PATH PLANNING FOR A DRONE USING STEREO VISION

AUTHORS  
Andy Clifford  
Richard Green (Supervisor)

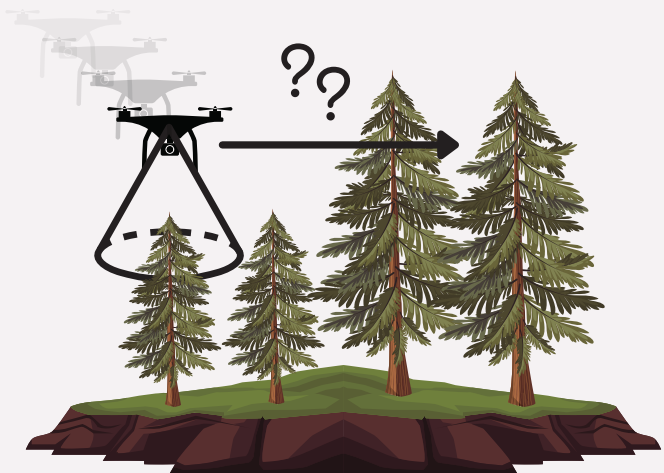
AFFILIATIONS  
University of Canterbury  
SPS Automation

## BACKGROUND

- There is currently more than **1.8 million hectares** of unwanted **wilding pines** across New Zealand.
- Wilding pines are a threat to **ecosystems, land** and **farms**. They compete with native plants and animals for both sunlight and water.
- If the spread of these pines is not stopped, it is estimated that **20% of New Zealand will be covered within 20 years**.
- Industry partner **SPS Automation** currently has a drone that can autonomously spray wilding pine trees with herbicide.
- Although, the current implementation does not include a **collision avoidance** and **path planning** system.

## OBJECTIVES

- Develop a system that can **spatially map** the environment and **track the drone's position**.
- The system should allow the drone to **query movement** in any direction within the mapped environment.
- This allows the drone to **move laterally** into areas it no longer has vision of without first having to ascend to a safe height.
- The system will contribute to the **reliability** and **longevity** of the drone.



## SCOPE SUMMARY

- We want to be able to determine if the drone can move laterally to the next tree without having to ascend to a 'safe' height where we know there are no obstacles.
- In order to achieve this, we need to create a **virtual map** of the environment so we can refer to it later when we want to move to an area we no longer have vision of.



## SOLUTION

- A downwards facing **ZED 2 Stereo Camera** is used to map a **point cloud** of the environment as the drone descends to the top of a wilding pine tree.
- The ZED 2 Stereo Camera allows us to easily keep track of the drone's position within the mapped environment.
- The **Python programming language** is used to perform rotational operations on the point cloud so collision free linear movement can be queried in any arbitrary direction.
- Using the **Aeronavics Navi** drone (pictured left) we simulated the movements of a real spray run in the **Christchurch Red Zone**, yielding promising results.

## TECHNOLOGY STACK



## CONCLUSION

- Achieved our objective of Simultaneous Localisation and Mapping (SLAM) functionality to keep track of the environment and the drone's position.
- Achieved our objective of being able to **query** the mapped environment for **linear movement** in any direction.
- The solution will **reduce collisions, maintenance costs** and **increase operational efficiency**.
- The solution needs to be integrated into the production system so it can be tested in a real spraying run.
- Future researchers will implement a **path planning algorithm** that can determine the **optimal path** between any two points in the environment.




# Student projects: Computer Science & Software Engineering

## Interactive Learning for Computability Theory


### Computability Theory

Computability theory aims to prove if and how problems are solvable using computers.


Many different languages are used in this field, and two of them are key to this project: **Lambda Calculus** and **Combinatory Logic**.




Modern Computers



Turing Machines



Combinatory Logic



Lambda Calculus

In computability theory, all of these languages for describing computability are equivalent and any written code for one can be converted.

### Can we teach this in a better way?

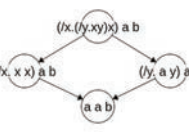
Computability is a complex topic full of languages and procedures.

Teaching computability through traditional methods is difficult and can often lead to "rote-learning" where students simply memorise the steps without understanding the underlying concepts.


Students of MATH230 could build a better understanding of computability if they got to see it in action. Luckily, computability works very well when taught on a computer.

### Online Quizzes for Lambda Calculus & Combinatory Logic

```
(λx. λy. xy)(λx. xy)(λa. λb
(λx. λz. xz)(λf. fy)(λa. λb
(λz. (λf. fy)z)(λa. λb. ab)
(λf. fy)(λa. λb. ab)
(λa. λb. ab)y
(λb. yb)
```



Build Graphs to Model Computation




Write and Run Your own Code

Learn the Algebra of Computability


### Making Learning Accessible

Building useful quizzes to aid learning is more than just writing good evaluation code.

Feedback was a key priority for all questions. The user should always receive positive hints and feedback when learning the topics.




Moodle Quiz server



Python

### Student Answers

  $(\lambda x.xx) a$   
 $S(K(SI))K$

Parser

Format Checker

Answer Checkers

- Line-by-Line
- Graph model
- Code Runner

Feedback Generator

Not quite, maybe try...

Correct! Well done.

### Testing the Quiz with Students

To ensure the quiz server was easy to use, a think-aloud study was conducted on students who were new to the topic.

Feedback was collected to improve the quiz quality and ensure the quiz could be intuitively completed by students.


5 students participated in the study.

### Outcomes

5/5 participants were able to progress through a full quiz on Lambda Calculus.

Quizzes for Lambda Calculus and Combinatory Logic have now been deployed to help students of MATH230.

In future years, the quiz framework could be extended to other topics in MATH230 or used in examinations.



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

## Computer Science & Software Engineering

Jack Craig  
Student

Walter Guttman  
Supervisor

23

## Student projects: Computer Science & Software Engineering

### Automated Design and Augmented Projection of Engineering Elements

Louis Davies

#### Motivation

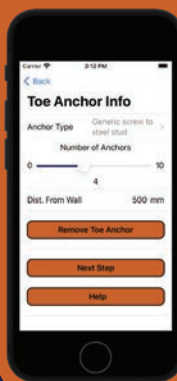
- Construction related spending accounts for 13% of the worlds total GDP
- Many engineers are still using hand drawn 2D sketches to communicate ideas

#### Objective

- Automate the engineering design process for interior wall mounted equipment
- Automate the production of 3D models for wall mounted equipment and display them in real space

#### Solution

##### IOS Application



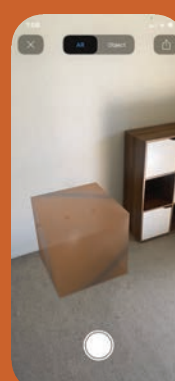
- Intuitive user interface for design info entry
- Display design information generated by API
- Display and augment a 3D model of wall mounted equipment
- Easily share design models



Swift



##### USDZ AR Models



##### Python Flask Web API



USD



- Computes utilisation of fixings for wall mounted equipment using BVT's engineering equations
- Generates 3D model using Universal Scene Description Python libraries
- Converts 3D scene into an AR capable USDZ package and sends it to the application



Computer Science &  
Software Engineering

Academic Supervisor: Fabian Gilson

Industry Sponsor: BVT Engineering

Product Owner: Matt Bishop

BVT Engineer: Luke Doyle





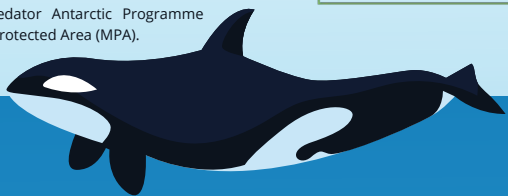
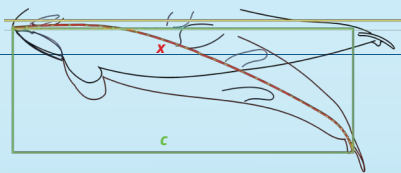


# Whale Geometry

## Estimate the Size of Free-Living Whales

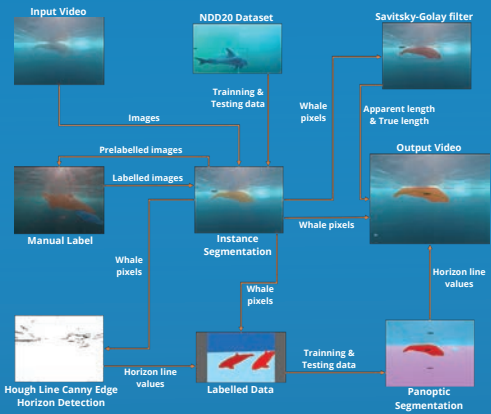
### MOTIVATION

- **Aerial photogrammetry** using drones and helicopters is a **current method** of **estimating the body length** of **killer whales** and **other cetaceans**.
- **Aerial photogrammetry** has **errors** that are **not negligible**, as the measurement of the body length provides an understanding of the biology of **killer whales** and **other cetaceans**.
- This project addresses **one** of the **several sources of errors** in **estimating body length**, the error due to the **curvature of the whale's body when visible at the surface**.
- We analysed videos of killer whales and estimated the ratio of the **apparent length** of the killer whale as seen from above (**c**) vs the **true body length** of the killer whale from the tip of the nose to the fork of the tail fluke (**x**).
- The variability of the **c/x ratio** during a **typical swim stroke cycle** will allow us to assess the error and find a method to estimate the body length more accurately.
- This research is part of the Top Predator Antarctic Programme supporting the Ross Sea region Marine Protected Area (MPA).



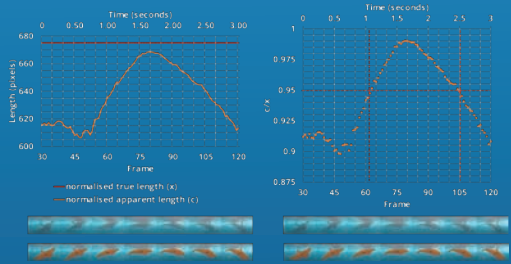
### SOLUTION

- **Detectron2** was used to train an **instance segmentation** model to identify killer whale pixels.
- Instance segmentation training and testing dataset from **NDD20 dataset**, with over 2201 labelled images of **Northumberland dolphins** (killer whales are in the dolphin family) below water.
- A **water horizon line identification method** was created with **Hough line** and **Canny edge detection** to create **panoptic segmentation training data** for the panoptic segmentation.
- **Detectron2** was used to train a **panoptic segmentation** model to identify the water above and below the horizon for estimating the angle of the water horizon line.
- The **true body length** of the killer whale from the tip of the nose to the fork of the tail fluke (**x**) was estimated by finding the y centre points of the killer whale along the killer whale's principal axis and smoothed with the **Savitzky-Golay filter**.
- The **apparent length** of the killer whale as seen from above (**c**) was estimated by finding the straight-line distance between the nose and the tail and then adjusted with the angle of the water horizon line.



### RESULTS

- **Six different killer whales** were analysed on their swim stroke near the water horizon in videos with frame rates of 29.97 frames/second.
- The **apparent length (c)** of surfacing whales was within **95% of the estimated true length (x)** for (mean  $\pm$  standard deviation) **1.5  $\pm$  0.8** seconds, range **0.2 - 2.4** seconds.
- There is a narrow time of ca. **1.5** seconds to photograph swimming whales for **determination of the body length** with acceptable accuracy, i.e. with **apparent length  $\geq$  95% estimated true length**.
- This does not consider any other **sources of error** such as parallax, turbidity, waves, or deviation from orthogonality.
- Findings suggest that **high-resolution video** may be **superior** to still images for whale photogrammetry due to the narrow time window.





## Student projects: Computer Science & Software Engineering

### FOREST FORECASTING USING DEEP LEARNING

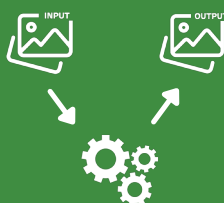
Jerome Grubb and David Turton supervised by Prof. Richard Green  
Advised by industry partners Cris Lovell-Smith and Julian Maclaren



#### Motivation

- Forests are a global resource that plays a vital role in climate change, ecosystem health, and biodiversity.
- Maintaining and planting new forests can be a challenging and daunting task. This is due to the variety of factors that contribute to the growth of a forest, such as climate, rainfall, and soil quality.
- Growing forests requires a large time investment, making it important that a clear plan is formed at the beginning of the process, as this will dictate its development years into the future.

#### Solution



- A deep learning model that will forecast the development of a forest over time.
- The proposed model is based upon the PredNet architecture, whose original use was to predict the future frames of videos.
- This model will take a sequence of satellite images of the desired forest, and will output a sequence of predictions for the next 9 time steps.

#### Satellite Imagery

- Landsat is a program that has a series of satellites which have been observing the Earth since 1972.
- Landsat gathered data was chosen due to its mid-range resolution (30 meters per pixel), the quantity of locations it has available and the large amount of time steps it has at each location.

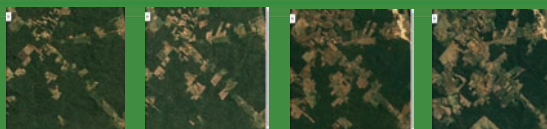
#### Extra Data

- Environmental data can also be used in conjunction with the aerial imagery as the models input.
- This assists the model by allowing it to take external factors that may affect the growth of the forest into consideration.

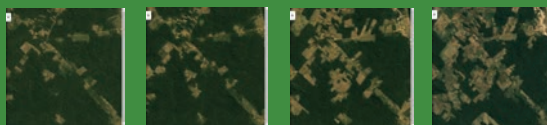
#### Evaluation

- The results were evaluated using the Mean Squared Error (MSE).
- The MSE is the average squared error between the predicted image and the ground truth.
- An MSE of 0.03 was achieved while running the model on Landsat imagery.
- This is a positive result, as the closer an MSE gets to reaching 0, the more similar the predictions will be to the ground truth.

#### Ground Truth



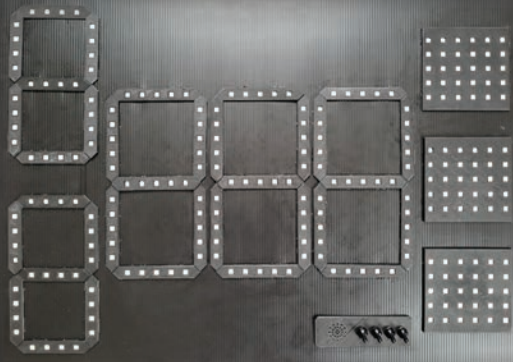
#### Predictions



#### Results

- The results shown above compare the model's predictions to their ground truth at different time steps.
- The ground truth is what each image is supposed to look like.
- If examined carefully, the predictions clearly look similar to the ground truth but do contain differences.

# LOW-COST ARCHERY TIMING LIGHTS




## 1 WHAT'S THE PROBLEM?


As with all sports, the growth of competitive target archery depends on its approachability to newcomers. Unfortunately the **expense of importing equipment** used for hosting competitions, such as timing lights, can be far **out of reach for smaller clubs**. Without a competition environment to practice in at their local club, new archers may be reluctant to start competing, as they'd have to learn many rules and regulations on an already-stressful day!


## 2 PROJECT OBJECTIVES

- Produce a **full-scale prototype** timing lights system
- Without compromising on **functionality or failing to abide by competition rules**
- For a **lower cost** than importable products already on the market. The solution aims to **cost less than \$5,585 NZD**, as that is the minimum cost of importing the system currently used in NZ from Pat's Archery in Australia.

## 3 TECHNOLOGY

**Hand-held Controller**  
  
android


**Radio Communication**  


**Internal Controller**  
  
ARDUINO


The on-field light units are controlled via radio signals, sent through a dongle connected to an Android app.


## 4 RESULTS


The **overall cost** to produce a set of timing lights in the proposed manner is **\$1695.75**. This is approximately **30%** of the cost of purchasing an existing solution.

**30%  
OF THE COST  
TO IMPORT**


The **material cost** for the full-scale prototypes totalled to **\$672**. The high expense is partially due to purchasing components in small quantities, where purchasing in bulk would significantly reduce costs. Furthermore, the frames for the light units were built from wood rather than the ideal material - plastic - due to limitations in construction. It took approximately **45 hours** to assemble the timing system. Using the living wage of \$22.75 per hour, the **cost of labour** to build the timing lights totals to **\$1,023.75**. The time to construct was significantly inflated due to an unfamiliarity with electronics and woodworking. However, due to the lack of experience the living wage was used rather than a profession-appropriate wage.

**Android app to control the lights**  
  
**USB-C OTG dongle**

**Radio module for wireless communication**  
  
**Adjustable width to fit any phone**

**Computer Science &  
Software Engineering**

**Supervisor**  
Fabian Gilson

**Student**  
Julia Harrison  


## Student projects: Computer Science & Software Engineering

**Computer Science &  
Software Engineering**

**scion™**  
FORESTS ■ PRODUCTS ■ INNOVATION

Department of  
Conservation  
*Te Papa Atawhai*



Eliminating

# Wilding Pines

By semi-automated spraying from helicopters

**Alex Hobson**  
**Supervisors**  
Andreas Willig  
Mark Jermy  
**Sponsors**  
James Griffiths  
Brian Richardson

**Project Members**  
Alex Hobson  
Ashton Burt  
Christopher Holmes  
Euan Widjaja  
Mitch Graham  
Renzo Childs

### CONTEXT

Invasive wilding pines are threatening both agricultural and conservation land in New Zealand. In order to control the spread, a pilot flies a helicopter over the trees and holds a trigger to dispense herbicide. To improve this process, DOC and Scion are using technology to automatically activate the spray nozzles when the helicopter is over a known tree location.

To spray semi-automatically, the software needs to know the helicopter's position relative to the trees. This is achieved with Global Navigation Satellite Systems (GNSS) technologies such as GPS.

### OBJECTIVE

Improve accuracy and sample rate of the measured position of the helicopter, suitable for targeting trees 1m wide

### RESULTS

The GNSS antennas from the tested devices were fixed to a steel boom to simulate being mounted to the helicopter. Both devices recorded the movement along the green line, demonstrating the accuracy of the receivers.

The AIMMS-30's results shows sparse points. This is because it outputs its latitude and longitude once per second to 5 decimal places (e.g. -43.52078 N). On the other hand, the Ublox M8N gives a position to 8 decimal places 5 times per second.



Actual path taken  
Ublox M8N (New)  
AIMMS-30 (Old)

### GNSS RECEIVERS

#### AIMMS-30

The 2020 prototype used the AIMMS-30. In order to improve the accuracy of the applied herbicide, alternative devices to replace the GPS functionality of the AIMMS-30 were explored.



#### Trimble RTX

- ✓ Best accuracy, receiving satellite-based corrections in real time
- ✓ Configurable sample rate up to 10Hz
- ✗ Antennas are not aviation-certified
- ✗ Unit is temporarily being leased



#### Ublox M8N

- ✓ Most cost effective alternative
- ✓ Easiest to integrate with existing system
- ✓ Configurable sample rate up to 10Hz
- ✗ No built-in compass: bearing is determined from direction of travel



#### Smartphone

- ✓ Capable of receiving signals from the most concurrent satellites
- ✗ Significant cost for good accuracy
- ✗ Hard to weather-proof






# RECORDING DESIGN DECISIONS

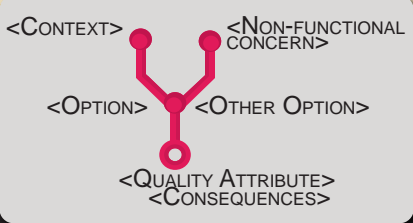
## ON THE FLY

ALYSSA JOSEPHS  
FABIAN GILSON




**PROBLEM:**  
Software Design Decisions are not effectively captured. We need a simple pipeline to capture decisions and classify them for storage

**NATURAL LANGUAGE PROCESSING**




**GRAPHICAL INTERFACE FOR LABELLING**



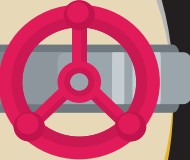
**SOLUTION:**  
Fine Tune a Transformer Dataset to recognise decisions and classify them to WH(Y)

Side Quest: Build a tool to speed the process to label training data


**python**




**PYTORCH**



**Transformers**



**FINE TUNED TRANSFORMER DATASET FOR MACHINE LEARNING**



**Test Subject** Sep 7th at 7:17 PM  
In the add user use case, we need to consider speed and reliability so use of a relational DB would be better than using SQLite. Though it may take extra effort to convert @DevBot

**DevBot** APR: 29 days ago  
Hey, it looks like you want me to add a design decision:

In the add user use case,

- ☒ USE\_CASE: 0.50
- ☐ OPTION: 0.14
- ☐ COMPONENT: 0.12

we need to consider speed and reliability

- ☐ OPTION: 0.27
- ☒ QUALITY\_ATTRIBUTES: 0.18
- ☐ COMPONENT: 0.14

so use of a relational DB would be better than using SQLite.

- ☒ OPTION: 0.19
- ☐ CONSEQUENCES: 0.16
- ☐ COMPONENT: 0.14


Though it may take extra effort to convert

- ☐ OPTION: 0.30
- ☐ COMPONENT: 0.20
- ☒ CONSEQUENCES: 0.16


**RESULT:**  
An 'intelligent' prototype bot that can be tagged to receive users' natural conversation, classify, and return results for storage.

**BOT INTERACTION AND CLASSIFICATION**

In the add user use case, we need to consider speed and reliability so use of a relational DB would be better than using SQLite. Though it may take extra effort to convert



LEARN MORE



30

## Improving Reliability and Ease of Bloodstain Analysis with Quantitative Techniques

Phillip Kim

Supervised by Richard Green, Andrew Bainbridge-Smith  
Industry Partner/Supervisor: Rosalyn Rough

## Background & Problem

Bloodstain analysis is a crucial part of forensic science as it can be used to determine what happened to the victim at the time of bloodshed. However, manually identifying and analysing each bloodstain on an image takes a long time and is prone to human error as the images are high in resolution. This led to a development of an automated bloodstain analysis tool. However, this tool came with its own problems and bugs.

Some examples of the problems are that the program had were inconsistent and inaccurate metric data being calculated such as the direction of the bloodstain and gamma value of the stain ellipse, as well as the ellipses' height and length values. When the program detects a stain, it tries to fit the stain into an ellipse. The height of the ellipse must be higher than the width as the height is the major axis. This project aims to improve the existing tool by conducting research on the problems and implement the solutions.

[illegible]

Stain Data	Pattern Data	
	Metric	Value
1.	Linearity - Polyline fit	-9.372E-05 x <sup>2</sup> + 1.062 x + 1619
2.	R <sup>2</sup>	0.1243
3.	Distribution - ratio stain number to convex hull area	2.644E-06
4.	ratio stain area to convex hull area	7.897E-04
5.	Convergence - point of highest density	(3817.5, 4313.1)
6.	box of %40 of intersections	lower left (x <sub>1</sub> ): (3545.3,3738.1) width: 540
7.	centroid	(4042, 5118)

Data produced by the analysis tool

## Methods & Results

To achieve this, research on various computer vision and bloodstain analysis techniques was conducted. New features such as finding the centre of the mass of the entire blood spatter pattern were also added. The user can also export a cropped square image of the pattern. This may become useful for the deep learning project.

The stain annotation pipeline was also overhauled to annotate only one stain at a time, whereas it could only annotate every stain before. Which caused a big clutter.

There are other areas of improvement such as redesigned ellipse direction determination process and the gamma calculation process.

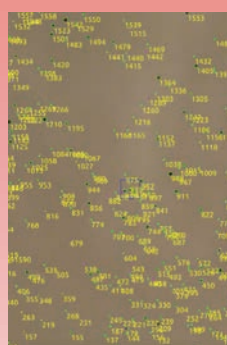
These improvements let the program produce more detailed and accurate data which significantly improves the reliability and usability of the program.



Original  
pattern  
image



Image cropped  
by the program  
with the centre  
of mass as the  
centre



Before the annotation pipeline overhaul, the annotation displays all information at once.



After the annotation pipeline overhaul, the user can choose which stain to annotate on the image.

## Conclusion


This project researched and successfully addressed limitations and issues with the ESR bloodstain analysis tool. From here, future work may involve improving the program even further and adding new features.

## Technologies



Student projects: Computer Science & Software Engineering


# IS THE PATIENT DIAGNOSED WITH CHICKENPOX?




Our local General Practice (GP) often stores consult information in the form of EMR. The goal of this project is to use this information to develop the best prediction model for visualising and analysing the risk of chickenpox in a live system used in the larger ongoing project CARE - Computer Assisted Reading of Notes for Epidemiology.

Cheng Yi Kok supervised by Moffat Mathews


## SOLUTION




ELECTRONIC MEDICAL RECORDS (EMRs)




LABELLER SOFTWARE




PRE-PROCESS



TRAINING & TESTING DATASET



HEU  
HEURISTIC



ML  
MACHINE LEARNING

VS

### The Best Prediction Model?


EMRs from 2010-2020 were sourced from a health clinic. Each record holds information about a single consult, and together they contain a patient's **medical history**. To obtain **labels** from doctors for training the chickenpox prediction models, a **labeller software** was created and hosted over a web server. Labels were assigned over the dataset which was **prioritized by age and likelihood of chickenpox incidence**.

The two prediction models under comparison were a **heuristic algorithm** and a **machine learning model**. The heuristic algorithm was built using a set of **NLP rules** against chickenpox-related terms. The machine learning model uses a **binary classifier** with a **stochastic gradient descent** optimizer to analyse **chickenpox diagnosis patterns**.


## UNDER THE HOOD

### Security


Security measures were implemented to **protect private patient information** and to comply with OWASP standards




Air-gapped Network




HTTPS Protocol



Session Timeout




Patient De-identification




Password Hashing

### Natural Language Processing (NLP)


Each medical record holds information of a single consult in the form of **unstructured free text**. Several techniques were used in the **pre-processing stage** to transform raw text into understandable formats.



Tokenisation



POS Tagging



Automated Spelling Correction

A **pattern dictionary** was also created for the heuristic algorithm. **Weightings** were assigned according to the **importance** of each chickenpox, vaccine-related and symptomatic terms. The context of each term was determined through checking for:

- 1 Negation ("no", "not", "never")
- 2 Temporal expression ("has", "had", "last year")
- 3 Uncertainties ("maybe", "resemble", "if")

## RESULTS

3030 records out of 19,000 records were labelled, with 186 true and 2388 negative chickenpox diagnosis classes. The labelled dataset was split into training (80%) and testing datasets (20%). Three appropriate metrics were chosen: **recall**, **precision**, and **F1-score** to assess the performance of the prediction models.

### Recall

HEU **94%** VS **71%** ML

Heuristic correctly predicted more positive chickenpox diagnosis classes than the machine learning model

### Precision


HEU **42%** VS **21%** ML

The true predictions of the heuristic were frequently correct, more so than the machine learning model.



### F1-Score

HEU **58%** VS **29%** ML





F1-score is a balance of precision and recall. The heuristic has a F1-score which doubles that of the machine learning model

Computer Science & Software Engineering

In collaboration with:

UNIVERSITY OF OTAGO  
Dunedin  
Canterbury District Health Board  
Te Pahi Hauora o Wairarapa

Tech Stack



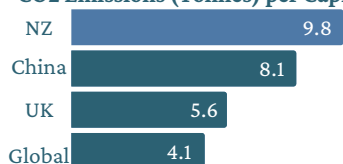
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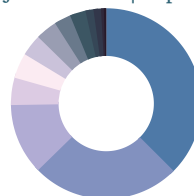
## Sustainability Vigilante

James Kwok | Supervisor : Miguel Morales

### CO<sub>2</sub> Emissions (Tonnes) per Capita



NZ has **2x** the global average of CO<sub>2</sub> emissions per capita.



## Overview

### Research Questions

1. What is the influence of game elements in regards to motivating sustainable behaviour?
2. What game elements have the most influence?

### What is Gamification?

Gamification is the use of certain elements found in games to motivate or persuade users to behave in a certain way.

### Goal

To incentivise sustainable commuting methods by motivating users through a gamified application.

### Method

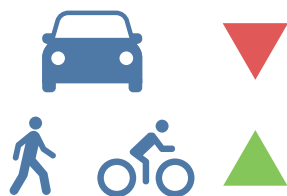
A survey was developed to determine existing incentives to commuting greenly, the game elements to be trialled, and the demographics of those who preferred them.

The most prevalent game elements were selected and periodically implemented into an Android application. Participants were interviewed after the study.

The application tracks commuting method and time. Either walking, biking, running or in a vehicle. It relies on the use of accelerometer data and the Activity Recognition Transition API provided by Google. The application recognises changes in commuting method and records the time spent in each.



## Survey



Participants ranked **Leaderboards, Badges, Daily Goal and Points** as their most preferred game element. These were implemented in the app.

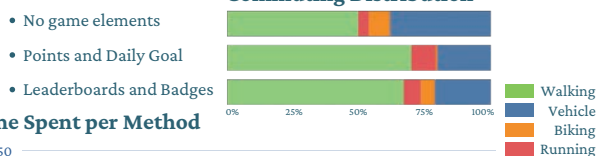
- There were 157 participants engaged in the survey.
- 43.3% of participants live within 2.5km of their workplace.
- Of the 75 participants who live more than 2.5km from their workplace, 24.0% walk as their method of transport.
- 51.6% of participants are incentivised by more sustainable methods being cheaper.

## Study

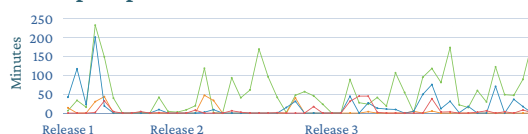
*"It was interesting to see a breakdown of my time spent travelling"*

The application had three releases, each lasting up to two and a half weeks.\*

### Commuting Distribution



### Time Spent per Method



### Results Discussion


- App usage increased by 129% in the second release and an additional 159% increase in the third release.
- Vehicle usage ranged from 38% to 5% to 20% in each release.
- The second release coincided with the COVID-19 lockdown restrictions.
- Leaderboards were the most preferred game element.
- Daily goals will be made adjustable based on the user's behaviour to increase its effectiveness.

\*The second release was extended to account for lockdown and term break.

## Conclusion

- Game elements successfully motivated users to commute more sustainably, with **increased engagement** for releases containing game elements.
- The release containing **leaderboards** and **badges** were the most effective.
- Mobile applications, game elements and sustainability resulted in a viable and successful combination.

# Student projects: Computer Science & Software Engineering



## DEVELOPING A TOOL TO HELP STUDENTS REFLECT

### USING PEER FEEDBACK

#### Motivation

**Self-reflection** is an important activity that helps students build **metacognitive skills**, allowing them to take control of their own learning.

- Self-reflection is especially valuable when learning a difficult to teach skill such as **teamwork**.
- Peer feedback** also has a large role as how the team perceives what a student does is an important aspect of teamwork.


However, **unrealistic self-reflections** will affect the effectiveness of this activity, and make it difficult for a student to recognise how they can improve themselves.

#### Solution

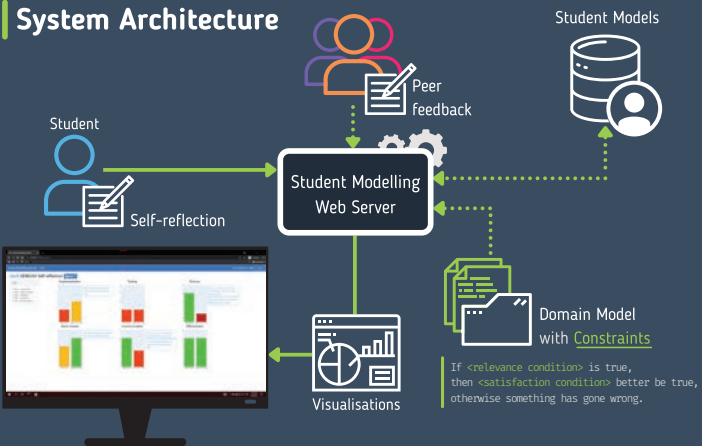
A web-based **student modelling module** was developed. Students can use the web application to see:

- Visualisations** that show their own self-reflection ratings and the mean average of their peers' ratings for them.
- Automated and personalised textual feedback** is generated from violating constraints around how a student has reflected on themselves compared to their peer feedback.

**Tech stack**



#### System Architecture



If <relevance condition> is true, then <satisfaction condition> better be true, otherwise something has gone wrong.

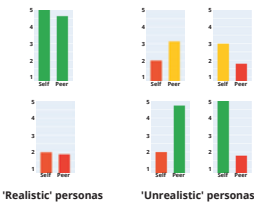
#### Evaluation

A **think-aloud study** with a **Tobii eye-tracker** was conducted to find if

- receiving peer feedback affects how a student perceives their own performance
- and if a visualisation of peer feedback makes a difference to this perception.

**Personas** .....>

**6 personas** were created based on different patterns of differences between self-reflection ratings and peer feedback ratings. E.g., 'Impostor' and 'Overconfident'



**Conducting the study** .....>

For each of the **6 scenarios**, participants were asked to give themselves **overall self-ratings** before and after seeing peer ratings as numbers and as a visualisation.


**10 INITIAL PARTICIPANTS** participated in the think-aloud study. These are students who are taking, or have taken, a software engineering group project course.

**5+ HOURS** of **eye-gaze recordings** and **audio recordings** have been collected over the 10 think-aloud sessions.


#### Results

On average, for 'unrealistic' self-reflection scenarios and personas:

- 95%** of participants **changed their initial self-ratings** after being shown peer feedback ratings.
- 20%** of participants' self-ratings were **different** between the being shown peer rating numbers and visualisations.



Eye-gaze heatmap for the 'overconfident' scenario



Computer Science & Software Engineering

Student

**Lydia Looi**

Supervisor

**Moffat Mathews**

## Student projects: Computer Science & Software Engineering

# CS UNPLUGGED

## Plugging it in

### Implementing Scratch for CS Unplugged "Plugging It In"

Rchi Lugtu  
Supervisor:  
Prof. Tim Bell

#### Background

CS Unplugged is a website that provides resources to teach computer science concepts without a computer. Research shows benefits when combining activities from CS Unplugged and computer programming. "Plugging It In" is a feature in CS Unplugged that offers students programming exercises in Scratch and Python.


#### Problem


Currently, users are forced to go out of the website in order to solve the Scratch exercises. This significantly decreases the website's usability and interactivity. Therefore, the aim of this project is to implement a more sophisticated Scratch system into CS Unplugged.

#### Solution

After researching into Scratch, we found that implementing it into CS Unplugged was not feasible. Therefore, this solution uses Blockly, which has been adapted to look like Scratch.


#### Old System






#### Programming Reminders:

Provides basic syntax about the new block-based language.




#### Recommended Blocks:

Displays the recommended blocks you need to solve the challenge!



#### Run Program:

Run your program without submitting it! Helpful for debugging purposes.



#### Interactive Block-based Editor:

Create your block-based programs here to solve the challenge!

#### Run Output:

See your program's output when clicking the Run button!

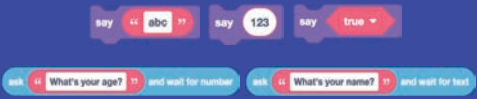
#### Submit Program:


Submit your program to get feedback on the challenge!

#### Feedback

This was evaluated by experienced teachers and they provided valuable feedback which will be taken into consideration for future development.


#### Block-based












Clicking  executes your program.


#### VS

#### SCRATCH




Clicking  or using  executes your program.





UC COMPUTER SCIENCE EDUCATION



Computer Science & Software Engineering

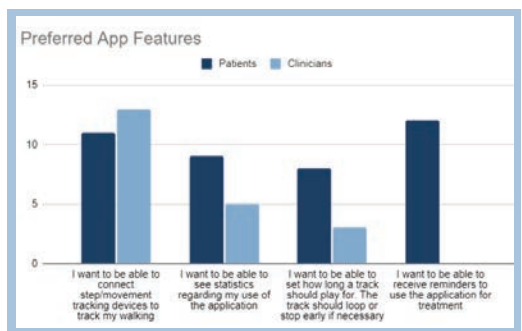


# The Power of Rhythm

## Helping fight walking difficulties felt by individuals with Parkinson's Disease

### PURPOSE

Parkinson's Disease currently affects approximately 4 million people worldwide. Some of the most common symptoms are difficulties with walking including decreased speed, stride length, and rhythmicity.



### WHAT IS RAC?

Rhythmic Auditory Cueing (RAC) has patients regularly walk in time to music or a metronome at a specific tempo. It has been proven to aid in managing walking difficulties and may help increase a patient's speed and stride length.

### SURVEY

A survey was carried out to find out what clinicians and people with Parkinson's really wanted in the Power of Rhythm app. It found:

- 89% of patients and 100% of clinicians have access to a smartphone
- >60% of clinicians preferred a phone app to a website; the rest had no preference
- One of the most preferred features participants listed was an ability to set how long a track should play for and loop it



### SOLUTION

The solution consists of two apps and a website, connected via a server:

### CLINICIAN APP

Using the app or website, clinicians can change aspects of their patient's treatment, including:

- Song selection - Choose between 5 songs and a metronome
- Tap-in-tempo - Tap to the beat of the patient's walking to perfectly match their timing
- Playing time - Specify the exact time a track should play for, making it loop if necessary



### PATIENT APP

This app makes it easy for patients to practice walking to the beat of music without their clinician present. It features:

- Clear font and large icons for ease of use
- Music plays even with the screen off
- No need for internet access when playing the tracks



# {code:WOF} Skill Categorisation

Rebekah McKinnon  
Supervised by: Prof. Tim Bell

## What is Code:WOF?

Code:WOF is a web application designed to help New Zealand teachers maintain their programming skills.

Using simple programming challenges, teachers are encouraged to use the app throughout the year, even when they are not teaching programming.

## Why?

### Programming for teachers

The Ministry of Education expected all schools to be teaching the Digital Technologies - Hangarau Matahiko curriculum from 2020.

As this includes programming, it is critical that there are resources available for teachers to learn and maintain programming skills.

### Skill fade

Skill fade is a phenomenon where the ability for a person to use a learnt skill fades with the time where it is not used. Typically, programming is taught once per year, so teachers are not maintaining their skills. The effects of skill fade may cause these teachers to need to re-learn programming every year.

## Problem

Questions are not classified and cannot be filtered. This means that users may struggle to find questions that match what they are trying to practise. We know that teachers are already lacking in time, so it is important for them to easily be able to find questions practising specific skills.

## New features

### Filters

Questions can be filtered so that users can work on specific skills and application.

Questions are classified by:

- Difficulty Level
- Programming Concepts
- Question Contexts

### Achievements

Users can earn achievements based on the skills they are working on. For example, a badge can be earned for completing 10 questions using the Conditionals programming concept.

The screenshot shows the Code:WOF filter interface. It has three main sections: Difficulty level, Concepts, and Contexts. Each section has a list of checkboxes. The 'Difficulty level' section has 'Easy', 'Moderate' (checked), 'Difficult', and 'Complex'. The 'Concepts' section has 'Display Text' (checked), 'Functions', 'Inputs', 'Conditionals', 'Loops', 'String Operations', and 'Lists'. The 'Contexts' section has 'Real World Applications', 'Mathematics', 'Simple Mathematics' (checked), 'Advanced Mathematics', 'Geometry', 'Basic Geometry', and 'Advanced Geometry'. There is a 'Reset' button at the bottom left and a 'Filter questions' button at the bottom right. A blue callout box points to the 'Moderate' checkbox in the Difficulty level section, stating: 'Indentation clearly shows that these are sub-skills. A user can select a general skill or a specific sub-skill.' Another blue callout box points to the 'Simple Mathematics' checkbox in the Contexts section, stating: 'Different question contexts allows the user to practise skills in different ways.'

## Future work

The next work on the skill classification for Code:WOF would be to implement a way for users to track their skill level which accounts for the effects of skill fade.

Extensive research and study is required to determine the exact effects of skill fade on programming.



Rebekah McKinnon: rmc209@uclive.ac.nz  
Tim Bell: tim.bell@canterbury.ac.nz  
Website: www.codewof.co.nz



Computer Science &  
Software Engineering



# Bloodstain Analysis Using Machine Learning

## The Problem

Bloodstain pattern analysis is used by forensic scientists to determine the cause of blood in a crime scene. These analyses are often used as evidence in criminal court cases. However, many of the **techniques currently used in bloodstain pattern analysis have irreproducibility** rates of up to 30%. This irreproducibility could lead to wrongful convictions in court.

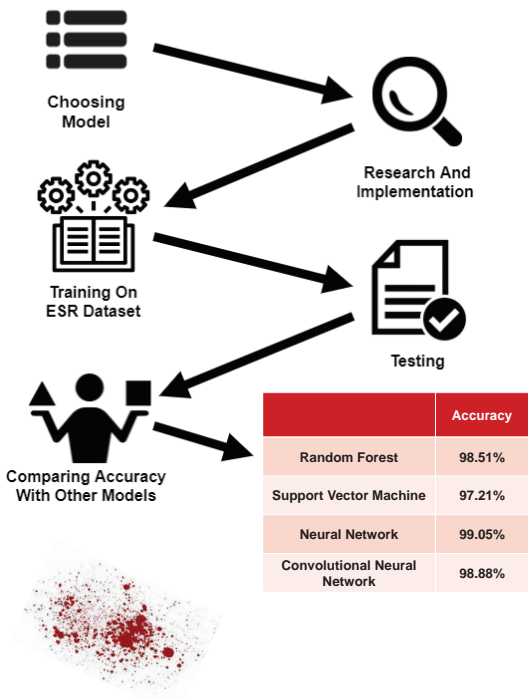
## Why Use Machine Learning?

In recent years machine learning has emerged as a powerful tool for quantitative analysis. Quantitative analyses base decisions on empirical data. This eliminates the possibility a decision will change if it is made again with the same data therefore **removing any risk of inconsistency**. As a result the use of machine and deep learning presents a promising possibility to resolve the issue bloodstain pattern analysis inconsistency.

## Which Model Performs Best In Bloodstain Analysis?

Although the choice to use machine learning for bloodstain pattern analysis was an obvious one, the choice of which machine learning model to use unfortunately was not. Because of this a series of **four different machine learning classifier models were created**, including a random forest, support vector machine, neural network (with 6 layers), and convolutional neural network (with a VGG architecture). The models were comparatively evaluated on their accuracy, using a test set of bloodstain patterns provided by ESR, to determine which model was the most suitable for use in bloodstain pattern analysis.

## Model Evaluation



## The Solution

The results of the evaluation revealed that the neural network model achieved the highest accuracy, being able to correctly classify bloodstain patterns, such as the Impact pattern above with **99.05% accuracy**. This strongly suggests that neural network models could be applied in real bloodstain pattern analysis to ensure accurate and consistent analyses.

Laurence McKnight | Supervisors: Richard Green, Andrew Bainbridge-Smith, Rosalyn Rough





# Automation of diabetic retinal screening

**Anzac Morel**

Supervised by Dr. Andrew Bainbridge-Smith



Computer Science &  
Software Engineering

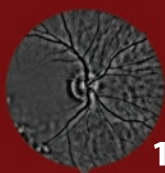
## Context

- Diabetic retinopathy is one of the seven globally leading causes of vision loss, affecting up to 80% of persons who have had diabetes for 20+ years
- Although early intervention can help prevent severe vision loss the current screening process is manual, taking months per patient
- Automation of the screening process using computer vision can exponentially decrease screening time

## Solution

A solution to automatically determine the quality of an image is proposed and works as follows:

- The image is pre-processed, equalising illumination and increasing contrast 1
- Vessels are segmented to obtain a binary vessel/non-vessel image 2
- The direction of vessels are recorded to generate a vessel direction map
- The optic disk is located using the vessel direction map and matched filtering 3
- The optic disk boundary is extracted using circular hough transform 4, 5
- The image is compared to New Zealand Ministry of Health quality guidelines



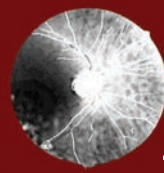
1



2



3



4



5

## Results

Image database kindly provided by Christchurch district health board

- The solution was tested on 100 randomly selected images
- Successful OD locations: 80/100
- Boundary extractions: 57/100
- Average processing time: 111s



# Autonomous Mussel Farm Monitoring

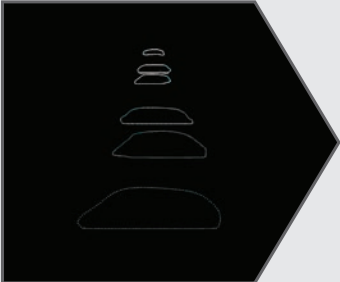
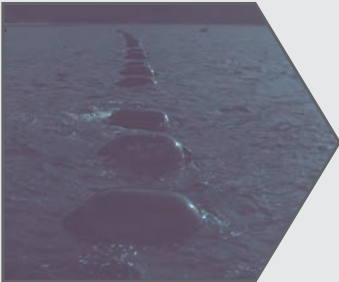
By Hamish O'Keeffe

## The Problem

- The New Zealand Government is planning to expand the aquaculture industry from 600 million to 3 billion dollars.
- To reduce the costs of manual labour, we need to implement automation

## The Solution

- We have implemented a Convolutional Neural Network using Detectron2.
- The CNN performs instance segmentation and outputs instance masks
- The perimeter of the mask is sampled to find the largest curve and match it in size to an unsubmerged float
- The two floats are then compared to determine distance and submersion of the float




## The Results

- In ideal conditions up to half of visible floats can be detected
- Mostly submerged or obstructed floats cannot be detected properly
- Large objects are detected with an average precision of ~70
- Medium objects are detected with an average precisions of ~14
- Small objects cannot be detected
- Float submersion and distance is somewhat overestimated


## The Future

- Export CNN to the TensorRT runtime
- Adjacent line detection (Will likely require an alternative to Detectron2)
- Improve detection of far away floats
- Improve performance across conditions



Computer Science & Software Engineering

Supervisor: Richard Green  
Special Thanks: Oliver Batchelor



Rep: Cris Lovell-Smith



Rep: Ross Vennell

# AUTOMATED FILTERING OF SPURIOUS COLLISION EVENTS FOR RUGBY

## USING VIDEO AND WEARABLE TECHNOLOGY

### CONTEXT

A Ph.D. Sports Science client **processes data** collected from professional rugby matches for **sports analysis**. The rugby match data produced comes from a variety of sources such as wearable technology, video streams of the match, and a file with an encoding of events.

### PROBLEM

The sources of data are **incompatible** and the data from the wearable technology can produce **invalid measurements** of impacts and **spurious high acceleration events**. Manually preprocessing this data is time-consuming and delays analysis on the match before upcoming matches.

### OBJECTIVES

- Create compatible data sources to facilitate analysis for sports analysis tool.
- Synchronise data with video stream by aligning impact events.
- Determine which impacts are false positive high acceleration events by using classification and the max average value.
- Generate a file that can be exported into the sports analysis tool with the impacts merged, aligned, and filtered.

## SOLUTION

Technology

Python JavaScript

Generate file that can be imported into the sports analysis tool

UC UNIVERSITY OF CANTERBURY

Computer Science & Software Engineering

Francheska Louise Oprenario  
Supervisor - Dr James Atlas  
Client - Hamish Dewar



# Student projects: Computer Science & Software Engineering

## {code:WOF}

### Enhancing Motivation through Peer Groups and Email Reminders

Tim Bell, Jack Morgan, Jackie Qiu

#### 1. Background

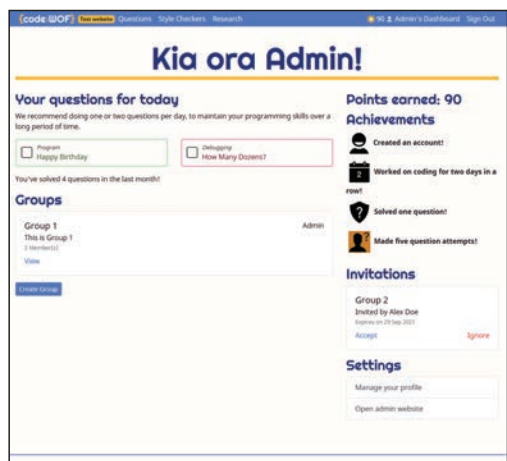
- Countries including NZ are introducing computational thinking and programming into their school curricula.
- Required thousands of teachers to learn to code.
- Coding skill decays over time.
- The Computer Science Education Research Group created CodeWOF, a website for practising coding to maintain programming skills.

#### 2. Objectives

- Identify features that could motivate users to use CodeWOF regularly to prevent skill decay.
- Design and implement the features.
- Evaluate the efficacy of the new features.

#### 3. Solution

- Added email reminders with selectable days.
- Added peer groups for teachers to collaborate.



#### Email Reminders

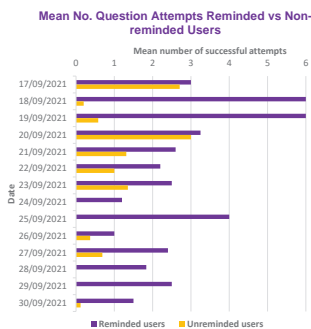


#### Groups



#### 4. Results

- Conducted a "think-aloud" evaluation with CSERG teachers. Identified and fixed UI issues.
- Conducted interviews with CSERG teachers after two weeks of use. New features were generally easy to use and successful at motivating.
- Deployed code to a study website, where teachers in NZ could participate. Collected usage statistics.



#### 5. Conclusion

- Project provided a greater insight into computer science education, web development, open-source project contribution, and working with real users to evaluate software.
- Possible next steps include allowing the time to be set for reminders, the ability to make a group public, showing group statistics for admins, etc.

UC<sup>o</sup> COMPUTER  
SCIENCE EDUCATION

Thanks to Tracy Henderson, Joanne Roberts, Melissa Jones, and other teachers around NZ for participating in the study.

Jackie Qiu: [jq26@uclive.ac.nz](mailto:jq26@uclive.ac.nz)  
Tim Bell: [tim.bell@canterbury.ac.nz](mailto:tim.bell@canterbury.ac.nz)  
Website: <https://www.codewof.co.nz/>

## Milestone Navigator: Re-engineering

**Milestone**  
Financial

## Package 1: Authentication and Authorization

## Background

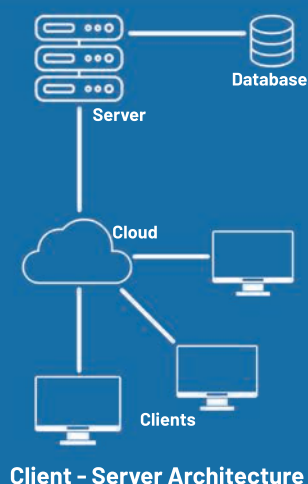
- The current version of the Milestone Navigator application operates as a single client application and is used by the advisors to help provide financial advice to the clients.

## Problem

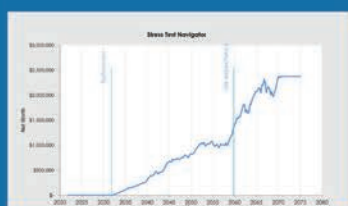
- Milestone Financial would like to distribute the Navigator software to other financial organisations.
- They would like the application to operate under a license/subscription fee structure so the software may be used by other organisations on the condition that they pay.
- Clients and advisor information must be secure, meaning it cannot be accessible by users outside the organisation.

### Solution

- The final solution involved implementing a client-server architecture into the Milestone Navigator tool.
- The existing client was modified to communicate with a SpringBoot application running on an external server, this server application also communicates with an external database.
- The new solution allows Milestone Financial to grant licenses to new organisations, selecting the expiry date, maximum number of clients and maximum number of advisors.
- Spring Security was used for managing authorization and authentication, a custom Authentication Filter and various other functions were used to secure client data.
- A number of roles and permissions were implemented to cater to different types of users, including organisational administrator and advisors.



### Pessimistic\*



Base\*



Optimistic\*



### All Cases\*

## Package 2: Navigator Stress Test using Monte Carlo Simulation


### Problem

- Currently, the Milestone Navigator tool has the ability to assist clients in planning their retirement spending through a steady state linear model of their financial performance.
- In reality, the financial markets do not operate in a linear state and are considerably volatile. If the variance is unaccounted for this can lead to clients running out of funds well before life expectancy.
- Milestone Financial would like a way for stress test their financial models to account for the variance that the financial market may face and provide some real level of confidence that their funds will endure or endure beyond life expectancy.

### Solution

- The final solution involves extending the current Spender panel in the Navigator application to include a new tab dedicated to displaying the data on a line chart.
- The stress test uses a variant of Monte Carlo simulation to emulate the variance in the real financial market.
- The percentile scenarios are selected, extrapolated, and applied to the investment return agreed by the advisor and client to generate the new Stress Test graph displaying a line for each percentage scenario.
- The 95th, 50th, and 5th percentage scenarios each respectively represent Pessimistic, Base, and Optimistic scenario.


\* Note that the images of the scenarios shown above are wireframes and the final solution may vary.



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# Block-based Python for CodeWOF

## The CodeWOF Website

- CodeWOF is a website that allows users to test and train their Python programming skills
- It provides daily programming tasks for the user to complete
- The existing website has four types of questions; Program, Function, Debugging and Parsons
- The CodeWOF team wanted to add Block-based Python as a new way to answer questions on the website


## Writing Code with Blocks

- Block-based programming is seen to have benefits for those who are learning to code
- It removes the need to remember language syntax, which can be one of the hardest things to learn as a beginner
- The drag & drop editing of block languages can be more interactive and engaging than regular text-based programming


## Blocks in CodeWOF

- Block-based Python has been added to CodeWOF as a new type of programming question
- The editor has a drag & drop interface making it easy to add and move code blocks
- The blocks are grouped under headings of related types to make navigation simple
- All blocks have helpful hint text that can be seen while hovering over the block
- Inputs, expected outputs and recieved outputs are shown below the editor


Input	Expected output	Received output	Status
24	34	34	Passed
36	46	46	Passed




Blockly



GitHub



django



python

Student:

Samuel Sandri

Supervisor:

Tim Bell



# Student projects: Computer Science & Software Engineering

## Hybrid Software Testing

test smarter,  
not harder

### Problem statement

**Unit testing** and **acceptance testing** are testing process with significantly different goals.

Because of this, we typically only think about one or the other when we design testing strategies.

As a result, the strategies we create might require testers to become proficient with two approaches that have little in common.

### Research questions

**Question 1:** What is the current state of research into software testing strategies? This will help us better understand our other results in relation to the domain as a whole.

**Question 2:** Are there testing strategies that are used for both unit and acceptance testing?

Using one strategy for both processes could help developers **become proficient more quickly**.

**Question 3:** How are the strategies identified in Finding 2 used in industry? It is important to know whether the strategies are applicable in an industry context.

### Process

1. Define a search query to find all academic papers that might be relevant to our research
2. Manually filter out papers not related to unit or acceptance testing strategies

Answer research question 1

4. Keep only the papers discussing testing strategies from an industry perspective
5. Read, categorise and make notes on the remaining papers

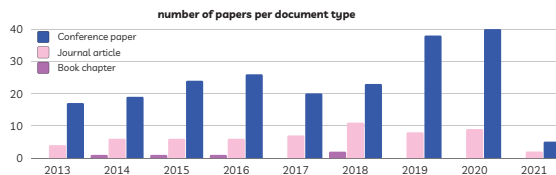
Answer research question 2

7. Design and distribute a survey to understand how these strategies are used in industry

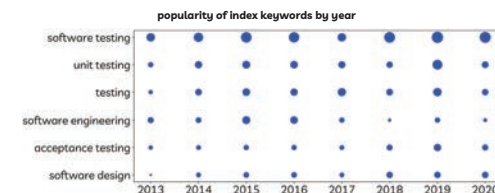
Answer research question 3

### Findings

#### Finding 1: Software testing is a growing field of research



An upward trend in the number of testing-related papers suggests that this is a growing field. The high proportion of conference papers suggests that new ideas are being introduced often.



The popularity of the 'software testing' keyword compared to 'software engineering' suggests that recently software testing has gained more recognition as its own discipline. Also, 'unit testing' appears to be a more popular research topic than 'acceptance testing'.

#### Finding 2: Two strategies from the literature are used for both unit and acceptance testing

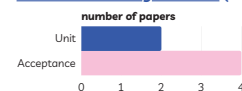
##### Test-driven development (TDD)



Tests are written before implementation begins.

TDD helps developers **think about design ahead of time**. It requires developers to adopt a different mindset, and to overcome a learning curve.

##### Model-based test generation (MBTG)



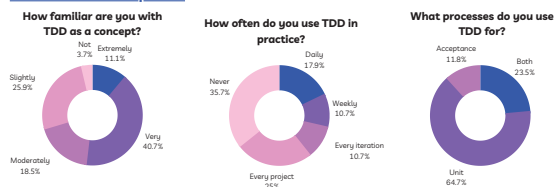
Models of the system are used to automatically generate tests.

MBTG allows **coverage targets to be met quickly**. However, generated tests are sometimes flawed due to problems automating the test oracle. Maintaining the models is also a source of overhead.

#### Finding 3: TDD is used often in industry, but MBTG is not

26 people from industry participated in a survey on how they use the strategies from Finding 2 in practice.

##### Test-driven development



##### Model-based test generation

The lack of use of MBTG in industry and the fact that most participants only received training at university suggests that MBTG is mostly a focus of academia.



Computer Science &  
Software Engineering

Student  
**Jack van Heugten Breurkes**

Supervisor  
**Fabian Gilson**

# WILDING PINES

## ELIMINATION BY SEMI-AUTOMATED HELICOPTER SPRAYING

### THE PROBLEM

WILDING PINES are invasive weeds that pose a great threat to the landscape, culture, and biodiversity of Aotearoa.

Currently, WILDING CONIFERS cover more than 1.8 million hectares of New Zealand and are spreading annually at an estimated rate of 5%. Without large scale intervention and control, 20% of New Zealand may be covered with these pests within the next 20 years.





### BACKGROUND

AERIAL BLANKET SPRAYING, the most common method to eradicate WILDING PINES, wastes herbicide and is harmful for native species in the surrounding area.

To combat these limitations, the 2020 WILDING PINES team developed and GROUND-TESTED a system prototype that specifically targets these pests.

The 2021 WILDING PINES team seeks to accelerate the previous system for a FLIGHT-TEST. When the helicopter flies over a wilding pine, the system will automatically deliver the optimal dosage of herbicide.

### GOALS

- Develop a map UI that displays the helicopter's position and TREATMENT AREAS; locations of wilding pines that have been—or are to be—sprayed.
- Enhance the communication and logging of spray data between the NUC and the UI.

### SOFTWARE STRUCTURE

#### USER INTERFACE

- Communicates with the WILDING PINES API
- Receives TREATMENT AREA and GPS LOCATION data from the NUC
- Downloads a map of the area from MOBAC
- Visualises the data on a map using OSMDroid



android

#### The NUC

- Most onboard processing, including the WILDING PINES API, performed on an Intel NUC computer
- Sends TREATMENT AREA and GPS LOCATION data to the UI



intel nuc

### RESULTS



- Indicates sprayed pine trees
- Indicates pine trees to be sprayed
- Indicates the current location of helicopter

the map rotates based on where the helicopter is facing

### TECH STACK





Department of Conservation  
Te Papa Atawhai



UC  
UNIVERSITY OF  
CANTERBURY  
Te Whare Wānanga o Waitaha  
University of New Zealand



scion  
FORESTS • PRODUCTS • INNOVATION

Computer Science &  
Software Engineering

Student: Euan Widjaja

Project Partners

Alex Hobson  
Christopher Holmes  
Renzo Childs  
Mitch Graham  
Ashton Burt


Industry Partners

James Griffiths (DoC)  
Brian Richardson (Scion)

Supervisors

Andreas Willig  
Mark Jermy

# Student projects: Computer Science & Software Engineering



## Green Fibre

### Sustainable Connectivity

#### Motivation

- Over 200,000 homes, businesses and schools in Christchurch and surrounding towns are connected by fibre, with 133,000 connected customers.
- ~100 Petabytes of data processed a month.
- What is the environmental impact of the operation of Enable's Fibre Network?

#### Objectives

- Model the environmental impact of Enable's Fibre Network.
- Create a software artefact that manipulates the created models.
- Research alternative communication network options.

#### Results

##### Software

- Artefact was created in Visual Basic to visualise and manipulate models.
- Model both existing and hypothetical areas within the network.

##### Research

- Investigation into Copper and Fixed Wireless alternatives.
- Best practice environmental impact reporting.

#### Hornby

Data used:  
Increasing 3% per month  
Carbon Emission trends:  
Increasing 2% per month  
Connection count trends:  
Increasing 1% per month

#### Hypothetical Zone: Prebbleton

Connections\*:  
2000  
Data used in a month\*:  
2 Petabytes  
Carbon Emissions/connection/month\*:  
0.22kg CO<sub>2e</sub>/connection/month  
\*Estimated


#### Fibre network in Christchurch

Total data in a month:  
100 Petabytes  
Carbon Emissions in a month:  
11,000kg CO<sub>2e</sub>  
Carbon Emissions/Gigabyte:  
0.00011kg CO<sub>2e</sub>


#### St Albans

Connections:  
13,000  
Data used in a month:  
9 Petabytes  
Carbon Emissions in a month:  
700kg CO<sub>2e</sub>  
Carbon Emissions/Gigabyte:  
0.00007kg CO<sub>2e</sub>

Student: Joshua Yee  
Supervisor: Andreas Willig  
Industry Rep: Melissa Keys  
Special Thanks:  
Enable Fibre Broadband




Computer Science &  
Software Engineering





# Recommendation Engine For Forest Restoration



Developed by:  
David Turton

In cooperation with:

Student:  
Jerome Grubb

Staff Supervisor:  
Richard Green

Nelson AI Institute:  
Cris Lovell-Smith  
Nikki Hawes  
Julian Maclaren  
Nick Butcher

Abstract

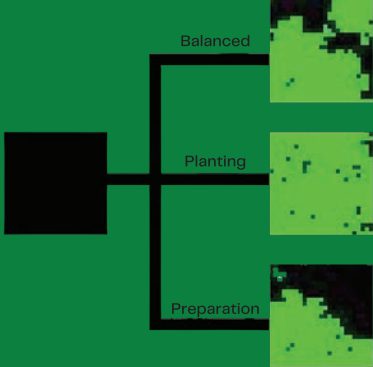
Nelson AI Institute is developing a set of tools for forest regrowth and restoration for an ecosystem planning platform. This particular tool is designed for the algorithmic optimization of forest growth working in tandem with a forecasting tool to generate the best possible solutions for tree growth. This tool will be used to assist in a planning platform used to optimize global ecosystem restoration efforts based on factors such as biodiversity, carbon sequestration, density, and cost. A combination of an evolution model for the prediction of the forest growth and a recommendation engine are intended to be used for finding the optimal growth solution. The development of this tool is necessary for the automation and optimization of solutions through the vast number of different possible strategies that can be taken in regards to planting new trees, managing the landscape, controlling pests, etc. The system is essential for considering these different objectives and analyzing the many different options for reforestation and helping to decide the optimal path.

This tool consists of a search-based restoration recommendation engine that generates a path weighted by tree growth for a provided start state. The tool takes into consideration several different forms of intervention, such as additional planting, pest control, fertility, etc.

Analysis

The system generates a map based on the user's input, with multiple randomized factors for each tile, such as the fertility, the average rainfall and whether animals are grazing nearby. Each of these factors influences the likelihood of neighbouring trees spreading to that local tile.


After the generation of this map, several different strategies are run over a given timespan, and the best, worst, and average results for each strategy are output. These strategies prioritize different "moves" such as a plant strategy consisting almost entirely of plating new trees, whereas a preparation strategy consists mainly of fertilizing soil and clearing away pests.




The generation takes a brute-force method running many iterations of each strategy over a simulated evolution model and outputting the average, best, and worst scores for each strategy, as well as the steps taken and a visual representation of the final grid. The current solution uses a simulated evolution model with rules that are somewhat arbitrary, however future iterations are intended to combine this optimization model with a more sophisticated evolution model based on data from actual tree growth. These models will work in tandem to create a full environmental simulation.

Conclusion

While this system demonstrates the starting steps for a optimal path resolution, further development needs to be made on optimization of the search algorithm and simulation of growth. The current system utilizes a brute-force method which will lead to exponentially larger times for generating a solution. Future developments expect to combine this system with the prediction engine developed alongside it for more accurate predictions for tree growth, as well as increasing the different optimization criteria for the system.



Nelson AI  
Institute



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CHRISTCHURCH NEW ZEALAND

Computer Science &  
Software Engineering

# Gamifying Software Engineering Project Courses

## Background

Team effectiveness, defined as "The real-time altering of behaviour and interactions to accomplish the shared team goal." is key to success in Software Engineering project courses. Essence Kernel "Alphas" can be used to measure areas of team effectiveness. As teams improve their process, they progress through different "states" of an alpha. A web application created integrated game elements and questionnaires to improve and track team effectiveness.

### Application Goals

- Improve team progress
- Recognise individual achievement
- Increase task diversity

## Survey

A survey characterised project course students and identified which aspects of the teamwork process game elements would benefit. 52 project course students completed this survey.

### Top stressors of project course students

1. Work will be left to the last minute
2. My teammates will slack off

### Top motivators of project course students

1. Improving development skills
2. Achieving a high grade

## Application



Compete with other teams on the **leaderboard**

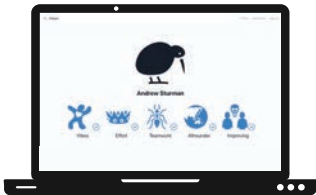
Students used the created web application to answer questionnaires set by lecturers to measure team effectiveness.



Award **badges** to recognize achievement



Earn **points** by improving team process



Choose custom **avatars** to show individuality



## Results



Game elements improved team effectiveness for **75%** of users

All users agreed **badges** were the most effective game element

"Figure out strengths of teammates"  
"Increases recognition for positive team attributes"  
"Gauge the sentiment of the team"



The team **progressed** their state from collaborating, through performing to adjourned

## Student projects: Electrical Engineering and Computer Engineering

# CARBON FROM SAR

Sponsored by Nelson AI Institute (NAII)

### Ko wai? - Who?

NAII is exploring using artificial intelligence to assist with forest restoration and regeneration, with emphasis on biodiversity and carbon sequestration. The long-term goal is to develop an ecosystem planning platform to enable the restoration of ecosystems globally in a way that is both cost effective and rapid, while also maximizing key ecosystem health factors such as biodiversity, habitat availability, and water + air quality.

### He aha? - What?

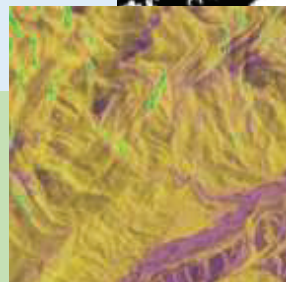
A significant challenge in forest restoration management is the accurate estimation of forest parameters using remote sensing data. Satellite-based synthetic aperture radar (SAR), especially using longer wavelength bands than are currently available, may improve on the current state-of-the-art, fusing multiple data sources (e.g. SAR + passive sensors) with modern neural network architectures.

### He aha ai? - Why?

This project is researching both existing and upcoming SAR data sources and determine the feasibility of accurate forest parameter estimations. Forest parameters of interest include: species, maturity, health, height, biomass, and sequestered carbon. This is intended to be a proof-of-concept study, designed to help NAII better understand the technical challenges involved in this concept.

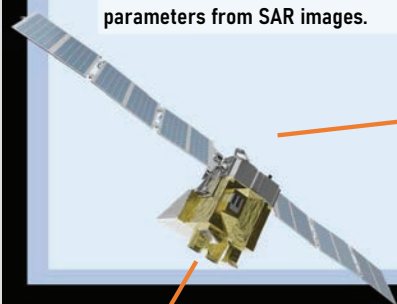
### Me pēhea? - How?

This project used many types of artificial networks both supervised and unsupervised. These include classification and segmentation convolutional neural networks, as well as self organising maps. These tools are what allowed us to extract forest parameters from SAR images.



### Tima - Team

Project Team: Brian Lauren, Sofie Studholme, Summer McNeillage, William Herewini  
Supervisors: Phil Bones, Mike Shurety






# UNINTERRUPTIBLE POWER SUPPLY (UPS)


UTILISING GRAPHENE ENERGY STORAGE

### WHAT IS THE PROBLEM?




A UPS PROVIDES POWER DURING UNEXPECTED FAULTS AND ARE USED IN MANY CRITICAL INDUSTRIES. THE MOST COMMON CAUSE OF UPS SYSTEM PROBLEMS ARE FROM BATTERY FAILURE. THIS CREATES A PROBLEM OF UNRELIABILITY AND INEFFICIENCY IN THE UPS MARKET.

### HOW CAN THE PROBLEM BE SOLVED?




A GRAPHENE BASED SOLID STATE HYBRID SUPER-CAPACITOR CAN BE USED AS AN ALTERNATIVE TO LITHIUM-ION BATTERIES. GRAPHENE TECHNOLOGY CAN BE USED TO CREATE A SUPERIOR, RELIABLE AND EFFICIENT UPS SYSTEM.


### WHAT MAKES GRAPHENE SO SPECIAL?




Faster charging




Quicker time to full capacity




Longer battery life



Wider operating temperature



More sustainable repurposing



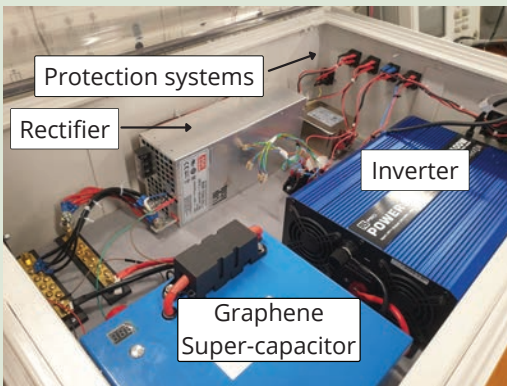
Less chance of chemical fires

### PROTOTYPE FEATURES

- 1500W DC POWER SUPPLY
- 1500W AC INVERTER
- 10AH 25V GRAPHENE BASED SUPER CAPACITOR
- MCU BASED POWER FLOW CONTROLLER

### PROTOTYPE ABILITIES

1. PROGRAMMABLE CHARGING CONTROL, WITH 10 MINUTE FAST CHARGING .
2. 10 MINS OF UNINTERRUPTIBLE POWER.
3. TEMPERATURE, VOLTAGE AND CURRENT CONTROL.
4. REDUNDANCY CONTROL VIA ELECTRONIC BYPASS.




### CONCLUSIONS AND RESULTS

MARKET RESEARCH SHOWS A GRAPHENE UPS HAS APPLICATIONS IN REMOTE USE INDUSTRIES, ESPECIALLY TELECOMMUNICATIONS





PRELIMINARY TESTING INDICATES THAT UTILISING GRAPHENE COULD REVOLUTIONISE THE ENERGY STORAGE MARKET. FURTHER DEVELOPMENT OF THIS TECHNOLOGY WILL CREATE HIGH QUALITY AND ROBUST UPS SYSTEMS.



**Team:** Nathanael Brown  
Paiaka Graham  
Emma Lloyd  
Bence Rizner

**Supervisor:** Maan Alkaisi  
**Sponsors:** Michael Durie  
Tony Martin  
Garry Parker  
Don Purdon





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CHRISTCHURCH NEW ZEALAND

# E03 - Trail Counter

**Team:**  
Max Young  
James Krippner  
Joel Swords  
Torben Stovold  
Jason Ui

**Industry Sponsors:**  
Rod & Geoff Druy

**Supervisors:**  
Alan Wood  
Phillip Hof

## Project Overview

Develop a trail counter to count pedestrians and cyclists, purposed to understand the usage of trails. A successful outcome is to provide reliable data to trail network organisations to improve their maintenance and resource management.

## Sensor Technology

- Low power Passive Infrared (PIR) Sensor used for standby detection
- Two Time of Flight sensors (ToF) are triggered for rapid and accurate speed and direction detection with an edge-detection algorithm.
- Pedestrians and Cyclists are differentiated with a simple velocity calculation
- Achieves up to 90% accuracy

## Software

### Data Management

- Entries record time, bike/person and direction

### Entry Receiver Tools

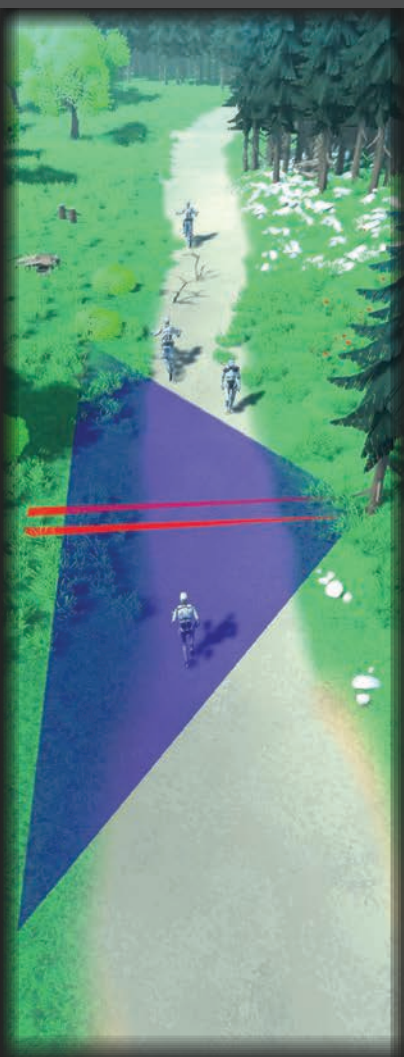
- Communications initiated by waving magnetic swipe card over the Trail Counter triggering a REED sensor
- PC and Android apps created to retrieve Trail Count data from the device via Bluetooth Classic, Bluetooth Low Energy or via cable

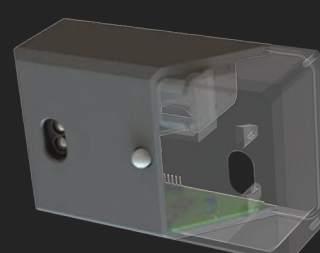
### Entry Explorer Tool

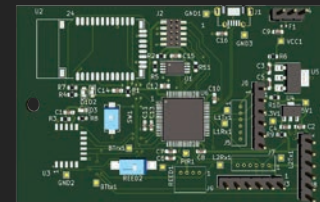
- PC software tool to view statistics and trends from Trail Count data

## Hardware and Electrical

- 3D Printed ASA Plastic Case
  - Strong mechanical properties and UV resistance
- Allows the case to be easy to produce in low build volumes
- Discrete and portable size at only 160x100x50 mm






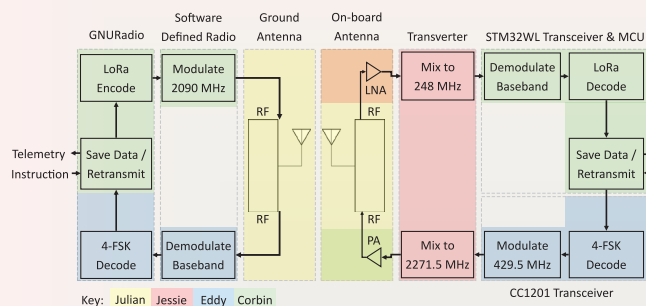


## Power Usage

- Transistors are used to switch the Bluetooth and ToF sensors off until the low power PIR or REED is triggered.
- This coupled with the low power STM32 F104 microcontroller gives a battery life of up to 6 months on 6xAA batteries.

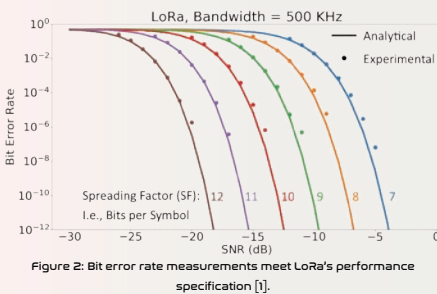


# End-to-end Full-duplex Communications System for Rocketry



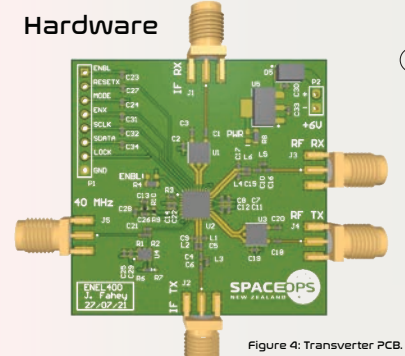
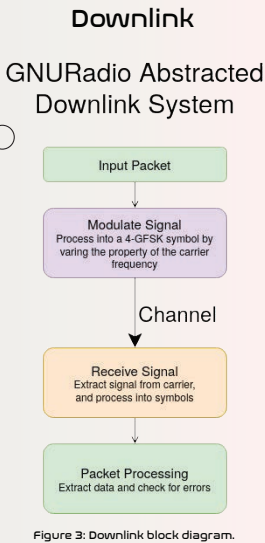
Reliable telecommunications is critical for rocket launch safety and success. This project builds upon UC Rocketry's current telecommunications system through a long-range uplink connection, retransmission, hardware improvements, and niche antenna design.

The project was split into command transmission (uplink), Radio Frequency (RF) design, and telemetry transmission (downlink) components. A block diagram of this full-duplex link is shown in Figure 1.



**Uplink**

The continuity of our telemetry data is paramount. For the uplink, data comprises crucial low data-rate commands. The chosen uplink modulation scheme, LoRa, gives a very low bit error rate for a given signal-to-noise ratio (SNR) (Figure 2); reliable data with minimal power consumption. Furthermore, a full-duplex retransmission system ensures that all data is correctly received by resending packets when they are lost or initially received with detectable errors.



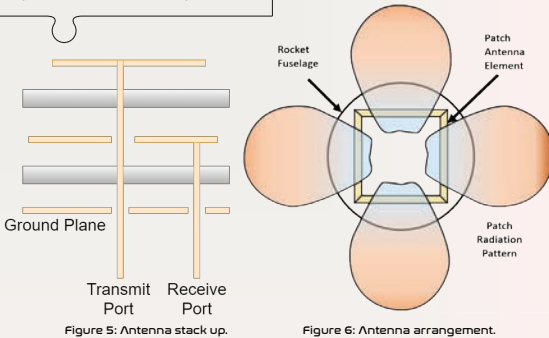
The communication system's ground station is implemented in GNURadio software for software-defined radios (SDRs), which have the advantage of increased flexibility and reusability over hardware-defined radios. The system's downlink uses 4-FSK (Figure 3).

The transverter (Figure 4) interfaces the S-Band antenna with the onboard transceivers labelled in Figure 1. It down-converts the received signal to 248 MHz and up-converts the transmitted signal to 2271.5 MHz. The transverter can be configured to convert any intermediate or S-band frequency by up to 2.7 GHz, which is helpful in the case of spectrum license changes or if using alternative Sub-GHz transceivers.

**Antenna**

The rocket antenna consists of four individual patch antenna elements that can be powered depending on which element is pointed closest to the ground station, optimising energy consumption (Figure 6). Each array element is a full-duplex, cross polarised, stacked patch antenna manufactured using a CNC machine and PTFE substrate (Figure 5). The antenna array elements are fed from an RF splitter network with power amplifiers boosting the signal and controlling the antenna switching.

In conclusion, each component of the holistic communications system has been validated individually. The amalgamation of these components in an upcoming November balloon launch will confirm their integration capabilities with the other sections of the project.



**Team:** Julian Topp  
Corbin Heywood  
Jessie Fahey  
Edward Marshall  
**Sponsor:** Great South Regional Development  
**Supervisor:** Dr. Chris Hann  
With Special Acknowledgement to Narottam Roy & Scott Lloyd



[1] T. Elshabrawy and J. Robert, "Closed-Form Approximation of LoRa Modulation BER Performance", IEEE Communications Letters, vol. 22, no. 9, pp. 1778-1781, 2018.

# Student projects: Electrical Engineering and Computer Engineering

## Surgical Tray Counter

### Background

Surgical trays are used to house surgical instruments for orthopaedic implants. After use, the full trays are steam-sterilised in an autoclave at 125°C for up to 30 minutes and then stored until needed for the next surgery. Regulatory bodies now require that surgical instruments be treated as medical devices, and they therefore must have an expiration date. The purpose of the surgical tray counter is to determine how many times a tray of instruments has been put through the autoclave in order to know how many surgeries the tray has been used for. This data will allow the manufacturer to know when the instruments must be taken out of service.

### Motivation for the project

Our client wants to develop a device that can be added to any surgical tray in order to count the number of times the tray has been used in surgery. The device needs to be passive and capable of long life through years of steam sterilisation. The data needs to wireless communicate with a transceiver that can store the data in the cloud, allowing an instrument manufacturer to know the utilisation rates of each surgical tray.



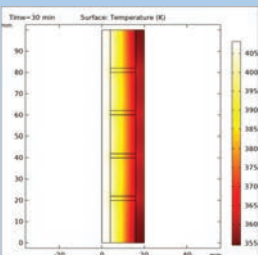
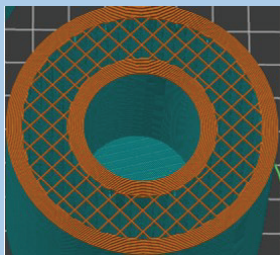
### Device

The team decided upon 5 year service life. Due to the high temperatures, the average current draw from the single primary cell battery will need to be less than 10 uA. This will be achieved by powering off/on the device using a small duty cycle, nano-current timer and switch. When the surgical tray is taken out of the autoclave and the device is powered on, a BLE (Bluetooth Low Energy) non-connectable packet is constructed and sends a signal to the transceiver containing the current autoclave count, battery voltage and tray ID. The transmission range of the BLE is 30 m. This allows a gateway transceiver device located in the tray storage rooms to detect device packets and parse them to then transmit to cloud-based services.

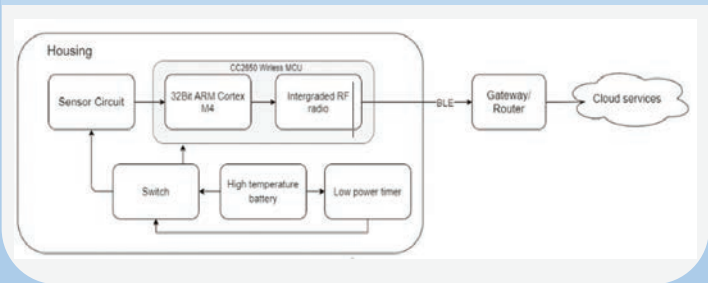


### Housing Design Simulations

The device housing must be waterproof but also protect the enclosed electronics from the high temperatures used in an autoclave. Most batteries and some electronics have temperature limits of as low as 85°C, so the device housing must provide some insulation, yet still be transparent to electromagnetic waves. We chose 3D printing of a plastic housing with an infill pattern to print housing with air pockets which help increase the insulation capability.



### Project Flow Diagram



### Cloud Services

Our design utilises Amazon's cloud services to transmit our signal output to the cloud database. Several different apps are required:

- Amazon S3
  - Stores and retrieves data
- Amazon Cognito
  - Authenticates access
- API gateway
  - Communication protocol
- Amazon Lambda
  - For coding without servers
- Amazon DynamoDB
  - Cloud service



Jeoff Antony  
Samuel Fraser  
Scarlett Garvey  
Alejandro Ramirez

Supervisor: Debbie Munro  
Client: Iain McMillan





# Student projects: Electrical Engineering and Computer Engineering



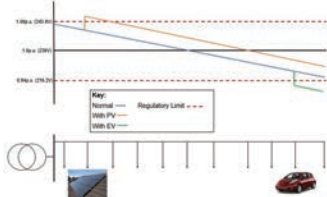
## Application of Voltage Regulation on the LV Distribution Network



Project Sponsors: Northpower, ETEL

### Introduction

Northpower is facing the challenges from PVs and EVs producing greater voltage swings on the existing LV than was envisaged when these networks were built. The purpose of this project was to test several Low Voltage Regulators (LVRs) to determine their effectiveness for reducing voltage violations on LV distribution systems



### Project Scope

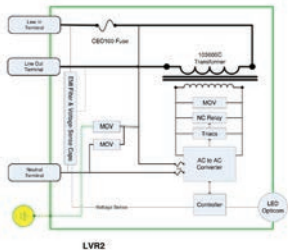
- Lab-Testing LVRs for Performance Verification
- LVR Field Trial
- Network and LVR Modelling
- Alternatives Research and Cost-Benefit Analysis
- Simulations of Transformer Life losses associated with Increased Demand.

### About the Microplanet LVR

AC Chopper and series injection transformer circuit capable of bucking and boosting AC voltages

$$V_{out} = V_{in} \pm D \left( \frac{n_2}{n_1} \right) V_{in}$$

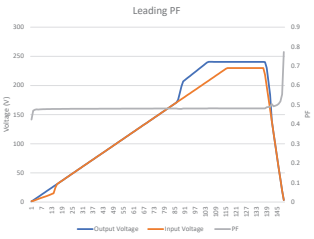
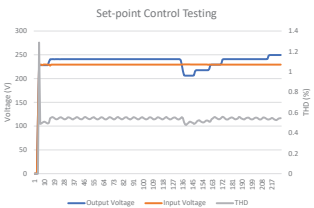
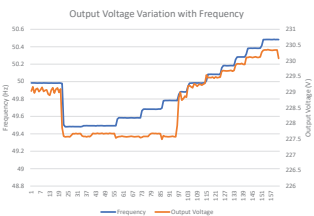
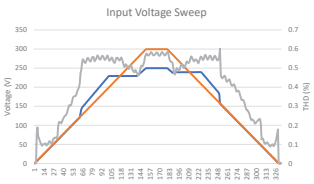
- Lack of mechanical moving parts
- Ability for Feed-back control of voltage.



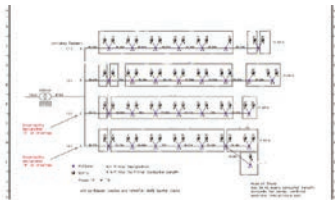
### LVR Performance Verification

A series of test procedures were established to verify the performance of a 20kVA LVR manufactured by Microplanet. Testing was designed to establish the follow performance parameters:

- Voltage regulation limits
- Frequency induced voltage drift
- Set-point control
- Leading and Lagging Power factor performance
- Four-Quadrant capability (reverse power flow)
- Harmonic Distortion



### Simulated Network



An urban LV network in Whangarei was modelled in PowerFactory and simulated PV Penetration and EV loads were added. The regulator was also modelled to evaluate the reduction of voltage violations.

### Regulator Simulations

#### EV (LOAD)



Simulations based on an existing LV network show how the regulator pushes the voltage back up when it went outside the voltage limit due to loading of Electric Vehicles (EVs).

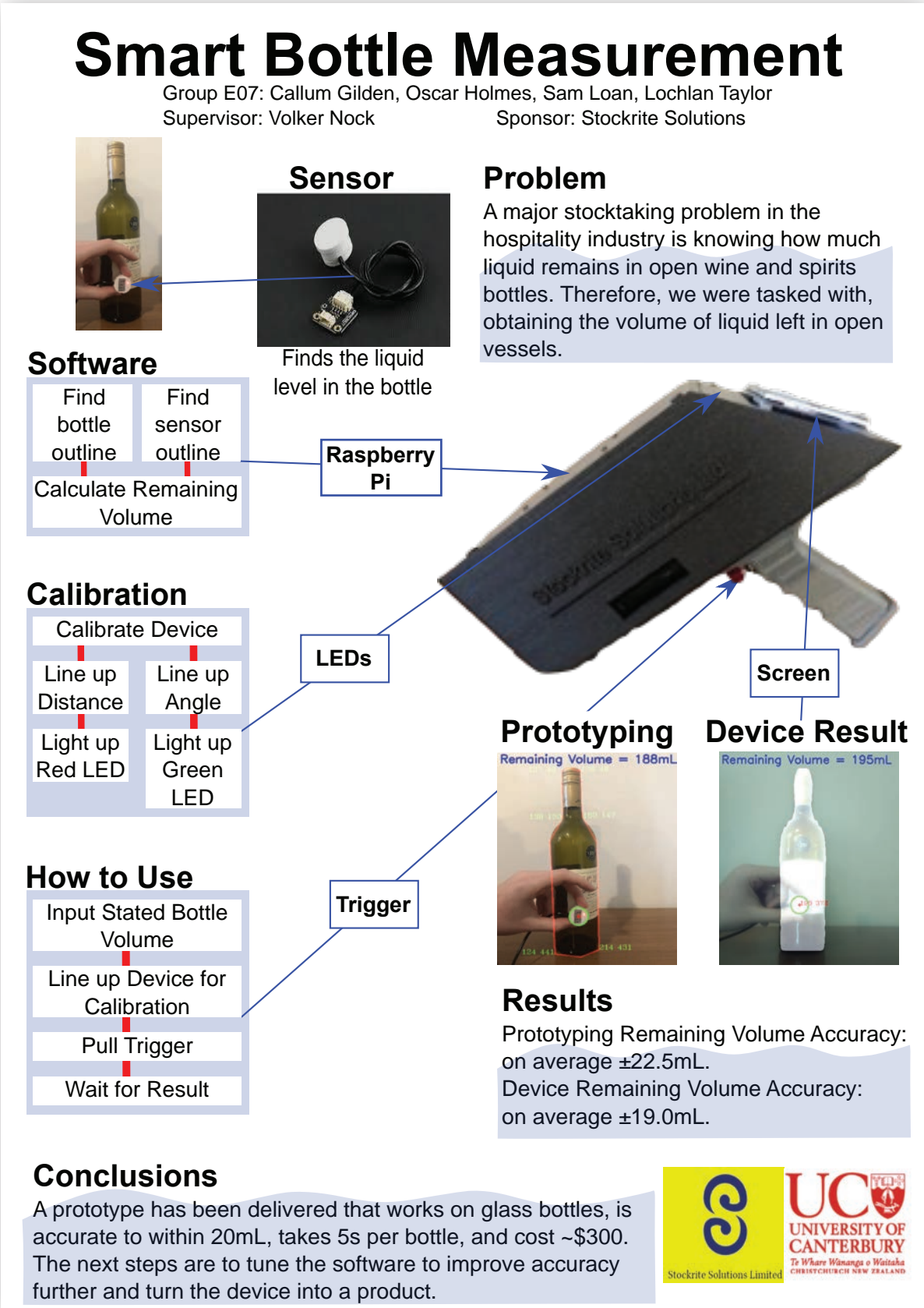
**Supervisors:** Neville Watson, Ryan Van Herel

**Sponsor Contacts:** Russell Watson, Dan Martin

**Project Number:** E06

**Students:** Connor McCarthy, Thomas Wang, Scott Parkin, Jansen Enriquez

**Technician:** Ken Smart, Edsel Villa



# NEPALESE PICO-HYDRO TURBINE AND GENERATOR

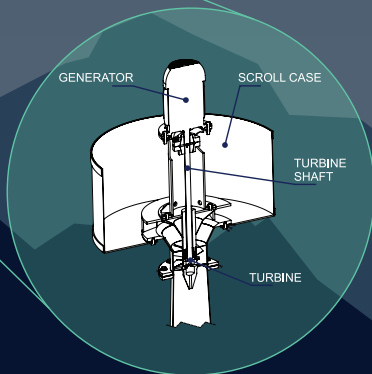
Pico-hydro turbines are turbines which generate under 5 kW of hydro power, typically by diverting small streams. In Nepal, the development of pico-hydro schemes has brought significant environmental, social, and economic benefits to communities, who largely rely on coal, diesel and kerosene to meet their energy needs.

Meridian Energy is one of New Zealand's largest electricity generators. The company's commitment to sustainability focuses on the United Nations' Sustainable Development Goals. In support of these goals, Meridian is sponsoring the development of a 1.5 kW pico-hydro scheme to provide power to rural Nepal.



## TEST RIG ASSEMBLY

The test rig is a closed loop water circuit, pumping water from a reservoir to an overhead channel, into the turbine, then flowing back into the reservoir.



The overall design and part manufacture of the rig was completed in 2020. Assembly and additional parts manufacture was the focus of this project.

## EFFICIENCY TESTING

Measuring turbine power output at a range of flow rates, rotational speeds, and blade angles to produce a graphical representation of turbine efficiency over its entire operating range (Hill Chart).

## LOAD CONTROLLER

The load controller maintains the output of the generator fixed by controlling the total load connected to it. The load controller measures the amount of power being used by the village loads and 'dumps' the excess power into a heating element.

## TURBINE SHAFT EXTENSION

Extension of turbine shaft to fit new scroll case design. This involved deflection and critical speed calculations, bearing selection, and re-design of the generator support.



## FLOW CONDITIONING

Conditioning of irregular, unsteady flow along the flume to ensure reproducible test conditions and results.




# AUTONOMOUS TRAVELLING IRRIGATOR

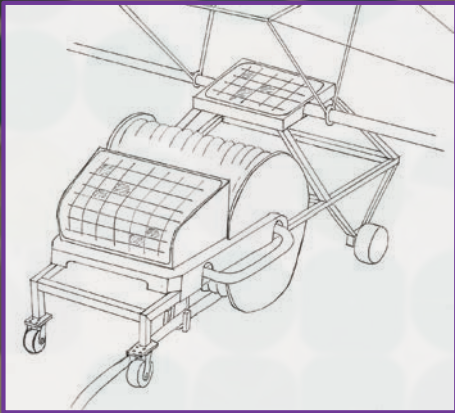
## PROBLEM

Irrigation makes farming in Canterbury viable, and centre pivot irrigators are the most popular choice. However, these leave odd-shaped corner areas without water. The challenge is to design a system which can be programmed to irrigate areas of a variety of shapes and sizes. It must be self powered, distribute water uniformly, and be able to run almost continuously during summer months.

## SOLUTION

The client intends to modify an existing irrigator model, adding functionality that will allow it to navigate and irrigate autonomously.





## FEATURES

- GPS position sensing
- Custom hose sensing system
- 150m hose length

- Solar powered with battery storage
- 3 BLDC motors (2x drive, 1x reel)
- Large boom to deliver water

## OPERATION

Loads relevant path

Determines speed setting

Begins irrigating

Forwards Mode

Following series of GPS path points

Hose is laid out

Reverse Mode


Tracks hose on the ground to re-trace path


Hose is picked up

CLIENT: FRIZZEL AGRICULTURAL ELECTRONICS

SUPERVISOR: MICHAEL HAYES

TEAM: A. HISLOP, J. HILL, G. LAY, D. PENLINGTON





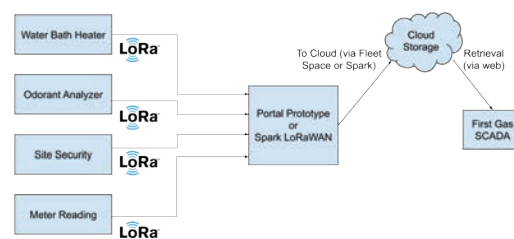


## Student projects: Electrical Engineering and Computer Engineering

## Remote Data Collection for First Gas

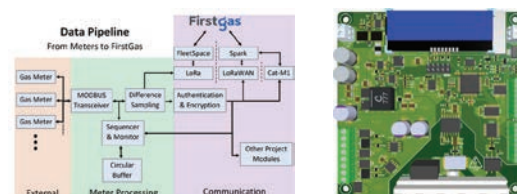
## E10

First Gas, one of New Zealand's leading providers of natural gas, has chosen to pursue the implementation of remote data collection into their remote sites. Implementing one of these systems into a remote work site or substation allows a business to reduce the costs associated with travelling to these sites, allowing personnel to be deployed more efficiently and effectively. A combination of Fleet Space or Spark LoRaWAN or cellular could provide this service, we have looked at LoRa for our method of communication.



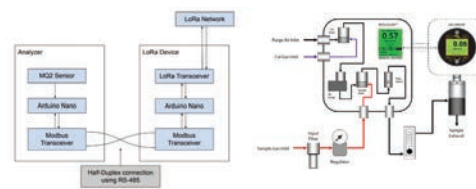
### Meter Reading

First Gas has an extensive metering network throughout the north island. Meter readings are currently transferred from sites through the hardwired telephone network. The proposed replacement utilises the existing meters but transmits the readings over LoRa, LoRaWAN or CAT-M1. First Gas wanted to use Fleet Space as the data carrier. Fleet Space uses satellites for carrying data. The proposed design utilises differential sampling of the meter readings to reduce the transmission size by at least half. LoRaWAN and CAT-M1 allow end-to-end encryption ensuring the security and integrity of the data while in transit from the remote sites to the First Gas office.



## Odorant Analysers

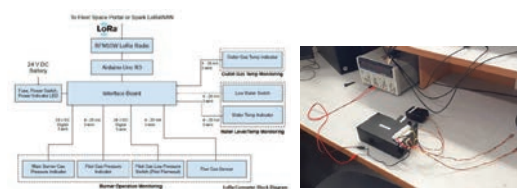
Odorant checking is a safety requirement to ensure natural gas could be detected if a leak occurred in the pipeline. Technicians currently sniff the gas and fill out a form detailing the characteristics of the gas. Odorant Analyzers sample, measure and store odorant readings autonomously without the need for a technician. Using a prototype, we have shown how an Analyzer might transmit measurements wirelessly using LoRa.



### Water Bath Heater Monitoring

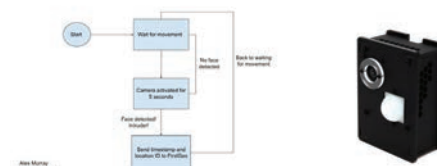
First Gas uses 120 water bath heaters to keep the temperature of the gas above regulatory limits. Many are on remote sites with no existing power supply or communications. Currently, technicians must drive several hours to each water bath heater every month to check it is operating correctly. Our team investigated methods of remotely monitoring the water bath heaters to reduce the number of site visits required.

We recommend using existing industrial 4-20 mA analogue and 24 V DC digital sensors to monitor burner operation, water level and temperature, and outlet gas temperature. A “LoRa Converter” prototype was built to demonstrate how signals from these sensors can be converted to a LoRa radio signal, allowing the sensor readings to be accessed via the Fleet Space or Spark communications networks.



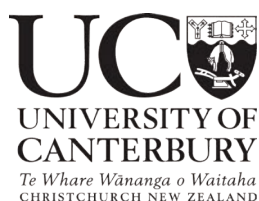
## Security and Threat Detection

Gas transmission pressure equipment sites need to be secure. There are many instances when people have broken into secure sites and First Gas were only aware sometime later when attending site for normal maintenance. Most sites currently do not have security cameras or communication options to be able to send alarms back to the centralized gas control. Because of this, security has been identified as a key need for First Gas's sites. To solve this problem, we have designed a security system which uses a motion sensor to wait for motion to be detected, that triggers a camera and a facial detection algorithm to determine if the movement was caused by something harmless like an animal, or a human intruder. If a human face is detected, an alarm is sent to First Gas's central control using LoRa communication.



**Academic Supervisor:**  
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**Team Members:**  
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8<sup>th</sup> October 2021

**Industry Sponsor:**  
First Gas

**Sponsor Contact:**  
David Innes

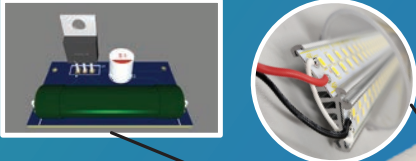


# Student projects: Electrical Engineering and Computer Engineering

## Festoon LED System


### LED Driver Circuit and LED Strip

- The **constant current driver** was chosen for its high reliability and lower power losses, it is required to supply a constant current for the LED strip inside the light unit. This is the third prototype developed.
- The **LED strip** is made up of 64 individual LEDs which are equally spaced throughout the casing, this gives equal distribution of light to surroundings.



### Interconnecting Cables and Plugs


- The plug will be dust and waterproof and designed with a secure **locking mechanism** along with a **compression gland tightening** for interchanging of wire sizes.
- The interconnecting cables between each lighting unit will be 16 mm<sup>2</sup>, two-core cable.



### Power Supply Unit

Two solutions for the SELV system's power supply unit were offered to Vynco as each have their own set of advantages:

- Transformer:** This was our initial choice as it is very reliable but must be custom ordered along with its enclosure.
- Switch-Mode-Power-Supply (SMPS):** This is not as reliable as a transformer but offers additional advantages. Its casing would be produced by Vynco. The chosen SMPS model is the **SWS1000L-60** by TDK Lambda.



### Background

Vynco assigned our team to design a **safety-extra-low-voltage (SELV)** adaption of one of their existing products, the Nomad Sabre Series. This product is a festoon lighting system designed with a focus on being robust and is intended to be used in a hazardous environment such as a construction site.

### Motivation

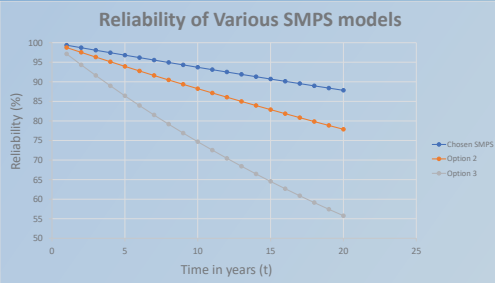
- An SELV system minimises the damage caused by an electric shock which could harm people and equipment – reducing expenses and project delay.
- SELV Lighting systems are currently mandatory on construction sites in Australia, and these regulations are expected to transition over to New Zealand.
- SELV systems do not require routine maintenance check ups every three months – saving time consuming and money.

### Requirements

- Achieve a minimum string length of 100 light units.
- SELV compliant according to AS/NZS and IEEE standards.
- Conductor insulation complies with AS/NZS 3012.
- Reliability and safety focused design.
- Power supply protected by an IP65 and IK08 enclosure.


	Advantages	Disadvantages
Transformer	<ul style="list-style-type: none"><li>Low electrical noise</li><li>Higher reliability</li></ul>	<ul style="list-style-type: none"><li>Less portable</li><li>Costly</li></ul>
SMPS	<ul style="list-style-type: none"><li>Small profile</li><li>Inbuilt safety features</li><li>Automatic fan cooling</li><li>More affordable</li></ul>	<ul style="list-style-type: none"><li>Electrical noise</li><li>Lower reliability</li></ul>

### Reliability of Various SMPS models



Time in years (t)	Chosen SMPS (%)	Option 2 (%)	Option 3 (%)
0	100	100	100
5	98	95	90
10	96	90	80
15	94	85	70
20	90	80	55

Reliability is the probability that a piece of equipment does not fail within a period of time. This figure shows that the reliability of our chosen SMPS unit stays above 90% for a 15 year time period and drops to 87% at 20 years. The expected timeframe of use for this product is less than 20 years so this is a satisfactory result.



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TEAM ( E11 )


KAGAN SIMONS  
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THANK YOU TO

SUPERVISOR:  
MARTIN ALLEN

TECHNICHIAN:  
EDEL VILLA

SPONSOR:  
BEN SOPPIT



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# Student projects: Electrical Engineering and Computer Engineering

## INDOOR POSITIONING SYSTEM

### Objective

SPS Automation requires an indoor positioning system (IPS) to transfer goods within a warehouse. Robotic distribution increases production efficiency and reduces risks. The IPS must provide a 3cm accuracy.


### System design

An IPS was designed and implemented with an accuracy of 5cm. The system was divided into 4 subsystems:

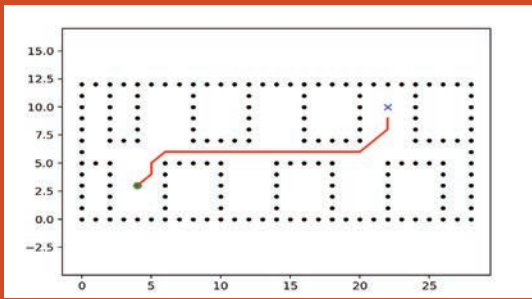
- 1.Marvelmind IPS
- 2.Path planning
- 3.Motion Control
- 4.Control Server

### Marvelmind

The proposed solution uses a commercial IPS called Marvelmind. The Marvelmind system locates the robot using ultrasonic beacons. The coordinates are sent to the control server where path planning is calculated.



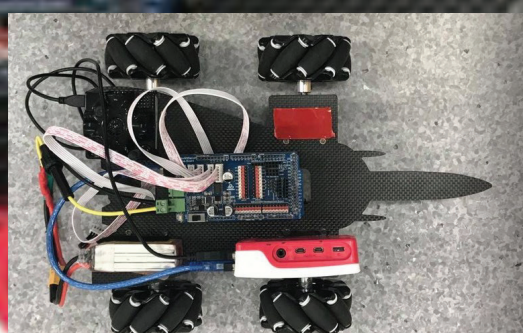
### Path Planning



Path Planning is used to guide the robot from source to destination. Multiple algorithms were tested and D star algorithm was implemented based on optimality, accuracy, completeness and execution time.

### Motion Control

A raspberry pi is used to move the robot in the desired direction. through serial communication. The speed is adjusted by a proportional controller.




### Control Server

A user-defined goal location can be set on the control server. Using the current location found by the Marvelmind system, the D\* algorithm is used to plan the path of the robot. Local goal coordinates are sent to the raspberry pi located on the robot.


### Next Steps

The accuracy could be improved by incorporating sensor fusion and upgrading the controller. The proposed method has been tested using one robot however the system design allows for more robots to be added.



SPS  
AUTOMATION

Student Team: Abhimanyu Chhabra, Micaela Cooper, Marcus Lee and Jon Narciso  
Supervisor: Le Yang  
Client: SPS Automation  
Client Mentors: Scott Spooner, Lachlan Brewster, Sheldon Coup and Ross Oliver



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# Te Uku Windfarm Investigation

Supervisors: Prof. Neville Watson, Ryan Van Herel

**Sponsors:** Dr. Michael Hwang (Meridian), Wei Hao Zhou (WEL Networks)

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## Transformer Monitoring Device (RIS) Investigation

## Background

Turbine transformers have attached RIS monitoring devices. Damaged RIS devices were found after lightning activity at the windfarm.



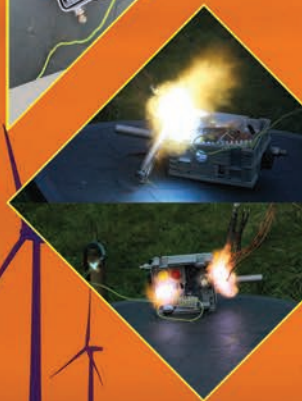
## Dismantling RIS

Dismantling the devices revealed that overcurrent were causing the failure. Damage included discolouration and disfiguration of wires and components. An exposed external screw showed evidence of conducting the overcurrent into the device.



## HV Testing

45kV impulses were applied between the exposed screw and the RIS ground. Similar damage to the provided devices was seen. The current path from the screw through internal wiring and actuators to ground was confirmed.



### Cause of Failure

It was determined that Earth Potential Rise caused the overcurrent. Lightning strikes raise the potential of the transformer case and the metal clamps which attach the RIS to the case, causing a potential difference between these clamps and the exposed screw. This can arc and provide the overcurrent path.

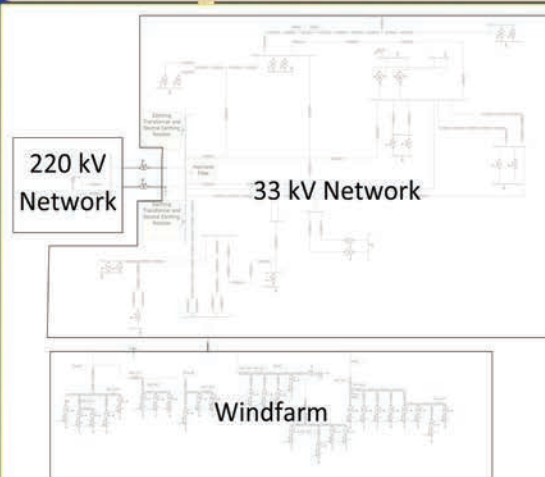
## Proposed Solution

The proposed solution based on effectiveness, cost, practicality and sustainability was to replace the metal clamps with a high-grade plastic, and the exposed screw with a non-conductive ceramic screw. This insulates the inside of the RIS device from the raised potential of the transformer casing.

## System Overvoltage Investigation

## Background

Overvoltages at the windfarm were observed during faults on the 33kV network. A model was developed to test solutions to address the overvoltage issue. Results from this model can be compared with actual readings from the windfarm.



The overvoltages were being contributed to by inappropriately sized neutral earthing resistors (NERs). Solutions centred around decreasing the size of the existing NERs and adding new NERs in parallel.

Halving the size of the two existing NERs and adding another NER at the windfarm decreased the magnitude of the overvoltage by around 25%.

### Overvoltage without solution

### Overvoltage with NER solution

Geeth Rathnayake, Azmelia Raihana

Hamish Weir, Thomas Anderson

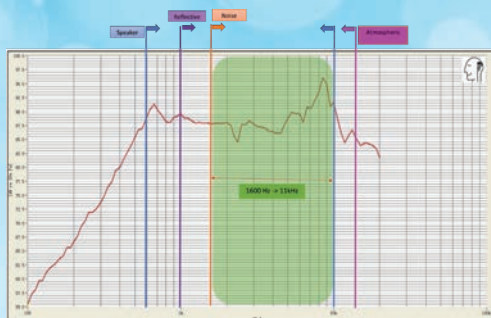


# INDOOR POSITIONING SYSTEM

wellnomics

## BACKGROUND

- Wellnomics specializes in ergonomic office improvement.
- Finding positional data of desks characterises the office space.
- Achieved by programming LIMPET devices attached to desks. The LIMPETs will emit and receive sound to measure distance and generate a 3D mesh.

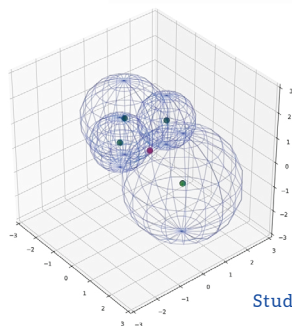
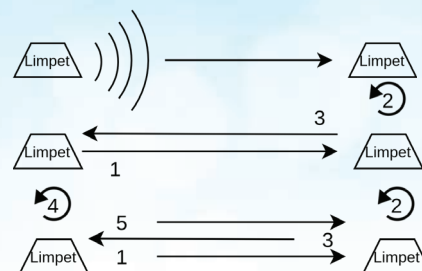


## SOUND

- The chosen sound has to be robust to the environment and the hardware used.
- The frequency chosen must be able to withstand noise and attenuation.
- The best-suited sound frequency range was found to be between 1.6kHz to 11kHz
- The best performing individual frequency was 10kHz

## DISTANCE

- Each LIMPET has a microphone and speaker.
- By emitting and receiving sounds, the device can find distances
- The microphone is capable of detecting the transmitted sound up to 24.5m
- Use of specific sound wave-forms to increase distance measurement accuracy.
- Use of virtual wall to asynchronously measure distance



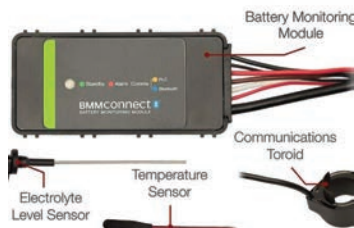
## 3D MESH GENERATION

- The calculation of every LIMPETs' location relative to every other location.
- Only requires distance measurements.
- Capable of working out the locations of LIMPETS that do not have a fully defined location.

Students: Aryan Srivastava, Bill Liu, Laurence Prins, Toby Bourke.  
Academic Supervisor: Shayne Crimp  
Technician: Diego Ramirez  
Sponsor: Kevin Taylor

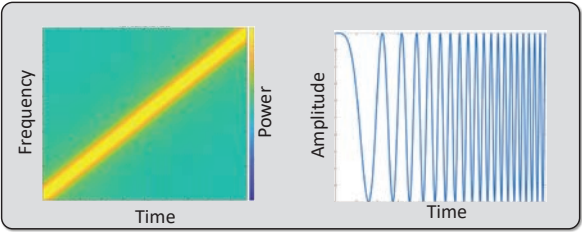
## Introduction

Battery monitoring modules are attached to forklift batteries and record data such as: battery voltage, temperature, and acid levels. The recorded data is transmitted to a battery charger when the batteries are plugged in to charge. Data is transmitted over charging power line via toroid inductors. This line is affected by heavy interference from the chargers themselves making communication difficult.



## Chirp signals

Chirp signals are sine waves with a continuously time varying frequency. Shown below is an up chirp where the frequency increases linearly in time. The spectrogram plot shown to the left shows how the frequency content of an up chirp signal varies in time.

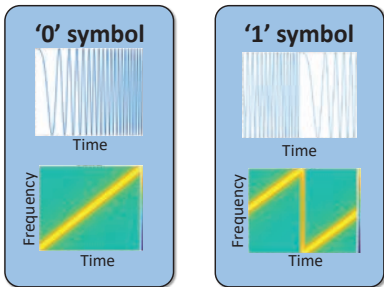


Chirp signals can be used for spread spectrum communications, which uses more bandwidth than necessary resulting in improved performance in low signal to noise ratio (SNR) environments. Chirp signals are also resistant to interference signals, such as those emitted from the battery chargers.

## Digital communication with Chirp signals

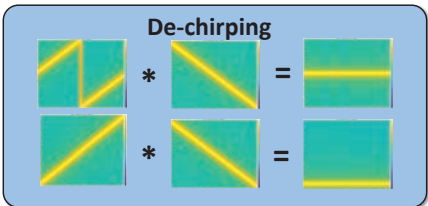
### Transmitter

Data is encoded into chirp signals by cyclically rotating an up chirp in time. Different data values are represented by symbols which are created by shifting an up chirp by different amounts in time.




### Receiver


1. **Downmixing:** The received signal is mixed down to the much lower baseband frequency to make processing more efficient.
2. **De-chirping:** The baseband signal is multiplied with a down chirp. Interestingly, this produces an output signal of a constant frequency.
3. **Fast Fourier transform:** A fast Fourier transform (FFT) is applied to the de-chirped signal to reveal the single frequency component or data.



# Student projects: Electrical Engineering and Computer Engineering




## E16: Smart Holds

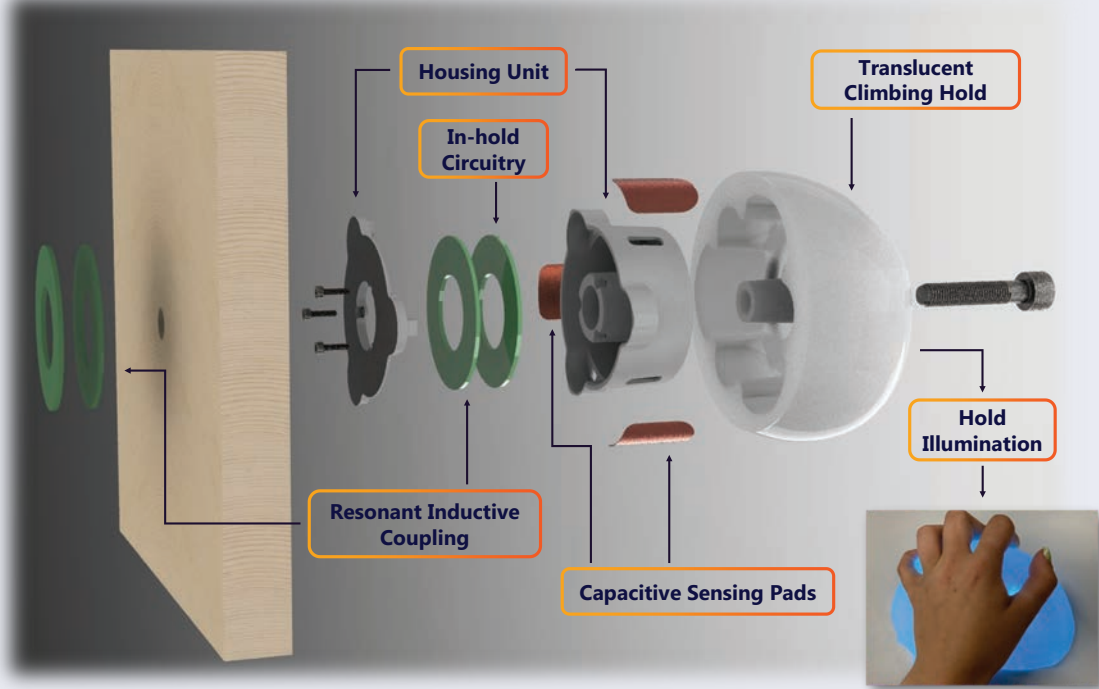


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**The Goal:**

Create a 'smart' climbing hold that reacts to human touch and other external inputs, via illumination. Stimulate competition in the sport through an open architecture software so that users can create their own routes, time trials and sub games with a system of smart holds. Holds should be completely modular, requiring wireless power transfer and communication.

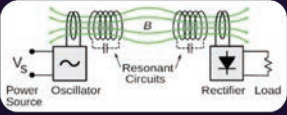




**Hamish Allan**  
**Power delivery**

The goal is to deliver 200mA @ 5V to the receiver board, without using normal wires.


Resonant inductive coupling is used to transmit power from behind the wall to inside the hold (across 25mm).



The quality factor was low due to the distance, leading to a ~10% efficiency achieved so far.


**Connor Edwards**  
**Sensing**

Human capacitance affects the properties of capacitive pads allowing touch recognition.




**Erica Shipley**  
**Communications**

NRF radios are used to achieve communication between the individual holds and a central controller with each individual hold having a unique address.



**Tobin Armstrong**  
**Hold design**

Space is created for the housing unit during the hold casting process using a silicone negative (pictured). A housing unit containing PCBs, sensors and smart LEDs can then be press fit into the poly-urethane climbing hold.

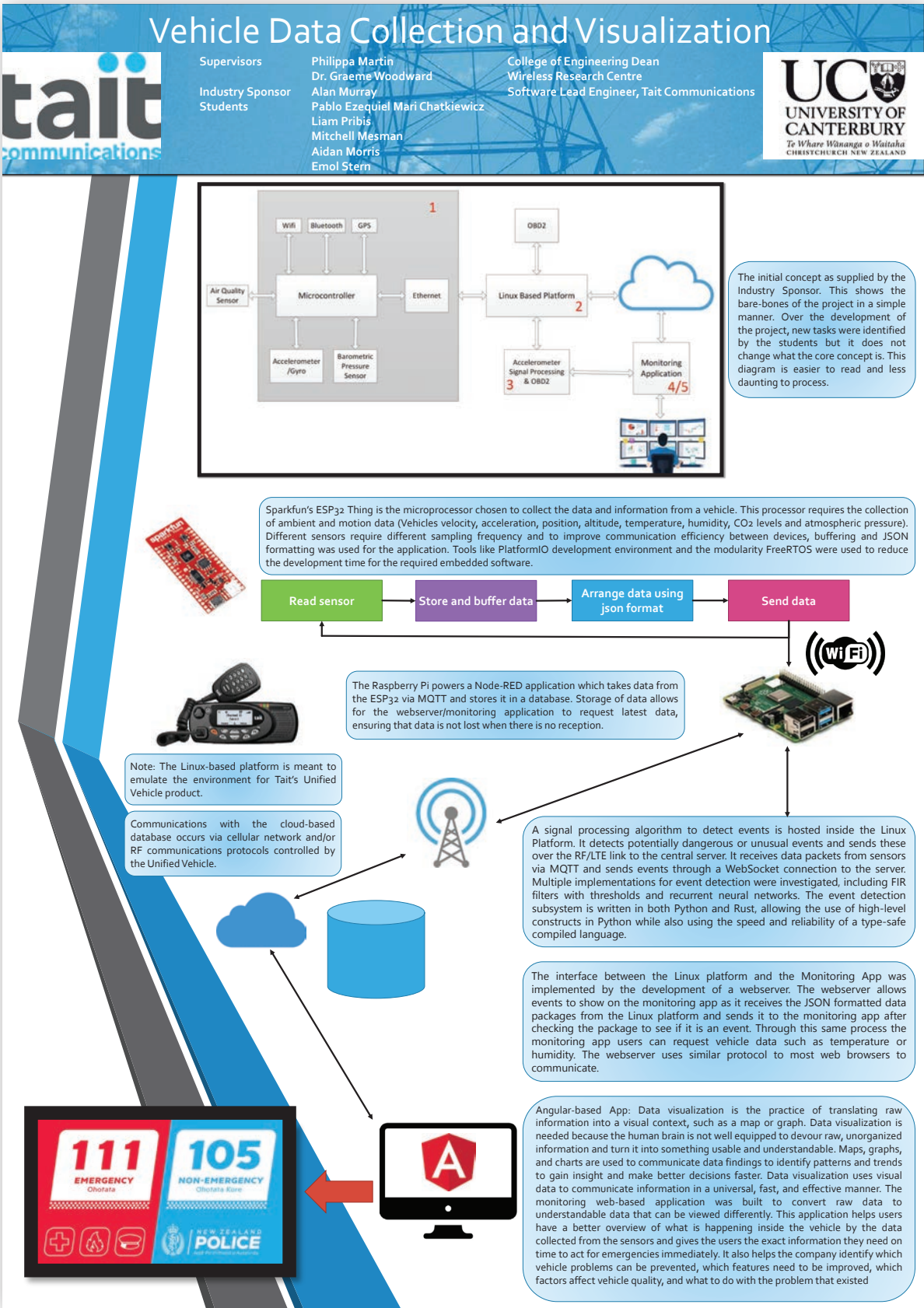


Academic Supervisor: Allan McInnes    Sponsor: Sefton Priestley – Uprising industries    Special thanks: Philipp Hof, Scott Lloyd, Barro De Gast

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# Student projects: Electrical Engineering and Computer Engineering



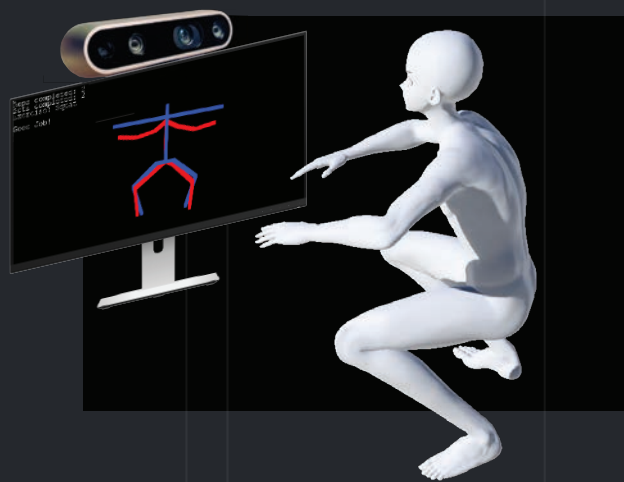
# Student projects: Electrical Engineering and Computer Engineering

## Rehabilitation Monitor



Orthopaedic patients are often prescribed daily exercises to aid their recovery. If these movements are done incorrectly, this can make the exercises ineffective or harmful.

Computer vision has been utilised in this project to create a game which helps patients complete their exercises accurately, by giving them real time feedback on their form & positioning.



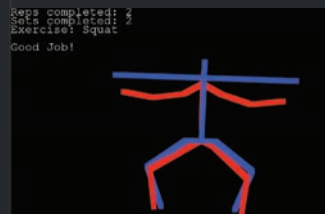
### Taking rehabilitation into the virtual world

Creating a representation of the patient in a virtual world requires hardware that can continuously scan and provide real-time positions of the patient in 3D space. The Intel RealSense camera used does just this. It is used to capture the patient's body, by providing depth, infrared (IR) and colour data to the game.



### AI hardware for accelerated performance

The rehab monitor uses NVIDIA's Xavier NX Development Kit to power it's patient tracking system. The Xavier is a purpose built board created by NVIDIA for AI applications. It's small form factor and power efficiency allows it to be easily integrated into patients' homes.



### Patients play to perfect their form

The game involves a skeletal representation of the patient displayed in red and a ghost body for the patient to follow in blue. Real-time feedback is given to the patient through the text displayed on the screen. The simple user interface communicates the capabilities of the system, and using the Unreal Engine this platform is ready to be built upon.

#### Team Members

Simon Read  
Ahilan Saravanapavan  
Grace Kaye-Blake

#### Supervisors

Ciaran Moore  
Dave Van Leeuwen

#### Sponsor

Iain McMillan





# Roboticising a Schmidt Camera-Telescope for Low Earth Orbit Satellite Tracking

## Overview

The Computational Design and Adaptation (CDA) group required a roboticised telescope mount that is able to point at and track satellites in low Earth orbit (LEO). The CDA group were given a Schmidt Telescope that they wanted digitised and lightened in weight. The design of the new 3D printable parts were provided [1] and after several design iterations, the Schmidt camera is now 4kg lighter than the original telescope.


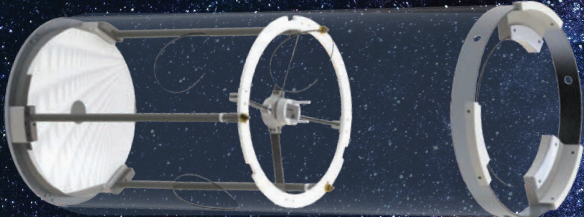
## Mount



A steel, altitude-azimuth mount was designed to support the telescope.

- A HDPE telescope holder secured the telescope to the mount.
- The A-frame design supported the external and inertial load from the telescope.
- A direct-drive stepper motor system controls the altitude axis, while a belt-drive stepper motor system controls the azimuth axis.

## Tracking

A Two Line Element set (TLE) and SGP4 algorithm was used to predict the position of each satellite [2]. To adjust for any errors in controls, computer vision algorithms check that there is a satellite in frame and if there is, it returns the centroid of that satellite.






Picostar captured by Schmidt Camera from 40m.

Computer vision algorithms detecting travelling satellite from a raw telescope image.

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### References:

[1] Woodbury. H, "Upgrading a Schmidt Camera for Space Situational Awareness", unpublished, 2020.

[2] D. Vallado, P. Crawford, R. Hujsak, and T. S. Kelso, "Revisiting Spacetrack Report #3," in AIAA/AAS Astrodynamics Specialist Conference and Exhibit

**Client:**  
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**Technical Supervisor:**  
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**Special thanks to:**  
UC Mt John Observatory  
Nigel Pink  
Vishnu Anand Muruganandan

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Group E20

Water Flow Sensor For

Irrigation Controller

QTECH

DATA SYSTEMS

Prepared By: Harrison Laing, David Barclay, Divya Patel

Supervisor: Richard Clare

Project Description

The primary goal of this project was to add a water flow feedback sensor to QTech’s irrigation point controller (IPC). QTech’s current IPC product is a battery-operated remote solenoid driver for controlling irrigation sprayers on/off with radio communication for scheduling and status reporting. The vast majority of IPC units are installed on fixed grid arrays of impact sprinklers, with a common failure mode of individual heads getting stuck off and not delivering water. The task from QTech was to design a sensor to be integrated into the IPC capable of detecting if water is flowing at the sprinkler nozzle. The sensor must add less than \$2 production cost and not interfere with the existing function of the IPC. A low-power electrical sensor integrated to the existing PCB was desirable to reduce cost, risk, and maintain waterproofing of the IPC enclosure. Designing for the majority of installations, impact sprinkler heads were the focus of our design, as they generate sharp impacts in normal operation. These strong vibrations can be detected by a sensor in the IPC mounted to the sprayer post.

Sensor Selection

Sensor	Plus +	Minus -	Data type	Prototype
Piezo	Low Noise Robust Cheap	Extra Analogue Hardware		
IMU	Hardware simplicity	Software drivers Code Complexity Cost		
Microp hone	Size	Cost Noise Analogue Hardware		
Spring Switch Sensor	Hardware &Software Simplicity Cost	Difficult installation Lack of robustness		

Design Flow

Our team designed a variety of sensors which are viable solutions to the problem, with a piezoelectric disc winning out as the recommended solution due to its resilience in testing and simplicity of design.

Algorithm Flow Diagram

Test Rig

This algorithm operates in real time with a dynamic threshold to access the impacts from the sprinkler to determine functionality.

If five consecutive periodic impacts are detected the algorithm determines water flowing.

Recommended Solution

The recommended solution uses a piezoceramic disk to detect vibrations produced by the impact arm. The piezo detects these vibrations and uses them to determine water flow in the sprinkler. The piezo and supporting circuitry is inside the IPC case to reduce costs. The final solution accurately detects impacts caused by the functioning impact sprinkler using a simple but efficient thresholding algorithm to determine water flow. The final solution costs a total of \$1.81 per controller and can easily be implemented into QTech's current IPC.

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# Student projects: Electrical Engineering and Computer Engineering

## DESIGNING AN EXPERT SYSTEM OF SAFETY IN DESIGN

### PROJECT DELIVERABLES

1. A Safety in Design Best Practice Guideline

2. A SiD website that guides the creation of a hazard register and risk mitigation for designers

3. A database that includes common hazards and risk mitigations

### STRETCH GOALS

1. Hazard Registers accessible by QR codes to allow easy sharing

2. Project Documents section to store information

3. User contact details such as phone or email

Safety in Design is improving the health and safety outcome of a structure throughout its life by performing the following safe design practices

Conception

Design

Construction

Use for purpose, maintenance & repair

Decommission/Repurposing

Demolition

1. Life Cycle Approach - Addressing each life stage's users and unique risks

2. Risk Mitigation - If hazards cannot be designed out, provide another solution such as PPE, barriers, or training

3. Documentation - Documents such as testing results, scope information, and safety data should be available to all site users

4. Monitoring and Review - Keep the hazard register accurate and the site users informed by monitoring and reviewing the site hazards

5. Capable Team - The Safety in Design process should include site users from every stage of the life cycle. The team should hold a large combined knowledge

The database has been created using SQL. There will be common elements in the database that can be assigned to the project, but unique elements can be added if needed. Each element has a series of hazards related to it. Each hazard has a series of mitigations to control the risk.

New Project:  
e.g. Office Building

Unique Building Elements:  
e.g. Building on River Edge

Common Building Elements:  
e.g. Underground Cabling

Unique Hazards:  
e.g. Soft Ground

Common Hazards:  
e.g. Trench Excavation

Unique Mitigations:  
e.g. Foundations

Common Mitigations:  
e.g. Hydro Vacuum

### SAFETY IN DESIGN REVIEW - USER EXPERIENCE

The diagram below shows a mock up of a hazard register created using the system. The hazard register displays the hazards and mitigations present at each stage of general EngCore upgrades

Project title: EngCore Upgrade

Project address:  
83 Christie Road

Project description:  
Upgrading Engineering Core. This is a building used for faculty and students of UC, predominantly engineering students. There is large foot traffic through the site daily and it is surrounded by residential and commercial buildings.

Stage	Hazard Click here to add hazards to table	List of mitigations associated with hazard
Concept and Design	Changes in Start Levels	Detailed Planning for each Covid-19 Alert Level
Concept and Design	Pedestrian Cabling	Correct Recording of Cabling
Construction	Noise from Excavation	Hearing Protection
Construction	Excavation Around Cables	Hydro Vac Trucks Paved Cables Personal Hand Excavation
Construction	Workings at heights	Lifting Scaffolds Use of Mechanical Aids
Concept and Design	Placement of Light Fixtures	Commissioning Design
Operation	Gaps from Security/Control Lights	Following the Relevant Standards
Construction	COVID-19 Transmission on Site	Contract Training Undertaken Throughout the Site Detailed Planning for each Covid-19 Alert Level
Construction	Pedestrians	Warning the Work Area Signage Information Routes for Pedestrians
Construction	Other Work on Site or near the Site	Communication with Adjacent Sites

This screen is the main way users will be able to add to and change their hazard reviews. This is done by adding or deleting hazards and their mitigations.

### OPERATION INSTRUCTIONS

One of the reasons this project was commissioned was to make Pedersen Read's Safety in Design process more streamlined and efficient. The following steps detail the steps taken to create a hazard register

1. Log in to the Site

2. Click New Project

3. Enter the project details including Name, Address, Description and then select any building elements and the building stages in which they occur.

4. Now view your project and select the hazards that could be caused by the elements.

5. Now from each hazard, select the mitigations to be used.

6. If any extra safety aspects need to be added this can be done by clicking the 'Add Safety Aspect' button.

7. This process can be repeated through each stage of the building cycle

TEAM: Bridgette Petrie, Ly Pham, Joseph Rule, Eva Wenham  
SUPERVISOR: Kim Rutter

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pedersen  
consulting electrical engineers  
read

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# Microfluidic Circuits for Machine Learning Applications

## Background

The microfluidic circuit is extensively used in the medical sector due to faster results and increased accuracy and precision. Despite the name, 'lab on a chip' devices are still mainly used in laboratories.

Therefore, implementing a neural network (ANN) would allow much more freedom in the applications of such devices as computation could be completed automatically because ANN's reflect the behavior of the human brain, enabling computer programs to recognize patterns and solve common problems.

## Method

### MICROFLUIDIC DEVICE

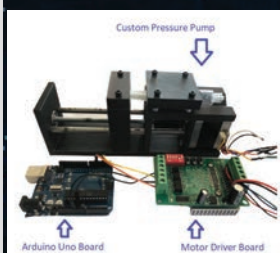
#### DROPLET GENERATOR

The droplet generators would be found at the very beginning of the neural network. Droplets were made through a combination of water and oil. Water would flow from the top most inlet and oil from the left most.

#### SPLITTER

The droplets need to be split to ensure droplets are moving throughout the entire circuit. At the T-junction the droplet itself is split. The extra inlet on the lower channel of the splitter allows the user to create a pressure difference between channels causing droplets to be unevenly split.

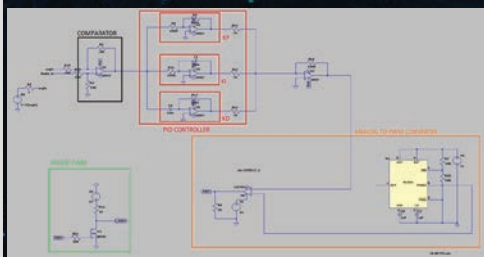
#### PRESSURE PUMP



A pressure pump is used to provide a flow rate for a microfluidic device.

Input Voltage: 10V - 35V  
Maximum Output Current: 3A  
Flow rate: 0.5 uL/min - 7.69 uL/min (operate with 24V)

#### FEEDBACK CONTROLLER



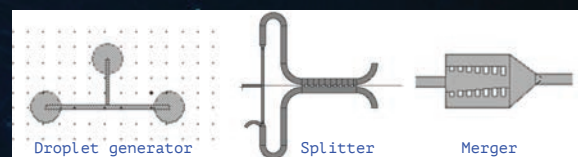
Feedback control loop with flow sensor FS1012 for the pressure pump

This project aims to integrate machine learning capabilities directly into microfluidic MEMS by implementing the key building blocks of ANNs as microfluidic channels.

This work paves the way to the physical realisation of an artificial neural network on a microfluidic circuit.

#### MERGER

is a part of the microfluidic circuit that replicates a neuron. It is used to merge the droplets into one big droplet. The merger variation was designed using L-Edit then were simulated using Comsol to dictate whether it will be able to merge droplets together.

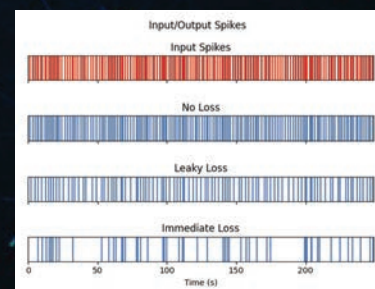


## NEURAL NETWORK

The type of ANN used was a Spiking Neural Network (SNN) where weightings between neurons are encoded as the time-gap between spikes (Spike Time Dependent Plasticity).

#### MERGER MODEL

Modelling the merger behaviour is important for determining how to match it to the neuron of an ANN. Spikes represent droplets. Three different output behaviours were explored. The leaky loss output matches the neuron model of 'Leaky Integrate and Fire'.



Merger model behaviors

**Team:** Luca Retimanu, Amber Ow Yong, Dael Summerhays-Sunnex and Duyen Bui


**Special thanks to:** Yiling Sun, Linda Chen, Volker Nock, and Gary Turner

**Supervisor:** Prof. Ciaran Moore

**Sponsor:** UC Electrical and Computer Engineering Department

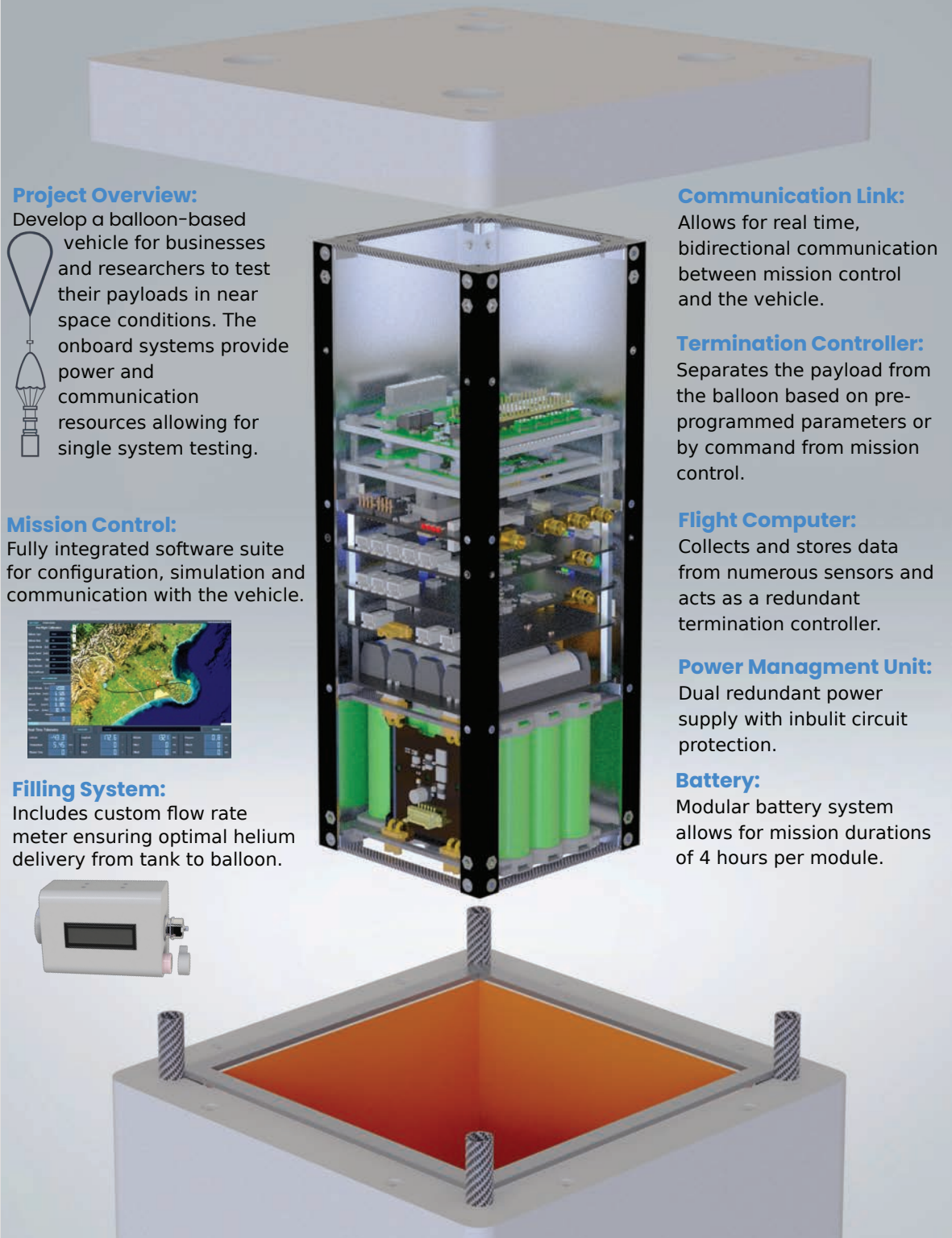


## Student projects: Electrical Engineering and Computer Engineering




Kea Aerospace


# High Altitude Balloon




**Project Overview:**  
Develop a balloon-based vehicle for businesses and researchers to test their payloads in near space conditions. The onboard systems provide power and communication resources allowing for single system testing.



**Mission Control:**  
Fully integrated software suite for configuration, simulation and communication with the vehicle.



**Filling System:**  
Includes custom flow rate meter ensuring optimal helium delivery from tank to balloon.



**Communication Link:**  
Allows for real time, bidirectional communication between mission control and the vehicle.

**Termination Controller:**  
Separates the payload from the balloon based on pre-programmed parameters or by command from mission control.

**Flight Computer:**  
Collects and stores data from numerous sensors and acts as a redundant termination controller.

**Power Management Unit:**  
Dual redundant power supply with inbuilt circuit protection.


**Battery:**  
Modular battery system allows for mission durations of 4 hours per module.

**Students:** Chris Dippie, Rey Dela Cruz, Randipa Gunathilake, Sam Corder, Logan Cane **Supervisor:** Chris Hann

# Student projects: Electrical Engineering and Computer Engineering

## CubeSat Experiment Monitor

Year 1: Concept Development




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A CubeSat micro-laboratory enables biological research in microgravity at low cost. Miniaturisation of microscope and sample handling systems is required, with tight control of environmental conditions. All work must meet high reliability standards.

Beginning a multi-year project, the foundation of a knowledgebase and the establishment of a framework for rapid iterative concept development led to several solutions and a variety of prototypes for each of the core components.

Microscope

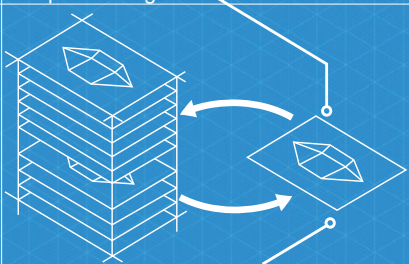


Camera


Magnifying Lens

Focusing Lens

Sample Exchanger

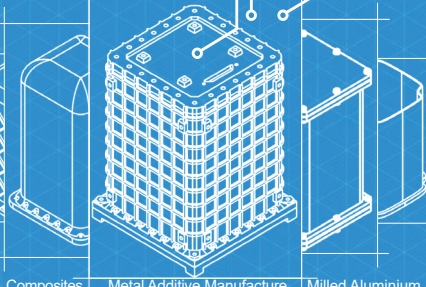


Lighting



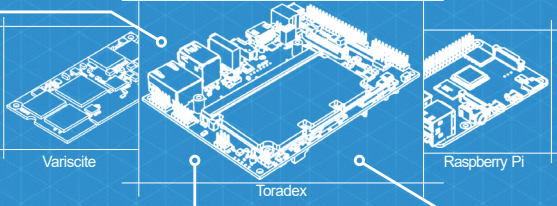
White, UVLEDs

Pressure Vessel




Composites   Metal Additive Manufacture   Milled Aluminium

Image Processor



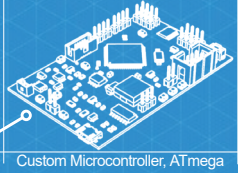
Variscite   Toradex   Raspberry Pi

Machine Vision




Open CV

Control Processor



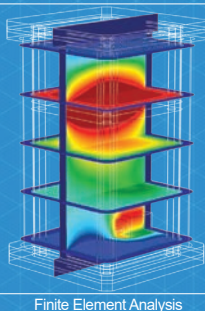
Custom Microcontroller, ATmega

Environment Control



Pressure, Humidity, Temperature

Thermal Model



Finite Element Analysis

The developed options and associated documentation will enable future project teams to quickly select, refine, and integrate these systems for a target launch in 2023.

Some design detail omitted by request of the client

**Team**


Simon Allen	(Environment Monitoring, Pressure Vessel)
Sam Dunbar	(Experiment Storage, Microscope)
Jonathan Edwards	(8-bit Devboard, SOM)
Ethan Jenness	(Thermal Model, Pressure Vessel)
Jessica Page	(Camera, Machine Vision)

**Supervisors**


Martin Allen	(Academic Supervisor)
Scott Lloyd	(Technical Supervisor)

**Client**

David Wright	(Asteria Engineering Consultancy)
Sarah Kessans	(UC School of Product Design)



Asteria  
Engineering Consultancy



UC  
PRODUCT DESIGN

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# OBJECT TRACKING USING DRONE SWARMS

## PROJECT OVERVIEW

The motivation for this project comes from a lack of vital information on insect behaviour. Tracking using drone swarms would enable this application, where conventional tracking methods are unable to perform.

The goal of this project was to create a working proof of concept for a swarm of five drones tracking a moving target.

### SWARM FORMATION

Four receiver drones are required to track the target in 3D space.

### MULTILATERATION

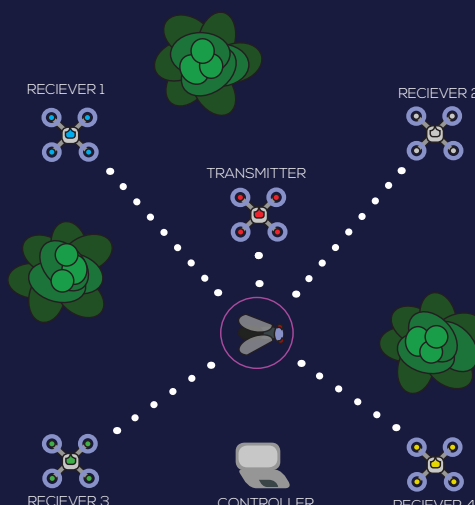
The transmitter drone emits a RADAR signal which bounces off the target and is received by the four receiver drones. This forms an ellipse of possible locations around each receiver drone. The estimated target location is the intersection of these four ellipses.

### KALMAN FILTER TRACKING

The drones are expected to operate in an environment with high sensor noise. A temporary dropout in communication between the drones is therefore likely. The Kalman filter tracks the position of the target and the drones. It can extrapolate their positions in the event of a dropout, allowing the swarm to continue tracking the target.

### FAILSAFES

Before the drones move, their commanded position is checked to make sure they do not collide, or endanger the system. Specifically the distance between the drones is checked to ensure it remains constant.



### COMMUNICATION

The transmitter drone hosts a WIFI hotspot which all the drones, and the controller connect to. Using this the drones can communicate their current position, state and radar readings with each other.

### HARMONIC TRANSPONDER

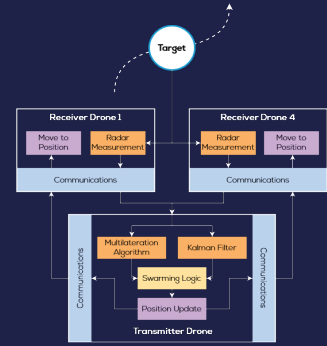
The target is equipped with a harmonic transponder which absorbs RADAR signals and emits them at a different frequency. This allows the target to be identified from background reflections. Multilateration is then used to determine the target's position.


### DATA LOGGING

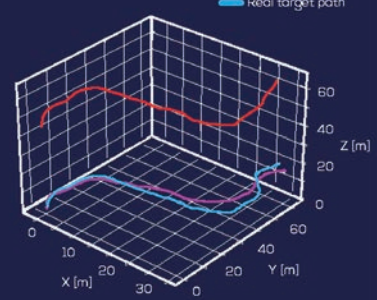
All drones log data related to system performance and operation. This includes the drones' positions, the target's positions and Kalman filter outputs. This data simplifies debugging.

### DRONE CONTROLLER

A GUI based controller was implemented to synchronise the drone communications and assist in test flights. Periodic updates are sent by the controller for synchronisation, and contain state information for controlling drone behaviour.







### SYSTEM BLOCK DIAGRAM

Receiver drones collect RADAR readings from the target. These are sent to the transmitter drone which groups the RADAR readings, and uses them to estimate the position of the target.

The drones' new positions are determined by adding an offset to the estimated target position. The new drones' positions are then sent over the WIFI network to each drone upon which they move their new positions and the process repeats again.


### TEST FLIGHTS

Weekly test flights were conducted where the system was tested in a physical environment. Initially one drone was physically flown and the other four were represented in a simulated environment. As the system became more reliable it could accommodate more real drones. The above picture is a flight test using two real drones in formation.

### RESULTS

The swarm was successfully evaluated in a practical flight test in which two drones were flying and three were simulated. In this test, the drones tracked a target moving at walking pace however the Kalman Filter was not fully integrated at this time.

The full swarm was tested in simulation with the Kalman Filter and a generated GPS path. The above Figure compares the generated path with the estimated path of the target which was found using the swarm. The swarm successfully tracked the target with an average error of 2.8m.



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Wireless Research Centre  
Steve Pawson

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Oli Dale, Rowan Sinclair, Alex Scott,  
Nicholas Ranum, Connor O'Reilly

SUPERVISORS  
Richard Clare  
Mike Shurety

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## Student projects: Electrical Engineering and Computer Engineering



# Eco-Car Electrical Design



### What is it?

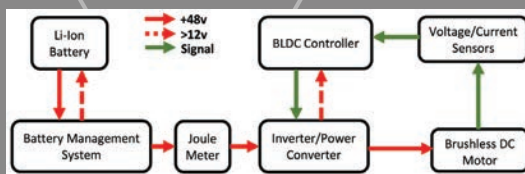
The Shell Eco Marathon provides students the opportunity to design efficient vehicles. This year we worked on the electrical drivetrain. The winner of the race is the team with the most efficient car!



### Why are we doing it?

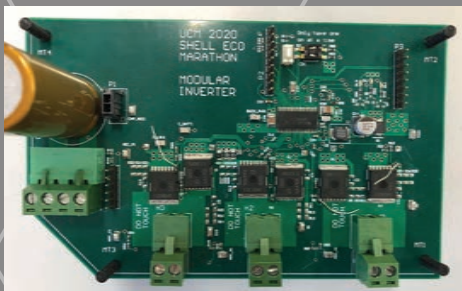
The transportation industry is demanding electric vehicles with efficient drivetrains. These electric vehicles will help reduce fossil fuel emissions; driving the future of sustainable transportation.

### The System



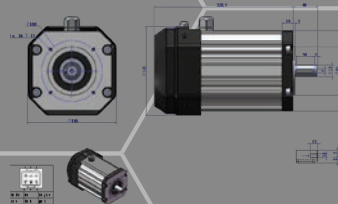
### The Inverter

An inverter takes energy from the battery and outputs it in a usable form for the motor. The inverter was built last year and has been performance tested and modified to run reliably this year.



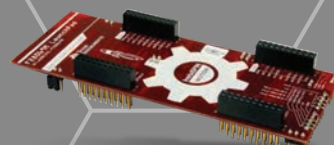
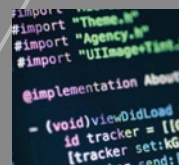
### The Motor

A 48V, 1kW motor that operates at an efficiency of 92% at 3500rpm was selected. This allowed the most efficient speed of 25km/h.



### Motor Controller

A controller was necessary to deliver appropriate current to the motor. The software is ready to be implemented into our own printed circuit board.



Group E27 - Sponsor: Bruce Robertson - Supervisor: Shayne Crimp - Technician: Edsel Villa  
Students: Mikael Ewans, Samuel Lowe, Connor Nisbet, Sam Smidt

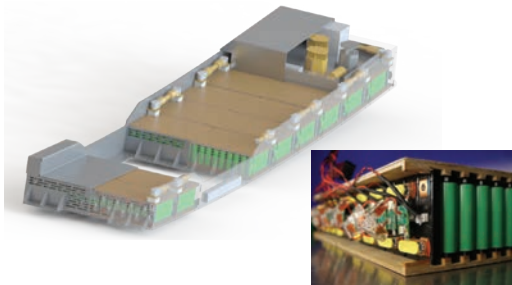
# Student projects: Electrical Engineering and Computer Engineering

## E28 University of Canterbury Motorsport UCM21 Electrical



### Overview

- + University of Canterbury Motorsport is a student team that designs and manufactures Formula Student race cars
- + UCM21 focuses on thermal performance and reliability
- + The electrical team was tasked with the development of new energy storage packaging, power distribution and vehicle diagnostic systems
- + These systems are integrated into a high performance, four-wheel drive, electric racecar

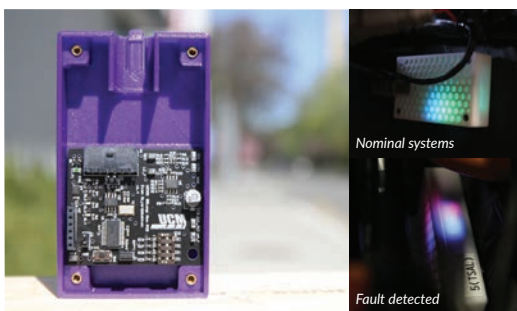
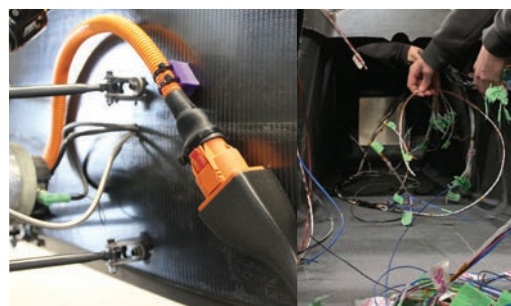


### Energy Storage

- + A novel accumulator container was developed to improve battery cooling and ease of maintenance
- + Battery cells are separated into 8 modules for a total of 580V capable of producing 120kW
- + An aluminium container was manufactured to retain the modules and provide ample airflow across the cells
- + Voltage and temperature monitoring systems were implemented to ensure safe operation

### System Wiring

- + The previous low voltage wiring loom was simplified to improve ease of assembly and maintainance
- + Reimagined tractive system layout to accomodate the new battery package
- + Repackaged inverter to accomodate new HV routing



### Diagnostics

- + Previous vehicles were difficult to troubleshoot during track testing due to inadequate diagnostic tools
- + New monitoring systems in the vehicle provide status and performance data, making it easier to find faults
- + The shutdown monitoring system detects faults in the vehicle's components and displays them on the dash
- + Improved signal integrity by converting signal transmissions from analogue to digital

Client: University of Canterbury  
Supervisor: Paul Gaynor  
Students: Will Eldridge, Oliver Cook, Evan Oijordsbakken, Jarrod Zhu

Faculty Advisor: Bruce Robertson  
Staff: Gareth Barlow, Julian Murphy, Zac Perston

# UCM

## Student projects: Electrical Engineering and Computer Engineering

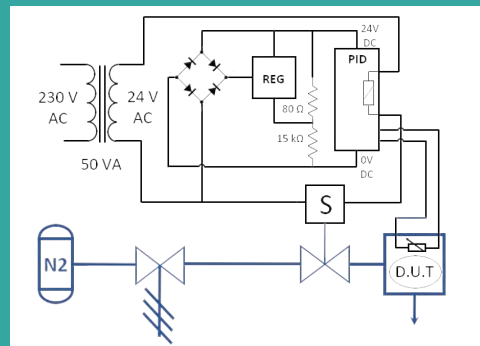
# CRYOGENIC POWER ELECTRONICS

## PROBLEM

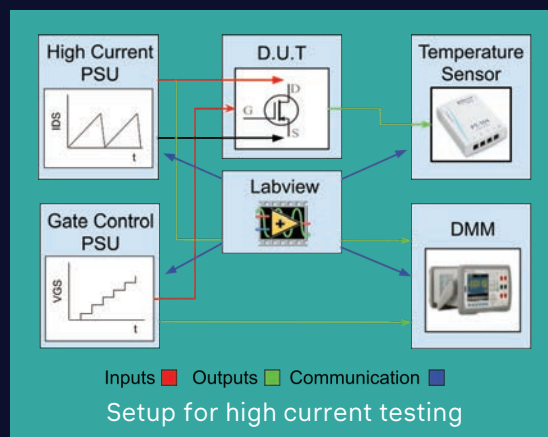
- Cryogenically cooled power electronics are key for large-scale electric transport.
- This project characterises different Gallium Nitride HEMTs down to  $-196.6^{\circ}\text{C}$ .
- Gallium Nitride is an emerging new semiconductor with many advantages over silicon.

## TESTING PROCESS

- Device Under Test mounted to PCB
- Gate-source voltage and drain-source current varied.
- Records voltage, current, and temperature.
- Process data in MATLAB.



Temperature control

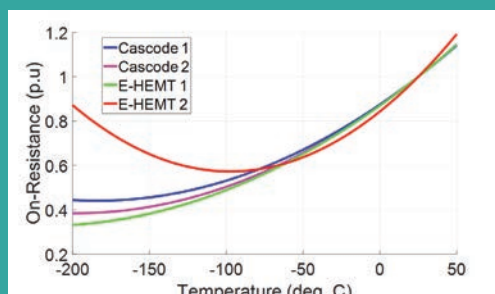


## COOLING

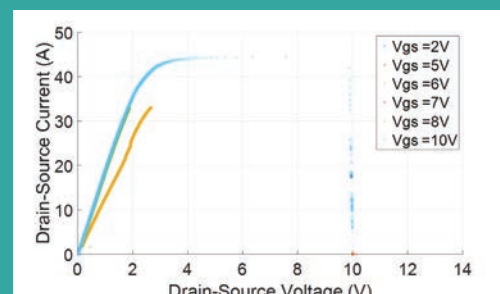
- PT100 temperature sensor on device.
- Early testing in liquid nitrogen bath.
- Pressurized nitrogen and valve control improves test speed and efficiency.



## RESULTS



On-resistance of all devices, relative to  $25^{\circ}\text{C}$



Output characteristics of a HEMT at  $-192^{\circ}\text{C}$

Team Members:  
Samuel Mora Henry Seaton  
Soren Subritzky Dylan Toms

Supervisor:  
Andrew Laphorn

Acknowledgements:  
Bill Heffernan David van der Byl  
Edsel Villa Ken Smart

This work was supported by the New Zealand Ministry of Business, Innovation and Employment under the Advanced Energy Technology Platform programme "High power electric motors for large scale transport" contract number RTVU2004.



# Fish Passage in the Forestry Environment

A study of instream structures within Tairua Forest



Prepared by  
Drew Wood

2021

For  
University of Canterbury  
ENFO410 – Forest Engineering Research

# GIS Based Culvert Design

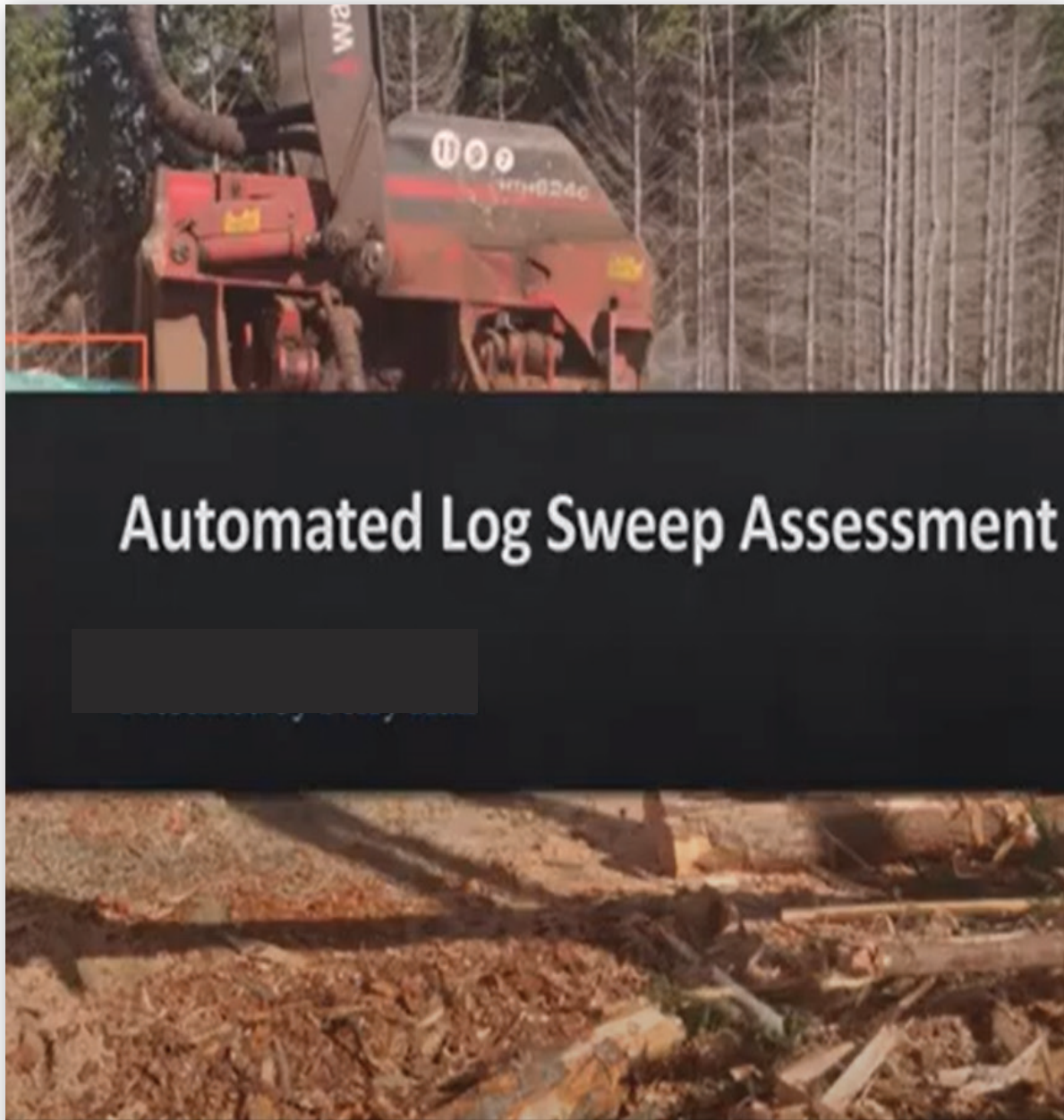


Prepared by Luke Wilson  
October 2021

ENFO410 - Forest Engineering Research  
University of Canterbury



## Student projects: Forest Engineering



Prepared by Perry Han  
October 2021

ENFO410 - Forest Engineering Research  
University of Canterbury

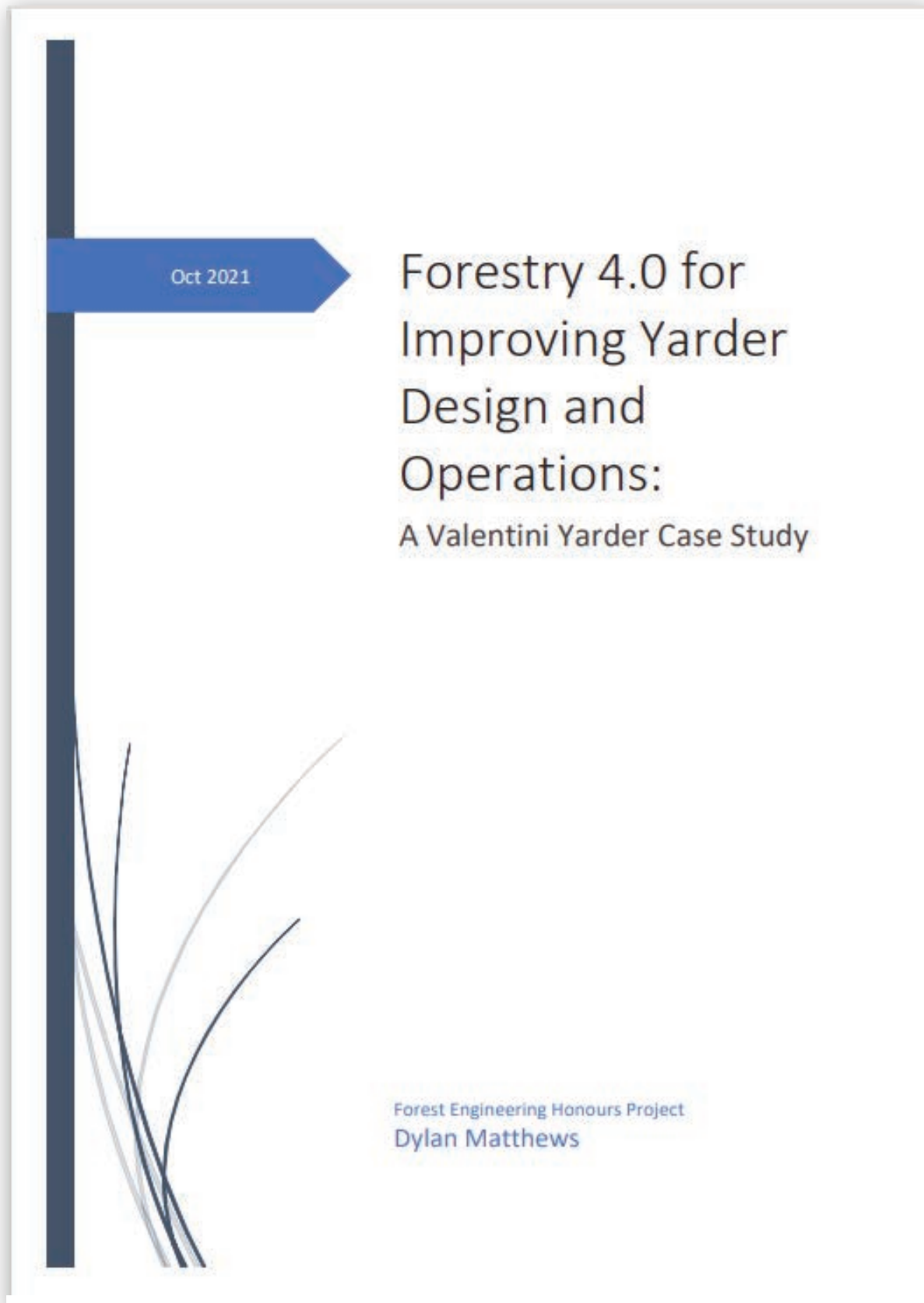


USING  
REMOTE  
SENSING  
TECHNIQUES  
TO  
SIMULATE  
WILD FIRE



Zihan Jin  
ENFO 410

## Student projects: Forest Engineering



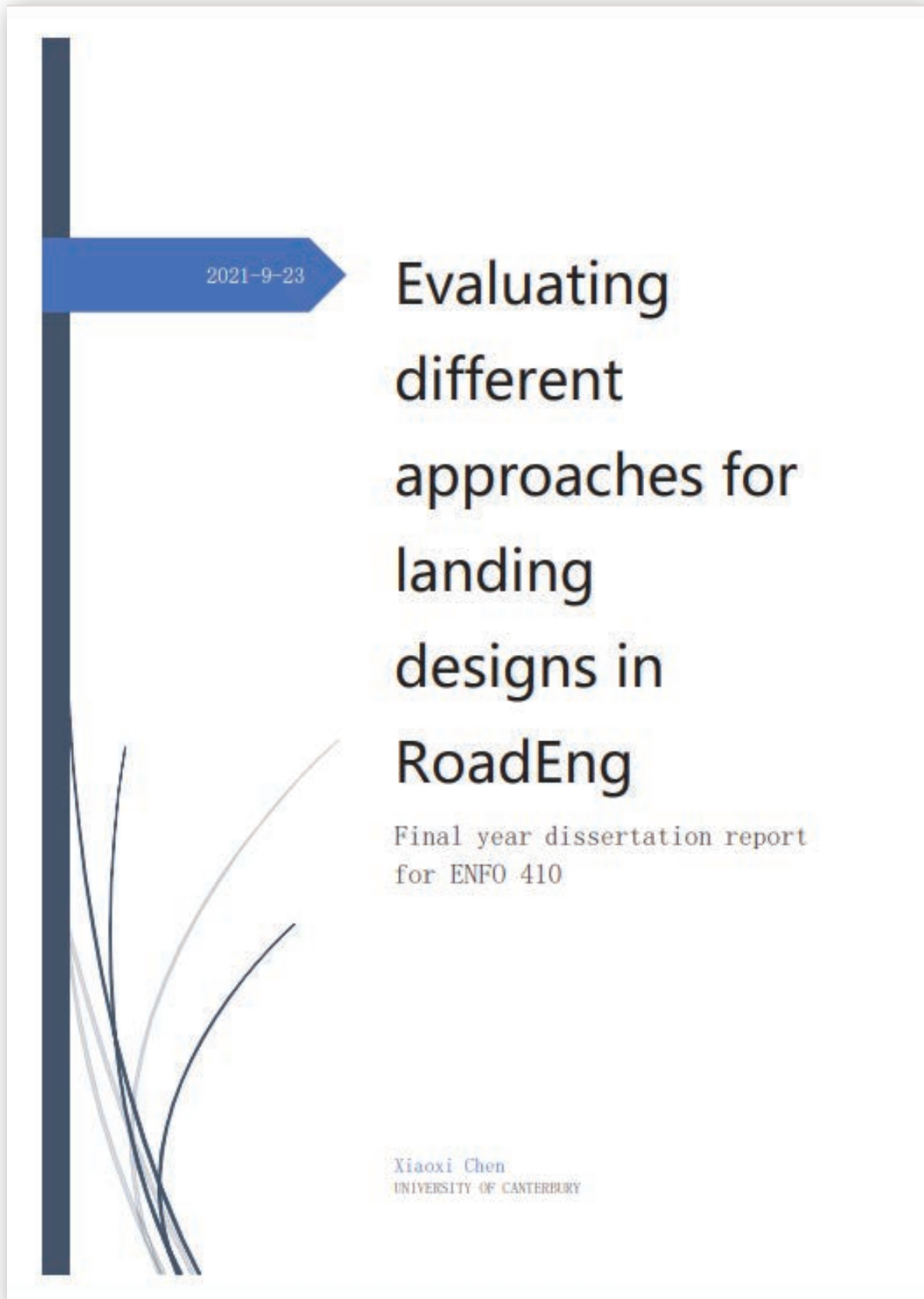
## Student projects: Forest Engineering

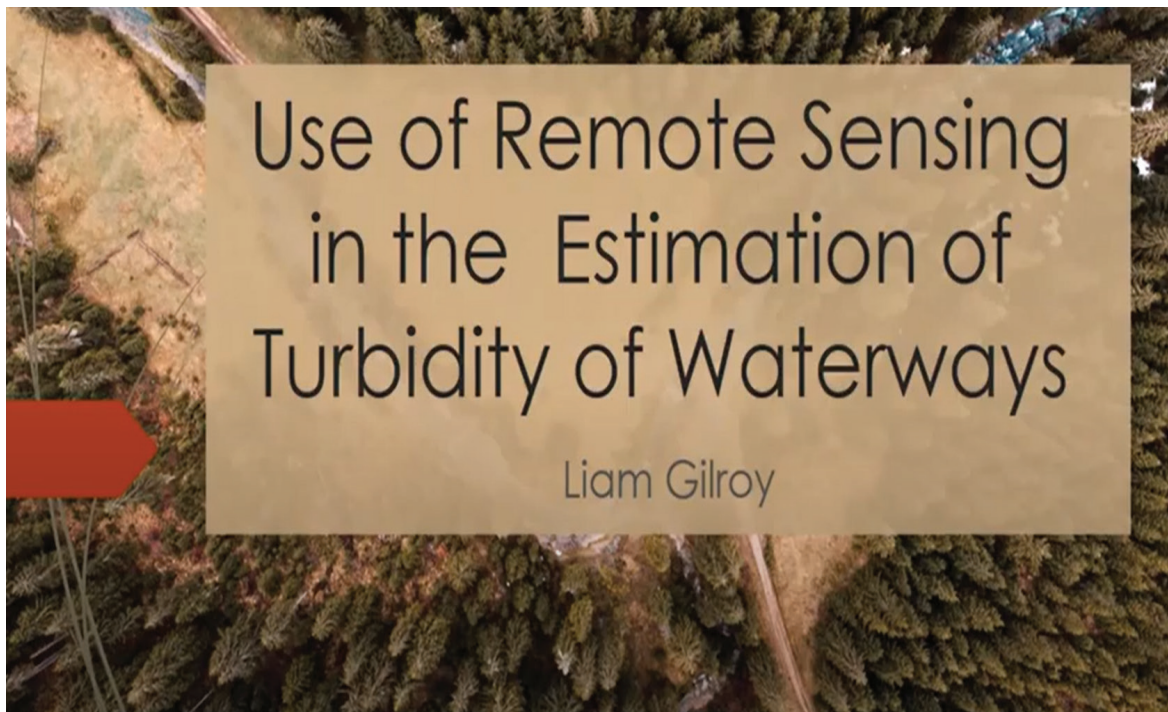
### Productivity Potential of the Harvestline Cable Yarder: Results of three Case Studies



**Hus Abeyratne**  
**Forest Engineering Honours Project**  
**October 2021**







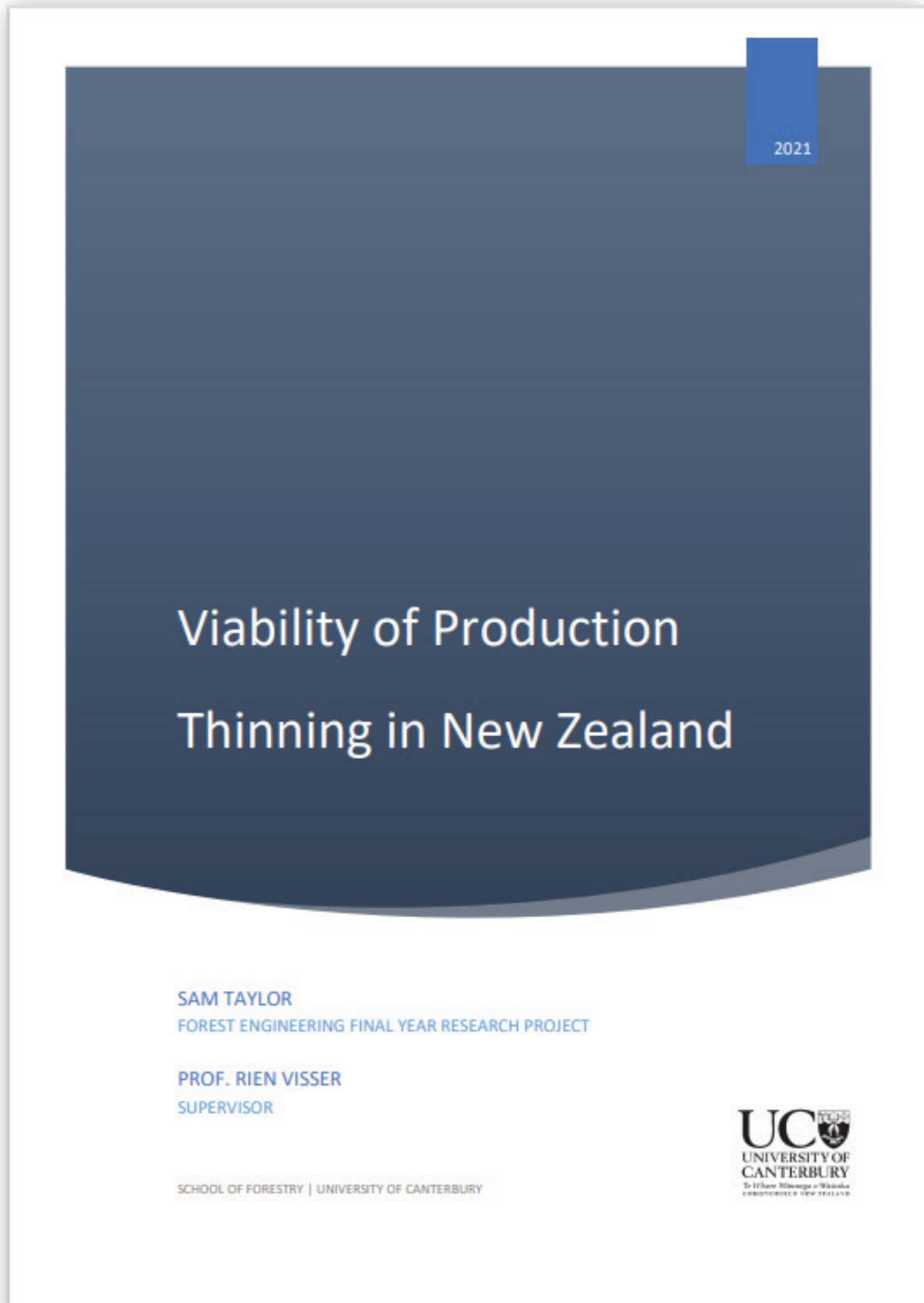
# Use of Remote Sensing in the Estimation of Turbidity of Waterways

Liam Gilroy

Prepared by Liam Gilroy  
October 2021

ENFO410 - Forest Engineering Research  
University of Canterbury

## Student projects: Forest Engineering





## Student projects: Forest Engineering



A Manulife Investment Management Company

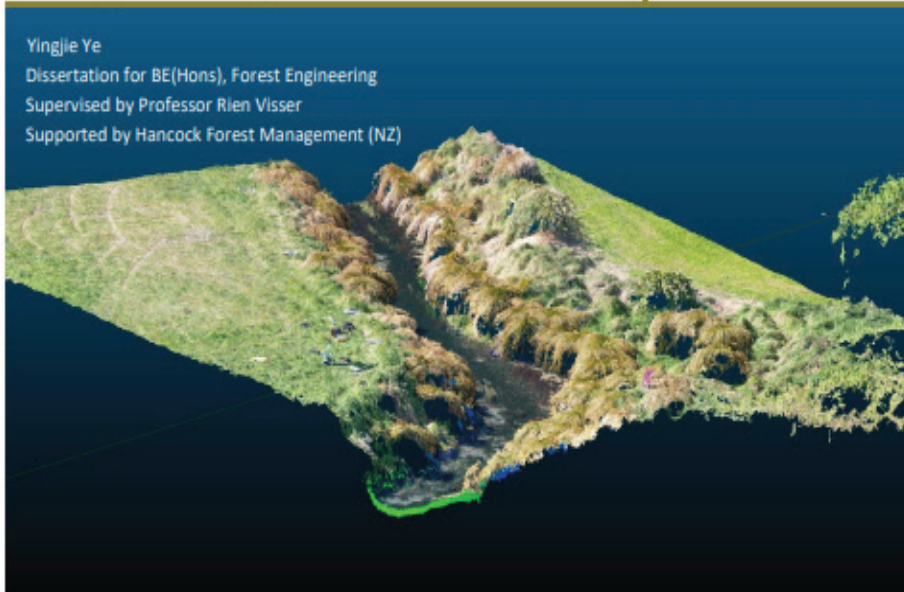
### UAV-SfM topographic stream survey:

Modelling underwater topography using  
UAV-based structure from motion  
photogrammetry

October

2021

Yingjie Ye  
Dissertation for BE(Hons), Forest Engineering  
Supervised by Professor Rien Visser  
Supported by Hancock Forest Management (NZ)




Student projects: Mechanical Engineering and Mechatronics Engineering

# SHEAR EDGE

## COMPOSITE MANUFACTURING



### THE INVENTION

Shear Edge's innovative new product aims to revive NZ's strong-wool industry by integrating the woollen fibres into polymer. The new composite material is stronger, lighter and will reduce the amount of polymer used to make any moulded product. The process aims to manufacture pellets that can be used in any traditional polymer moulding process.



### THE AIM

- Design a new system to feed wool into an extrusion machine
- Optimize pellet manufacture to ensure even dispersal and consistent ratio of wool
- Construct and commission the proposed manufacturing solution



### THE SOLUTION

#### WEIGH BATCH

The polymer is fed in by an automatic weigh batch system.

#### IN-FEED

Can coiled wool is fed into the head of the extruder from a spool.

#### EXTRUDER

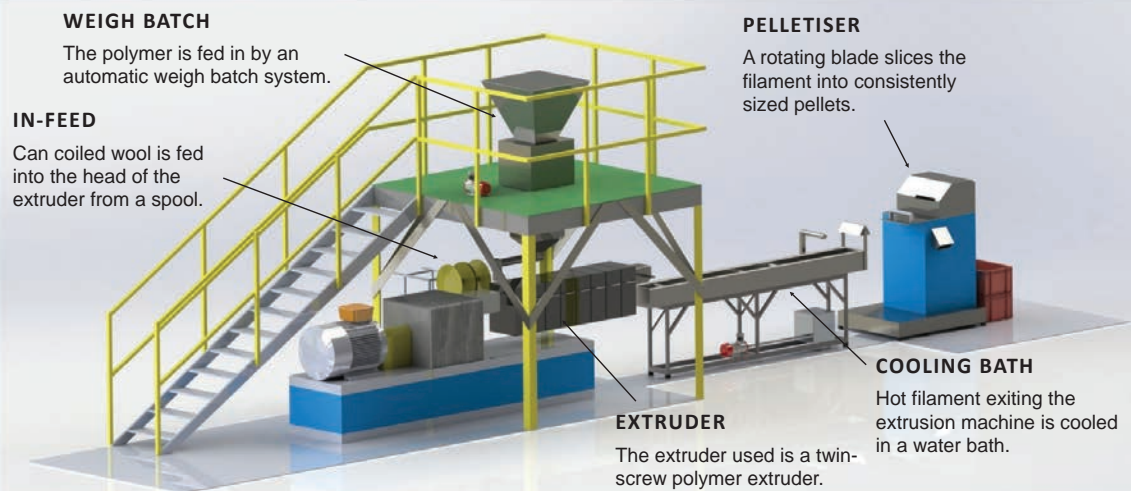
The extruder used is a twin-screw polymer extruder.

#### PELLETISER

A rotating blade slices the filament into consistently sized pellets.



#### COOLING BATH


Hot filament exiting the extrusion machine is cooled in a water bath.



### THE CONCLUSION

- Manufacture of Shear Edge pellets
- Products made using Shear Edge pellets, including:
  - Victory Knives
  - First woollen boat with FATCAT Catamarans
  - More to come shortly





## SHEAR EDGE

NEW ZEALAND  
MERINO

Mechanical Final Year Project (M01):

Team Members:


Harrison Ball  
Charles Barty  
Ben Frame  
Mathew Saul

Supervisor:

Dr. Yilei Zhang

Shear Edge Representatives:

Logan Williams  
Thomas Nye



88

# Fisher & Paykel Healthcare Test Lung Development

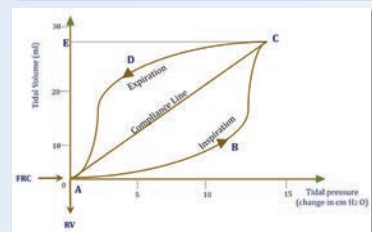
Final Year Project – University of Canterbury, 2021

Students: Baxter Williams, Cam Maslin, Olivia Kennington, & Roseanna Porter

**Purpose:** Neonatal lungs change dramatically in the period following birth as new-borns begin to breathe for themselves. Often, premature babies must be resuscitated because they have difficulties breathing due to fluid in their lungs or they are born not breathing. To accurately demonstrate Fisher & Paykel Healthcare's resuscitation and respiratory equipment, we have developed a framework to create test lungs with varying compliances to reflect the range of lung compliances among neonates.



Fisher & Paykel Healthcare's Baby LIV device



Typical compliance curve demonstrating the breathing process [2]

**Materials:** Silicone has similar hyper-elastic properties to biological tissue [3]. Therefore, Smooth-On silicone was used to cast each prototype test lung. Tensile testing was conducted for a range of silicone variants to capture each material's non-linear stress-strain behaviour. This data was used to build a digital Ogden (hyper-elastic) material model.

**Digital Modelling:** Digital testing of prototype test lungs was conducted using COMSOL Multiphysics. By using digital simulations, different lung designs could be tested rapidly, allowing investigation of how different changes influence lung compliance without physically moulding each design.



Uninflated Lung



Inflated lung

**Framework for Test Lungs:** A set of parameters were identified to modify the overall compliance of the lung. These parameters included the number of baffles, baffle size, angle of the baffles, and wall thickness. For every 1% increase in baffle size, the compliance increased by 0.6%. Additionally, the number of baffles changed the overall compliance by 18% per baffle relative to the original lung with 5 baffles.

Clients: Dr Andrew Hilliard & Daniel Wilson

Supervisor: Dr Tim Giffney

Special Thanks: David Read, Dr Oscar Torres, Daniel Bishop, & Dr James Hewett



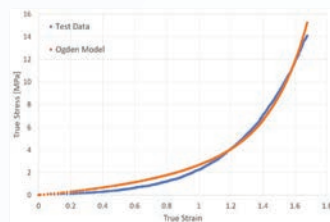
References:

- [1] Battisti, O., Bertrand, J. M., Rouatbi, H., & Escandar, G. (2012). Lung Compliance and Airways Resistance in Healthy Neonates.
- [2] Goldsmith, J.P., Karotkin E., Suresh G., & Kesler M. (2016). Assisted Ventilation of the Neonate.
- [3] Sparks, J. L., Vavalle, N. A., Kasting, K. E., Long, B., Tanaka, M. L., Sanger, P. A., Schnell, K., & Conner-Kerr, T. A. (2015). Use of silicone materials to simulate tissue biomechanics as related to deep tissue

**Background:** Lungs are characterised by their compliance, the change in volume as a function of applied pressure. Neonatal compliance has been observed to vary in the range of 0.2–2 ml/cmH<sub>2</sub>O [1]. In clinical practice, each lung must be appropriately treated to avoid lung damage. The current test lung, with a compliance of 0.3 ml/cmH<sub>2</sub>O, only represents very premature or ill neonates so a larger range of test lungs is desired.



Tensile testing equipment



Ogden and material stress-strain curves

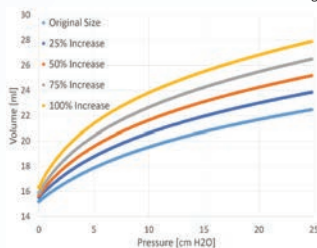
**Prototyping and Physical Testing:** To validate the results obtained from COMSOL, various lung iterations have been cast using Dragon Skin™ 20 silicone. Each prototype lung is tested with a quasistatic pressure-volume syringe test to compare the true compliance with the simulated compliance. The overall compliance is measured for each breath as  $Compliance = \frac{\Delta V}{\Delta P}$ .



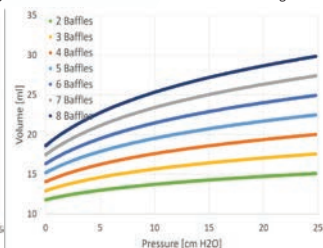
Mould used to cast test lung



Cast test lung



Effect of baffle size on compliance




Effect of the number of baffles on compliance

**Fisher & Paykel**  
**HEALTHCARE**



Student projects: Mechanical Engineering and Mechatronics Engineering

# ULTRA LOW COST SATELLITE PROPULSION



DAWN  
AEROSPACE

In-space transportation of satellites is a crucial part of harnessing space. Satellite propulsion modules are used for, orbital insertion, station keeping, obstacle avoidance, and de-orbiting. This project, aims to develop propulsion technology that uses non-toxic/safe propellants and is mass-manufacturable. In 2020, Dawn Aerospace partnered with the University of Canterbury to:

**"Develop a propulsion module based on H2O2 monopropellant thrusters capable of delivering 150m/s ΔV to a 16U CubeSat for less than \$2000 USD in component cost."**

### CONTROL HARDWARE

The control electronics operate the propulsion module in response to commands received from the host satellite. Burns are undertaken by pre-calibrated firing profiles that sequence valve and motor actuations to produce the required thrust.

### ACTUATION

To achieve the low speed and high torque required at the pump, high torque at low rotational velocity COTS motors were used. The motor provides a high holding torque when unpowered allowing the system to remain pressurised for extended periods with no electrical power expenses.

### PUMP

Due to the small form factor of a CubeSat, propellant storage volume is very limited. To achieve the required Δv, propellant fed to the thruster needs to be at high pressure. The primary task of the pumping system is to take the low-pressure propellant and increase it to a higher pressure.

### PROPELLANT TANKS

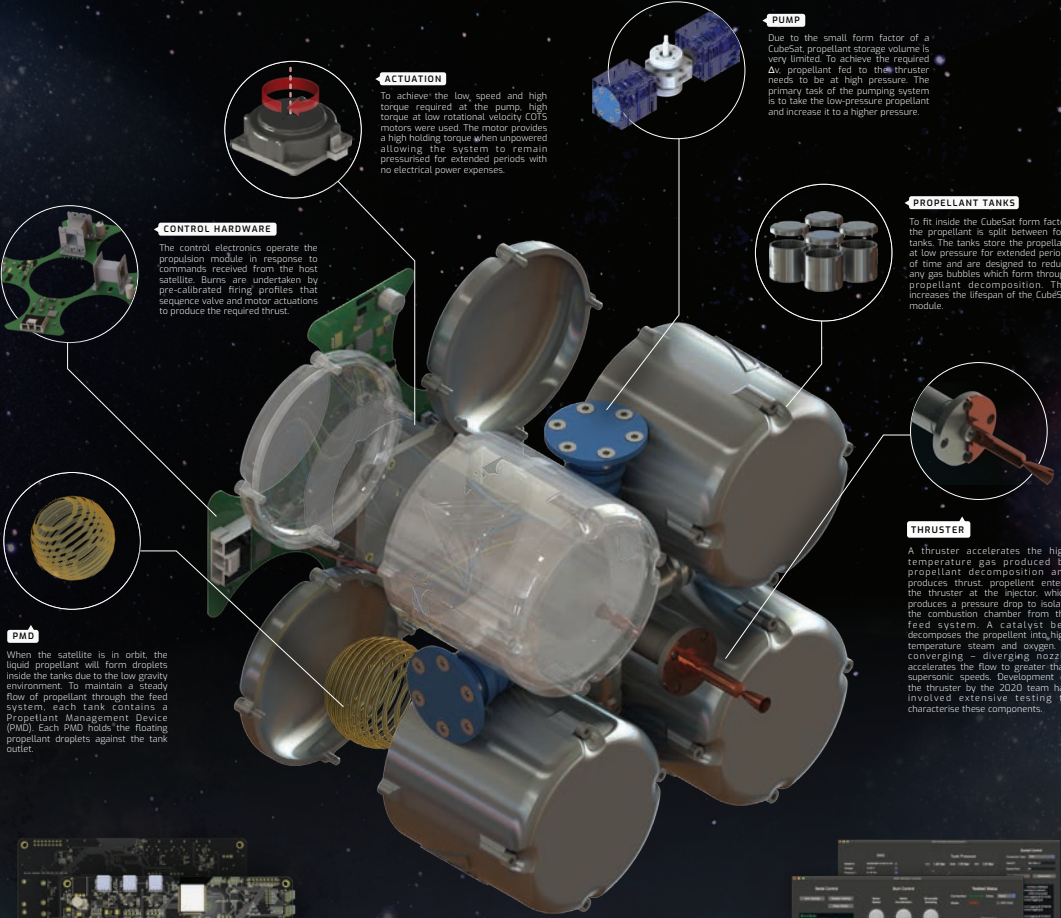
To fit inside the CubeSat form factor, the propellant is split between four tanks. The tanks store the propellant at low pressure for extended periods of time and are designed to reduce any gas bubbles which form through propellant decomposition. This increases the lifespan of the CubeSat module.

### THRUSTER

A thruster accelerates the high temperature gas produced by propellant decomposition and produces thrust. Propellant enters the thruster at the injector, which produces a pressure drop to isolate the combustion chamber from the feed system. A catalyst bed decomposes the propellant into high temperature steam and oxygen. A converging – diverging nozzle accelerates the flow to greater than supersonic speeds. Development of the thruster by the 2020 team has involved extensive testing to characterise these components.

### PMD

When the satellite is in orbit, the liquid propellant will form droplets inside the tanks due to the low gravity environment. To maintain a steady flow of propellant through the feed system, each tank contains a Propellant Management Device (PMD). Each PMD holds the floating propellant droplets against the tank outlet.



### DATA ACQUISITION

Obtaining a stream of live data was key for the testing and iteration process. To do this, a printed circuit board was produced to manage the testing of the propulsion module. Instrumentation readings were made available through a 2.4 GHz TCP server hosted on the second core of the microcontroller. During testing, our data acquisition application would ingest sensor readings to give realtime insights into system pressures and heat flows. By recording the timings of valve toggles and actuator states, the system dynamics could be analysed relative to each burn.

- DAQ
- x16 Unique Instrumentation & System Readings
- WiFi Live Plot and Tabular Visualisations
- 10ms Packet Sampling & Logging Rate

### HOW IT WORKS

When burn commands are sent to the module from the main flight computer, electrically actuated control valves are opened to allow flow from the tank to the thruster. As the propellant passes through the pump, the pressure is increased to levels sufficient for the thruster. Thrust is produced by accelerating the decomposition products to high speeds as it passes through the nozzle. The system has been designed with the space environment in mind. COTS components have been used where possible to minimize technical risks to the project.

- SUBSYSTEMS
  - Propellant Tank
  - Pump
  - Instrumentation
  - Thruster
- FLOW
  - Propellant
  - Steam
  - Oxygen
- COMPONENTS
  - Valve
  - Actuator
  - Nozzle
  - Catalyst Bed

### TEST CONTROL

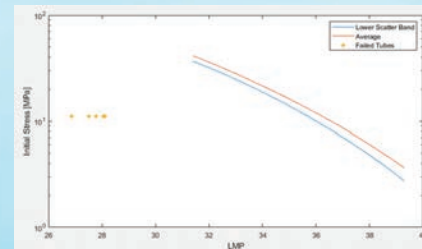
The propulsion module was remotely controlled from a command interface. This interface simulated realistic communication with a CubeSat flight controller with features including burn control, system diagnostics, and configuration commands. Communication occurred over a wireless link using a custom control and command protocol compliant with CANFD, SPI, UART and I2C. For real-time testing diagnostics, a data acquisition interface streamed instrumentation and status information from the control board via a TCP socket.

- CONTROL
  - x128 Unique Control & Configuration Commands
  - 4-bit CRC Packet Verification & Error Handling
  - 90m High-Bandwidth Wireless Operation Range

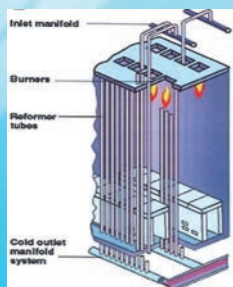
## Methanex Reformer Tube Investigation

### Problem

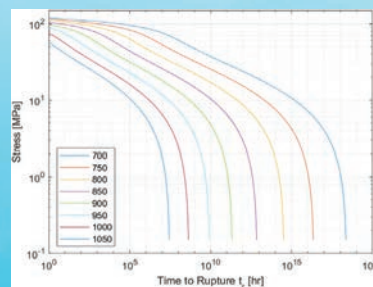
Methanex has experienced failures of reformer tubes in the colder regions of their New Plymouth Motunui methanol reformer furnace. At \$20,000 per tube, and with 680 tubes in operation, managing reformer tube life is a critical business parameter. Research has established that the twice daily manual pyrometer tube temperature measurements –known as “tubeshoots” were correlated with early failures and shortened tube lives. The 2021 FYP team set out to confirm this hypothesis with pc Tube™ modelling, Metallurgical analysis and experimental Creep-Fatigue testing.



Failed Reformer Tube Parametric Stress Rupture Curve



Reformer Tube Service Arrangement



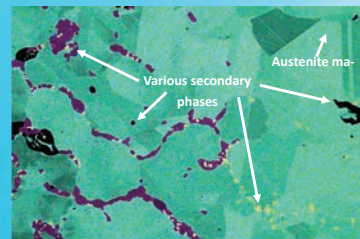
Expected Reformer Tube Life Parametric Life Curve

### pcTube™ Simulation and Modelling

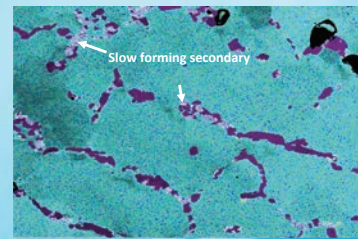
- Aim was to determine whether the tubeshoots negatively affect the overall reformer tube life using pcTube™
- 1-D Transient Finite Element model of reformer tube wall
- 12 Elements through wall with advanced creep modelling
- Opening doors for tubeshoots leads to large temperature transients increasing stress and strain shortening the life through thermal fatigue. This may be ameliorated by reducing frequency of tubeshoots.

### Metallurgical Analysis

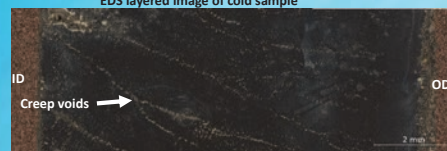
- Eight samples examined from a failed reformer tube
- Creep voids have coalesced along the grain boundaries of columnar grains
- Creep damage observed in the mid section of ‘hot face’ samples
- A range of secondary phases formed and varied from hot and cold face samples
- High temperature and slow forming secondary phases identified near the tube fracture which have lower creep properties



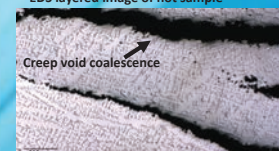
EDS layered image of cold sample



EDS layered image of hot sample



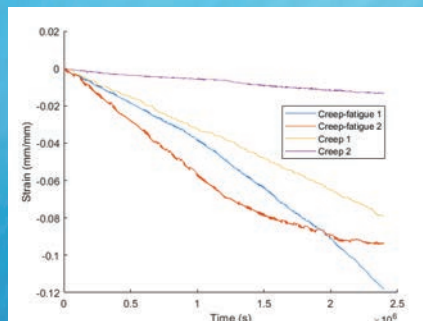
Stereo microscope image displaying creep void formation



Optical microscope image showing void coalescence

### Creep-fatigue Testing

- Four specimens from an ex-service reformer tube were loaded into creep testing apparatus
- A stepper motor and drum were used to apply cyclic loading to two samples, the other two were statically loaded
- Fatigue specimens were cyclically loaded between 18–24 MPa.
- Test duration of around 6 weeks, or 1000 cycles



Strain data from creep-fatigue testing

### Conclusions

- Analysis of modelling data implies that reducing frequency of tubeshoots will measurably extend tube lives and decrease failures in colder regions
- Simultaneous creep damage seen in the microstructure provide evidence of the creep-fatigue interaction
- The resulting strain data from testing display the impacts that fatigue effects have on measured strain compared to standard creep specimens



# Student projects: Mechanical Engineering and Mechatronics Engineering

# TERRA Fx

## Ground Effect Race Car Aerodynamics

### Project Goals

Mechanical and powertrain optimisation had been completed prior to the project, but the aerodynamic performance of the vehicle had yet to be studied. The team's task was to investigate and give practical advice on how to refine the shape of the Terra Fx race car to improve its aerodynamic performance and decrease simulated lap times.



Research → Track Testing

2D CFD

Wind Tunnel

3D CFD → Improved Design



### Track Testing

Understanding the aerodynamic performance of the Terra Fx was essential in setting a baseline for innovation and developments. Load sensing suspension and precise speed measurement allowed lift and drag forces to be found for a variety of car configurations. These results were used to validate CFD results and understand the current car dynamics.

### Wind Tunnel

Broad geometric changes to the car body were investigated using the UC closed loop wind tunnel. Wind tunnel studies allowed lift and drag forces to be quickly determined and compared for each change made to a scaled model of the race car. The most promising changes were then confirmed and optimised using 3D CFD.



### Computational Fluid Dynamics (CFD)



CFD was utilized to assess different geometry changes to the base CAD model of the Terra Fx. Research, track testing and wind tunnel testing all guided the areas that were tested with CFD. This technique outputted drag and lift coefficients which could be compared against the current car.

### CFD Improvements

Lap Time Reduction: 2.33 seconds

Downforce/Drag Increase: 34.9%

**Team:** Alex McNicoll  
James Gordon  
Joseph Lynch  
Caitlin Lipsham

**Client:** Mark Galvin  
Access Automation

**Supervisor:** Natalia Kabaliuk  
University of Canterbury 2021







**wyma**

THE BEST FROM EVERY HARVEST



Final Concept

- Foam Roller drying efficiency - 68%
- Final Concept drying efficiency - 95%

**Schematic**



Air Knives

Infrared

**Infrared**

- 5  $\mu\text{m}$  wavelength
- 500°C bulb temperature
- Bacteria deactivation
- Remaining surface - moisture removal

**CFD Simulation**



- FLUENT
- Outlet velocity 500 km/h
- Coanda effect
- 16 kPa Inlet pressure

## Produce Surface Moisture Removal

Inadequately dried potatoes can lead to rot and produce wastage. The client sought a solution to effectively remove surface moisture from potatoes in a continuous production line environment. The automated solution uses a combination of high velocity air and infrared radiation to achieve this.



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*Te Whare Wānanga o Waitaha*  
CHRISTCHURCH NEW ZEALAND

Client:  
Cory Smitheram  
Reuben Miller

Supervisor:  
Yilei Zhang

Team Members:  
Ricky Bingham  
Tom Young  
Scott Bol  
Alex Humphrey

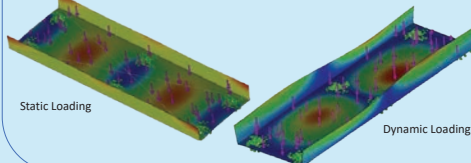
## Vibratory Conveyor Linear Electromagnetic-Derived Unbalanced Design

### Aim

Vibratory movement is one of the most efficient methods of conveyance of granular and particulate materials due to its hygienic design and speed. An electromagnetic drive vibratory conveyor had been designed from sketch, built and tested. The working principle and optimization of the conveyor were summarized and can be used in further research.

### Tray Configuration

- Designed from 314 stainless to meet food safety regulations
- Finite element analysis undertaken to determine thickness
- Optimized to minimize weight and deflection
- 100 kg distributed load produces a 1.8 mm static deflection and 0.36 mm dynamic deflection



### Composite Leaf Spring

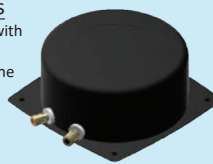
- Concise design compare with coil spring system
- For the same flexural modules, composite material is lighter than traditional metal leaf spring.
- The mats on both side provide better resistance to forces from other direction than fiberglass material.



- Double mat leaf spring
- Less fragile than fiber glass
- Average Flexural modulus 38.7 GPa
- Maximum Flexural Stress 567 MPa
- 100 mm width \* 283 mm length \* 6.5 mm thick

### Electromagnetic Actuators

- Vibratory force can be applied with accuracy to specific points
- Amplifier give current to drive the pistons
- 5-500 Hz frequency range
- ASX11504-50W
- Four Actuators with 180 N force



### Result and Conclusion

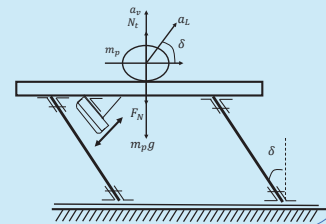
- The conveyor is required to be mounted securely to a robust structure, where should absorb the reaction forces that are created from the dynamical motion of the conveyor trough.
- Small scale design can be applied to theoretical testing and easy to adjust.
- Tray movement is approximately 1mm peak-to-peak and conveying speed 0.08 m/s for potato.
- The suitable vibration frequency: 30 Hz, resonance frequency: 27 Hz.
- Maximum load is 100 kg.

### Dynamics

- The theoretical behavior of a particle on a horizontally arranged vibratory conveyor is modelled with an inclined composite elastic bar.
- Conveying process is based on a sequential throw movement of particles.
- Throw Index K determines the power, throw distance and altitude
- Optimal vibration angle  $\delta$  is  $20^\circ \sim 26^\circ$

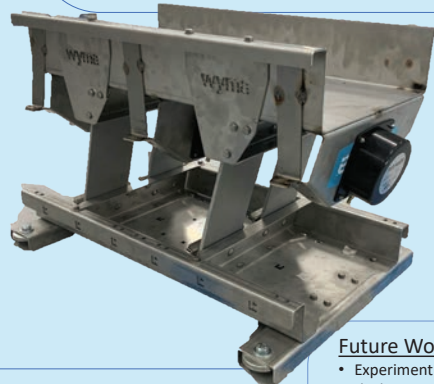
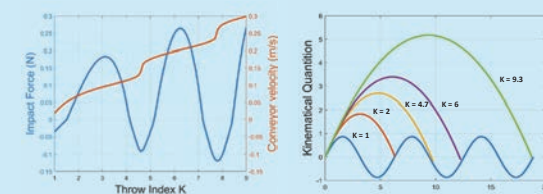
$$K = \frac{(X_L \cdot \Omega^2 \cdot \sin \delta)}{g}$$

$X_L$ : Vibration tray amplitude (m)  
 $\Omega$ : Vibration frequency (rad/s)  
 $\delta$ : Vibration angle (deg)  
 $g$ : Gravity acceleration ( $9.81 \text{ m/s}^2$ )



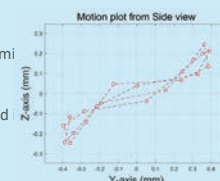
### Optimization

- The most rational regime is provided by a continuous micro-throw of the particle, so that time of its pass is equal or multiple to the total oscillation period of the vibratory conveyor.
- The most interesting practical case is when the throw index ranges  $3.6 < K < 5.8$ .
- Consideration of reaction force between particle and tray.



### Future Work

- Experiment with different spring thicknesses to determine relationship between stiffness and power
- Increase actuator power to improve conveying velocity
- Determine the effect between spring / actuator angle and amplitude
- Scale up and commercialize the conveyor



THE BEST FROM EVERY HARVEST

**Project Teams:** Matthew Furkert, Peter Peng, Martin Cruz Villanueva, Zhechen Gong  
**Supervisor:** Dr Dan Zhao,  
**Acknowledgement:** Kent Stewart



# Student projects: Mechanical Engineering and Mechatronics Engineering

## Small-Scale Seismic Source

### Background

Seismic sources produce an impact on the ground surface and impart sound waves that interact with and reflect off the materials below. The returning waves are recorded using an array of sensors and give insight into the ground structure and properties. We were tasked with designing a device that improves on the current method used by our sponsor.

### Requirements

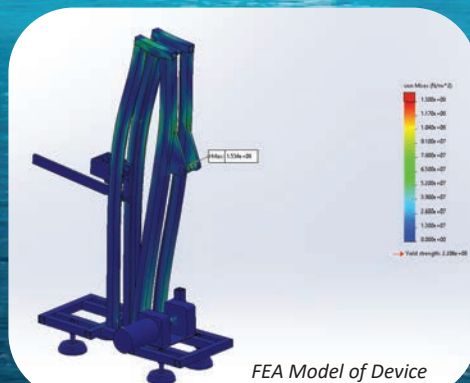
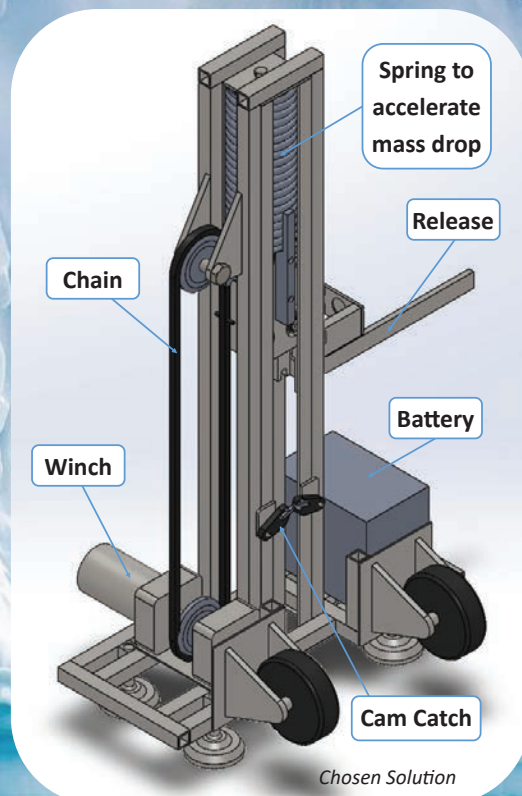
Key requirements of an improved solution are:

- No mechanical noise during the 10 seconds of data recording
- No secondary bounce after the primary impact
- Delivers consistent impact energy and input source
- Provides a trigger signal at time of impact for recording devices with repeatability within 0.25ms
- Portable by hand in rough terrain
- Suitable for use in both New Zealand and Antarctic conditions

### Chosen Solution

The chosen solution functions in the following manner:

- The battery provides energy to the motor and chain which lift the mass
- As the mass is lifted the spring is compressed and energy is stored
- When the operator is ready the mass is released and the spring propels it toward a plate on the ground
- The falling mass activates a trigger which starts data recording and provides an impact-time reference
- The mass impacts the plate and transfers the energy to the ground
- The cam system catches the bouncing mass preventing a second bounce



### FEA Modelling

FEA of the structure was carried out to confirm the design was suitable for the loadings. Results were used to reduce stresses and optimize the design.

### Next Steps

Complete manufacturing of the prototype and begin testing phase to assess performance against requirements before handing over to the client.



# Stress Corrosion Cracking of Manganese Bronze Bushings

## 1. Introduction

AW Fraser produces cast, extruded and machined components in a variety of bronze and brass alloys. Alloy 863 is a manganese bronze used to produce high performance industrial bushings.

## 2. Problem Statement

The manufacturing process for these parts involves casting, heat treatment to remove residual stress, rough machining, then final machining. Cracking is noticed in these parts after rough machining. The cause was discovered in previous projects to be intergranular stress corrosion cracking (IGSCC) as shown in figures 1 and 2. Failed parts add extra time and cost to the manufacturing process. The current solution is to cast at twice the wall thickness. This is expensive. Our objective is to find a more efficient solution.

## 3. Stress Corrosion Cracking (SCC)

SCC is the growth of cracks due to a corrosive environment, tensile stress, and a susceptible material all present simultaneously as shown in Figure 3. The source of stress and the corrosive environment were un-

## 4. Susceptibility Testing

Removing the stress or corrosive environment will eliminate SCC. From literature review and previous projects it was found that ammonia, salt water, water, and machining coolant may be aggressive to this alloy. We developed a c-ring test rig as shown in figure 4, to test susceptibility to SCC in these environments following ASTM G38.

The c-rings were stressed between 95% and 25% of the yield strength. Failures in deionised water were seen down to 35% yield stress. This was determined to be the threshold stress as shown in figure 5. Failures in water occurred the fastest and was determined to be the likely corrosive environment for 863 at AW Fraser. No failures occurred in coolant. Mattsson's solution was used as an ammonia environment following ASTM G37.

## 5. Heat Treatment

Discovering that water is an aggressive environment for this alloy indicated that eliminating the stress factor of SCC is a more viable option. There is residual stress in these parts from casting and machining. We developed a method following ASTM E837 to measure residual stresses using strain gauges as shown in figure 6.

AW Fraser heat treats 863 in the as cast form at 260°C for 4 hours. We heat treated parts after the rough machining stage at temperatures up to 300°C

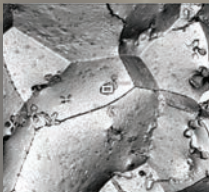
## 6. Results and Discussion

Rough machined parts that were heat treated at AW Fraser **after casting** had a residual stress above the threshold for SCC. Parts heat treated by us **after rough machining**, had the residual stress almost completely removed as shown in figure 7. A finished bushing only had a slight residual compressive stress of 5 MPa. This indicates the largest residual stresses are likely introduced from rough machining. Therefore, heat treatment after rough machining may be a suitable solution to removing large residual stresses from the parts.

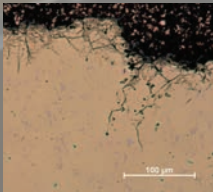
## 7. Current Possible Solutions

- A second heat treat immediately after rough machining
- Change rough machining process to minimise residual stress introduced (slower machining)
- Avoid rough machining process and go straight from cast to final machining (Difficult to reach final tolerances)
- Minimise time between rough machining and final machining so cracking does not have time to occur
- Store cast and roughed parts under shelter to minimise exposure to water


## Figure 1: SEM Image Intergranular Crack




## Figure 2: Optical Image IGSCC Branching



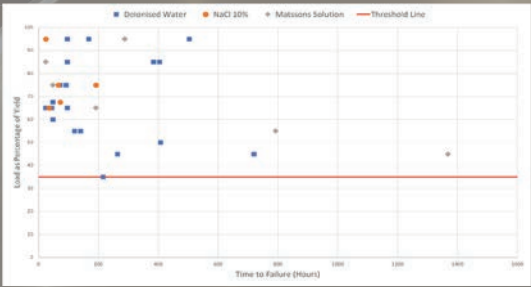
## Figure 3: SCC Requirements




## Figure 4: C-ring Test Rig



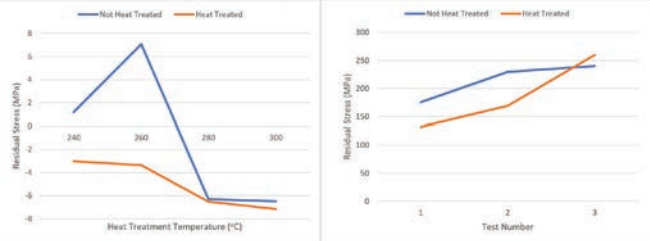
## Figure 5: C-ring Test Results With Threshold Stress




## Figure 6: Strain Gauge Residual Stress



## Figure 7: Residual Stress Test Results





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Te Whare Wānanga o Waitaha  
CHRISTCHURCH NEW ZEALAND

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Client


Phillip Benson

Supervisor

Professor Milo Kral

Special Thanks

Shaun Mucalo  
Oscar Torres  
David Read  
Julian Phillips



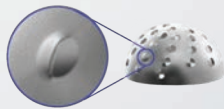
96

# Automated Forming of Reamer Teeth

# M13

Acetabular reamers are used to remove bone from the hip socket for hip replacement surgeries. Press forming individual tooth profiles is currently done by hand and is a bottleneck in the manufacturing process. The alignment of each hole with the press tool must be automated in order to decrease production time and increase yield from the forming process.

## Reamer Tooth Profile



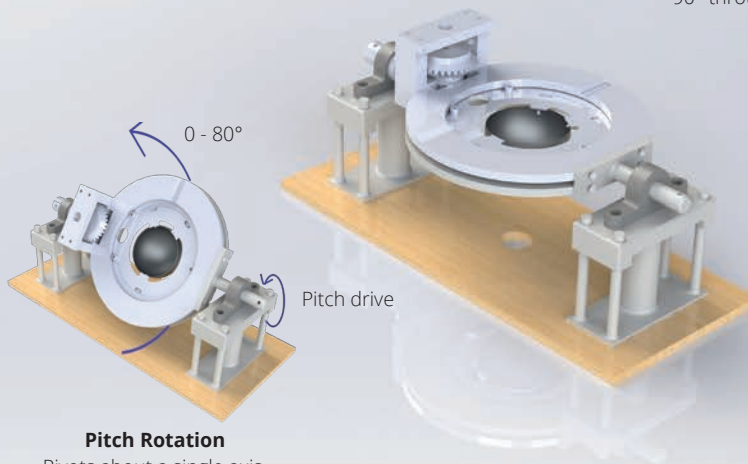
The primary objective of the project was a 3D printed proof of concept positioning system. The main challenges faced were:

- Holding reamers while allowing access to holes near the edge.
- Ability to quickly and consistently load and unload reamers.
- Achieving reamer positional accuracy relative to the press tool.
- Shock resistance to withstand loads from the press tool.



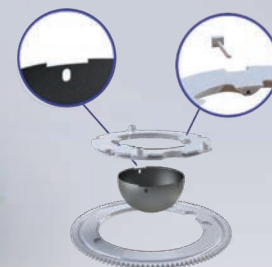
## Yaw Rotation

A bevel gearbox transmits power 90° through a concentric driveshaft.



## Pitch Rotation

Pivots about a single axis.



## Fixture

Seats and tapered pins attach to mounting features in the reamer. The fixture is removable for loading and unloading.

## Key Outcomes

- Development of 3D printed prototype.
- Able to position to 3mm sized holes.
- 88% hole indexing accuracy.
- 0.6 seconds mean time between successive hole indexing.

## Future Developments

- Implementation of positional feedback systems.
- Catalogue components for the implementation of the design in industry.



## Vertical Movement

Spring-loaded mounts enable the device to compress onto the press tool when the press is activated.

**enztec**

## Team Members:

Tessa van den Beuken  
Kaleb McGillivray-Seaton  
Luke Woodfield  
Fletcher Walmsley

## Client:

Dr Iain McMillian

## Supervisor:

Chris Pretty

## Special Thanks:

Rodney Elliot  
Angus McGregor

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CHRISTCHURCH NEW ZEALAND

# REMOTE FARM SURVEILLANCE

Albert Kim  
Arian Asghari  
Christopher Tichborne  
Ryan Carter



## THE PROBLEM

The problems modern farmers face include:

- Stock losses due to theft
- Stock escaping
- Ineffective monitoring of livestock in distress or late pregnancy.

This costs the farming community over \$120 million per year on stock theft alone. Therefore, it was identified that aspects of current farming could be modernised to improve efficiency and effectiveness.

## SOLUTIONS

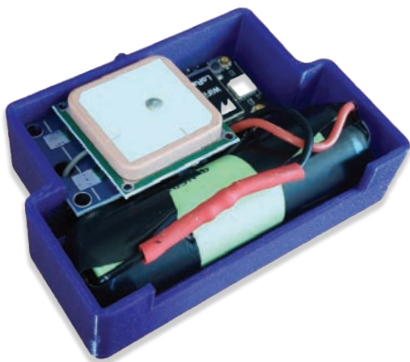
### Tracking Tag

An embedded system connected with a GPS module and battery.

- GPS data is obtained and sent to a gateway via LoRa. It is then processed through a cloud server to navigate the drone.
- Max transmission range can be up to 15 km in ideal conditions, with transmission of data only using 105mA. When idle/sleeping between GPS updates, 19.5 mA is consumed.

The initial prototype was deemed too large and expensive. After initial functionalities were completed, the solution to this was a custom PCB. This would lead to the tag being;

- 1/3 rd of the volume
- 1/5 th of the price



## THE PROJECT

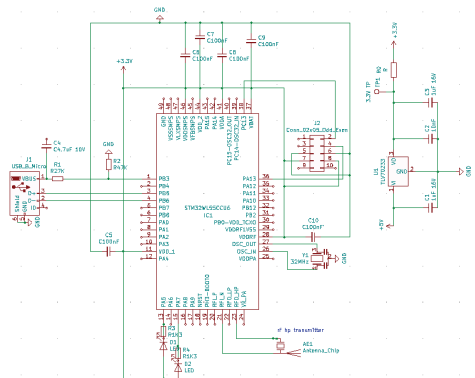
The project aimed to create an alternative to the current solutions available in the farming industry, through the use of a drone livestock surveillance system. This solution was to allow farmers to efficiently track, monitor and locate livestock. The system consists of two main components, a drone, and a tracking tag.



### Drone

A drone with a camera is to be used along with the tag. By using a drone and a suitable app, we can:

- Fly directly to any point or animal with the coordinates given by the tag.
- Monitor the livestock at any time.
- Monitor the fencing and irrigation.
- Create flight paths that complete daily, monthly, or yearly checks without leaving the house.



## PROJECT SUCCESS

We have managed to provide the client with a fully functional tagging system that has been tested in the field. We have completed our proof of concept and provided the client with a drone and tracking system, as well as an app that can be developed and used to connect the two sub systems together. Early PCB designs have been completed, consisting of research documents and parts lists that will be used in future development of the project.

**Client:** Joshua Hammett, Matt Shanks  
**Supervisor:** Paul Docherty  
**Technician support:** Garry Cotton, Ben Mitchell, Will Sloane, Graeme Woodward, Kevin Barnsdale



## RETHINKING REFORESTATION

### BACKGROUND

Restoration of native forest in New Zealand is a process that is currently expensive, time-consuming and physically demanding. Modern technology has the power to improve on these limitations, particularly in the context of large-scale reforestation efforts.

### PURPOSE STATEMENT

The project purpose is to design and build a working prototype of a system that will help to automate the three key steps of the planting process. Automating these processes will help to overcome the current limitations of native reforestation in New Zealand.

### THE PLANTING PROCESS

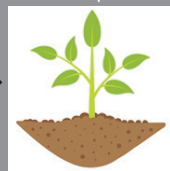
#### 1. Create Hole



#### 2. Insert Plant



#### 3. Tamp Soil



### 1. CREATE HOLE

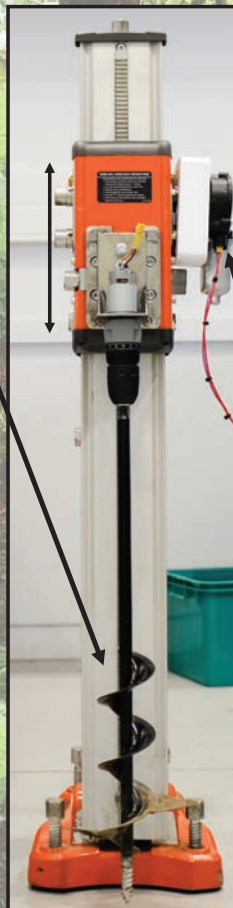
An auger that is attached to a drill motor is used to create a hole. A typical auger does not create a hole that is ideal for plant growth. An optimised auger has been designed which loosens soil rather than removing it. Loose soil is important for the development of plant roots.

### 3. TAMP SOIL

A third attachment for the drill stand is a soil tamping device. This firms and secures the soil around the roots of the plant.

### CONTROL SYSTEM

The system utilises three DC motors which are controlled via an Arduino. The motors are wired to a control box which allows the user to safely operate the system from a distance.



### 2. INSERT PLANT

A planting spike (Pottiputki) is used to open a hole in the loosened soil and drop a plant in. The planting spike uses a linear actuator to open and close the jaw. The linear actuator applies up to 600 N of force. It attaches interchangeably with the auger to the Husqvarna drill stand which actuates the planting spike into the ground.

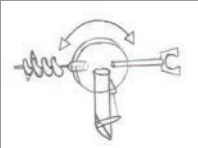


### VERTICAL ACTUATION

A DC motor is used to move the tool carriage up and down the drill stand. This provides a large 14 Nm of torque to push the auger, planter and tamper into the ground as well as hold them all in place with ease. The process of creating a hole, inserting a plant, and tamping the soil takes 38 seconds (excluding tool changing).


### NEXT STEPS

Conceptual design of a 'clock face' mechanism to automate the interchanging of the auger, planting spike, and tamper has been undertaken. The system has been designed such that it will be able to be mounted to a farm vehicle or autonomous multi-terrain robot.



# Reinventing the Glove

Hyperlocal, Tailored, Compostable Gloves On Demand

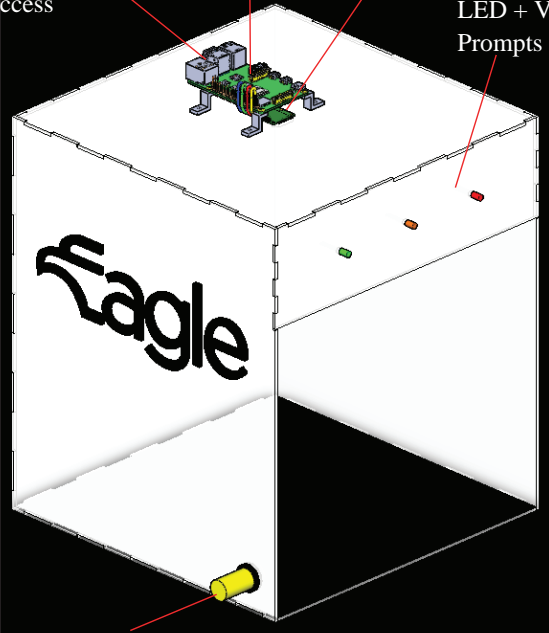


USB + Ethernet Access

Raspberry Pi Computer

Camera Module

LED + Voice Prompts




Infrared Sensor

### Background

30

Number of years glove production process has remained unchanged



Long lead times + lack of quality control

1.24m

Tonnes of glove waste per day in US

### How it Works

1

IR sensor triggered by hand motion

2

Photo of hand taken + stored in memory

3

Hand edge detected via computer vision + noise removed

4

Two scaling factors applied for an optimal fit

5

File converted to DXF + sent to laser cutter

6

Glove shape is laser cut on two layers of bio-plastic forming a weld

7

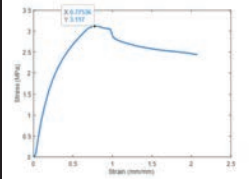
Employees can subsequently use their workplace ID card to trigger software that will laser cut the gloves needed on demand

### Weld Testing

**Weld porosity:** Fill glove + record leakages over 3 minutes. No leakages indicates successful weld.

Material	Laser height	Leak rate (g/min)
Bio Plastic	2961	1.5
	2971	132.5
	2991	176


**Weld Strength of chosen bioplastic**



- 5 trials
- Average Maximum Tensile Strength of 3.1 MPa
- Average maximum Strain of 200%
- Decreases material tensile strength by 22.5%


### Scaling Materials

**Computer Vision:** Scaling with Dilation Function



**SOLIDWORKS:** Modelling fingers, thumb and palm as cylinder for scale factor

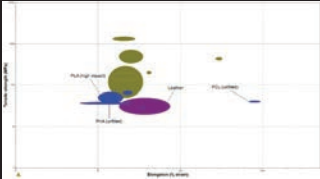
	Index	Middle	Ring	Little	Thumb
Average Surface Area	3.34	3.32	3.32	3.34	3.42
Scaling Factor from 2D	3.34	3.32	3.32	3.34	3.42




Scaling finger trace surface area by 3.32 to convert 2D to 3D

### Materials Research

Material selector software narrowed 4181 polymers to 5 suitable under constraints of 15 MPa tensile strength, 20% elongation and biodegradable. Five suitable polymers are: BioPBS,





PBAT, PLA, PHA + PCL  
Recommendation: PLA + PBAT



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**Team:** Jack Ballard, Matthew Comber, Ella Gilroy, David Zhu  
**Academic Supervisors:** Dr Sid Becker and Dr Mark Staiger  
**Technicians:** David Read and Oscar Torres  
**Clients:** Bryn Hill, Frances Toulmin, Kath Row, Gareth Brooks



100

Student projects: Mechanical Engineering and Mechatronics Engineering



# TETRAPLEGIC PATIENT LIFTING DEVICE FOR LOW-RESOURCE SETTINGS

CLIENT: RUSSELL TAYLOR  
SUPERVISOR: KEITH ALEXANDER

## FINDINGS

Background research into existing solutions, brainstorming and concept generation was conducted. Various concepts were prototyped and tested. The chosen prototype consisted of a wooden frame with a bottle jack secured in a slot. The bottle jack slotted into a bored hole within a wooden peg. This peg distributed the load across the backboard. As the bottle jack is raised, the patient is transferred to a seated position. The patient can be transferred onto this device once, with the assistance of the local community. The device can be slept on permanently when lowered.

A limitation of the chosen prototype was deflection of the bottle jack under a 200kg load. Hence, an alternative concept using a hinge similar to that of a tip truck was investigated and a small scale model was created.

A scope extension was proposed by the client to completely lift the patient off the ground, allowing both elevation of the patient's upper body and lowering of their legs. This concept was tested using an engine crane. The identified solution consisted of a hinged wooden sheet, connected via ropes to a pulley. This concept has not yet been tested on a 200kg patient as this was outside of the scope of the project. In the future, research and testing should be conducted surrounding methods of building a hoist and pulley system.

SCOPE EXTENSION FLAT



SCOPE EXTENSION ELEVATED



SMALL SCALE MODEL



CHOSEN PROTOTYPE



## PROBLEM

People with tetraplegia and paraplegia living in remote communities in Tonga often have difficulty accessing lifting equipment, leaving them confined to a mattress on the ground. The goal of this project was to improve the quality of life of tetraplegics in Tonga by developing a functional prototype to shift a tetraplegic patient into a seated position on the floor.

## CONSTRAINTS

- Inexpensive
- Resources and Tools Available in Tonga
- Lift a Patient of 200kg +
- Operated and Built by a 50kg Caregiver
- Fully Mechanical


BRIAN LUO  
SOPHIE WHITE  
QUINN MIRAMS  
CHARLOTTE PALMER



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101






Group M18: Fibreglass Material


## Acoustic Properties of Recycled Fibreglass Panels



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Christchurch 8140 New Zealand




**Mechanical Properties**



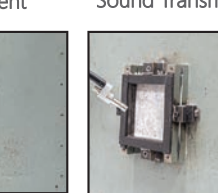
Mechanical 40 % < 1mm	
Elastic Modulus	30 MPa
Shear Modulus	13.8 MPa
Ultimate Tensile Strength	5.0 GPa

**Damping Measurement**



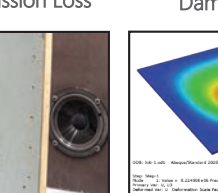
Damping Ratios	
40 % 1-2 mm	3.0 % 380 Hz
40 % < 1 mm	2.5 % 450 Hz
60 % < 1 mm	2.0 % 460 Hz

**Sound Transmission Loss**



Sound Transmission Class	
Gypsum Plyboard	46 dB
40 % < 1 mm	45 dB
60 % < 1 mm	42 dB

**Damping Model**



Modal Analysis	
40 % 1-2 mm	390 Hz
40 % < 1 mm	460 Hz
60 % < 1 mm	460 Hz

**Team**

Rhys Blaas  
Quin Stanger  
Thomas Spillane  
Samuel Tzikoucos

**Supervisor:** John Pearse

**Sponsor:** Gracol Composites

**Acknowledgements:**

Stefanie Gutschmidt  
Raj Prasad  
Oscar Torres  
Seigan Hayashi

# Student projects: Mechanical Engineering and Mechatronics Engineering



## LION ENCOUNTER EXPERIENCE



**CURRENT LION ENCOUNTER VEHICLE**

**PURPOSE**

Our aim was to reimagine the lion encounter vehicle at Orana. This required:

- Increasing visitor capacity
- Lowering the viewing platform
- Minimising environmental impact
- Meeting the AS3533.1-2009 standard for amusement devices
- Producing a cost efficient solution

**DESIGN PROCESS**

The main workstreams comprised of concept ideation, detailed design and documentation. It was an iterative process, which involved extensive research, planning, budgeting, calculations and Computer Aided Design (CAD) modelling. Proactive consultation with Orana established an integrated design pleasing both teams.



**NEW LION EXPERIENCE**

**ANALYSIS**



The vehicle design was produced using the SolidWorks CAD package. Initial calculations were used to size components, before a detailed strength analysis was conducted using Finite Element Analysis. Validations were then computed using First Principles.

**LION STEP**



**RESIDENT LION**



**NEXT STEPS**

The vehicle design will be certified by a registered consulting engineer to ensure it meets all legal and safety requirements, before Division Architectural Engineering are commissioned to fabricate the vehicle. Orana will then purchase a tow unit to guide the trailer. Keep an eye out, as you can expect to partake in the new lion encounter experience soon!



**Team Members**

Alan Kirk  
Donovan Knowles  
Niamh Scott  
Calum Sutherland

**Supervisor**

Dr. Malcolm Taylor

**Client**

Orana Wildlife Park

**Special thanks to:**

Division Architectural Engineering  
Murray Meyer


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# DOC: Eliminating wilding pines by automated spraying from helicopters

## The Wilding Pines Problem

- Cover 1.8 million hectares.
- Spreading at 5% per annum.
- Without Intervention, 20% of New Zealand's landmass will be covered by 2040.



1998

2004

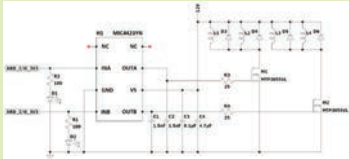
2015

## User Interface

- Displays spray data in the cockpit via a tablet.
- Provides manual nozzle control.
- Displays data on sprayed herbicide volumes.
- Shows current position and target tree locations.

## Nozzle Control System


A power electronic gate drive circuit responsible for switching the solenoid spray nozzles on and off. The NUC relays information to an Arduino that sends control signals to the nozzle control system.



## Our Solution

The previous Wilding Pines team completed a prototype spray boom. This year we have accelerated their design and we are now ready to complete a flight test.

The solution is a spray boom that automatically sprays wilding pines. When the helicopter flies over a pine, the spray nozzles automatically deliver the optimal dosage of herbicide without pilot intervention.



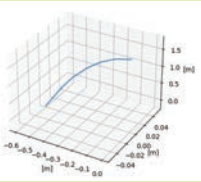
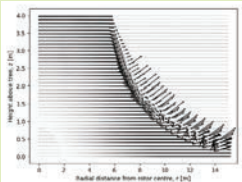
## Electronics Enclosure

The nozzle control system and GPS units are stored in a custom designed and manufactured electronics enclosure, which is completely water tight.



## Droplet Timing Model

A model was created that predicts where spray will fall in real time given rotor downwash, wind and droplet size.



Cross-section of simulated rotor downwash from the helicopter. Droplet tracking example in 3D space.


## Spray Boom

- Has capacity for 20 nozzles.
- Steel construction and welded together by the team(labtechs?).
- Length is < 80% of helicopter rotor diameter to meet CAA regulations.
- Quick connect fitting to pump.
- Quick drain system.
- Replicates existing helicopter mounts for use.

## GPS Tracking


Two GPS units measure the location and compare it to target pine data.


The average of both unit's measurements is continuously computed and sent to the droplet timing model.



GPS units AIMMS-30 (Orange), Ublox M8N (Cyan), Actual path (Green) compared.

## The Team






Department of Conservation  
Te Papa Atawhai



scion  
FORESTS • PRODUCTS • INNOVATION



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# RAINFORCE

## Heat Recovery Shower

### PURPOSE

Showers require significant amounts of energy to heat the water. This project develops Lantec Showers' concept for a heat recovery electric shower for a more efficient and environmentally friendly shower, without compromising the showering experience.

### HOW IT WORKS

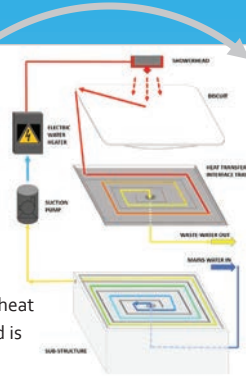
Heater heats fresh water to desired shower temperature

Pump increases fresh water pressure

Cold water flows up through the heat exchanger at a low pressure and is heated by the hot water

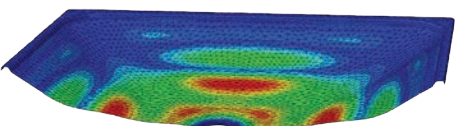
Hot water flows out of shower head

Hot water flows through heat exchanger and down the drain



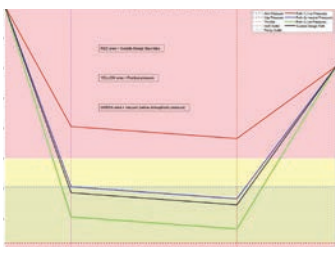
### MODELLING

The stiffness of the heat exchanger tray was modelled for different flow pressures and tray designs.



Flowrate	T_hot in	T_cold in	T_cold out	Efficiency
4.5L/min	40	10	27.6	59%
6L/min	40	10	26.7	56%
6.5L/min	40	10	26.5	55%


The pressure of the cold water flow through the heat exchanger was modelled to determine pump specifications and avoid cavitation.



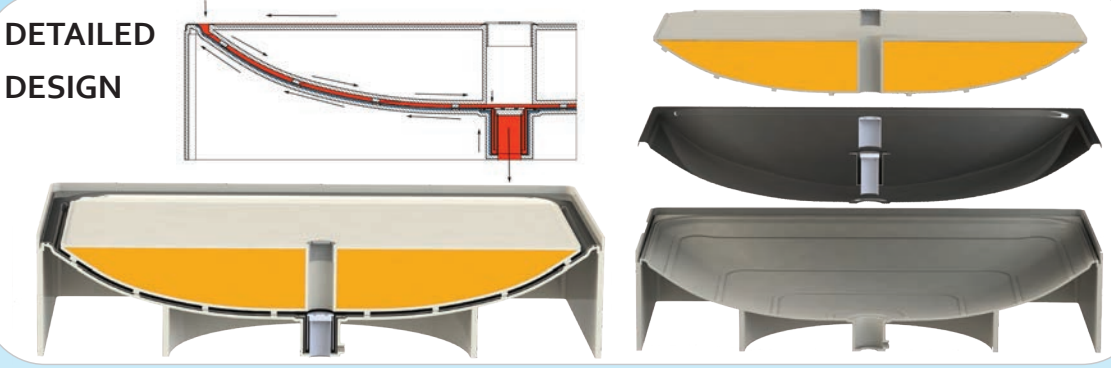
The heat transfer through the heat exchanger was modelled to determine the theoretical efficiency of the shower system.



### VALIDATION OF RESULTS

Lantec Showers provided a prototype of a heat exchanger. A test rig was made to measure the effectiveness of the heat exchanger tray with varying flow channel width and depth. The experimental results were compared to the modelling results to validate the new design.



### DETAILED DESIGN





TEAM

Zac Bensemann  
Sophie Hickmott  
Maria Todhunter  
Jinshen Tong

CLIENT

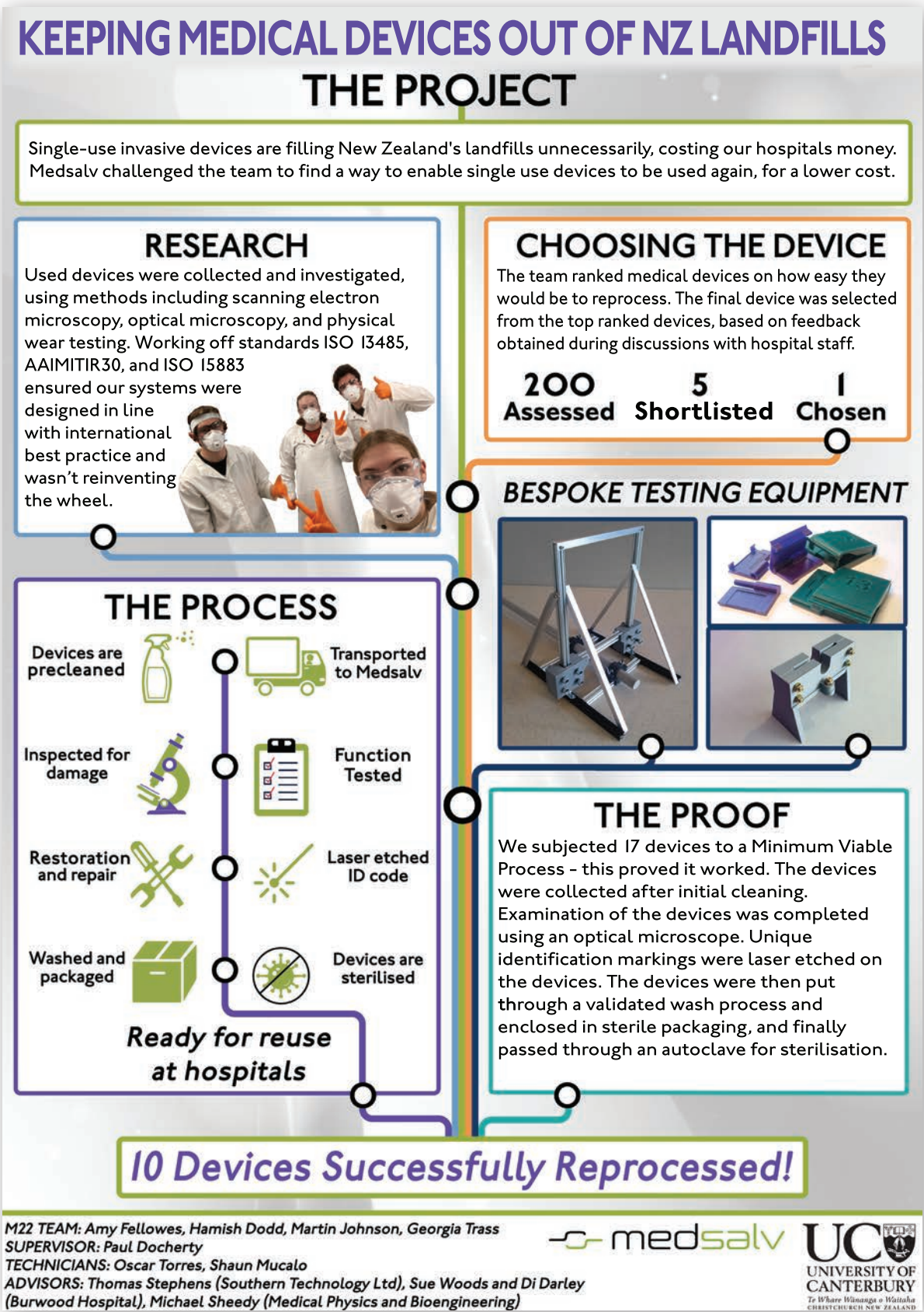
Tom Fuller

SUPERVISOR

Mark Garnich

THANKS TO

Dr Bill Mohs  
David Read  
Tony Doyle  
Prof Mark Jermy



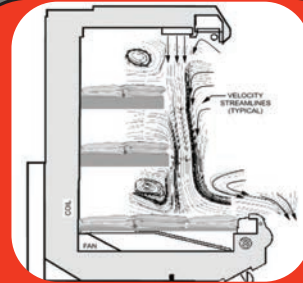
## Characterising Air Flow in Open Front Refrigerator

### Background and Problem Statement

- Open front refrigerators keep cool by utilizing an air curtain
- Air infiltration is the leading cause of heat gain in the fridge
  - Air may also circulate in the shelf rows

The goal of this project is to characterise the infiltration of the air curtain in the model OD330 fridge using 3 methods:

- Hot Wire Anemometry (HWA)
- Particle Imaging Velocimetry (PIV)
- Computer Fluid Dynamics (CFD)

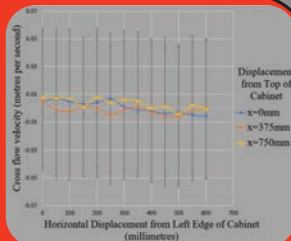


An illustration detailing the air curtain design found in open deck refrigerators<sup>[1]</sup>.

### HWA



Experimental Set Up of traverse and data capturing equipment for HWA Testing



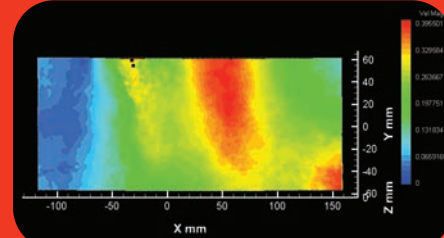
Results of 3D HWA testing of cross-flow in cabinet, across the width and height of the cabinet, that shows the flow is dominated by vertical motion.

### PIV



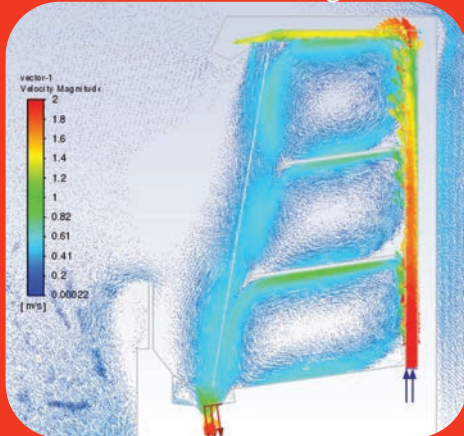
PIV works by tracking the change in position of illuminated smoke particles between two images taken in rapid succession.

This data was used to generate a high-resolution image of the flow to validate our CFD model.



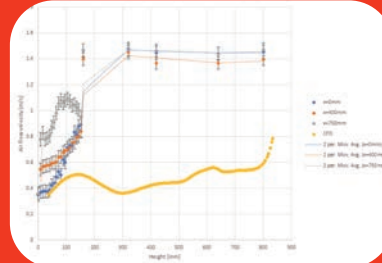
CFD Results showing velocity profile of the air curtain directly below the outlet, showing peak velocity at the front of the air curtain.

### CFD Modelling



- Model of Air Velocity in Cabinet
- Created in ANSYS Fluent 2021 R1
- 0.02 Million Node Mesh
- k- $\omega$  SST
- 2 pairs of velocity-inlet and pressure-outlet boundary conditions

### Comparison of Results



A graph plotting the HWA measured air velocities against our CFD model along a line from outlet to inlet. The two diverge as the flow develops, suggesting that our model does not fully capture the turbulence that is present.



## Student projects: Mechanical Engineering and Mechatronics Engineering



# WAR S

## Weeding Agricultural Robotic Solution

**Purpose**

Plant Research (NZ) Limited are plant breeders based in Templeton, Christchurch, specialising in peas, oats, wheat and triticale. They commissioned a modular, autonomous robotic solution, capable of weeding between their crop rows to reduce the cost of manual weeding by casual labourers.

**Scope**

Delivery of a robot featuring autonomous navigation, off-road driving, and an attachable weeding module, along with supporting documentation. The robot had to navigate custom paths through PRL's crops autonomously. Supplied documentation included user instructions, a manufacturing guide, and an operating manual.

**Local Navigation**

- Crop row detection using computer vision.
- Program detects crop edges, and steers robot towards centre of rows.
- Developed on an Nvidia Jetson Nano using Python, OpenCV and Nvidia CUDA libraries.



**Weeding Module**

- Weeding system selectively targets weeds using computer vision.
- Directional jet nozzle delivers micro-dose of herbicide to kill weeds.





**Global Navigation**

- Autonomously guides robot through user-defined paths.
- Advanced GPS-RTK system, accurate to 5cm, combined with magnetometer for bearing.
- Localisation using Particle Filter to accurately determine the robot's pose.



**Robot**

- 4x hub motors in a skid steering arrangement, turns on the spot with top speed of 5 m/s
- 2x 300Wh Lithium batteries.
- Chassis fabricated from welded steel bars, with room for future modules

**User Interface**

- Graphic User Interface to switch operating modes and view data logs.
- WebSocket connects directly to Robot Operating System.
- Connect device to robot over WiFi, allowing remote control.





**Plant Research (NZ) LTD.**

**Team:**  
Matthew Bertschinger  
Daniel Bowles  
Luke Burke  
Tristin Weastell

**Supervisor:**  
Dr. Tim Giffney

**Client:**  
Plant Research (NZ) Ltd.

**Thanks:**  
Tony Doyle  
Julian Murphy  
Richard Green  
Daniel Bishop



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# Modular Refrigerator

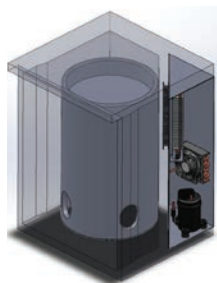
## Background

Refrigerators are often hard to recycle and form a large component of NZ waste. Additionally, the commonly used R134a refrigerant is being phased out due to environmental concerns. As such there is demand for recyclable refrigeration utilising more sustainable refrigerants.

We were tasked with developing a refrigerator capable of fermenting, chilling and then serving beer. The design is to have refrigeration components in a removable module which can easily be replaced or repaired.

## Concept

- Module removable without tools
- Space maximisation - Cabinet must fit 25L keg
- Module inserts from the back
- Edge to edge interface design
- Easiest way to modify the cabinet



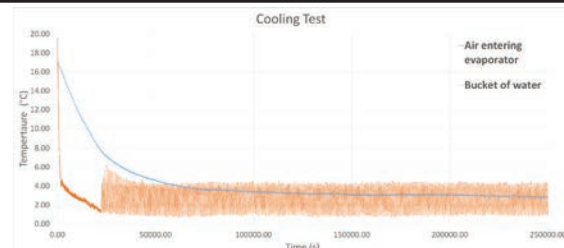
## Prototype

- Refrigeration cabinet and components supplied by client
- Cabinet cut and reinsulated
- Heats via a hot gas bypass
- Controller parameters set
- Overuse of fasteners
- Noise and insulation
- Insufficient seal



## Testing

- UA testing - increased by 0.26 W/K
- Heating and cooling
- The prototype was able to sufficiently cool, heat and maintain temperature

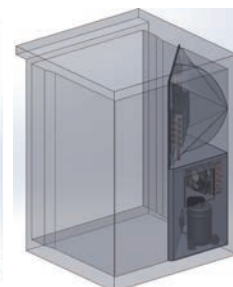
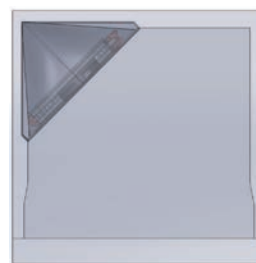


## Findings

- The coefficient of performance (COP) of the system was less than 1 with average power use of 185W. A typical refrigerator would have a COP of ~3.
- The goal was to achieve full functionality, therefore, optimisation of the unit has not been carried out.

A new concept is to be produced using what was learnt during the prototype build and what is required for mass production. This will include:

- Front inserting design
- Component selection and optimisation (R134a phase out, optimisation)



### Team

Scott Wylie  
Andrew Wedlake  
Refin Saphio  
Conor Handley

### Supervisor

Bill Mohs  
**Special thanks to**  
Tony Doyle

### Client

Sam Wood  
WilliamsWarm



# DIFFERENTIAL THRUST CONTROLLED PVTOL DRONE DEVELOPMENT

PROJECT AIM

A **Planar, Vertical, Take-Off and Landing (PVTOL)** drone utilises the benefits of increased manoeuvrability during vertical flight whilst still being capable of highly efficient planar flight. The project aim is to develop a working prototype of a PVTOL without control aerodynamic surfaces, based on the client's existing concept.

Vertical Take-off

Planar Flight

Vertical Landing

Design

V0  
MDF

V1  
3D PRINTED

V2  
FIBRE GLASS

Build

Flight Testing

V0

✓ Electronics Validation  
✓ Control System Validation

V1

✓ Hover Flight Testing  
✓ Proof of Concept

V2

✓ Planar Flight Testing  
✓ Transition Testing

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CHRISTCHURCH NEW ZEALAND

THE TEAM:

- Connor Kwon
- Matthew Fraser
- Sam Hogan
- Sam Wainwright

Special Thanks To:

- Julian Murphy
- UC Motorsport
- William Rangi
- Bill Mohs

Client: Dr. Rafael Rubin

Supervisor: Dan Bishop

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# Student projects: Mechanical Engineering and Mechatronics Engineering

## TISSUE MECHANICS

Biomechanical property testing

### The problem

There is little existing research on high speed impact response of human tissue. The solution to this was to design a test rig for impact testing cranial bone, and impact tensile testing of soft tissues. The desired operating speeds are specified between 2m/s to 10m/s, with 30cm to reach these speeds.

### Finite element analysis

FEA used to estimate the deflection of frame during an impact test

1. Maximum deflection: 1.01 mm
2. Maximum stress: 139.5 MPa


#### 1 Pneumatic Actuator

Accelerates impactor head to desired speeds using pressurised air

#### 2 LED lights

Illuminates sample for high speed camera to accurately record motion

#### 3 Frame



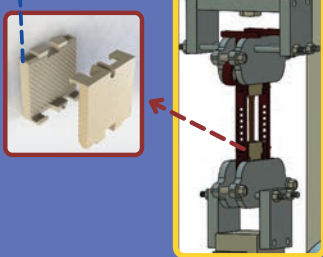
#### 4 Sample Clamps

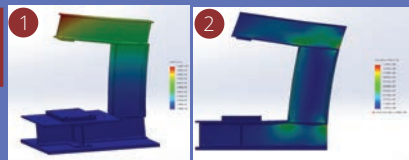
Adjustable supports for bone sample, with **three** possible degrees of motion

1.  $\pm 20^\circ$  rotational adjustment
2. 30mm vertical adjustment
3. 125mm horizontal adjustment

#### 5 Soft tissue clamps

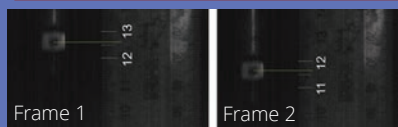
3D printed with pyramid extrusions to grip soft tissue for tensile testing





### High speed testing

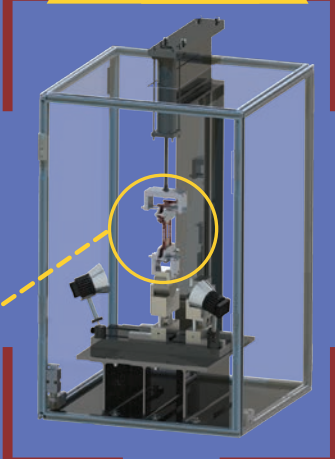
Using a high speed camera and Labview software to find distance covered by impactor head. Confirmed that pressure of 8 bar can push piston to 10m/s in under 30cm.



### Safety mechanisms

- Interlock system
- Perspex screens for flying fragments


### Tensile test



### The final product

- 10x lighter and 6x smaller than existing impact rigs.
- Can be used in both compression and tensile impact tests
- Can be disassembled for transportation, and carried by two people.
- Reaches the desired speed range

Department of Mechanical Engineering



**Team members:**

Clarice du Toit  
Gregor McIntosh  
Jack Owles  
Briana Steven

**Client:**

Dr Johann Zwirner


**Supervisor:**

Prof Mark Jermy

**Associate contributions:**

Garry Cotton  
Tony Doyle  
Bill Mohs  
Julian Phillips

Department of Anatomy  
School of Biomedical Sciences



M28 University of Canterbury Motorsport  
UCM21 Chassis



Chassis Objectives

- + Design and manufacture a rules compliant carbon fibre monocoque chassis.
- + Consider the novel accumulator packaging concept, aerodynamic package integration, and thermal management capabilities in designing the geometry.
- + Optimise the carbon fibre layup schedule to reduce weight while retaining a target torsional stiffness.

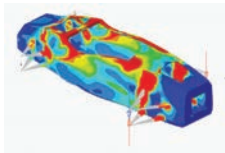
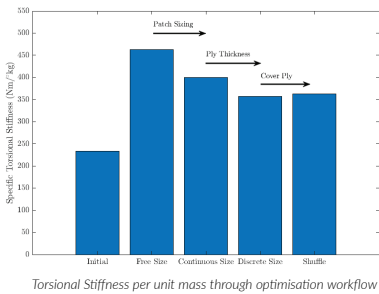


Design and Manufacture

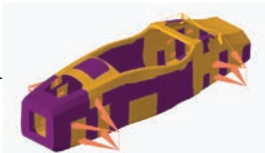
- + Single piece carbon fibre monocoque with aluminium honeycomb core material.
- + Three-axis routed positive MDF plugs and negative carbon fibre moulds.
- + Laminated front roll hoop and bolt-on main hoop for roll over protection.
- + Novel firewall setup to protect driver from high voltage components while ensuring comfortable driving position around the accumulator.
- + Undertray profile and diffuser incorporated into chassis geometry.
- + Large access hatches for easy maintenance on internal components.

Analysis and Optimisation

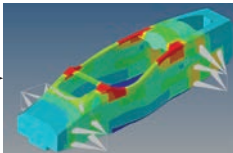
- + Three stage optimisation procedure of the carbon fibre layup schedule in Altair Hyperworks.
- + Free size optimisation determined a laminate design concept, which was followed by the addition of manufacturing constraints.
- + The layup schedule and patch shapes were exported and converted into templates, which allowed accurate reproduction of the optimised layup.
- + 37% increase in torsional stiffness per unit mass. Final torsional stiffness of 5100 Nm/°, in line with target value for desirable suspension behaviour.



Free Size Optimisation



Patch Sizing



Sizing Optimisation

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1200	1200	1200	OK

Shuffle Optimisation

Client: University of Canterbury  
Supervisor: Digby Symons  
Students: Felix Edgar, William Rangi

Faculty Advisor: Bruce Robertson  
Contributors: Garry Cotton, Adam Waterhouse,  
David Read, Max Zhang, Jono Kidson



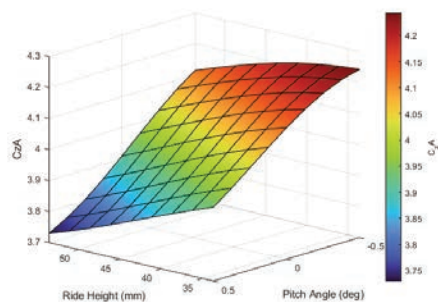
# Student projects: Mechanical Engineering and Mechatronics Engineering

## M29 University of Canterbury Motorsport UCM21 Aerodynamics



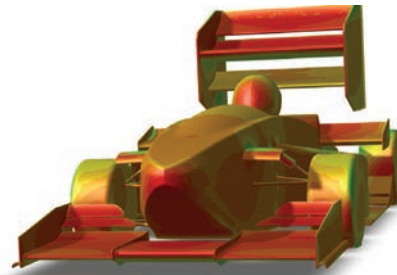
### Aerodynamic Objectives

- + Improve vehicle dynamic performance with high aerodynamic efficiency and minimal design sensitivity to pitch, roll and yaw degrees of freedom.
- + Enhance cooling air flow to thermally-limited components to address heat management and reliability pitfalls.
- + Enable package tunability to trim vehicle performance across a range of various low-speed dynamic events.



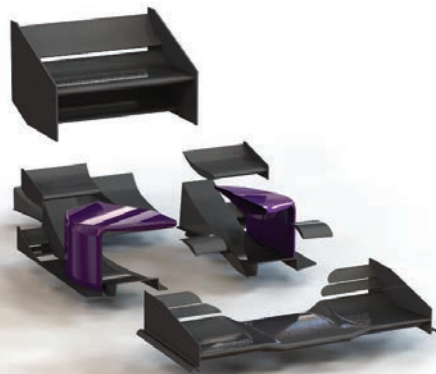
### Features

- + Triple element, adjustable front and rear wing to tune handling characteristics.
- + Aerodynamic elements on the side of the vehicle to enhance duct extraction and improve centre of pressure migration in cornering.
- + Vehicle layout optimized to exploit ground effect.



### Design Process

- + ANSYS Fluent CFD-driven design, improvements characterized using lap simulation software.
- + Package configuration generated using optimal space-filling design response surface, interfacing with weighted multi-objective output.
- + Wind-tunnel-validated and track-tested design.



### Final Design

- +  $C_L A$ : -4.15 m<sup>2</sup>
- +  $C_D A$ : 1.09 m<sup>2</sup>
- + Lift to Drag ratio: 3.78
- + Total downforce at 100 kph: 1920 N
- + Aero Balance: 46% front, 54% rear

Client: University of Canterbury

Supervisor: Dan Zhao

Students: Jared Brown, Lev Chernyshev

Faculty Advisor: Bruce Robertson

Staff: Zac Perston, Bill Mohs, Adam Latham

# UCM



# FATIGUE IN 3D-PRINTED TITANIUM

## Purpose

The suspension arm on the Rodin F-Zero utilises flexing joints made from 3D-printed titanium alloy (Ti-6Al-4V). The aim of this project is to test and determine the fatigue properties and compare the effects of surface coatings and finishes, and to design and build a fatigue testing machine for an entire suspension arm for Rodin to use.

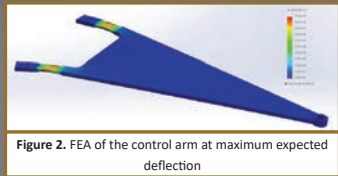


Figure 2. FEA of the control arm at maximum expected deflection



Figure 1. The 5 surface finishes/coatings tested in this

## What is Fatigue?

Fatigue is the initiation and propagation of cracks through a material under an oscillating load.

## Fatigue Testing:

Fatigue testing was done using four rotating bending machines. Samples were loaded with systematically varied stress amplitudes, and tested to failure with the number of stress cycles to failure recorded. The machines run at 50Hz. Test duration varied from 5 minutes to over a week. Summary data is shown in Figure 3.

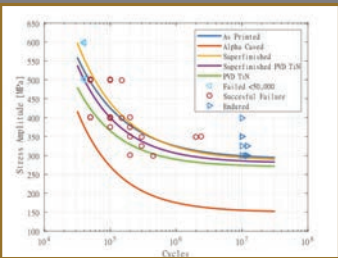


Figure 3. Comparison plot of the fatigue test results with data points from the as-printed samples showcasing data spread

## Testing rig:

The custom fatigue testing rig was designed to be strong and rigid and was made from welded SHS steel sections. An Arduino controlled LinMot solenoid actuator was chosen as the force driver, delivering a maximum force of 255 N at a frequency of 4.5 cycles per second.



Figure 5. The custom suspension arm fatigue testing rig

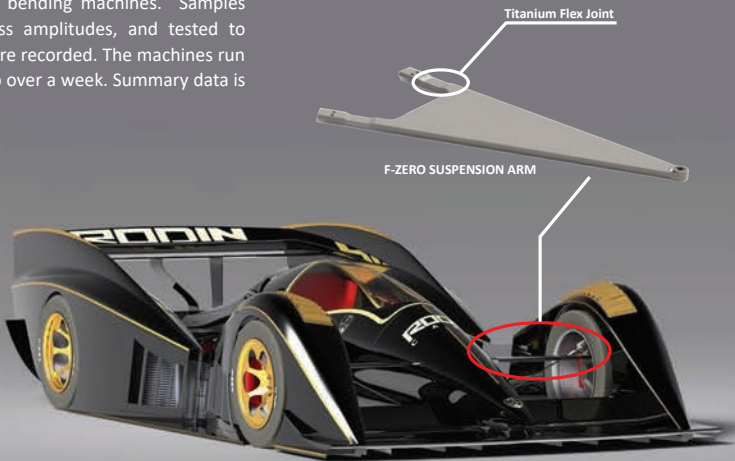



Figure 4. Fracture surfaces of an As Printed sample (left) with SEM image showing the defect that initiated crack (right)

## Findings:

Our testing shows that 3D printed Ti-6Al-4V has lower and more unpredictable fatigue properties when compared to wrought Ti-6Al-4V. Superfinishing acted to positively impact the fatigue strength whereas PVD TiN coating reduced fatigue properties. Components that have been alpha-cased are significantly more susceptible to fatigue. The custom fatigue rig should be used to prove the control arm flex joint concept to see if it can reliably withstand the loading in the FZero.



# NICU INNOVATIONS

NOVEL DESIGN FOR NEONATAL INTENSIVE CARE UNIT THERAPIES

## PURPOSE

### Umbilical Arterial Catheterisation (UAC):

300+	10 min - 2hrs+	3+ hands	12%	7.3%	\$88M
Procedures in New Zealand annually	To insert an umbilical artery catheter	Are required to perform UAC	Failure to insert catheter	Die or have permanent impairment as a result	Cost in life

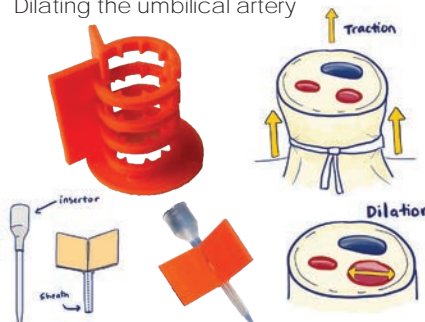
### Endotracheal Tube (ETT):

1000	?	Inaccurate	Life long
Neonates require ET ventilation in New Zealand annually	Unknown volume of air leaks back through the airway	Readings of volume delivered on ventilator	Effects from tracheal wall damage


### UAC Selected Designs

The two-device solution improves UAC by:

- Applying traction to the umbilical cord
- Dilating the umbilical artery




The split-sheath design allows for clean and easy removal from the catheter after use.




These devices reduce the number of doctors required, operation time and complications.

### ETT Concepts

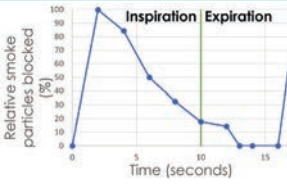
3 row wide flap



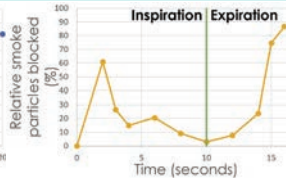
3 row narrow flap



### ETT Validation and Results

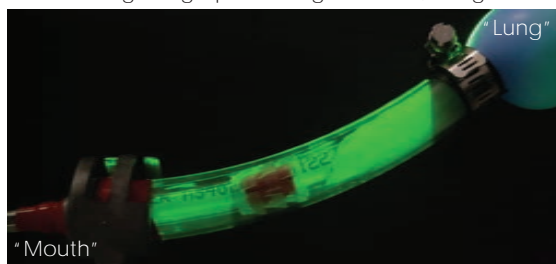


3 row wide flap



3 row narrow flap


The percentage of smoke particles blocked from leaking was calculated relative to the empty test apparatus. These values were found using image processing software, ImageJ.



Smoke visualisation testing apparatus.

### UAC Validation

Testing on a phantom umbilical cord found the devices can be easily placed and inserted. The time taken to perform UAC was reduced to less than one minute.




### Canterbury

District Health Board  
Te Poari Hauora o Waitaha

Client  
Dr Matt Wallenstein (CDHB)

Team  
Rachel Budgett  
Josie Dixon  
Trudy Caljé-van der Klei

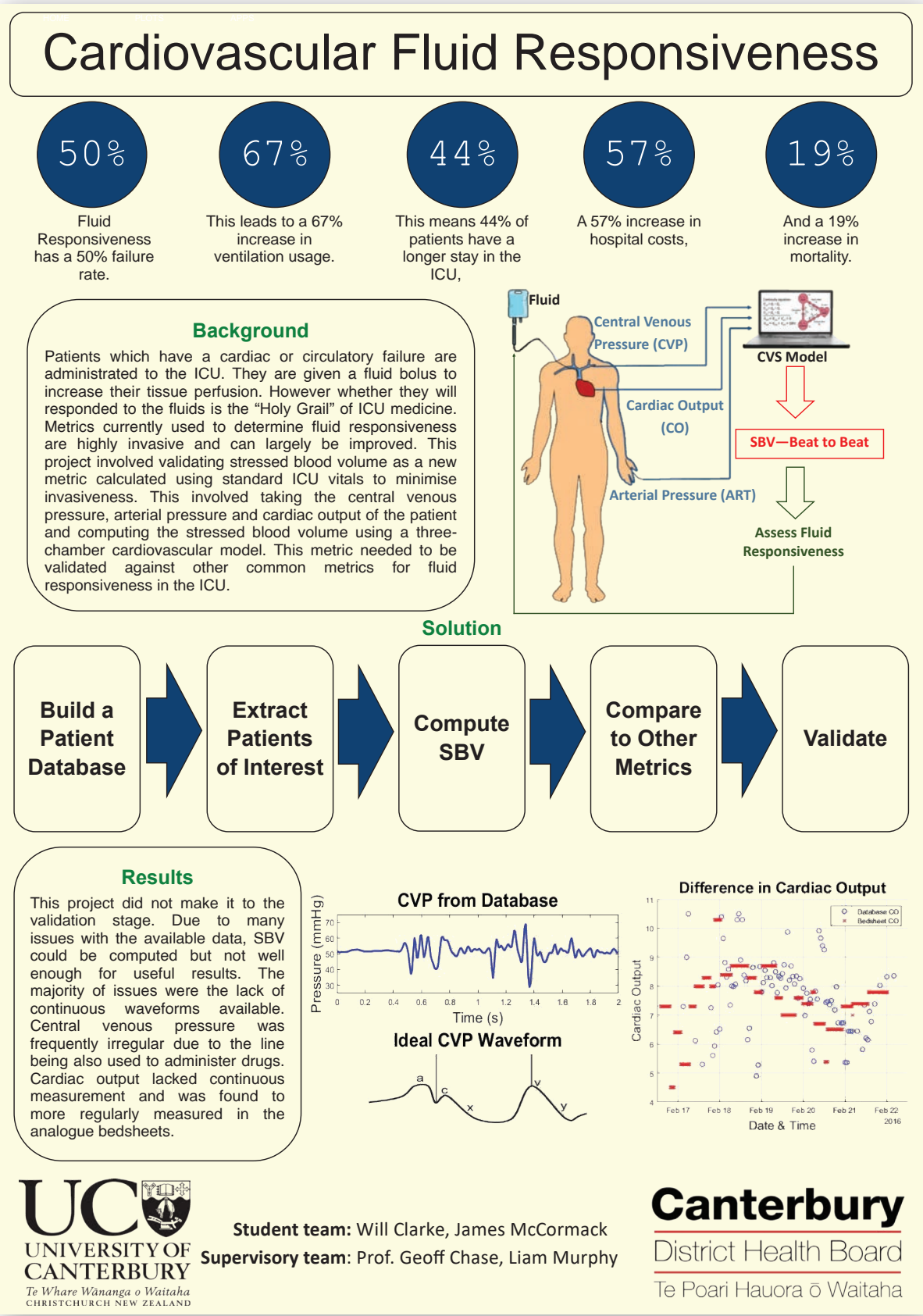
Supervisors  
Dr Geoff Chase  
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Student projects: Mechanical Engineering and Mechatronics Engineering





# Rail Stress Measurement Project

### The Problem:

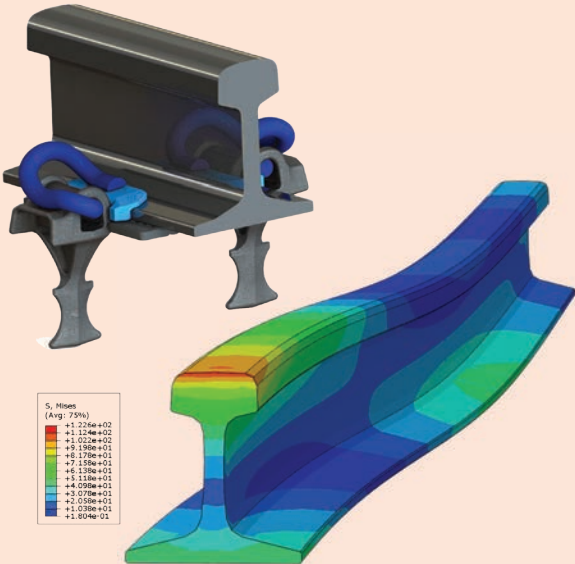
Modern continuous rail systems undergo varying stresses due to thermal cycling. To manage this, the Stress-Free Temperature (SFT) of the rail must be kept near the midpoint of rail temperature fluctuations. If the SFT decreases too much, the compressive stresses can cause buckling. KiwiRail periodically measures the SFT in the rail to keep within safe limits. The current test method is time-consuming as requires 20m of rail to be unfastened from sleepers.



Example of a buckled rail caused by thermal expansion in Victoria, Australia.

### Aim & Objectives:

- Reduce unfastened length required to perform SFT testing, and improve rail lifting mechanism. This will be achieved through:
1. Research
  2. Site-visit and preliminary results
  3. Finite Element Analysis and modelling
  4. Verification of models and simulations
  5. Findings and recommendation



Top, CAD model of fastened rail [Pandrol].  
Bottom, FEA model of displaced rail. Units in MPa



RailFrame equipment being used to measure force

### Outcomes and Next Steps to stay ‘On Track’

Experimental testing on the main south line and initial analysis determined that the non-linear problem of shortening the unfastened rail must be solved through finite element analysis. These analyses have shown that inaccuracies in the measurement are amplified when the test length is shortened, so more precise test techniques or accurate measuring equipment may be necessary to reduce testing times.

The RailFrame procedure must include a balance of operational requirements to improve testing times whilst maintaining and/or improving force measurement accuracy. Results thus far suggest a test length of 16m is possible while maintaining accuracy. This length may be able to be refined even further, which will be the focus of future on-track testing.

FYP M34, 2021



**Student Team**  
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Ollie Strang  
Samuel Hewitt

**KiwiRail Team**  
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Mark Fleet  
James Kynaston  
Rob Harris

**Supervisor**  
Assoc. Prof.  
Mark Garnich  
**UC Technicians**  
Tony Doyle



### Concrete 3D Printing

Concrete 3D printing is a form of additive manufacturing (AM) used to create structures in **new shapes** not previously possible, in a **faster, cheaper, and more environmentally friendly** manner. This project was formed with the goal of designing a **portable, simple, and low-cost** concrete printer capable of printing modular housing, furniture, and artwork.

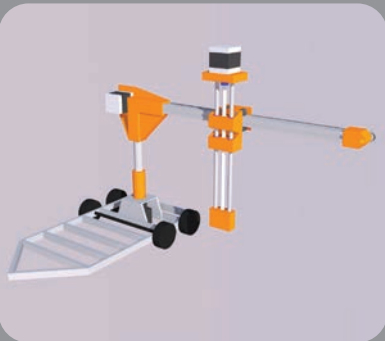


#### Current UC 3D Printer

- Utilised to study concrete AM and its challenges.
- 8 litre print capacity, 1.5m x 2m x 1.5m (LxWxH) print volume.
- Use of PrusaSlicer software allows for printing of any STL file.
- Highly customizable for printing of various cementitious materials.

#### Full-Scale Concept Design

- Concept design completed for full-scale printer.
- A trailer mounted system printing in cylindrical coordinates was selected.
- Allows for a large print size to be completed in a simple, low-cost, and portable manner.



#### Scale 3D Printer

- The scale model was developed to replicate the full-scale design, and will be used to explain the underlying concepts and benefits of the design.
- Manufactured using 3D printed and laser cut components, including scaled parts indicative of those used in the larger design.

# BLAIR'S ADAPTIVE TRIKE



## PROJECT OBJECTIVE

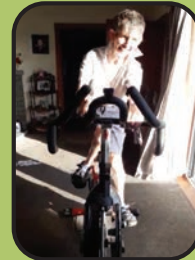
To design and build a rolling chassis for an adaptive mountain bike that allows Blair (who has Cerebral Palsy) to go mountain biking with friends. The bike was designed so Blair can operate it independently.

### Research Areas:

Cerebral Palsy  
Quad wheel vs trike  
Upright vs recumbent seating  
Existing market options.

### Testing:

- Pedal strength
- Step height
- Upright balance
- Grip strength
- Mount/dismount
- Steering range of motion



### Modelling and Design:

The design was modelled from start to finish using Solid works. Loading calculations were done on each of the members to determine appropriate sizing and material selection.

### Trike fitting Discoveries:

The steering mechanism was light enough for Blair to comfortably steer with his strong arm.

The turning circle was sufficiently manoeuvrable while minimising body roll

The seat was remounted further forward to allow Blair to reach the pedals better



### Next steps:

The next for this rigid prototype is to develop and build a suspended version of the trike so Blair is able to take it mountain biking. Adaptations will be made to the frame of the current bike to achieve this.

Sponsored by: **wattwheels**  
"POWER TO THE PEOPLE"

Client: Shayne Crimp  
Supervisor: Digby Symons  
Technician: Tony Doyle  
Student Team: Fin Tse, Sam Hall,  
Jackson Stewart, Gareth Wadsworth

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CHRISTCHURCH NEW ZEALAND



# M38: MANUFACTURE AND TESTING OF CONTRA-ROTATING DRONE PROPELLERS

Highly swept propeller blades

Contra-rotating set of blades

Variable pitch propeller hub

6-axis force measuring device

Developing methods to manufacture highly swept propeller variants and test their aerodynamic performance

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**Client:**

Dr Michael Kingan

**Special Acknowledgments:**

David Read

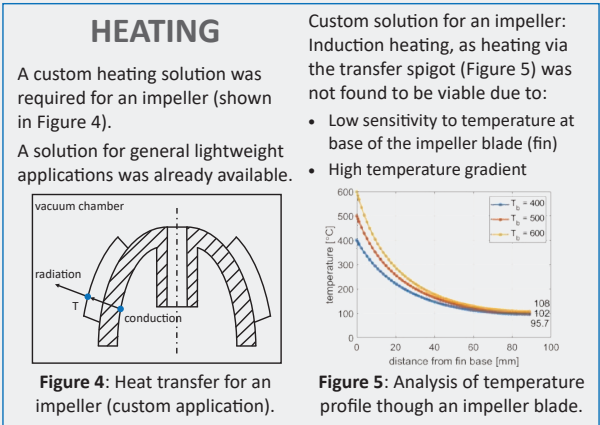
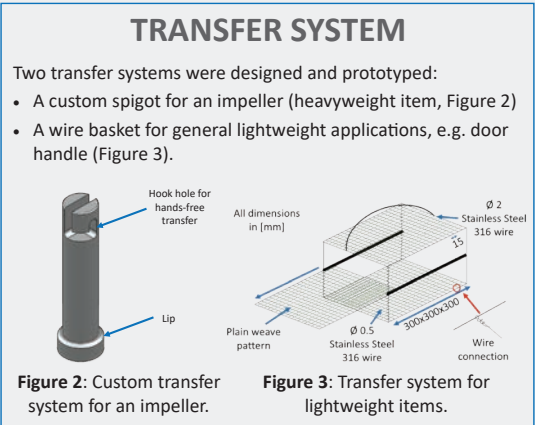
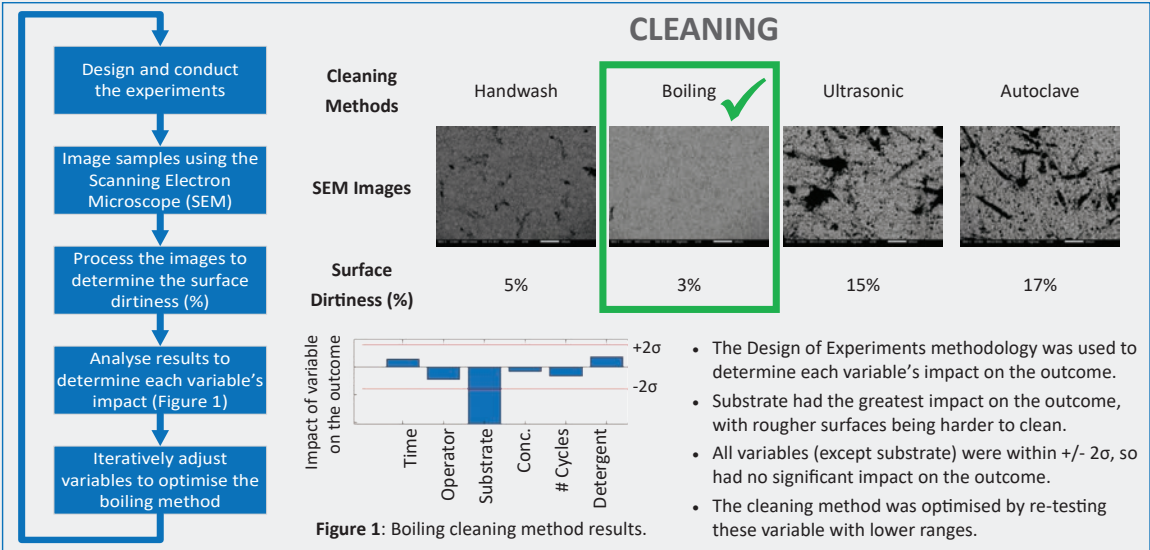
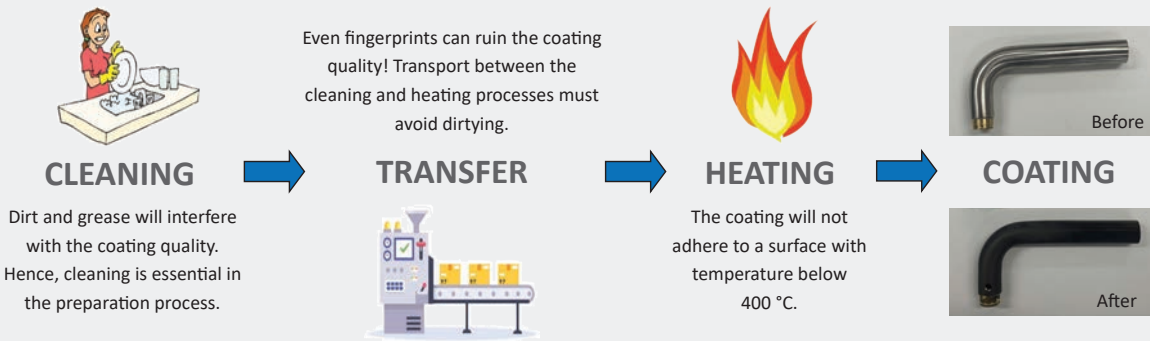
Bill Mohs

Julian Phillips

Ben Murton

# MANUFACTURE OF CORROSION RESISTANT COATINGS

Aegis Ceramics sought a new, state of the art preparation process for their **pulsed pressure metal organic chemical vapor deposition** (PP-MOCVD) coating process. The new preparation process was to be semi-automated (for general and custom applications) and include:



# Automation in the Powder Coating Process

## Problem Statement



The aim for this project was to advise the client, ENI Engineering Ltd, on pathways for progressing the current manual powder coating lines into an automated system that would increase efficiency and accuracy of the process while lowering long term costs. The team analyzed four major aspects of the current manual process: pre-treatment, hanging strategies, quality control, and powder application.



## Laser Cleaning

Parts require thorough cleaning before they can be powder coated. Laser ablation cleaning was identified as a viable automated cleaning method for several reasons:

- It is easy to automate
- It can selectively re-move material
- It does not require solvents or chemicals
- It can be used to texture surfaces for better powder coat adhesion

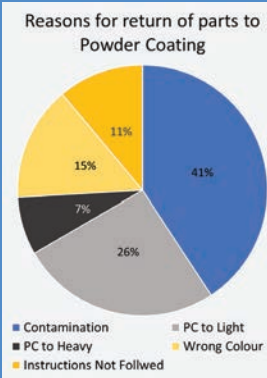


## Hanging Strategies

- Hooks must be made from materials with good conductivity to ensure proper grounding.
  - Must have good strength to weight ratio as less hooks used the less spots are missed due to the hooks covering them during the powder coating process.
  - Copper plated steel hooks were investigated as they provide great conductivity and strength allowing objects daisy chained together for powder coating
- Objects daisy chained together for powder coating
- Objects to be daisy chained as seen in the figure on the right for longer chains. However these hooks are too expensive for the objects ENI are coating as they have finite use.



## Quality Control



- 5 common reasons for return were identified from ENI's QC data.
- Using an ultrasonic thickness gauge to set parameters on the first part of a batch will eliminate ~33% of returns
- Digitally labelling parts and IoT communication between plant will reduce human errors.

## Powder Application

The team believes the following two methods are the most effective for autonomous powder application.

### ➤ Reciprocating Guns:

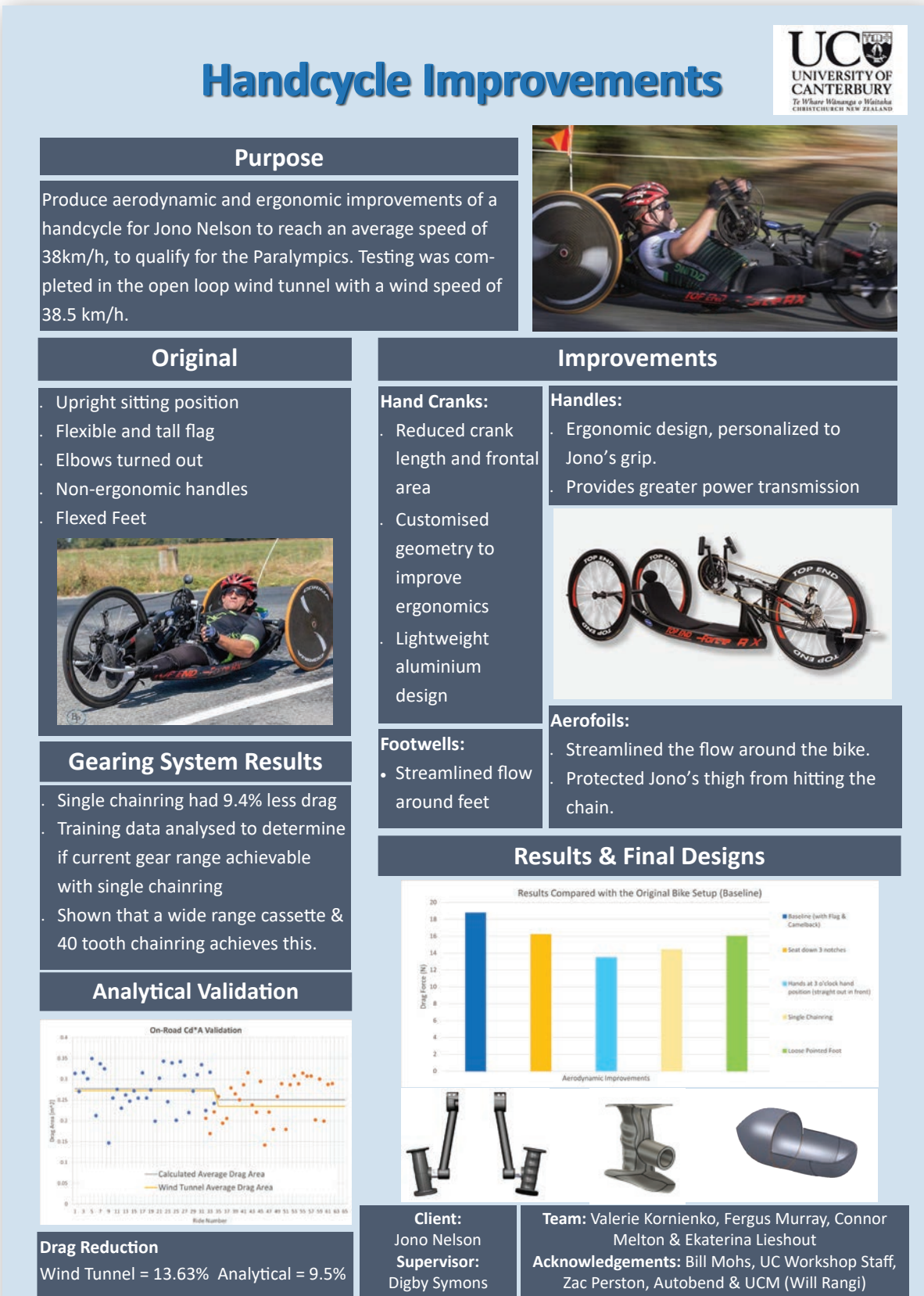
- Advantages: Fast, easy to integrate into existing system, simple control
- Disadvantages: Lots paint used, slow color change, not good for complex designs

### ➤ Co-Bot:

- Advantages: Can work around people, versatile as are 'taught' through human motion.
- Disadvantages: Need to be taught for every new part.







LOW-QUANTITY CUSTOM SEAL MANUFACTURING

Project Objective:

Develop an economical process for the manufacture of custom Polyurethane seals in low quantities (0-100 units). Finished products must have comparable porosity to mass-produced industry parts.

Motivation: Pacific Seals Ltd. distribute and manufacture hydraulic and pneumatic seals and cannot manufacture custom low quantity seals on site. Seals are often made from Polyurethane, with harder material seals machined from cylindrical billet. Softer Polyurethanes (<90A Shore) cannot be machined from billet due to excessive deflections. Open casting has been trialed, however this leaves significant air pockets on sealing edges making the product unusable. Overseas manufacturing is costly and time consuming for low-quantity orders.

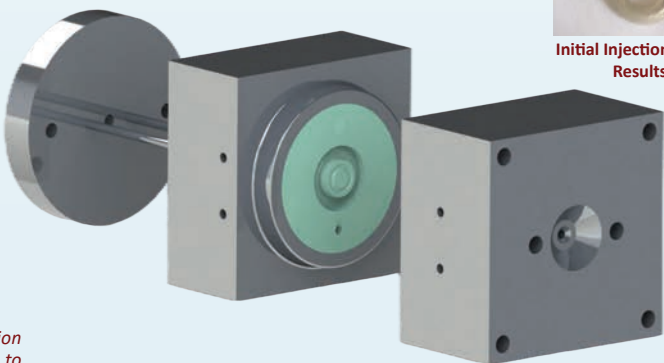
Process Option 1

— Injection Moulding (Thermoplastic Polyurethane):

Common method used in industry for mass-production of seals. Most injection moulding processes utilize aluminium dies as these are robust for high cycle numbers. These are expensive as a new die is required for each profile. 3D-printed photopolymer mould inserts were trialed due to proven low-cycle performance and low cost. This meant that the costly aluminium die could be reused for a variety of profiles.

Process Option 2 —Vacuum Casting (Thermoset Polyurethane):

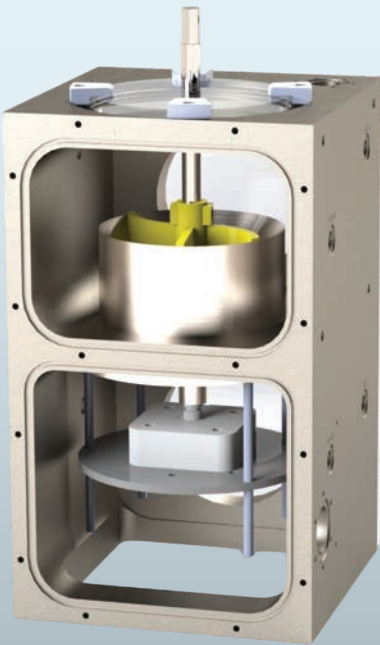
Common method used to produce high resolution plastic prototypes. It has not yet been applied to seal man-



Injection Mould Die Assembly (Aluminium Dies with 3D-Printed Inserts)



Initial Injection Mould Results

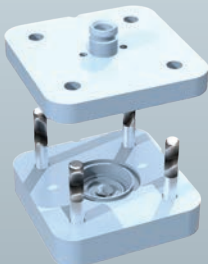


Dual Vacuum Chamber Assembly

Dual Vacuum Chamber

Casting Process:

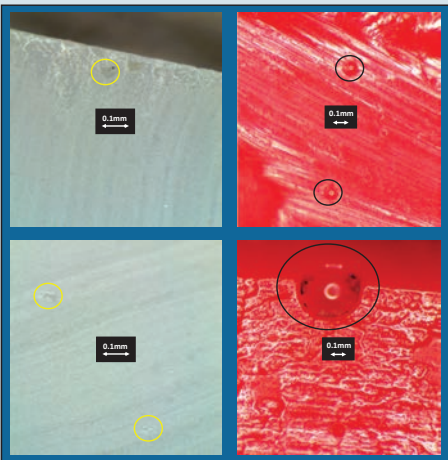
- Vacuum used to degas resin parts in upper chamber prior to mixing. Resin is then mixed in a funnel using a hand driven stirrer.
- Stirrer is lifted, opening a channel for Polyurethane to flow into the mould.
- Differential pressure between upper and lower chambers is created using an atmospheric vent in the upper chamber to ensure the material fully fills the mould cavity.
- The chamber is then fully vented to atmosphere to allow removal of filled mould. The part is then oven cured.



Vacuum Casting Mould Assembly

Vacuum Casting Results:

Trials using a single chamber were conducted to prove the concept. Samples produced were compared in porosity to open-cast samples under an Optical Microscope. Vacuum casting was found to be superior, with significantly lower frequency and size of voids (up to 70µm diameter) compared to open cast samples (up to 200µm in diameter).



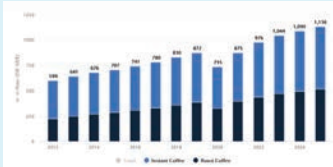
Microscope Images of Seal Porosity (Circled) From Vacuum (Left) and Open (Right) Casting Processes

# VIBREW

## IMMERSION COFFEE BREWING DEVICE

### MOTIVATION

- Growing coffee industry (market need)
- Flourishing start-up space

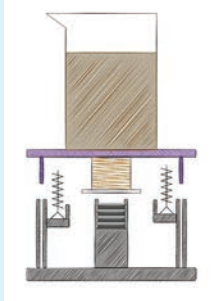


Coffee revenue in New Zealand

### CONCEPT DEVELOPMENT

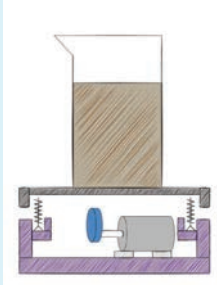
Vibration Enhanced Coffee Brewing:

Using frequency vibration to improve brew quality, break the crust on top of the brew, and reduce brewing time.



#### Solenoid Vibration table

- Flat plate supported with return springs
- Copper wire coil encasing magnetic solenoid
- Pulsing current = frequency vibration of top plate




#### Cam Vibration table


- Flat plate supported with return springs
- Brushless DC motor rotates off centre cam in contact with top plate
- Constant rpm = frequency vibration of top plate

### TESTING

Comparing extraction yield % (coffee brew strength) to industry recognised limits.




Extraction yield: French Press 3




### FUNCTIONAL PROTOTYPE

Display model design | Proof of concept

Solenoid Vibration Table



1. Statista, “NZ Coffee Consumer Market, Revenue”, (2020)  
FOR: DR. JAMES RAMSAY  
BY: TAINE THOMPSON, POPPY HOLMES, MAX INWOOD AND PATRICK BELL.  
SUPERVISOR: DR. MATHIEU SELLIER



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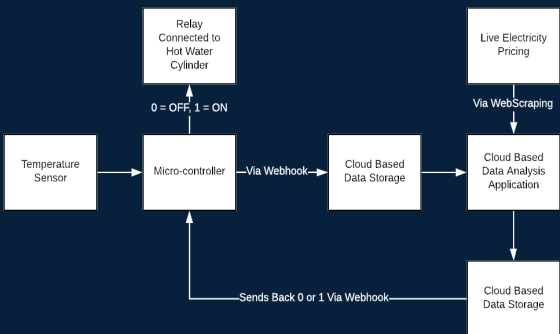
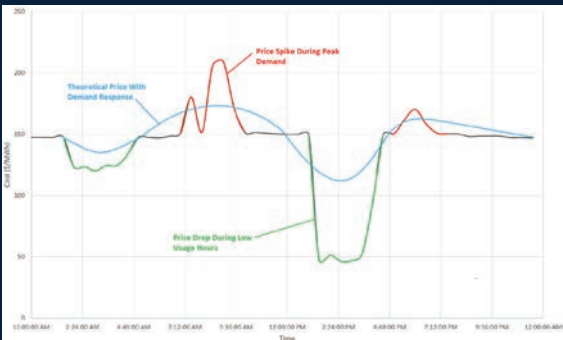


# HOT WATER CYLINDER SMART CONTROLLER

**Project Brief:** Design and produce a retrofittable hot water cylinder smart controller that uses live spot prices to implement demand response at a domestic level.

## Objectives:

- Price responsive retrofittable device.
- Device moves electricity demand to times of high renewable energy generation.
- Produces electricity savings by shifting the hot water cylinder (HWC) heating periods.



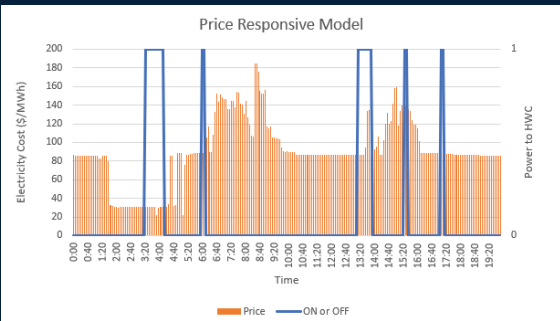
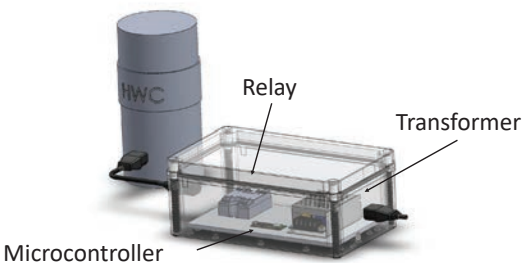
## The Device

- Device can be easily installed to existing hot water cylinders.
- Device will pay itself off within two years
- A microcontroller takes temperature readings, and switches the hot water cylinder on and off
- Analysis and data storage is done on cloud based services.

## Findings

- Standing losses determined to be negligible.
- Temperature sensor (DS18B20) mounted to uninsulated panel adjacent the mechanical thermostat is accurate within 3°C of outlet water temperature.
- The use of temperature sensors and energy balances to evaluate mass flow through the cylinder is inconsistent due to mixing and stratification in the hot water cylinder.

Solid Works model of device (No wiring shown).



## What's next?

- Developing a complex, price based model.
- Research into trends regarding household hot-water usage.



Student projects: Product Design - Applied Immersive Game Design



# Getting below 60:

## Finding ways to optimize Black Salt Game 's fishing game

### The Game

Dredge is a Lovecraftian fishing game in where you send your boat out and fish up strange artifacts and fish. Do quests from towns folk, find dark secrets, and make sure that you keep your sanity in check!

### The Goal

The goal is to find a performance overhead so that the game is 60 frames per second on the Nintendo switch. The game developers have already been working on optimizing the game, so am I able to find good ways to improve fps?

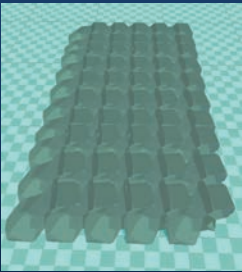
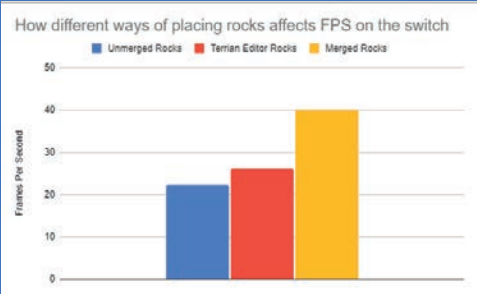


### Optimizing static prefabs

In unity, there are three different ways a person can place environment assets such as rocks in the world. You can place lots of rocks individually into the world, you can place them semi- automatically with unity's terrain editor, or you can set up and combine the rocks together in a separate program into one big model and then put it into unity.

#### Results

It was found that merging rocks together gave the best performance overall, however it is more difficult to implement compared to other methods.



Small version of the rock tests

### Textures

Having the smallest size and number of textures is incredibly important when optimizing for the Nintendo switch. The switch has a small amount of video memory, like a mobile device, so keeping textures small is important. Luckily, Black salt games has already made all of their textures very small, so there wasn't much to do there.

### A new FPS recording system!

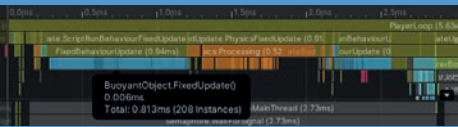
For this project, a new framerate recording system had to be made. This system records the average, the minimum, and the maximum frames per second and then posts it onto the screen. It will post multiple logs and is helpful when doing various tests. This new system will also be useful for the developers so they can see how well the game runs.

MIN: 121 MAX: 145 AVG: 128.3893  
Log 1 = MIN: 110 MAX: 148 AVG: 128  
Log 2 = MIN: 114 MAX: 150 AVG: 127.6667

### Cpu Bottleneck

When making a change to the shaders of the game, there seemed to be no difference in framerate for my desktop computer, even when the shaders were deleted! Why was that?

Usually that means that there was some sort of bottleneck causing the issue. Luckily, in Unity it is possible to profile the game to find these issues. After profiling, it was found that a buoyancy calculation script was taking a big proportion of time on the CPU, which means it had less time to give data to the GPU to calculate



Fixing the issue improved the performance of the game dramatically! Which was a very good success for the project. Always remember to check whether the code you make doesn't take too much processing time with the unity profiler.

### Black Salt Games: Art pipelines and optimisation

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**Interactable VR Music Performance**

**Troy Woods**  
Applied Immersive Game Design

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**Halcy Thomas**  
Applied Immersive Game Design

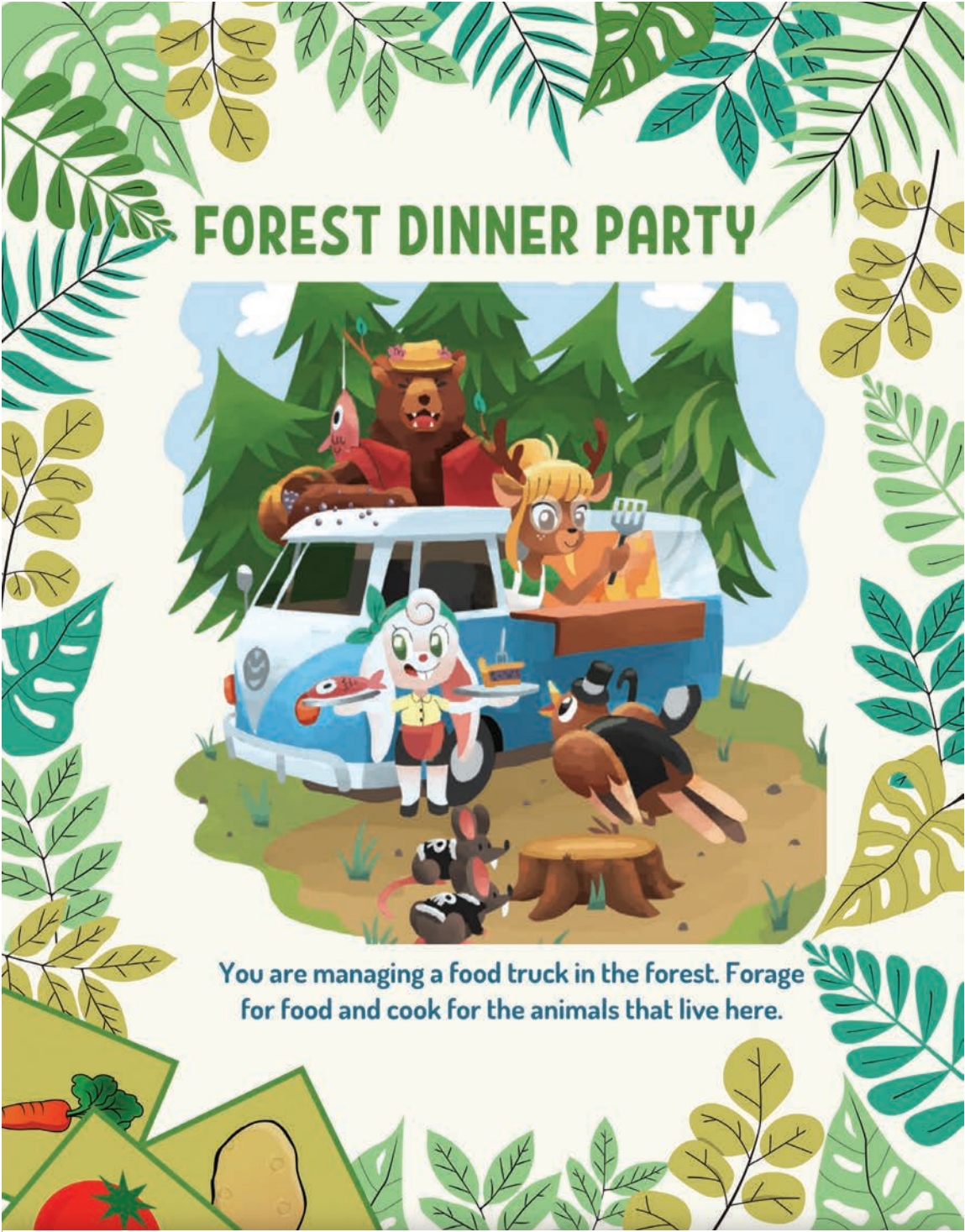
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A vibrant, cartoon-style illustration of a forest scene. In the center, a blue and white food truck is parked on a dirt path. A bear wearing a red shirt and a yellow hat is on the truck, holding a large fish. A deer with blonde hair and a green shirt is on the truck, holding a fork. A rabbit with a white body and a red shirt is standing in front of the truck, holding a plate with a fish. A dog with a black and white coat is sitting on the ground next to a tree stump. A mouse with a black and white coat is sitting on the ground next to the dog. The background features green trees and a blue sky. The entire illustration is framed by a border of green leaves and branches. At the bottom left, there are illustrations of a carrot, a tomato, and a potato.

# FOREST DINNER PARTY

You are managing a food truck in the forest. Forage for food and cook for the animals that live here.

**Forest Dinner Party**

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Student projects: Product Design - Applied Immersive Game Design








# Deep Dive



### Project Brief

Runaway Play is looking to prototype their new on-rails photography game idea 'Deep Dive'. In Deep Dive, the player uses a submarine to explore the depths of the ocean and take photographs of its inhabitants. They can discover different species and capture unique behaviours to unlock boosts and upgrades.





Clam

King Crab

Fishes

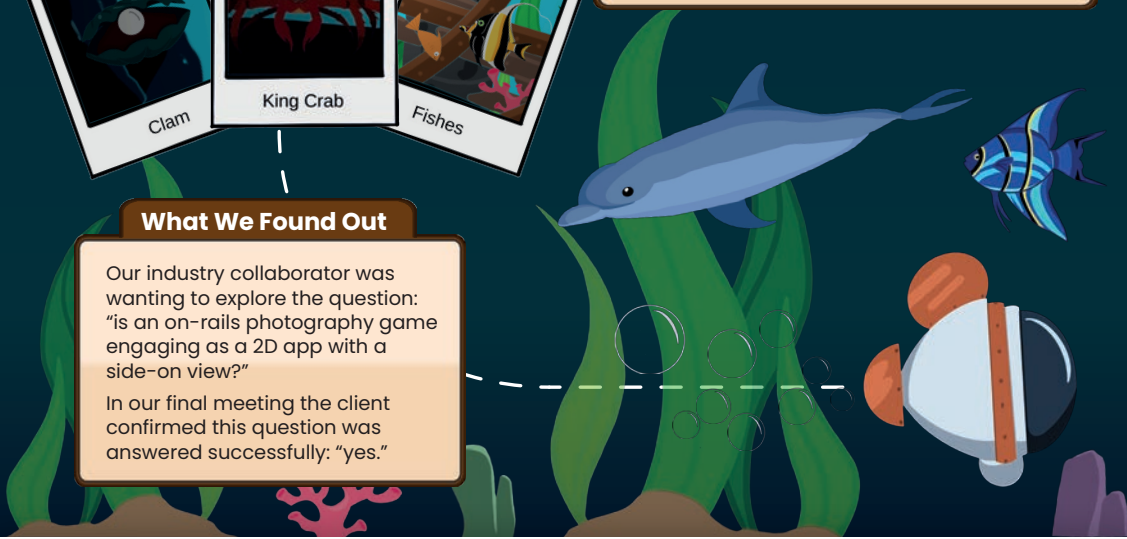
### What We Achieved

- Implementing the core game mechanics
  - taking pictures and camera control.
- Creating an expedition
  - submarine movement and photo scoring.
- Adding basic metagame
  - upgrading and customisation.

### What We Found Out

Our industry collaborator was wanting to explore the question: "is an on-rails photography game engaging as a 2D app with a side-on view?"

In our final meeting the client confirmed this question was answered successfully: "yes."



## Deep Dive

Binyang Han | Melissa Ta | Timothy Wilson

Applied Immersive Game Design

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# Underwater Movement Mechanics IN VR

**Introducing the VR Underwater Movement System.**  
Create breathtaking underwater experiences in virtual reality effortlessly with our new locomotion system.

**The system includes two production ready mechanics:**  
The submarine to ride in style, and simulated flippers for a truly immersive swimming experience.  
Also included are many other systems and virtual devices to get your players moving, such as powerful underwater currents and underwater scooters.



**The system includes a robust swimming animation system that dynamically reacts to the movement of your player's character through space.**

**The IK enabled avatar will kick their legs in time with your inputs and sit down correctly as you climb into vehicles.**



**Explore the depths of the ocean in a search for lost artifacts with the sample minigame, Included to showcase the strengths of each movement mechanic.**

**You must search for underwater locations of interest using your fast moving submarine, before exiting the vehicle and searching the area for the dagger.**  
Once it is found, you may return to the submarine and add it to the collection wall inside.



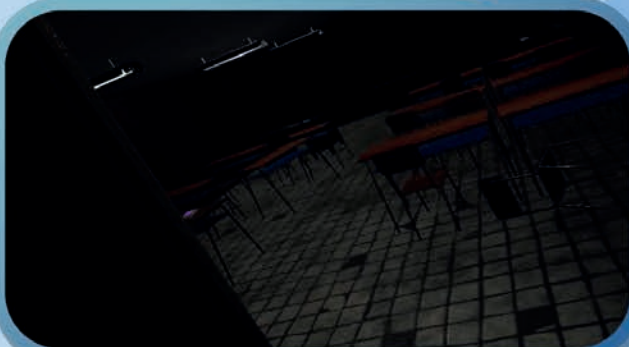


**Underwater Movement Mechanics in VR**

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# Asymmetric VR Party Games

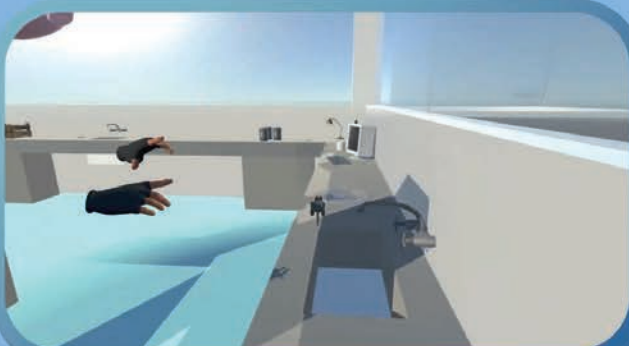
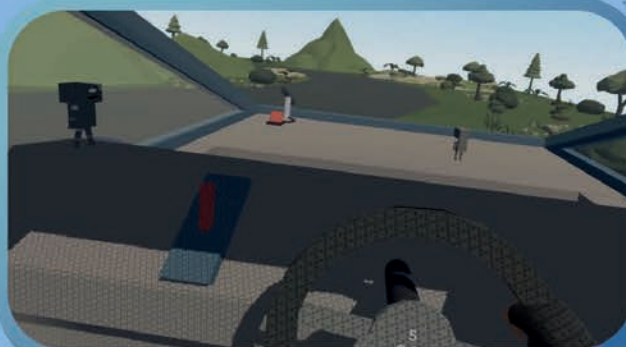


## Horror Puzzle Game

Make your way through an abandoned asylum, receiving help from some ghosts, solving puzzles along the way

## Car Fixing Game

Try and reach your destination while fixing your car before it breaks down



## Lab Rats Game

Play as lab rats and escape a mad scientist before they perform experiments on you!

### Asymmetric VR Party Games

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Adrian Taylor, Backyard Games

UC<sup>42</sup> PRODUCT DESIGN

St Anne's College  
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# INTERACTIVE PROJECTOR KIOSK

## BRIEF

This project is being done for my industry partner Giles Ostermeijer. Currently, The School of Earth and Environment have created a map display kiosk with a touch screen, 3D model of Aotearoa New Zealand, and a projector to project maps and animations onto the model.

## PROBLEM STATEMENT

How should I design the interface so that users will continue to use this Kiosk for their study or interests? And how to visually display data effectively to support the maps? How can I design and create a system that is easy to use and modify for future developers?

## PROJECT AIM

The purpose of this project is to redesign and create a new user-friendly and intuitive interface and add new features to visually support geological maps and data. I followed Nielsen's heuristics to guide my design.

## TARGET AUDIENCE

For the App, I was focused on two types of users, people who know some geography-related knowledge and looking to find a specific map/series of maps and people who do not have geo-related knowledge and are just curious and exploring the display.

## WHAT I DID

**Main Menu**

**Physical Geography Interface**

My idea for interface design is to keep the layout and information as simple as possible while conveying the main function information to the user. For the main menu, I used combinations of icons and texts to guide the user on how to interact with the interface and inform them what type of maps each button is related to by using icons. I keep the layout of each category interfaces the same. The type of map is displayed at the top and users can select more maps by clicking on the arrows on either side, or just sliding the map options. The text below it is used to introduce the information of the map. This is done to follow "Aesthetic and minimalist design", "Visibility of system status", "Consistency and standards" and "Match between system and the real world" from the Usability Heuristics.

## FEATURES

I have implemented three functions in this App, the first one is Video. By playing a video that is related to the current map content to the user, it can help the user better understand the content.

The second function is Graph and Charts, I think adding graphs or charts can better help users understand the data visually.

The third function is the slider. The user can watch a series of maps by sliding the Slider. I think the advantage of the Slider is that the user has the control and freedom to watch the changes of the maps at different time periods.

## CONCLUSION

I have managed to redesign and create a new interface for the Kiosk and three functions (Video, Graph, Slider) that can be edited by others. I will make sure that my project framework is able to be added and edited by other developers by including detailed documentation. Write details on how to add new tabs, graphs, sliders, videos, and how to run the application in the correct way.

### Interactive Projector Kiosk

**Kevin Wang**  
Applied Immersive Game Design

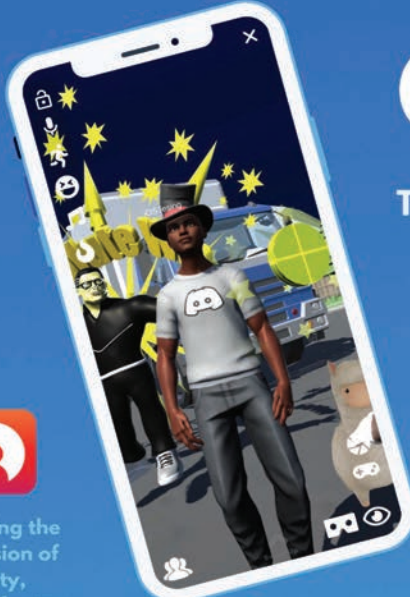
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INDUSTRY COLLABORATION  
Giles Ostermeijer  
The School of Earth and Environment  
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## Student projects: Product Design - Applied Immersive Game Design



# OASIS AR

THE WORLD'S FIRST AR SOCIAL AVATAR APP



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GET IT ON Google Play

Visit our website at: [www.matrixreality.app](http://www.matrixreality.app)


"Blending the immersion of reality, with the fantasy of dreams"

### What is the project?

Since the release of ARKit and ARcore in 2017, the mobile AR market has not seen a killer AR app. For this project, we set out to explore what the best use cases for AR are on mobile, and create the killer AR app for the mobile market.


### What did we create?

OASIS AR is the world's very first augmented reality social app for the smartphone market. Inside of our app, users can create a virtual avatar of themselves with millions of customizable options and get into immersive spatial calls with their friends. Inside of the calls, users will be able to see life-sized versions of their friend's avatar's project directly in front of them using AR, so they feel like they're in the same room as them, even while they are far apart. Together, they can play multiplayer games, explore majestic virtual environments and so much more, the possibility is endless!



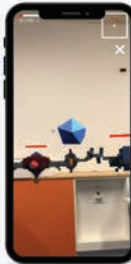
**See Life-Sized Avatars of Your Friend Directly in Front of You!**

WANT TO EXPERIENCE THE MATRIX?




**Create Your Virtual Look-A-Like with Millions of Options**

THE DEVIL WEARS WHATEVER YOU WANT IN OASIS AR!



**Play Fun AR Multiplayer Games with Your Friends**

IT'S LIKE YOU'RE IN A REAL ARCADE



**Explore Majestic Virtual Environments**

THE PANDEMIC CAN'T STOP YOUR HOLIDAY THIS TIME!

**OASIS AR**

David Huang  
Applied Immersive Game Design

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## EMDR DIGITAL EXPERIENCE

## WHAT IS EMDR?

**Eye Movement Desensitization and Reprocessing (EMDR)** is a psychotherapy technique typically used to treat Post-Traumatic Stress Disorder (PTSD), and other mental disorders. It is used to help decrease the intensity of distress experienced in response to a memory, thought, or feeling. This involves activating the two hemispheres of the brain, a process known as bilateral stimulation. This is normally done through visual stimulation using eye movement, but tactile/haptic, and auditory stimulation works too.

## PROJECT OBJECTIVE

The aim of this project was to recreate the EMDR exercise digitally so that techniques learned from learned during therapy can be practiced outside of clinic times. Due to timing constraints of the course, the focus was only on the Preparation Stage of EMDR. This is the part where the person mentally establishes or creates a safe space. This stage can also be used later on as a form of grounding or calming technique when distressed.

It is important to note that this system should be used in addition to, not instead of physical clinical treatment.

## RESULT

In this project, a digital recreation of the Preparation Stage of the EMDR process was developed using the Unity Game Engine. The system is able to provide three different feedback modalities which are:

- **Visual** - eyes tracking the ball moving left and right
- **Haptic** - alternating vibration of Xbox controllers
- **Audio** - a beep sound moving from ear to ear

This will allow the user to pick their preferred feedback mode. There is also the option to adjust the speed or frequency according to the user's comfort. All three feedback modalities are synced for ease of changing the mode.

The system displays a nature scene for those who find it difficult to come up with or create their own safe space.



*Example of the system set-up:* A standard desktop screen to display a scene with a ball tracker, two Xbox controllers (one for each hand), and headphones.

## EXPERT CONSULTATION

Due to the risks involved in testing on target users, expert consultation was conducted instead of user-testing. Two experts were spoken to, both clinical psychologists who are trained and currently practice EMDR with patients. The purpose of the consultation was to gain more insight as to how EMDR works, ask the experts about their own experiences with this form of therapy, and clarify system requirements.

## Findings

- There are differing views on the neurological underpinnings of EMDR - bilateral stimulation versus taxing working memory.
- There is an ever increasing need for remote consultation tools which support psychological trauma rehabilitation.

## FUTURE WORK

- Integrate EMDR protocols as guided tutorials to allow people to practice the Preparation Stage without human guidance.
- Research into differing views on the neurological underpinnings of EMDR and effectiveness of each.
- Conduct clinical evaluations of digital EMDR experience in conjunction with qualified clinical psychologists.



Scan the QR code to connect with me on LinkedIn to follow any future updates.

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## EMDR Digital Experience

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Student projects: Product Design - Applied Immersive Game Design

# WhoDunit?

Play on:  oculus



*You wake up the morning after a masquerade ball only to discover that the host has been murdered. Detained with several other suspects you must discover these strangers' darkest secrets.*

*Accuse or be accused, the murderer could even be you!*



WhoDunit combines multiplayer VR, procedural dialogue and real time text to speech to immerse you in the story.

Talk to other characters to find out more about them and yourself as your honest and false answers help you piece together character connections and backstories.

Eavesdrop on others, unraveling their lies and deceptions and discover the truth behind the mask.

WhoDunit?

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### 3D Minesweeper:

The perspective of user experience to research and redesign

Xiaojie Wang

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#### Abstract

This project aims to explore how about user experience when traditional 2D minesweeping games are converted to 3D mode. By analyzing and evaluating the existing 3d minesweeper games on the market to find out their problems and differences, try to optimize and improve the 3d minesweeper. Finally, through the user's play test, compare the finished product of this project with the existing 3d minesweeper game to get feedback.

#### Pre-Evaluation

The existing 3D minesweeper games are divided into 2 types.

1. "Half 3D": Using 3D environment or models but only have mines on the surface which is still 2D minesweeper game mode.
2. "Total 3D": Using 3D environment or models and have mines even inside the model, such as many small cubes form to be a big cube and each small cube may have a mine.

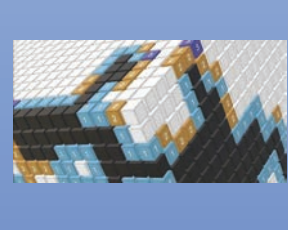


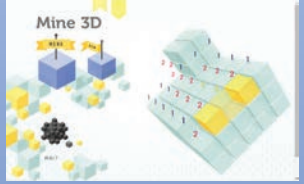

#### In Development




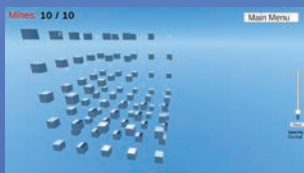
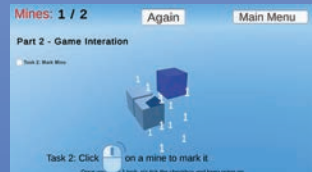
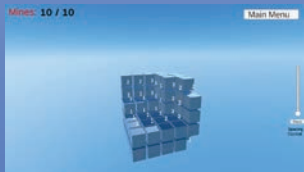


After implementing the basic game mechanic, start to add improvements to the game.

1. Customize level & difficulty setting.
2. More practical and understandable tutorials with task list to make the players feel more immersive and interactive.
3. Numbers inside the cube will keep face to the player while rotating.
4. A slider to control the space between cubes so that the player can easily interact with the cubes in the center of the big cube or been surrounded by many numbers.

#### Feedback and Summary

In fact, minesweeping games are not suitable for 3D mode. If the mode is retained in 2D plane, the game effect and user experience will be better. For ordinary players, a game that is too cumbersome and too difficult is obviously not attractive, unless it is a very small number of players pursuing challenges who would like it, even after the optimization of this project, the difficulty of 3D minesweeping is still too great.





### 3D Minesweeper

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Student projects: Product Design - Chemical Formulation Design



Kōaka – skincare range; An industry design project

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## Student projects: Product Design - Chemical Formulation Design



Natural      Non-toxic      Water based

Peita Waikano - meaning 'watercolour' in te reo Māori, offers a line of naturally pigmented paints using a combination of native plants, spirulina's and earth minerals to colour their products. Their watercolour palette comes with a selection of eight vibrant colours and is packaged in a recycled Rimu box. Also in the product line is a set of liquid paints in the primary colours. Their product's are non-toxic, hand-crafted and made with aroha. Creating a more sustainable and eco-friendly option for the artists and creative souls of Aotearoa.



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Student projects: Product Design - Chemical Formulation Design

# Effortless.

## DRINKS

**My mission is to make cocktails at home easier, enjoyable and more affordable. Providing a unique experience to be the new “go to cocktail choice.”**

**PRODUCT CONCEPT**

Effortless drinks are concentrated cocktail flavourings in solid and liquid forms. The user places the flavourings into a glass of their favourite alcohol and water to flavour and colour their drink. The products contain colour, flavour, fragrance, and glitter to enhance the drinking experience. The liquid flavouring is packaged in a convenient squeeze-snap package to easily pour the concentrated flavouring into your glass. The solid flavouring comes in a circular bomb which dissolves once it is placed in liquid, dispersing flavour and colour in an entertaining bubbling manner. These products are intended to be enjoyed alongside a social event such as a bridal shower, birthday party or even a dinner party with friends and family. This has shaped the brand identity to become social, mature and balanced.

**TARGET MARKET**

The target market are young millennials who desire a new drinking experience during a mature social event. This demographic typically have a stable routine and financial position which allows them to try new products. Their social circles enjoy using social media to share memories with friends and family while they are navigating through new experiences such as buying first

homes, getting engaged or milestone birthdays. The project is currently under final prototyping alterations in order for an MVP to be developed and sold in the near future.

**PRODUCT EXPECTATIONS**

These products are aimed towards consumers who desire an easy alternative to cocktail making. This means a product which is easy to use in every aspect, such as the use, packaging and storage. Consumers are also looking for a product with an authentic brand they can create brand trustworthiness with. Cocktails can be perceived as “hit or miss” when trying a new brand or flavour, so it is important to attract customers with a reliable product.

**THE PROCESS**

The prototyping process consisted of ensuring food safety regulations were complied as well as achieving the desirable taste and experience of consumers. Various surveys and consumer testing allowed me to optimise my understanding of these subjective variables. Other parameters consisted of testing stability, dissolution time for the solid formulation and ease of use.







Effortless drinks

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Student projects: Product Design - Chemical Formulation Design



Pregnancy Safe Skincare

Măe is a pregnancy safe skincare company that creates easy to use products that help improve skin during pregnancy. Unlike other pregnancy skincare brands Măe's products are designed to help with skin conditions caused by pregnancy such as acne, dry skin and melasma which occur on the face. The ingredients used are researched to ensure they are safe and effective at treating skin. Măe has a range that forms a simple skincare routine that is designed to be quick and easy to use. It has 4 steps including a foaming cleanser, hydrating serum, moisturising face cream and exfoliating clay mask.

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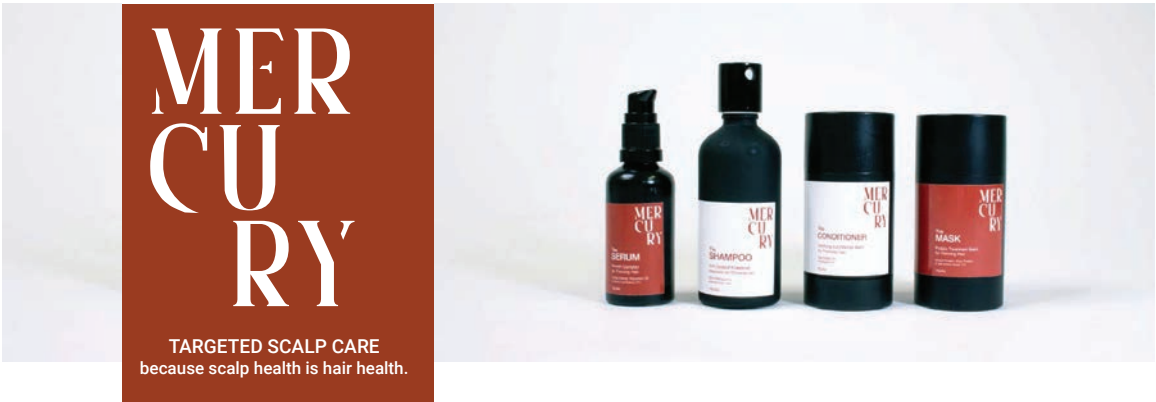


UC<sup>PRODUCT DESIGN</sup>





# Student projects: Product Design - Chemical Formulation Design



### PROPOSAL

Mercury is an innovative new scalp care range for adults experiencing the early stages of hair loss. Mercury aims to slow hair thinning in adults before it becomes irreversible later in life, valuing quality and synergy between products. Most of all, Mercury values creating confidence. Hair loss is something that seems uncontrollable and can be an insecurity that affects people's self-esteem. Rather than fight to reverse the natural course of aging, or promise to counteract our body's response to stress, Mercury offers products to slow hair loss, create a healthy scalp, and bring that control back to help people regain a part of their identity. The range includes four products which may be used separately or as a 3-to-4-step system depending on the consumer's needs.

### THE PROBLEM

Statistics show that 40% of men notice visible hair loss by 35, and 40% of women see hair loss by 40. To put it in perspective, that's around 480,000 Kiwi millennials. Hair loss can occur at any stage in the follicle growth process. Mercury products aim to improve follicle activity and create a healthy environment for stronger hair growth.

### THE OBJECTIVE

Mercury aims to solve a social problem by offering a solution to early onset hair loss. This will help individuals feel more confident about their appearance, because hair is a large part of our personal identity. Mercury also aims to avoid contributing to the current waste crisis, by offering recyclable and refillable products, formulated as concentrated as oils and balms to last longer than a standard hair care product.

The collection contains a shampoo, conditioner, serum and mask. Each product targets a scalp-related concern and works towards promoting healthy hair growth. Each also contains active ingredients such as rosemary oil to support hair-thickening claims and avoids the use of harsh or irritating ingredients such as SLS, excessive fragrance, colour, parabens, and allergens. Removing these ingredients was chosen to keep up with current consumer preferences, and positions Mercury as a "clean" haircare brand. Mercury is closely aligned a sustainable brand philosophy, so the product line is waterless and avoids unnecessary plastic packaging. The ingredients are naturally derived when possible. The product line will be distributed among hair salons and barbershops willing to partner with Mercury. It will also be available in pharmacies, department stores such as Farmers, and online through the Mercury website. We aim to have our products on shelves by August 2022, with potential to expand to Australia if successful in New Zealand.

### TARGET MARKET

The target market is adults aged from 30-45. This target market describes family-oriented working professionals with little time in their day, who may lead stressful and busy lives and struggle with the reality of hair loss. As this age group generally works full time, the product price range will be from \$25-\$45. While remaining competitively priced within the market, this price bracket softly communicates quality and efficacy to the consumer.



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### THE MASK

Mercury's strengthening protein hair mask is designed as a once weekly treatment mask for weak hair. It reduces breakage which helps hair appear fuller over time and works alongside the other Mercury products to encourage growth and restore hair density, priced at \$40 for 75g of product. The key actives are hydrolysed wheat and rice protein, silk amino acids, and the signature ingredient of the range, rosemary oil. It self-emulsifies from a balm to a milk with water, which prevents thin from being weighed down by excessive oils or too much product.

### THE SERUM

Mercury's serum is the product consumers go to for a hair-loss fix, despite its simple oil-based formulation. The difference between Mercury's serum and others on the market is that Mercury has a minimal, natural formulation with no unnecessary bulking ingredients. The hair oil moisturises the scalp and promotes growth with science-backed extracts. The oils were chosen specifically for their small molecule size which allow them to easily penetrate the hair shaft, and antioxidant activity to support a healthy scalp.

### THE SHAMPOO

Mercury's powdered exfoliating shampoo uses salicylic acid and zinc pyrithione to fight dandruff. The powder is travel-friendly and longer-lasting, increasing value for money. Salicylic acid is a chemical exfoliant for more effective removal of keratinocytes, while zinc pyrithione is an antibacterial and antifungal agent that targets dandruff-causing bacteria to reduce dandruff over time with consistent use. Rather than using concentrated actives, the shampoo promotes a healthier scalp, which gives the hair follicle a better environment for growth.

### THE CONDITIONER

The conditioner contains the light soothing oils found across the range and rosemary oil for hair growth, as well as panthenol to support healthy hair growth and oat bran extract. It is designed with sensitive scalps in mind, so nourishes and conditions the hair to add shine without overloading the scalp with actives. As it is designed as a wash-out product, some of the lighter oils from the balm were swapped for a heavier oil that would soften the hair after shampooing like coconut oil, which has a slightly higher molecular weight. The conditioner is priced at \$25 for 100g.

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University of Canterbury 2021



Student projects: Product Design - Chemical Formulation Design



supers berry lactation smoothie

150g net

6 servings

mumma's everything butter

thalavari • milk • thistle • moringa  
almond • sunflower • cashew  
flax seed • chia • pumpkin

nine . nine

this is a brand of functional foods for breastfeeding mothers that are convenient, delicious with scientifically backed active ingredients that support lactation. nine . nine mothers to grow healthy, strong babies but to also help end global malnutrition through donating profits to charities that actively work to reduce such inequalities. nine . nine is a vehicle for change and envisions a future where everyone can be happy, healthy and strong

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Student projects: Product Design - Chemical Formulation Design

# Restorative Cosmetics



### Restorative Cosmetics Mission

Restorative Cosmetics mission is to create products catered towards those who may be suffering from panic disorders, anxiety, stress, or depression and provide them an escape, outlet, and routine to help aid them in recovery. It could even simply just be as a coping mechanism or something that helps get them out of bed and through the day.

### Radiant Cushion Cream

The second initial product formulated is an extreme hydrating, 'radiance cushion cream'. The purpose behind this product is to help restore a glow back to the skin and help heal acne and sores that can be caused from an episode of panic attacks or severe anxiety. It is a thick cushiony texture to stick with the theme of unique feeling formulations to create a more fun and different user experience.

### Brand Concept

The main concept behind Restorative Cosmetics is to make colour cosmetics and skincare that work alongside each other to cure the mental and physical side effects of mental health through selected ingredients and art therapy.

The market Restorative Cosmetics is targeting is 18-25 females as this is the demographic that is most likely to suffer from panic disorders



### Jelly Shadows

For the first products, I'm going to make jelly eyeshadows. A pigmented oil in water formulation that is made to be spread across the eye using a finger or flat brush and reflect the light that hits it. The use of colour cosmetics works as a form of art therapy which helps to ground the mind and stop spiraling thoughts. I have made three shades, a peachy pink with gold reflects, a sheer purple with pearl and blue glitters dispersed through and a classic bronze.



Restorative Cosmetics

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Student projects: Product Design - Chemical Formulation Design

# ELEVATE

Brain Care System.

*Elevate is a brain care system that caters to stressed and busy individuals with high demanding lifestyles. The system is designed to care for the brain during every task throughout the day, by supplementing nutrients that are essential for the brain health, stimulating brain cognition to decrease stress and providing aromatherapy techniques to calm and relax a busy brain. The Elevate brain care system includes Energy Effervescent Tablets, Focus Capsules and an Aromatherapy Balm.*



### Why Brain Care?

Our brains are arguably the most important organ in the human body. They coordinate our actions and control our feelings. Everything that makes us human. Whilst we care for the other parts of our bodies, our brains are often neglected. Brain care elevates daily tasks resulting in higher energy, increased brain performance, and stronger cognition to increase overall productivity.

### Mission Statement

Elevates mission is to create a system for individuals to prioritise care of their brains and bodies, allowing them to excel in their daily activities without compromising their mental and physical health.

### Target Market

Elevate is aimed towards a target market of young adults in corporate environments, who lead busy and demanding lifestyles. These consumers have stressful lives and are looking for an outlet to destress, focusing on their mental and physical wellbeing without compromising their careers and other commitments.

### Step 1. ELEVATE ENERGY



The Elevate Energy tablet is formulated to care for our brains and provide sustained energy with raspberries, blackcurrants and blueberries which are high in antioxidants that protect your brain from free radicals in the environment, alongside polyphenols that can optimise brain function and increase cognitive performance. These berries are formulated alongside Japanese matcha, which includes the well known stimulant caffeine and the amino acid L-theanine to provide the brain and body with long-lasting, sustained energy.

**Ingredients**  
Coconut water, branched chain amino acids (2:1:1 leucine, isoleucine, valine), raspberry powder, sodium bicarbonate, sorbitol, organic Japanese matcha, blueberry powder, tartaric acid, blackcurrant powder, citric acid, beetroot powder, stevia, natural flavours.



### Step 2. ELEVATE FOCUS



Elevate Focus is a nootropic supplement formulated with ashwagandha, brahmi and algae oil to stimulate the brain, enhancing cognition and improving memory. This is an encapsulated formula that is designed to be taken during one-off moments where cognition, memory and focus are imperative.





### Step 3. ELEVATE CALM



The Elevate Aromatherapy Balm is designed to soothe tired skin and calm a tired brain through aromatherapy. The balm is formulated with 5 luxurious oils that are infused with kawakawa and arnica to provide the skin with anti-inflammatory effects which soothe an over worked body. The aromatherapy benefits are delivered from the essential oils of lemongrass, lavender, ginger and peppermint, which penetrate the nose to relieve stress within the body and brain.



**Ingredients**  
Simmondsia chinensis (Jojoba) seed oil, Helianthus annuus (Sunflower) Oil, Olea europaea (olive) oil, Cannabis Sativa (Hemp) seed oil, Oryza Sativa (Rice) Bran Wax, Candelilla Cera, Cocos Nucifera Oil, Macropiper excelsum (Kawakawa), Arnica montana (Arnica), Mentha piperita oil, (Peppermint) citratus (Lemongrass) Leaf Oil, Cymbopogon (Lavender) angustifolia (Lavender) Flower Oil, Zingiber officinale (Ginger) Root Oil, Citral\*, Citronellol\*, Linalool\*, Geraniol\*, Limonene\*

### Elevate – Brain Care System

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Student projects: Product Design - Chemical Formulation Design



WAVE Hair is a company based on providing a hair care range that caters for any gender with wavy, curly and coily hair. We want to create clean formulations that use ingredients that are backed by research to make sure that consumers are getting everything their hair needs and nothing it doesn't. The products' overall function is to hold, enhance and protect natural curls all day, every day against different environmental factors. The product line includes a shampoo bar, a conditioner, a hair oil, and hair gel. WAVE Hair brand commitment to their consumers is to ensure that clean formulations are produced as well as providing an education into why ingredients are chosen and what benefits they have in each product. The target market that WAVE Hair any gender aged high schoolers to late twenties, therefore, the products are affordable and gender neutral to provide satisfaction to consumers.

WAVE Hair- Curly Hair Range

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# Student projects: Product Design - Chemical Formulation Design



*Swimcare for swimmers.*

**ABSTRACT**  
Over 16 weeks, SWYM Haircare was created to prevent and eliminate chlorine damage from hair whilst using non-harsh chemicals to restore moisture and hydration to the strands.

Enriched with macadamia oil as our hero ingredient, we aim to provide clean, travel-friendly hair & body care products for swimmers. Simply clip our travel pouches onto your swim bag for a lightweight, easy-to-find, travel-friendly option.

**MISSION STATEMENT**  
To provide **clean, travel-friendly** hair & body care for swimmers.

"Each year, there are approximately 20 million visits to public swimming pools by New Zealanders and visitors to New Zealand." (Water Safety, n.d.)

With more than **1.1 million** people swimming each year (Water Safety, n.d.), roughly **1 in 5 New Zealanders** could benefit from using **SWYM Haircare**.



**TARGET MARKET**  
SWYM Haircare targets a range of swimmers including **recreational or competitive swimmers, swim instructors, lifeguards** or other customers who participate in water-related activities.

These **gender-neutral** products may be used by anyone whether you're a child, an adult or an elderly fellow.



**REFILLABLE**



**CLEAN**



**CONVENIENCE**



**TRAVEL-FRIENDLY**

**PRODUCT LINE**  
The SWYM Haircare line consists of four products:

- / Pre-Swim Hair Barrier Cream
- / Moisturising Shampoo
- / Hydrating Conditioner
- / Scalp and Hair Clarifying Treatment Powder

The product line is designed to **prevent and eliminate chlorine damage** from hair whilst using non-harsh chemicals to restore moisture and hydration to the strands.

SWYM products are also **sulfate-free, paraben-free, phthalate-free**, and **silicone-free**.

**INGREDIENTS**

**Macadamia Oil** - *The hero ingredient of SWYM Haircare.* Regulates oil production, hydrates the scalp, tames dry and frizzy hair as well as restores damaged hair.

**Hydrolysed Rice Protein** - Provides hair with moisture. Improves strength and flexibility of hair. Increases hair volume.

**Shea Butter** - Moisturising and anti-inflammatory properties. Reduces scalp irritation caused by chlorine and other pool chemicals.

**Aloe Vera** - Moisturising, healing and rejuvenating. Deep cleanses hair. Leaves hair smooth, soft and shiny.

**Panthenol** - Antioxidant and humectant. Improves moisture retention of the hair shaft.

**1 PRE-SWIM HAIR BARRIER CREAM**  
The Pre-Swim Hair Barrier Cream provides a nourishing barrier to protect your hair from chlorine and mineral damage in the pool. Enjoy swimming without the stress and frustration of dry, dull colour and green hair.

**PREVENT**



**2 MOISTURISING SHAMPOO**  
The Moisturising Shampoo gently removes pool elements that otherwise attach onto hair while swimming. SWYM Moisturising Shampoo combats crunchy, dry, brittle hair whilst retaining hair's natural oils for maximum moisture and shine.

**REMOVE**



**3 HYDRATING CONDITIONER**  
Enriched with Macadamia Oil, the Hydrating Conditioner rehydrates, repairs and detangles hair after swimming. The Hydrating Conditioner preserves the texture, look and feel of hair when exposed to pool water.

**REPLENISH**



**4 CLARIFYING TREATMENT POWDER**  
Deep clean your hair once a week with this powder to foam treatment powder. SWYM's Clarifying Treatment Powder removes chlorine build-up and other minerals whilst preserving the texture, look and feel of hair.

**REVIVE**



**REFILLABLE**  
SWYM travel pouches can be refilled using SWYM refill bottles. The SWYM Shampoo and conditioner are both available in **850mL** whereas the Pre-Swim Barrier Cream is available in **450mL**. The Clarifying Treatment powder is available in **10 x 2g sachets**.

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## Student projects: Product Design - Chemical Formulation Design

# sola SKINCARE

### Introduction

The brief for this project required an original brand with a minimum of two products to be developed. The products had to solve either a social, economic or environmental problem. Sola Skincare is a skincare brand that focuses on producing products for acne prone skin while reducing food waste by utilising potato peel waste in products. Sola Skincare solves an environmental problem by reducing food waste and carbon emissions.

### Mission Statement

At Sola Skincare we aim to create products that help to support blemish prone skin while reducing food waste and our brand impact. We strive to create products that are affordable, effective, sustainable and high quality.

### Target Market

The target market for Sola Skincare is teenagers and young adults as this is the age group that struggles with acne the most frequently. Researching the target market shows that these people need products that are effective, high quality, affordable and environmentally conscious. People in the target market are at a wide range of life stages and have a wide range of incomes. Some members of this group likely have very little disposable income making it important for our products to be affordable. Young people are also becoming increasingly concerned for the environment. Sola Skincare focuses on sustainability and minimising our environmental impact.

### Market Analysis

Market analysis shows that the anti acne skincare market is highly competitive and oversaturated. Competitors for Sola Skincare include brands such as The Ordinary, Thursday Plantation and Neutrogena. These brands all produce products for acne prone skin although are not considered environmentally conscious companies. This leaves a gap in the market for products that are sustainable and at a low price point. This is where Sola Skincare plans to position itself. Products will be sold in supermarkets, pharmacies and on the brands online website. Products will retail for between 10 -20 NZD each.

### Sustainability

A major focus of the brand is extracting ingredients such as starch and cellulose from potato peel waste to use in our products. By doing this we help to reduce food waste and carbon emissions. We also use recycled materials in our products to help avoid creating new plastics.

### Products

The three products in Sola Skincare's product line are a Barrier Repair Moisturiser, Blemish Patches and an Exfoliating Powder. The Barrier Repair Moisturiser contains occlusive, humectant and ceramide ingredients to hydrate the skin and to create an ideal environment for the skin barrier to heal. This is an important product in the line as a damaged skin barrier can be a cause of acne, so working to heal this will reduce the amount of acne that occurs over time.

The Blemish Patches are hydrogel spot treatments made from cellulose and alginate. The patches are infused with salicylic acid. Together the hydrogel material and the salicylic acid work to reduce the appearance and severity of active acne.

The Exfoliating Powder contains a mixture of physical and chemical exfoliants that help to reduce dead skin cells. The powder contains salicylic acid as a chemical exfoliant. This ingredient is known to prevent further acne from forming. The product line is designed to work together to prevent and treat acne.

### Packaging Design

Sola Skincare's brand aesthetic is simple and modern with a muted but fun colour palette. This choice was made to help attract the target market to the products by making them look mature while still having an element of fun. A branding board was made collating all the brand aesthetic details. This proved to be a useful tool for creating the packaging designs. Packaging designs for the products were kept simple and minimalistic. Boxes were designed to look cohesive while the labels on the containers were each printed in a single colour. This helped to maintain a clear brand identity while also allowing for clear differentiation between products.



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PROD334 - Chemical and Healthcare Product Formulation 2B

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# Student projects: Product Design - Chemical Formulation Design

## SAFE AND EFFECTIVE.

SKINCARE FOR MELANIN RICH SKIN

*Hyperpigmentation line*

# M+ Skin



### BRIEF

The intention of this project was to design products that solves an economical, social or environmental problem. M+ skin will be focused on creating safe and effective skin-care for melanin-rich skin tones.

### ABSTRACT

We live in a world where skin color is the trait most commonly associated with race. Picking up the social issue of the lack of diversity in skincare and how needs of people of color were not being met, M+ Skin was created. M+ Skin is an inclusive brand focusing on closing the race gap in the skincare market by providing safe and effective skin-care for melanin-rich skin tones to fight hyperpigmentation, the discoloration of skin.

### PRODUCT LINE

The four products consisting of a gentle mandelic acid cleanser bar, a photoprotective face serum, a moisturizing body milk and an underarm brightening deodorant, help target common areas where hyperpigmentation may occur in people of color. M+ Skin is formulated in New Zealand using actives such as mandelic acid, vitamin C, niacinamide, wool powder, shea butter, coconut oil and more, in the most effective combinations backed up by scientific research.





**INDIVIDUAL CAPSTONE PROJECT - 2021**  
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## Student projects: Product Design - Chemical Formulation Design

# A DAM GOOD IDEA





# Y2KOSMETICS

## The Baddie Collection



### Abstract

Cosmetic formulas of the future, cherishing the uniqueness of the past. Y2KOSMETICS was created to cater to individuals who feel their creativity and expression is not celebrated in today's conservative society. The brand is an outlet of expression for confident, unapologetic and independent "baddies". Y2KOSMETICS combines the Y2K (2000s) era of attitude and style with quality cosmetics. "THE BADDIE COLLECTION" is the debut capsule collection from Y2KOSMETICS, embodying the essence of Y2K and baddie energy. The collection contains a 10-pan eyeshadow palette, 3 hydrating lip glosses in clear, pink and rosy brown shades, 2 blushes in pink and rosy brown shades and a pair of heart-embellished lashes to finish the perfect baddie look. This collection can be used to express many styles, from simple to dramatic. Y2K aesthetic has made a significant comeback since lockdown as people are experimenting with fun and playful cosmetics and fashion, and taking the time to reflect on past era's.

### Mission Statement

Y2KOSMETICS provides people who feel like they don't fit in a conservative society, an outlet to express themselves through quality cosmetics.

Confidence
Pretty energy
Expression

Individuality
Independence
Unapologetic

### Target Market

The target market for Y2KOSMETICS is simple, it is a niche market of individuals who enjoy expressing themselves through beauty and fashion. They are unapologetic, confident and independent with themselves and their expression. This market are mostly individuals born in the 1990's or early 2000's as they grew up in the Y2K era. This market may also feel misunderstood by society for their expression of style, and Y2KOSMETICS plans to be the outlet to their expression.

### 3D design



### Competitor Positioning

Y2KOSMETICS will be competitive in this market by expressing the essence of the 2000s era (which has not been done by an entire brand before) and the baddies that embrace it. The brand speaks to the people who feel they cannot express themselves in a conservative society. By giving these baddies a platform and an outlet to do this, it ultimately opens the door for more people and flattens the curve in society. From this strong marketing message, Y2KOSMETICS will be able to compete both in quality and price.



When the future is uncertain, the automatic behaviour is to find refuge in past events and calm anxious feelings with known points of references

- Marie-Michèle Larivière



**glosses**

A trio of juicy, hydrating lip glosses in clear, pink and rosy brown shades



**palette**

10-pan eyeshadow palette with a fully 3D printed component - shades inspired by baddies of the Y2K era



**lashes**

Heart embellished 20mm faux mink lashes completes the baddie look



**blush**

A duo of blushes inspired by the BELLA and BADDIE lip gloss shades (non-formulated)



**the baddie collection**






website: [y2kcosmetics.myshopify.com](https://y2kcosmetics.myshopify.com)  
 instagram: [bella\\_y2kcosmetics](https://www.instagram.com/bella_y2kcosmetics)

**Y2KOSMETICS presents: THE BADDIE COLLECTION**

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Student projects: Product Design - Chemical Formulation Design



**Kia ora and haere mai to niho!**  
We are a brand created specifically for kiwi tamariki to enjoy and be excited to take care of their teeth. **50% of kiwi tamariki have one or more dental cavities by the age of five.** This rate is significantly higher for Maori and Pasifika. Niho's mission is to change this.

Our products include an **oral spray, gummies, and lollipops** that are all 100% sugar free and contain safe and innovative actives to fight bacteria causing tooth decay.

niho oral care

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# THE MOBILE MOP

## WHAT IS THIS PROJECT ABOUT?

- The Hygienic home is a project that focuses on exploring the difficulties that the elderly may experience when cleaning floors and what options they take to resolve the problem.
- The target user group of this project are the elderly of the 70+ year old demographic, as cleaning floors at this age range can be too physically demanding on the lower back, wrists and knees.
- Therefore, The Mobile Mop is a dedicated design solution that emphasises on ergonomics, ease of use and encouraging independence for the elderly.



## WHAT ARE THE PROBLEMS?

- Studies from both Fausset et al and Rogers et al involved questioning the elderly user group on which indoor/outdoor tasks are considered the most difficult and what kind of options and solutions would be taken to resolve the task.
- 37% of the participants voted for cleaning and outdoor tasks to be most challenging at their age range, which makes sense as both cleaning and outdoor tasks require more effort and stamina to maintain regularly.
- Over 53% of participants voted for outsourcing when choosing an option to resolve a task they have failed to complete halfway through, which indicates lack of independence and strong reliance on others to help complete their tasks.

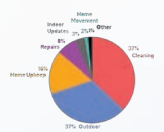


Figure 1: Percentages of difficult tasks mentioned for maintaining a home. (Fausset et al. 2017)

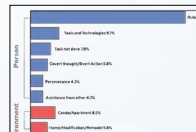


Figure 2: Percentages of types of solutions mentioned in difficult home maintenance tasks. (Fausset et al. 2017)

## CONCEPT EVALUATION



- CHAMPION CONCEPT 1**  
Emphasis on double sided cloth feature, extendable frame and multiple gripping positions. Does have poor maneuverability and non-ergonomic handle positions.
- CHAMPION CONCEPT 2**  
Emphasis on self extraction feature, triangular shaped sponge and dual handling. Poor indication of intuition and simplicity as well as being potentially dangerous and obtrusive to users when operating.
- CHAMPION CONCEPT 3 (WINNER)**  
Emphasis on precise maneuverability via twisting handle mechanism, easy microfibre attachment method. Limited manufacturing processes and untested viability of twisting mechanism.

## FINAL DESIGN DEVELOPMENT



Iteration by iteration, more consideration and detail on key components and structure are shown.

## KEY COMPONENTS OF THE MOBILE MOP

- HANDLES**  
Both dominant and secondary handle underwent lots of iterations, focusing on handle diameter shaping, angle from horizontal as well as the distance between to fully enable comfort for all users when operating.
- AXLE**  
The original axle design for the champion concept was suspect of durability concerns, therefore the iterations focused on strengthening the axle overall as well as the connections between the head frame and handle.

- FOREARM REST**  
The forearm rest was the most challenging to iterate, as accounting for the target user's diverse forearm and wingspan sizes affected the shaping and slant angle of the armrest significantly.
- HEAD FRAME**  
From Champion Concept 3, the head frame went through multiple iterations, emphasising on simplistic looks, effectiveness and how easy it is for an elderly person to perform the action.



## WHAT DOES THE MOBILE MOP SOLVE?

- RELIEVES WRIST STRESS**  
Incorporating two handles for both arms enables the user to have better control over the mop with less effort. The dedicated forearm rest reminds and ensures that the user's wrist remains aligned with the forearm for minimal wrist stress during long operations.
- INCLUSIVE TO ALL USERS**  
The dual handles are not only symmetrical in vertical space but also adjustable to an extent. The secondary handle can be adjusted to account for a user's wingspan through a couple simple steps. This action only needs to be done once per user.
- CLEANS WOODEN & TILE FLOORS EFFECTIVELY**  
Microfiber cloths are super water and dust absorbent due to their internal core structure. They can move smoothly across wooden and tile surfaces; dry or wet. The maneuverability that the Mobile Mop provides to the user is superior to many other mops where swivelling at angles is less controllable.  
The head frame of the mop has cut out curves on the sides that can be used to clean tight isolated spaces like chair legs, rounded corners and many more.
- EASY MICROFIBER ATTACHMENT**  
The head frame is designed to make it an easier times for users to attach the microfibre cloth compared to other cleaning products which uses complex mechanisms. The in-and-out cloth wrapping around the head frame is simpler to perform than perceived and maintains the tension required to move backwards and forwards effectively.

## The Hygienic Home

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# Student projects: Product Design - Industrial Product Design

### Brief

The industry brief 'Allbirds in our current climate' is looking into our generation's most pressing issues of climate change, climate activism/justice, and inclusivity. Due to the wide scope of the project, the brief was narrowed down twice after initial research had been carried out. The brief was condensed into the following problem statement: How might I incorporate hemp into the Allbirds solution for communities most vulnerable to the effects of climate change? After evaluating my four concepts and pivoting the project, the projects aim was altered to **'design a product that incorporates hemp for an Allbirds consumer involved in activism against climate change.'**

### Design process

The double diamond design process was used for this project.

**Discover:** Project planning initiated the project with creating a Gantt chart and choosing a design process. Secondary research was carried out exploring climate change, climate activism, and fossil fuel polluters. User empathy was gained understanding vulnerable communities due to global warming, and extreme weather events.

**Define:** The brief was condensed to designing with hemp for vulnerable communities. Aims and objective and Product design specifications was then penciled in. Ideation was also commenced with four champion concepts brought forward including hemp agriculture/regenerative farming, face mask, organics bin, and watercraft.

**Develop:** The four concepts were evaluated using Pugh's decision matrix using the projects objectives, PDS and feedback from the industry client. The final concept of a face mask was then brought forward and developed further. The concept was physically and digitally prototyped with user testing and feedback implementation.

**Deliver:** Design embodiment and implementing design features into the final design which included brand styling and appealing to a typical Allbirds consumer.

#### Concept 1

Watercraft to transport people/goods safely due to an increase in flooding caused by global warming.

#### Concept 2

A compost or organics bin made out of hemp wood. Designed for countries which do not have proper organic waste infrastructure in place causing preventable methane emissions from landfills.

#### Concept 3

Hemp agriculture - regenerative agriculture, low-cost vertical farming, or raising hemp fields to protect it from flooding or storms due to climate change.

#### Concept 4

Hemp face masks which was originally explored due to an increase of air pollution and wildfires.

#### Hemp

In the define stage the project went down the route of material sustainability and emission reduction. Research was conducted into natural materials and carbon sinks. Trees are one of earth's best defenses against climate change. They suck and sequester carbon dioxide into their trunks and roots mitigating the greenhouse effect which causes global warming. From research I discovered that Hemp is 400% more efficient in CO2 absorption than any forest or commercial crop. A ton of hemp absorbs 1.63 tons of CO2 and yields four times drier habitat compared to an average forest. Hemp crops are also ready for harvest only 2-3 months after planting. Hemp is a fantastic material for a face mask as it is breathable and uses up to four times less water to manufacture compared with cotton. Hemp is also super sustainable as it can be upcycled at its end of life or biodegraded in a home compost. Hemp is also protective against UV rays, feels light and soft against the face, and doesn't cost the earth. Because Allbirds low working with natural and renewable materials, choosing hemp was a no-brainer as it fits in perfectly with the company's ethos.

Greta Thunberg wearing the mask at the front of a climate change protest (School strike for climate) demanding political leaders and businesses take action on climate change. Wearing this mask at a climate rally has the potential to be a symbol of activism, and not only through protesting. Consumers are making a conscious decision and choosing with their wallets to buy a sustainable product that sucks enormous amounts of carbon out of the atmosphere, while protecting rather than destroying the environment.

### Prototyping

### Final design

The final design was a result of going through the design process. From research, ideation, prototyping, and achieving the specifications and objectives set out from the brief. The final design is a two layered hemp mask. The string is also made out of hemp, and the cord locks for tightening/loosening the string is made out of injection molded ABS. The SweetFoam pattern is an Allbirds design feature hidden in some of their shoe's foam padding. I enlarged these fun shapes, and they are screen printed on top of the fabric, they can also be embossed if needed. The tongues are made out of hemp fabric scrap and are sewed on. The left tongue has -0.04KG CO2E written on it, this number represents the amount of kilogram of carbon dioxide energy the hemp mask has stored throughout its lifetime. The minus sign means that it is carbon negative (storing more than it emits) which is a huge positive. The other tongue features the Allbirds logo and hemp icon. This small but detailed illustration instantly lets the user know which company made the product, and out of what material. The hemp icon is very distinctive and recognizable, although it could also be misinterpreted as the cannabis icon. However, what's important is it stands out, and sparks that initial conversation with people.

### Hemp face mask

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Student projects: Product Design - Industrial Product Design



MACPAC

CIRCULAR BACKPACK

Design a concept backpack that is easy for the consumer to disassemble into clear mono-material groups for recycling in a circular system, once the product has reached its end of useful life.

OHANGA AMIOMIO  
THE CIRCULAR ECONOMY

The crucial concept central to designing for a circular economy is to ensure we can unmake everything we make. A product is considered to have a circular lifecycle when it is designed for the longest possible use, and can be easily repaired, remanufactured, recycled, composted or biodegradable. Using resources more efficiently and changing the way we think about products and production processes by considering reuse, repair and recycling options in advance of production are all aspects that can help designers create more circular products.



THE CIRCULAR ECONOMY'S 3 KEY PRINCIPLES:

Designing out waste and pollution

Keeping products and materials in use

Regenerating natural systems



THE SOLUTION

Focusing on the REDUCE aspect of the 3 R's, the entire bag is made from recycled Nylon. This material ensures the bag has maximum durability, aiming to slow the product waste cycle by extending the bag's lifespan as much as possible. No tools are needed to replace the fast wearing components as the cord can simply be pulled out and threaded back into the tubing. At its end of life, the entire bag will simply be recycled using fibre-to-fibre recycling technology, stripping back the fibres for reuse, made simpler by using only one fibre colour.

THE MARKET

The bag is built for the active commuter, easing the transition between everyday and adventure. The extendable storage space using the top and bottom flaps allows for a quick walk to work or an overnight hike. The internal sleeves and hidden pockets provides secure storage for valuable items while travelling. Its versatility is enhanced by the classic Macpac aesthetic making it the perfect accessory that will never go out of style.



ADJUSTABILITY

Like any other popular bag, this design is fully adjustable. To maintain its recyclability, the adjustment system uses the same material as the pack shell and fits into the fibre-to-fibre recycling system. Natural closures were explored to achieve this, and the design uses knots and ties instead of permanent hard material components. An innovative but simple larkhead knot is used for the front closure and strap adjustment, meaning the user can easily pull down on the cord to tighten. This cord design also allows the user to modify the system to their own preferences; whether it be customising the colour, length or harness size. If extra storage space is needed, items can be tucked underneath or clipped onto the exposed cord making it even more adjustable to the users lifestyle.



Macpac Circular Backpack

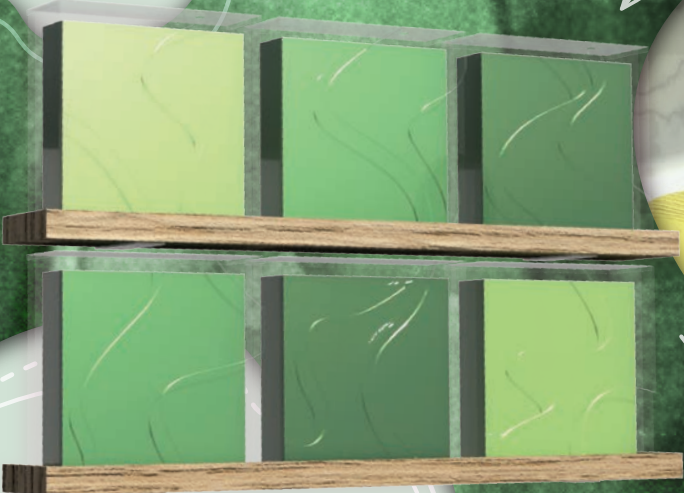
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## Problem

The problem we face in this modern world is the exponential growth of waste materials with a lack of resources and space to manage them efficiently, consequently being detrimental to the planet's environment. Continued demographic pressures into the future will necessitate further research and development into alternative fuel sources that mitigate the effects of climate change. The current concept and treatment of 'waste' is unsustainable, ultimately resulting in fatal depletion of earth's finite and renewable resources.

An innovative approach to this predicament is crucial in preserving what's left of the world's natural resources, and managing excess waste that corrupts it. The product or system designed must be as close to 100% eco-friendly as possible, utilising waste materials or providing aid to the matter.

## Solution

Migrow is an at home spirulina microalgae farm, used to cultivate and eat spirulina, providing a reliable nutrient dense food source that can replace unsustainable meat farming. The micro-organism simultaneously has the ability to absorb carbon dioxide in the air, thus combatting air pollution. The nutrients in spirulina contribute greatly to the daily recommended intake value for humans, making this practice a great and healthy addition to daily routines. My research has found that microalgae may be the key to creating a healthier, environmentally friendly fix for the future. Migrow embodies the brief – create a way to eliminate the idea of waste in a developed society – by starting small, at home.

### One man's waste

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# Shrewsbury Gym Bag

**Brief :** To create a gym/work bag that has functional compartments alleviating disorganisation often found in bags. Aesthetically suitable for young professionals to take to their work and gym.

The Shrewsbury Gym Bag is both a functional and professional bag. Targeted at young professionals, it is suitable to take to both work and the gym. With a functional divider system you will never have to worry about having an unorganised bag again.

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Perfect Size for  
Gym Lockers



Internal Divider System  
to keep items organised



16" Waterproof  
Laptop Sleeve



Magnetic Buttons



Supervisor : Matt Smith

Industry Collaborator : Shrewsbury

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## Standard Stakka

by Fence It



### Design Brief

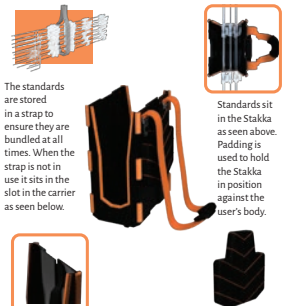
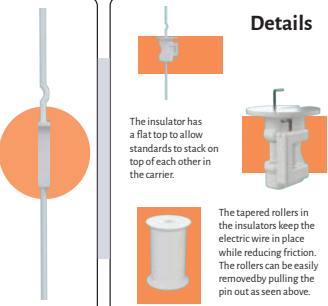
Every year, farmers carry stock through the winter to maintain their stocks' weight even though there's little grass around. Typical methods of winter feeding include break feeding or using preserved feed such as bales, silage or grain. Break fencing is the use of temporary fences to keep stock on limited crops throughout winter, allocate and conserve feed, and clean up old pasture. Personal experiences have found break feeding to be a long, tedious process that could be made more efficient through better design. This project uses critical evaluation of existing equipment to improve the user experience and save users time and money. The analysis of primary and secondary research around the use of break fencing equipment defined the project direction. This was to find a solution to carry 20 standards easily, simplifying the process of assembling break fences. Additional research highlighted the tendency of insulators breaking, so they have been developed to reduce in conjunction with the development of a standards carrier.

### Storyboard



1. Pick up a bunch of 20 standards
2. Put them into the carrier
3. Remove strap and hook it into the side of the carrier
4. Pick up carrier and put strap on shoulder
5. Distribute the standards and assemble the fence

### Details



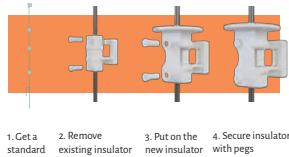
### Materials & Manufacturing

The insulators, insulator pegs and main Stakka body will be made using HDPE as it is strong, lightweight and easy to injection mould (Granta Edupack, 2021). It is also fairly UV resistant so will not be affected by being in the sun and is water resistant. Its toughness means that it can withstand the daily impact it may receive.

The rollers inside the insulator will be made from nylon and are designed to prevent wear on the insulators due to rubbing from the wire. Nylon is a strong material and can resist the abrasiveness of the electric fence wire. It also does not absorb moisture which makes it ideal for being used outdoors in harsh weather (Granta Edupack, 2021).

The straps are made from Polypropylene and can hold the 8kg weight of 20 standards. The strap connector is leather which is strong and flexible, and the padding is made from mid-density foam.

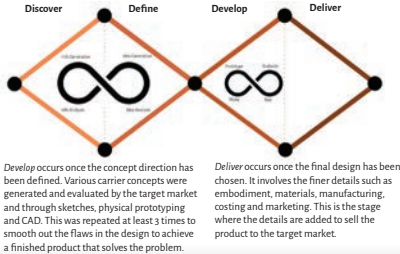
### Insulator Installation



### Design Process

Discover involves gathering primary and secondary research through different methods including trying out the experience to understand it from a user's point of view, engaging with the target market, and researching online through various resources.

Define involves analysing the research gathered in the "Discover" phase. This is where the project direction was defined as a solution to carrying standards and being able to distribute them evenly, as well as designing insulators that are less likely to break.



### Standard Stakka

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Why carry standards when you can stack them?

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# STRATUM SIX



## PROJECT OVERVIEW

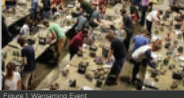
The tabletop terrain kit is a project focused on designing a set of terrain. Wargaming terrain is essentially scale model buildings that wargamers use to represent large buildings when they play tabletop miniature warfare with their own scale model army miniatures. The project was originally focused on the terrain being suited for wargaming event play due to the lack of terrain but the needs of players. However, the proposal was changed after discovering that the cause of the issue was not the lack of terrain but the new player influx. The proposal was updated to have the target user be the new players rather than the event organisers. After completing the design process the final product is a set of terrain pieces that are created from MDF, painted and use custom moulded brackets to hold together. The design is focused on being able to be easily assembled and disassembled so it can be stored away by the user. The design is also able to be stored and transported. The design is customisable but is also ready to be used straight out of the box.

## DISCOVER & DEFINE

The first stage of the design process involved researching a variety of aspects. The research methods used were:

- Market research
- Interviews
- Surveys
- Materials and manufacturing research
- Legal research
- Existing product analysis
- Aesthetics research

During this phase the proposal shifted to focusing more on newer players over the previous event organisers (Figure 1).



## GENERATE & EVALUATE

**IDEATION**

As part of the generating phase ideation was undertaken, the ideation techniques that were used for this project can be broken down into two stages. The first stage involved techniques that were more focused on generating ideas conceptually and abstractly. This involved using techniques such as:


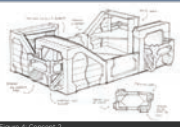

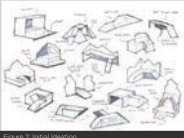
- Brainstorming
- Mind mapping
- Scamper
- FAST technique

The second stage of the ideation process involved using more time-consuming techniques to generate more fully realised ideas. This stage used both 2D and 3D media such as:

- Sketching (Figure 2)
- CAD modelling
- Physical modelling

**CONCEPTS**

For the evaluation phase three champion concepts were created and developed to a stage where they could be evaluated against each other (Figures 3-5). The concepts were then ranked using a controlled convergence matrix in order to determine which concept would be fully developed.







## DEVELOPMENT

**PROCESS**

Once the final concept had been determined final development was undertaken. This stage involved creating three iterations of the design. With the goal of improving the design with each iteration (Figures 7-10). The iterations had sub stages of:

- Sketching development ideas
- Creating a CAD prototype
- Creating test prototypes

The iterations were tested for their assembly process (Figure 8) and game play functionality as they were key PDS.



## PROJECT AIM & SCOPE

Tabletop gaming has had significant growth in recent years. This growth can be seen all over the world with new players joining into the hobby rapidly due to its modern-day accessibility. The problem is tabletop games in particular tabletop miniature wargaming require a gaming board and terrain pieces to play the game. These resources are generally provided by gaming clubs and by event organisers to the players. This is because the majority of the terrain is modelled by hand from scratch, which is a very time-consuming compared to the other entry requirements such as purchasing the miniatures.

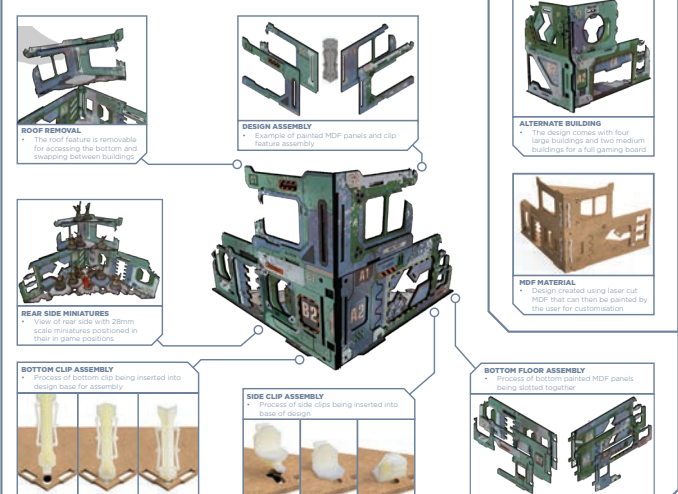
- This project involved designing a terrain kit to be used for a single gaming table (approx. 15 x 6m).
- The terrain kit is functional towards all the relevant game system(s) at 28mm scale.
- While also being thematic and aesthetically compatible with the relevant game system(s).

The project had a main focus on space-saving and modular design. This is due to the current terrain taking up too much space when not being used.

- Due to the number of tables that are required for tabletop events the project will also focus on optimising mass production and reducing manufacturing costs as much as possible. This also gives new players entering the hobby a cheap non-time intensive starting point.
- The design also provides new players everything they require terrain-wise to have a non-stall and time intensive way to play wargames.


With all that in mind the official aim of the project was: Design a set of functional and aesthetically appropriate tabletop terrain to be used by new players, event organisers, and gaming clubs.

## PROJECT OUTCOME



- ROOF REMOVAL**
  - The roof feature is removable for accessing the bottom and sleeping between buildings.
- DESIGN ASSEMBLY**
  - Complete of painted MDF panels and clip feature assembly.
- ALTERNATE BUILDING**
  - The design comes with four large buildings and two medium buildings for a full gaming board.
- MDF MATERIAL**
  - Design created using laser cut MDF that can then be painted by the user for customisation.
- BOTTOM CLIP ASSEMBLY**
  - Process of bottom clip being inserted into design base for assembly.
- SIDE CLIP ASSEMBLY**
  - Process of side clips being inserted into base of design.
- BOTTOM FLOOR ASSEMBLY**
  - Process of bottom painted MDF panels being slotted together.

## USAGE PROCESS



- OPEN PACKAGING**
  - First step is to open the packaging to get to the terrain inside inside.
- PUSH OUT PIECES & ASSEMBLY**
  - User pushes out each of the pieces from the MDF pieces for assembly.
- GAME PLAY**
  - Set terrain pieces positioned in their set game board position during game play.
- TRANSPORT AND STORAGE**
  - User can use carry tray to transport the terrain and then store it away after play.

### Tabletop Terrain Set

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# Forty5

## The Hygenic Home



Seniors frequently feel as if they are losing their independence and are gradually becoming a burden to those around them. In response, a mop has been created to enable seniors over the age of 70 to maintain their independence for longer.



The mop will be available in a variety of colours to appeal to a wide range of aesthetic preferences.

Forty5 was created to improve the ergonomics of existing products on the market in an attempt to improve the cleaning experience for seniors. The product's name originates from the mopping angle of 45 degrees as it is at a 45 degree angle, preventing injury and back pain. Consequently, "Forty5" promotes the benefits of comfort and safety measures.



Senior's hand strength decreases by 16-40%. Therefore, the handle is ergonomically constructed and accommodates a wide range of hand sizes. The handle is angled to reduce stress on the hand and wrist.



The idea behind Forty5 is that the frame of the mop stops the pole at a 45 degree angle, preventing users from leaning over and allowing them to mop with good posture, reducing back pain.

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# COLOUR ME SAFE CLIP

## 1. Background

Nowadays, whether men or women of all ages, hair dyeing has become popular to make their appearance look younger and more beautiful. Relatively, the cases of hair dye reactions to a common permanent hair dye ingredient Paraphenylenediamine (PPD) have increased. Although not everyone gets an allergy to PPD, but reactions might not appear the first time when you colour your hair and can develop with the number of exposures (Ngan & Gomez, 2002).

Traditionally, professional and quality salons will provide allergy alert tests to their customer as shown in Figure 1.

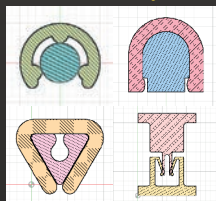
However, this would result in time-consuming and inefficient as the application of an allergy alert test can undertake in less than 5 minutes, or customers might be waiting in the salon for 45 minutes to rinse off the dye.



Figure 1: Process of allergy alert test.

The project sponsor company "Colour Me Safe Limited" wants to transform the traditional hair colouring allergy alert test to a mailable system in which the customer can carry out the test safe and easily at home.

## 4. Concept Develment

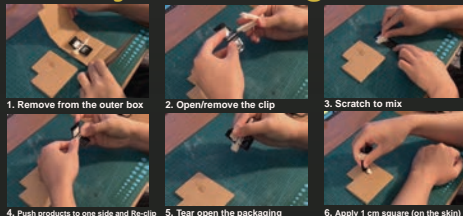


The direction was developed to several basic shapes in CAD. The designs were then modified and improved based on some consultation responses to achieve physical modelling.

The concept U shape (top right) was then chosen by its visual look and the possibility of branding.



## 6. Storyline of Usage



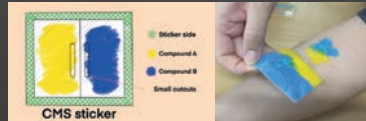
## 2.Design Brief

Develop a packaging to contain two reactive hair colouring chemicals *separately*.

The packaging will be mailed to the user. After receiving, the user will mix the two chemicals and apply to themselves according to the given instructions.

## 3. Ideation

Three main concepts were chosen through development:



"Colour Me Safe (CMS) sticker" is a sticker that contains the two colouring compounds, allowing the user to stick and mix it on their skin.



The "business card bush" idea as shown in the image above, uses half of the card as a bush to apply/spread the product to the skin.

Through consulting with the project sponsor, understand that they would like to develop the packaging as a minimum viable product (MVP), starting with a basic, allowing room for development and keeping within the budget. Therefore, the clip idea (with heat sealed bag) from the initial research turns out to be a suitable concept to start as a direction for the project.



## 5. Final Design



### Colour Me Safe

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COLOUR ME safe  
HAIR DYEING KIT

SUPERVISOR  
Barro De Gast  
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Colour Me Safe Limited  
UCV PRODUCT DESIGN  
To learn more about  
productdesign.ac.nz

# Student projects: Product Design - Industrial Product Design

PROD314 2021

PROJECT INTRODUCTION

PRIMARY RESEARCH

SECONDARY RESEARCH

DISCOVER

DEFINE

AIMS & OBJECTIVES

PDS PRODUCT DEFINITION

IDEATIONS & CONCEPT GENERATION

TEST PROTOTYPES

ANALYSIS & REFINEMENT

CREATE PROTOTYPES

FINALISE DEVELOPMENTS

PROJECT SOLUTION

Design Process:

PROJECT INTRODUCTION

PRIMARY RESEARCH

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CREATE PROTOTYPES

FINALISE DEVELOPMENTS

PROJECT SOLUTION

LivingKind

Aria Cressy

21870239

Brief

Matt Smith, the supervisor for this project, had previously produced a brief that was related to the building of new homes, but through a collective agreement the brief changed to keeping existing homes safe and healthy for reducing the need to build new properties. This project looks to create a solution that reduces the relative humidity in a room to a healthy range. Mould growth has said to have an impact in health issues within children and elderly, with acute respiratory infection being one of the main complications. Excess humidity is one of the contributing factors in the creation of mould in many older homes that do not have the ventilation required to prevent growth. Many current solutions for this issue involve either high installation costs, or high running costs, meaning there are many existing homes that are currently being degraded by mould, which could have the opportunity to become healthy, dry homes, which, in turn, would extend the life of the property.

PDS

- Reduces the relative humidity of a room to a range of 40-50% within 24 hours.
- Must be able to reduce a room's humidity without the use of power.
- Must be non-intrusive and/or able to be installed in a door without reducing the value of the home.
- Must not reduce the quality of soundproofing the original door had by 5%.
- Requires little to no installation, and a service installation occurs it must be able to be installed within a day.
- Must not reduce a room's temperature by more than 5%.

Design

Easy to install and change dimensions for different needs, as intensity of airflow depends on sizes of rooms and current areas of airflow.

Material choice can vary depending on budget arrangement; there are more intensive sound proofing materials such as Acoustic Timber (Autex Acoustical). But MDF and custom wood options would be most commonly used as economically friendly alternatives.

Soundreflective panels reduce the noise travelling through the vents, which are provided to ensure airflow is able to move thoroughly back and forwards. This means there is no stagnant air within a room, and a central heating/cooling system can be installed without extra costs to provide airflow to all rooms.

500mm

200mm

24mm

Alpha Prototype

Testing

Original Environment

Open Window

Calcium Chloride

Door left open

This test was conducted with the window open 15mm wide. It is key to note that the temperature and RH levels did not vary heavily, but stayed above the healthy level of 55% for a majority of the time.

A test was conducted using 100g of Calcium Chloride. Visually it was clear that the Calcium Chloride had begun to absorb moisture. As seen on the chart, compared to opening a window, the RH and temp were varied, with RH decreasing dramatically when temp goes up, which was as expected, also did not go below 55% as required.

From initial testing in the environment it was found that opening the door, compared to desiccants and windows being open, conclusively suggests that air flow through-out the home can decrease the relative humidity to a healthy range of 40 - 55%.

1.

2.

3.

After the physical tests were conducted, Simscale, an online CFD program was used to represent whether or not an open door truly was the best way of creating airflow compared to that of a window.

The first image is of the kinematic velocity of the room with the door open, as you can see the most airflow is at the bottom of the door, due to gravity.

The second image represents the temperature changes which occurred, which the temperatures for the air from the door can be adjusted, but a temperature of 20 degrees Celsius was chosen as seen on the diagram.

Finally, the last image is where within the room has "satisfactory" temperature and humidity - mostly based on temperature, but the ideal humidity was set as 55% within the program. As shown on the image the lowest and highest points are which one the most uncomfortable areas in the scenario. Because of this, I believe the design should be placed around halfway of the height of the room, to still gain the airflow, but allow more of the "satisfactory" airflow through, rather than letting cooler, likely more humid air through if the design was placed at the bottom.

LivingKind

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LivingKind

UCV

UCV PRODUCT DESIGN

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# Student projects: Product Design - Industrial Product Design

## Think Flat Design Process

**The starting points.**

After researching the relevant areas of design, manufacture and user needs, a series of concepts were imagined.

**Brief:** Research, ideation and development of folding product designs that compliment the existing Fozzils product lines (Fast + Light Series, and Base Camp Series). Fozzils materials (injection moulded PP or die-cut PP) & patented folding techniques can be utilised though other materials and panel based folding techniques may be used.

**Illumination.**

Fold Away Light concept. After the concept evaluation process and discussion with Bart and Barro, the lighting design was chosen to be fully developed. Ideas around ambient and focused light were explored and incorporated. The ambience fulfils the feeling of warmth and focus gives function to the task at hand.

**Design. Build. Test. Repeat.**

Design of the folding topology required 50+ prototypes advancing in small iterations each time. Paper and cardboard was used for fast tests and PP sheet for further validation and refinement.

Prototypes were developed in 2D and realised in 3D physically. 3D CAD had little to no cross over to the real world. Because of this, the designer has to understand how crease lines and geometry will translate when folded.

**Focus. Finalise.**

The final form has been optimised to meet a number of requirements:

- **Base stability**
- **Light beam angle**
- **Visual line continuity**
- **UI accessibility**

This was made possible due to fine adjustment to the 2D pattern and the newly developed slide lock system.

Light function and dimming is controlled via a **capacitive touch bar**, the same technology used in smartphones.


The printed graphics provide a user interface as well as visual interest around the light.

A low profile injection moulded part is fused to the rear, housing the battery and electronics.


A USB Type C port facilitates charging and plugged in lighting via a 5v adaptor.

A flex cable connects the electronics to the LED strip to allow for the collapsible design.


### The result: Platypus Light



The Platypus light easily folds down into a compact form factor (23x187mm). In this configuration, the light weight and robust PP construction minimises the impact on carrying. The material can flex and conform to the shape of the bag or comfortably against the body.



Assembly/disassembly is made easy with a slide lock system. Simply align the tabs and push inwards to snap into place. Disassembly is even easier with by reversing the process.




The Platypus light provides focus and ambience for a variety of use cases. This is made possible by the dimming LEDs, aesthetic design and light interaction.

The compact folding design facilitates use in smallest of places. There is always somewhere the Platypus light can slide into, whether it be a van, apartment or tiny home.

Platypus balances a cute aesthetic with a serious undertone, making it additionally suitable for use in the home or office. Wireless use gives freedom to be used anywhere.

The robust, lightweight and water resistant design breaks barriers and opens new opportunities for the humble lamp.

**It is light you can take with you.**



### Think Flat: Platypus Light

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## Student projects: Product Design - Industrial Product Design

# HEAT WAVE'S NIPPY DRY SURF GLOVES

## DESIGN PROCESS

### GENERATE

#### Market Analysis

Colour Price Materials Eco-friendly Seams Thickness Size Range

Features (eg Grip pads, Wrist Cuffs, Windproof)

#### Customer Survey

- 1) What age group are you in?
- 2) How would you rate your surfing skills?
- 3) Would you consider buying surf gloves?
- 4) How important would the gloves comfort be to you?
- 5) What type of colour would be the most desirable on surf gloves?
- 6) What colour is your current body wetsuit?
- 7) What reasons do you usually surf in?
- 8) What price would you be happy to pay for a pair of surf gloves?

### DEFINE

#### Main PDS Review

Topic	Need
1 Product Specifications	Marketed as a mid range priced pair of surf gloves which last up to 4 years of regular use. Suitable for all skill levels and both male and female.
2 Unique Selling Point	Gloves are completely waterproof and keep the users hands dry for up to 2 hours of use (padded after concept was finalised)
3 Materials	All materials possible are either recycled or eco-friendly
4 Performance	Thickness of the glove is less than 2mm to ensure full hand manoeuvrability as well as being a lightweight option.
5 Performance	Gloves regulate users hand temperature, retaining warmth and expelling perspiration.
6 Performance	Meets all additional surf glove performance requirements such as grip potential, wind proof and UV ray resistance.
7 Aesthetics	Final product will be Aesthetically pleasing and follow common market trends of other popular surf gloves appearances.
8 manufacturing	Glove fabric and materials will be sourced from suppliers and then assembled in overseas facilities to ensure high quality standards.

### IDEATE

#### Size / Dimensions

SIZE	HAND CIRCUMFERENCE	HAND LENGTH
XS	4.5in	16.5in
S	7.0in	19in
M	8.5in	21.5in
L	9.5in	24.5in
XL	10.5in	26.5in
XXL	11.5in	28.5in

### DEVELOP

#### Material Development

Refer to general fabric makeup  
G Silicone printed Pattern (testing required to find pattern area)  
Nylon and Elastane Blend  
Polyurethane Tape. Seals seam sealing

#### Seam Specifications

BLIND STITCHING  
TAPES  
GLUE  
GENERAL FABRIC MAKEUP  
THREAD

#### Product Features

Wrist Cuffs  
Grip Pad Pattern  
INTERNAL LINING  
INSULATION LAYER  
MEMBRANE/ EXTERIOR LAYER

### DELIVER

#### Surf Glove Redesign

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#### UC PRODUCT DESIGN

# Student projects: Product Design - Industrial Product Design

## TAC

TRANSTIBIAL  
ADJUSTABLE CAST

For Below Knee Amputees

The TAC is a single use adjustable post operative cast for transtibial (below knee) amputees to contain and protect the residual limb. The TAC is custom fit by heating and moulding to the patients limb as well as being able to cut to fit. It requires little training and can be applied with only one staff member.

Custom fit and adjustable to fit any limb size and shape

Allows full knee joint range of motion


Easy to use and only needs one staff member for application

Promotes early ambulation

Protective against external traumas

Controls oedema and swelling

Slight conical shape promotes correct limb shape for first weight bearing prosthetic fitting




**DISCOVER**


Over half of patients are larger than the average person. These large patients cannot use the current casting method as the cast does not fit over the residual limbs. These patients are left with no cast and consequently have a longer rehabilitation process due to increased risk of external trauma and poor oedema control.

- 50% of patients amputations are due to diabetes or vascular disease
- 60% increase in healing time due to the use of soft dressing in comparison to rigid dressings
- 1 in 3 amputees will fall while in recovery


Heat




Adjust




Fit




Inspect Wound



Protect



Easy Wipe Clean



**DEFINE**

**Project Aim**


The aim of the project is to create a product for larger sized patients to wear immediately post-op to contain and protect the residual limb. The product needs to be adjustable to accommodate for residual limb volume changes due to the variation in swelling. The product needs to be a generic fit that offers support to all limb shapes, sizes, left or right leg. The overall goal is to improve the rehabilitation process to those patients into early ambulation and fitting of the first weight bearing prosthetic.

**Specifications (PDS)**

- Must be comfortable
- Must not hurt the patient to put on
- Must be applied with minimal training
- Must be light weight
- Must cost less than \$100
- Must be a hard external material
- Must be adjustable to accommodate to limb volume changes due to swelling
- Must be removable

**DEVELOP**

Ideation methods of SCAMPER and bisociation were used. Development of the ideation into three project direction included different ways to manufacture a similar concept. The final direction was chosen after evaluation method of PDS evaluation matrix to confirm to develop the direction or injection moulding.



**Validation**


A test was completed on Solidworks to simulate a 100kg patient falling onto the cast from standing. This resulted in a 2mm deflection of the cast. This proves the cast will protect the limb in large load falls and small knocks.

**Manufacture**


To be manufactured with low volume injection moulding. The mould will be 3D printed to reduce tooling costs, resulting in a cheaper single use design.

**Materials**



Recycled PETG is low cost and has a low heat deflection temperature (HDT) allowing the TAC to be heated to 73 degree C for 15 minutes becoming soft for a custom fit. This temperature is ideal as it won't burn or irritate the skin at such a low temperature. These materials allows the product to be light weight at an overall weight of 343g.



**PETG**



**Nylon Velcro**



## Post Operative Adjustable Residual Limb Cast for Below Knee Amputees

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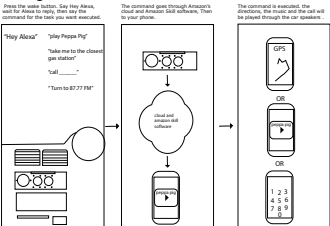
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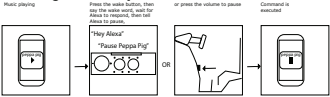
## Brief

Amazon released a product for the automotive market. The product was the Alexa Echo Auto, a hands-free device for your car. The design team faced many challenges during the design process. Therefore, the brief was to create version 2 of the Echo Auto. Version 2 of the Echo Auto resolves the issues that both the designers and the public had with the product.

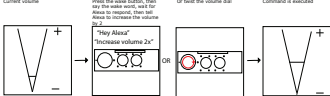
### Using A.K.I.T.T



### Pausing music or podcast.



### Changing the volume



## Discover

This stage is the beginning stage. At this stage you seek out as much information as you can. For the project, I carried out firsthand and secondhand research. For my firsthand research, I went out and bought and used the product. For my secondhand research, I investigated the competition, reviews about the product and so on.

## Develop.

This stage focuses on generating ideas, sketching concepts, iterations of concepts, feather research and evaluation of concepts. For this project I came up with 3 concepts. The concepts are the CD station 300, solar X and the Alexa unit. In my concept evaluation stage, the Alexa unit was the most practical solution. I then went on to feather developing this idea till I came to my final concept. The final concept is called A.K.I.T.T.

## Unique selling point

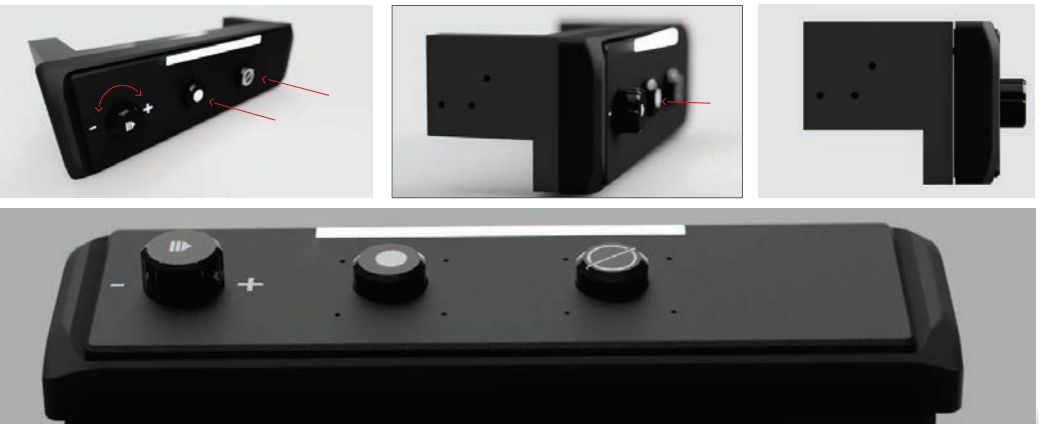
A.K.I.T.T has a lot to offer compared to the original. The first is; the A.K.I.T.T replaces your radio and mounts in the same location. The second is the cable management. The third is the A.K.I.T.T features a volume dial, which has a play/pause function when pressed in. This increases response time and the overall user experience. The last is the improved aesthetics. Because the A.K.I.T.T replaces the radio suits the car's interior better than the original, as seen in the two picture and lastly the added features make it like a radio.

## Define

This stage is where you analyze the information you have gathered, define the problem you are trying to solve, feather research into for more insight and create a Product Design Specification.

## Deliver

This stage focuses feather refinement of the concept. This consists of feather research, physical and CAD prototyping and testing, feather design development, and delivering a final design. In this project, this process was done by researching materials, manufacturing, electronics and so on, by designing cad prototypes, developing my design and delivering a final design.



## Echo Auto Redisgn

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# TECTONICA

## A 3D Puzzle to Understand Plate Tectonics

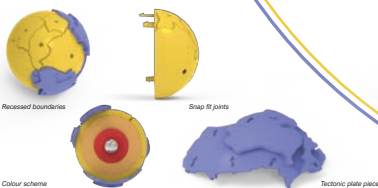


### Final Design

This project aimed to design an engaging and educational 3D tectonic plate puzzle for children aged 7-12 years old, to improve understanding of geological concepts and increase awareness of natural hazards, such as earthquakes and volcanoes.

Tectonica is a spherical globe puzzle which incorporates physical features of plate tectonics, including crust thickness, boundary types, and the interaction between tectonic plates on the globe. An accompanying information booklet, map, and clue set provide educational value to users, and the internal layers of the Earth (the mantle, outer core, and inner core) are hidden inside the puzzle as an extra learning opportunity. Tectonica is the only 3D tectonic plate puzzle on the market, and allows children to learn in an active, hands-on way.

The product is intended for use in schools and similar educational environments (such as libraries and museums), and aims to inspire children to learn about the world we live in!



Tectonica incorporates recessed boundary outlines, a vibrant colour scheme, physical features of tectonic plates (including crust thickness and arrows to represent plate boundaries), and snap fit joints to provide an exciting learning experience for children.

### 1. Solve the clues



Learn about the features of Earth's tectonic plates, including types of plate boundaries (convergent, divergent, and transform), and types of crust (oceanic and continental) in the information booklet. Use the clues to match these physical features to each tectonic plate.

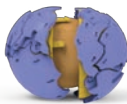
### 2. Assemble the puzzle



Place the tectonic plate pieces on their correct location on the globe, with the help of the clues, information booklet, and map of the world.

### 3. Unlock the hidden elements

After you complete the puzzle, the mechanism unlocks and the globe splits in half, revealing the inner layers of the Earth (the mantle, outer core, and inner core).



### 4. Learn about Earth's layers



Remove the inner layers of the Earth - you can stack them up, create your own 3D diagram, and rebuild the Earth from the inside out!

### Design Process

This project followed an iterative version of the Stanford Design Process:



#### 1. Empathise

The Empathise stage is about understanding the users. In this stage, I conducted primary and secondary research, including interviewing stakeholders to gain an understanding of how a 3D tectonic plate puzzle might be beneficial to the target market.

#### 2. Define

The Define stage involves finding the essence of the design problem. This included conducting a competitor analysis and researching safety and gameplay requirements to create product design specifications. These specifications were used to inform the Ideate, Prototype, and Test stages.

#### 3. Ideate

In the Ideate stage, mind mapping, freehand sketching, SCAMPER, storyboarding, and the FAST technique were used to generate ideas. These ideas were narrowed down through multiple rounds of evaluation to select the final concept.

#### 4. Prototype

The Prototype stage involved several iterations of CAD modelling and 3D printing to refine the globe locking mechanism, puzzle retention mechanism, and the overall size and dimensions of the product.

#### 5. Test

The Test stage included materials selection, safety testing (such as the small parts test and small balls test), and user testing to validate the design. These tests were based on the product design specifications, which were established in the Define stage.

### Tectonica

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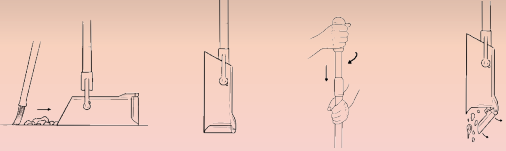
# LIDU DUSTPAN

The foldable dustpan by LIDU makes hard floor cleaning easier, redesigning a foldable dustpan by introducing a lid opening mechanism, making disposal of rubbish easier than ever.

RSA Competition Brief - The Hygenic Home

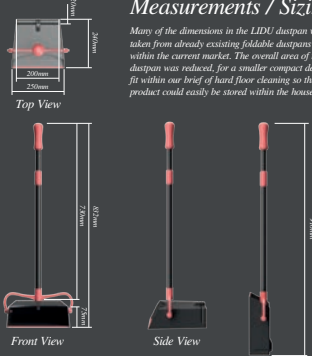
To design or redesign a floor cleaning product that is targeted at older adults to make cleaning easier and more effective, enabling them to maintain independant living longer.

Other colours available



### Measurements / Sizing

Many of the dimensions in the LIDU dustpan were taken from already existing foldable dustpans to fit within the current market. The overall area of the dustpan was reduced, for a smaller compact design to fit within our brief of hard floor cleaning so that our product could easily be stored within the household.



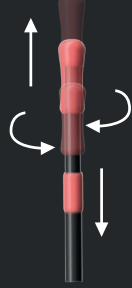
Top View

Front View


Side View

### Mechanism

The handle incorporates a twist lock mechanism seen in telescopic handles which allows the handle to be used to trigger the lid opening mechanism. With the mechanism users are also able to adjust the overall height of the handle, targetting people with different heights to use the product.

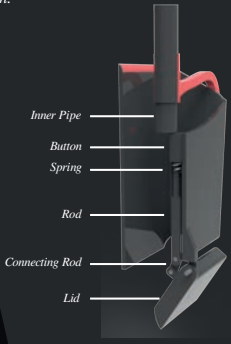
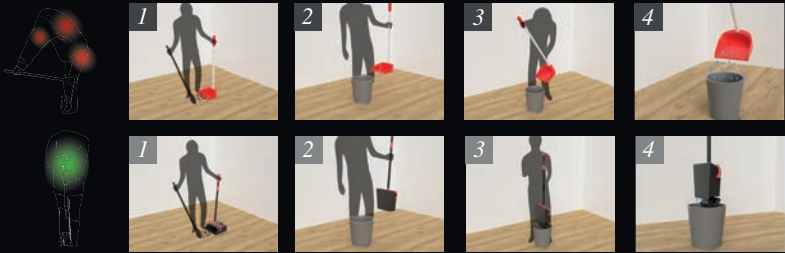


The lid opening mechanism operates off a main rod which moves along one axis, and a connecting rod which connects the rod and lid together. A spring is used to push back up the rod, closing the lid back by itself. The mechanism is triggered when the user twists and pushes down on the inner pipe which also pushes down onto the button making the lid open.



### Problem Solving

The main problem I found with regular dustpans is that they have a terrible implementation when it came to disposal of rubbish. I did not like the idea that the entry the rubbish is collected was the same as the entry that it disposed at. When it came to disposing rubbish with a regular dustpan the user had to lean and bend over to tip the rubbish out which can cause severe back pain especially as an older adult. With my design the user is able to keep their back straight and dispose rubbish with a simple motion, casuing no pain when disposing rubbish





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Student projects: Product Design - Industrial Product Design

# CBW<sup>2</sup>


## Contemporary urban mobility.

CBW2 is an electric front loader cargo bike handbuilt in Otautahi, New Zealand. With cities becoming busier and consumers becoming environmentally-conscious, CBW2 has been created out of necessity of providing a convenient transport solution for people in a busy urban environment. The rationale behind CBW2 is that it can comfortably and efficiently navigate around a city better than a traditional automobile, whilst not compromising capability. The bike has a cargo bay positioned in front of the rider, which can carry loads of up to 80kg. An electric hub motor provides assistance to the rider and can comfortably propel the bike at 40 km/h. CBW2 could well be the catalyst of an urban mobility revolution.






The frame of CBW2 has been heavily refined and developed using Finite Element Analysis. The final frame layout deflects 3.7x less under load whilst experiencing 2.6x less stress than the existing offering from Cargo Bike World. The 50x75x2.0mm RHS boom tube structure is principally responsible for this, providing inherently improved structural properties compared to the existing 50.8x2.0mm CHS.




A weldment beam model was drawn in Solidworks CAD software to represent the frame elements of the bike. Fixtures were located at points where the wheels attach to the frame. Two load cases were then applied being derived from journal articles on parametric bicycle design.

Case 1: 2400N applied perpendicular to the seat tube, representing the rider's mass on the bike

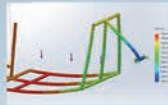
Case 2: 800N applied along the boom tube, representing the maximum cargo load of the bike.



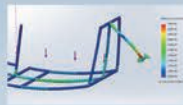
Case 1 Displacement: 4.24mm




Case 1 Stress: 180 MPa



Case 2 Displacement: 1.46 mm




Case 2 Stress: 55 MPa



A unique feature of CBW2 is its two-part frame. The two parts are joined by a flange with M8x25mm bolts. This flange is located just in front of the steerer tube.

The main reason for this is to allow more workshop space during construction. In turn, it also increases production efficiency, as multiple halves can be created at the same time without changing tooling or techniques.

The two-part frame also offers customisability. Consumers may request different length cargo bays or differing rear geometry to accommodate their needs.






The rear dropout was another component which was analysed. This part is laser cut from 6mm sheet steel which currently weighs 280 grams. A topology study was initiated that developed regions which could be removed whilst still retaining the required structural properties. These were modified slightly to increase form and practical aspects. The final design has lots of triangular sections, which have a rugged industrial aesthetic. It is also 57% lighter weighing in at 177 grams, whilst satisfying the structural requirements of the part.

Cargo Bike Frame Refinement

Industrial Product Design

PROD314 2021






Caleb Huston

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Supervisor : Dr. Nick Emerson

Industry Collaborator :  
Pete Thornton,  
Cargo Bike World







Student projects: Product Design - Industrial Product Design




# Desireable Orthoses

A Brace That Won't Hold You Back







Fully waterproof wrist splint that can be worn in the shower or even at the beach.




Aesthetically pleasing pattern that enables for a more breathable wrist splint.



Customisable splint allowing users to create their own desired aesthetic.



Highly reliable, strong and durable BOA tightening mechanism.



Custom moulded to the wrist, ensuring an ergonomic form.

Student projects: Product Design - Industrial Product Design

LOCAL, SUSTAINABLE, CUSTOM, ROAD BIKE SHOE

Foundational Research

In 2020 the bike market had a boom due to Covid-19 lock-downs around the globe (Zhong, 2020; Goldbaum, 2020). This was an increase of recreational biking. These cafe-bound road cyclists are the target market for this project.

Covid-19 was a major disruption to global supply chains. Local, distributed manufacturing will help build resilience against these shortages.

Brief

Road bike shoes have one primary job, to transfer power to the pedal. To do this they need to be stiff and fitting.

Traditional bike shoes are designed around narrow, athletic European pro-cyclist feet. To achieve their stiffness, they use glass/nylon or carbon-fiber/epoxy composites that are energy intensive to produce, non-recyclable and do not biodegrade.

The use of local manufacturing tools allow for flexible small scale manufacturing. This allows for novel sustainable materials, custom fitting shoes, and reduced shipping emissions by distributing manufacturing.

Concepts Dev



There are no road specific flat-sole bike shoes. More research needed. Perhaps for another project.



Natural fiber/bio-resin composites address sustainability at the source, but not the end-of life.



Metals such as copper and aluminum can be recycled easily. Concerns are durability and denting.



Combining Metal and wood was considered to improve woods strength.



Material testing made it clear that both reclaimed Rimu and Ash are more than capable. Ash was chosen as it is less prone to denting and scratching.



Manufacture



Measurements of the rider are transferred to a digital last.



Traditional leather shoe making techniques are used to make the upper.



Sole is cut from Ash wood.

The LSC



- 1. Tongue
- 2. Leather Upper
- 3. Woolen Liner
- 4. Woolen Felt Mid-Sole
- 5. Wooden Sole
- 6. Leather Pads

Local

The shoe can be constructed using tools found in a generic small work-shop.

Sustainable

Completely bio-degradable except for three small aluminum inserts that can be recycled.

Custom

A shoe last is created for each individual. Digital tools (Fusion 360) allow for an efficient process.



Local, Sustainable, Custom Road Bike Shoe

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UC&PRODUCT DESIGN

Goldbaum, C. (2020, May 18). Thinking of Buying a Bike? Get Ready for a Very Long Wait. The New York Times. <https://www.nytimes.com/2020/05/18/sports/bike-shopping.html>

McCraw, A. D. (2012). November 20. Optimizing long-distance cycling speed. <https://www.mccraw.ca/2012/11/20/optimizing-long-distance-cycling-speed/>

Strode, A. N., & Kram, R. (2013). Effects of shoe type and shoe-pedal interface on the metabolic cost of bicycling. <https://doi.org/10.1016/j.jbiomech.2013.11.041>

White, C. (2016). The Actual Effect of Design on Cycling Speed: Side-by-Side Comparison of Custom and Mass-Produced Road Bikes. <https://www.youtube.com/watch?v=ZK8p8p8p8p8>

Zhang, B. (2020, August 17). Sorry, the World's Biggest Bike Maker Can't Help You Buy a Bike Right Now. The New York Times. <https://www.nytimes.com/2020/08/17/sports/bicycles.html>

440 Fly of White Road Bike  
https://www.440fly.com/

# Student projects: Product Design - Industrial Product Design



## Storyboard



**Set up.**  
After finding a place to sit, place the Rolley where needed.



**Unfold.**  
Start rolling out the table from the base. Let the smooth flow do the work and simply roll it as it fixes position.



**Relax.**  
Enjoy the Rolley.  
Enjoy the environment while either working or taking a break.



**Pack up.**  
Easy to pack.  
Simply start rolling from the edge of the surface and make your way to the other end.

## Rolley



### Brief

The aim of the project was to provide a surface for users to study and work on. These users are mainly aimed at remote workers or students who face difficulty with production and face mental breakdowns. One of the solutions to this issue was taking them out into nature which helps relieve stress.

So, the brief of the project is to design a portable outdoor table for those wanting to spend time either studying or resting out in the fields.

### Details

The design model has a unique folding mechanism where the entire table rolls like a yoga mat and when it is open, the tightly compressed pieces make a flat stable surface. When rolled, it gives a nice smooth circular roll that makes it easy to carry. The edges of each piece are rounded to deliver a clean professional look.



### Design process

**Empathy**

- Project Plan
- Research
- Competitor Analysis

**Define**

- User Research
- User Requirements
- PDS

**Ideate**

- Brainstorm
- Concepts

**Prototype**

- Initial model
- Trial and Error
- Development

**Test**

- Material Selection
- Feedback



```
graph LR; Empathy --> Define; Define --> Ideate; Ideate --> Prototype; Prototype --> Deliver; Deliver --> Feedback; Feedback --> Empathy
```

**Project title: Rolley**

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**UCo PRODUCT DESIGN**  
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Student projects: Product Design - Industrial Product Design



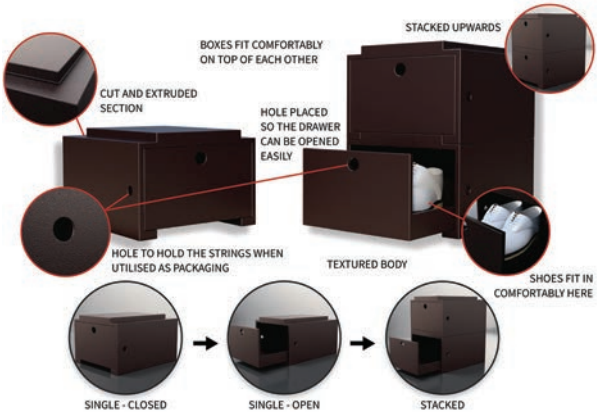
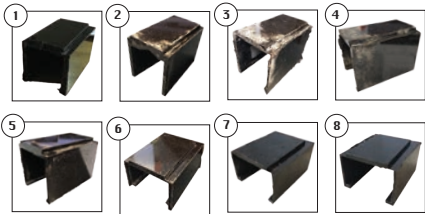
Brief

Utilising the waste material, coffee grounds as a primary material source in this project, re-design a shoebox, which can be used as a storage solution after its initial use. This product must be aware of any environmental harm that it may imply. In the end, this product should aim to be fully biodegradable so that it does not cause any more potential waste into the environment.

Aim

Re-purpose the waste material, coffee grounds to create a packaging to storage unit fit for designer brands to market exclusively to their customers

Prototypes



KOFEX is a shoebox to storage solution that is made entirely with just coffee grounds and resin. This product has a 50:50 ratio of coffee ground to resin, where the process of resin casting is used. This product is primarily targeted to those in the upper-middle class to the upper-class range, where it is thought to be marketed through designer brands as an exclusive product. KOFEX itself utilises the natural colour of the mixture and organic imperfections to its advantage as an aesthetic feature. The colour ranges from dark brown to black (depending on your coffee grounds), where the design is fit for more modern homes.



**KOFEX**  
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UC<sub>PRODUCT DESIGN</sub>

## Student projects: Product Design - Industrial Product Design



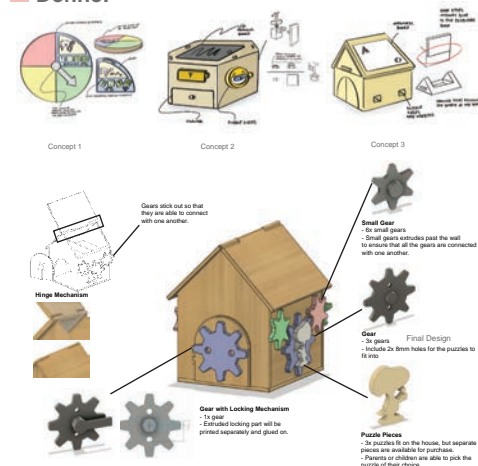
**Background:**

In the UK, it has been found that around half the amount of adults have difficulty getting “good” sleep, due to personal concerns. Due to this, it causes individuals to feel more restless, experience frequent negative moods, and have difficulty focusing. Sleep is an activity that is crucial to every individual, and good sleep must be undertaken to prevent health issues. The Sleep Matters brief focuses on trying to find ways for individuals to get better sleep.

**Discover:**

From research undertaken, it was found that bedtime resistance is among one of the causes for autistic children to have difficulties sleeping. From research undertaken by McLay, et al (2020), it was found that among the participants within the study, 20% of the participants had shown evidence of bedtime resistance.

**Define:**



**Aim:**

To create a product that will help autistic children between the ages of five to seven years old, who have difficulty sleeping, sleep better.

**Brief:**

Sleep is an activity that must be undertaken by every individual, however, is unable to be done well or properly by many people. Possible causes for this could be due to stress, worries, medical issues or more.

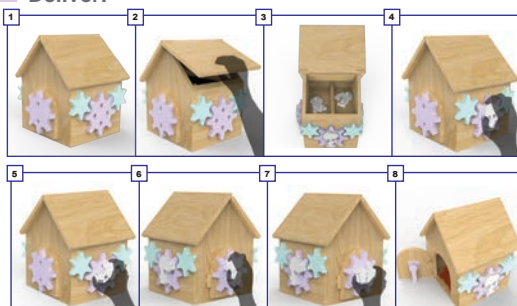
The competition brief of “Sleep Matters” by the RSA focuses on creating a product, service or system that will be able to help enhance the quality of sleep.



**Develop:**



**Deliver:**



Mixer

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Student projects: Product Design - Industrial Product Design

# LuxTemp



## Design Process

Define

Discover

Develop

Deliver

Solution

**Double Diamond Process**

The double diamond process was used for this project to widen the scope of the research and to "be abstract" in terms of redefining the brief. After widening the scope of research and narrowing down to validate the product design specification phase of the project.

## Research Process

Crucial information about the target user market was accumulated through the use of Google forms, surveys were given to colleagues, students and customer at PB Tech (Currently sales person at PB Tech). The diversity of those who participated in the survey proved to be effective as new insights about sleeping products were found.

Competitor products could also be easily found due to working at PB Tech and being exposed to sleep assistance products everyday, effectively making it easier to analyse their strengths and weaknesses.





## Ideation Process

**Mind Map - Bisociation Idea Generation**



Using the bisociation idea generation method of the ideation process, it allowed further insight and questioning into why a product needs a function, why the user needs that function, what way does the function help the user with what their needs.

## Evaluation Process

Criteria	Weighting	Prototypes			
		Prototype 1 Functionality	Prototype 2 Form	Prototype 3 Aesthetics	Prototype 4 Usability
Function	5	2	3	4	5
Form	3	4	5	3	2
Usability	2	5	4	5	3
Aesthetics	2	3	4	5	4
Weighted		10	12	20	10

Criteria	Weighting	Prototypes			
		Prototype 1 Functionality	Prototype 2 Form	Prototype 3 Aesthetics	Prototype 4 Usability
Function	5	2	3	4	5
Form	3	4	5	3	2
Usability	2	5	4	5	3
Aesthetics	2	3	4	5	4
Weighted		10	12	20	10

**Weighted Matrix**

The weighted matrix was used with the Product Design Specification as the criteria to evaluate the ideations and concepts made after the research and develop stages in the double diamond process. It allowed the project to evaluate and assign a numerical ranking based on the scores of each ideation/concept.

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# Akedo.

## Origin

Akedo is a portable arcade machine, designed to be flat-packed and delivered all around the globe. The name Akedo comes from the word "Arcade" in Japanese, even though arcades were not invented in Japan, they were popularized by Japan and hence the name Akedo.

## Abstract

Akedo is a personal project to solve problems with the portability of an arcade machine. An arcade machine is traditionally quite large, heavy and very immobile, and some potential customers don't have the space for a big and heavy arcade. The objective of this project is to create a solution for a portable arcade machine that can be moved or carried around with ease.



## Discover

Research first started with looking into the history of the arcade machine to get to know why arcade machines are as popular as they are, using online resources, it is found that credible sources are quite limited in terms of user market, customer preferences, portability of it and more. Thus a survey was created to find more data that are suited for this project.

After conducting the survey, it is shown that most of the interested people are within the 40-50 age range. With games being the most important aspect by far, then style follows close behind. Those who own an arcade already tend to look for a more traditional arcade experience. Compared to those who are still looking to get one, they tend to go towards the size of the arcade and the manoeuvrability.

## Concepts



Concept 1  
An elevated version of the classic arcade machine with portability in mind



Concept 2  
Arcade machine with an extended joystick panel



Concept 3  
Smaller sized machine best used with a surface to put on

## Develop

A CX FMEA process and convergence matrix were used to test and develop Akedo, through convergence matrix I've found that a more original and simple appearance ranked amongst the top. While using the FMEA, most of the failure modes are due to the user not knowing what to do, to improve on this, Akedo was made to be simpler than other arcade machines in the market.

## Deliver

The final product was made in both physical and digital form, with a 1:1 working prototype. The dimension of Akedo was chosen to be a bit smaller than normal arcade machines to improve on weight, as well as using MDF as the main body material. As it is 1 of the cheapest and lightest materials that best suited Akedo.

# COLOUR ME SAFE CLIP

## 1. Background

Nowadays, whether men or women of all ages, hair dyeing has become popular to make their appearance look younger and more beautiful. Relatively, the cases of hair dye reactions to a common permanent hair dye ingredient Paraphenylenediamine (PPD) have increased. Although not everyone gets an allergy to PPD, but reactions might not appear the first time when you colour your hair and can develop with the number of exposures (Ngan & Gomez, 2002).

Traditionally, professional and quality salons will provide allergy alert tests to their customer as shown in Figure 1.

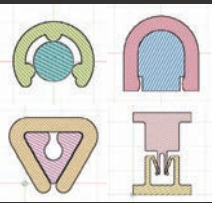
However, this would result in time-consuming and inefficient as the application of an allergy alert test can undertake in less than 5 minutes, or customers might be waiting in the salon for 45 minutes to rinse off the dye.



Figure 1: Process of allergy alert test.

The project sponsor company "Colour Me Safe Limited" wants to transform the traditional hair colouring allergy alert test to a mailable system in which the customer can carry out the test safe and easily at home.

## 4. Concept Devement



The direction was developed to several basic shapes in CAD. The designs were then modified and improved based on some consultation responses to achieve physical modelling.

The concept U shape (top right) was then chosen by its visual look and the possibility of branding.



## 6. Storyline of Usage



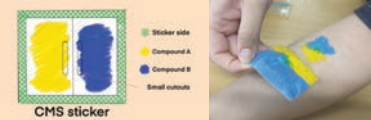
## 2.Design Brief

Develop a packaging to contain two reactive hair colouring chemicals *separately*.

The packaging will be mailed to the user. After receiving, the user will mix the two chemicals and apply to themselves according to the given instructions.

## 3. Ideation

Three main concepts were chosen through development:



"Colour Me Safe (CMS) sticker" is a sticker that contains the two colouring compounds, allowing the user to stick and mix it on their skin.



The "business card bush" idea as shown in the image above, uses half of the card as a bush to apply/spread the product to the skin.

Through consulting with the project sponsor, understand that they would like to develop the packaging as a minimum viable product (MVP), starting with a basic, allowing room for development and keeping within the budget. Therefore, the clip idea (with heat sealed bag) from the initial research turns out to be a suitable concept to start as a direction for the project.



## 5. Final Design



3D printed prototypes

Reference: Ngan, V. (2002). Allergy to paraphenylenediamine. Dermatol NZ. <https://dermatology.onlinelibrary.wiley.com/doi/10.1111/j.1754-0755.2002.00002.x>  
Figure 1: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1450000/pdf/000007fig1.pdf>

### Colour Me Safe

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# Student projects: Product Design - Industrial Product Design

## MAGWAVE RADIO

The Magwave Radio is a communications device designed to improve on the downfalls of modern radios, prioritizing safety and



### Operation Instructions



Attach the radio base plate to the arm using the velcro strap.



Wear jacket over top of base plate.



Clip the radio on top of the jacket using the magnets.



Press the power button to turn the radio on.



Use the dials and side buttons to adjust volume and frequency.



Press the speak button button and talk into the microphone.

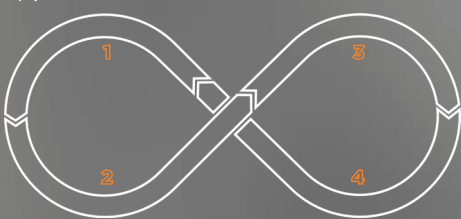
### Design Thinking

#### 1 - Discover

This phase was dedicated to finding out information about existing radios, and finding areas to innovate. During this phase the target market was narrowed down to search and rescue, ambulance officers, and mountain climb-ers. This phase also found info on how radios were used through talking to users and various other methods of research. This info fed into the define phase of the project.

#### 3 - Develop

Develop was all about taking the problems from the define phase and producing proto-types to test solutions to these problems. These prototypes often showed all the flaws and short-comings of the current iteration. This also helped determine the ideas with promise that could be taken forward and implemented into the design. This info fed into the deliver phase of the project.



#### 2 - Define

During this phase, time was spent on finding out information such as problems that existed within modern radios. From this research, the problems identified were the coiled cable, connecting the radio and microphone being un-comfortable, the antennas snagging on other items, and the clip often failing to hold the radio onto clothing. A lot of the first half of the project was spent here.

#### 4 - Deliver

Deliver was all about taking the learnings from the prototypes, and deriving the origin of these issues and benefits. For example when the magnets were tested with a 3D printed prototype the magnets held strong when used, but some of the edges of the prototype were sharp and dug into the user's skin. This allows more research to be done into solutions to said issues.

### Design Thinking Summary

In the initial phase of the project, only the first two phases of the design process are used. This is to gather a large amount of accurate information as quickly as possible in order to get a concrete basis to build the project from. From there the design process expands into stage 3 and 4 to test ideas generated in the first two stages. Once the idea is tested, it goes back to stage one and the cycle begins once again.

The design process above is used to make decisions and progress through the project, and often when the project feels like it wasn't moving, it's solved by either moving forward or backward a step.

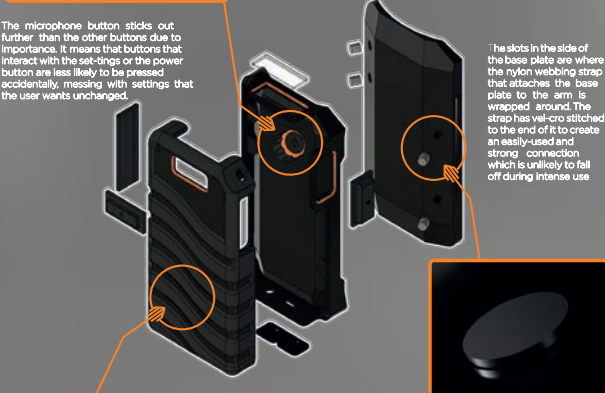
### Design Features



The microphone button sticks out further than the other buttons due to importance. It means that buttons that interact with the settings or the power button are less likely to be pressed accidentally, messing with settings that the user wants unchanged.

There is orange etching around the device which signifies what buttons and dials do, and how to operate them. Orange was chosen over colours such as red because although both colours showed importance, red was too aggressive compared to orange and didn't suit as well. This is why an orange trim was used to highlight areas of importance around the device.

The display was located on the top of the radio to allow the screen to be seen while the radio is being worn. This reduces how often the user needs to interact with the radio.



The slots in the side of the base plate are where the nylon webbing strap that attaches the base plate to the arm is wrapped around. The strap has velcro stitched to the end of it to create an easily-used and strong connection which is unlikely to fall off during intense use.



The speaker slits in the front of the radio are designed to allow sound to pass through while stopping as little water as possible from getting through. This is needed due to ambulance workers commonly working outside and exposed to the elements. It does this by having slits on the bottom side of the grip ridges, which provides a slight overhang over the gaps. This helps to prevent rain water from entering the device while in use in the outdoors.



The magnets in the base plate and in the bottom of the casing are inserted via shrink fitting, and are used to hold the body of the radio in place through a jacket. This is further emphasized by the magnets sitting slightly out from the surface they're attached to. This helps to increase the pressure around the area where the magnets connect, decreasing the distance between the pairs of magnets.

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Flynn Macnamara

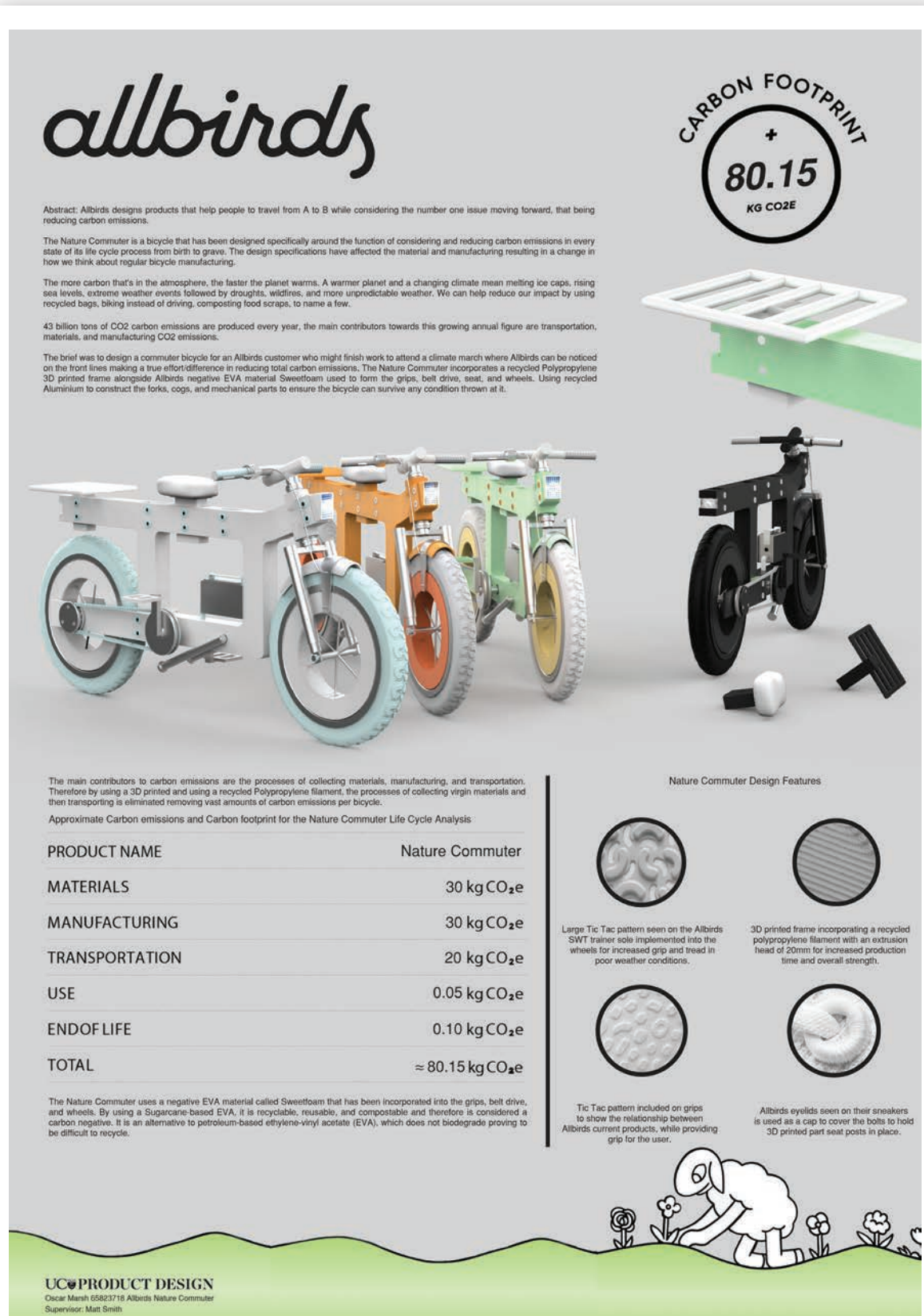
Industrial Product Design

Thomas Woods

UC PRODUCT DESIGN



## Student projects: Product Design - Industrial Product Design



# Student projects: Product Design - Industrial Product Design

## ≥ adaptdefy pedals

### Aim

The adaptdefy pedals were developed to be used on the adaptdefy bike, a two wheeled bike being developed to be ridden by wheelchair users independently, on two wheels.

### Outcome

A prototype pair of pedals which engage to a cleat bolted to the bottom of a mountain bike shoe. Users can engage and disengage the pedals by holding their legs just below the knee. As the rider will be strapped into the seat, the pedals are designed to never release the feet without the user actuating a remote lever. The pedals offer a small amount of sprung rotation to absorb rough terrain and impacts with obstacles.

### Design Process

The sports design methodology (Wilson, Thomson, & Riches, 2017) was selected for this project as it encourages a high level of evaluation and testing. It breaks the project down into four stages: research, conceptual design, design development and design refinement.

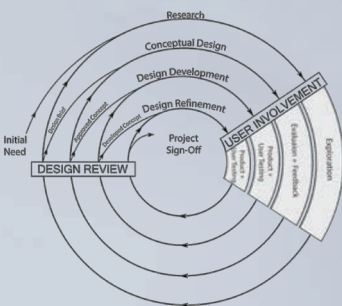


Image 2: The sports design methodology, as shown above, was created specifically to guide the sports design process and therefore lends itself perfectly to this project.

### 1. Research

In this phase, first and second-hand research was conducted to better understand the problem. This included interviews with the clients and users as well as research into current cycling and adaptive technologies. This informed the writing of a more specific brief and design specification.

Key product design specifications

- The system will not release without input from the user or an assistant.
- The pedal should be usable by able bodied persons not wearing specific shoes or shoe cleats.
- The system will not release without input from the user or an assistant.
- If the systems release mechanism has the potential to fail, an emergency release mechanism must be present.
- Should be look similar a to standard flat mountain bike pedal.

### 2. Conceptual Design

A range of concepts were sketched. Evaluation techniques such as stakeholder feedback and a Pugh's evaluation matrix were used to select a concept to move forward with. The 'wedge' concept was selected as it was expected to be the most simple and reliable design while having the potential to meet all product design specifications.

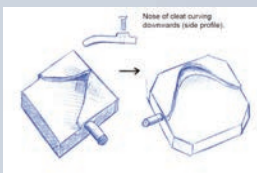


Image 3: A sketch of an early variation of the 'wedge' concept.

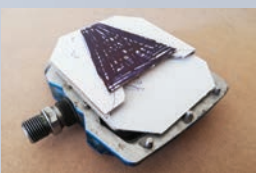


Image 4: This cardboard prototype of the wedge concept was used when evaluating the conceptual designs.

### 3. Design Development

The wedge concept was developed into a functional design that meets all design specifications. This was achieved through iterative testing of various prototypes with target users.



Image 5: A selection of the prototypes created and tested over the course of this project.



Image 6: Testing one of the prototypes with Liam Kearns.

### 4. Design Refinement

The design was adapted to be more manufacturable and aesthetic styling was added.



Image 7: The final design.



Image 8: The original side design that was adjusted to the final side design (bottom) for ease of manufacture.

### adaptdefy pedals

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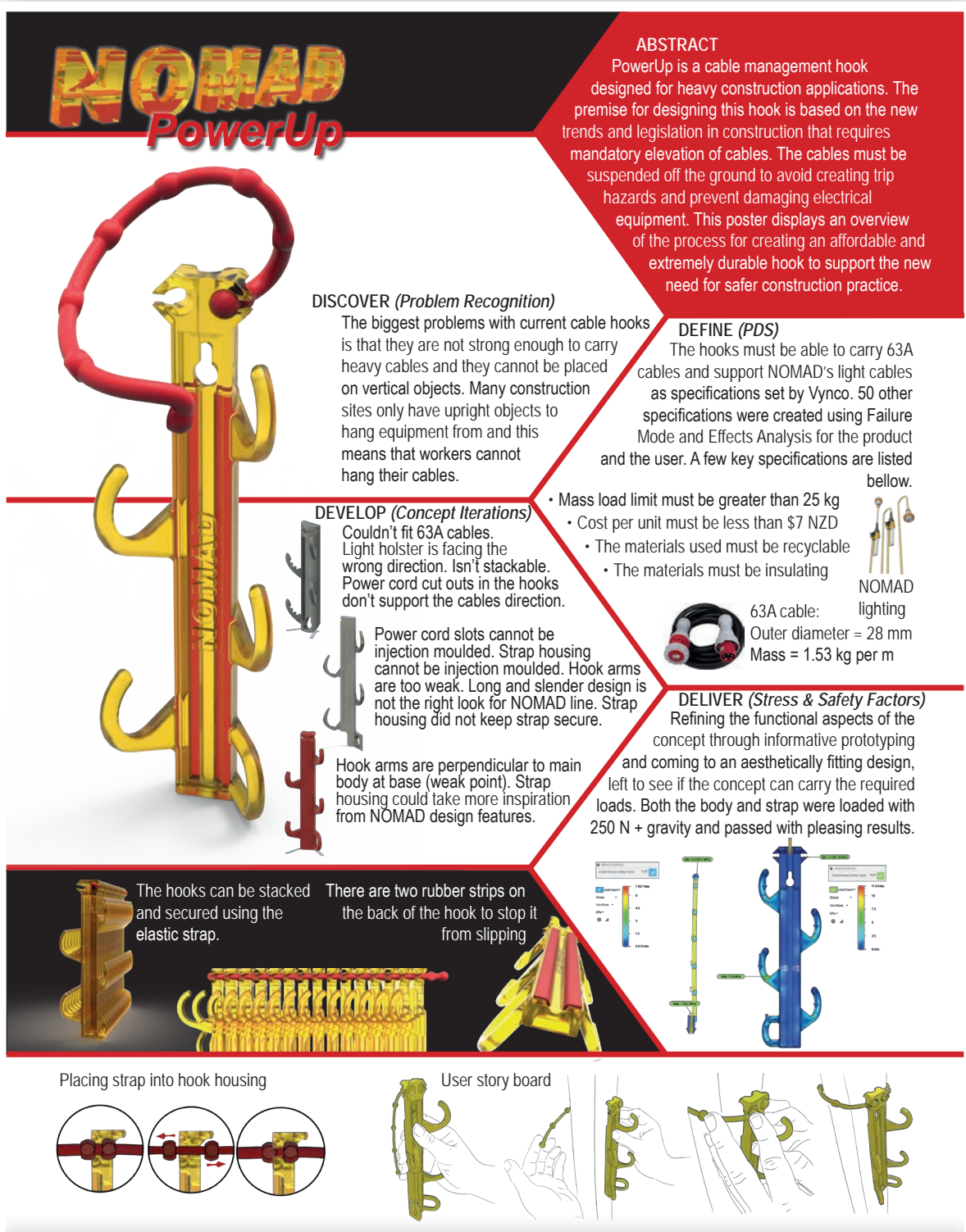
SUPERVISOR  
Nick Emerson

INDUSTRY COLLABORATOR  
adaptdefy

UC PRODUCT DESIGN  
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productdesign.ac.nz

References  
Wilson, A., Thomson, A., & Riches, P. (2017). Development and implementation of the final design process model for sports equipment design. Research in Engineering Design, 405-505.

# Student projects: Product Design - Industrial Product Design





Student projects: Product Design - Industrial Product Design

Generation Global | Mid-Haul Aircraft Seat Cushion

Abstract | Tuhinga whakarapopoto

Generation Global focus on 'Human Centered Design' for their design of covers and seat cushions. Their current process incorporates heavy amounts of prototyping, use specialist foams and work to suit existing seat frames.

So, for this project to be successful, a 'one-cushion-fits-all' solution should be designed where the cushion can be adapted to different applications in different aircraft.



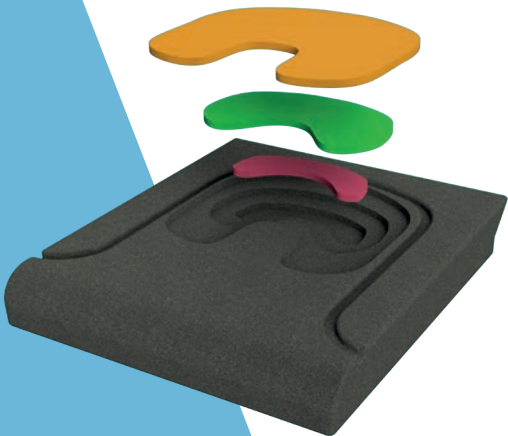
Unique Selling Point | Aronga motuhake

The key point of difference between this seat design and competitors or less desirable than the set options, is the adaptability between different situations, where a whole new mold isn't required. A different set of foam inserts can be fitted to each cushion to provide different qualities that may be more described in this project. For example, a complete set of three memory foams may be desired for a maximum softness and cooler material warmth perceived by the user.

Brief | Kaupapa whakaahua

Design a comfort quantitative test that can be used for both initial and long-term comfort to compare and contrast different prototypes and designs as well as to compare competitors cushions. This will be used to ensure that the final design has a higher score than current designs. Using ideation, prototyping and CAD modeling to achieve a plausible final design.

Choose appropriate materials and manufacturing techniques for this seat design while still thinking about EOL, carbon footprint and product warranty. Another consideration is the cover material as the surface tension needs to be considered in order to ensure that the seat comfort isn't compromised.



Sam Mason  
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PROD314 - Final Year  
Utku Yalcin

# Student projects: Product Design - Industrial Product Design



## Creating Attractive Urban Environments Using By-Products

TE HANGA TAIAO TAONE ATA AHUA MA TE WHAKAMAHI I NGĀ HUA PARA

### Discover

KITEA

#### Project Brief:

'Sustainable is Attainable' (SIA) is an initiative that was formed by Venture Timaru in 2019. It involves finding design solutions for waste-stream problems within 20+ food processing and manufacturing businesses in South Canterbury. This project involves using by-products from SIA businesses to promote an attractive urban environment in Timaru. Improving the urban environment in Timaru ties in with the "Building Better Homes, Towns and Cities" National Science Challenge, with which AgResearch is involved.

#### Attractive Urban Environments:

I endeavoured to find out what makes an attractive urban environment before exploring ways to utilise food industry by-products. I found that urban environments are created by the physical infrastructure in a city – the 'body' – but their attractiveness is linked to city members' perception of the city – the 'soul'. I had never been to Timaru, so paid a visit in August to better understand the soul and body of the existing environment. The Timaru District Council also shared their findings from a recent community survey in their "City Hub Strategy Report", to aid my understanding of what the city needs.



18/10 participants identified slippery footpath tiles as something to remove from the CBD for Q19 "If you could change/improve one thing about the Timaru city centre – what would it be?"

During my visit, I was pleasantly surprised by the historical character of the city. The survey showed that residents agree, however, it was clear that slippery tiles are a huge ongoing problem in Timaru.

### Define

WHAKATAU

I defined the project aim as:

"To engage in **community-based design** to develop a feasible urban design solution that promotes an **attractive, sustainable environment in Timaru**, using **food industry by-products** outlined in the 'Sustainable is Attainable' initiative."

The problem I intended to address was slippery tiles in the CBD, by designing a waste-material paver. The current tiles are a safety issue that make the urban environment feel unsafe and less attractive as a result. The waste-based paver itself would be an element of the CBD's body. For an attractive urban environment, it is also critical to regenerate the soul element. This is why from an early stage I decided to use community-based design methods to involve residents in the design of their urban environment. If people have a role in designing the spaces they live in, they are more likely to feel a connection to the space.

### Develop

WHAKAWHANAKE

#### Material-Based Paver Development:

Diatomaceous earth (DE) sludge is a waste product from the beer industry. During a tour of the DB Brewery in Washdyke, I learnt that there is no way to divert DE from landfill in New Zealand, making it a big problem for breweries. Overseas, there are studies where DE has been incorporated in various bricks. While researching this, I had an idea brewing. DE has porous properties which could potentially reduce slipperiness if incorporated into a paver. *What if I could solve the slipperiness issue by using DE, while introducing a novel route to prevent it from ending up in landfill?*

None of the DE brick examples I found were 100% waste-based. Further research led me to Genge Makers, a company founded in Kenya by Nzambi Matee, who produce pavers from a mixture of mostly waste plastics, and some sand. Inspired by their work, I began experimenting with a similar mixture of waste plastics and DE, which are both SIA by-products. For the plastic component, I used polypropylene (PP) which can be easily re-melted. PP could be sourced from many food processing and manufacturing businesses, but in this project I used PP from a RO-UF membrane cover, disposed by the dairy industry.

#### Design with Community:

Alongside paver development, I involved the community in the design of a pavement layout. In September, members of the public in Timaru were invited to create designs with miniature tiles at Strathallan Corner, in the heart of the City Hub. Their ideas were blended to produce three concepts.

An online survey allowed Timaru residents to have a say in which concept they preferred. From the survey results, two concepts – "Tukutuku Inspiration" (along the bottom of this poster) and "Alps to Ocean" – were synthesised to create the final proposed concept, "Ki uta ki tai".

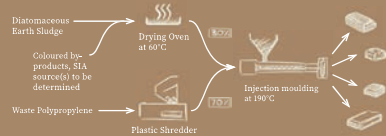
Ki uta ki tai is an approach to seeing the mountains, river, lakes, sea as connected. This links to an idea in the City Hub Strategy Report, that Timaru is the "gateway to everywhere", "alps to ocean and all in between".



### Deliver

TUKU

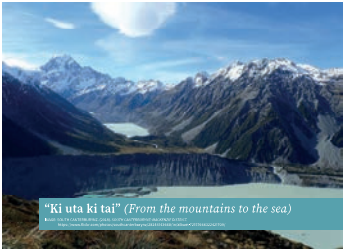
The most advanced prototype made so far is a 1/2 scale proof of concept, which could be mass manufactured using the following process:



#### Next Steps:

The paver development is still at an early-stage and more mahi is required before they are ready to reach Timaru streets. I will pursue paver development, in the summer of 2021-22.

Once I am confident the paver can resolve the slipperiness issue in Timaru's CBD, and introduce no new problems, I will return to the development of the pavement layout. This will involve further community-based design. In particular, I hope to build a relationship with Te Rūnanga o Arowhenua and collaborate to honour 'ki uta ki tai' in the final design.



"Ki uta ki tai" (From the mountains to the sea)



## Creating Attractive Urban Environments Using By-Products

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**SUPERVISOR**  
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**AgResearch & Venture Timaru**  
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Student projects: Product Design - Industrial Product Design

# GULPS GLOVE

## Guided Utility in Pharyngeal Swallowing

**OVERVIEW:**

The **GULPS** (Guided Utility in Latency of Pharyngeal Swallowing) Glove is a collaborative project between the School of Product Design and the Rose Centre for Stroke Rehabilitation and Recovery. The basis of this project is to develop a dysphagic rehabilitation device, utilising established methods of rehabilitation.

**AIM:**

Develop a dysphagia rehabilitation device that utilises **manometric or waveform (time-based) data** to assist in skill-based rehabilitation by providing users with **feedback** and **feedforward** about their swallow.

**RESEARCH SUMMARY:**

Dysphagia is often characterised as a patient's inability to swallow but is clinically defined as "an abnormal delay in the movement of a food bolus from the oropharynx to the stomach" (Chilukuri et al., 2018). Dysphagia is a significant issue in the aged 60+ demographic, with some reports of up to 80% prevalence in care homes in the United States (Steele et al, 1997). Eating and drinking are embedded into social culture, and losing this ability impacts more than the physical body, with mental and emotional implications being serious consequences as well. There are 2 established methods for rehabilitation: strength-based and skill-based. Skill-based rehabilitation appears to produce better patient results in the long term and incorporates concepts of **specificity**, **challenge** and **feedback**.

**IDEATION AND CHOSEN CONCEPTS:**



**USE:**

**1a**



The clinician can undertake manometry with the user/patient and upload their timings to the glove via the USB-C connection or bluetooth. This utilises the feedback nature of the glove.

**1b**



The user presses a button on the top of the glove to activate the haptic motors. They can then feel the sequence of their swallow based on their manometric results. This may be mis-sequencing of the haptic motors or unusual patterns and will then try to correct the sequence based on established manometric pressure timings.

**2a**

230ms



The clinician can load established manometric timings onto the device. The haptics will vibrate sequentially over 230ms.

**2b**



The user can then use the device as a feedforward system for use in both clinical and domestic settings.

**DEVELOPMENT:**



The chosen concept included a hard plastic plate to protect the electronics controlling the glove. However, this was altered to accommodate for the organic and varied shape of the hand; instead of the hard plate a material covering, complete with a zip pocket was designed.

**PROTOTYPING:**

**VERSION 1:**



**VERSION 2:**



The design then went through an iterative prototyping series, resulting in the finalised product. The finger material was moved from the top of the fingers in Version 1, to the underside of the fingers in Version 2 to allow for greater movement of the patients fingers and a smoother transition from the electronics box stored in the pocket on the top of the hand to the haptics on the finger pads.

**FINAL PRODUCT:**

**1**



Photo 1: adjustable velcro straps to account for different sized hands. N.B. the button

**2**



Photo 2: representation of the glove worn on a user's hand

**3**



Photo 3: electronics pack being charged. The zip pocket allows for easy access to the electronics pack for charging, data transfer and repair



The **GULPS** Glove assists in skill-based rehabilitation through providing a **specific** sequence of haptic sensations to the user, who is **challenged** to repeat or correct the pattern. The patient will receive **feedback** from either the glove itself (depending on the timings loaded onto it) or the clinician facilitating the training.

COURSE: PROD314  
SUPERVISOR: Dr. Euan Coutts

STUDENT: Teaghan Mower  
INDUSTRY CONTACT: Prof. Maggie-Lee Huckabee

UC<sup>PRODUCT</sup> DESIGN

THE UNIVERSITY OF CANTERBURY  
ROSE CENTRE  
FOR STROKE REHABILITATION & RECOVERY  
AT ST GEORGE'S MEDICAL CENTRE  
AND ROSE HALLS IN DUNEDIN




Student projects: Product Design - Industrial Product Design

# KIWISAT

## 1U CubeSatellite



**William Murrell**  
*Industrial Design*



**What is a KIWISAT?**  
The KiwiSat is a 1U cube satellite designed to protect sensitive payloads from intense vibration and acoustic environments during the ascent of an orbital rocket.



### About the Project

#### Abstract

The overall aim of this project was to test the secondary properties of unidirectional harakeke fibre provided by KiwiFibre Innovations to determine the possible engineering application(s) and the positive environmental impacts that it may have on an industry. This project has determined the preliminary properties of harakeke reinforced with epoxy resin and determined a possible application of the material to showcase its strength and endless possibilities.

#### Brief

Industries such as marine, sport & rec and many more are looking for new types of natural fibres to use in their laminates. This project aims to test and validate different material properties such as sound absorption and vibration dampening of harakeke laminates. From these results, possible products are to be designed to be made from this material with consideration of any possible engineering and manufacturing constraints.



### Material

Harakeke was incorporated into two different hybrid composites to complement the properties of the other materials within the laminate. The first composite is the structure designed to provide structural integrity, and the other is a sub-structure intended to reduce the intense acoustics and vibrations felt by the payload.

### Sub-Structure

The sub-structure is a hybrid composite of harakeke and cork, optimised through testing to dampen acoustics between 90 and 1800Hz. This material has an acoustic absorption coefficient of between 0.4 and 0.8.

### Structure

The structure is a hybrid composite of harakeke and carbon, mass optimised through FEA to provide structural integrity. With the rule of mixtures, the structure was found to have a longitudinal young's modulus of 35 GPa.



**Continous Harakeke Composite**  
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# Student projects: Product Design - Industrial Product Design



**SITE  
HOLD**

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Project Supervisor  
Tom Keen

**Aims** I made a fake press release to gather keywords which become my aims and values which I intend to uphold with the Sitehold. The Sitehold is a revolutionary work holding solution for tradesmen. The Sitehold is the most accessible, easy to use work holder currently available for the tradesmen who are always working offside, it's convenient, stable, strong and easily maintained.

The Sitehold was created to make sure every tradie gets home to their family unscathed after long days at work. We don't want to make another gimmick which safety commissioners require you to use, we want the SiteHold to be your go to when it comes to work holding on the job site. We want it to be easy but effective to use. The SiteHold will get the job done and done right!

## The Sitehold Design Process

This is the design process I followed during the creation of the Sitehold. This is a iterative process where it is repeated over and over until specifications are met. Here is a summary of each step and what I did.

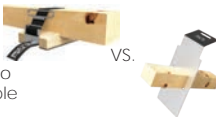
**1. Abstract** Identify the problem.  
I have decided to focus my brief on work site safety as over the last summer I was working as an apprentice of an engineering company. I noticed I would find myself in unsafe conditions whilst working when a stable work holding would have solved this issue.

**2. Research** Verify the issue.  
The construction industry is the most dangerous industry with about 37,000 claimed injuries per year. This is why it should be in our best interest to reduce the risk of these injuries occurring with innovative solutions.

**3. Imagine** Possible solutions.  
Concepts



**4. Plan** Select a promising solution.  
Using a convergence matrix against specifications to find best possible concept.



**5. Create** Prototyping.  
Prototype to inform inherent design problems.



**6. Test** Evaluate Prototypes.

Validate design using specifications, to gain feedback.



**7. Improve** Redesign.

Using feedback and results from prototypes, refine and solve the issues and problems



**Repeat** Until The Final Design.



Once the goals are met the cycle stops and we are left with the final design.

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# Forever Fresh

## Background

Dairy Farming is one of New Zealand's most important industries, and for those working in the field, good equipment that helps to get the job done is very important.

One piece of equipment that gets daily use is the trusty gumboot. However, despite the great job that they do keeping out the wet, they can also be a cause for discomfort.

After minimal time wearing gumboots, doing anything remotely physical can lead to sweat build up around the feet, and wet socks even on cold days. This can lead to medical issues.

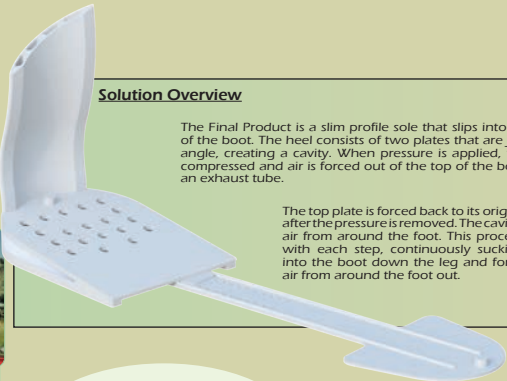
This Project explored possible solutions to this issue, and developed a well-considered and complete product.



## Solution Overview

The Final Product is a slim profile sole that slips into the bottom of the boot. The heel consists of two plates that are joined at an angle, creating a cavity. When pressure is applied, the cavity is compressed and air is forced out of the top of the boot through an exhaust tube.

The top plate is forced back to its original position after the pressure is removed. The cavity refills with air from around the foot. This process happens with each step, continuously sucking new air into the boot down the leg and forcing humid air from around the foot out.



The exhaust tube is curved to fit the back of the users calf and the form of the gumboots leg. The tube is reinforced by three stainless steel strips that give the tube extra rigidity and help to prevent it from collapsing.

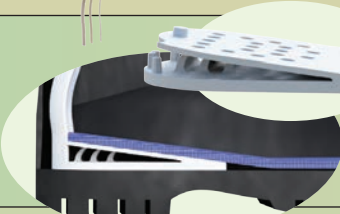
The tubing is also curved to make sure that there are no sharp edges that the user will feel during use.

The bottom of the tube opens to the side, which serves as the opening.



To hold the top of the exhaust tube in place and to stop it from moving around while walking, a stainless steel clip has been added. A lip at the top of the tube gives the clip a snap fit, while also facilitating the user in removal of the product.

The airway within the tube is split into 4 separate tubes, creating ribs which give the tubing more support.

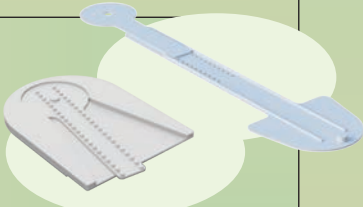


The two plates of the heel come together at an angle, leaving a space below. Curved protrusions from the base plate serve as the spring mechanism that return the top plate to its original position.

The back edge of the top plate follows the profile of the exhaust tube, creating a snug fit which allows the plate to move while only a minimal amount of air can pass through.

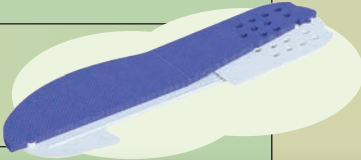
Two thin sheets act to hold the heel in place by putting pressure against the toe of the boot. The first piece is set into the underside of the bottom plate and can rotate to some degree. This rotation allows for the change in angle that occurs between the heel and the toe as shoe sizes change.

The two pieces snap together, and can easily be adjusted to fit the desired shoe size. The distance changes in 4mm increments, corresponding to the difference between each shoe size.



A piece of fabric layered with plastic wraps around the back of the heel, forming the final wall of the cavity and sealing it. There are four protrusions on the back of the bottom plate, each of which fit into one of the four airways in the exhaust tube. This provides a solid connection for assembly.

A special sole is held in place by two protrusions, one on the tip of the toe and one on the top plate. The sole has holes which correspond to those on the top plate, allowing the air to flow through. However, there is a thin filter attached to the underside of the sole which does not have hole. This stops any debris and dust from entering the cavity and causing blockages.



## Forever Fresh

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# Student projects: Product Design - Industrial Product Design

## SLEEP RHYTHM

### DISCOVER: WHY?

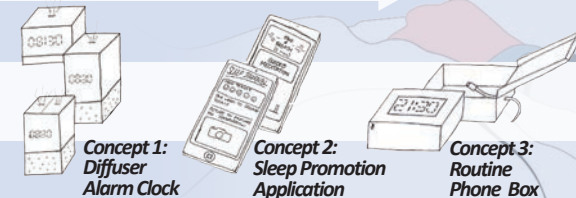
Attention deficit hyperactivity disorder (ADHD) has affected my quality of life daily and it always will. It impairs all or most executive functions which can have impacts on self-esteem, relationships and studies/work (Brown, 2021). Experiencing ADHD first-hand has motivated me to create a product that will not only help those with ADHD but anxiety (often comorbid with ADHD) as well. People with ADHD and anxiety often struggle with the quality and quantity of sleep they get regularly. A lack of sleep can amplify symptoms. Most people with ADHD and anxiety struggle with falling asleep and waking up. Often battling with an overflow of thoughts and anxiety right before bed (Golden, 2017). An online survey conducted found only 20.1% of participants get the recommended amount of sleep. This validates why this is the direction I have chosen for the project.

### DEFINE: WHAT?

**Aim:** To create a product that improves sleep quality for people aged 18 to 64, with ADHD or anxiety.

To ensure target market satisfaction and refine project direction, product design specifications (PDS) were implemented. The most important PDS requires focusing on the consumers' needs through the use of empathy. The product must also be engaging, easy to use and promote a calming environment to maintain user interaction.

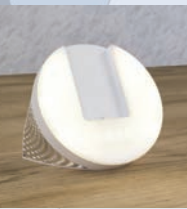
### DEVELOP: DESIGN PROCESS



### 3D Printed Prototypes for Routine Phone Stand



### Champion Concept



### DELIVER: HOW DOES SLEEP RHYTHM BENEFIT YOU?



### Sunrise/Sunset Alarm:

Alters brightness of natural light LEDs to simulate a sunset/sunrise. This will work with the body's circadian rhythm, which will cause the body to regulate its sleep cycle.



### Alarm Tones & Sleep Aid:

Soothing alarm tones to make waking up easier for those with ADHD and anxiety. Optional sleep aid was implemented to help users fall asleep easier.



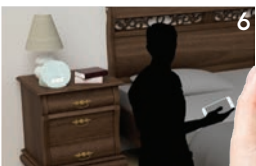
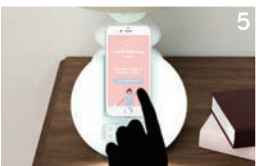
### Routine Builder & Enforcer:

Having scheduled routines allows the mind and body to associate those activities with falling asleep/waking up. The application offers rewards and punishment if the user attempts to use their phone during their scheduled sleep period.



### SLEEP RHYTHM APPLICATION!

- Personal routine builder
- Tracks sleep progress
- Unlockable achievements



TRY THE APPLICATION DEMONSTRATION!

### SLEEP MATTERS

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# Seaweed Plasterboard

Research & Development

## Introduction



What if there is more use for algae(seaweed) than cosmetics, food, and fertilizers? The project aims to develop a fire-resistant, moisture-controlling biocomposite panel for wall and ceiling plasterboard to eventually replace conventional plasterboard. Seaweed panels cannot only reduce the carbon footprint of building materials but also help to contribute to safer and more livable homes in Aotearoa/New Zealand.

## Development

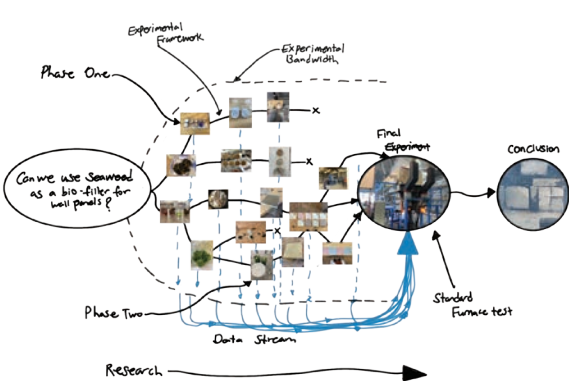


During the research, I found three different types of seaweed: **green**, **red** and **brown**. Each type had distinct characteristics and features that could affect the performance and strength of the plasterboard. A few different compositions between seaweed and plaster were trialed.

Detailed information about the development and final results of the seaweed plasterboard cannot be disclosed due to intellectual property confidentiality.

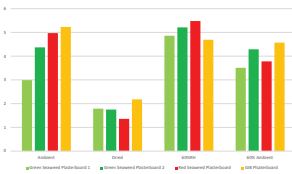


## Design Process



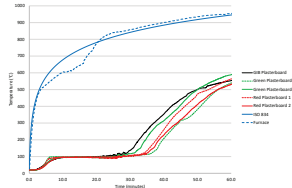
## Results

### Moisture Control



Compared to the average GIB plasterboard, seaweed plasterboards are up **64% better** at absorbing moisture in a humid environment (60% relative humidity). They can also take out the moisture to the environment up to **92% better** when the humidity level goes down.

### Fire Resistance



GIB's fireline reached 300 degrees first, meaning that the encapsulation rating will be 43 minutes. All seaweed plasterboards achieved a higher encapsulation rating of **45-50 minutes**, which is better than the fire-resistant plasterboard.



## Seaweed Plasterboard

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Innovation Jumpstart 2021 Greatest Commercial Potential winner

SUPERVISORS  
Dr. Tim Huber and Dr. Dennis Flau  
UC **PRODUCT DESIGN**  
To learn more about  
productdesign.uc.ac

Student projects: Product Design - Industrial Product Design

# MixUs

Bringing inclusivity to mixing and baking

**BRIEF - "Beyond the kitchen table"**

To develop and design a suitable kitchen product that influences people of diverse ages and abilities to prepare food in an inclusive and engaging way.

**BRIEF SUMMARY**

This design project has the purpose of allowing me to develop and produce an enjoyable kitchen product/solution that enables people of diverse generations to engage, prepare, entertain and enjoy being together whilst in the kitchen. This brief has allowed me to design and create a delightful solution that can allow people to be more active in the kitchen as well as effectively and efficiently use kitchen spaces comfortably. All whilst being concise of diversity, differing ages, abilities and interests. This product targets the elderly range of my market, with health symptoms such as arthritis, as well as targeting kids who want to become included and comfortable with the mixing and baking methods.

**SPECIFICATIONS**

Product

- Easy to use
- Engaging
- Easy to clean/mini-mess
- Inviting

User

- Provide confidence whilst using
- Inclusive of diverse generations

Mixing arm can rotate 360 degrees in any direction desired.

**Ice**      **Storage**      **Hot Water**

**ALTERNATIVE APPLICATIONS**

**Ice-cream maker**

In this method, the bottom bowl can be filled with ice to form a colder temperature for the upper/top bowl which contains the mixture. This method can be used in the absence of an ice cream maker.

**Bain-Marie/Double boiler**

A Bain Marie is used to cook delicate items at low temperatures utilizing the steam created by the Bain Marie. A Bain Marie can be used to slowly melt goods like butter or chocolate for use in baking mixtures. (Gemma, 2017)

Whilst baking using this method, children can learn and become educated with knowledge on heat transfer, temperatures and state changes of ingredients or foods.

**Section Views**

**Usage Storyboard**

- User places the product where they intend to use it, in a safe work-space on a flat bench top surface. Assistance on surface grip/friction comes from the silicone base layer.
- User unscrews the top bowl and removes it to reveal the bottom glass bowl. This is only necessary if they intend to add content to this glass bowl, or use this compartment as storage.
- If required, the user may now add content such as ice or hot water. This is an alternative option for bain-marie or ice cream methods.
- User then screws the top bowl back onto the bottom glass bowl and creates a seal. The user is now free to add baking ingredients to the top bowl, rotate the mixing arm and operate the product.

Pin Cap - Stainless Steel

Handle - PET Plastic

Mixing Arm - PET Plastic

Handle Pin - Stainless Steel

Silicone Edge - Silicone Rubber

Top Bowl - HDPE Plastic

Bottom Bowl - Ceramic Glass

Base - HDPE Plastic

Rubber Base - Silicone Rubber

Beyond The Kitchen Table

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## Student projects: Product Design - Industrial Product Design

# Aotearoa Adaptive Archery Project 2021

PROD314: INDUSTRIAL PRODUCT DESIGN 2B

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SUPERVISOR:

Barro De Gast

SPONSOR NAME:

Christchurch Archery club

### AIM:

To create a device/ system that aids visually impaired children from the ages 10-18 to engage in the sport of archery.

### Product Design Specification

Device must aid the user to shoot the arrow up to 50 m without the assistance from spotter by having a sample group of archers test it out.

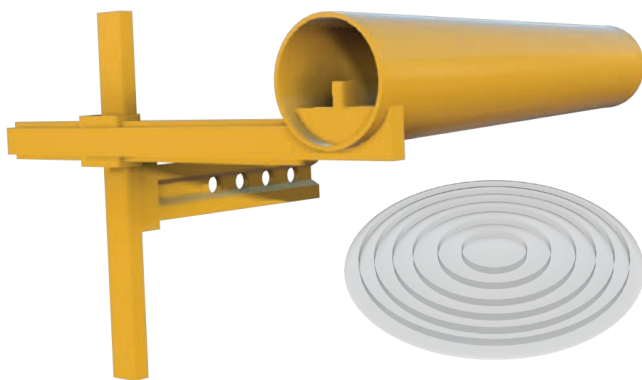
Device must be dust resistance and can withstand water splashes for any angel with IP54 rating .

Device must be able to be used by beginners that are using a recurve bow for target archery by having a sample group of archers test it out.

Devices must be able to be used by children of age 10-18 by having a sample group of children test it out.

Devices must take a maximum of 20 minutes to assemble by having a sample group of random tests.

Devices shouldn't change the overall design of the archery equipment and must comply with world archery competition rules and regulations.



### Product Evaluation

The final product is a simple and cost effective method in aiding children with visual impairment to play archery. The first being a sight, this can only be used by partially or low visually impaired people as that is what most of the market is made up of. It was concluded that the current tactile device is the most effective product that could be used by people who are legally/ fully blind. This is achieved by having a scope which is used in rifles to be placed where the sight would be placed. The only thing which is moving is the parts which are holding the scope upright. There are two buttons on the scope which help the shooter move the scope 5mm in the x or y direction to aim at the center every time. The circle move the scope left to right and the square move it up and down.

The second being the lens which are used in the scope. It was decided that as a beginner, there is no need to use expensive products when they do not understand the function of the product. The lens would be turned into a fresnel lens. Making it smaller yet having the same effect that a normal lens has. This also used less material and did not cost a lot to replace . The lens will be made out of clear plastic to prevent it from harming the child if anything happens. As the child is learning they could use different shapes, and find the one that sees them the best.

The final product to the set being a spotter board, it is an interactive board which allows the visually impaired person locate where they may have shot their arrow at. This will work as the spotter must be present for safety reasons, they will not communicate which the child or person is shooting. They will only play the pins closest to where the original arrow has been shot. Each individual coloured ring will be on the board as the colour that is on the board but brighter. The rings can also be differentiated by the different layers, the ring will be offset from the ring they are next to, this will help the shooter identify the different rings. The pins have an indentation on the end of it, this helps the shooter find the pin without a problem.

### POTENTIAL TECHNOLOGY

#### Frightprops reflective beam sensor

The frightprops reflective beam sensor works as a motion sensor when the beam is broken. This sensor works great with other manufacturing controllers. This triggers contact closure for the controller to be activated. Requires a power supply to be able to work. The maximum distance that can be in between the beam and the reflector is about 4m (13 feet). Should have a DC 12-30V and relay contact output of 250 VAC, 2.5A MAX. The light source is a red LED and is retroreflective. It is a compact size. (Frightprops, 2015).

#### Linear Stepper Motor

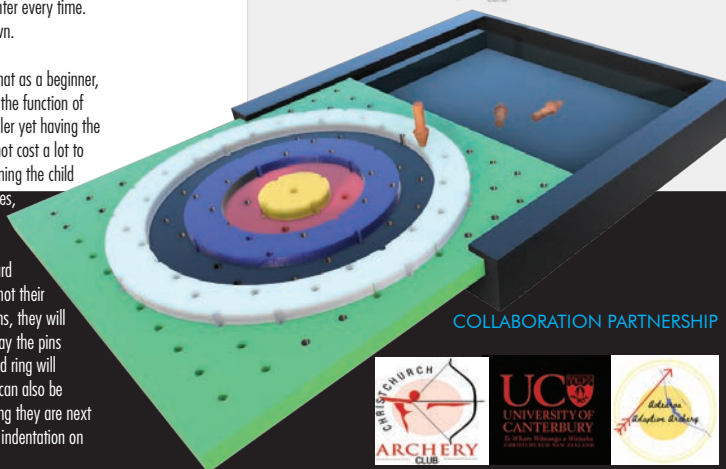
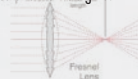
A linear stepper motor stages allow another device or product to be placed on top of the moving plate which is moving on a single axis. The LSS-01 6-04-006-01A-ME Low profile linear stepper motor stage by H2W Technologies is a new addition. The brushless linear motor on the device allows the stage to move more faster and accurately along the path. The product from H2W Technologies has a low profile, is of compact size, has a small footprint and a flat stage board to place other items on top of the platform.

#### Spotting Scope

Spotting scopes is a product which looks similar to a mini telescope, instead of having 2 eyepieces like a binoculars, a scope only has one from the person to look through. It is usually placed on top of a tripod as it is not to be used as a hand held device unless it is fixed onto another device which will hold the scope up. The scope magnification starts at about 15-20x while zooming out and at a 40-60x when zooming in. As shown below the two pictures are taken from a binoculars and the other one with a scope, the first one is with a photo taken using a binoculars and the one to the right is taken the same way but with a scope. (Bird & Nature Blog, Birding, Entryway to Birding, 2020)

#### Fresnel Lens

Is a lens which is compressed into a sheet form compared to a normal lens where it takes up space due to the shape of it. It is used to magnify objects. It can be made out of glass or plastic which can reduce the cost of a normal lens. It is used in places like lighthouses and traffic sights.




COLLABORATION PARTNERSHIP




# Student projects: Product Design - Industrial Product Design

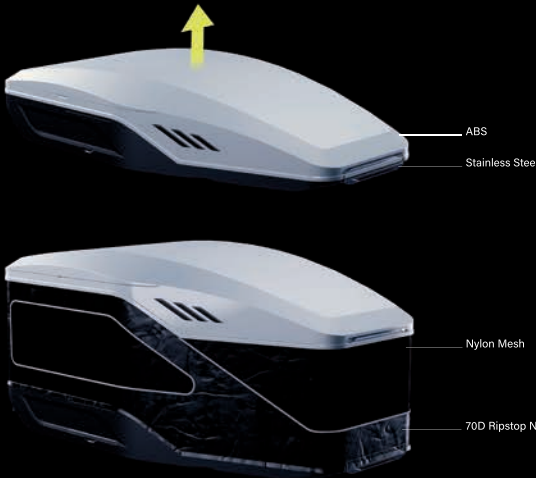
Weight: 60kg  
Storage: 35kg  
Roof Box: 600L

ABS Plastic 4mm  
\$5500

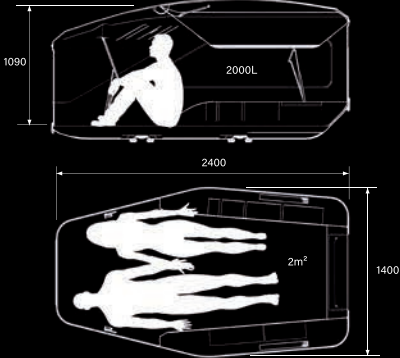


The Raven is a unique hybrid between a roof top tent and a roof box. The tent sleeps 2 people and provides a storage capacity of 35kg. The bottom and top ABS shells create a unique design with the material combo. Regular roof boxes meet at a straight plane while the Raven has a curved plane where the two shells meet to provide functionality for storage and aesthetics. The tent self assembles using the 4 gas strut linkage systems. The top shell comes in 3 main colours, Silvia, Vermilion Red and Ocean Blue. The colours can also be custom made to match your SUV colour.






ALL DIMENSIONS IN MM



The tent floor shape is created to make better use of area and space to provide extra storage room. People are wide in their shoulders and narrow at their feet. The shape accommodates for this by being narrow at the back and tapering out as it gets to the top to allow room for the shoulders and arms.


The Design has one release bar at the front and two release latches at the back. When these are released the tent will automatically be open up to form the tent. It uses 50-200N adjustable struts that can lock out when opened to prevent the tent from dropping under heavier loads. There's two side windows and one large front window that's designed to open the tent to the landscapes surrounding it. the windows can be opened to let air in or closed to have a fully blacked out interior for those morning when you want to sleep in.

For ventilation during the night and for quick canvas drying the design has 3 vents on either side that bring air in. the air travels through drying the canvas and exits out the rear vents. You can adjust the vent opening or close them from the inside on cold nights. The vents are also a unique design feature not seen on any existing roof top tents.



**Roof Box Tent**  
Renato Poenar  
Industrial Product Design

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Website

SUPERVISOR  
Wendy Zhang  
INDUSTRY COLLABORATOR  
Individual Brief

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## Student projects: Product Design - Industrial Product Design



Allbirds at the front lines of a climate march

# The Mother Slides

Made from nature, for nature

CARBON FOOTPRINT

+ 2.0

KG CO2E





MOTHER EARTH  
MOTHER NATURE & A  
KOMBUCHA MOTHER  
THATS IT!

### Kombucha SCOBY

Dried and waxed Kombucha SCOBY, a planet-friendly solution to leather—one of fashion's most damaging and most commonly used materials. It's naturally pigmented and fully biodegradable, leaving a much smaller footprint after its time is up. This bacterial cellulose strap lets us re-imagine what's possible with sustainable innovation.

### Sweetfoam®

Allbirds' very own sustainable material Sweetfoam® made from sugarcane incorporated into a bouncy footbed, engineered for serious foamy comfort. With a bold and fun added texture that increases comfort and grip, pushing both you and fashion forward into the future.

### Natural Cork

100% hand-harvested cork from super carbon-absorbing cork trees in the Mediterranean. A sculpted and contoured ergonomic sole that moulds to your feet for ultra instep comfort.

### Industry Brief

Climate justice, activism, and inclusivity are themes that are important to Allbirds. What does an Allbirds product look like at the front lines of a climate march?

### Problem And Purpose

The fashion industry is the second biggest polluter in the world. Not to mention it dumps a whopping 2.1 billion tonnes of carbon dioxide into the atmosphere every year. That's equal to the pollution from 456,707,817 cars in the same time frame. The industry's become obsessed with using harmful materials, plastics and synthetics. So I asked myself a question: If mother nature gave us these fabulous materials, why aren't we using them?

Please refer to booklet for design process.

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# Student projects: Product Design - Industrial Product Design

## THE BETTER LADDER

### ABSTRACT

The Better Ladder was a collaborative project between the University of Canterbury, and industry partners Talbot Technologies Ltd. and Ladder Solutions PTY Ltd. The goal of the project was to redesign several key parts of the single sided stepladder in plastic, with an aim of providing increased functionality and safety for a future range of step ladders. The design process was heavily influenced by many factors such as research, industry consultations, and iterative ideation, to produce a final product that meets the requirements of the initial brief and embodies the concepts of the design effectively.

### DISCOVER

Research was a key part of this project. Using information and performing literature review provided valuable insight into potential solutions before any design work even started, and allowed for greater understanding of what the problem actually was, and why it needed to be solved.



Figure 2: Ladder Solutions' LA20, PROPTT, and PROPHDTS accessory offerings used for early research and inspiration

### DEFINE

It was important to take the findings from the discover and research phase and use these to create a clear PDS. This PDS was used as the framework for the design process, aiding in ideation and guiding design decisions in future stages of the project. The PDS was primarily developed around the safety standards for ladders, with respect to the parts being designed in this project, along with using Ladder Solutions' design philosophy and existing stakeholders to help guide the concept designs.

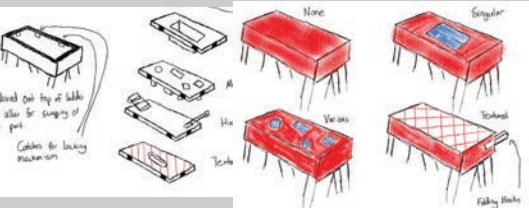


Figure 4: Early sketching development of the modular top system

### DELIVER

This final stage comprises of testing the solution, using prototyping, computer analysis, and expert opinion, to ensure the concept has been properly embodied through the final design. 3D printing was used to produce the prototype of the parts that will be injection moulded in the actual product in a 1:1 scale, and two cut-off ladder frames for the top and bottom of a ladder produced to model them in their respective positions. The dimensions were all developed based on industry standards, and with the ability for the parts to go on any size ladder in the product range. The end product will be made from Nylon 6-6, with glass reinforcement if required for strength. High contrast yellow colours were selected to help with safety, and make the parts stand out on the end product.

### BRIEF

The brief is to explore the redesign of these elements using plastic as a material and provide additional features which enhance functionality and safety. "The aim is to help complete design and development of a new range of specialist ladders destined for export markets that include India, Indonesia and the USA."



Figure 1: Parts of the ladder specified for redesign from the brief

### RESEARCH

Research done was primarily performing literature review of the relevant safety standard for metal step ladders, AS/NZS 1892.1:1996. The relevant tests for the parts being designed were the Ladder Compression and Foot Distortion Test, the Stile Cantilever Test, and the Foot Friction Test. In addition to the literature review, research into Ladder Solutions' range of products was also performed, to gain a better understanding of their design philosophy and the range of products they sell. Finally, using Ladder Solutions' existing stakeholders, user profiles were developed to test design concepts against.



Figure 3: Ladder Solutions existing PROS and TRDS models in their INDALX range.

### DEVELOP

Early development consisted of ideation techniques such as brainstorming and SCAMPER. Three core concepts were created, and through both individual evaluation, and with industry professional consultation, from Talbot Technologies and Ladder Solutions, for their evaluation, the final concept was selected and developed further. The chosen modular concept was developed further, and low-fidelity models were produced as a proof of concept before higher level development began with CAD modelling and 3D printing.

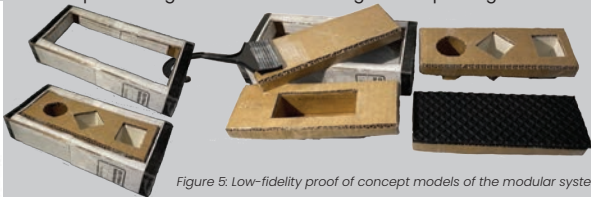


Figure 5: Low-fidelity proof of concept models of the modular system

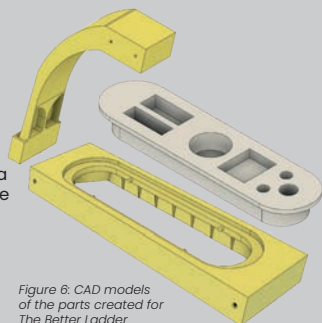


Figure 6: CAD models of the parts created for The Better Ladder



Figure 7: Prototype part of the ladder top frame and insert using 3D printing

#### The Better Ladder

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Industrial Product Design

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**Talbot Technologies**  
Inspired Solutions in Plastic

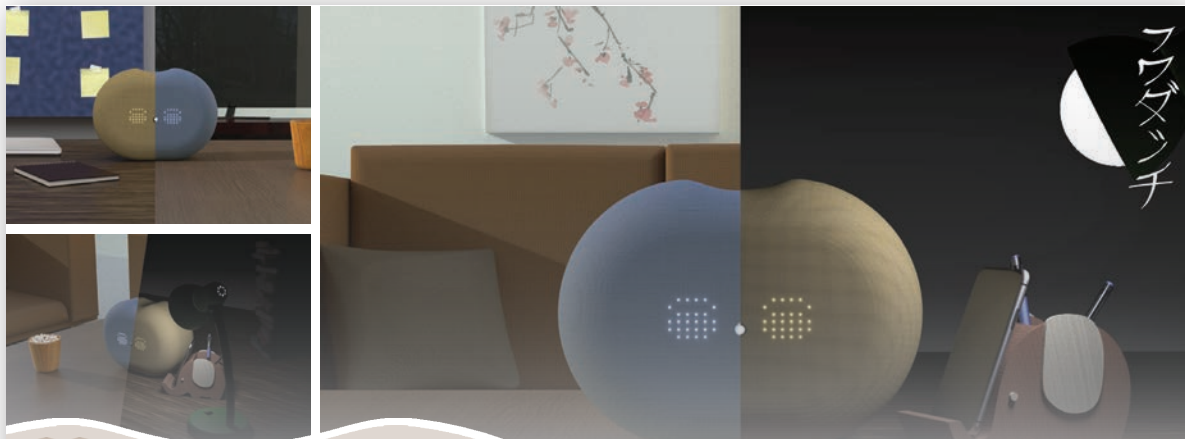
**LADDER SOLUTIONS PTY LTD**

SUPERVISOR  
Will Duncan

INDUSTRY COLLABORATOR  
Talbot Technologies & Ladder Solutions

**UoC PRODUCT DESIGN**  
The School of Design  
productdesign@uclive.ac.nz

## Student projects: Product Design - Industrial Product Design



# DISCOVER

Loneliness is an emotional state arising from insufficient meaningful connections with others. Causes of loneliness are generally internal (from within), situational (from external forces), or developmental/growing pains. Symptoms can lead to development of depression, stress, anxiety, alcoholism, irregular sleep, Alzheimer's disease, and/or suicide.

Research of New Zealand wellbeing in 2020 determines younger demographics reported to have the greatest percentage of loneliness. Along with that, loneliness has a strong relationship to high introversion and neuroticism. In surveys and interviews, some methods of reduction were physical face to face interaction, social media, and pursuing hobbies.

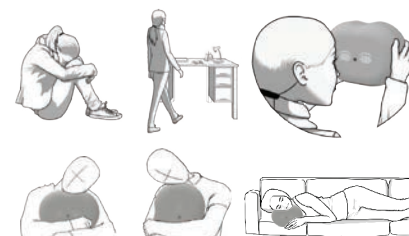


## ABOUT

Fuwadatchi acts as another avenue of communication for young adults to interact with friends or loved ones. Developed from the rise of self-quarantining during the Covid 19 pandemic, this uses facial capture technology to create a face to face like interaction. Physicality is also added through the pillow which is often lost with digital communication channels.

## DEFINE

The project brief was to develop a physical product which allows for communications with others wirelessly for long distance conversations and/or to help individuals in self-quarantine and general isolation. Target users are young adults 18-25 years old likely beginning their life as an adult and requires the product to sustain interpersonal relationships over long distances through promotion of face-to-face interaction. It must also accommodate for introverted and neurotic individuals, allowing for expression of vulnerability, reduce stress, and encourages physical intimacy.



## DEVELOPMENT

Conceptualization, development and prototyping were done with feedback from target users. Ideation was highly varied but were based of facilitating social interaction and communication. It was also a priority to make physicality apart of the product to both justify itself and add a new dimension to long distance communication.

Feedback from users aid in narrowing the concepts to the final "Rabbit Pillow" which was iterated upon to be made in industry. Target users helped test prototypes along with material choices, ergonomics, size and shape, and quality of life choices. Research into face capturing technology was done to help promote specific behaviours similar to face to face. Additional Research was conducted on similar products, materials, manufacturing, business and electronics to gauge desirability and increase feasibility.



## DELIVER

The Fuwadatchi captures user face and audio data using a face tracking program. This is then transmitted to a synched pillow and outputs as eyes through a LED matrix and speakers. From this, it provides a face to face like interaction while users are physically apart.



To recharge the pillow with a micro USB.



Fabric:

- Cotton Spandex fabric 95% cotton and 5% Spandex.
- Sourced from Ichimen, a Japanese textile company.
- Highly flexible, stretchy, gentle, soft to the touch.
- Requires delicate care but long lasting.



**SWITCH:**  
**POWER:** Hold down the button  
**MUTE:** Short push of the button  
**ROTATE:** Adjust speaker volume

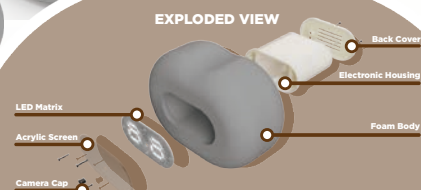
- **Foam body:**
  - Medium seat back foam 20-100U. Used in furnitures like chairs and sofas
  - Density of 20kg/m<sup>3</sup> and a hardness of 100 +/- 10 N
  - Body shape uses a circular rectangle shape with a middle dip to emphasize the eyes and allow users to rest their arms and head.
  - Treated with antimicrobial chemicals.



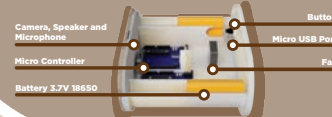
Can be customised to have additional accessories, colours and alternate functions.



### EXPLODED VIEW



### INTERNAL COMPONENT ARRANGEMENT



## Fuwadatchi

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UC  PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

# Gidget

the discrete fidget accessory

**brief.**

Do you ever find yourself biting your nails, twirling your hair, or clicking your pen when you're in a meeting or waiting room? Fidget toys are used to focus movement onto an object, causing the user to be more attentive and calmer. They can also be used to focus attention and improve learning ability. Fidget toys enable the user to give their hands something to do, while allowing their brain to focus on the task at hand.

I have set out to design a fidget accessory; a fashionable fidget product that can be carried and used in any environment. It aims to remove the social stigma around bringing a specialty designed product into stressful situations. Instead, it will be disguised as an accessory. A fashionable product which appears to be a single purpose item to the blind eye.

**research.**

Research identified that fidgeting is not limited to those with mental health diagnoses such as ADHD and Autism Spectrum Disorder. Rather, there are four key reasons why people fidget, and everyone undergoes these feelings throughout their lives. These reasons include Explore, Active, Focus and Relax.

The final products should solve all four reasons for fidgeting, ensuring they can be used in all situations. Market research highlighted the need to design for both men and women between the ages of 18 – 29 years, however, the products are not limited to this market segment. They should be handheld and useable in any environment while not distracting others. The products should aim to mitigate the negative social stigma around adult fidgeting habits.

In terms of aesthetic aspects of the products, plastics and bright colours should be avoided as they are seen as low quality and immature. High quality materials such as metal and wood should be used to reflect the sophisticated nature of the target market.

**ideation.**

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Each of the six main concepts solve two of the four reasons for fidgeting. The magnetic and kerf bent bracelet and gear keychain, which solve the Explore and Active reasons, utilise big movements carried out by two hands. The products can be manipulated and moved in multiple ways, ensuring the user does not get bored of the products easily. The ball bearing keychain, spinning phone case, and spinning ring utilise a simple, repeated motion which can be carried out with one hand, meaning they solve the Focus and Relax reasons for fidgeting.

The Gear Keychain concept was taken forward to further develop and see whether a single concept can solve all four reasons for fidgeting.

**prototype & deliver.**

Prototyping highlighted the need to have different size and shape options as well as the ability to customise the products.

The fidget accessory can be used in any environment or situation, utilising small and big movements with one or both hands.

Gidget currently consists of five products which harness a spinning motion. Each product has been carefully designed with the end user front of mind. With three shape options, two different sizes and three material options, the customer can essentially 'design their own product' which satisfies their needs and behaviours. There is the option of engraving patterns on the medium density fiberboard products. The patterns can be selected by the customer and painted if desired. Additional senses have also been included by incorporating essential oils and surface textures in order to maximise the user experience. The additional lobster clasp and keyring enables the products to be attached to a set of keys, backpack or handbag, meaning the product will be available whenever it is needed. The Gidget products can be used in all environments the user deems necessary, including the workplace, during lectures, in restaurants and even at home.

The products will be ordered on the company website, with an interactive interface for customers to design their own fidget accessories.

Chynae Rigter  
18785644  
Bachelor of Industrial Product Design  
Supervised by Wendy Zhang  
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# the perendale chair.

### the context

Overconsumption of materials, combined with 21st century consumerism, is driving irreversible environmental damage. The solution to which lies in more efficient, affordable and sustainable systems and initiatives. Of these, there is no one single system or initiative which will solve all of our problems, but rather many small things that we can do. One of these is addressing the materials used in our products.

**The role of a designer is to solve problems by understanding people.** Applying this to the problem of overconsumption of products, materials, and 'stuff', we start to learn about the intrinsic connection we share with them. This is what this project is about. If we can understand how to design an emotional connection with a product, and figure out how to encourage responsible consumption, then we can start to design out waste, establish circular economies of materials, and start to turn the tide of consumerism.



### Harakeke and coarse wool.

These are two fibres which industries became obsolete when synthetic materials entered the market at a fraction of the economic cost... but when it came to the environmental cost, we simply pulled the wool over our eyes.

Coarse wool/strong wool is a wool grade which makes up around 85% of NZ's total clip and fetches prices so low it barely covers costs of shearing and is often discarded. Coarse wool was a popular choice for carpets before synthetic carpets pushed wool out of the market. Finding new product applications which offer exposure for the material will be integral in increasing demand and therefore price.

Harakeke/flax is abundant, fast growing and, as your lawn mower will know, incredibly strong. It compares well to fibres already used in the natural fibre composites industry such as hemp, sisal and flax, which are already used overseas to make boat hulls, skis, car body panels and even satellites. It has not been used commercially since the early 20th century when it was New Zealand's biggest export earner. The time is right to revive the harakeke industry and bring the fast growing natural fibre composites industry to New Zealand, creating jobs and sustainable economic growth to a number of sectors.

### the project

This project aimed to explore short/non-continuous harakeke and coarse wool fibres and their potential as materials in product design.

It investigated the processability of those fibres, and the interactions the user experiences when exposed to the material. The project considered many material forms and a range of possible product applications before deciding upon a direction for the project.

In order for the chosen product to be successful, it had to be visible to a wide range of people, embrace the irregularity and roughness of natural fibres, provide a unique interaction experience when used, utilise typical properties of natural fibre composites and still be easily manufacturable for the purpose of the project and to keep projected cost down.

### the design process

The project was split into two major stages; *material development* and *product design*.

During the material development stage, a number of harakeke and/or coarse wool materials were created to assess processability and suitability for developing into a product. This ideation process was based on research but was heavily experimental, and relied on new processes for fibre mixing and cutting. The coarse wool/harakeke composite material was chosen as it is a combination never seen in a product before. Using both fibres in a product also nicely ties together the story of the industries and the shared mission people have of reviving them.

In the product design stage, a shortlist of applications was analysed against the product design specification and what it needed to achieve in order to promote the fibres. Keeping in mind the processing limitations of using an experimental material, the chair design was developed and improved over time.

### the material

91%\* This is the content of the chair which is natural material.  
With advancements in resin technology, and as the harakeke-wool composite material is further developed, this number will only increase.

The material that was developed is a hybrid biocomposite material utilising harakeke fibre and coarse wool, infused in a plant-based bioresin. It features a smooth finish on most faces, except the rear of the backrest which features exposed fibres, providing a unique touch experience to the user. \*It is made of 3 4kg bamboo plywood, jessie | 16kg seat base and 42kg seat back. Assuming the bio-resin is 40% bio based.





Natural Fibre Centred Design  
**Ben Scales**  
*Bachelors of Industrial Product Design and Commerce*  
91751092

Supervisor: Tim Huber  
**UCo PRODUCT DESIGN**  
*Te Kura Hanga Otinga*

# Reflex Stem

## Design Brief

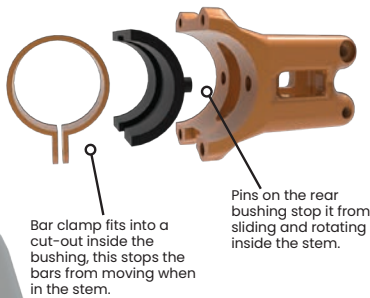
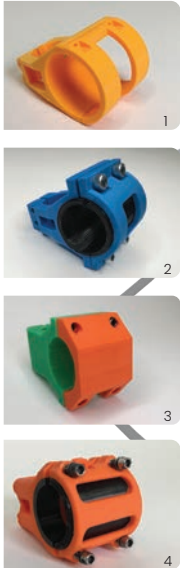
Mountain biking is a sport that is growing at a rapid pace and so are the trails and technology behind it. With bikes constantly becoming faster trails have also evolved to become faster and more technical to push these modern bikes and riders to the limit. This increase in speed and technicality of trails has resulted in lot more forces being transmitted into the riders hands and arms. Regardless of their skill level this causes pain and discomfort when riding and increases the risk of crashing.

The design brief for this project was to create a product that reduces the about of fatigue a rider feels when out riding by reducing the vibrations traveling to the riders body.

## Design Specifications

- To ensure the design solved the problem identified in the design brief a set of design specifications where made from information gathered in the research phase. The key design specifications where as followed.
- The stem needs to reduce vibrations at the handle bars by at least 10% compared to using nothing at all.
- Should inspire confidence when riding by not flexing too much and making the handling of the bike feel vague.
- The stem needs to be safe and strong enough to use on a bike and meet all the requirements set by the ISO standards organisation.
- The stem should be compatible with existing 35mm handle bars.

## Design Progression

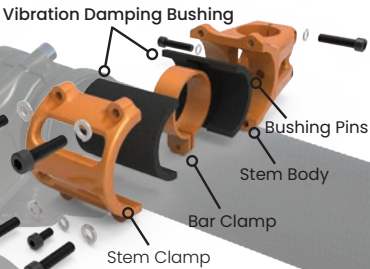
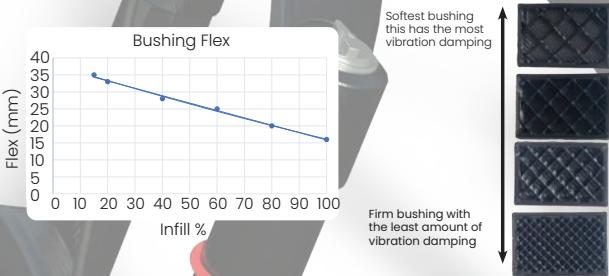


## Design Development

The design went through 4 main design iterations the first design a slightly oversize clamp that accommodated a 2mm thick solid bushing, this design was tested and it was found that the stem was too weak and the bushing when tested in a separate jig was to thin and it did not compress much. The second design increased the thickness of the stem this made the stem stiffer and allowed for the bushing to be tested. A thicker solid bushing was tested and did not provide much flex in the bars or compression so a hollow busing was tested which provided much better results. The third design was made even stiffer and a clamp was added that locked the bars in place as they could still rotate when surrounded by the bushing. For the final design different bushing designs were made and tested for flex this allowed for a wide variety of bushings for different riders. The shape of the stem was also refined and pins where added to the bushing to stop it sliding in the stem.

## Bushing Design

The bushing is made from a 3D printed flexible polyester filament, this has a shore hardness of 45D, by using additive manufacturing to make the bushing the internal design of the bushing can be fine tuned unlike traditional bushings that are usually solid . By changing the wall thickness and infill density of the bushing the sided to side flex and compression of the bushing can be manipulated.



## Final Design

The final design is a evolution of the previous models the shape has been refined and the excess material has removed through the use of simulated stress analysis. Internal sections have been hollowed out to reduce the weight off the stevm, the mounting points for the stem clamp and the stem body have been made smaller as such a large surface area is not needed when it is manufactured out of 6061 aluminium. The design of the bushing has now been refined by adjusting its internal design to allow for it to compress and flex depending on the riders requirements.

Hari Singh  
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SUPERVISOR: Uttku Yalcin  
Industrial Product Design  
UC<sup>o</sup>PRODUCT DESIGN

## Student projects: Product Design - Industrial Product Design



**Brief:**

To redesign the user experience of Tait's mobile radio line-up. This will include both the head portion of the radio, as well as the handset. The user interface will be redesigned to benefit the needs of all users and to make sure that they can complete their jobs safely and efficiently. User experience is also important, so the redesigned interface of the mobile radio will include the latest technology available, to ensure the users can get the most out of it.

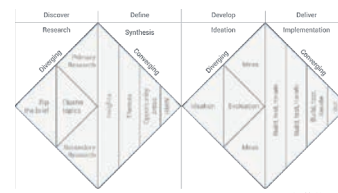
### Double Diamond Design Methodology:

During the Discover phase of the project, a range of research techniques were used to gather as much information as possible about mobile radios. This information ranged from the current market place and what is available through to who the users are, what they want and where the product is frequently used. All of this research would help me to get a better understanding of what exactly needs to be designed.

During the Define stage I started to analyse all the research and focused on determining the core problem(s) I needed to solve. The most helpful research method that I used was to survey all the current users of the radio. These users provided me with problems and ideas they had which helped to narrow in on what problem(s) needed to be solved.

The Develop stage started with a large amount of ideation. The ideation was an accumulation of all the possible directions that the project could lead to. After using a range of ideation techniques, Mind map, Sketching, and SCAMPER, I had three possible directions the project could take. A chosen concept was then selected to be developed further, into a final design.

During the final Deliver stage, I continued to do more research, prototyping, testing, and development on the final concept. I also continuously revisited the brief to make sure that I was still designing what the users wanted and needed. Tait was also involved in the later stages of the design process as they provided both ideas and feedback on the proposed design.



### Design Details:

The details of this radio include a large 4-inch OLED display with a resistive touchscreen panel, a smaller 1.5-inch OLED display, 8 microphones for voice pickup and noise cancelation, 4 speakers, 2 in the handset and 2 in the head unit, and a rechargeable Li-Ion battery. The radio also includes 2 knobs to control volume and channel/menu functions, 7 tactile multi-function buttons, 1 push-to-talk button, 2 USB-C ports for data transfer and fast-charging, an audio jack, and a standard handset connection port.

### User Feedback:

The feedback I received from the user market as well as Tait was positive. The user market feedback included things like: "Having the option to use wired or wireless is helpful." "The touchscreen allows for more customisation." "The style of the radio makes it look more modern."

Tait believed that the product could fit right into their current line-up as a "transition" between their current mobile radios and the unknown future. The inclusion of lights around the buttons and dials was received well as it would increase user safety and be customisable for different functions. Tait also liked the new squared off design as it made the radio look more modern and appealing to new and current users.



**References:**  
Nessler, D. (2016, May 20). How to apply design thinking, HCD, UX or any creative process from scratch. Medium.  
<https://medium.com/digital-experience-design/how-to-apply-a-design-thinking-hcd-ux-or-any-creative-process-from-scratch-b8786efb612>

## Mobile Radio Future User Interface Design

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**tait**  
communications



# Student projects: Product Design - Industrial Product Design

## ABSORB.

A Shock Absorbing Mountain Biking Derailleur Hanger.

### Design Brief.

Mountain biking is a sport where equipment is easily damaged when out riding in a forest. This can be from 30 minutes to hours biking away from the nearest point of help. The drivetrain (gear system) on a mountain bike is susceptible to damage by rocks, roots, trees and hitting the ground when crashing as the components are located low to the ground and stick outwards from the main frame of the bike. The breakage of the Derailleur Hanger (hanger) which connects the frame to the rear derailleur can be a ride ender, resulting in the user walking back home or to the car.

This project aims to design a universal shock absorbing rear derailleur hanger for high end mountain bikes to absorb the impacts from the derailleur when a rider crashes, hits a rock or roots on a mountain bike trail. While still protecting the more expensive frame and derailleur components. With the hanger returning to the optimal pedalling position to keep the user continuing on there ride without having to carry a full replacement hanger in pocket each time they go for a ride.

### Design Specifications.

- Target market: To design a shock absorbing hanger for mountain biker users who damage hangers and/or derailleurs more than twice a year.
- Performance: The hanger should absorb shock by using a mechanism which moves when the derailleurs hit to prevent the hanger from breaking while still protecting the derailleur and frame.
- Performance: The hanger should remain intact or be able to put back together after an impact to allow the rider to be able to ride home (instead of walking with a broken drivetrain).
- Weight: Maximum of 100g to avoid a large weight penalty.



### Concepts.



Using an evaluation matrix The Clamped elastomer (concept 6) and Dog bone (concept 7) concepts best matched the specifications and were prototyped to find the best solution.

### Development.

An iterative and incremental development technique was used to find a hanger design. Using Fusion 360 to create the models of concept 6 and 7, they were physically made via 3D printing for quick model iterations to be tested to determine which design would be taken forward.



The hangers were tested in three stages. Stage one began by rotating the drivetrain components on a bike stand to test the strength against hold the derailleur in a static position. Once capable stage two was testing shifting smoothly when riding on flat ground. In the third stage the hangers were tested in the mountain biking environment on grade 1 - 5 trails at the Port Hills in Christchurch. This testing was compared to the specifications each time, with changes made to improve the design each iteration. Each model was put through the process with iteration 27 being the final design.

### Key Features of Final Design.

Top chamfer re-rails chain if it bounces off the cassette.

Inside edge guides wheel into place.



Plexible Polyester Elastomer; shore hardness 45D, are located in dog bone shaped slots.



Anodised Black CNC Aluminium 6061



Notch locks hanger in position and slides under impact allowing flex on elastomers.

Elastomers absorb impacts and returns to optimum position for pedalling.

Elastomers are pretensioned with the red elastomer being 1 mm shorter and blue 1.2 mm shorter than the dog bone slots.

Higher pretension on blue elastomer pulls hanger back inline faster. Under very high energy impacts the blue elastomer will break first as passed the elongation limit, protecting more the more expensive derailleur and frame.

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PROD314 S2 2021

Supervisor : Dr Nick Emerson

Student projects: Product Design - Industrial Product Design

# allbirds

## Design Process

Ways to live  
Young professionals  
Showroom  
Towel  
Pets  
Cute Work  
Transport

Food  
Drinks  
Car  
Friends  
Bike  
Cafe

Memo  
Cloud  
Comfort  
Classes  
Simple  
Sustainable

Convenient  
Shoes  
Run here  
Heads right

Wing  
Filter  
Air pollution  
Pollutants  
Smoke  
Dust  
Fossil fuels  
Street  
Health

Brief: Explore what an Allbirds product would look like for the segment of population most affected and active in the areas of climate change, activism and industry while ensuring to pass through careful consideration of sustainability, climate change, carbon footprint, material selection, energy use, among many others. The form of the solution is not restricted and may explore open source manufacturing and alternative materials, etc.

Problem Statement  
to design an Allbirds solution that can help to reduce air pollution, but more importantly influence people to be more aware and shape a better tomorrow

Initial Exploration & Ideation

The broad scope of the project brief resulted in a slower start. Research, brainstorming and mood boards were done to gather information and define the direction. The initial three key concepts were created.

Design & Development

The shoe concept was chosen during concept evolution based on how it meets the objectives and shows promising potential. Meetings with Matt and Jamie has also helped to highlight the good elements of the designs and move forward with them.

A broad collection of different design concepts were imagined, different materials and form styles were explored to innovate. Developing a design style that has a good balance between Allbirds original design and feature emphasizing style was very challenging. Sketching was the quickest and best method to get down different ideas with the complex shape down. The two main features, that the final product need to communicate to the viewers, are the 'breathing' sole and changeable uppers.

Card models were made to justify the feasibility of the overall structure of the final design. Small adjustments of some surface angles were made to improve the functionality.

### Testing, Modelling, Finalising

Different methods of physical modelling and digital modelling were explored to understand the complex surfaces and forms, as well as deciding on the method that gives the best result to deliver the final design presentation.

Various tools were used including physical card and foam modelling and carving to understand the forms and ratios. Digital tools include gravity sketch, Blender and Fusion was used to experiment on achieving smooth but complex surface curves and angles.

The most organically shaped upper and insole were created in Blender. Sketching wireframes and surfaces in 3D space in VR gravity sketch helped with surface modelling in Fusion. The rest of the Urban Breather model was modelled in Fusion, by doing 3D sketch of the edges and flow lines, then patch the surface together.

This stage took longer than the expectations due to my complex surface modelling skills hasn't been trained before from design courses.

### 'Breathing' urban air to make urban air breathable.

\* The changeable upper design can extend the overall product lifetime, as well as adding a unique trait.

\* The simple two-part structured sole allows the shoe to effortlessly 'breathe' to filter air while being used.

\* It's new but intuitive.

**Urban Breather**

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# Student projects: Product Design - Industrial Product Design



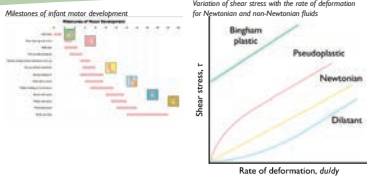
## Challenge

To design an engaging sensory play tool for infants aged 4–24 months that utilises non-Newtonian fluids; while developing their understanding of scientific principles and improving concentration and problem-solving.

## Empathise

During the empathise stage, research was conducted into the competitors, stakeholders, and technical details.

The sense of smell was identified to be underutilised in existing sensory play products and that engaging multiple senses develop several areas of the brain as well as prevents the infant from being overstimulated. The physical and psychological development of infants narrowed the target age range, indicated scale for the objects, and furthered understanding of the vast psychological development of infants under 24 months. Early childhood education philosophies were researched to gain an understanding of how sensory play is integrated into the education of infants and what they look for in a product for their educational environment. Demographics of parents such as income and age provided an understanding of how much they would be willing to spend on the product. A definition of sensory of play was developed for the project, theory and applications of non-Newtonian fluids, and how to ensure the product is safe for infants.



## Define

In the define stage, the product design specifications were developed and refined using a needs-metrics matrix. This featured 14 main specifications relating to safety, component dimensions and ergonomics, materials, weight, cost, sensory engagement, fluid requirements, philosophy, environment and aesthetics, packaging, maintenance, life in service/product life span, disposal, and documentation.

## Ideate

During the ideate stage, two ideation techniques were used: the FAST approach and SCAMPER. These ideas were developed into four concepts. The ideas and concepts incorporated a range of factors such as diverse play options, ability to be used over long periods of development, engaging multiple different senses, storage, ease of cleaning, whether the fluid is contained, if it fits into and early childhood education environment, and using a variety of non-Newtonian fluids. From the FAST approach, six distinct ideas were created, which were then modified into seven more using SCAMPER. These ideas were evaluated and developed into four concepts before being re-evaluated and a final concept was selected.



3D printed prototypes

Scented Oobleck prototyping



## Prototype

Prototyping of the Oobleck and scent solution, play tools, and the lid was conducted during the development process. After selecting and starting to develop the final concept, prototyping of the scratch-and-sniff scent method, scented Oobleck scent method, play tools, and lid.

For the alpha prototype, a combination of fused filament fabrication (3D printing), laser cutting, vacuum forming (thermoforming), vinyl cutting and printing, and scent formulation were used as well as finishing processes such as sanding, polishing, and painting.

## Test

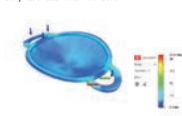
To test the final solution, user evaluation and finite element analysis were used to identify any areas for improvement and simulate tests from the toy safety standard. User evaluation from third-year product design students provided insight into changes that needed to be made to the instruction manual and play tools, as well as identifying positive aspects such as specific play tools that worked well and that the overall experience was enjoyable.

Static stress analyses in Fusion 360's simulation space were used to test the play tools against the reasonably foreseeable abuse tests in the AS/NZS ISO 8142.1:2019 Safety of toys standard. Three different types of loading were tested – torque, tension, and compression. Despite some small areas of high stress, all of the components passed the tests as the stress on the object was less than the yield strength of the material.

Formative user evaluation



Compression test - watermelon sieve



## Outcome

The Sensity non-Newtonian sensory play toy has been designed to encourage infants to use their senses of touch, smell, and sight. The Oobleck (dilatant non-Newtonian fluid) provides an opportunity for them to engage with a fluid that is unlike anything they would usually encounter in day-to-day life, and the act of squeezing and handling it can improve fine motor skills.

Components of Sensity include an injection moulded polypropylene tray with a screw top lid which includes a soft PVC centre, five scent and colour solutions, and five injection moulded high-density polyethylene interactive play tools. The five different scents with the five corresponding colours and shapes of the play tools encourage integration between the sense of smell and sight and help them to associate what they smell and what they see. The design of Sensity's tray and lid means that it can accommodate either contained or messy fluid play.

This variety of sensory engagement helps to keep little ones interested and to develop different parts of their brain without overstimulating any one area.



## Non-Newtonian Sensory Play

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# Student projects: Product Design - Industrial Product Design

The aim for this project was to design an engaging learning tool for 7 to 10-year-olds that encourages them to learn how to tell analogue time.



## Solstice

A time telling game.

Solstice is a time telling board game that has been designed to be fun for all children (and parents, and older siblings), even once the child has mastered the skill of telling time.

More than anything, Solstice promotes togetherness. Children must interact with each other and work towards a common goal. They must also compete, which in return drives them to be the best, and to learn. This interaction with each other and with a physical product brings the children together, and combines fun with learning.

### Design Process

For this project, an extended double diamond methodology was utilised. The stages were: Prepare, Discover, Define, Develop, Test, and Deliver.

#### Prepare

Prepare is a fundamental stage that involves the activities of the designer before they kick start the project. This included activities such as preparing the design process, reviewing the brief, creating aims and objectives of the project, a Gantt chart, and completing some preliminary research.

#### Discover

During the discover stage, I completed wider research including research about the user, and about the market. I discovered that the majority of the time teaching toys on the market are not very engaging, and often rely on battery powered operations.

#### Define

The define stage involved translating my research from the discover stage into a set of specific Product Design Specifications and Ideation. The focus during ideation was to come up with many different solutions. I used a number of techniques including a morphological chart and SCAMPER.

#### Develop

In the develop stage I completed concept development, and a number of rounds of evaluation. The focus of evaluation was to narrow down a large number of ideas to find the most viable concept to move forward with. I narrowed down to three key concepts, and then one final concept, Solstice.

#### Test

The test stage was very important, as it involved testing the gameplay of the game, and the sizes of the parts. My designer colleagues were the first to test Solstice. This testing helped me refine Solstice into the final design that is, and also to develop a theme for the game - seasons.

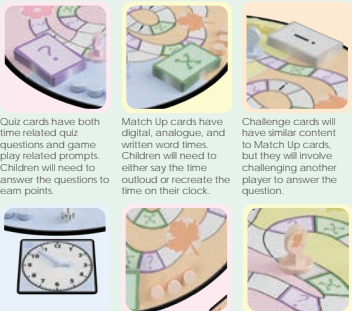
#### Deliver

The deliver stage was about design details. These include producing a CAD model, renders, a cost analysis, material and manufacturing details, a business plan, storyboards, a portfolio, working prototype and poster. These details really brought Solstice to life.

### Design Details



The player's objective is to travel around the board, and complete time-telling activities along the way. Players can earn points by successfully answering quiz questions, matching up digital, analogue, and written word times, and challenging other players. Players must collect tokens from each of the other seasons, and then head back to their own season to end the game. The player with the most points at the end of the game wins!



Quiz cards have both time related quiz questions and game play related prompts. Children will need to either say the time out loud or recreate the time on their clock.

Match Up cards have digital, analogue, and written word times. Children will need to either say the time out loud or recreate the time on their clock.

Challenge cards will have similar content to Match Up cards, but they will involve challenging another player to answer the question.

Each player will have a personal clock that they can recreate times on.

The objective for the children is to collect a token from each season by passing the home spaces. Once they have all three tokens they can return to their own season.

If the child's game piece lands on a space that is already occupied by another player, they can decide to send them back to their home space.

### User Interaction



### Time Teaching Learning Tool

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Student projects: Product Design - Industrial Product Design



TRI BAG SWING

On-Jin Yook 85842753

ABSTRACT

The main goal of this project was to design a home boxing equipment that develops fitness and confidence. Initial secondary and primary research was conducted to develop key needs for boxers, which were developed into a collection of Product Design Specifications. Ideation was then conducted with the Product Design Specifications in mind, which was developed into 3 main concept outcomes. Prototyping evaluations and a controlled convergence matrix were used to highlight the best possible outcome. This was then used as the champion concept, that would be developed in CAD through Fusion 360, evaluated through Finite Element Analysis and evaluated through prototyping.

BOXING APPLICATION



DISCOVER

The COVID19 pandemic has resulted in the isolation of the public and more time spent at home. This has hindered the public from going to gyms and their access to exercise equipment. Therefore, there is an increase in demand for exercise equipment that can be used at home.

Competitor products were critiqued. A common negative found within these products is the weighted base stability after punch impact.

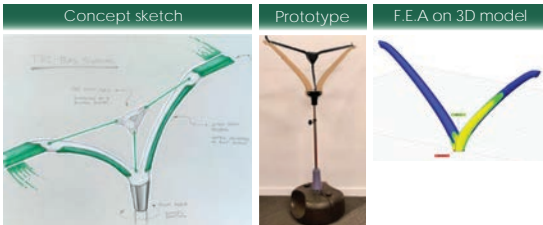


DEFINE

PDS no.	Specification
1	Be able to withstand a force of 2415N
2	Exercise boxing technique (striking, footwork and defence)
3	Develop user's strength and conditioning

Product Design Specifications were formed from the research conducted for this project. Research involved secondary research in the form of a literature review and primary research was conducted on boxers/trainers in the form of interviews. (main PDS points shown).

DEVELOP



DELIVER

The final CAD model is developed on Fusion 360. This is also used to help with the final prototype through 3D printing.





Student projects: Product Design - Industrial Product Design

# EELS & FERNS

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## SESSION 1

**DISCOVER:**  
In discovery tamariki learn about Kaiiakitanga and the three principles of circular design. This is introduced as a regenerative model that aims to address the futures within the linear system of take, make and waste. Circular design is founded on three principles: design out waste, keep products and materials in use and regenerate natural systems which are explored in detail during this session. The lesson takes approximately 45 minutes.

## SESSION 2

**CREATE:**  
In session two tamariki create biodegradable game pieces, which correspond to one of the circular design principles.  
1st Principle = Coffee waste composite.  
2nd Principle = Egg shell composite.  
3rd Principle = Clay and seed composite.  
Each composite takes 20 minutes to make.

## SESSION 3

**PLAY:**  
This culminates in a snakes and ladders style board game. Players roll the dice to move around the board, if they land on a question mark they must correctly answer the question to proceed. The question cards are colour coded to match the ring of the board the player is on. The cards test the tamariki's knowledge on the three principles of circular design. Eels take you down the board and ferns take you towards the centre. The winner is the player who reaches the centre first. The game lasts 15 minutes on average. At the end of the session the game pieces can be planted and the board game kit passed on to the next class.

## BACKGROUND

There is a growing awareness of the impact our actions have on the environment. It has become evident it will take more than one generation of engagement to find sustainable solutions for the way we consume products. The current take-make-waste model is inherently flawed as it ends with the accumulation of rubbish and typically uses materials from non renewable resources. Circular design was created to address the issues within this linear model. This is achieved through the three founding principles. The first principle is to design out waste, the second is to keep products and materials in use and the third is to regenerate natural systems (Ellen MacArthur Foundation, 2017).

## USP

Eels and ferns is an educational kit, that seeks to assist teaching tamariki about circular design through hands on learning and play. It goes against the plastic intensive toy industry as biodegradable materials were chosen to construct this game. The board and base is made from locally sourced wood. The composite molds are made from biodegradable TPU (Thermoplastic Polyurethane) which is durable, recyclable and biodegradable in 3 to 5 years (Life without Plastic, 2021). Both the board game and molds will last for at least 3 years, allowing the kit to be passed between schools and classes. The composites are made from natural ingredients and all biodegrade. The third composite is embedded with seeds, thus can be planted and nurtured by the class to reinforce the learnings from the activity.

## DETAILS

**CARD STAND**  
**STACKED GAME PIECES**  
**RECIPE CARDS & COMPOSITE MOLDS**  
**BOARD BASE**  
**PLANTING GAME PIECE**  
**DISCOVERY BOOKLET**

## DESIGN PROCESS

The design thinking process was used as the backbone for my design work allowing me to follow the five steps illustrated below. I combined the design thinking process with the circular design process as this modification better represented the nature of my project.

### DESIGN PROCESS

#### DISCOVER

In the discovery phase I carried out Primary and Secondary research to better understand the circular economy and sustainability education within NZ. The methods I used included a literature review, interviews and in school observations. I discovered that circular design thinking shifts ownership of access from product to service. This influenced creating a kit that could be shared between classes. Within the NZ curriculum sustainability is recognised as important, but with ambiguous regards of priority leaving it up to the teachers to incorporate into the classroom. However, lack of time and competing priorities get in the way of teaching sustainability.

#### DEFINE

The define phase consolidates my findings from discovery and culminates in a redefine of the aim, key challenges and design specifications. I went through this process three times as I discovered more which shaped the direction I wanted to take this project.

My final aim was to:

Educate Primary School tamariki aged 10 to 13 years old about circular design principles through hands-on learning that is fun, collaborative, and connects them with their environment.

#### IDEATE

**FIRST CONCEPT:**  
1. Biodegradable waste collected by tamariki which is melted and moulded into planter pots that have a game embedded on the back.

**DEVELOPED CONCEPT:**  
2. As plastic is exponentially harmful for the environment, looked into using natural materials instead.

**CHOSEN CONCEPT:**  
3. Wooden board game that is passed between classes. Tamariki get to make their own biodegradable game pieces.

#### PROTOTYPE

Experimenting with molds to make the composite game pieces, tried to identify best possible solution.

**MOLD #1:**  
Layered MDF mould sealed with tape, flat square with the layers staying square.

**MOLD #2:**  
Added horizontal and vertical slots to keep the layers square. Used candle wax to seal the mold.

**MOLD #3:**  
Changed material to biodegradable TPU which is 3D printed so this is more durable than MDF which is not suitable for continuous moulding.

#### TEST & DELIVER

Carried out a 2 hour testing session with 4 Year 7 girls aged 10 and 11, in their high-school science classroom. This was helpful to refine my final idea and ensure it met my design specifications. This session indicated I needed to create a base for the board game to house all the loose components.



# A NEW DISTRIBUTION BOARD

## AIM

The aim of this project was to consider improvements to modern distribution boards. One important thing to consider was the updating of Australian/ New Zealand standards for distribution boards where boards in an internal wall need a steel plate behind them as an assurance to prevent modern screws from drilling through the board from the other side of the wall.



## A LESS INTRUSIVE DESIGN

With the door being a thin flat panel with rounded edges, the design does not cast as vibrant of shadows as modern alternatives. Making the panel easier to incorporate into the design of a household. A Matte finish on the design also strives to detract attention to the panel as well as providing a good surface for a coat of paint to allow it to match the walls colour.



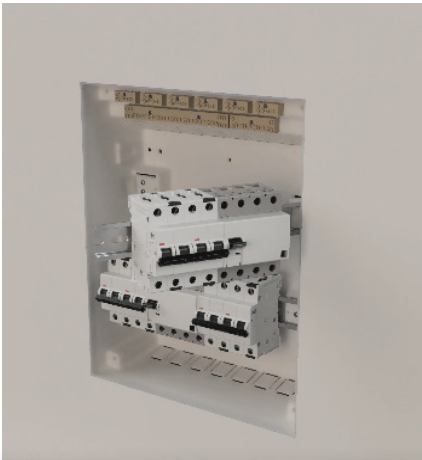
## A SIMPLE SAFETY SOLUTION

With the steel safety plate needing to be able to be mounted, the solution for how came from the current Vynco Range. With their boards being modular, the back of the design has mounting holes that can easily have a bolt put through it, allowing the design to have a solution that comes from the current range.



## HINGING MECHANISM

One of the Key selling points is the polypropylene hinges on the DIN rails so that the rail can be pivoted out and wires can be run under the rail with minimal effort instead of needing to thread through the wires like you would typically need to. This also allows electricians to cable tie wires directly to the rail to more neatly pack the lines.



### Vynco Distribution Board

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Student projects: Product Design - Industrial Product Design


# Urbanza

The PC Case you always needed

## The Flatpack PC Desk Case



Urbanza is unlike its competitors in that it avoids the gamer aesthetic in favour of a design that resembles a conventional workstation. Allowing it to be used in a variety of settings, Urbanza caters to a wide range of people, not only gamers. Installing and maintaining a PC is significantly easier with a removable motherboard tray.



Easy installation of PC components and rapid access to components during maintenance are made possible by a removable motherboard tray. A standardised ATX sized PC component can be stored in the motherboard tray.






Urbanza has ample room to accommodate three 24 inch monitors and up to two 32 inch monitors



Urbanza was created with ergonomics in mind by using anthropometric measurements of median female measurements help give the right dimensions for comfortable use.



The drawer system has a total storage volume of 85 litres with the top drawer having 9 litres of storage and the bottom drawer having 76 litres of storage. This gives Urbanza adequate storage



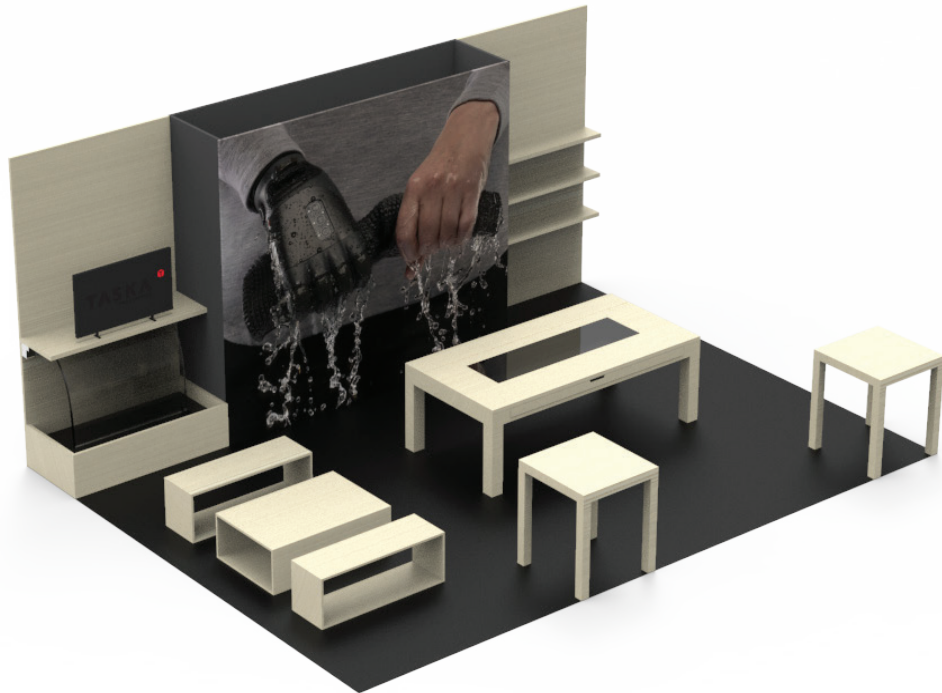
During the design stage, the urbanza has gone through several iterations. And in each iteration, changes were made to ensure that every element of the Urbanza had met the needs of the user and that of the specification that were set for it.

Flatpack PC Desk Case

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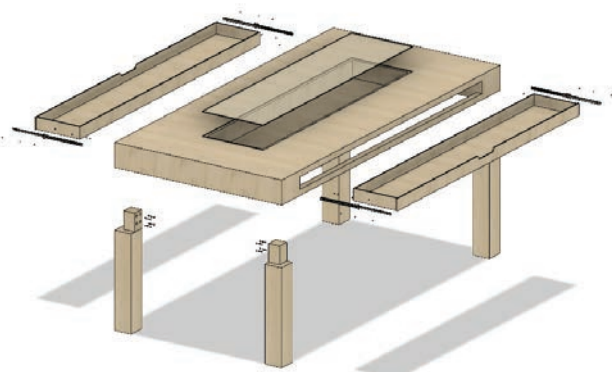
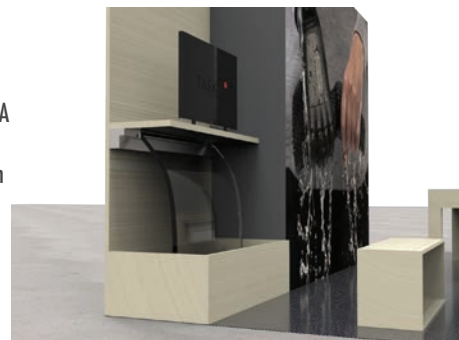
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## Student projects: Product Design - Industrial Product Design



### Features

- Large display table with glass cabinite to safely display TASKA products
- Presentation area with water feature below TV to demonstrate TASKA Hand's waterproof capabilities.
- Multipurpose seating are for use during presentations and seats with table for further discussion.
- Dedicated walk in storage area to securely store products overnight and staff belongings during the day.
- Large hero image to draw in crowd from a distance.
- Two bar leaner height tables to enable conversation.



### Manufacturing

- All wooden aspects made from a light ash wood.
- Wooden structure made of dimensional lumber with an ash veneer.
- All aspects of the design will be manufactured by a third party in Germany to reduce costs.
- Display table can be easily disassembled with the legs fitting into the display cabinet for transport to TASKA's European offices.

TASKA Booth OT World

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productdesign.ac.nz



# Student projects: Product Design - Industrial Product Design

## VineKinds JUSTAIR

**Brief**

The New Zealand wine industry loses large quantities of grapes to frost every year. Current solutions include spraying water in the vineyard to encase the buds/grapes in ice and flying helicopters to cycle the warmer air. All existing methods come with their issues and environmental impacts. A reliable vineyard frost control system, that ideally doesn't use diesel, petrol, LPG or other carbon emitting fossil fuels, is needed. This solution should be suitable for production in New Zealand where possible.

**The Need**

All over the world the destruction of vineyards due to frost damage is the single most cause of economic loss compared to any other weather related phenomenon for New Zealand it is no exception. With frost leaving vineyards with blackened shoots, considerably smaller crops and grapes maturing from secondary buds leading to a far worse quality of wine. Frost damage can be devastating for vineyards leading to millions of dollars lost and tonnes of grapes damaged and ruined with just one unexpected frost event, one example of these happened in Hawke's Bay in 2005. With preferred growing temperatures going through August to September early budburst had occurred for specific types of vines, when frosts started late September early October the impacts were disastrous. Three frosts over three weeks led to production plummeting 80%, with an estimated 6000 tonnes of grapes damaged or destroyed, equating to approximately \$6,000,000 lost in revenue for Hawke's Bay viticulture. These frosts not only effect and harm growers but the New Zealand Economy as a whole, viticulture is a major primary industry through exporting wine earning New Zealand 249 million every year in 2003 and now in 2021 1.8 billion. These huge losses as well as it being New Zealand's goal to have the wine industry be carbon neutral by 2050 it shows the need for a sustainable solution and there is a market for a product that will help with frost protection.

**Research**

The level where the temperature movement changes from an inversion to a lapse is called the ceiling. A weak inversion has a high ceiling and happens when the temperatures aloft are only slightly higher than the temperatures near the surface and a strong inversion has a low ceiling and is when the temperature changes drastically with height. As the protection methods are most effective during the low ceiling, strong inversion radiation frosts.

This product keeps grapes safe from frost damage by grabbing the warmer air higher up from the surface and the pushing it back down towards the grapes

\*\*\*\*\*

Inversion Layer

Internal components of the JUSTAIR

Solar Panel collects enough power on an average day to charge battery 2.5 days and also acts as a cover for the air intake protecting it from rain

Typical Layout of vineyard using the just air system. Multiple emitters along one row and multiple JUSTAIRs per block

Brass Valves make it easy to set up a system of multiple air emitters and JUSTAIRs, with the option to close open ends

Air emitters are only 220mm high allowing for ATVs maneuver around while they are left out.

Holes in Tyvek fabric, where air is released into the vineyard

Tyvek can be wrapped around ends of emitter making for easy storage

Packed emitters can be stored in the JUSTAIR itself underneath the compressor

PROD-314

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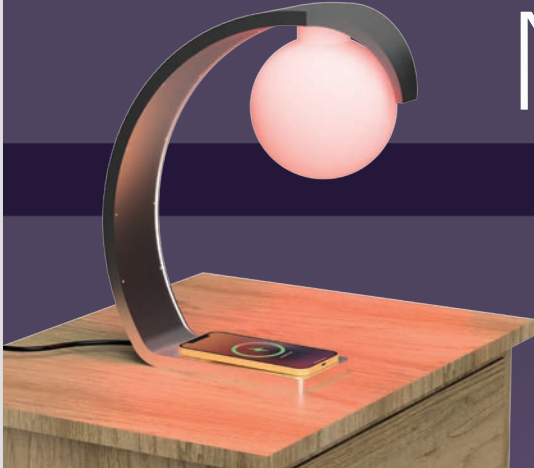
Matt Smith

INDUSTRY COLLABORATOR

VineKind

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Student projects: Product Design - Industrial Product Design



# Night Arc

### Abstract

Night Arc was designed to meet the brief 'Sleep Matters'. The aim of the brief is to design a product, service or system that enables better sleep. The result of this brief is Night Arc which aims to improve sleep through the use of red light. Night Arc was developed after research into how light affects the circadian rhythm or sleep-wake cycle. Blue wavelengths suppress the production of melatonin, the absence of blue wavelengths encourages melatonin production. Melatonin tells your body to prepare for sleep and is responsible for many of the important maintenance activities your body carries out while its asleep, such as consolidating memories and processing information. Further research found that red light had the lowest amount of blue light wavelengths, this meant that red light could be used in stead of blue light in the evenings and it would not suppress melatonin production.

### Design Method

Issue

The issue addressed by this project is the increase in sleep problems in today's population.

Define

Sleepless lifestyles, lack of exercise and bright lighting all contribute to the rise in insomnia. What natural responses does our body have to lighting and does it have a way of regulating sleep?

Ideate

During the ideate stage I used brainstorming and SCAMPER. Brainstorms help generate broad ideas and SCAMPER helps to narrow down ideas.

Prototype

Prototyping for this project was a quick process. Once my idea was chosen it was a matter of quick prototyping to make sure the product would be stable when standing.

Test

Testing included making sure that the red light was effective in improving sleep. This was done by red hand research to test whether red light before bed improved my sleep.

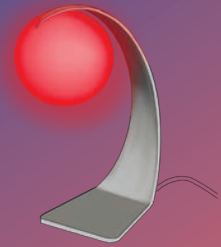
### Ideation

Left

Right


Back

Front




Sunrise

Sunset



### Initial Ideation



### Research


Sleep can be mistaken for a period of inactivity, however the opposite is true (Mental Health Foundation et al., 2011). During sleep your brain is busy carrying out essential activities such as, processing information, consolidating memories and so much more! These processes are what help us function effectively while we are awake (Mental Health Foundation et al., 2011).

Everyone needs different amounts of sleep, although the average adult needs 7-8 hours sleep a day (Mental Health Foundation et al., 2011). When we sleep we go through different stages, these stages can be broadly defined as non-rapid eye movement (non-REM) and rapid eye movement (REM) (Mental Health Foundation et al., 2011).

Our bodies sleep and wake cycle is regulated by our circadian rhythm. Circadian rhythm is then regulated by lightwaves through out the day (Burkhart & Phelps, 2009). Blue light waves suppress the production of a chemical known as melatonin which is responsible for telling our body to sleep. Since there is strong blue light during the day our body suppresses melatonin and keeps us awake (Burkhart & Phelps, 2009). However in the absence of light our body produces melatonin and this is what makes us sleepy at night (Burkhart & Phelps, 2009).

Red light has the lowest amount of blue light waves and therefore it does not suppress melatonin production. Infact a study by Zhao et al., (2012) investigated the effects of red light and the sleep quality and endurance for female Chinese basketball players. After 14 days of red-light exposure for 30 minutes at 3000lux, Zhao et al., (2012) found that sleep was improved, serum melatonin level increased, and the endurance of the basketball players improved. While this study is not directly related to the circadian rhythm, it did show how effective red light is at improving sleep quality.

### Wireless Phone Charging



#### Night Arc

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# Student projects: Product Design - Industrial Product Design



## SUSTAIN Nopal 1.0 SG

The rugby boot saving the plant, one step at a time

### Brief

In the final year of the industrial Product Design degree at the University of Canterbury, students set out on a capstone project. With the collaboration of an industry partner, driving an opportunity to pursue a specific area of interest. Throughout this project I have worked on my own personal brief in the sustainable sport footwear industry. With a design brief of designing a pair of rugby boots, made from sustainable materials with improved product life for adult male rugby players.

### Background

Rugby is a high intensity, contact team sport. Rugby can be a complex game, yet one of the core pieces of gear used is rugby boots. Originally designed as bulky, leather footwear to give players traction and ankle support, the evolution of the game and technologies has turned these into high-tech pieces of sport gear. Looking at present day boots, the focus is around performance, however one ignored aspect is the impact that these products have on the environment. I have recognized that boots can fall apart in many different ways over a very short period. And with the very limited recycling options, they are usually thrown in the bin. Along with this, the materials are commonly non-recyclable, and there are extremely limited sustainable options. Around 300 million pairs of footwear are sent to landfill every year, with rugby boots being a part of that number. 20% of the emissions that makes up the product is sent to landfill. Not to mention the pollution emitted during manufacturing of these materials. With the tightening crisis of climate change constantly rising, this presents an opportunity for change.

### 01. Discover

Research was the most important stage of this project. A thorough research phase helped to cover all aspects of the product in depth, which would then be translated into a set of PDS to help drive and guide following design stages. The research was sectioned into three main areas of focus: performance, users and market, and sustainability. Early looking at performance, this included sub-sections such as biomechanics/ergonomics, and performance features. Users and markets explored all aspects of my target user (male adult rugby players), competitors, and the current market of sustainable footwear as well as rugby boots, being the most important areas of sustainability, and what factors impact this such as materials, manufacturing, and recycling.

The most significant outcomes from this stage was firstly the area of sustainability. This helped to establish a broad understanding of what affects a product's environmental sustainability and how, recognizing that there is much more to a sustainable product than just CO2 emissions and recycling. Also that the sustainability of a product is impacted right from the beginning of its life cycle. From the sourcing of the materials through to the recycling of the product, research in this area was continuous throughout the project. This allowed me to build more knowledge throughout and consistently refine and improve the design.

The other important outcome was the recognition that rugby boots are heavily user-focused performance features through to aesthetics are all influenced by the target user, and so understanding all aspects in breadth and depth was crucial. The research too which had the biggest impact on this was the target user survey. This allowed me to collect qualitative and quantitative information on all areas of the product straight from my target users.

#### What performance attributes do you want most in rugby boots

38 responses

Attribute	Percentage
Good stability and support	38 (79.7%)
Lightweight and increased speed	28 (73.7%)
Prevent moisture and heat sores	9 (23.7%)
Increased power and take off	12 (31.6%)

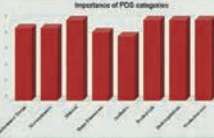
In the mind of one of our user rugby players

### 02. Define


The define stage of the project began with the translation of the previous research phase. This was crucial as it would ensure a set of design specifications (PDS) could be made which would drive and measure the following design stages. The PDS was refined and developed throughout the project, with the most important categories being: materials, product life, standards & regulations, and production & costs.

Following the creation of the PDS, was the ideation and concept stages. The approach I took was breaking the product down into two design goals. The design features of the boot and the sustainability. The aim was to cover all fundamental design features, but focusing on the continuous research and information building process with possible materials and sustainability aspects. The embodiment of all details came in later stages. At the end of the define stage, three design directions were created. Each with a focus on different ways of achieving sustainable design through materials, manufacturing, and product life, with some exploration of different design features.

#### Importance of PDS categories



#### PDS requirements






Sustainable materials  
Sustainable manufacturing  
Sustainable product life

### 03. Develop

The develop stage of the project was where the design of the boot started to develop and consider fine details, beginning with the development of the three possible design directions. These were explored in terms of performance features and design, but further research and development of possible materials and sustainability options was also done simultaneously. Concepts were created, which were then refined into 3, and finally one finalized concept. Materials were explored in more detail in regard to material properties, and sustainability to help meet the required design specifications.

Concepts were developed and narrowed down through the use of two stages of evaluation, using techniques such as point of convergence matrix and user feedback techniques. This allowed me to compare multiple designs and features, but then also evaluate the materials against criteria influenced by research and target users. Producing a final design with the best materials for each component.


The end of the development stage included a very narrow process of prototyping, CAD modeling and testing. Testing of the materials was the final outcome, however time and resource constraints prevented this. Therefore the prototyping and testing of the design was largely oriented towards aesthetics, and materials/sustainability was backed by thorough research and evaluation. Prototyping and testing was done on the last/form, insole, sole board, heel counter, studs and then overall completed model. This helped to finish the develop stage with a refined and viable final design.



### 04. Deliver

The final design of the Sustain Nopal 1.0 SG features all major performance features desired by the adult male rugby player. The durable design, with supportive and stabilizing features, as well as a lightweight aerodynamic form. Also providing an ergonomic and wide fit for comfort and biomechanical support, as well as protection from impact, moisture and overloading. However the core benefit lies in the sustainability of the Sustain Nopal 1.0 SG.

- **Total eco content of 76%**, with the use of recycled and renewable resources such as cork, rubber, plastic, and recycled plastic, nylon, and PVA foam. Compared to competitor rugby boots with 0% eco content, and nearly 10% greater than the eco content of some sustainable competitor boots.
- **100% recyclable**, producing 25% less CO2 emissions when recycled compared to existing virgin materials.
- **38% less CO2 emissions** produced during manufacturing compared to competitor materials.
- **68% less water usage**, and **36.2% less energy consumption** compared to competitor materials.
- **Programme in place to gift used boots** to less fortunate players, extending product life.



Nopal Cork + Cork boots + Plastic bottles + Nylon rubbish + Old EVA foams = Sustain Nopal 1.0 SG

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Student projects: Product Design - Industrial Product Design

# Switchy



MULTIPLE FUNCTIONS ALLOW YOU TO DECIDE YOUR OWN WAY TO GO TO SLEEP, PRIMARILY FOCUSING ON HELP WITH INSOMNIA

## Design Brief

DESIGN A PRODUCT TO IMPROVE HEALTH AND WELLBEING BY ENCOURAGING AND/OR ENABLING BETTER SLEEP, BY APPLYING EXISTING TECHNOLOGY TO ACHIEVE HELP WITH INSOMNIA AND MULTIPLE FUNCTION USE.

### TARGET GROUP

SWITCHY AIMED TO HELP WITH INSOMNIA AND THE TARGET GROUP IS YOUNG ADULTS BETWEEN 18-25 YEARS OLD WHICH ARE MAINLY UNIVERSITY STUDENTS. BASED ON A SOUTHERNER CROSS HEALTH SOCIETY SURVEY REVEALED ALMOST A QUARTER OF KIDS FELT TIRED OR FATIGUED EVERYDAY BY RISING TO 36 PERCENT FOR UNDER-30S. SLEEP ISSUE FOR YOUNG ADULTS NEED TO GET AWARENESS.

EXHIBIT 1: A CHART



Chart 1: Different group of age having trouble with sleep

### THE FINAL DESIGN



### Mobile control



Mobile Bluetooth module can be connected with the Switchy app. The app can be used to control the device. The app can be used to control the device. The app can be used to control the device.

### Features and components

#### TOP AUDIO SPEAKER, USB CHARGE PORT, BATTERY



USB charge port: Two USB 3.0 aluminum 3 port hub allow fast speed charging.

Battery: Battery life without connecting the power line is between 8-10 hours. Battery type is 5000mAh battery. Top audio speaker is a half circle shell with speakers circuit and battery inside. There is a mesh covered on top of the audio speaker to provide the best sound quality.

#### BLUETOOTH CORE CIRCUIT



The circuit was separated with four different areas which are: charging, power supply, audio and Bluetooth. The charging is handled by a linear technology LTC4054. (introduced before from the research part) The IC is an SOT-23-5 package and requires minimal external components. There are four resistors each with 2K ohms to set the charge current. The charge rate of the circuit is 500mA. The power supply uses two AO4401 MOSFETs to switch between the lithium battery or the USB power supply. There is a boost converter that supplies 6V of power to the circuit. The audio section contained two components which were an audio amplifier and an op-amp. The audio amplifier is a stereo amplifier that supports two outputs up to 3.2V.

The Bluetooth section is the last section of the circuit. The Bluetooth module used in this circuit is CSR8615. This Bluetooth module supports Bluetooth 4.0, wireless stereo audio and wired-in audio which are suited for this project.

### Materials



Materials: The materials used in the device are: 3D printed parts, acrylic, aluminum, and lithium battery.

### Colour



Colour: The device is available in four colors: white, black, red, and blue.

### FOUR LAYERS OF GLASS, LIGHT STICKER



Light sticker is the inside to work as a light source. Within four layers of glasses that contain different colors. The light source came from the light sticker and it was to be used to create different colors of light. In the case, the light source was made of a light sticker and the light source was made of a light sticker. The light source was made of a light sticker and the light source was made of a light sticker.

### SECOND VERSION OF THE PRODUCT (LARGER SIZE)



Bluetooth, POWER LINE AND SPEAKER

Since the price of the high density glass was quite expensive. Therefore, the second version of the switchy was introduced. The second version of switchy was manufactured with a separate glass to create a similar effect of the first version. The glass was made of a high density glass material. Which gives you more consideration when they make the product.

On and off switch was installed at the base part of the light. But when the off switch was made more considerate of light when the environment of the light was very dark. The product was made of a high density glass material. The product was made of a high density glass material. The product was made of a high density glass material.

Reference:

Xia Yuxia Nixi(2020, September 18). Unsplash from <https://unsplash.com/photos/29RC1WV985>

Vladislav Mubakov (2017, May 28). Unsplash from <https://unsplash.com/photos/CaUu1UAG75c>

**Project Title:** Sleep matter

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Student projects: Product Design - Industrial Product Design



# Sportstir

## Perfection with a simple pull

**Abstract -**

Sports Supplements is a huge market that is increasing in size and hugely popular with the age range of 18-29, they are most commonly found in powder form and require a shaker cup to consume them. So, the aim of the project was initially to find a way to mix supplements more efficiently than shaking for long amounts of time only to find that your protein shake is still lumpy and hard to drink. Carrying out research and analyzing common problems allowed a better understanding of what the product needed to be. From this information ideas and concepts could be formed to help solve the problems found. The concepts were then evaluated multiple times, tested and refined which resulted in the best possible outcome. The final outcome of this process was the Sportstir.

The main feature of the design is the pull feature located in the lid which allows supplements to be mixed with the effectiveness of an electric mixer but with just a quick pull.

Other features include, stackable storage units (evenly distribute powders through storage lid), no-leak seals, easily cleanable body and can hold up to 600ml of liquid.

**Discover -**

The initial problem was chosen, the next step was to conduct first and second hand research in order to understand and empathise. Surveys and interviews were carried out to find information about common problems, how people were taking supplements, and any other useful information. Second hand research was also conducted, assessing the market, competitors and serving sizes was gathered. This information was then collated together and analyzed.

**Define -**

The define step was taking the gathered research, analyzing, and figuring out what the main problems were. This could then be used to start creating solutions for the problems found. Some of the main problems found were

- Mixing the powder effectively
- Having to carry large supplement containers on person
- Cleaning effectively
- Shaker leaking

**Develop -**

The problems found in the previous define step were then used to form a PDS (Product Design Specifications), using the PDS and other ideation methods, many possible solutions were formed. These were then evaluated to find the top 3 best solutions. These top 3 concepts were then again evaluated in order to find the most viable solution to develop further. The top concept was then developed further through testing and prototyping.

**Deliver -**

The design repeated the testing and refining process until a final design was completed and ready for market. Successfully comparing the design back to the PDS insures that the design has met the original problem found and is complete.



**Features**



Pull Ribbon can be pulled quickly out from the Sportstir, mixing the supplement powders quickly and effectively.



The nozzle cap is leak proof and swings back for ease of consumption. Rounded extrusions around the lid allow for better gripping.



Storage consists of a lid and a main body. The lid allowing even distribution of supplement powder into liquid for a better mix. A small finger hole for removing the lid.



Multiple storage compartments can be screwed together for different powders or servings.

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Student projects: Product Design - Industrial Product Design



E.V.A.

The In Vehicle Siren Alert System is a product that aims to assist in the driver recognition of an approaching emergency vehicle, lowering the chance of accidents and increasing emergency vehicle response time.

Product focus is improving product effectiveness through a refined and effective user experience.

Beginning with background research into the problem and previous products addressing this issue. Then identifying broader directions based on researched user testings and pertinent information. After reviewing and refining concepts through testing and analysis, a final concept is presented that satisfies the project aim.

The Problem.

Emergency vehicle drivers are faced with a huge amount of danger each time they respond to an emergency. This isn't from the emergency itself, but from navigating the roads on route to the emergency. On-road crashes account for the 2nd most deaths of fire-fighters.

By increasing drivers on the road's recognition to approaching emergency vehicles, we decrease the number of fatal crashes as a result of this and increase the average response time for emergency vehicles.

The Solution.

This product/system aims to solve the issue of unnecessary Emergency Vehicle Accidents by increasing the awareness drivers have of approaching emergency vehicles. Increasing the time a driver has to react, thus improving the likelihood of correct reactions. This also increases the effectiveness of emergency services as there will be faster response times and safer trips in emergency vehicles.

The target market for this product is primarily hearing-impaired drivers, as this was identified as an at-risk group to Emergency Vehicle accidents. This is due to the nature of the alert system of emergency vehicles. However, through research, I have found that this is a growing issue among all drivers, as driver distraction has been increasing.

This has broadened my target market beyond just the hearing-impaired. Possibly also benefiting other drivers, e.g. drivers with multiple passengers or loud music playing in their car.

Focusing on the user notification.

The Notification is the other part of this system, this is the part that lets the user know there is an approaching emergency vehicle. This part of the system is what the user will directly interact with. This part of the system will be the focus of my project as I have noticed with previous systems that have tried to develop a similar system, have failed in the effectiveness in this area.

From my analysis, this is the primary reason that stopped the adoption of the previous system.

I believe that a non-intrusive but effective means of notifying the user of an approaching emergency vehicle is the part of this system that is underdeveloped and will lead to the technologies adoption and subsequent benefits.



Driving down the road



E.V.A. is off



E.V. approaches from the right



E.V.A. lights up and indicates the direction of approaching E.V.

E.V.A.


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Student projects: Product Design - Industrial Product Design




# Quiver Killer


The aim of the project was to make the use of a ski quiver easier by designing a way for skis to change between skis quickly and easily so the skier can have a performance ski for various snow conditions. An iterative design process was employed throughout along with a heavy reliance on user empathy various avenues of research over a broad scope of skiing were conducted to ensure that the brief was met with the best option possible for the skiing community and market. Once the necessary research was conducted and what the market needed was understood a range of ideas/concepts were created to attempt to solve the brief. This process delivered a wide range of creative solutions with the purpose of meeting the end user and skiing markets needs fully. This wide spread of designs was then evaluated against the PDS created with the user in mind, and the extensive research done into skiing to ensure that the user's needs and wants were fully met. Through this conceptual design process and evaluation, a final design was decided on influenced by the market, skier themselves and the research undertaken into the world of skiing. Concepts, developments, evaluations and further designing was continuously done throughout this design process to create a representation of the research undertaken and the markets needs and wants that lead to a finalized design that could enter the skiing market.

The final design settled on is a creative and different solution to the problem in skiing now that will hopefully meet the user's needs and wants.

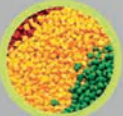
## Materials



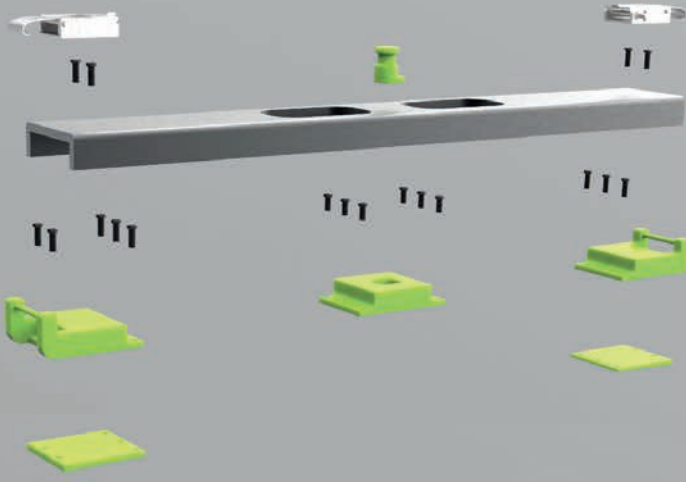
**Stainless steel**  
Stainless steel is going to be used on the Tension clips that hold the binding to the base plates on either end of the design. The manufacture of these clips offered either nickel plated or stainless steel for the material. Stainless steel was chosen for its resistance to water and corrosion which will be important around snow.




**Magnesium Alloy**  
The outer binding and the locking pins are going to be made from Magnesium. This part is going to be manufactured through die casting. This material was chosen because of its high mechanical damping which will dampen the vibrations from the ski making the ride smooth. Magnesium also has a high stiffness and doesn't react in cold temperatures very highly making it the perfect material for a ski.



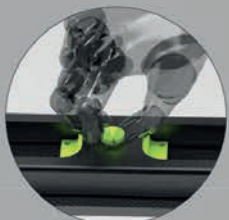
**PA 612**  
The base plates and wedges are going to be made from this certain type of thermoplastic. PA 612 was chosen for these parts because of its low density adding a lightness to the bindings that couldn't come from the magnesium. Furthermore, this material also doesn't react very much in the cold temperatures while also being a stiff and strong material. These parts are going to be injection moulded.



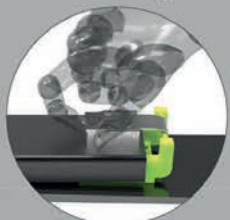
### Unclip



### Twist



### Unclip



Name: Rossan Aitchison 64018702  
Supervisor: Will Duncan

UC<sup>o</sup> PRODUCT DESIGN

# Student projects: Product Design - Industrial Product Design



### DESIGN PROCESS

The process of design was done in 4 steps. Empathise, ideate, prototype, implement. These 4 steps were done again and again to ensure the final design was an illustrative and visualisation of the specifications found from the research.

### EMPATHISE

Empathising helped gain a personal understanding for what the customers of the market were looking from their work vehicle. This was done by conducting primary and secondary research using questionnaires, interviews and reading literature. This helped create and define a series of specifications that would be used to keep the project going in the right direction.

P  
D  
S

MODULARITY  
ADAPTABILITY  
ORGANISATION  
CUSTOMISABILITY  
AUTONOMY  
RELIABILITY

### IDEATE

Ideation was done by exploring creatively with an open mind; ensuring concepts created could be compared and evaluated responsibly against the aspects found from the research. Ideas would be combined together even if they may not seem practical, helping ensure all possible avenues were explored.



### PROTOTYPE

Prototyping allowed for visual evaluation of concepts. Prototypes allowed for visual evaluation against the specifications created. It helped understand if the designs needed to be taken back steps in the process or had potential to keep developing. Many ideas had potential many did not.



### IMPLEMENT

Implementation of the designs occurred after evaluation of the prototypes. Potential that was shown could be implemented through developments which helped shape the material, manufacturing and final details parts of the design. Mainly, implementation helped understand when the design needed to be re-evaluated and taken back steps in the process. This helped lead to a final developments and designs.



With this, the final concept was aimed to be as much of a visual and illustrative representation of the research as possible. Empathising, ideating, prototyping and implementation happening repetitively to reach a point where the design was ready to enter the market. Leading to a final design, m1 CARGO.

# m1 CARGO



**Problem**  
Tradespeople today are struggling to stay organised and motivated in the workplace. Research showed a gap in the market for a work space that allows for autonomy, adaptability and modularity.

**Aim**  
The aim of the project was to find a unique but motivating way for tradespeople to organise their work vans to better improve work motivation and organisation.

## VAN ORGANISATION m1 CARGO

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# Student projects: Product Design - Industrial Product Design

The purpose of this project was to conduct research and experiment with 3D printing methods, namely Fused Deposition Modelling (FDM) to create a working paper pulping apparatus. 3D printed pulp tooling is becoming increasingly popular in recent years with Multi Jet Fusion (MJF) and Electron-Beam Melting (EBM) printing methods entering the industry. These printing methods pose a threat to traditional CNC tooling for their relatively low cost, leadtimes and rapid prototyping capabilities. Fused Deposition Modelling (FDM) is still relatively new and experimental with paper pulp manufacture capabilities.

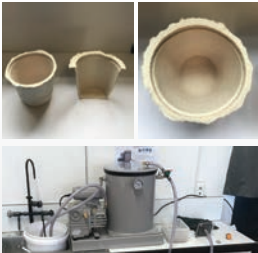
Design process was largely trial and error through prototyping with FDM and Stereolithography (SLA) printed molds in attempt to replicate principles used within industry for pulping paper. Principles needed to achieve paper pulping are water extraction, vacuum pressure and paper/wood fibre. Traditional tooling uses CNC aluminium block with a sintered wire mesh to allow for vacuum pressure and water to extract. By creating a porous geometry through either CAD, CURA or Meshmixer software enables these pulping principles to be replicated. The main software utilized for this project was Ultimakers CURA slicer. CURA enables multiple infill patterns and densities to be printed within a geometry to reduce print times and save material. Multiple FDM printed molds with varying infills were experimented with to achieve water extraction through varying geometries.

**Design Aims:**

Utilize 3D printing to create fine detail paper pulp molds with integrated water extraction on a paper pulping machine

**Design Objectives:**

- 1. Experiment with 3D printing methods to achieve fine mesh for water extraction
- 2. Create a workflow & templates for printing 3D moulds to be used on the pulping machine
- 3. Create a working paper pulping apparatus with possibility of interchangeable moulds
- 4. Create Pulp examples of types of products & materials achievable with the machine



**FINAL DESIGN**

The final design embodies two parts:

The first, a pulping apparatus replicating principles used in industry. Created from a modified degassing chamber, incorporating a cold trap to condense out any moisture before the motor. Brass barbed threads are tapped into acrylic and vacuum hoses are utilized for delivering the positive and negative pressures required.

The second, a FDM 3D printed vacuum plate, capable of having customized 3D printed mold tools attached for rapid prototyping and mold development.

**Unique Selling Proposition**

Traditional tooling for paper pulping is typically \$30,000 USD making it not economically viable for small scale enterprises to use sustainable paper pulp packaging without a production run of 50,000 units if not more. These input costs of traditional molded fibre tooling creates a entry barrier for low volume production.

FDM printed molds can cost less than \$400USD of material and also enables cheap mold prototyping. Currently existing pulp products used for customized packaging solutions require a minimum order quantity from 1000-5000units to offset input tooling costs. There is potential for a gap in the market to present itself for low volume enterprises that are in demand for sustainable customizable packaging options for production runs as low as 50units. Currently, this market only has cardboard, kraft, poly, padded mailers and plastic bubble wrap as a sustainable packaging options.

**Paper Pulping Machine Specs**

- Vacuum Plate • Snap lock
- Air Compressor • Positive Pressure Mold Ejection
- Cold Trap Condenser
- Vacuum Pump • Chamber

**Vacuum Plate Features**

- Injection molded snap lever locking mechanism
- Capable of withstanding both positive and negative pressures experienced during manufacture process
- Water/Air tight silicone seal
- Locator pins for easy mold alignment

**Mold Features**

- Gyroid Infill pattern
- 100% infill
- 8mm wall thickness
- 2mm shell

## Exploring The Possibilities Of Paper Pulping

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Barro deGast  
INDUSTRY COLLABORATOR  
deGast

UC<sup>o</sup>PRODUCT DESIGN



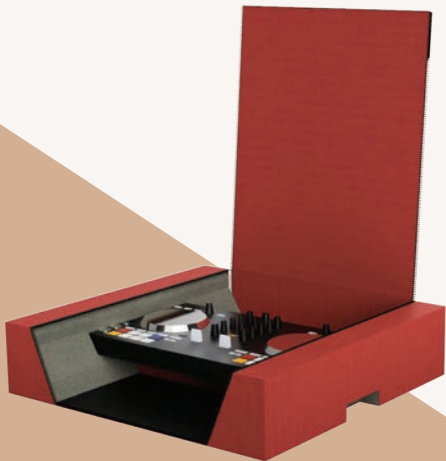
# Student projects: Product Design - Industrial Product Design

## Zip'n'Flip

The Zip'n'Flip is a multi-use protective case for DJ hardware. its lightweight foam design means it can be transported with ease and it's inner sleeve can be changed to cater to the specific size and shape of your controller, making it universally friendly no matter the controller.



Discover  
100% of people interviewed said that their biggest concern when taking their hardware to a party is damage from liquid spillage, which is interesting considering only 60% of those people have a legitimate case for their equipment. This is most likely for monetary reasons, as 3/5 people interviewed stated that they would only be happy to pay around \$200, a tall order considering the average cost of the cases I investigated during my re-



- Shields the front of the controller from liquid spillage
- Two forms of use: 'Transport mode' and 'In use mode'
- Briefcase design with handle allows for seamless and comfortable carrying
- Multi-layer sponge protection absorbs impacts from drops
- Gore-tex material allows for many different colour options
- Suspended controller design leaves space below, allowing for storage of things such as laptops and cords
- Handles on side offer maneuverability when in use mode



Define  
The aim of this project is to design & develop a product that facilitates the safe and secure transport, setup and protected use of dj controllers, that is cheap enough to be marketable to students and young adults without a sizeable sum of disposable income. I will achieve this by producing and developing concepts based on a list of parameters found through first & second hand research, making prototypes, and developing digital models. My objectives will be to Justify that the project will create something meaningful by composing a literature review, and conducting stakeholders interviews to mould a set of PDS. "

Transport.



Setup.

Develop  
Ideation methods of sketching and brainstorming were used to develop six possible directions for the project. The final direction was decided on after creating a decision matrix graph and comparing all six concepts against my PDS to see which one would meet the majority of my requirements. Once this direction was chosen I could start development on my CAD model and work out the technical details surrounding the product. Once a design had been finalised I also started working on a physical prototype, which gave me a hands on feel for what would and wouldn't work in my design.



Use.

- Material and Manufacture
- Interior Protective Sleeve
    - Material: Charcoal Foam
    - Manufacturing Method: Foam Casting & Moulding
  - Exterior Protective Sleeve
    - Material: Polyethylene Foam
    - Manufacturing Method: Foam Casting & Moulding
  - Protective Fabric Shell
    - Material: Gore-Tex
    - Manufacturing Method: Cutting & Sewing
  - Plastic Support Panels
    - Material: Acrylic
    - Manufacturing Method: Extrusion to Appropriate Size

### The Zip'n'Flip Protective Case for DJ Controllers

Thomas Murray  
Industrial Product Design

SUPERVISOR  
Will Duncan  
INDUSTRY COLLABORATOR  
N/A

UC<sup>4</sup> PRODUCT DESIGN  
To know more about us  
productdesign@uc.ac.nz

# Exploring Safety & Ergonomics Centered Design

## Breif Description

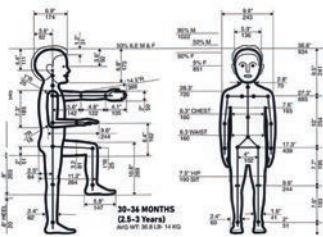
For this project, I got to work with a New Zealand company that creates mountain biking accessories that aim to encourage interest and engagement in this area. The scope of this project focuses on the ergonomics and safety considerations of the design. While also being athletic and usable to create enjoyment in the outdoors.

## UC PRODUCT DESIGN

Shannon Ruscoe, 13601364  
PROD314: Industrial Product Design 2B  
Supervisor: Nick Emerson,  
Industry Colaborator: Audrey Chevillat

### DISCOVER ○ Research

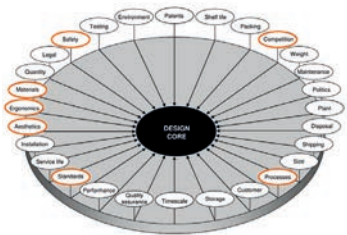
Initial background research into the brand and its competitors was carried out to gain a general understanding of the project, what was already available and what could be improved. The ergonomics were researched primarily through the analysis of anthropometric data. While a better understanding of the safety aspects for this design was gained through looking at potentially related injuries and common safety features of products, including from other types of products where safety is paramount and what could be used to prevent these. Researching standards was another important part of this project to gain an in-depth understanding of the specifications that would have to be implemented into the design of the product to best fit the needs of my client and the safety of their customers.



Ergonomic data of children from 9-36 months (Tilley & Associates, 2002)

### DEFINE ○ Design Specifications

The specifications for this project outlined the requirements to meet the brief and therefore produce the best possible design solution. The key specifications included safety, ergonomics, standards, competition, aesthetics, materials, and processes. These were all developed and explained to meet the client's brief while keeping athletics and the useability of the product for the best customer experience.



Product design specifications (Butler, 2002)

### DEVELOP ○ Ideation

Through the use of ideation methods such as mind maps, SCAMPER, mood boards, and sketching, possible design solutions were generated and evaluated. Through several iterations feedback was given to further develop the best concepts.

### ○ Prototyping & CAD Development

Using the final concepts generated in the ideation stage prototypes were created to verify the proportions and shapes of the designs. Through feedback and further development of design details, the final design was then developed.



### DELIVER ○ Final Design

Final details such as the material research and the development of the final prototypes were then carried out to bring together all aspects of the final design. To conclude, the details of the final design were communicated through the design portfolio.



To see more of my projects check out my portfolio below.







# Submit a project for 2023 or summer project for 2022

If you have a project idea - half a page is sufficient at this stage (the brief can be refined later)  
- please email the following information to [engindustry@canterbury.ac.nz](mailto:engindustry@canterbury.ac.nz):

- Title of the project.
  - Contact name and contact details for the project.
  - Summary of your expected project outcomes, for example, what you want to achieve or the problem you would like to solve.
  - Constraints and/or expectations that need to be taken in to account for the project.
  - Type of sponsorship option (individual/group).
  - Support (time, resource & equipment) your business/organisation will provide (in addition to sponsorship).
  - Any other information you consider relevant.
- Or complete the online form: [www.canterbury.ac.nz/engineering/industry/project-sponsorship](http://www.canterbury.ac.nz/engineering/industry/project-sponsorship)

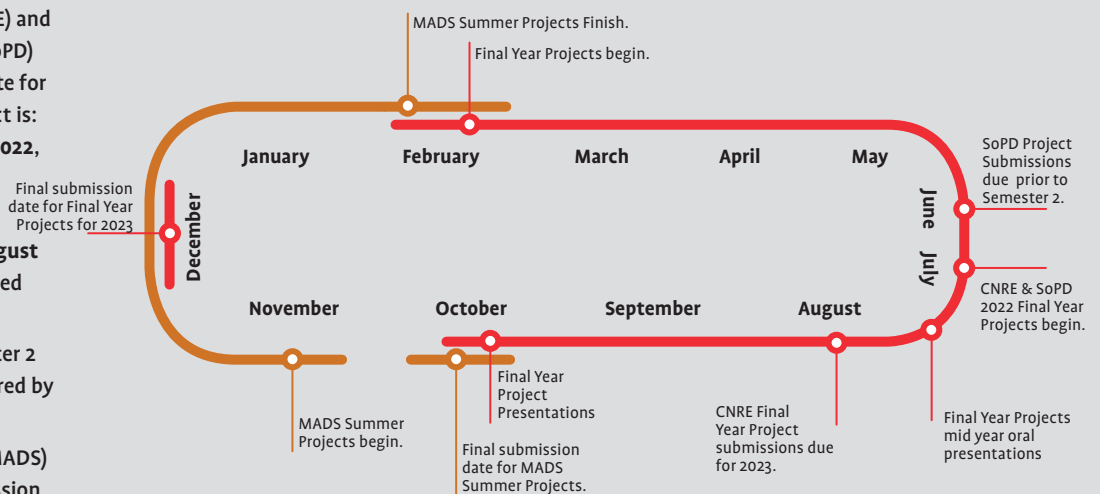
## PROJECT TIMELINE:

With exception of Civil & Natural Resource Engineering (CNRE) and School of Product Design (SoPD) the preferred submission date for an idea for a Final Year Project is: **Wednesday 21st December 2022**, for projects to be started in February 2023.

For CNRE it is **Friday, 12th August 2022**, for projects to be started in July 2023.

For SoPD, FYPs run in Semester 2 only with submissions required by **30th June 2022**.

Master of Applied Science (MADS) Summer Project final submission date for a project is: **Friday, 30th September 2022**, for projects to be started in November 2022.



As student numbers are limited, and vary from year to year, we recommend starting this process early to avoid missing out on having your project selected.

## Contact us

To find out more about these opportunities contact:

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Industry Engagement Manager

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