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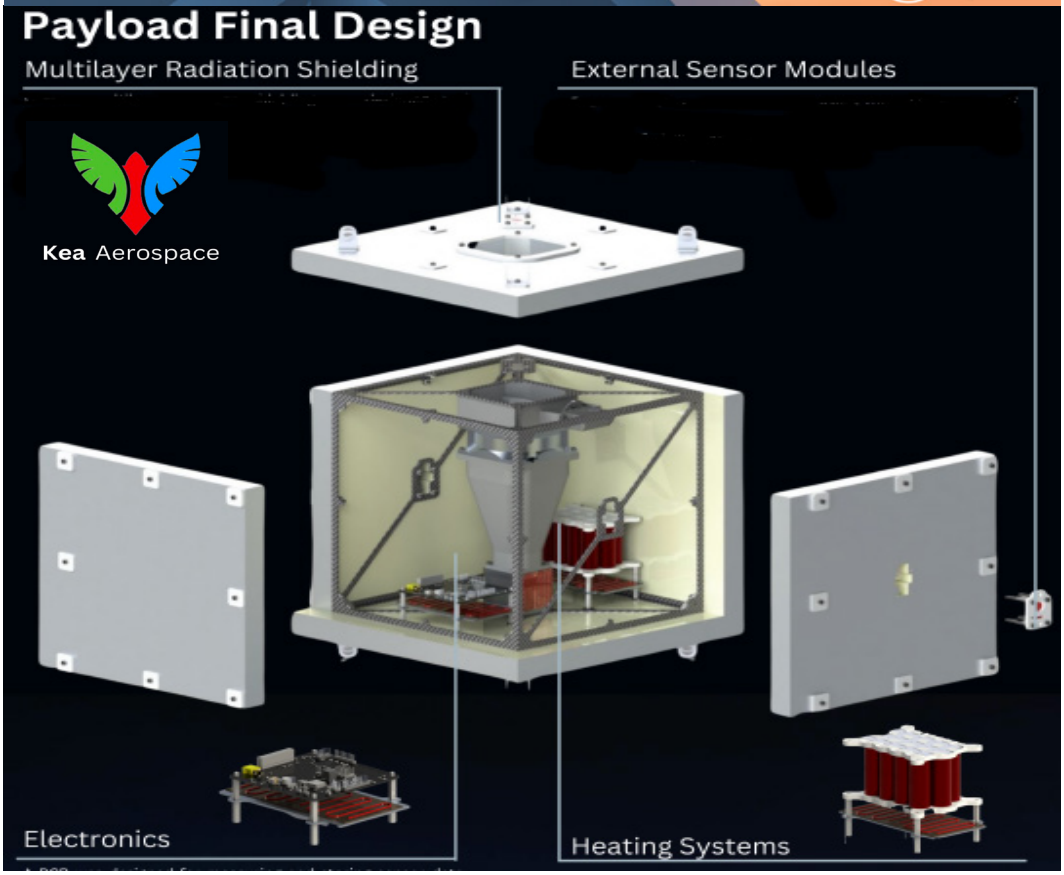
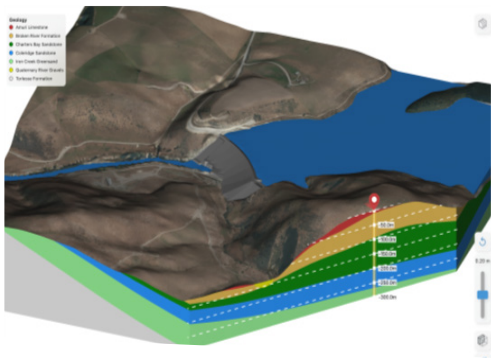
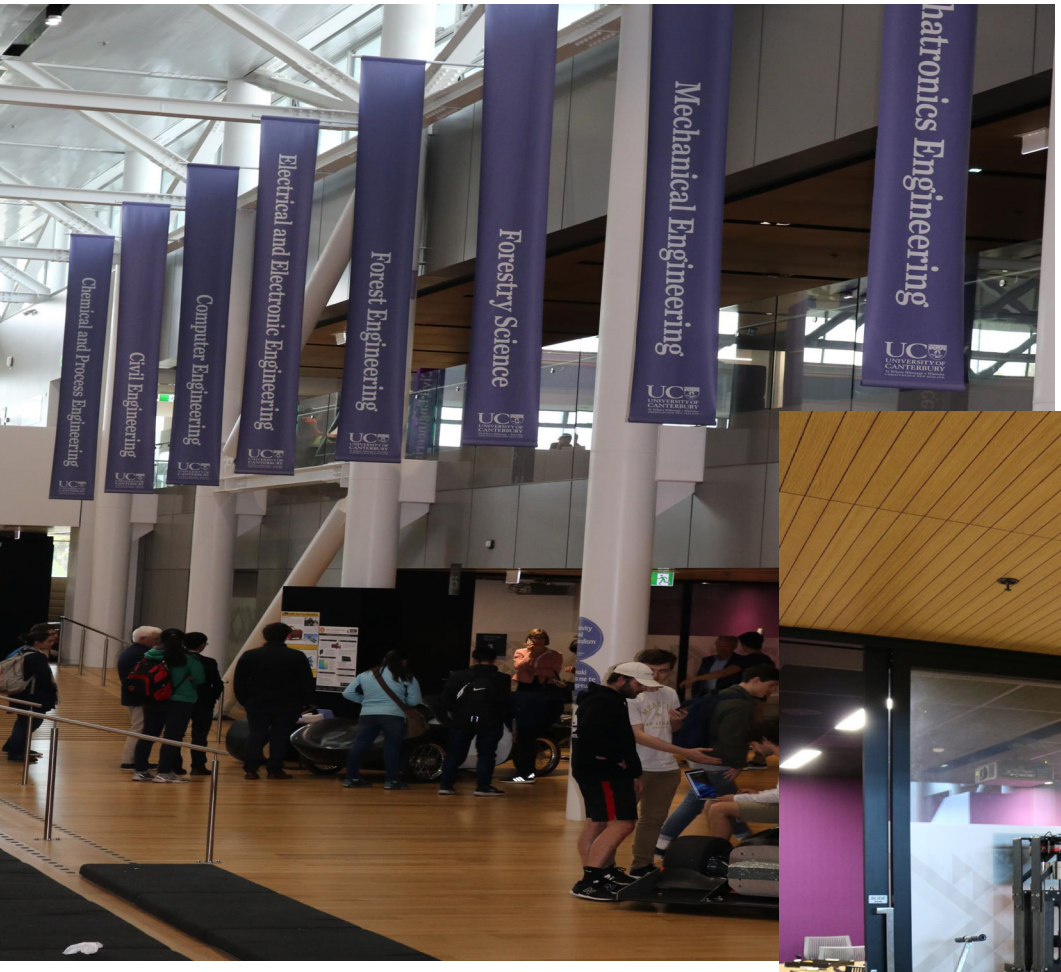
Final Year Projects 2022





UC UNIVERSITY OF CANTERBURY | Engineering Pūhanga

Contents



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Pink is the new Blue-Green

Ashley Gutteridge, Carlo Carere

UNIVERSITY OF CANTERBURY

Introduction

Over 2 billion people worldwide are estimated to suffer from starvation and malnourishment, with the latter causing 45% of deaths in children under 5 [1].

Galdieria sp. RTK37.1 is a blue-green NZ native strain of polyextremophilic algae, which grows at 45° and pH of 2.5 [2]. The genus has demonstrated potential as a supplementary food source for essential amino acids, vitamins, and other biomolecules which benefit human health.

Oxygen supply in large-scale cultivation of algae can prove a significant challenge. Mixed cultures including *Galdieria* spp. have been observed to turn pink during suspected oxygen limitation however this has not been definitively linked to *Galdieria* spp.. The pink compound is suspected to be an intermediate photopigment, coproporphyrin III [3-4].

Production of Coproporphyrin III

The key step lies with the conversion of coproporphyrinogen III to protoporphyrin IX, which relies on an oxygen dependant enzyme (EC 1.3.3.3). Without oxygen, this step does not proceed and instead coproporphyrinogen III accumulates and is excreted in its oxidised form, coproporphyrin III.

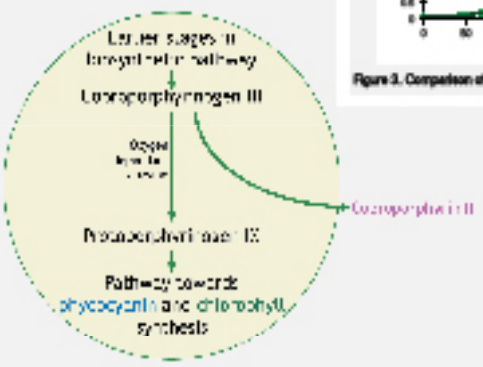

Figure 1. Inferred pathway for coproporphyrin III expression under oxygen-limiting conditions. Adapted from [5].

Aim

To investigate the production of a pink-porphyrin like compound in *Galdieria* sp. RTK37.1 under oxygen-limiting, photoautotrophic conditions.

Method

Cultures of *Galdieria* sp. RTK37.1 were grown in baffled flasks with V4 media at pH 2.5 in a shaking incubator at 45°C supplied 103 μmol m^{-2} s^{-1} warm white LED light. Cells were supplied 3% (v/v) CO_2 in air until an OD of 1 was reached, then the cells were sparged with 3% (v/v) CO_2 in nitrogen to strip oxygen. Absorbance measurements were taken using a scanning plate-reader. Coproporphyrin III was measured by OD_{630nm} normalised by the average of OD_{750nm} and OD_{810nm}.

Results and Interpretations

Coproporphyrin III was not detectable during the initial aerobic growth phase.

After beginning oxygen stripping by sparging with CO_2 in nitrogen, coproporphyrin III is detectable for 140 hours (Figure 2). There appears to be an initial decrease in growth rate upon commencing oxygen stripping.

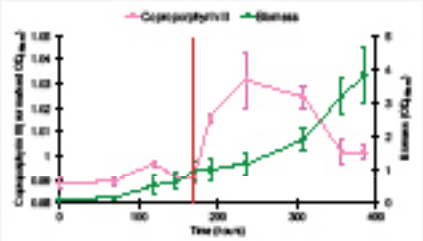

Figure 2. Growth curve and coproporphyrin III expression, initial aerobic growth with oxygen stripping at 170 hours (indicated by dotted red line).

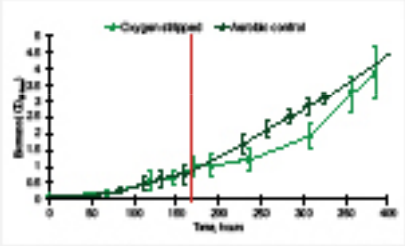

Figure 3. Comparison of oxygen-stripped growth and aerobic growth control curve.

The growth during oxygen stripping can be compared to the growth of aerobically growing *Galdieria* sp. RTK371 (Figure 3)

It is found that oxygen striping has a significant effect on the growth rate of *Galdieria* sp. RTK37.1 for the time in which coproporphyrin III is detectable (*t-test: p-value < 0.024*).

Conclusions and Implications

Coproporphyrin III has previously been expressed in mixed cultures containing *Galdieria* spp., and this has been attributed to the inactivation of an oxygen-dependant enzyme in the biosynthetic pathway. The current experiment demonstrated in axenic cultures of photoautrophically growing *Galdieria* sp. RTK37.1 that it is oxygen limitations which result in the expression of coproporphyrin III.

The rate at which coproporphyrin III appears in the media may allow for early detection of stress due to oxygen limitations in industrial scale cultivation. This can address the limitations of oxygen sensors, which can be faulty and only sense local oxygen concentrations. In addition, this combats the limitation in the several-day timescale required to infer oxygen limitations from slowed growth.

Literature cited

[1] – Food Security Information Network. (2022). 2022 global report on food crises. Wfp publication.

[2] – Buckingham, S. (2022). Investigating the feasibility of light (in)dependent continuous cultivation of an Extremophilic Alga: *Galdieria* sp. RTK37.1. Christchurch, New Zealand: The University of Canterbury.

[3] – Saito, T.N.U., et al. (2003). Functional differentiation of two analogous coproporphyrinogen III oxidases for heme and chlorophyll biosynthesis pathways in the cyanobacterium *Synechocystis* sp. PCC 6803. *Plant and cell physiology*, 44(5), 450-462.

[4] – Stadnichuk, I.N., et al. (1988). Inhibition by glucose of chlorophyll a and phycocyanidin biosynthesis in the unicellular red alga *Galdieria partita* at the stage of coproporphyrinogen III formation. *Plant science (Limerick)*, 58(1), 11-20.

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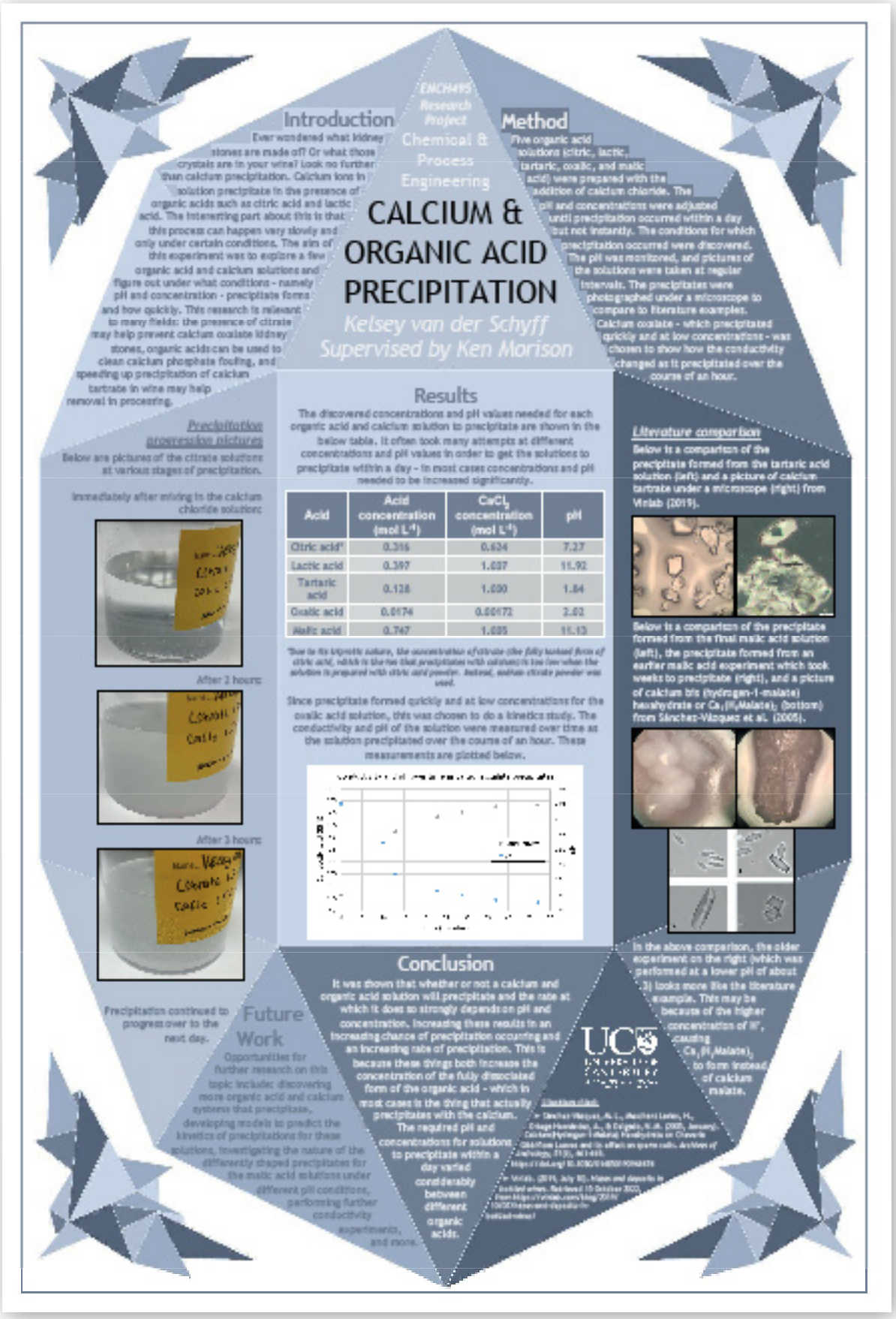
ENCH466: Research Project

Student projects: Chemical and Process Engineering



UTILISING BREWER'S SPENT YEAST

A Brewing By-Product with High Potential

UNIVERSITY OF CANTERBURY

Sara Dooney
Supervisor – Rachael Wood

ENCH495 Research Project
Department of Chemical and Process Engineering

INTRODUCTION

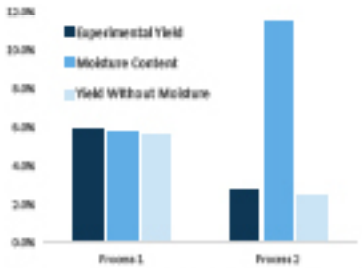
Brewer's spent yeast (BSY) is a major by-product of the brewing industry, with current output primarily being stock feed or disposal. Preliminary research has demonstrated that yeast extract produced from BSY is high in nutrients and has potential for use as a cell growth media ingredient.

This project focuses on the production of yeast extract powder from BSY and investigates the potential for it to be utilised on an industrial scale. Economic analysis was undertaken to determine the feasibility of the process.

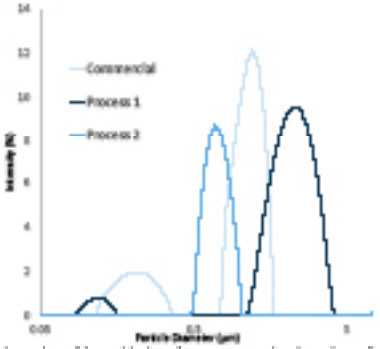
METHODS

Two methods of yeast extract powder production from BSY were used to determine the most efficient and cost-effective method. Both methods included centrifugation, seperation, and spray drying, but differed by cell lysis techniques.

The yield, particle size, and moisture content of each powder were found to assess the efficiency of the process and stability of the product.



Yields and moisture content data from small-scale experimentation.



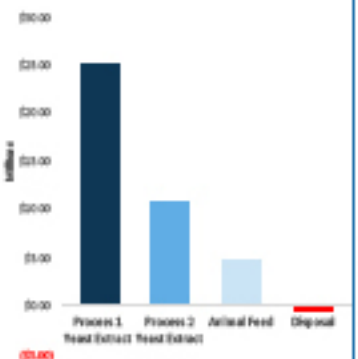
Comparison of the particle sizes of yeast extract produced experimentally and commercially.

KEY FINDINGS

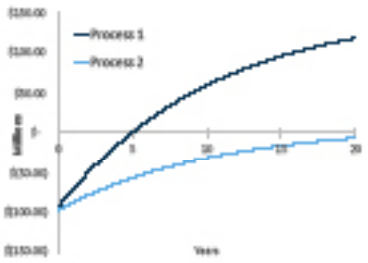
- Process one produced powder with a higher yield and lower moisture content.
- Process one took 22 hours longer than process two.
- The size of process one particles were larger than commercial and process two particles.
- Process one would pay back the cost of equipment in 5 years, compared to 25 years with process two.

ECONOMIC ANALYSIS

The current output for the BSY was compared to the value of the yeast extract, with both processes showing greater potential. Required capital expenditure was evaluated to give an understanding of the economic feasibility.



Value of yeast extract produced in comparison to current output, on a yearly basis.



Cumulative value of a yeast extract production plant.

CONCLUSIONS

Both processes successfully produced yeast extract capable of use as a cell growth media. Process one was found to be more efficient and cost effective. However, further research should be undertaken to reduce the production time. The implementation of either process would improve the sustainability of the brewing process and provide a further source of income.

YEAST EXTRACT POWDERS

Process 1

Process 2

REFERENCES

[illegible]

Student projects: Chemical and Process Engineering

Chemical Hydrogen Storage

Study of phosphetane borane as a potential hydrogen storage system

Elsie Wadie
Supervisor: A/Professor Sarah Masters

UNIVERSITY OF CANTERBURY

Purpose

Climate change is a real and present threat to our planet. One way to reduce the impact of human activity on the climate is to find alternatives to fossil fuels.[1] Hydrogen offers a clean alternative, combusting to produce water. However, storage of hydrogen onboard everyday vehicles is difficult, with current options limited to pressurised or cryogenic tanks. Chemical systems could be used to store and release hydrogen as needed within a car instead.[2] Requirements for good chemical hydrogen storage are:

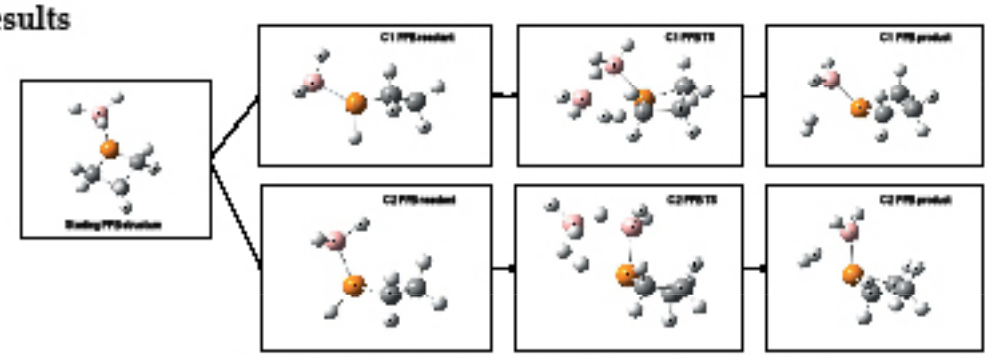
- Good volumetric and gravimetric capacity of H_2
- Good release and regeneration of H_2
- Good energy requirements (will H_2 be released with less energy than any other bonds are broken?)

In this project phosphetane borane (PPB) is being explored as one possible chemical storage system. Cyclic amine systems have previously been shown to show good hydrogen release when self catalysed by BH_3, therefore exploring the replacement of N by P provides valuable information regarding dehydrogenation processes for heterocyclic compounds.[3]

Computational Methods

Computers are capable of accurately predicting molecular structure and behaviour. Programs such as Gaussian 16 are used to determine the optimal structure of a molecule. The program searches for the minimum points on a potential energy surface with transitions states between minima also being locatable. Various properties of phosphetane borane, such as the molecular structure, vibrational frequencies, transition states (TS), dissociation of the P-B bond, and thermochemistry were investigated using the HF, MP2 and M06-2X methods (to determine electronic energy) with the 6-31G*, 6-311G* and 6-311+G* basis sets (to determine electron location).

Results

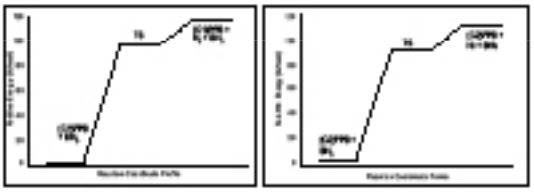


Optimised structures of the self-catalysed PPB dehydrogenation reaction steps for conformer one (C1) and two (C2).

Two conformers of phosphetane borane were located on the potential energy surface. The dehydrogenation profiles for both were explored further. Transition state calculations were completed, and it was found the dehydrogenation reaction where the BH_3 self-catalysed the process gave a reasonable transition state, indicating dehydrogenation would occur, while the uncatalyzed reaction did not.

The reaction coordinate shows a barrierless reaction which indicates even though, with enough energy, dehydrogenation could occur it would likely cascade back to the reactant state.

This shows that phosphetane borane would not be a suitable candidate for chemical hydrogen storage.



Reaction coordinate profiles of the catalysed PPB (C1 & C2) dehydrogenation.

What Next?

The next step for phosphetane borane is to look into the cyclic stability of the molecule to assess the effect of saturation of the ring. Following this phosphetane alane should be explored, in this molecule the boron atom of the BH_3 Lewis acid is replaced with aluminium which is below boron on the periodic table. Properties to investigate include reaction barriers, and dehydrogenation pathways compared to bond dissociation.

Acknowledgements and References

I wish to thank my supervisors A/Professor Sarah Masters and Rilna Mohamed Irfan.

[1] Zou, A. M., University of Canterbury PhD Thesis 2020.
[2] Amendola, R.; Bolland, V., The hydrogen issue. ChemSusChem 2021, 4 (1), 21-36.
[3] Masters, S. L.; Zou, A. M., Essential B–N interactions in linear and cyclic donor–acceptor complexes: a review. Chemistry in New Zealand 2020, 84.

Student projects: Chemical and Process Engineering

Endometriosis Invasiveness Modelling

Not just a 'benign' disease

Imogen Cunningham supervised by Dr. Rachael Wood

UC UNIVERSITY OF CANTERBURY

Introduction

Endometriosis is a chronic inflammatory gynaecologic disease categorised by the presence of endometrial cells outside the uterine cavity (1). The pelvic region is predominately affected however there is clinical evidence of disease spread to nearly all organs and tissue, including the brain, eyes, and liver (2,3). Despite affecting an estimated 10-15% of reproductive age women, endometriosis remains unresearched and there is a concerning disparity between the disease presented in literature as 'benign' and the severe disease being treated in clinic (4).

The aim of this research is to model and quantify the invasive behaviour of endometriosis, using mammalian cell culture, to develop a more comprehensive understanding of the diseases pathogenic mechanisms. Additionally, this project aims to contribute evidence that highlights that endometriosis is not a benign condition but instead a serious invasive disease that deserves more public and professional awareness.

This research builds on work completed by Katie Ellis (Mech. Eng. student) and was conducted as part of final year CAPE research project.

Cell Lines

EEC-12Z
Endometriosis
Invasive

SW-1353
Bone Carcinoma
Invasive

MDA-MB-231
Breast Cancer
Invasive

NIH3T3
Mouse Fibroblast
Non-invasive

2D Invasion Modelling

Scratch Assay

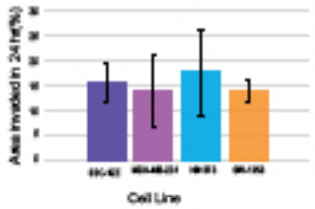
1. Seed cells onto lower surface of well, add media and incubate
2. Once surface is covered remove media and scratch surface
3. Add new media and incubate
4. Image migration every 24 hours until scratch is closed

3D Invasion Modelling

Matrigel Transwell Invasion Assay

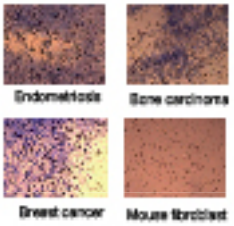
1. Place serum free cell suspension in top chamber and chemoattractant media in lower chamber
2. Incubate for 48 hours. Invasive cells will travel down through Matrigel to the membrane layer
3. Remove the non-invasive cells and media before staining invasive cells violet for imaging and quantification

Scratch Assay Results

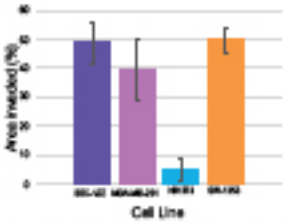


2D scratch assay invasion quantification results are non-conclusive due to high errors.

Matrigel Transwell Results



Violet colour indicates presence of invasive cells.



EEC-12Z exhibited invasive behaviour similar to breast and bone cancer. Graph compares invasion with 10% FBS chemoattractant.

Conclusions

2D invasion assay was not conclusive, due to high variance between repeats.

Invasive hypothesis was supported by the Matrigel invasion assay.

Invasive behaviour of endometriosis is comparable to some metastatic cancer.

Future Work

Incorporate immunocytochemistry staining to investigate invasive cell expression and probe the link between cancer invasion characteristics and endometriosis.

Repeat experiments utilising primary endometriosis tissue.

In vivo models need to be developed to confirm these findings.

Literature cited

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

[illegible] Research Project

From Beer to Beef

Utilising spent brewers yeast as a growth medium for cellular agriculture

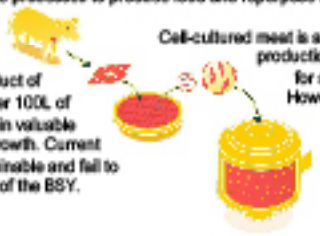
Paige Hansen, Rachael Wood

UNIVERSITY OF CANTERBURY

Introduction

Our current methods of food and beverage production are unsustainable and threaten global food security. As a result establishing alternative processes to produce food and repurpose by-products is vital.

Brewers Spent Yeast - BSY
BSY is the 2nd largest by-product of brewing with 2kg produced per 100L of beer. Yeast is known to contain valuable elements that stimulate cell growth. Current disposal methods are unsustainable and fail to utilise the valuable properties of the BSY.



Cellular Agriculture
Cell-cultured meat is a rapidly growing alternative food production method which offers potential for a more sustainable food system. However, current research has been hindered by the lack of suitable growth media.

Objective

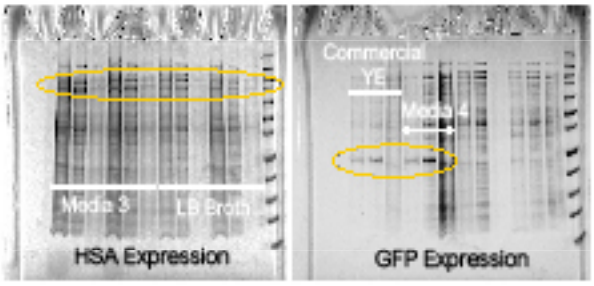
This research aims to verify the concept of repurposing spent yeast into a yeast extract for growth media by comparing its properties to commercial products. In addition to this is it also aims to investigate the applications this growth media may have in cellular agriculture by characterising expression of human serum albumin.

Scope

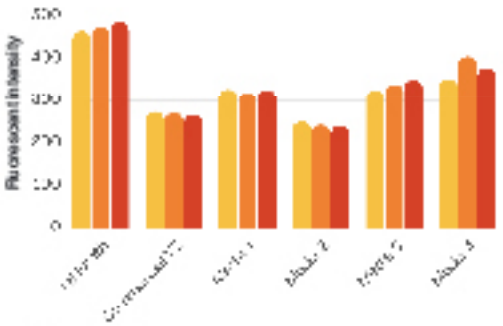
1. Compare the growth rate of E.coli TOP10 cells in commercial yeast extract against yeast extract derived from BSY.
2. Culture cells to test expressions of green fluorescent protein and human serum albumin in E. coli cells using yeast extract derived from brewers spent yeast.
3. Characterise expression and growth of green fluorescent protein and human serum albumin in yeast extract derived from brewers spent yeast.

Results

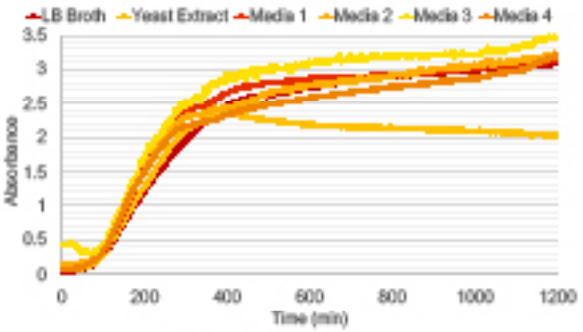
Verifying Expression of Green Fluorescent Protein and Human Serum Albumin



Quantifying Green Fluorescent Protein Expression



E. Coli Growth Rate



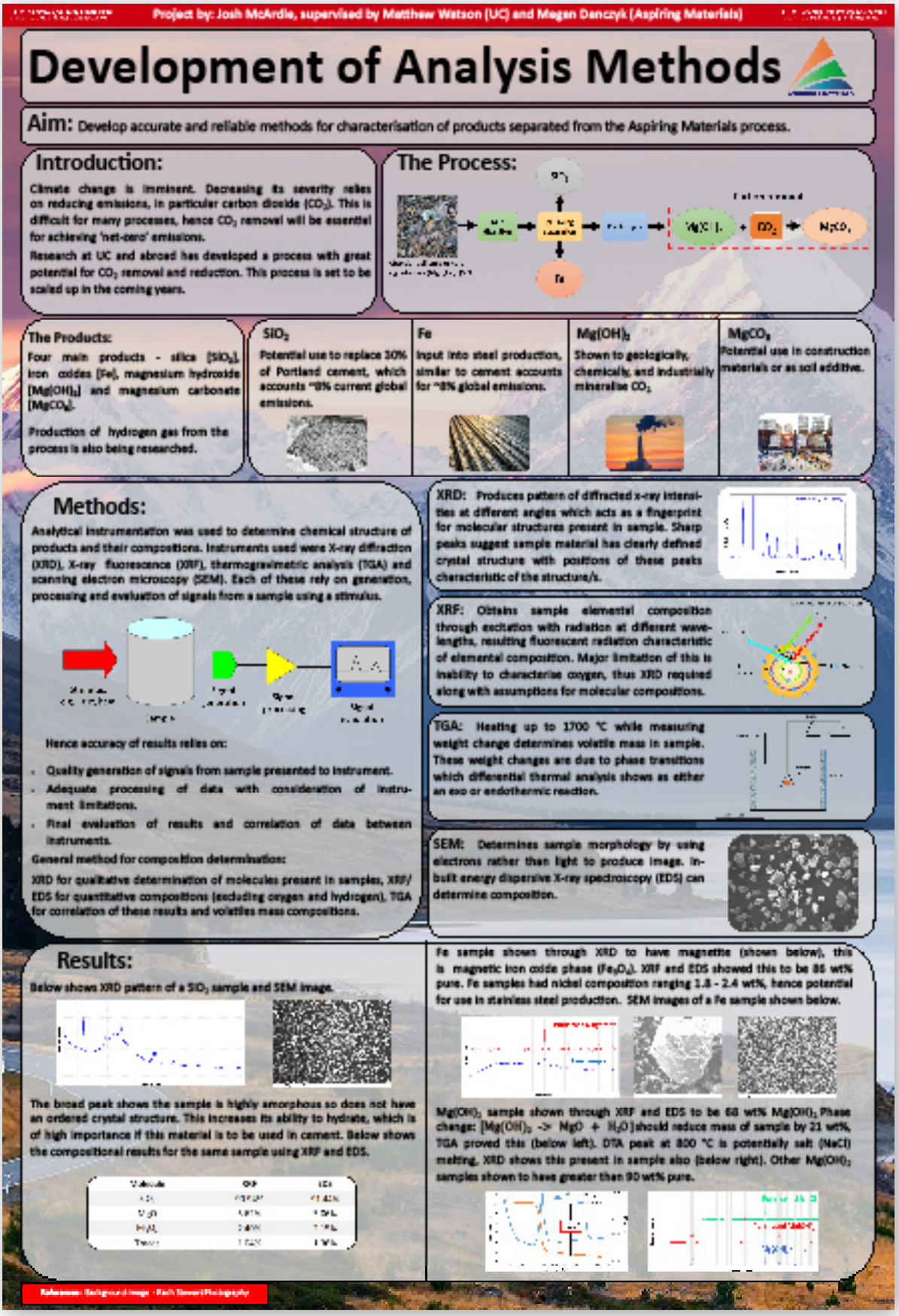
Conclusion

The results indicate that utilising brewers spent yeast as a growth media is viable option. In some instances the BSY derived growth media was not only found to grow cells and express GFP and HSA at similar level to that of the commercial yeast extract it was better. When compared to other commercial growth mecias such as LB Broth, GFP was found to be expressed better in this medium while HSA was not. Interestingly, commercial LB Broth appears superior to commercial YE when compositionally they are the identical.

Future Work

The next stage of this research aims to focus on the purification of expressed HSA using a 3D printed chromatography column. This purified protein can then be further analysed to determine its solubility and it's application in serum free media for cellular agriculture.

Student projects: Chemical and Process Engineering



Student projects: Chemical and Process Engineering

$Ru_XMn_{1-X}O_2$ Catalysts for PEM Water Electrolysis

Glen McClea, Aaron Marshall

UNIVERSITY OF CANTERBURY

Abstract

Noble metal loading of PEM Water Electrolysis catalyst was reduced via Mn substitution, resulting in improved catalytic performance with increased Mn composition. However, it was determined that Mn is not an appropriate partial substitute for RuO_2 because of its instability in accelerated lifetime tests.

Introduction

The Proton-Exchange Membrane (PEM) is a promising technology for the production of Green Hydrogen. Current catalysts for the reaction contain expensive noble metal oxides such as IrO_2 and RuO_2. The catalyst's noble metal loading can be reduced via the partial substitution of RuO_2 with MnO_2.

Dimensionally Stable Anodes (DSA) with various Ru-MnO_2 compositions were synthesized and electrochemically tested to determine their catalytic performance and stability for PEM water electrolysis.

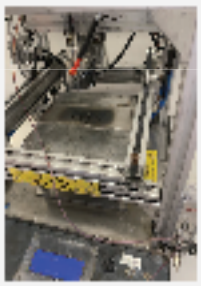
Methods

Catalyst Synthesis:

- Direct Thermal Decomposition of $RuCl_3xH_2O$ and $MnCl_2x4H_2O$ on Ti substrate through atomized spray
- Annealed at 400 °C for 1 hour

Electrochemical Testing:

- Linear Sweep Voltammetry
- Cyclic Voltammetry
- Chronopotentiometry and AES



Results

Catalyst Performance:

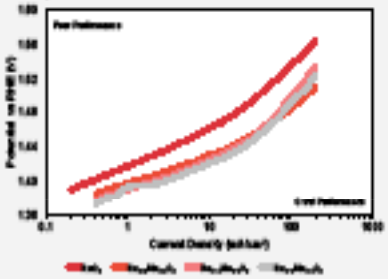


Figure 1: Polarisation curve of RuO_2, $Ru_{0.8}Mn_{0.2}O_2$, $Ru_{0.6}Mn_{0.4}O_2$ and $Ru_{0.4}Mn_{0.6}O_2$ between 0.2 and 200 mA.cm^{-2}.

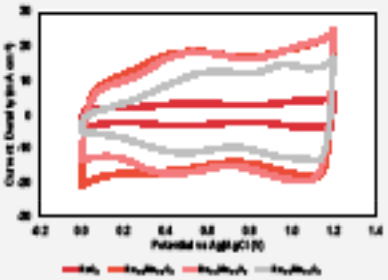


Figure 2: Cyclic Voltammetry of RuO_2, $Ru_{0.8}Mn_{0.2}O_2$, $Ru_{0.6}Mn_{0.4}O_2$ and $Ru_{0.4}Mn_{0.6}O_2$ at a 100 mV s^{-1} scan rate.

Catalyst Stability:

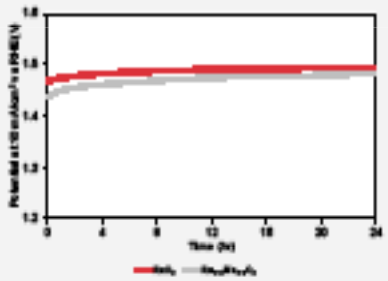


Figure 3: Accelerated lifetime test of RuO_2 and $Ru_{0.4}Mn_{0.6}O_2$ at a current density of 10 mA.cm^{-2} for 24 hours.

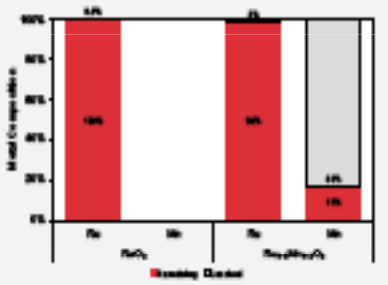


Figure 4: Remaining and leached metal composition of Ru and Mn in RuO_2 and $Ru_{0.4}Mn_{0.6}O_2$ after 24 hour accelerated lifetime test.

Conclusions

An increase in catalytic performance was observed with an increased Mn composition (Figure 1). RuO_2 and $Ru_{0.4}Mn_{0.6}O_2$ both appeared to show catalytic stability during a 24-hour accelerated lifetime test (Figure 3). However AES analysis revealed that up to 83% of Mn was leached from the $Ru_{0.4}Mn_{0.6}O_2$ catalyst during the accelerated lifetime test (Figure 4), this has not been reported in the literature. The stability and increased performance from this catalyst is therefore likely due to the remaining highly porous RuO_2. These porosity trends are shown in cyclic voltammograms (Figure 2). In contradiction to the literature, it is concluded that Mn is not an appropriate partial substitute in RuO_2 catalysts due to instability.

Literature

A. T. Marshall, "Electrocatalysts for the Oxygen Evolution Electrode in Water Electrolysers using Proton Exchange Membranes: Synthesis and Characterisation," in PhD Thesis, Norwegian University of Science and Technology, 2005.

S. Trasatti, "Electrocatalysis in the anodic evolution of oxygen and chlorine," Electrochimica Acta, vol. 29, no. 11, pp. 1503–1512, 1984.

J. L. Fernandes, M. R. Oliveira De Chalins and A. C. Chibeles, "Preparation and electrochemical characterization of $TiPtRuMn_xO_y$ electrodes," Journal of applied electrochemistry, vol. 33, no. 4, pp. 313–322, 2003.

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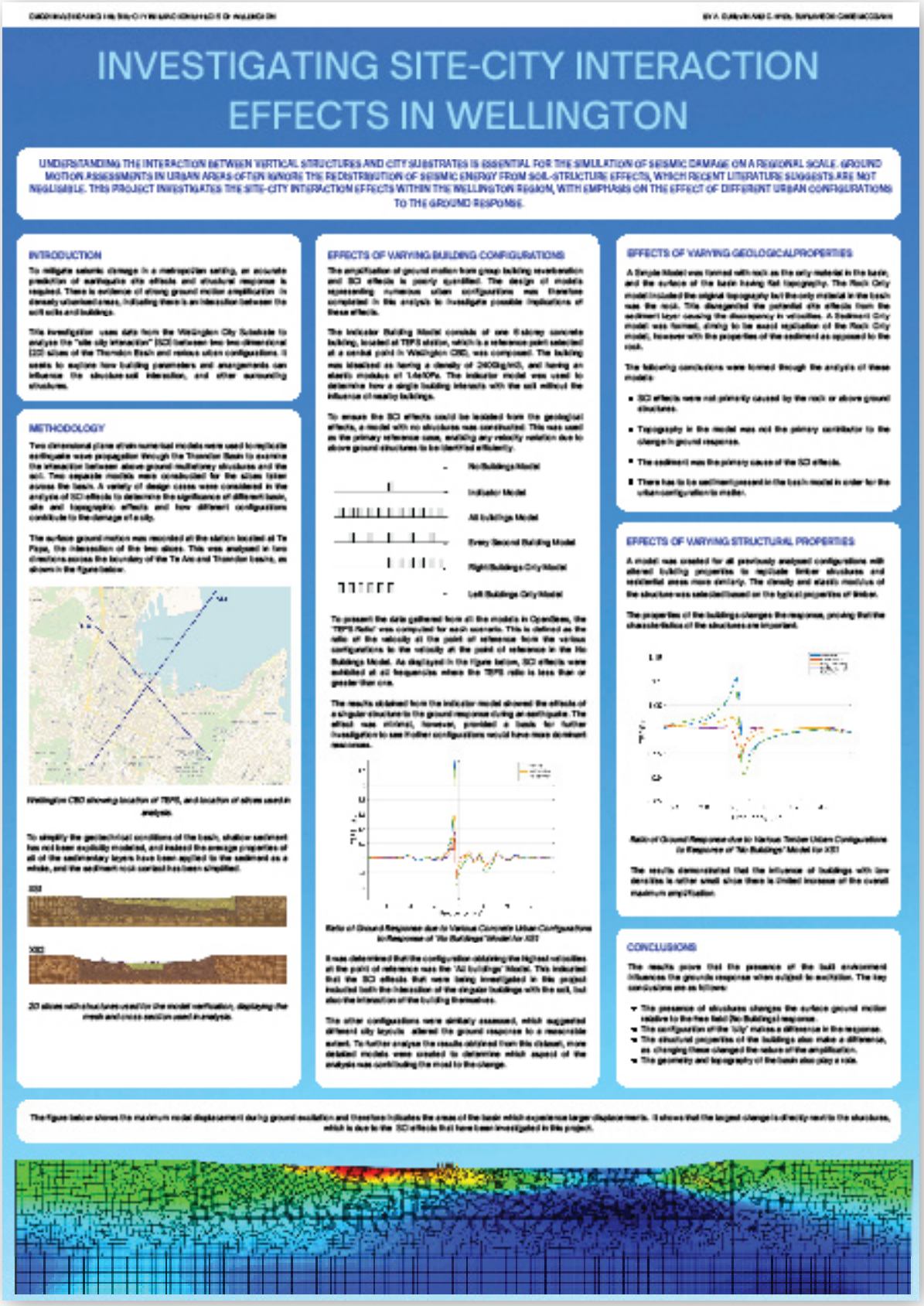

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Virtual Reality Smoke?
It'll break your stride!

Cameron Davis and Chelsea Sole

Background

Designing for fire safety relies on accurately estimating movement speed. It is extremely difficult to observe the movement speed of occupants during a real fire. This means experimental studies are very important to investigate how visibility loss impacts movement speed. However, physical experimental studies of movement through artificial smoke can be very expensive.

Virtual reality could be a cheaper method to accurately simulate virtual smoke effects. Previous studies have found that virtual reality results for human behaviour in fire have similar validity to classical laboratory studies[1]. However, most studies have not used the participant's physical preferred walking speed as their speed in the virtual environment.

Experimental procedure

Advertisements were posted on Facebook and campus noticeboards. Most of the 42 participants were university students, and 76% indicated they had prior experience with virtual reality. A $5 café voucher was offered to each person following the experiment.

Experiments took place in the Civil and Natural Resources virtual reality lab. A wireless self-contained head mounted display was used to immerse participants in a virtual version of the lab. There were five experiment scenarios: without virtual reality, virtual reality with no smoke, and virtual reality with smoke reducing the visibility to 3.5 m, 2.5 m, and 1.5 m. Each participant experienced the smoke scenarios in a different random order and repeated their first smoke scenario at the end.

Objectives

- Determine the relationship between physical movement speed and virtual environment visibility.
- Compare movement speed through smoke in a virtual environment to existing experimental data.

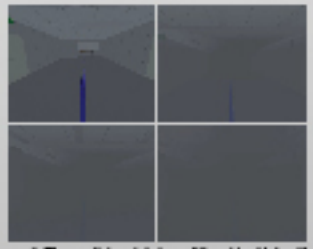

Figure 1. The participants' view of the virtual lab with no smoke (top left), 3.5 m (top right), 2.5 m (bottom left), and 1.5 m (bottom right) visibility.

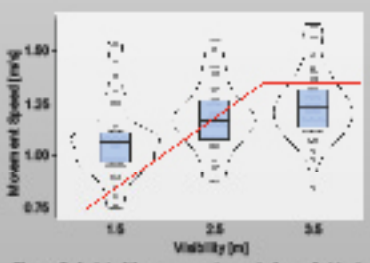

Figure 2. A plot of the movement speeds from all virtual reality smoke scenarios with the mean experimental data curve[2] overlaid in red. The box shows the interquartile range (25-75% of datapoints), and the horizontal line in the box is the median. The outline shows the distribution of datapoints.

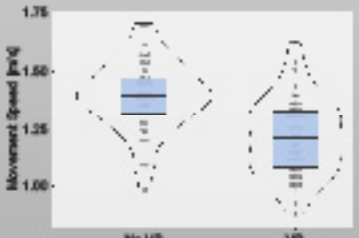

Figure 3. The unimpeded movement speed without the head mounted display compared to the unimpeded movement speed in the virtual lab. The box shows the interquartile range (25-75% of datapoints), and the horizontal line in the box is the median. The outline shows the distribution of datapoints.

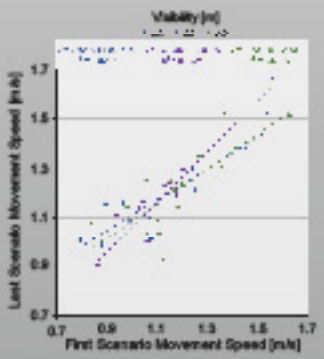

Figure 4. The correlation between the first and last trial of each visibility level with the linear trendline equations and R^2 (goodness of fit) values provided.

Comparison to past experiments

Participants tended to walk slower as their virtual visibility decreased. This general trend was expected based on previous experimental results[2]. However, the virtual reality experiment results did not clearly fit the established data curve. On average at 3.5 m of visibility participants walked slower in virtual reality than in previous experiments. Decreasing the visibility in virtual reality also had less impact on movement speed than expected. This was probably because participants knew there were no obstacles, and so felt more comfortable walking in the low visibility environments.

VR slows people down

A Welch's t-test was conducted with the null hypothesis that participants' unimpeded movement speed would not be significantly faster in the real lab than in the virtual lab. This returned a p-value of under 0.1%. Since the p-value was less than 5% a significant difference in speed was shown, and the null hypothesis was rejected. This was confirmed by plotting the two samples, as while the data range overlaps slightly both medians are clearly outside the other's interquartile range. The reason for participants walking slower in the virtual environment was probably unfamiliarity with the situation.

Was there a learning effect?

Participants in the 2.5 m smoke scenario did not significantly change their speed between their first and last trial. However, they tended to walk slower on their final round of both the 1.5 m and 3.5 m scenarios. The reason for being slower in the final 1.5 m scenario is likely due to the contrast effect, as participants tended to think the last 1.5 m scenario was the worst after experiencing the other scenarios. The linear trendline fits the 1.5 m and 2.5 m scenarios well, but not the 3.5 m scenario. One reason could be that participants felt more relaxed on their second 3.5 m trial, so there was more variation in their walking speeds.

Conclusions

Virtual reality smoke was shown to decrease the physical movement speed of participants. However, decreasing the virtual visibility did not have as much impact on movement speed as was observed in past real-world experiments. Increasing the realism of the virtual environment could decrease this gap between virtual and real-world smoke experiment results.

Acknowledgements

Daniel Nilsson and Humayun Khan for supervision and support throughout the project.

Civil and Natural Resources department for funding inducements.

This experiment was approved by the Human Research Ethics Committee of the University of Canterbury (HREC 2022/47/LR).

References

1. Kinateder, M., E. Ronchi, D. Nilsson, M. Kobes, M. Müller, P. Pauli, and A. Mühlberger. 2014. "Virtual reality for fire evacuation research." 2014 Federated Conference on Computer Science and Information Systems, FedCSIS 2014, 313–321. Institute of Electrical and Electronics Engineers Inc.

2. Ronchi, E., E. Ronchi, D. Nilsson, and H. Kinateder. 2016. "The reproduction of evacuation movement in smoke-filled underground transportation systems." Tunnelling and Underground Space Technology, 55: 39–51. Elsevier Ltd. https://doi.org/10.1016/j.tust.2015.10.018

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ToVCC: Isabella Ryan, Charlotte Duke

HYDRAULIC BARRIERS TO NATIVE FISH MIGRATION

UC UNIVERSITY OF CANTERBURY

PURPOSE STATEMENT

Understand the backwatering effect, caused by Fyke nets and stop nets, as it relates to fish passage. Create a device that reduces the backwatering effect in culverts.

BACKGROUND

There are eighteen species of New Zealand native fish which migrate as part of their lifecycle. Fish passage is an important consideration in New Zealand streams, however, hydraulic barriers such as culverts pose challenges to fish passage as they are designed only to transport water out of a system quickly and efficiently. Fish passage solutions have been developed and tested under laboratory conditions, meaning their success in the field is relatively unknown. One method of testing the success of fish passage remediations in-situ is mark and recapture trials.

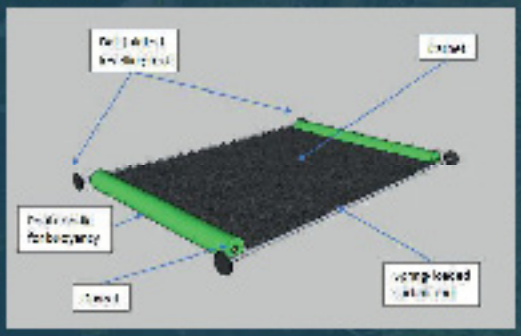
In mark and recapture testing, a stop net is placed at the upstream and downstream end of the culvert to isolate the test environment. However, by adding this barrier, the hydraulic properties of the reach are affected, creating a backwater effect, particularly in reaches with high debris loads. Backwater rise is where the water in the reach is backed upstream, creating an area of deeper water. This poses an issue as the testing is supposed to be done in natural hydraulic conditions. This research involves the design of a 'no-backwater' device which allows for mark and recapture trials that do not disrupt the culvert hydraulics. The device has been designed and tested to determine whether it is effective in minimising backwater rise.

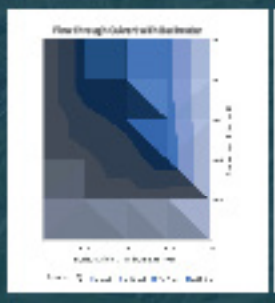
DESIGN OF PROTOTYPE

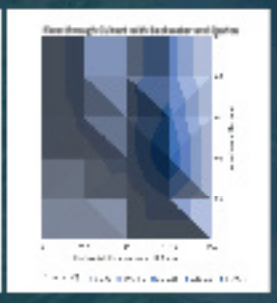
From previous studies, it has been found that the backwater rise caused by obstructions in the flow can potentially be mitigated by a carpeting effect. In a natural stream, a carpet of debris can form around an obstruction, which can decrease the rise of backwater. This carpet effect is the basis of our design for this prototype.

The prototype for the no backwater device has been designed to mimic this carpet effect. It consists of several main components as shown on the figure on the right. The curtain rods provide structure to the device, with the spring-loading making them adjustable, securely fitting in a range of culverts. The rods have the added attachment of ball-jointed levelling feet, which can be adjusted to grip onto the sides of the culvert. The frame also consists of two dowels, covered by pool noodles to provide buoyancy, keeping the device on the surface of the water. A sheet of material is stretched across the frame. This component is designed to mimic the carpet effect.

PROTOTYPE







TESTING AND RESULTS

The device has been tested in a range of culverts throughout Christchurch to verify its effectiveness at minimising backwater rise. A backwater was created using a net at the culvert outlet. The velocity, stream depth and change in height (backwater height) were recorded. The no-backwater device was then placed in the stream, upstream of the net. The velocity, stream depth and change in height were recorded again.

The results show a 26.6% reduction in the backwater caused by a net. This is because the no-backwater device acts as a carpet, efficiently directing flow through the net. The flow profiles both before and after intervention show different flow behaviours. Before the device is installed, the flow profile shows the expected flow behaviour for an open channel; the flow is fastest at the water surface and approaches zero towards the sides of the culvert. After the device is installed, the flow behaves more like a pipe. The no-backwater device introduces a surface at the top of the flow (flow at this surface is approximately zero), meaning the fastest flow occurs in the middle. Additionally, the overall flow is reduced (excluding an area of high flow in the centre), contributing to the reduction in backwater.

FUTURE METHODS

The no-backwater device is intended to be used in-situ to reduce the backwater caused by fyke nets and stop nets. This will improve the accuracy of mark and recapture trials by ensuring that fish have near-normal conditions to ascend a culvert by reducing changes to culvert hydraulics.

The results show that the device alters the flow behaviour at the backwater location. The purpose of the device is to minimize changes to flow behaviour in culverts. To prove its effectiveness, further testing should be conducted to model the flow throughout the culvert reach. This would show that the flow is only altered at the device location.

Supervisor: Prof. Tonny de Vries

Special Thanks To: Stephanie Patchett, Aude Thierry, Fabio Silveira, and Alisha Olney.

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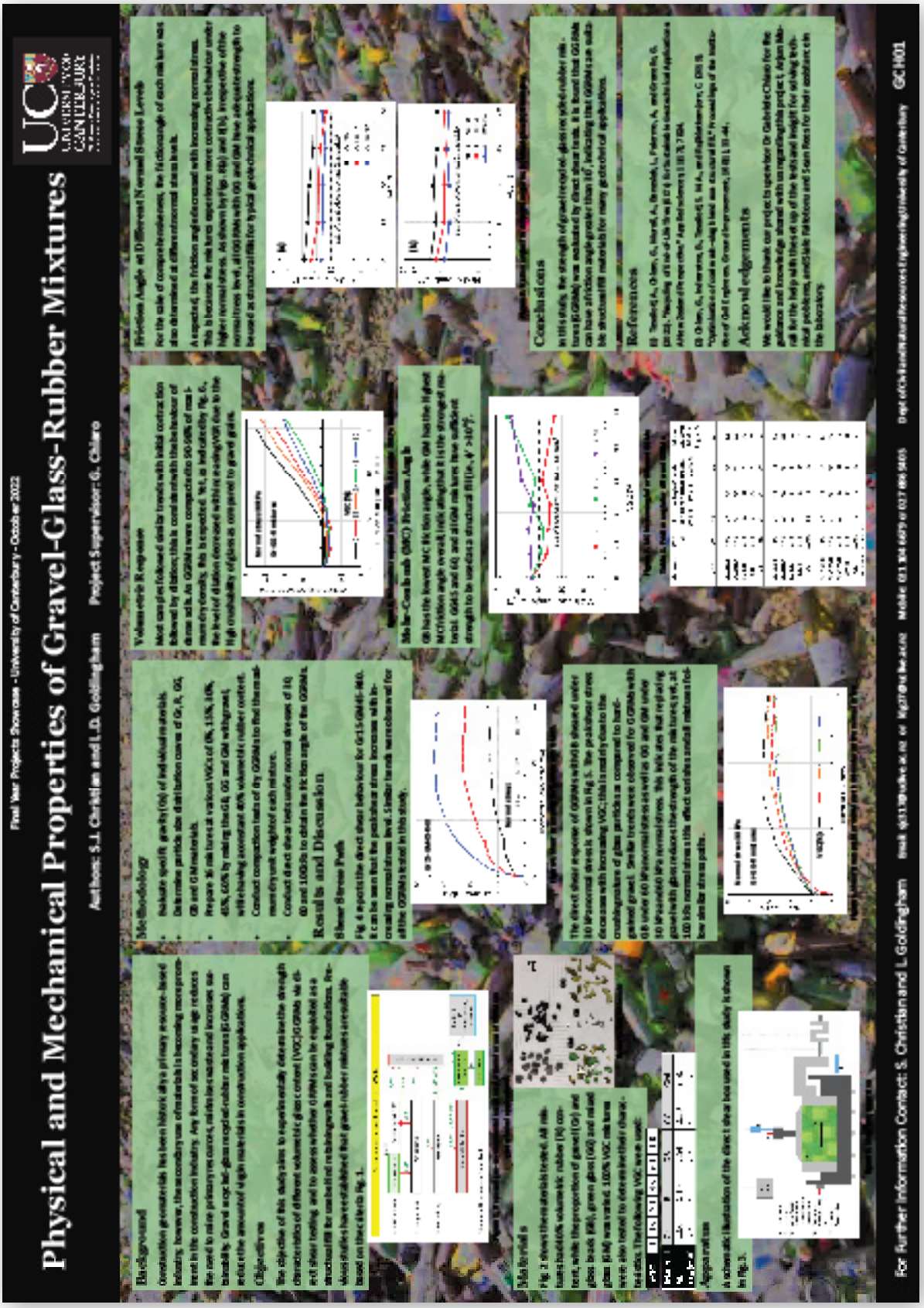

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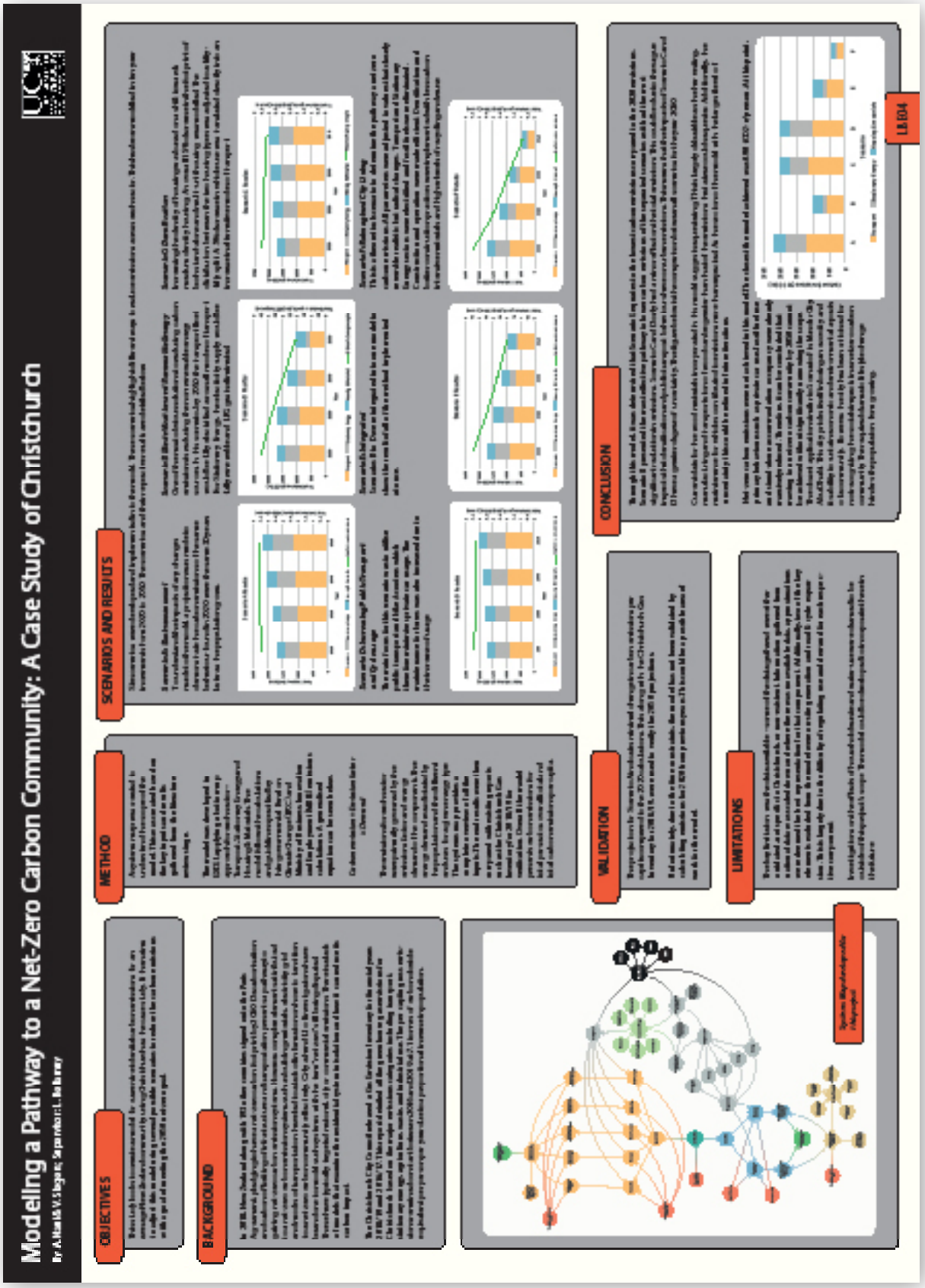

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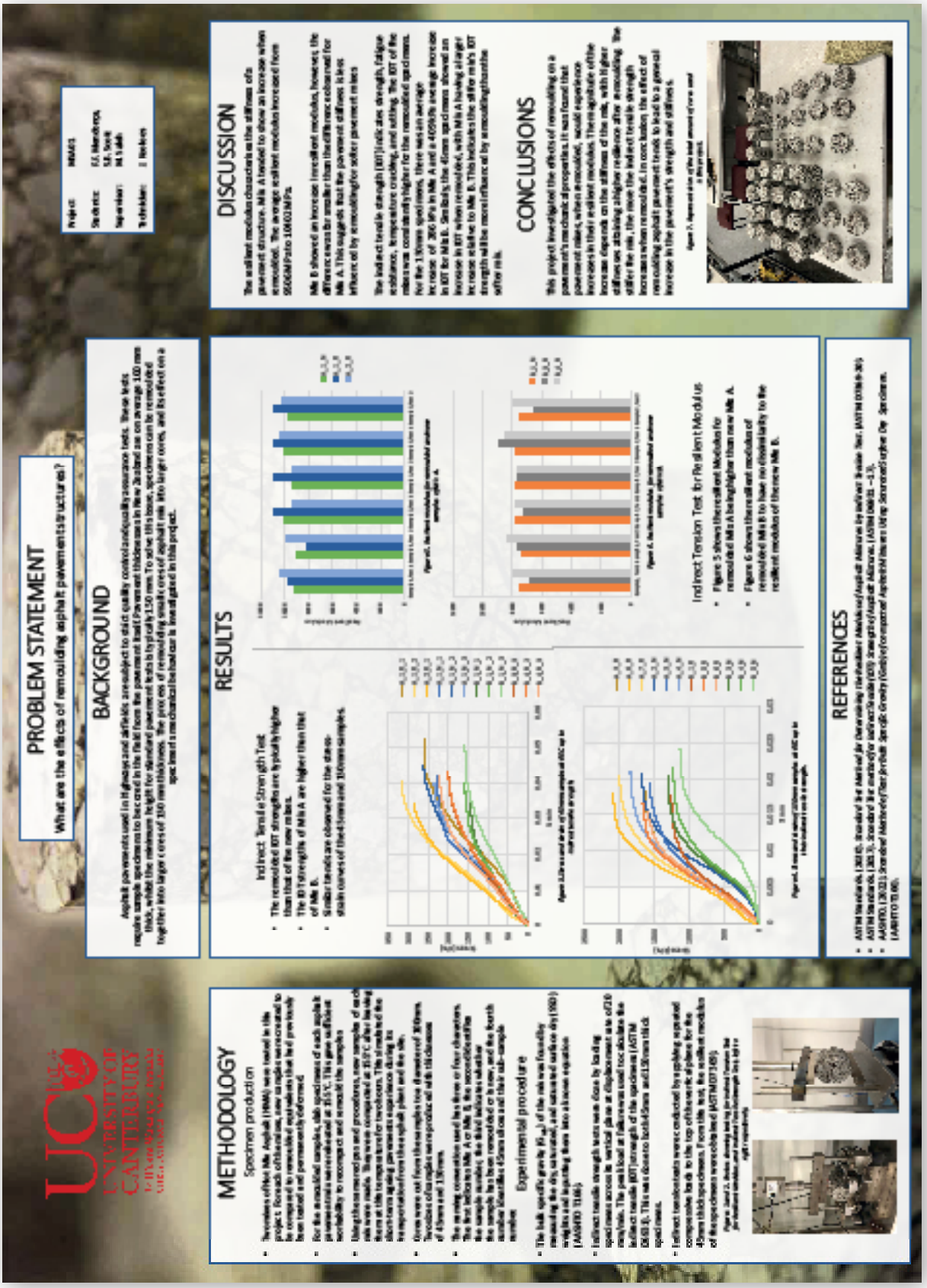

IMPRINT
CARBON EMISSIONS CALCULATOR

enable fibre broadband

WHY COUNT CARBON?

- More people are working remotely and an understanding of environmental impact is needed.
- Organisations are striving to adopt sustainable working environments.
- A method to compare the personal carbon footprints of working remotely to working in office would be useful in validating sustainable working decisions.

OBJECTIVES

1. Design a model to calculate the emissions created by individuals when working from home and working in the office.
2. Create a user friendly web application to actualise the model

MODEL

Total emissions =


+

+


Traveling to work
Commuting is the largest emissions contributor to working from the office.

Virtual meetings
Internet connection type, meeting lengths, and camera use are factors of the emissions created during online meetings.

Home heating
Heat pumps, electric oil heaters, gas heaters, and fireplaces all emit carbon at different rates.

WEB APPLICATION

The required input parameters are:

- The number of days working from home and from the office
- Commute distance and travel modes
- Online meetings:
  - Duration
  - Use of camera
  - Internet connection type
- Frequency of heating in winter and what heating technology is used.

Results are displayed to the user in approximate kilograms of carbon dioxide created in a year and the number of fully developed trees required to offset the greenhouse gases.

USABILITY SURVEY

21
Participants

8.7/10
Intuitiveness score

114s
Average completion time

44s
Standard deviation

UCC University College Cork
Computer Science & Software Engineering

Student
Ronan Avery

Industry supervisor
Melissa Keys

Academic supervisor
Andreas Willig

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AUTOMATED 3D SCENE RECONSTRUCTION

FROM 360-DEGREE VIDEOS

Henry Barrett

BACKGROUND

FACILITYtwin®, a digital twin platform developed by Beca, helps owners and managers of manufacturing and utilities facilities get easy access to the data they need to make better decisions about their assets through 360-degree photo virtual tours. The creation of 360 tours is limited because the virtual tours are "flat" in that they use 2-dimensional 360 degree photos.

Neural Radiance Fields (NeRF) allow for the creation of complex 3D models from regular photos using neural networks.

The technology offers an advantage over traditional photogrammetry tools, which often require expensive LiDAR equipment, time, and experience to capture a scene.

OBJECTIVES

- Generate a 3D model from 360 photos or videos
- Produce a 3D "doll house view"
- Place locations of the photos into the 3D scene

NVIDIA. COLMAP

PROCESS

An automated processing pipeline was developed that simplifies the creation of 3D models from 360 degree photos or video.

1 **Capture** 360 video

Minimise motion blur
+
Ensure each object in the scene is observed multiple times from different directions.

2 **Decompose** frames

Extract still frames from video.
+
Take revolving perspective projections from equirectangular images

3 **Triangulate** camera positions

Structure from motion on images using COLMAP
+
Bundle adjustment using known constraints

4 **Train** neural model

Using Nvidia's instant Neural Graphics Primitives NeRF implementation
+
Network learns to represent scene

RESULTS

Dataset used is of a living room featuring a single large open space (limited and simple geometry, similar to that of a large open facility.

The model is able to be cropped to allow for viewing from completely novel perspectives such as a dollhouse view.

When viewed from these perspectives, visual quality is reduced due to floating artifacts.

Consistent lighting and dynamic masks help to reduce the presence of artifacts.

Exporting NeRF model to mesh provides easier integration into other systems at the cost of visual quality.

Surface geometry is not accurately captured, limiting the quality of generated meshes.

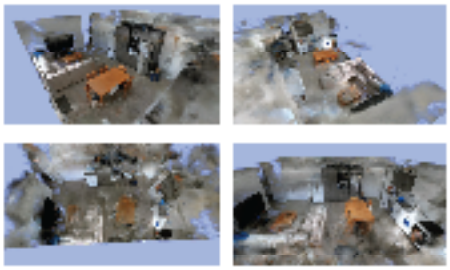
Model accuracy is measured to be 28 dB (PSNR) on training images captured from a 1m:12s video (144 total frames).

Trained models were able to provide better visual quality when viewed from positions close to training views.

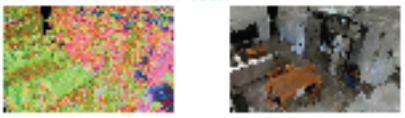
It is found that NeRF is better suited for "outside-in" reconstructions, where cameras all point inward towards a single subject.

For "inside-out" reconstructions, such as indoor scenes, a greater number of observations/input images are required.

Novel Views



Mesh



Surface normal | Vertex colour

Training View

Ground Truth

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Fabian Gilson | Supervisor
Sam Houghton | Industry Partner
Stephen Wilhenden | Industry Partner
Heath Simons | Industry Partner

Beca

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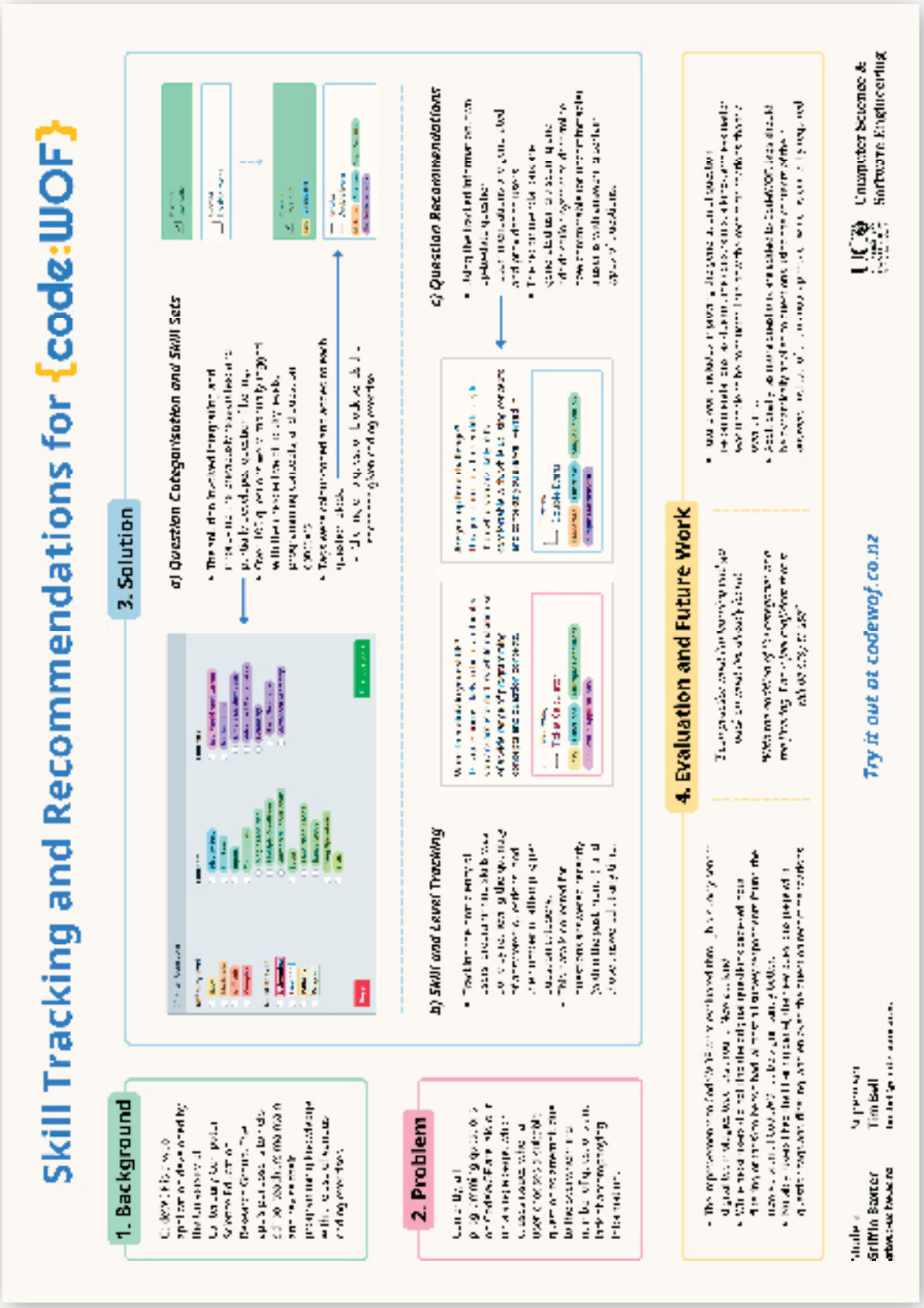

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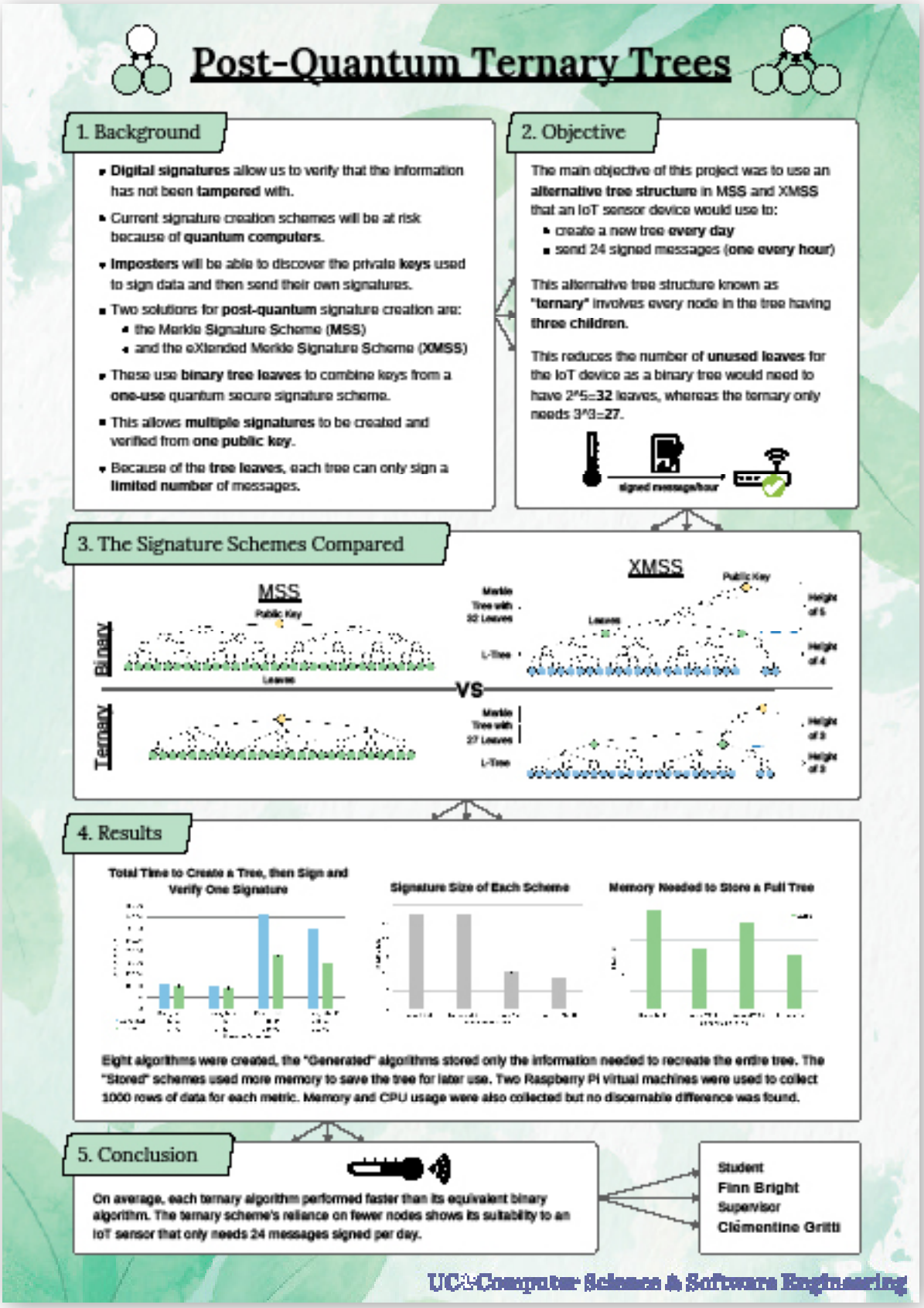

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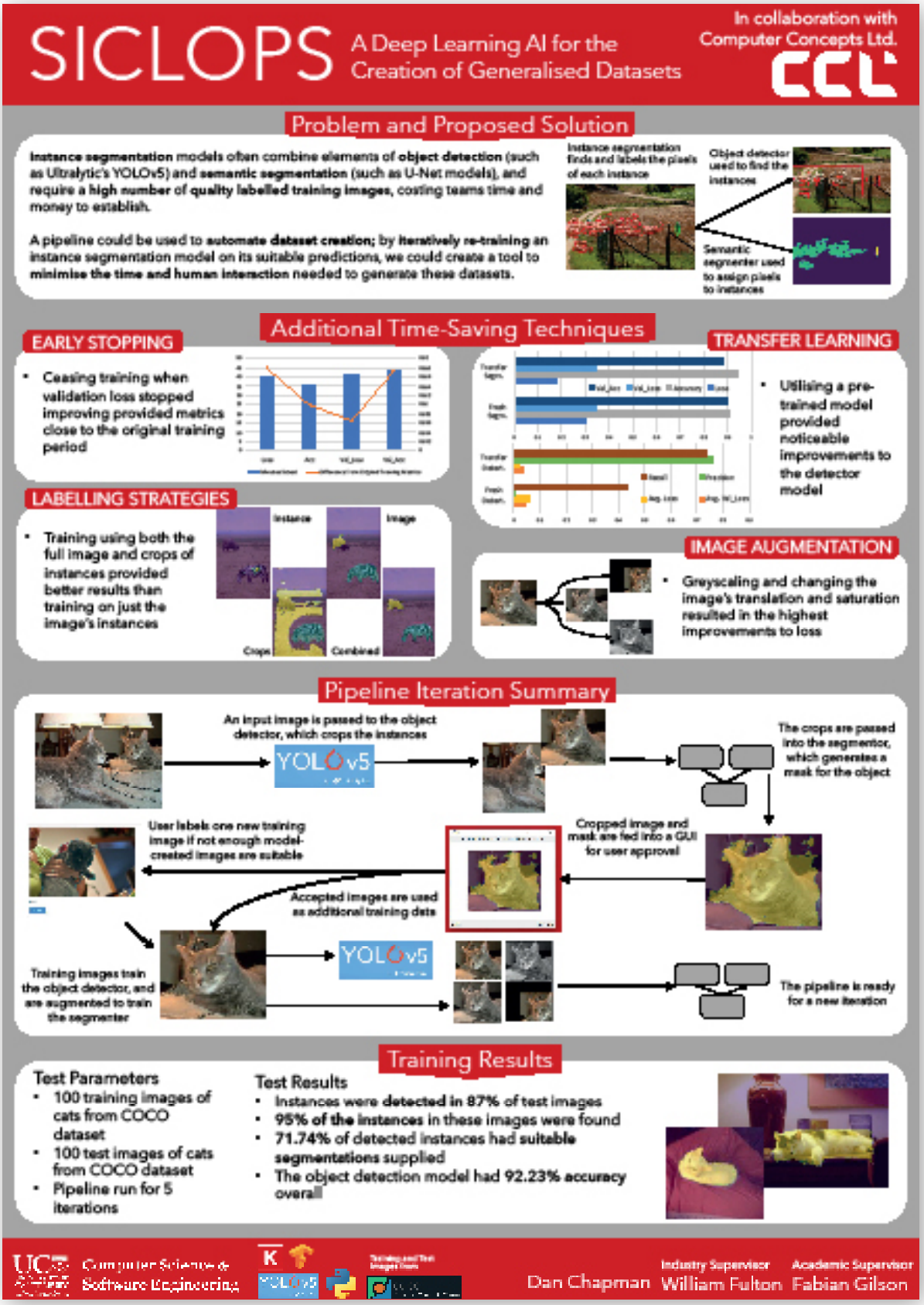

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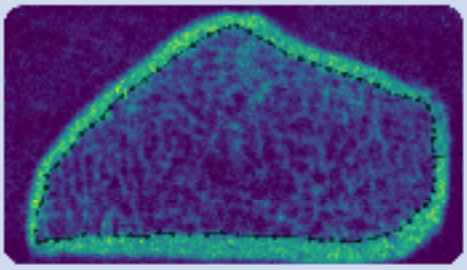
MEASURING BONE HEALTH FEATURES

IMAGE SEGMENTATION WITH MINIMAL USER INTERVENTION

mars



MOTIVATION

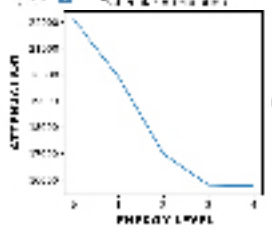
- Manual segmentation by drawing polygons can take [illegible] to complete.
- With this solution, the speed and accuracy of segmentation can be significantly improved.

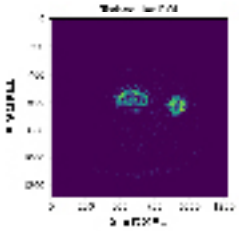
OBJECTIVES

- Reduce user input required for segmentation.
- Compare different segmentation approaches.
- Reduce time taken to segment trabecular bone from CT scan slices.

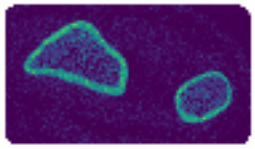
SOLUTION

- The initial solution was to use the attenuation values of each voxel over five energy levels.
- This solution included manually selecting a trabecular region for the attenuations to be calculated from.
- Voxels [illegible] regions in the attenuation within the [illegible] at all energy levels.





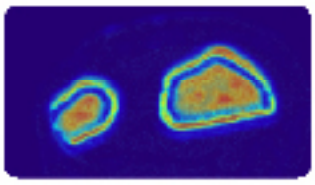
- The proposed solution was to use a range of [illegible] convolutional neural network [illegible] for segmentation.
- This solution used synthetic training data, building different models. Then training the models.



CNN

EVALUATION

- Gradient-weighted class activation mapping was used to map important regions.
- The heat-maps [illegible] for CNN's [illegible] learning the [illegible] key features.



- The datasets used to test the models were also manually segmented by MARS employees who used their manual regions of interest (ROIs) to calculate bone health features.
- By using the trained models to find ROIs for these datasets the bone health features could be calculated in the same way.
- By comparing these results to the accuracy of the models were examined.

RESULTS

[illegible] MODEL TESTING RESULTS AFTER 50 EPOCHS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- [illegible] ROIs are combined with the thresholding algorithm defined in the initial solution to give a range of masks for the image above.

- Using MARS Vision for bone health features [illegible] are calculated.

[illegible] OF YOUR TRAINING DATASETS WITH MANUAL SEGMENTATIONS

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

- [illegible] [illegible] the models are segmenting the trabecular region of the bone [illegible].

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Computer Science & Software Engineering

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OLIVER CRANSHAW

INDUSTRY SPONSOR
MARS BIOIMAGING

ACADEMIC SUPERVISOR
JAMES ATLAS

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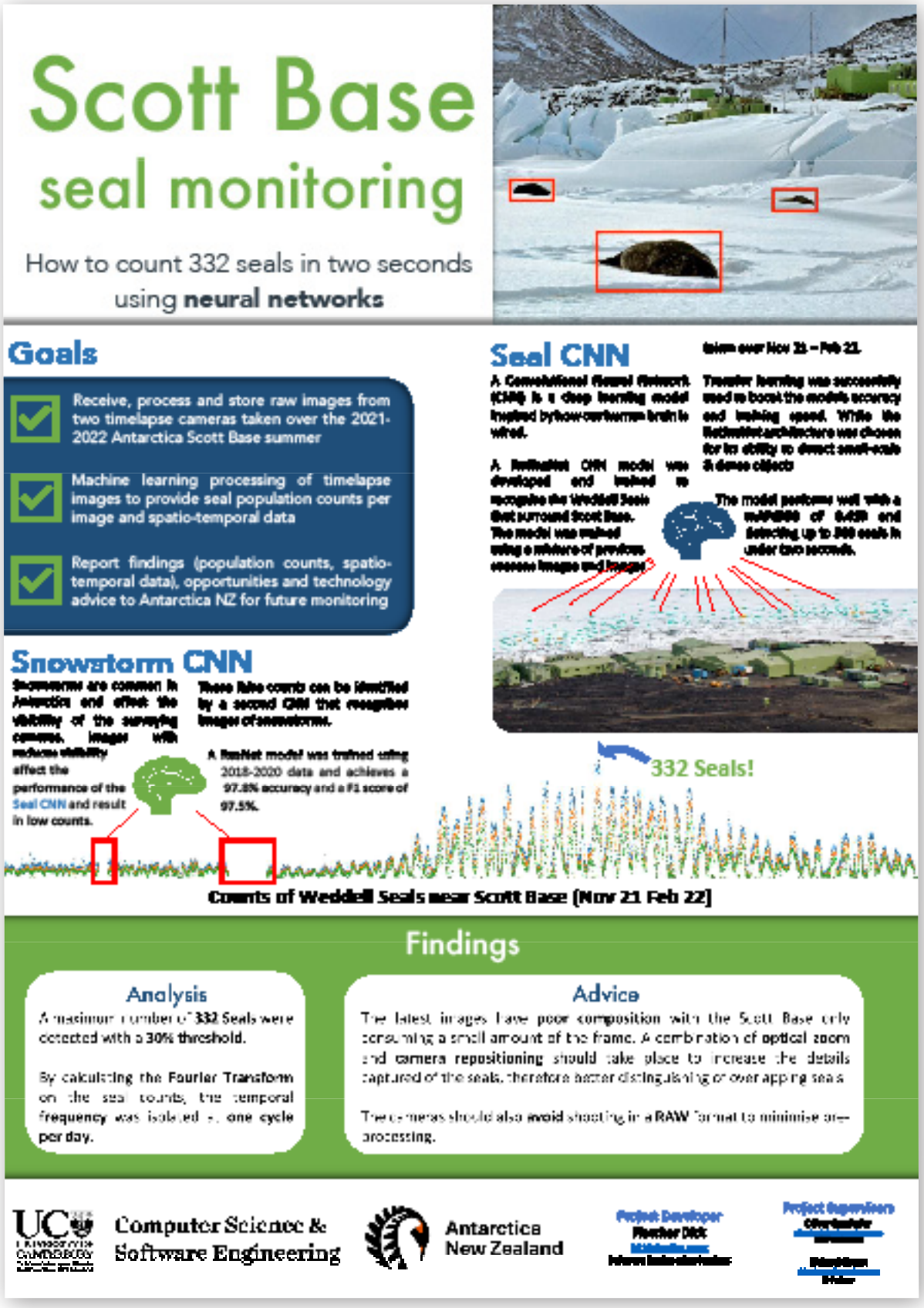

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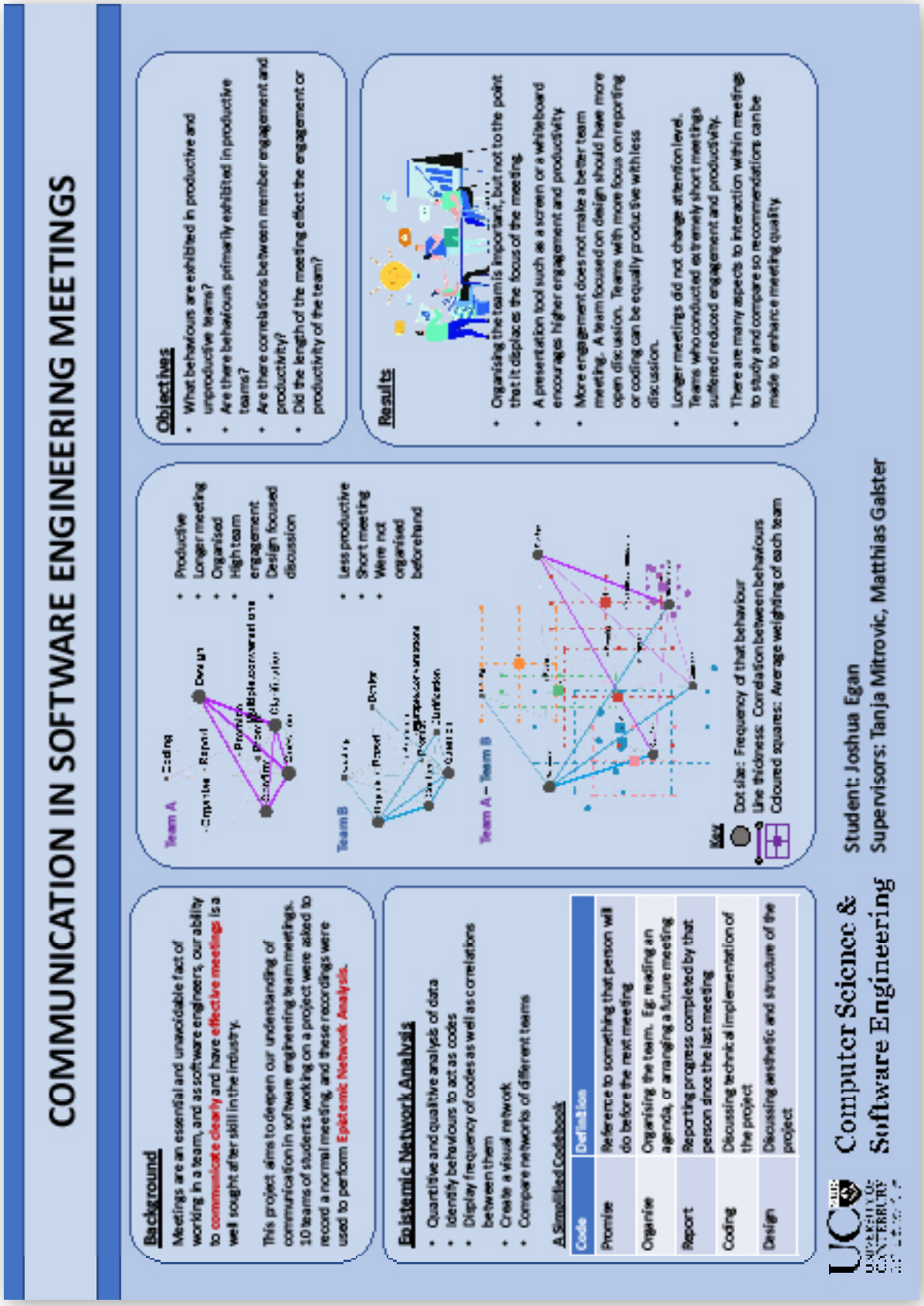


Student projects: Computer Science & Software Engineering

3D Reconstructions of Tumour Resections Using Cross Sectional Images

Computer Science & Software Engineering

Mitchell Freeman

Supervisor: Ramakrishnan Mukundan

Background

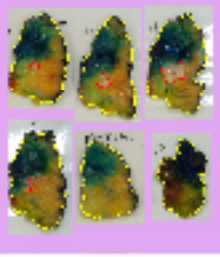
Surgical resections of tumours are traditionally stored as [illegible] glass slides for histopathological evaluation. Recently, digital images of these slides, known as digital pathology, have made it possible to obtain high resolution whole slide images (WSIs) of tissue specimens. 3D reconstructions of these specimens can then be created which will provide pathologists and surgeons with valuable information such as extents of surgical margins in different directions useful for diagnosis and treatment. This project aims to develop and evaluate methods for [illegible] 3D tumour resections from images of breast conserving surgery specimens.

Objectives

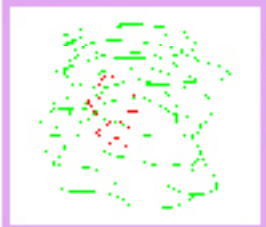
The main objective of this project is to develop a method for constructing and rendering a three-dimensional mesh surface representing a tumour resection using only a few images of cross-sectional slices. To this several different methods of spline interpolation were considered. The first was Catmull-Rom splines. This provides a simple method for constructing a curve that passes through all the points in a set. Because of the nature of the spline, the Cardinal spline provides a tension parameter to alter the resulting spline. This spline has control points that control how wide the curve is near the control points. Another method is Kochanek-Bartels splines, which provide three parameters, tension, continuity, and bias. Tension is equivalent to a Cardinal spline's control [illegible]. Bias controls how much the curve goes through the control points. And continuity controls how smooth the spline is.

Process

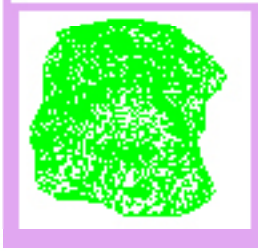
Initially 3D reconstructions were made using gyrified data so that cells could be viewed for more correspondence and to compare and evaluate the different types of splines. Then [illegible] was found that Kochanek-Bartels splines were most useful for creating 3D reconstructions from sparse data. Once this was done real world data was used.



Cross sectional images [illegible] are annotated by pathologists outlining the sections of interest. The tumour and non-cancerous tissue.



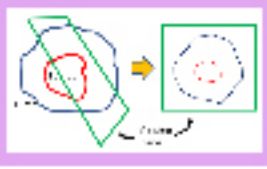
The annotated whole slide images are converted into a [illegible] binary image process and are stacked on top of each other.



The stacked layers are connected together using Kochanek-Bartel splines [illegible] Depth Complexity [illegible].

Ongoing Work

The resulting 3D reconstructions are currently being presented to a pathologist for review and subjective evaluation to determine accuracy. Additionally, a method for creating the cross-sectional slices for reconstruction using a rotating plane is being developed. This will allow pathologists to visualize surgical margins from any angle.



Future Work

[illegible] multiple areas that can be worked on to extend or improve the methods. Currently, pathologists need to manually annotate the whole slide images. This process would improve by being able to automatically [illegible] regions of interest with [illegible] tumour cells. Another improvement would be supporting multiple nested regions of interest. When looking at whole slide images of breast tumour samples, the regions of [illegible] tumour and the distance [illegible] tumour. This can be [illegible] in different directions. As likely more regions would be required. To do this, the method would need to correlate contours between layers, likely using a pairwise distance measure.

UNDERWATER BLUE LIGHT (BIFI) COMMS FOR UNDERWATER DRONES

Background

- Autonomous Underwater Drones are in development at the University of Canterbury as part of the MBIE SFTI Precision Farming Technology for Aquaculture project.
- A communication protocol is being developed to allow the drones to send video data back to an operator on the surface.
- An existing protocol (BiFi) uses blue LEDs to transmit/receive data underwater.

Objectives

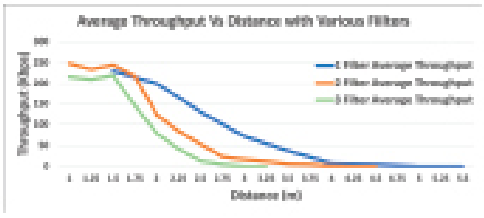
- Make the delivery of the video data more robust by extending the existing BiFi protocol to implement medium access control and link layer protocols to support standard error discovery and repair.
- Test the protocol at a range of distance and levels of interference to determine its performance in regards to packet loss and throughput

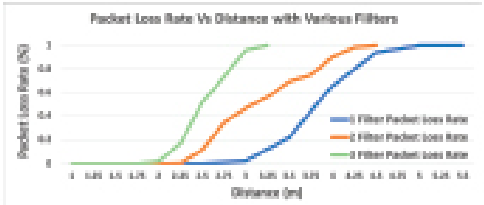
Solution

- The proposed solution uses a combination of the Selective Repeat ARQ protocol and ALOHA protocol to increase robustness to errors.
- Selective Repeat ARQ introduces retransmissions for packets that were damaged or lost in transmission increasing reliability as data is less likely to be truly lost.
- The ALOHA protocol introduces a short random backoff after failed transmissions which decreases the chances of a subsequent transmission also failing.

Results

- The protocol was tested above water as the equipment is not waterproof. Paper filters were used in place of water to simulate turbidity (the scattering of light in water).
- Tests were performed with 1, 2, and 3 paper filters to simulate various levels of turbidity, with more filters representing murkier water.
- The below graphs show the performance of the protocol in terms of average throughput (how much data is delivered per second) and packet loss rate (packets lost even after a number of retransmissions)





Student: James Harris
Supervisor: Andreas Willig
Special Thanks: Kelvin Bonnedale

Deep Learning for Retinal Image Quality Assurance

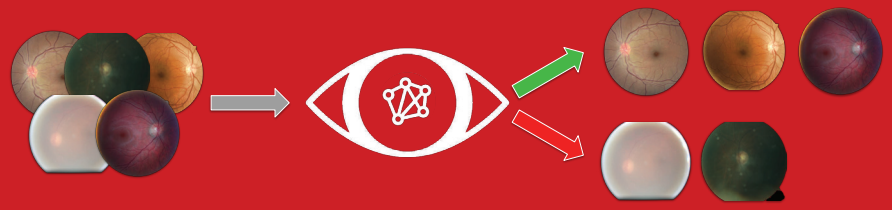
We created two convolutional neural network assess the quality of retina images

Convolutional network architecture:
- VGG16
  - Trained from scratch & transfer learning
  - Batch size 16/8
- EfficientNetB4
  - Transfer learning
  - Batch size 8

Platform:
- Web app:
- Android (apk):

Dataset:
- Training: Private dataset from collaboration between University of Otago and Canterbury District Health Board
- Testing: DRIMDB

Deep Learning for Retinal Image Quality Assurance



Deep neural network can provide **real-time result** for retinal image quality assessment.

There are **no useful dataset** for the neural network to learn, so we **created** a labelling platform

Take a **picture** to **view** the **full paper**

Result:

VGG16 Large:

	precision	recall	f1-score	support
0	0.98	0.93	0.95	1786
1	0.93	0.97	0.95	1583
accuracy			0.95	3369
macro avg	0.95	0.95	0.95	3369
weighted avg	0.95	0.95	0.95	3396

VGG16 small:

	precision	recall	f1-score	support
0	0.93	0.52	0.67	1786
1	0.64	0.96	0..77	1583
accuracy			0.73	3369
macro avg	0.79	0.74	0.72	3369
weighted avg	0.8	0.73	0.72	3396

EfficientNetB4:

	precision	recall	f1-score	support
0	0.98	0.65	0.78	1786
1	0.72	0.99	0.83	1583
accuracy			0.81	3369
macro avg	0.85	0.82	0.81	3369
weighted avg	0.86	0.81	0.81	3396

Author: Nathan Huynh
Supervisor: Andrew Bainbridge-Smith

Canterbury District Health Board Te Poari Hauora ō Waitaha
University of Otago Te Whare Wānanga o Otāgo New Zealand
UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand
Computer Science & Software Engineering

Recording Design Decision in Slack

Student: Zachary Kaye Supervisor: Dr Fabian Gilson

1 Problem

In agile software development, design decisions are often poorly documented or not documented at all.

2 Solution

Messages sent by developers in Slack can contain valuable rationale and design decisions. Therefore, the current solution is a Slack bot that records design decisions. The Slack bot prototype:

- stores recorded design decisions in a MariaDB database
- allows searching and editing of decisions
- outputs recorded decisions to a linked GitLab Wiki
- can be used in multiple Slack workspaces
- classifies design decisions based on the WH(Y) model

3 Evaluation

Preliminary findings from a user study include:

- The accuracy of the classifications made by the bot can be improved using the recorded design decisions from the user study as a training set.
- It is somewhat easy to record and search decisions. However, it is more difficult to manually classify design decisions.
- The presence of the Slack bot may encourage users to document more design decisions, with recorded decisions being of high quality i.e. they provide sufficient context and details.

UCC University College Cork
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Tech Stack

Learn More

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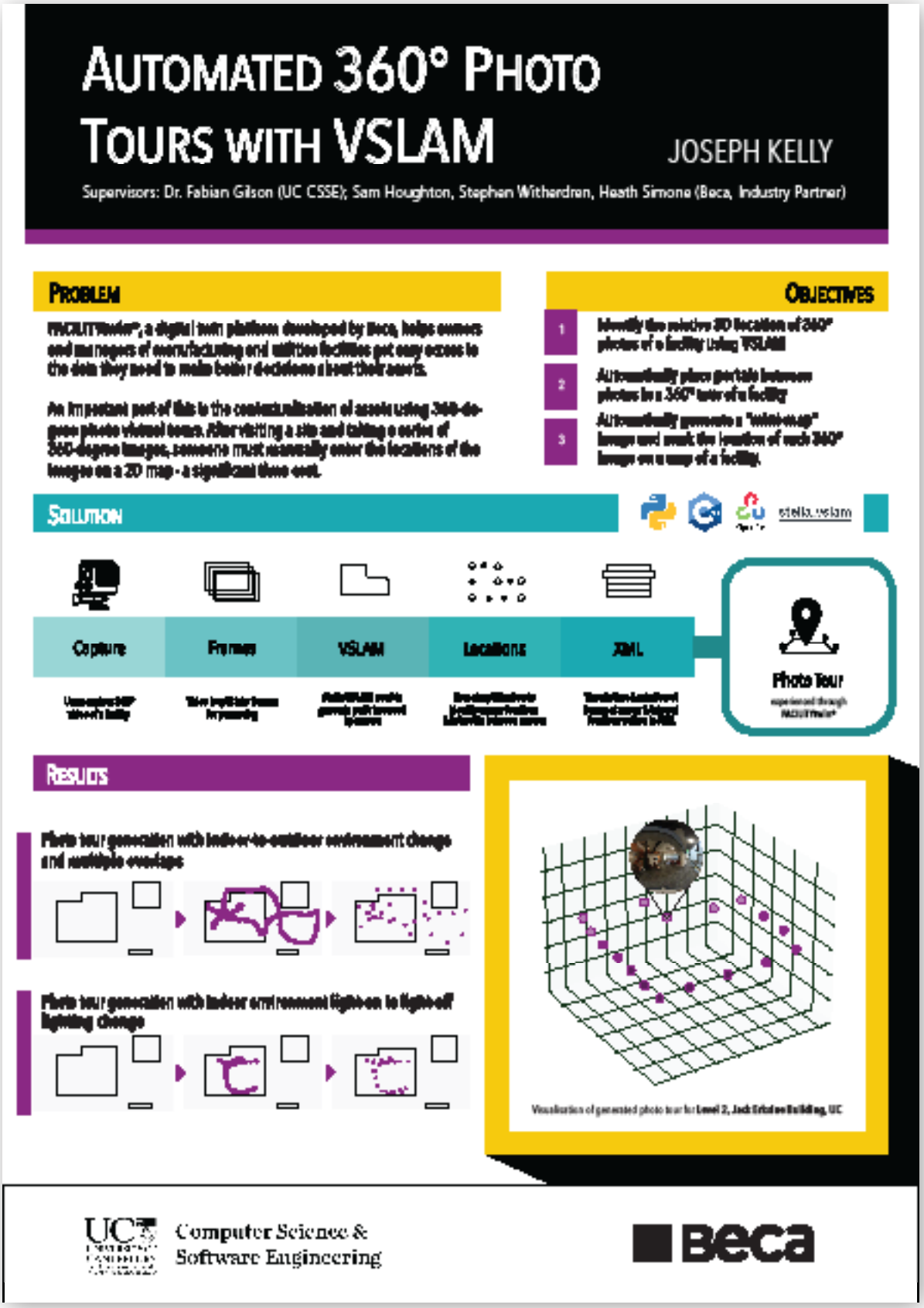

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GAMIFIED SCRUM RETROSPECTIVES

BACKGROUND

Gamification in education aims to enhance student performance by utilizing game mechanics and elements in learning activities.

Scrum retrospectives are used in software projects to reflect on work completed and make improvements for future work.

This study aims to assess the viability of a collaborative gamified retrospective tool in software development education.

OBJECTIVES

Identify suitable game elements that foster motivation and engagement in a collaborative environment.

Design and implement a scrum retrospective game using the previously identified game elements.

Evaluate the game in an educational context by trialling with undergraduate software engineering students.

APPLICATION

Individuals earn points for submitting answers to questions.

Team members collaborate to categorize their answers.

Individuals points are combined to give a team score to compete with other teams on the leaderboard

RESULTS

Scores, awards, avatars, leaderboards and progress bars are the most common game elements used in gamification.

Teams, collective scoring and inter-team competition stand out as key elements that promote collaboration.

CONCLUSION

Gamification can provide a more engaging and motivating environment than traditional learning.

Promoting collaboration is most effectively achieved through elements such as team play, collective scoring and inter team competition.

UC University of Canterbury Te Whare Wānanga o Waitaha

Computer Science & Software Engineering

Student
Seth Kingsbury

Supervisor
Miguel Morales

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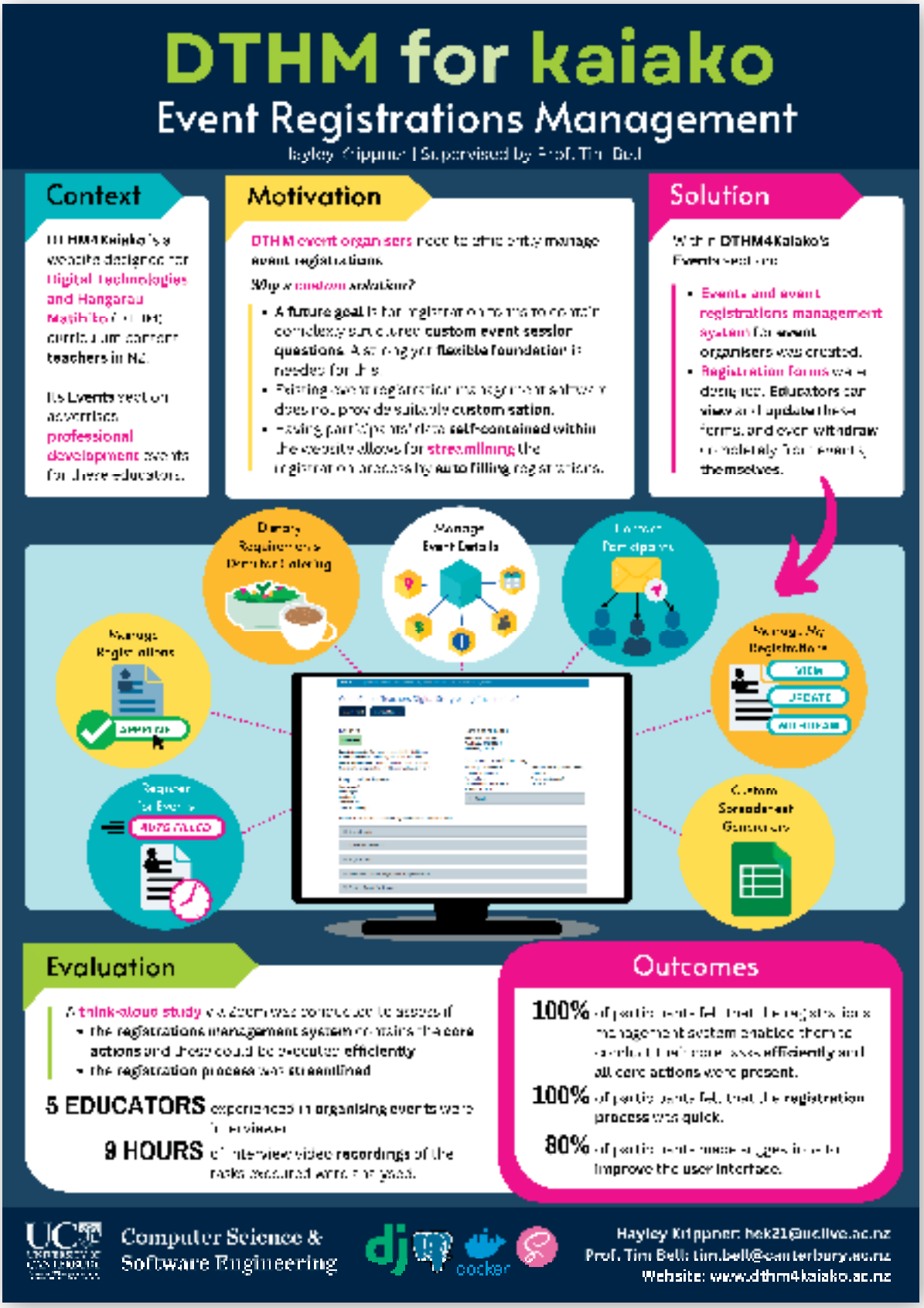

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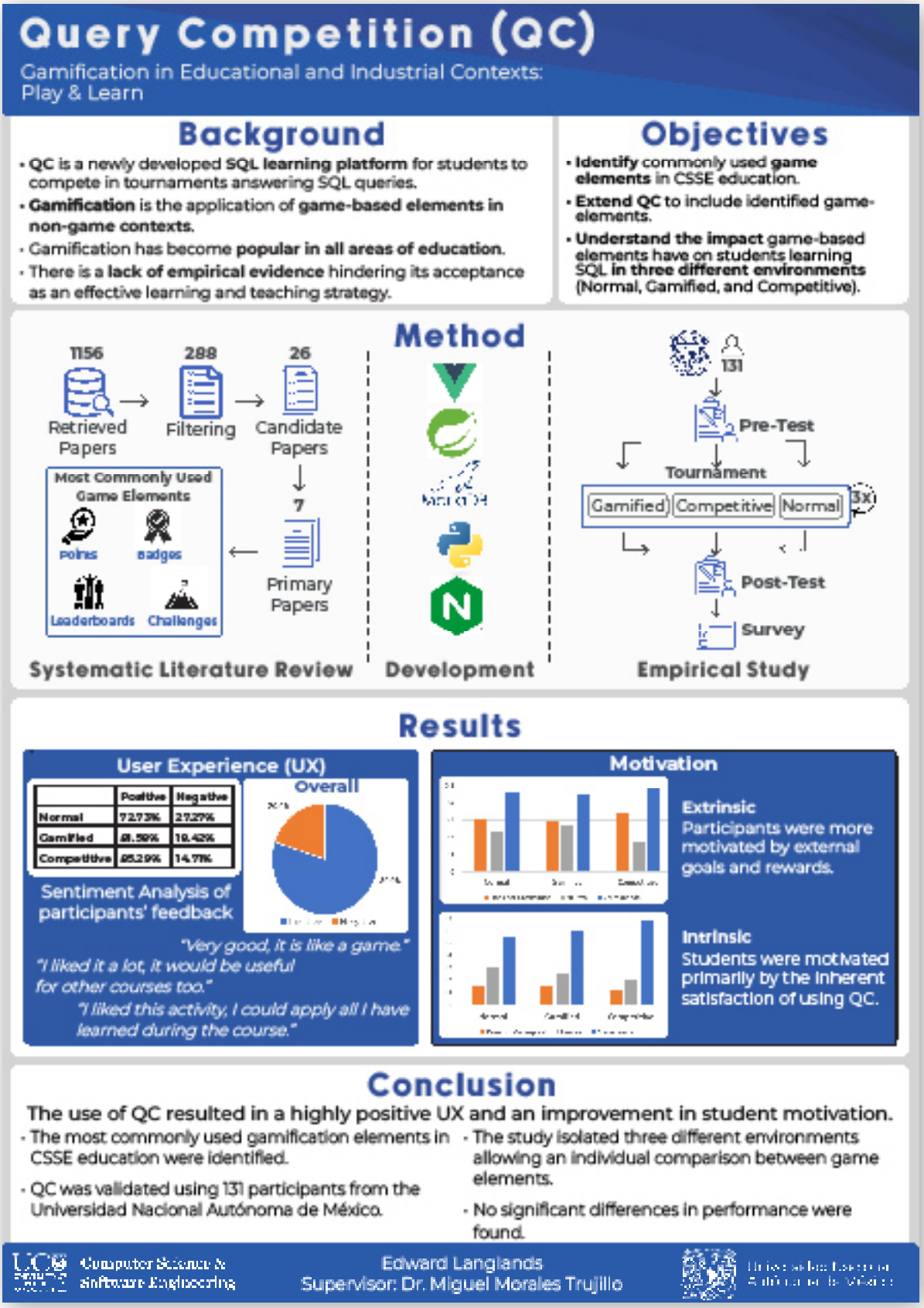

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QUESTION TRACKING SYSTEM FOR MOODLE

Computer Science & Software Engineering

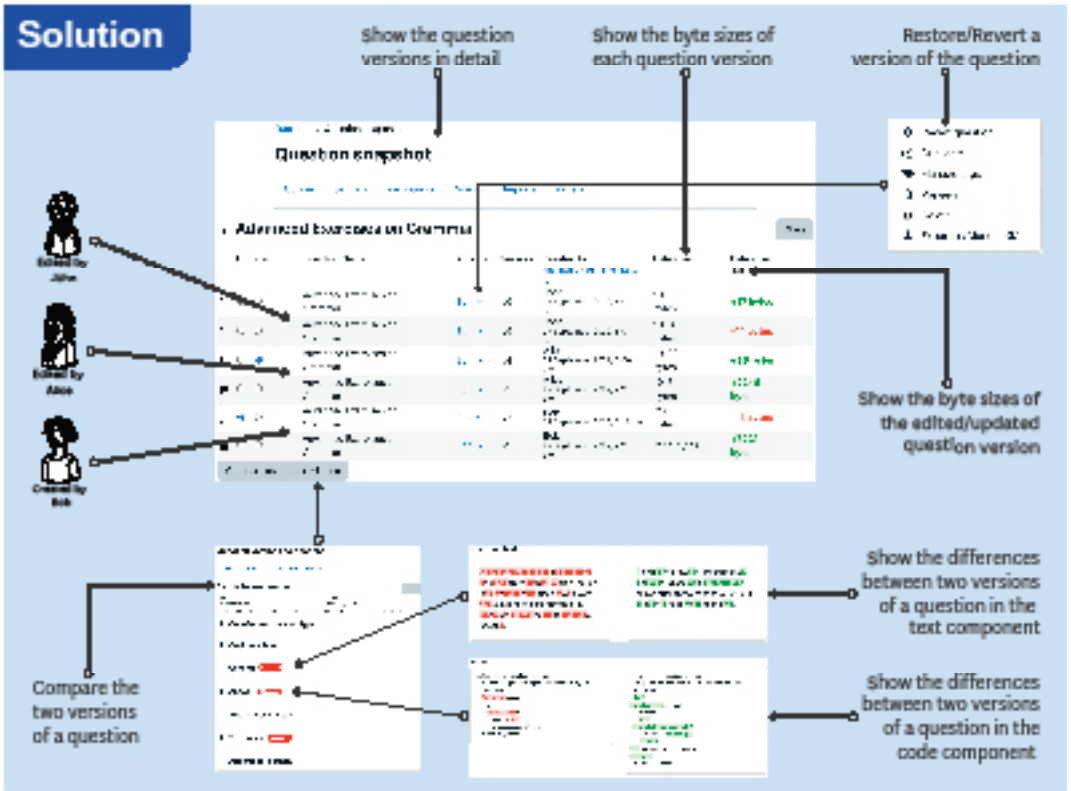
Motivation

- **Moodle** is a web-based learning content **management system**, used at the University of Canterbury. It has a **question bank system** where teachers can **create and edit questions**. However, the existing question bank system does not have the ability to **trace question history**, which results in confusion sometimes, especially when **tracking historical changes** of the question.

Objective

- Teachers can track all **historical versions** of a question.
- Teachers can **restore/revert** a version of a question.
- Teachers can **compare two versions** of a question.

Solution



Result

- The following data is from 6 lectures/tutors' evaluations:
  - **66.7%** of the users think this Question tracking system is **very useful.**
  - **33.3%** of the users think this Question tracking system is **sometimes useful.**
  - The **most popular** feature is **"Compare two versions of a question".**

Future Work

- A further step would be to enhance the feature that allows the user to compare two versions of a question. First, comparisons for a wider range of questions can be provided. Next, the algorithms for text comparison can be refined to improve their accuracy.

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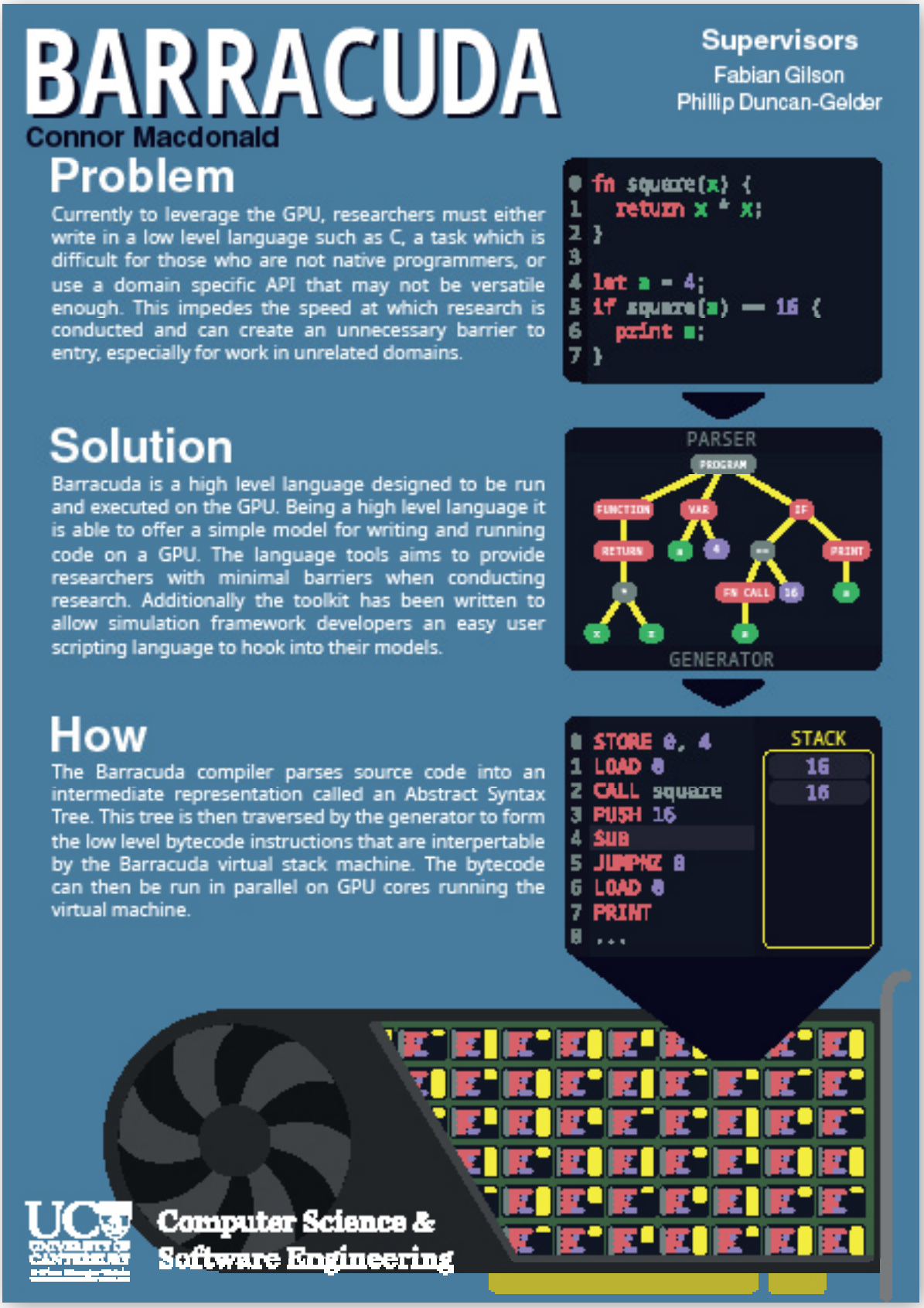
Tech Stack


BARRACUDA
Connor Macdonald
Supervisors
Fabian Gilson
Phillip Duncan-Gelder
Problem
Currently to leverage the GPU, researchers must either write in a low level language such as C, a task which is difficult for those who are not native programmers, or use a domain specific API that may not be versatile enough. This impedes the speed at which research is conducted and can create an unnecessary barrier to entry, especially for work in unrelated domains.
fn square(x) {
return x * x;
}
let a = 4;
if square(a) == 16 {
print a;
}
Solution
Barracuda is a high level language designed to be run and executed on the GPU. Being a high level language it is able to offer a simple model for writing and running code on a GPU. The language tools aims to provide researchers with minimal barriers when conducting research. Additionally the toolkit has been written to allow simulation framework developers an easy user scripting language to hook into their models.
PARSER
PROGRAM
FUNCTION
VAR
IF
RETURN
PRINT
FN CALL
16
GENERATOR
How
The Barracuda compiler parses source code into an intermediate representation called an Abstract Syntax Tree. This tree is then traversed by the generator to form the low level bytecode instructions that are interpertable by the Barracuda virtual stack machine. The bytecode can then be run in parallel on GPU cores running the virtual machine.
STORE 0, 4
LOAD 0
CALL square
PUSH 16
SUB
JUMPNZ 0
LOAD 0
PRINT
...
STACK
16
16
Computer Science &
Software Engineering

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ENVIRONMENTAL DATA VISUALISATION TOOL

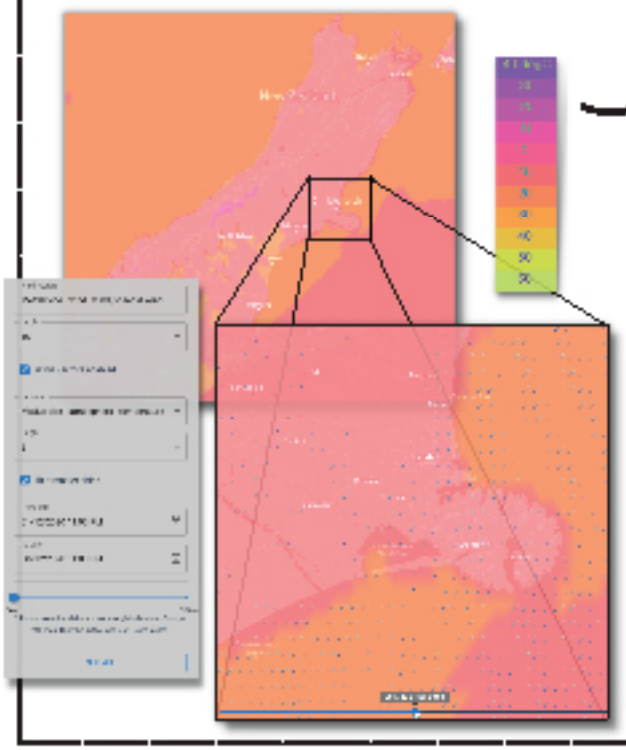
MOTIVATION

- We live in a **data rich world**, where often, access is **technical**.
- With open access comes more **innovation**.
- Currently no **simple** way for general users to **visualise** Envlibs wealth of data.

xarray | www.envlib.org | tethysts.readthedocs.io

OBJECTIVES

- A **correct and accurate** visualisation of data provided by Envlib.
- A **filter system** for accessing different times, heights and locations to look at particular weather events.
- Access to **alternative / multiple datasets** provided by Envlib.



SOLUTION

- Custom API layer that **preprocesses data** from Envlib (tethysts), enabling customised outputs better suited to geographic representation across time.
- A **traversable map** through all dimensions. Lat, Lon, Height, and Time.
- Multiple **visualisation** methods. A heatmap for most data and a wind speed / direction vector layer for wind data.
- Multiple **available datasets** for visualisation.
- All of these to bridge the gab between complex data and simplicity through visualisation.

FUTURE

- Additional datasets.
- Host online for all to access.
- Additional layers for visualisation.
- Rework filter system for more clarity.
- Additional computed parameters like a fire weather index.

mapbox

UC Computer Science & Software Engineering

STUDENT
Darcy Maddren

SUPERVISORS
Assoc. Ben Adams, Marwan Katurji, Jaiwei Zhang

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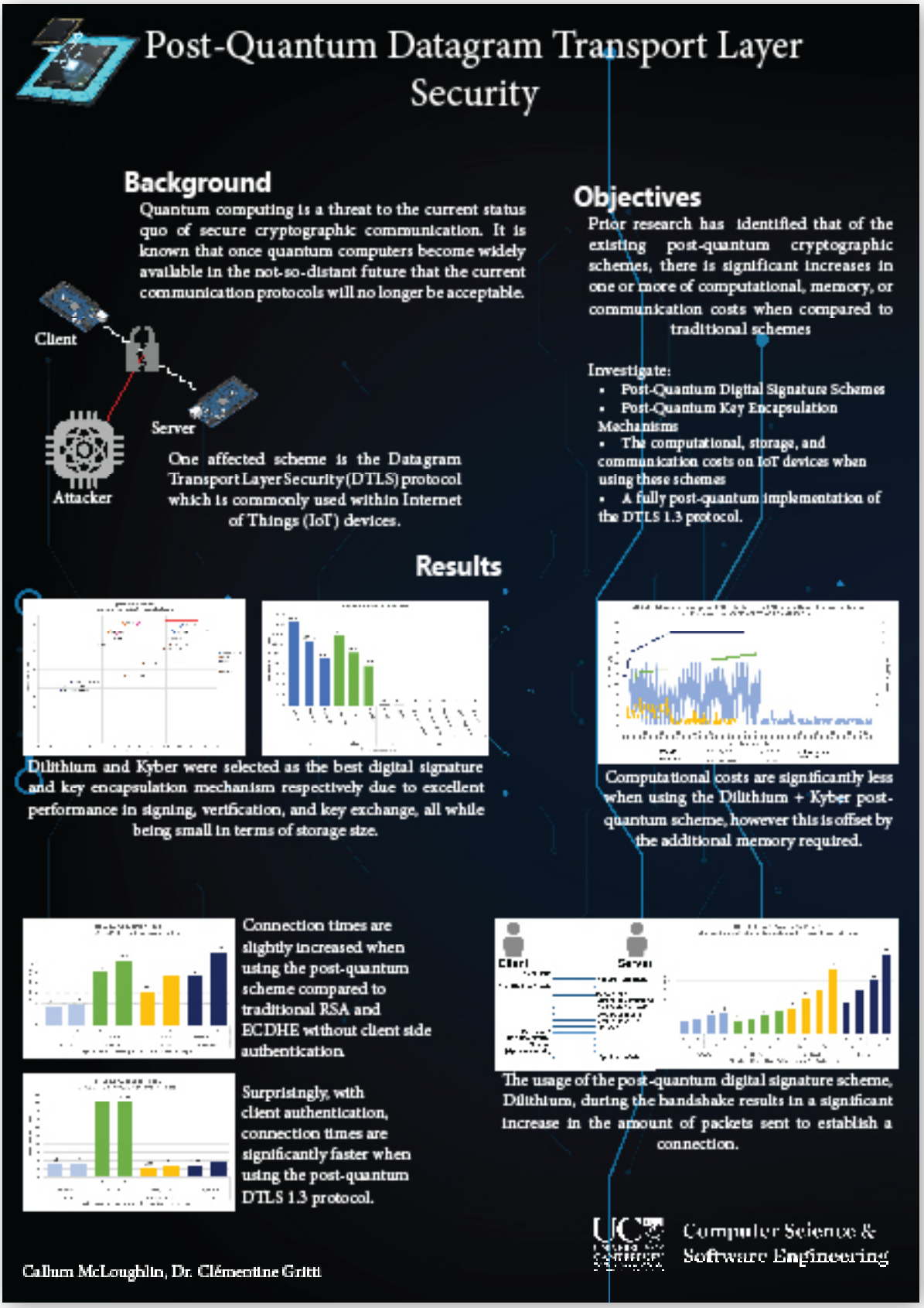

Software Quality Tools in the Wild

Michael Morgoun
Supervised by
Miguel Morales

Context

Software quality is a **crucial** factor in the development of software. It can impact not only the **functional** use of software but also the **satisfaction** of its users and the **longevity** it has as a product.

The usage of tools is one of many ways of measuring/improving software quality and yet there is a **lack** of **empirical** research done on software quality tools in the **industry**.

Research Questions

RQ1 - What are the most popular software quality tools in the industry?

RQ2 - How do software practitioners define software quality?

RQ3 - What metrics do software practitioners use to measure/assess the quality of what they're developing?

Method

Interviews

Semi-structured interviews would give qualitative answers which would provide a deeper insight into the perspective of the interviewee.
Interviews were to target experienced software practitioners working in the industry with at least a few years of experience.

Survey

Instead of qualitative answers, surveys would give mostly quantitative answers.
Surveys were to target any software practitioner that had any experience in the industry.

Results

Most Known Tool/Framework

According to the survey, the most known tool was **Postman**, 2nd was a tie between **Cucumber** and **Selenium** followed by **Cypress**.

Most Used Tool/Framework

The most used tools was found to be a tie between **Cypress** and **Postman** in 1st place, 2nd was **Apache JMeter** and third was another tie between **Selenium** and **SoapUI**

Testing-related tools/frameworks were found to be the most common genre of tools being used. This is opposed to other genres such as management. The interviews showed that almost all participants used **Jira** and yet the surveys didn't express the same popularity.

"It definitely is a quality tool. It's not something that I would traditionally have associated with it, but it's part of that whole development workflow" - Interviewee

Software Quality Attribute Word Cloud

All of those interviewed were asked for the most important software quality attribute through the perspective of a **developer**, a **company executive** and a **user**. It was found that overall the perceived most important software attribute was both **maintainability** and **reliability**.

"I've worked in this codebase for probably five years and for me it's really important that it's a nice place to work because I live in this code base every day." - Interviewee

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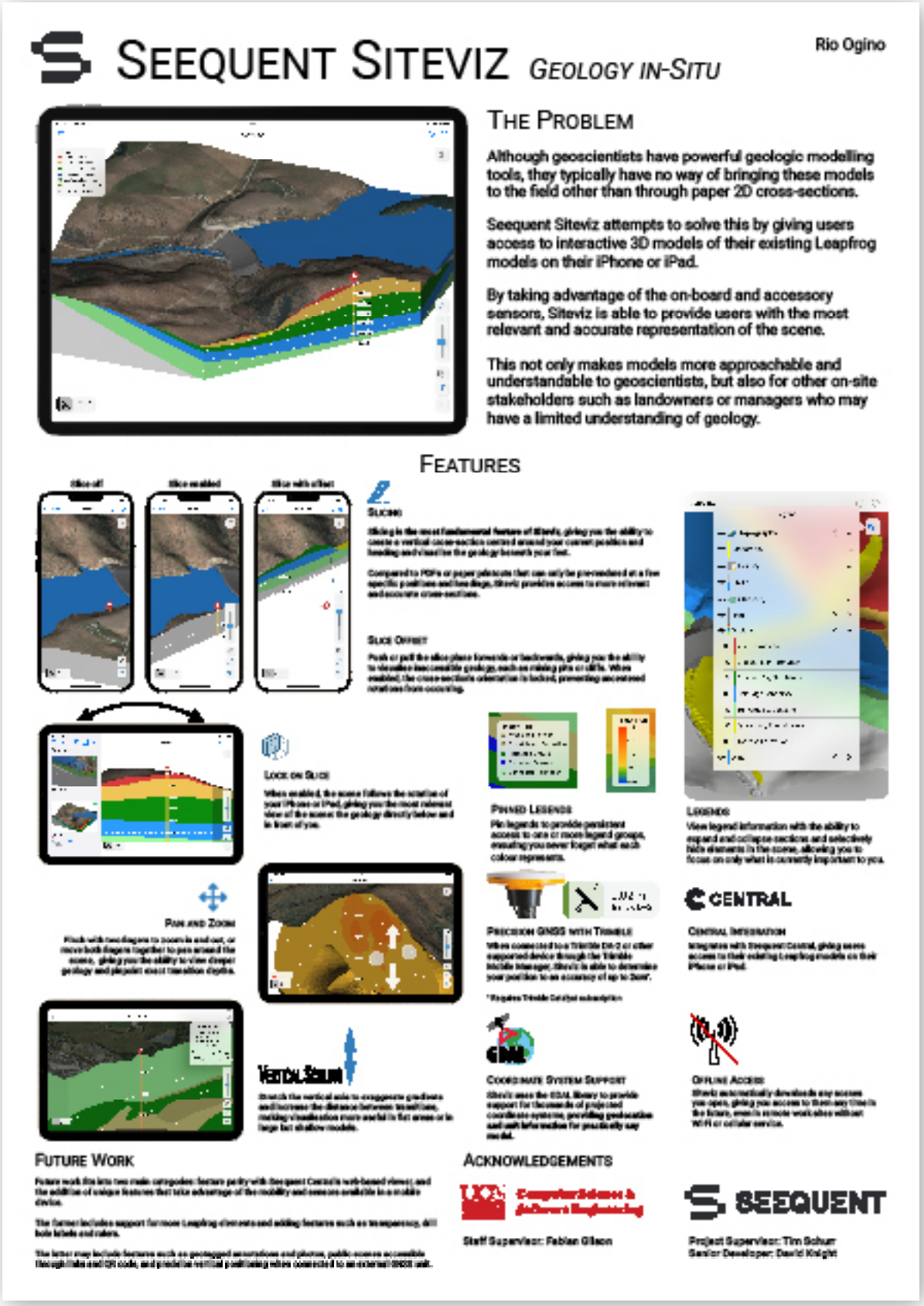

SEEQUENT SITEVIZ *GEOLOGY IN-SITU*

Rio Ogino

THE PROBLEM

Although geoscientists have powerful geologic modelling tools, they typically have no way of bringing these models to the field other than through paper 2D cross-sections.

Seequent Siteviz attempts to solve this by giving users access to interactive 3D models of their existing Leapfrog models on their iPhone or iPad.

By taking advantage of the on-board and accessory sensors, Siteviz is able to provide users with the most relevant and accurate representation of the scene.

This not only makes models more approachable and understandable to geoscientists, but also for other on-site stakeholders such as landowners or managers who may have a limited understanding of geology.

FEATURES

SLICING

SLICE OFFSET

LOCK ON SLICE

PAN AND ZOOM

VERTICAL SCALE

PINNED LEGENDS

LEGENDS

PRECISION GNSS WITH TRIMBLE

CENTRAL INTEGRATION

COORDINATE SYSTEM SUPPORT

OFFLINE ACCESS

FUTURE WORK

ACKNOWLEDGEMENTS

Staff Supervisor: Fabian Gilson

Project Supervisor: Tim Schurr
Senior Developer: David Knight


DIFFERENTIAL PRIVACY TOOLS FOR SMART CONTRACTS
MOTIVATION
There does not exist a way to securely and anonymously view differentially private summary statistics for data stored in Smart Contracts on a blockchain.
Current differential privacy solutions exist for Smart Contracts on Ethereum, which has a public ledger.
The Secret Network provides a way for encrypted on-chain data to be decrypted and operated on without being revealed to validators and the public.
OBJECTIVES
Implement differential privacy algorithms for Smart Contracts on the Secret Network.
Build a frontend web application so users can view differentially private summary statistics for data stored in Secret Contracts.
SMART CONTRACTS
DIFFERENTIAL PRIVACY
FINAL SOLUTION
Model and Backend
The Substrate fixed Rust library was used to represent real numbers as fixed-point numbers. These were converted to strings and stored as bytes.
An entropy pool of bytes was used to build a secure random number generator.
The Laplace Mechanism produces a noisy number.
Functions were created to get the differentially private mean and count for data stored in the Smart Contract.
Web Application
A frontend web application was created. Users can view differentially private count and mean statistics, for data stored in the Secret Contract.
Users connect their Keplr wallet so they can interact with the application.
Users can input data into the Secret Contract using this application.
Computer Science & Software Engineering
STUDENT
KYE OLDHAM
SUPERVISOR
BEN ADAMS
TECH STACK

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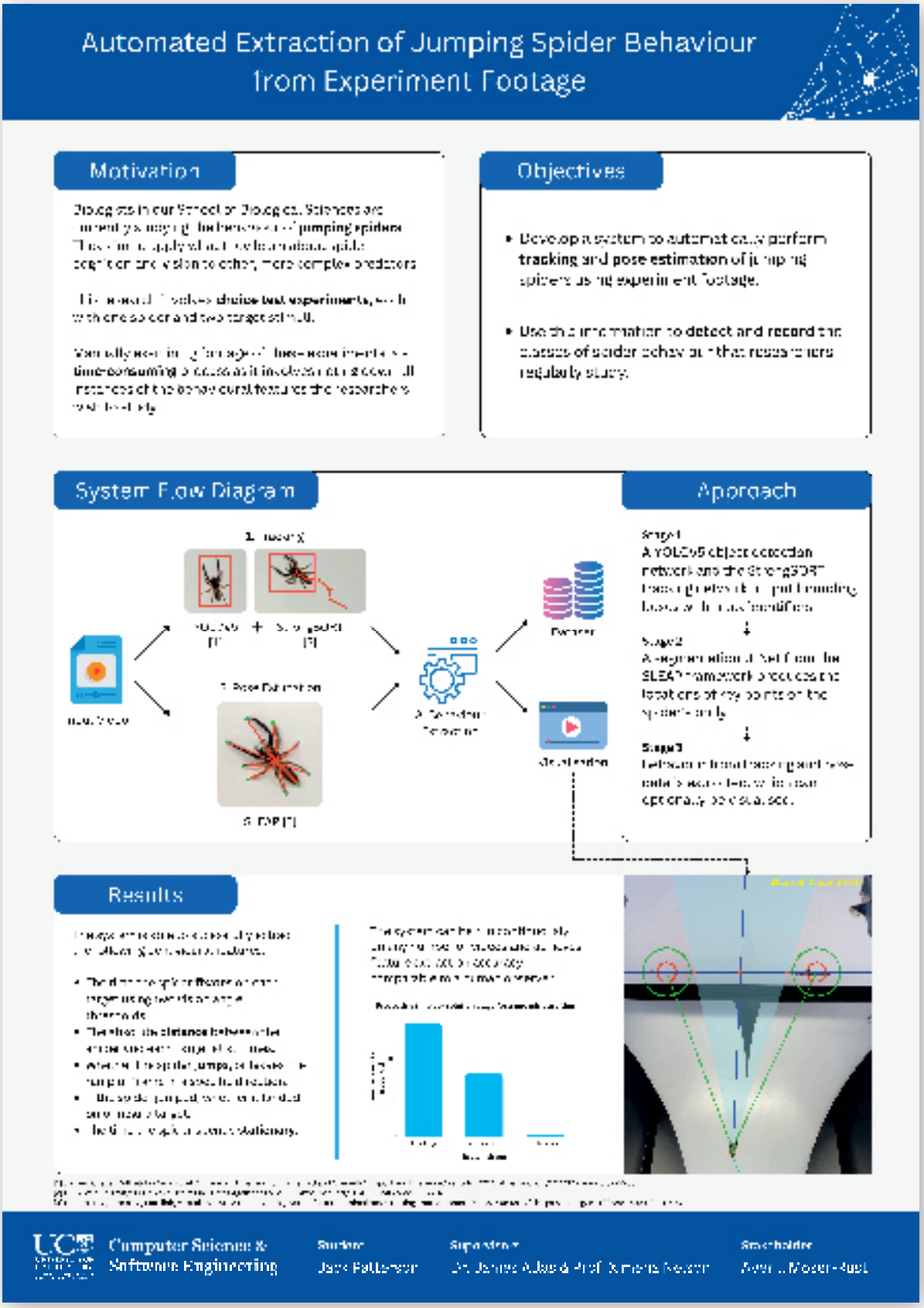

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ARCHITECTURE & SAFETY FRAMEWORK FOR UAV FORMATIONS

Background

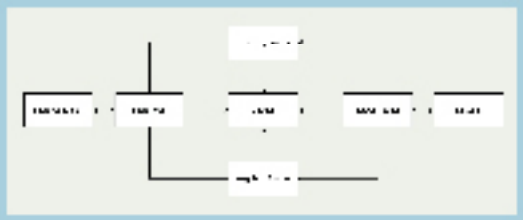
Objectives

Design

Architecture

Logging

Collision Avoidance



Computer Science & Software Engineering

CameraX

Next Generation of Field Capture

Background

- Trimble supplies instruments that are equipped with high-end camera, IMU sensor and GPS antenna for photogrammetry.
- The technologies provide great customer experience, but new simplified workflow could be explored.
- Trimble believes this technology can provide new customer value unexplored by the market until now.

Objectives

- Automate the image capturing process for photogrammetry.
- Automate the data gathering process for photogrammetry.
- Allow users to control the camera parameters to adjust the image quality.
- Make the image capturing process user-friendly.

Solution

As the solution, an android application has been developed. This application has a user friendly User Interface which allows the user to capture high quality images with device location and orientation tagging in the background.

Camera
Auto Capture. Focus. ISO. Shutter Speed. Metering.

Location
Longitude. Latitude. Altitude. Accuracy.

Orientation
Yaw. Pitch. Roll.

Resulting Point Cloud

Result

Response from 4 Trimble employees who tested the app :

- App felt easy to use
- Easy to understand UI, not much setup needed.
- Straight forward to use, camera feed is smooth and clear.
- Cool app, super easy to use and functional.
- Simple UI, no lengthy set up process.
- Makes gathering images easy.
- Room for improvement to make the UI more intuitive.

UC Computer Science & Software Engineering

Nitish Singh Supervised by Fabian Gilson

Industry Sponsor: Trimble
Product Owners: Stuart Ralston, Guillaume Clin

Trimble

DRONE CATKIN HARVESTING

Eric Song supervised by Sam Schofield and Prof. Richard Green

How to harvest from 20m tall trees? Drones! (And some software)

P. Radiata pines form catkins harvested for pollen. But manual harvesting is slow, and can't reach most of the catkins on adult pines.

Could we use unmanned drones to harvest catkins from any pine, no matter how tall?

P. Radiata Catkins

DJI Matrice 300 RTK

OBJECTIVES

Detect and track multiple catkins reliably in real-time (15fps)

Guide pruning drone to catkins*

Use only onboard Intel NUC computer + D435 depth camera

*Without crashing the drone, pruning off anyone's fingers etc.

METHOD

1. DETECT

Efficient YOLOv5-nano neural network.

Trained with 210 training and 70 validation images: 3,887 catkins total.

Custom augmentation reduces false positives by superimposing objects:

2. TRACK

KLT tracker matches corner points (green) to track while moving.

Perspective transform calculated each frame with RANSAC to remove outliers (red).

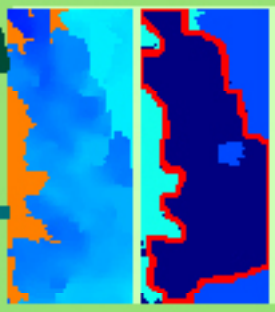
YOLOv5 detections matched with tracker predictions.

3. LOCALISE

Remove background from depth image for 'true' depth of catkin.

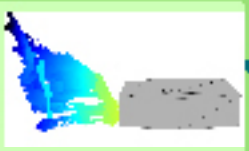
Meanshift algorithm clusters depth image. Novel optimization with prefix sum + binary search.

Remove small and concave regions from clustering.



4. GUIDE

Straight-line path to catkin, check pointcloud to avoid collisions



RESULTS

82% of catkins detected

mAP of 0.87 - misses small or dark catkins

Accurate to 1.2mm

1.2mm RMSD within 1200mm distance. Significant camera error past 1200mm. All detections successfully tracked at 1m/s

Single catkins pruned

Thick needles hinder sustained cutting reliability

FUTURE WORK

Detect optimal cut point to avoid needles

Improve performance in dark conditions

More powerful hardware e.g. Nvidia Jetson with higher resolutions

Tree detection or GPS to approach P. Radiata from long distances

UC Computer Science & Software Engineering

Student projects: Computer Science & Software Engineering

Networking Protocol for Autonomous UAV Formations

Mike Talmud, Caleb Sim, Nicholas Varley, Simon Wallace Blakely, Jiang Xiao Guo

1. Context:

UAVs are highly mobile tools that are rapidly gaining popularity in situations where the environment is dangerous or difficult to gain access to. Drone formations provide an even greater functionality in these areas due to the greater area of control provided. There are many applications where this is useful such as search and rescue operations, wildlife surveillance and insect tracking.

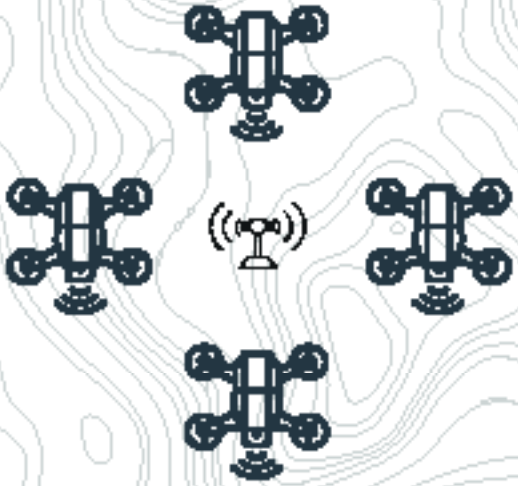
A method of communication with the drone formation is required to control the drones autonomously.

2. Objectives:

The communication method needs to supply all drones with the target location set by the user. The method must also ensure the drones know each others position to avoid collisions. These objectives need to be met with a certain level of quality, especially the position updates.

Issues to overcome:

- **Information Loss:** The formation needs to be able to continue operation when information doesn't get received by a particular drone or ensure all drones get the information needed.
- **Latency:** The drone needs to be updated quickly to ensure safety information gets distributed within a reasonable timeframe.



3. Solution:

The drones are connected to a network hosted on a drones companion computer. The network protocol sends minimally sized packets to minimise packet loss due to collisions.

The solution is separated into a master and slave processes. The master process is designed to be operated by a human at this stage and transports locations to the formation. The slave processes are further seperated into three parts; a receiver process, transmitter process and neighbour table.

The transmitter process is tasked with sending packets to the rest of the formation. The packets are broadcast periodically to minimise the impact of missing one packet. The neighbour table is tasked with saving information received such as the neighbouring drones GPS position, this information is then used to prevent collisions. The receiver is tasked with receiving packets and separating the different packet types to send to their respective locations.

Command Packet:

Drone Id	Command

Periodic Update Packet:

Drone Id	Seq. No	Lati-tude	Longi-tude	Alti-tude

4. Outcome:

Three drones flying in formation using proposed networking method. The drones executed a square flight path supplied by the master process with no manual human control necessary.

Project supervised by Dr-Ing Andreas Willig and Graeme Woodward with help from Sam Pell

UC UNIVERSITY OF CANTERBURY

Computer Science & Software Engineering

3D MODEL FOR A DIGITAL-TWIN OF A PLANT

Inga Tokarenko, Supervisor: Richard Green

INTRODUCTION

Only **3% of the world's water is fresh water** and of that, **70% is used for agriculture.** Currently 2.7 billion people struggle to find enough clean drinking water. Better water management in agriculture could help alleviate the fresh water shortfall.

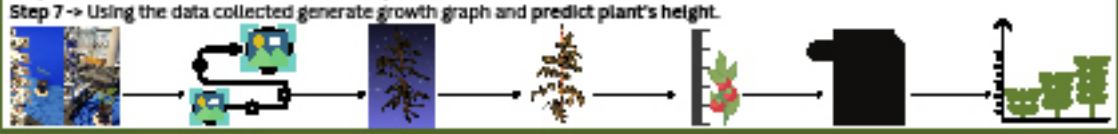
The goal of this project is to begin a solution that **minimises the current impact of the agricultural industry.** This project aims to create a digital-twin of a tomato plant in the form of a 3D model and measure and predict the plant's height. The solution's goal is to create a perfect growing environment for a plant to minimise water usage.

OBJECTIVES

1. **Generating a 3D Point Cloud**
   Construct the first step of the 3D model of the tomato plant using a 3D point cloud. This step requires processing of the images in order to construct a 3D point cloud from those images.
2. **Generating a 3D Model**
   Take the constructed 3D point cloud from Objective 1 and construct a 3D model of the tomato plant.
3. **Measure and Predict Plant's Growth**
   Analyse the plant and determine its height based on the 3D model or image processing. Once the height is determined predict future potential growth.

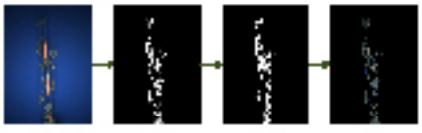
METHOD

Step 1 -> Collect the data using a robot with 6 cameras attached to it and a turn table with the plant on top of it.
Step 2 -> Process the images by creating a **mask** and then apply the mask onto each image to **remove the background.**
Step 3 -> Generate **3D point cloud** using **Metashape API.**
Step 4 -> Generate **3D model** using **NumPy** and **Open3D.**
Step 5 -> Measure the height of the plant using the 3D model.
Step 6 -> Save all the data collected on the plant onto the CSV database.
Step 7 -> Using the data collected generate growth graph and **predict plant's height.**

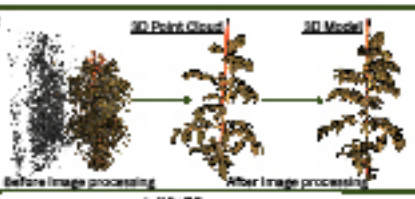


RESULTS

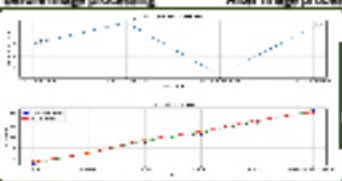
- **Image processing** was conducted by creating and applying image masks.
- The **masks** were originally made by **removing any non-green pixels.**
- The **masks** were then **refined** by taking an average colour within a circle based on a radius.



- Image processing allowed to create a **noise reduced 3D point cloud.**
- Using Metashape API with a **Multiplane Layout** allowed to create a 3D point cloud using more than one camera.
- **3D model** is created using the 3D point cloud.



- Due to limitations of the 3D reconstruction, the plant's **height was measured by the image's pixel count.**
- The **prediction** was based on the collected data by taking an average from previous heights.



Note: The dates used in the graphs were fabricated

LIMITATIONS

- Due to time restrictions the full life cycle of the plant was not able to be captured.
- The methodology did not preserve the scale of the plant in the 3D reconstruction, so absolute measurements were taken from the original images.
- Sensor resolution was not sufficient to capture the plants smallest features.

FUTURE RESEARCH

- Determine the health of the plant using attributes of the 3D model, pH, moisture, temperature sensors.
- Determine a pathway to measure the plant's height using the 3D mesh.
- Create a UI that will allow to view plant's health attributes and growth.

Student projects: Computer Science & Software Engineering

Post-quantum MQTT Protocol

Background

MQTT is a communication protocol used in the Internet of Things. It is often used in conjunction with private data such as cameras and sensors so cyber-security breaches could be significant.

Current methods for providing digital authentication (verifying who you are communicating with) rely on algorithms which can be broken by quantum computers. Thus when quantum computers become widely available, current security methods will no longer be secure.

Objectives

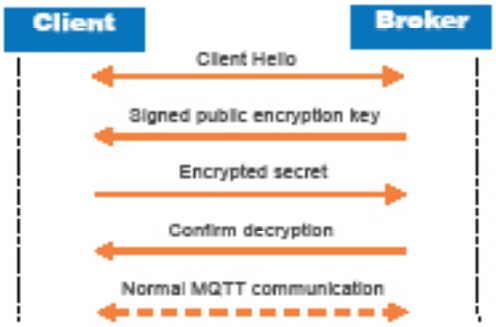
1. Find methods and algorithms to add quantum-safe authentication to MQTT between the client and broker.
2. Compare potential methods for adding quantum-safe authentication in terms of:
   - Memory used
   - Bandwidth required
   - Computation time

Solutions

1 Signature-based Scheme

The first authentication method is to implement a signature based scheme. Digital signatures work just similar to real life: someone signs a message, and anyone else can verify it was that person's signature.

The handshake between the client and broker is as follows (simplified):



2 KEM-based Scheme

The second option is to use key encapsulation mechanisms (KEM) to authenticate. This involves encrypting a secret which only one person can decrypt, so you know it must be them if they can decrypt it.

The handshake between the client and broker is as follows (simplified):

Results

Algorithms

Based on NIST research[1] *on quantum-safe algorithms:*

CRYSTALS-Dilithium[2] is a suitable signature algorithm.

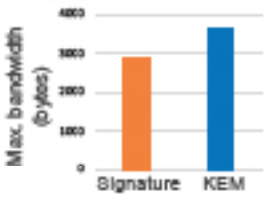
CRYSTALS-KYBER[3] is a suitable KEM algorithm.

Memory

+ 1184 Bytes

Both signature and KEM based schemes require an extra 1184 bytes for the client.

Bandwidth



Time

The KEM based scheme is **7% faster** to complete authentication on average.

1. https://doi.org/10.6028/NIST.IR.8413-upd1 2. https://doi.org/10.13154/tches.v2018.i1.238-268 3. https://doi.org/10.1109/EuroSP.2018.00032

UC Canterbury | Computer Science & Software Engineering

Student
Raven Townsend

Supervisor
Clementine Gritti

Vineyard Visualisation

1. Objectives

- Train a deep learning AI model to detect grape vine plants.
- Build a system to identify individual plants using images.
- Web interface to join the detection and identification systems to retrieve historical data about an individual plant.

Using deep learning AI and image comparison techniques to detect and identify individual grape vine plants.

4. Results

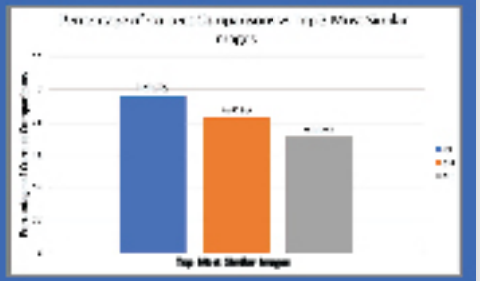
- Tests were completed using image scans collected by UC Vision. Detected grape vine plant images were masked and grouped per individual plant.
- All images were compared against all other images, the top three most similar images were recorded
- The graph below shows the percentage of images where the plant was correctly identified. The percentage of the top three most similar images are shown.

2. Background

- UC Vision currently has no easy way to retrieve historical data about individual image scanned grapevine plants.
- The historical data can be used to see growth patterns, disease outbreaks, and plant health. The image scans made by UC Vision aid with analysis for vineyards.
- The current solution requires intimate knowledge of the codebase, unintuitive design requiring exact knowledge of the row and plant, and can only be accessed by members of UC Vision.
- The solution currently in use is no longer suitable as it is not portable and does not allow vineyards to access and observe the project as it is developing.

3. Solution

- To detect grape vine plants a deep learning AI approach using Detectron2 was used. A custom model was trained using the image scans created by UC Vision. Images with different lighting, focal lengths, and angle were used to train the model to increase generalisation.
- Masks of each plant are created when detected and saved. The masked vine plant images are compared against each other using two computer vision algorithms, one to detect and compare features (ORB) and another to detect structural similarity (SSIM).
- The web interface gives remote access to the detection and identification system, allowing images to be uploaded and compared out in the field or in the office. The historical data of the most similar plant is displayed for the user.
- GPS data is used with the historical data collected to increase accuracy and decrease the number of plants compared when out in the field.



Student: Niels van Antwerpen
Supervisor: Richard Green

UC University of Canterbury Computer Science & Software Engineering

UC University of Canterbury Computer Vision

MaaraTech

Virtual Reality Interaction for Apple Thinning Training Tool

1. Motivation

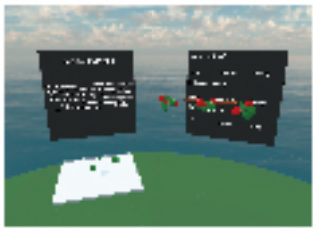
2. Technologies

3.1. Interaction 1

3.2. Interaction 2

3.3. Interaction 3

4. Trial Game



5. Results

6. Future Work

Student
Rutger van Kruiningen

Industry Supervisor
Maaratech

Academic Supervisor
Prof. Richard Green

Computer Science & Software Engineering

UC VISION

Maaratech

Student projects: Computer Science & Software Engineering

Tumour Region Segmentation in Whole Slide Images

Mitchell Veale | Supervisor: Prof. Ramakrishnan Mukundan

Background

In 2020, breast cancer was the most commonly diagnosed type of cancer, making up 11.7% of global cancer diagnoses and 6.9% of global cancer diagnoses resulting in death. An important step in the identification of breast cancer is to extract and analyse a biopsy of the affected tissue. Manual analysis of biopsies can be time consuming and can lead to issues due to the subjective evaluation that can occur from pathologist to pathologist. By converting biopsies into digital whole slide images (WSIs) using high resolution digital microscopes it is possible utilise modern image processing methods to automate analysis tasks.

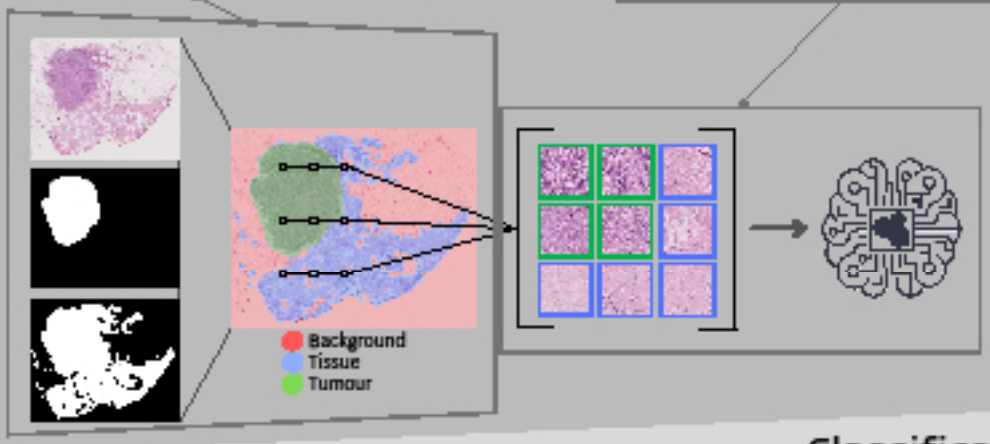
Objective

The objective of the project is to develop a machine learning algorithm to automatically identify tumour regions in whole slide images, and to validate the results against manual annotations by expert pathologists (provided by TIGER challenge [https://tiger.grand-challenge.org]).

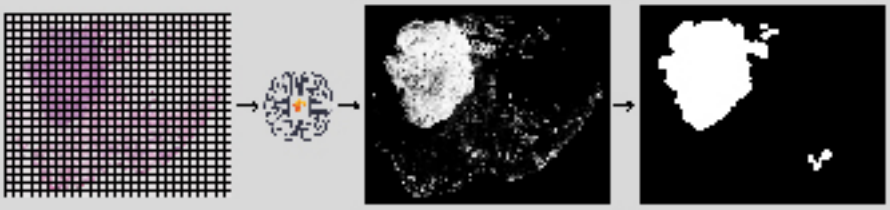
Training

An automatically generated image showing tissue regions (bottom) and a manually generated image showing tumour regions (middle) are used to classify a WSI (top)

Small image tiles (64x64) are extracted from the tissue and tumour regions of the classified WSI and fed into a Convolutional Neural Network (CNN) machine learning model with their corresponding label



Classification



When classifying a WSI the provided image is split up into tiles, where each tile is fed into the trained CNN and a tumour probability map of the image is constructed. The map is then cleaned up to only keep large contiguous regions of identified tumour tissue.

Results

The trained CNN model managed an average accuracy of over 85% when evaluated against a balanced validation dataset and an average balanced accuracy of 77% against the 93 WSIs in the available dataset.

The average processing time for all images the dataset was 21 seconds with the median time being 13 seconds*

*Performed on an Intel i7 7700HQ CPU

Metrics

Validation Accuracy	85.2%
True Positive Rate	71.2%
False Positive Rate	16.9%
Precision	83.0%
Balanced Accuracy	77.2%
F1 Score	73.2%

Future Work

Future work would involve making improvements to the machine learning model to include detailed analysis of several features of tumour microenvironment (such as stain concentration, nuclei proliferation, and tissue texture characteristics) to improve classification accuracy as well as further improvement to the accuracy of training and validation dataset labelling.

Future work would also include the development of a graphical user interface that would allow users to select whole slide images and view analysis results

Computer Science & Software Engineering

Student projects: Computer Science & Software Engineering

Measuring Cortical Health Features with Minimal User Intervention

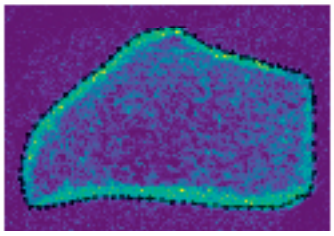
mars

Background

- Radiologists interested in cortical bone's density, thickness, and volume.
- Currently MARS manually selects regions of interest (ROIs) on an axial slice.
- Manual ROI tracing is incredibly time-consuming.

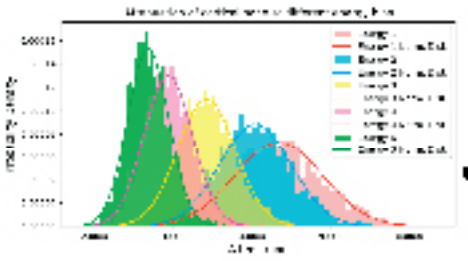
Objectives

- Increase automation of extraction of cortical bone.
- Reduce time to select ROI across multiple slices.
- Provide more accurate diagnoses of cortical health.
- Analyse multiple segmentation algorithms.



Solutions

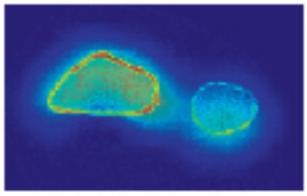
- In the initial prototype, the cortical attenuation distribution over five energy bins was used to segment axial slices.
- Gaussian distribution of cortical attenuation is used to calculate confidence intervals for each energy bin.



- Final solution used neural networks to learn and segment the cortical region in each slice.
- U-Net, U-Net++ and Attention U-Net models were used.
- Training data was made through manual segmentation.

Results/Evaluation

- Grad-CAM highlights model's predicted cortical regions of image.
- Neural Network models compared after 11 epochs of training.
- Cortical thickness used to compare automated and manual methods.



Conclusions

- Automated approach looks to be a promising replacement for MARS' current process.
- Initial prototype struggled to segment thin cortical regions.
- U-Net was the most accurate and fastest model.
- With more training data, neural networks are viable for segmenting cortical bone.

Neural Network Model Comparison

Model:	Dice Score (%):	Loss Function:	Run Time (s):
U-Net	87.0	0.00985	914
U-Net++	85.9	0.0106	2107
Attention U-Net	86.3	0.0101	1079

Manual vs Automated Measurements

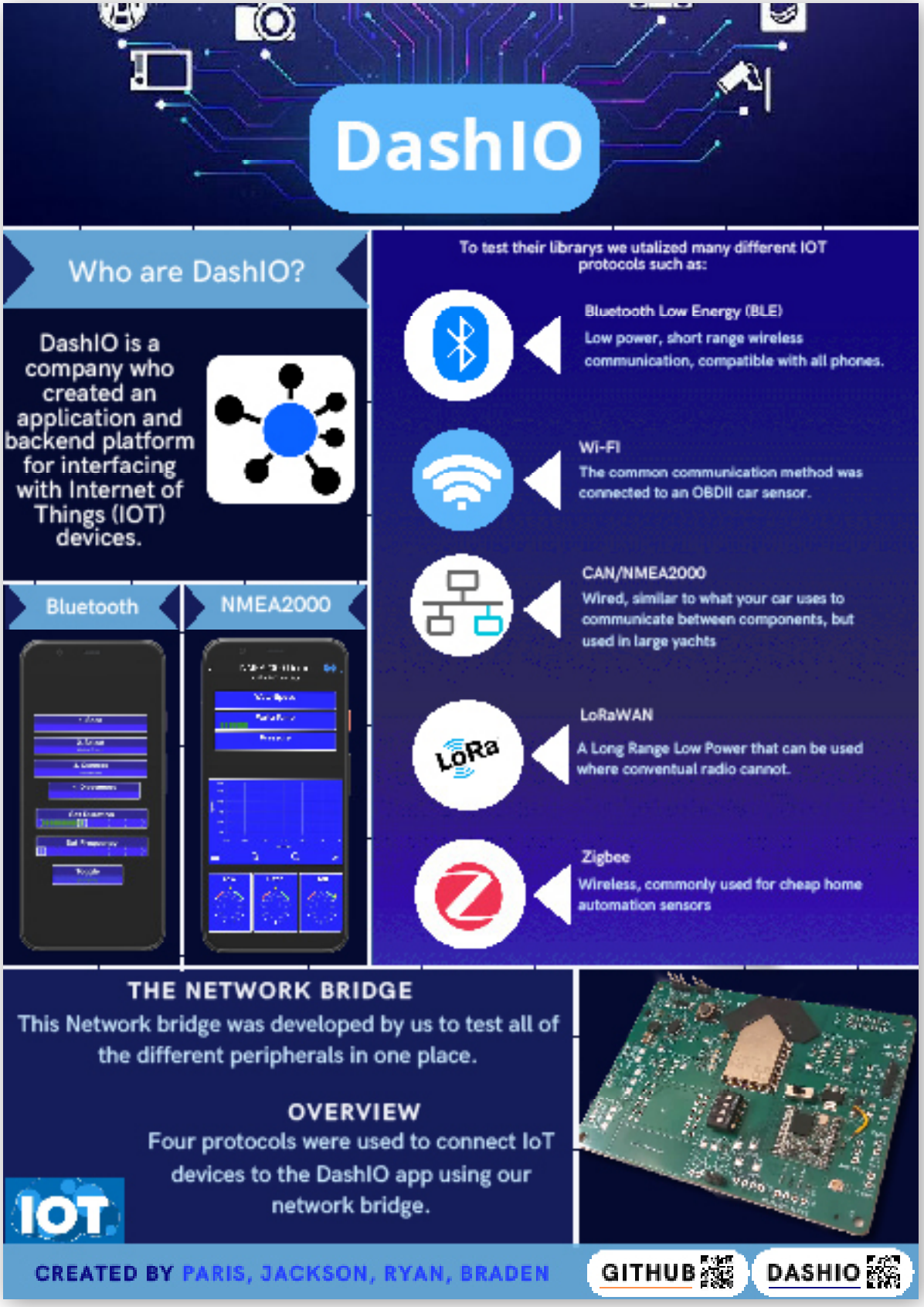
	Manual:	Automated:	Expected:
Cortical Thickness (mm)	1.06	1.07	1.02 ± 0.2

UCW Computer Science & Software Engineering

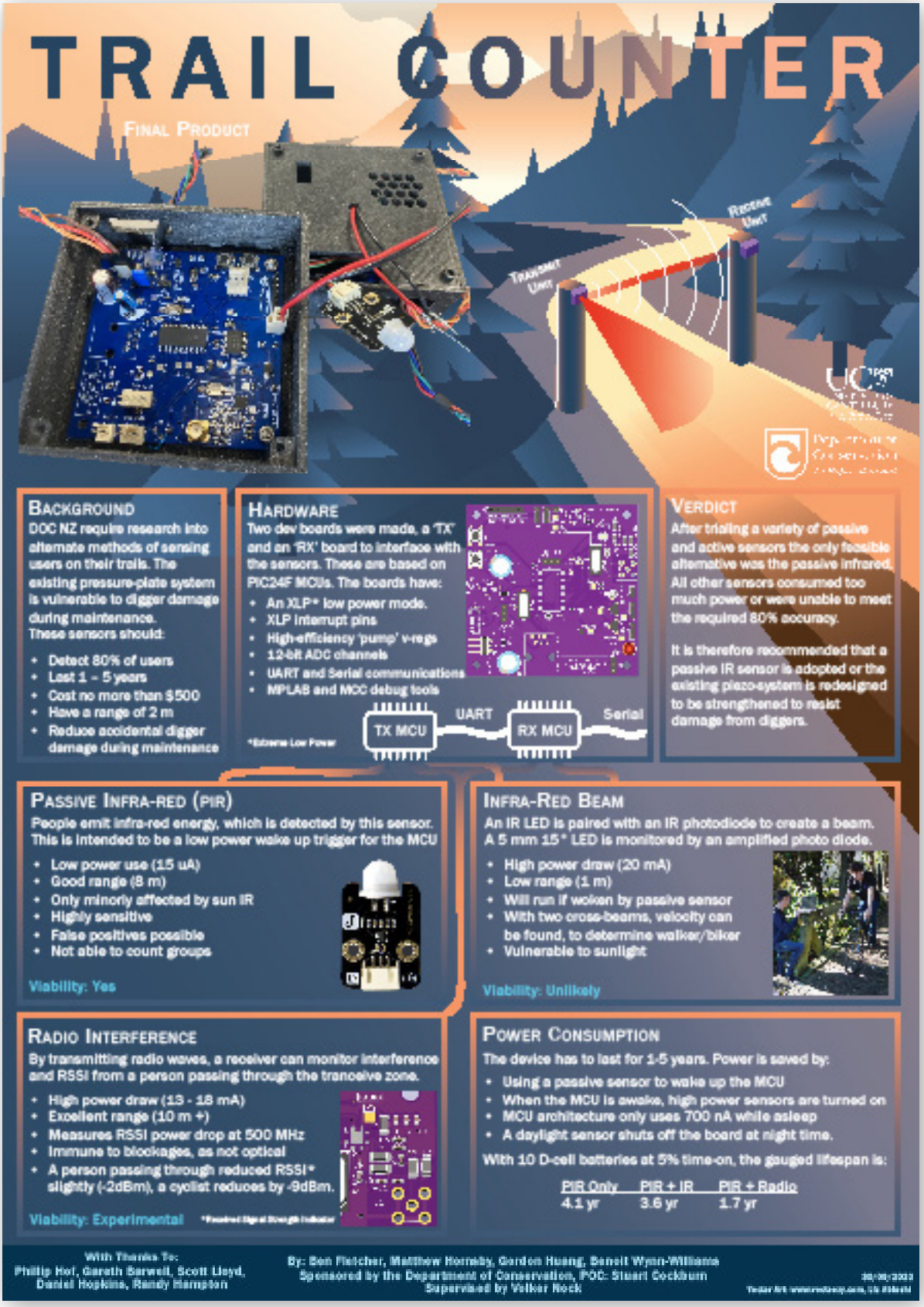
Michael Woodard
Student

James Atlas
Academic Supervisor

Mahdieh Moghiseh
Sponsor - MARS Bioimaging Ltd.


DashIO
Who are DashIO?
DashIO is a company who created an application and backend platform for interfacing with Internet of Things (IOT) devices.
Bluetooth
NMEA2000
To test their librarys we utalized many different IOT protocols such as:
Bluetooth Low Energy (BLE)
Low power, short range wireless communication, compatible with all phones.
Wi-FI
The common communication method was connected to an OBDII car sensor.
CAN/NMEA2000
Wired, similar to what your car uses to communicate between components, but used in large yachts
LoRaWAN
A Long Range Low Power that can be used where conventual radio cannot.
Zigbee
Wireless, commonly used for cheap home automation sensors
THE NETWORK BRIDGE
This Network bridge was developed by us to test all of the different peripherals in one place.
OVERVIEW
Four protocols were used to connect IoT devices to the DashIO app using our network bridge.
IOT
CREATED BY PARIS, JACKSON, RYAN, BRADEN
GITHUB
DASHIO

Student projects: Electrical Engineering and Computer Engineering



Buzzwire Wand

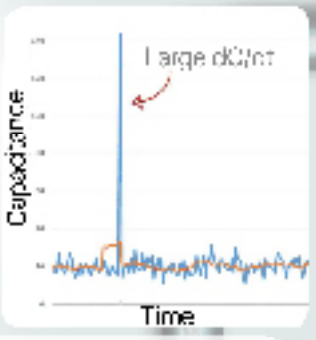
Background

- Gap Filler want to make a giant Buzzwire game.
- Buzzwire is a game where there is a hoop with a handle threaded through a wire maze.
- The goal is to get the other side of the maze without touching the wand to the maze.
- If the hoop touches the maze a buzzing sound is played.
- Gap Filler has made multiple giant buzzwire courses, several meters long and use 50mm stainless steel piping as the 'wire maze'.

Aim

Develop and prototype a wand which:

- Can detect when it's contacted the maze.
- Is light enough to be held by a child.
- Is robust enough to be left unattended outside 24/7 at Christchurch CBD.
- Is wireless.
- Is fun to use.

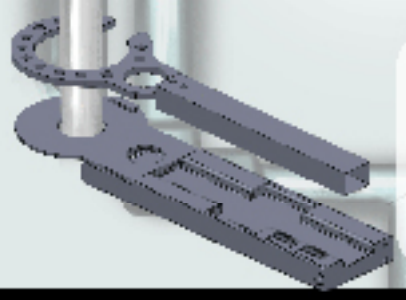


Features

- Multiple RGB LEDS for colour changing lights.
- Piezoelectric buzzer for sharp buzzing sound.
- Powerful vibration motor for notable vibrotactile feedback.

Detection

- The wand detects contact using a capacitive sensor.
- When the wand touches the maze there is a large change in capacitance [dC/dt].
- The large dC/dt triggers various lights, sounds, and vibrations for the 'buzz'.
- The wand automatically re-calibrates itself to work in different environments.
- Works reliably even when wet.



Power

- There is a charging station at each end of the maze.
- Placing the wand on the charging stand gives the time taken and number of times the user got 'buzzed'.
- Induction coils wirelessly charge the lithium-ion battery.
- Temperature and charge sensors regulate the charge to the battery, making it safe to leave unattended.

Buzzwire team:
Josh Tait
Sam Heustice
Kyle Wrangham
Cory Pilkam

GAP FILLER

UC UNIVERSITY OF CANTERBURY

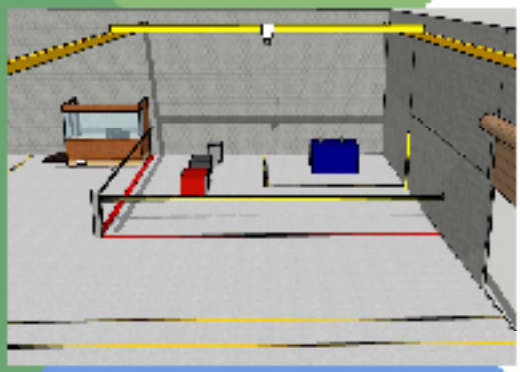
High Voltage Testing Facility Upgrade

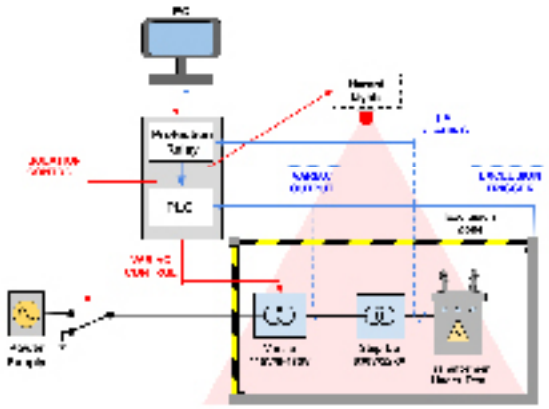
Background

A reliable supply of electricity is important for New Zealand's health and economy. Ventia test high voltage transformers to maintain the reliability of New Zealand's electricity network. Ventia's test facility in Palmerston North uses dated analogue control equipment to perform these vital tests. It is important to upgrade the facility so Ventia can continue to test transformers safely and accurately.

Project Goal

Upgrade the control, protection and safety systems of the high voltage transformer testing facility. Use digital electronics to maintain existing functionality and include automation of testing tasks. Combine upgraded systems with existing test equipment in an appropriate layout.





Protection Design

Keep circuit conditions within test equipment ratings using:

- SEL351 Protection relay
- Metal Oxide Varistor (MOV) surge protection devices.

Safety Design

Keep personnel in the facility safe during and in between tests using:

- Laser sensor and belt barrier exclusion zone.
- Hazard Lighting and sound
- Earthing contactor
- Earthing sticks

Control Design

Control test equipment to perform tests and monitor test measurements using:

- Allen Bradley Programmable Logic Controller (PLC).
- Computer for human interface

Sponsor: Ventia - Tyrel Bishop
Supervisor: Shayne Crimp
Thanks: Allan Diaz, Paul Agger, John Morris, Andrew Lapthorn
Project team: Arno Knight, Jack McDonald, Mac Karalus, Zac Jensen

Student projects: Electrical Engineering and Computer Engineering

NEPALESE PICO-HYDRO

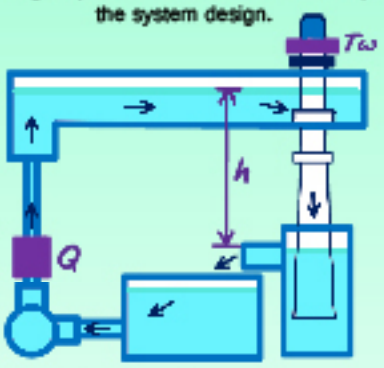
E08 – ENEL400 FYP

This is an ongoing project working to generate 1.5 kW of renewable hydropower for a Nepalese mountain village. This project is sponsored by Meridian Energy and aligns with its commitment to clean energy for a fairer, healthier world.

Power is generated using a reaction turbine that utilises power from both the velocity of the water and the pressure head of the system. This scheme uses a Kaplan turbine, which is suited to high flow rates and low heads, and is capable of very high efficiencies.

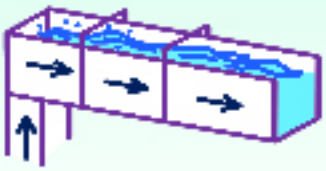
Mechanical Optimisation

A test rig has been developed over the last 3 years to simulate flow conditions. This is for gathering empirical data to evaluate and improve the system design.



Flow Conditioning

Flow conditioning was implemented along the flume for a more laminar flow for testing.



Real and Reactive Power Control

Suitable operating conditions must be maintained for the generator and the users will require steady voltage and frequency, despite the variable input power. This was implemented with a resistive dump load and single phase STATCOMs.

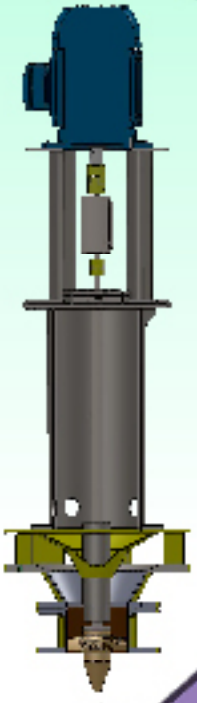
Load Simulation

For testing purposes, a Chroma regenerative grid simulator was used to provide the reactive power for the generator, and to simulate the village electrical load. This stabilises the system for mechanical efficiency evaluation.

Sensing and Efficiency

An ultrasonic flowmeter and a rotary torque transducer were used to gather the data needed to evaluate the mechanical efficiency of the turbine.

$$\eta_{turbine} = \frac{shaft\ power}{power\ available\ in\ the\ water} = \frac{T\omega}{\rho g Q h}$$



Turbomachinery and Support Structure

The support structure was designed to maintain very accurate concentricity. This is necessary to avoid cavitation effects around the blades from too much clearance, whilst also avoiding interference issues. A new design was manufactured, aligned, assembled and installed this year.

Preliminary Results

A range of Kaplan blade turbine angles have been tested, and the current efficiency is ~80% which is already an increase from the ~30-60% that was achieved last year.

The next project team will try to get this to 90%, then the implementation design can begin.

Team: Gussy Collet, Chloe Nicholson, Lydia Smith, Campbell Stevens, William Thomas
Supervisor: Andrew Lapthorn

Technicians: Ken Smart, Paul Agger, Edsel Villa, Nigel Pink, Tony Doyle
Meridian Sponsors: Rowan Sinton, Prakash Gautam

Meridian

UC UNIVERSITY OF CANTERBURY

KIWICARE

Multi-kill predator control system

Rats, possums, and other invasive predators cause huge damage to our taonga species. The Department of Conservation operates hundreds of thousands of traps and spend millions of dollars operating and maintaining them. By reducing the upkeep required for maintaining effective pest control, the goal of making New Zealand predator free is brought closer to reality.

Project Goals :

- Multi-kill, long life pest and predator control system.
- Similar weight, size, and cost to existing trap systems (e.g. DOC200 spring trap).
- Safe for user to carry and maintain.

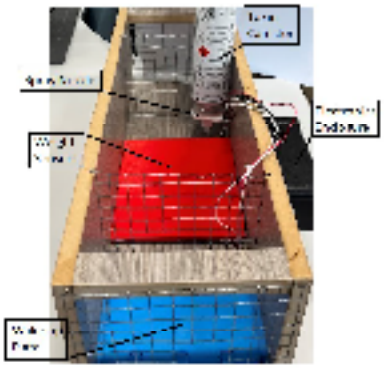
Features :

- Weight activated aerosol toxin spray.
- Retrofit to existing trapping tunnels.
- Greater than 4 month life with no maintenance.
- Toxin dosage adjusted by animal weight.
- Ability to install chemical lure dispenser.
- Adjustable for different toxins and target animals.

Design Process

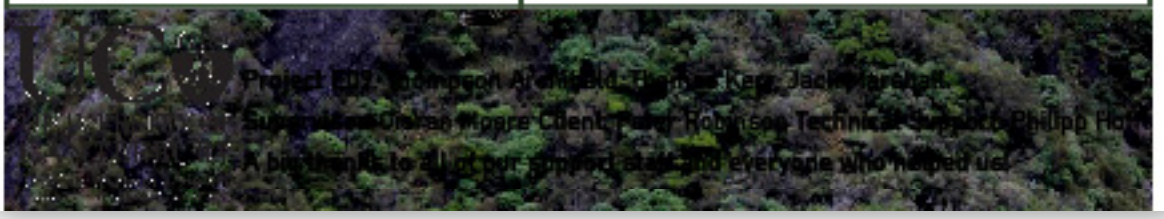
The focus of development was ensuring the system was highly robust while minimising cost.

- Detects pests using simple pressure-sensitive resistors over a more expensive computer vision system.
- Controlled by low-power, low-cost 8-bit MCU.

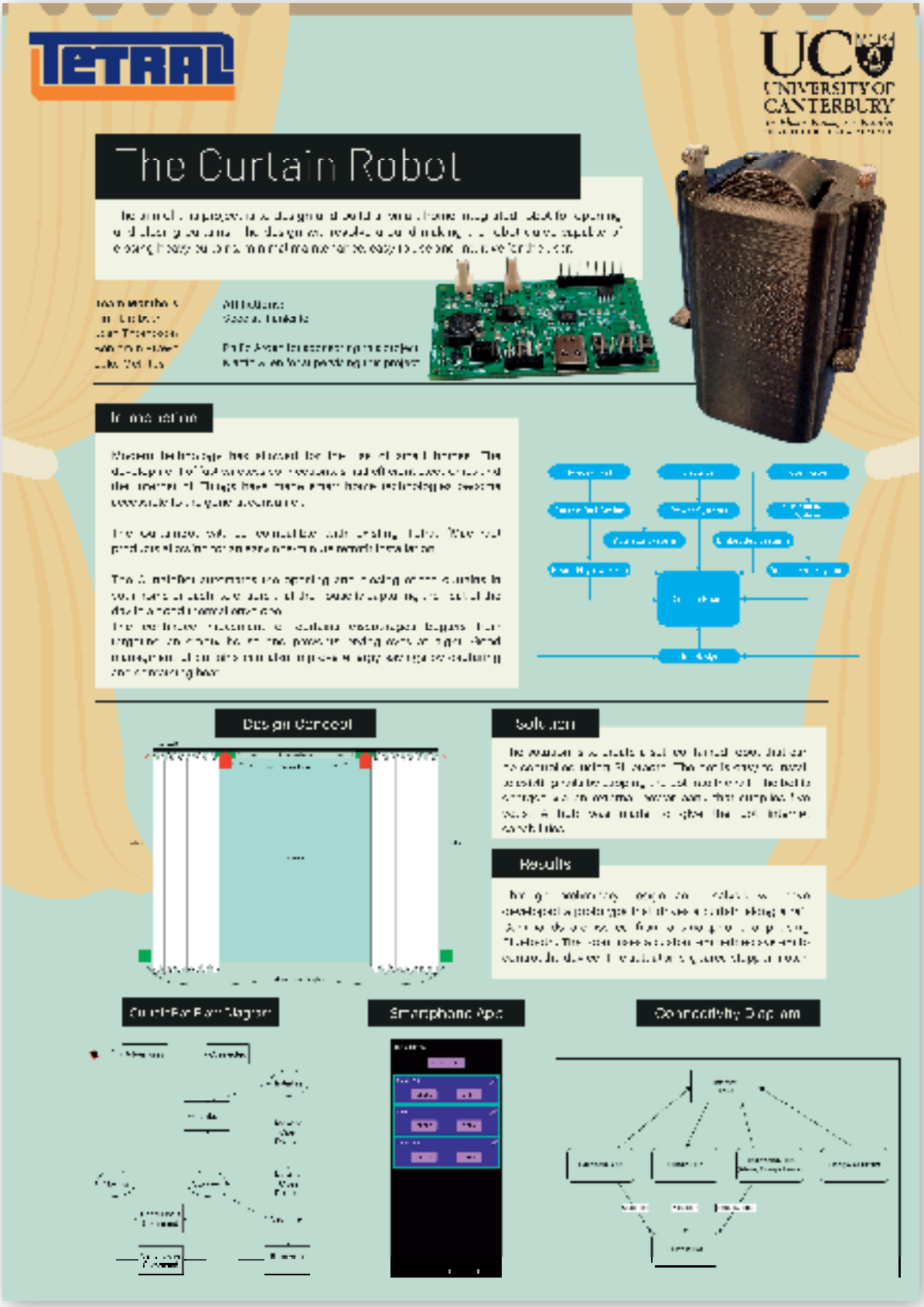


Potential future developments:

- More sophisticated animal distinction.
- Communication system for remote monitoring and integration with other Kiwicare traps / bait boxes.



Student projects: Electrical Engineering and Computer Engineering



RAT BAIT STATION MONITOR

CONTRIBUTING TO A PREDATOR-FREE NEW ZEALAND

KIWICARE
SPONSOR

Motivation

Pest bait stations are legally required to be checked regularly by owners. Kiwicare is interested in developing a remote monitoring device to improve the efficacy of the Kiwicare No Rats® bait station by reducing labour.

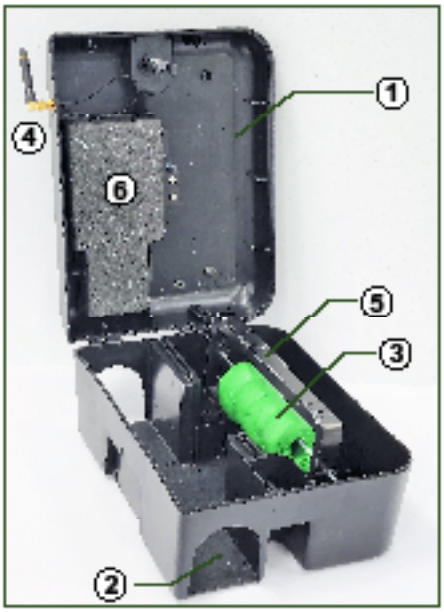
Project Goals

Develop a device that:

1. Is retrofittable
2. Measures bait levels
3. Communicates data to the owner wirelessly

Prototype Device Overview

1. Existing bait station
2. Rat access funnel
3. Rat bait
   Pelleted or toxic.
4. External antenna
   Tuned to assigned NZ LoRa bandwidth
5. Bait sensor
   Proprietary optical bait sensor. 20–25% resolution.
6. Electronics casing
   Designed for injection moulding with bittering agent and IP34 rating. Protects electronics from rats and moisture.



Prototype Testing Findings

- The sensor can measure the remaining bait in 25% increments.
- The device can communicate bait and device battery level data, timestamps, and any custom data.
- The device can communicate over 750m with line of sight outdoors, and 150m in a concrete and steel building.

Summary

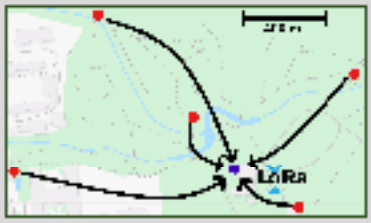
This prototype is a successful proof-of-concept for a product that can eliminate the need to check stations in person. Kiwicare will investigate commercialising this device in the future.

UC UNIVERSITY OF CANTERBURY

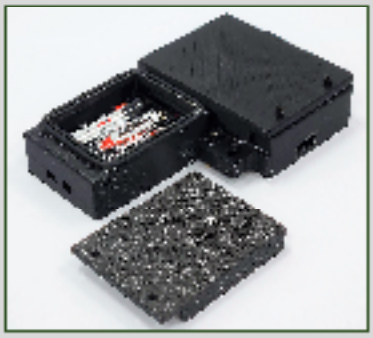
PROJECT MEMBERS
Christopher Dewhurst
Ashley McBride
Edward Twomey
Dion Robinson

SPECIAL THANKS
Prof. Philippa A. Martin (Supervisor)
Dr Peter Robinson (Kiwicare)
David Britain (Kiwicare)
Thomas Emmitt (DOC)
Stuart Cockburn

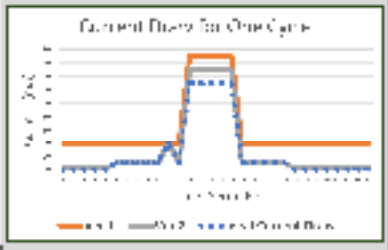
Device Features



LoRa Network
Peer-to-peer LoRa radio modulation transmits data from bait stations to a central device. Network is expandable to 240+ stations. Hardware is in place for LoRaWAN connectivity if desired.

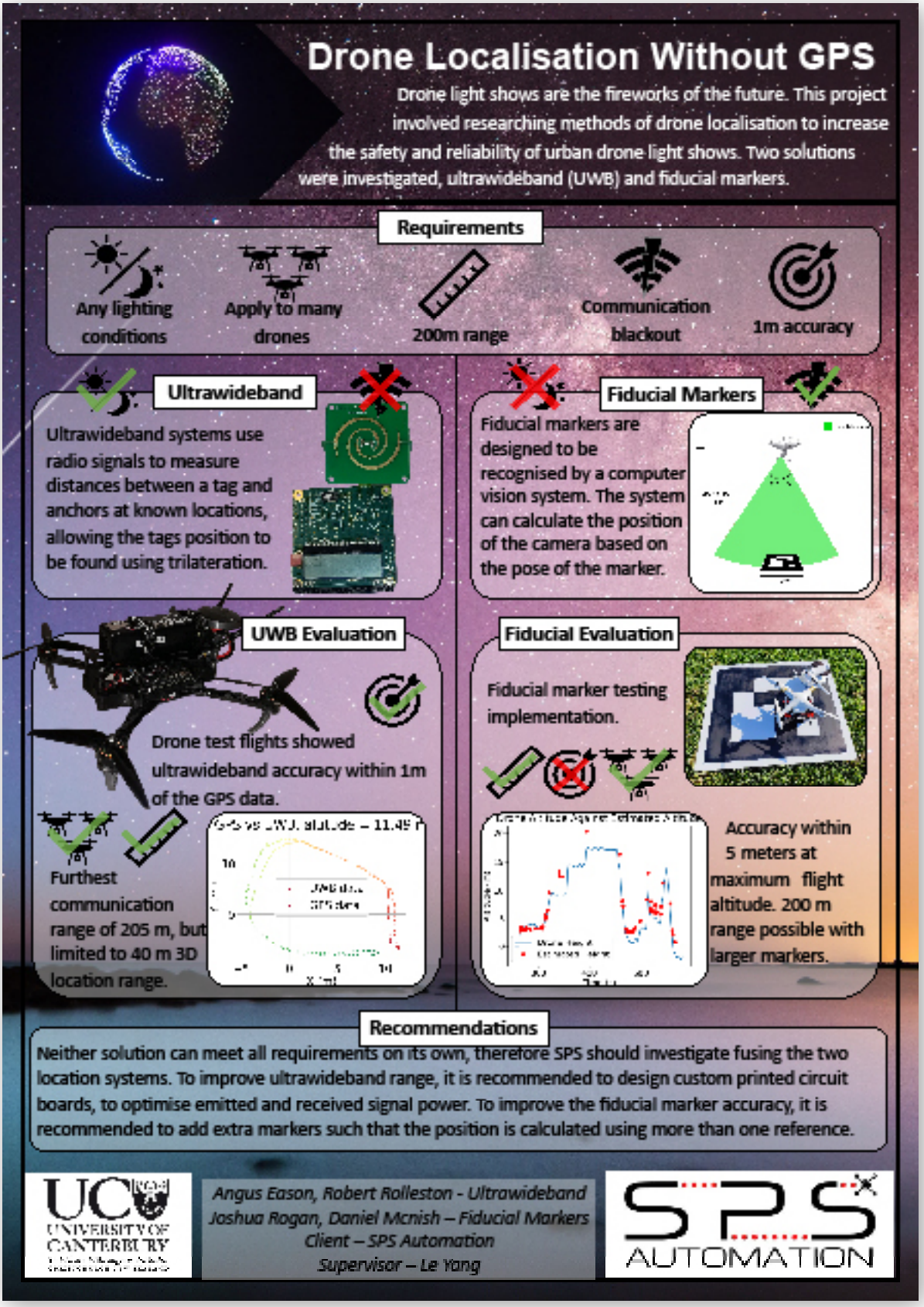


Waterproof electronics
Weatherproof casing with separate battery compartment.



Power-saving mode
A deep-sleep mode gives the device a battery life-time of over two months.

Student projects: Electrical Engineering and Computer Engineering



FUTURE ARCHITECTURE OF THE NETWORK

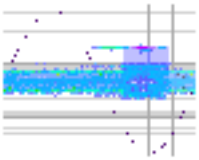
Repurposing AC Components for DC Applications

The Future Architecture of the Network is a research project focused on the future of New Zealand's electrical network. As part of this project, we have tested a representative selection of assets in the grid to compare component behaviour under AC and DC. Our project goal was to determine which assets are fit to repurpose in a hybrid AC/DC network.

Insulators

The leakage current and partial discharge were measured under AC and DC for a selection of porcelain insulators and a polymer surge arrester.

The partial discharge under DC was higher than under AC, but the leakage current was lower.



Medium-Voltage Cables

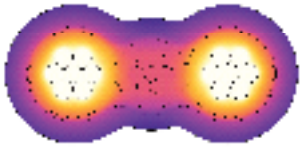
The leakage current and partial discharge were measured for a 33kV XLPE cable under AC and DC.

Like the insulators, the partial discharge under DC was significantly higher than under AC, but the leakage current was much lower.

Low-Voltage Cables

1mm² to 6mm² TPS cables were injected with various current densities to determine the temperature rise under AC and DC. The cables were tested in an unenclosed environment.

The steady-state temperatures of the cables under AC and DC were very similar.



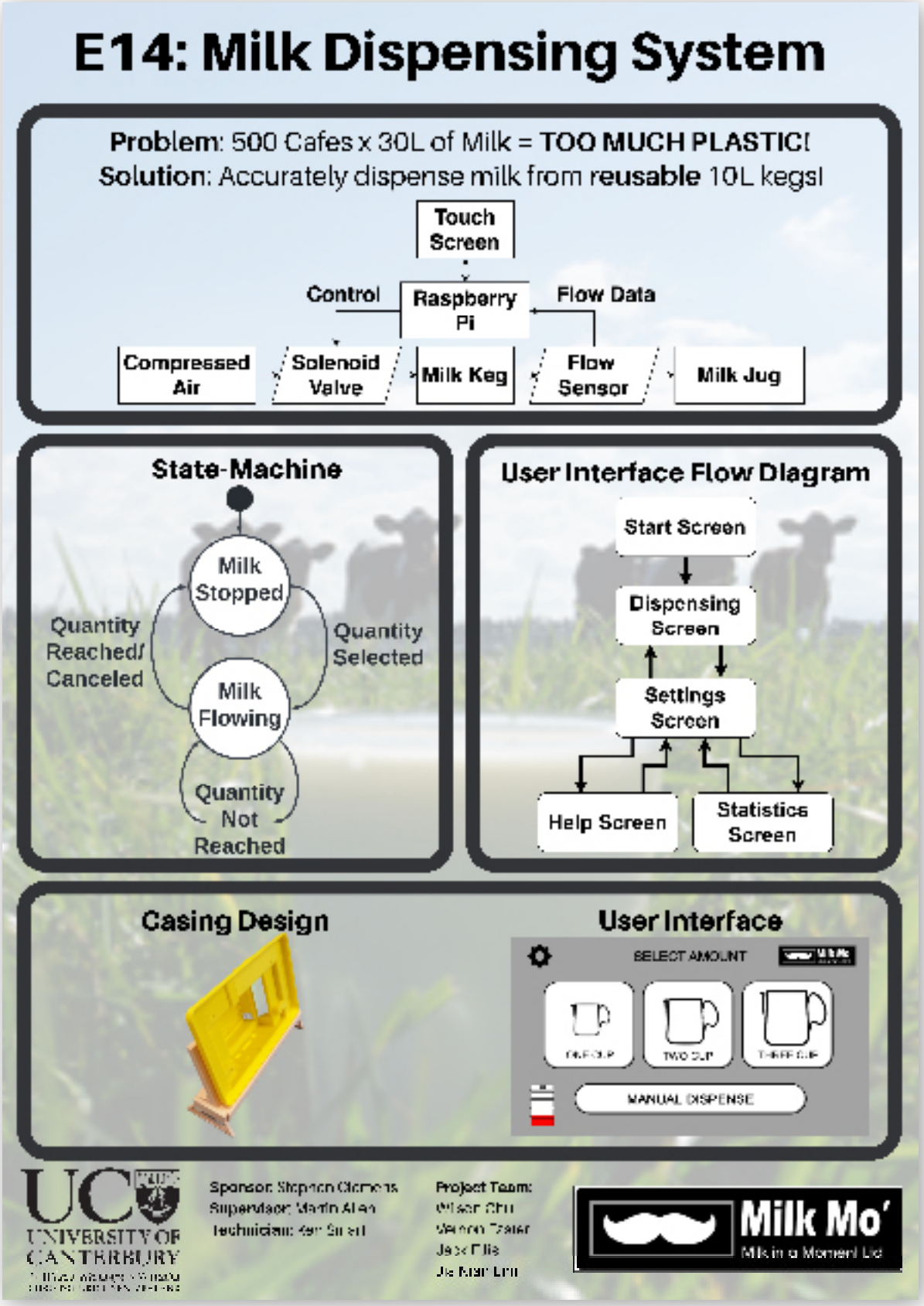
Modelling

Finite element models were created to verify the experimental results. The modelled and experimental insulator leakage current were in agreement. The modelled cable temperature rise was similar to the experimental results, but there were discrepancies due to the dynamic experimental conditions.

Group Members:
Erin Shaller
Rezukiel John Estolas
Weizhe Qiu
Mengyan Huang

Special Thanks:
Sponsor: Andrew Lapthorn
Supervisor: Neville Watson
Lab Technician: Paul Agger

Future work includes increasing the sample size and variety of components and materials. Additionally, the studies should be extended to compare AC and DC performance in realistic environments. This means investigating the effects of water and pollution on the insulators and medium-voltage cables, and surrounding the low-voltage cables with thermal insulation.


E14: Milk Dispensing System
Problem: 500 Cafes x 30L of Milk = TOO MUCH PLASTIC!
Solution: Accurately dispense milk from reusable 10L kegs!
Touch Screen
Control
Raspberry Pi
Flow Data
Compressed Air
Solenoid Valve
Milk Keg
Flow Sensor
Milk Jug
State-Machine
Milk Stopped
Quantity Reached/ Canceled
Quantity Selected
Milk Flowing
Quantity Not Reached
User Interface Flow Diagram
Start Screen
Dispensing Screen
Settings Screen
Help Screen
Statistics Screen
Casing Design
User Interface
SELECT AMOUNT
MANUAL DISPENSE
UC
UNIVERSITY OF CANTERBURY
Sponsor: Stephen Clemens
Supervisor: Martin Allen
Technician: Ken Smith
Project Team:
Oliver Chu
Jack Ellis
Milk Mo'
Milk in a Moment Ltd

The Smart Climbing Wall

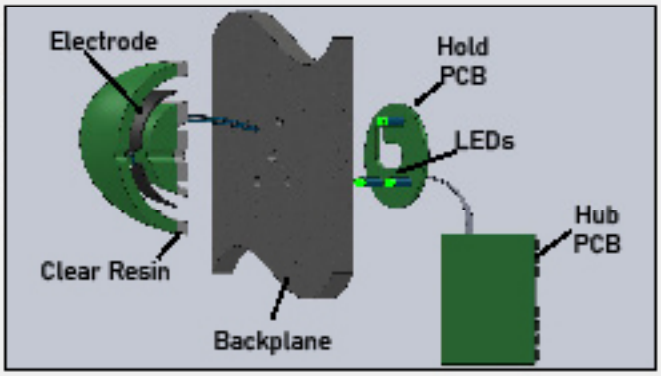
Felix Backhouse, Connor McArdle, Tabitha Batcheler, Jun Noh

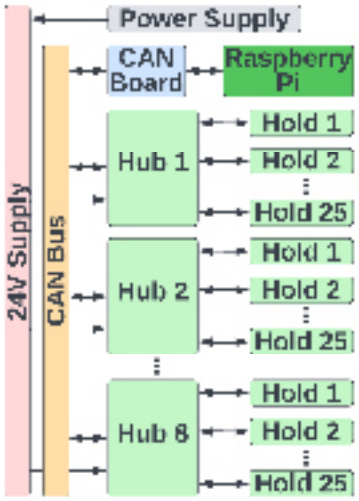
Overview

Uprising Industries is looking to add a "smart" climbing wall into its existing portfolio of climbing hardware. As such, this project's goal was to create a full-scale prototype while ensuring its economic viability.

The final prototype can light up individual holds, sense climber's movements, and combine these functions to show and track various routes.

This system improves user experience by allowing almost unlimited routes without the need to move holds.





System Architecture

The hub and spoke model allows scalability up to 200 holds while remaining cost-effective.

Working Principle

Each Hold PCB has a capacitive touch sensor, which connects to three electrodes in the hold to detect the climber's hand or foot.

The microcontroller in each Hub communicates with the capacitive sensors to detect climbers, and can also set the LEDs to a wide range of colours. The LEDs shine through a thin layer of optically clear resin to illuminate the outline of the hold.

Conclusions / Recommendations

Our design is scalable up to 200 holds and the hardware cost is less than $10 per hold, fulfilling Uprising's key requirements.

Future developments could include gamified climbing and more refined user installation process.

UC UNIVERSITY OF CANTERBURY

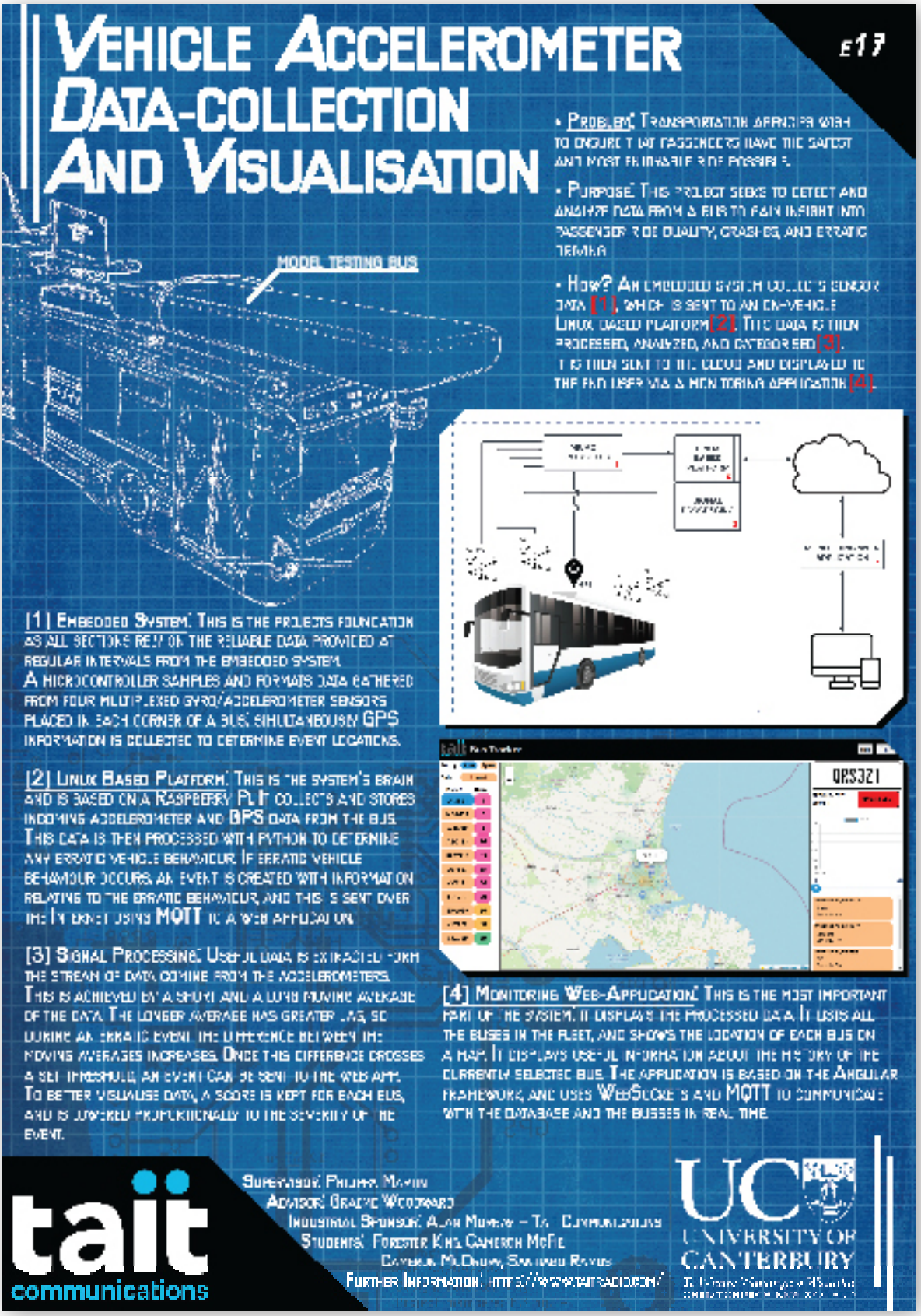
Project E16

Sponsor: Sefton Priestley & Uprising Industries

Supervisors: Allan McInnes & Nina Pernus

Technician: Phillip Hof, Edsel Villa

Student projects: Electrical Engineering and Computer Engineering



Student projects: Electrical Engineering and Computer Engineering

E22 - Smart Air Quality Sensor Network

Team: Alex Delyagin, Harry Shea, Jorden Nom, Oliver Kidd and Tristan Tiong

Supervisor: Shayne Crimp

Client Supervisor: Anna Farquhar

Introduction

Human health is dependent on the quality of our air. Since we started living in urban centres with high population density the management of air pollution has become more difficult, and more important than ever.

To be able to understand the impact air quality has on human health, we need to be able to measure the quality of the air.

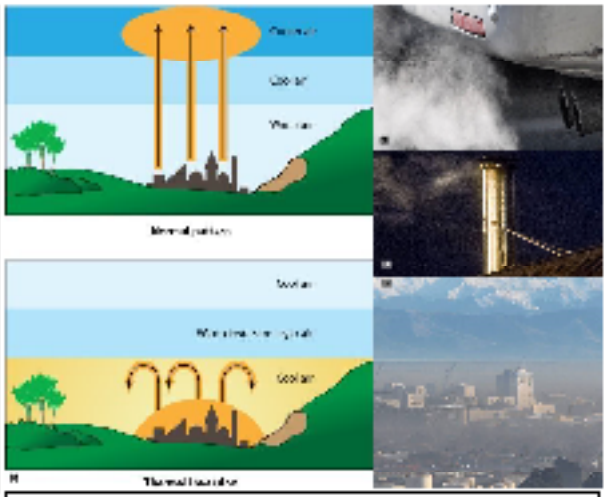
Christchurch has a history of poor air quality due to a thermal inversion layer caused by the port hills which traps pollutants at street level.

Presently, there are only three monitoring stations in Christchurch, these provided limited information.

Pollutants can be broken up into two categories, gases, and particulate matter.

Particulate matter (PM) is a broad term to cover suspended particles in the air, common examples are dust, smoke, and smog.

PM is characterised by size in microns, as an example PM_{10} refers to all particles 10 microns and smaller.



Solution

The design contains sensors to measure PM_{1}, $PM_{2.5}$, nitrogen dioxide and ozone. It is fitted with a micro-controller which manages the reading of the sensors, communications, storage to a SD card, getting the current time and updating the status LEDs.

To lower the cost of the design and facilitate future development of the platform, the design has made use of common development boards where possible.

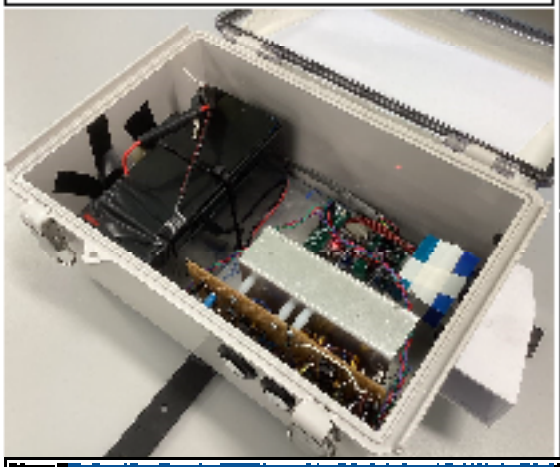
A custom main board PCB and driver circuitry for the gaseous sensors was developed.

The code was written using the Arduino framework.

Wi-Fi has been tested and is ready to connect to the cloud. The hardware has a port set aside for use with an lte-m modem to connect to Christchurch City Council's computer servers.

The box will be fitted within a weather-tight enclosure for outdoor use.

The approximate cost of the design is $238.58 for one unit, but the sensors were supplied by Aeroqual so the actual price would be higher. This cost could be further reduced through refinement of the design and purchasing components in volume.

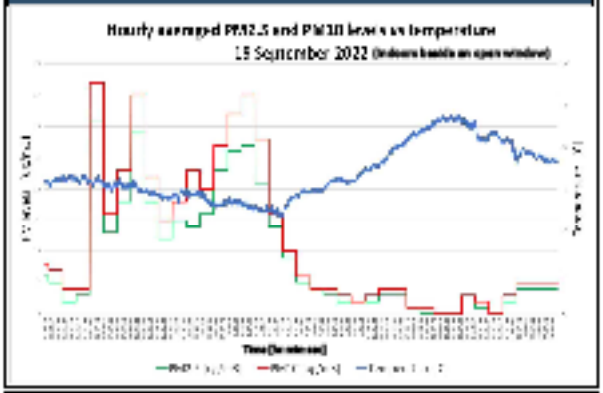


Goal

The CCC have tasked us with designing and building a low-cost pole-mounted device to measure air quality. To aid us in the development of this device, Aeroqual, are providing their air quality monitoring expertise.

We have identified PM_{10}, $PM_{2.5}$, NO_2, and O_3 as key pollutants to monitor. These four pollutants come from the burning of fossil fuels, with particulate matter also coming from burning of coal and wood for home heating. Our device will measure these four pollutants and relay the data back to the Christchurch city council via an Itron network. We would like to deploy a network of these devices around Christchurch to provide localised air quality information.

Results



Next Steps

1) Deploy the prototype at a ECAN air monitoring station for a week long test to calibrate the sensors.
2) Develop a PCB for the driver circuit of the gaseous sensors.
3) Develop a 2nd version of the main board to incorporate improvements.
4) Add Itron functionality.
5) Develop design to the point where it can be mass manufactured for city wide deployment.

Autonomous Formation of Drones

Problem Motivation

- Search and Rescure
- Environment/conservation research

Problem Definition

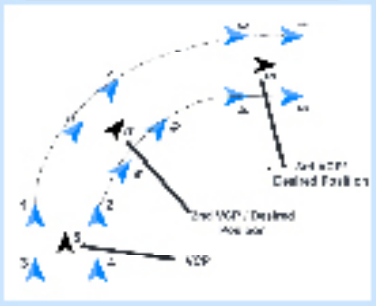
To design, implement and test a software- and (wireless) networking general framework to safely operate a formation of autonomous drones in a rigid formation.

Simulation Enviroment

GAZEBO ROS PX4 autopilot

- Gazebo provided all the tools necessary to load drone models and visualise simulation flights in 3D.
- ROS is an open source robotics software that provides the framework that the algorithm is built from.

Developed Trajectory planning and Testing



Each drone maintains its position with respect to heading and position of the center of the formation.

By moving the centre point the formation will attempt to maintain its shape as each drone acts to hold position.

Test Flights/Results

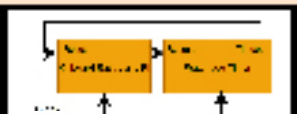
Our final flight successfully flew three drones around a 10 x 10m square while maintaining the formation. Successfully replicating our simulations!

The results from our final flight tests concluded that the control algorithm successfully controlled three drones with hardware faults preventing further tests with a full formation of five active drones.

Timeout Hardware Failsafe

To prevent drones from losing control a failsafe timer is used to reset the Raspberry PI's onboard each drone.

This failsafe timer reset the Raspberry PI in case of program halt or system failure.



Hardware reset circuit summary

To fit the circuitry on the drone without weighing it down a PCB was created that fit nicely on the exterior of the Raspberry PI.

PCB designed to reset Raspberry PI in a system failure

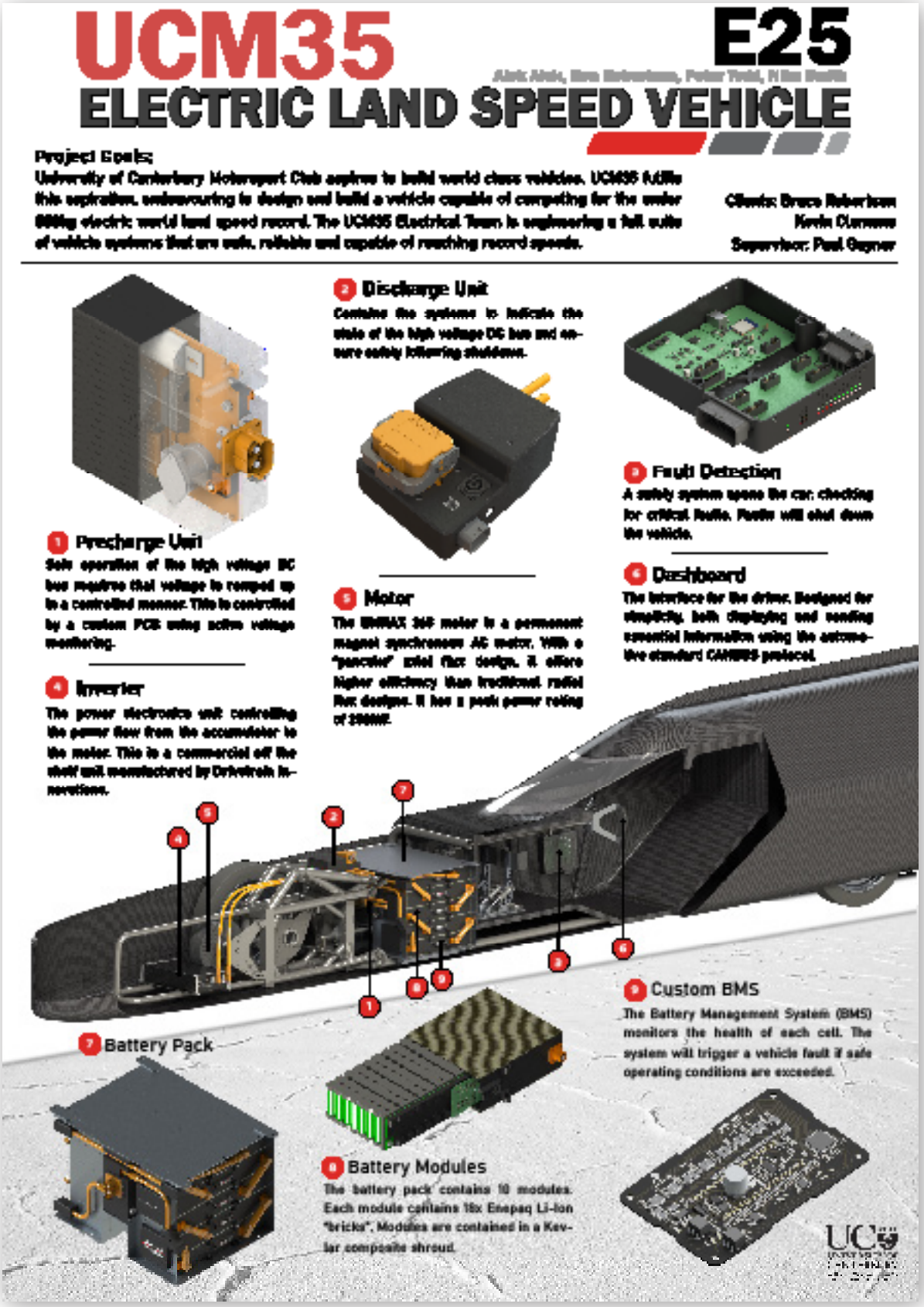
UC UNIVERSITY OF CANTERBURY

Team members:
- Nicholas Varley
- Simon Wallace-Blakely
- Caleb Sim
- Niko Tainui
- Jianqulo Guo

Academic Supervisor:
- Joe Chen

Project Supervisors:
- Dr Graeme Woodward
- Prof Andreas Willig

Clients:
- UC Wireless Research Centre
- UC Computer Science and Software Engineering Department


UCM35 E25
ELECTRIC LAND SPEED VEHICLE
Project Goals:
Clients: Bruce Robertson
Kevin Clemens
Supervisor: Paul Gagner
1 Precharge Unit
2 Discharge Unit
3 Fault Detection
4 Inverter
5 Motor
6 Dashboard
7 Battery Pack
8 Battery Modules
9 Custom BMS
The Battery Management System (BMS) monitors the health of each cell. The system will trigger a vehicle fault if safe operating conditions are exceeded.

Vibration and Acoustic Analysis of The Wand Turntable

Project Statement and Aims:

The needle in a vinyl record player tracks oscillations in a record groove fractions of millimetres wide. These oscillations are converted to voltage signals in the tonearm. This voltage is then converted to the audio signals played by speakers. Any unintended disturbance to the needle affects the voltage signal, and in turn alters the music quality.

Design Build Listen proposed that the team would investigate the noise that reaches the needle from both mechanical and acoustic sources.

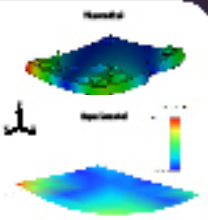
Methods:

- Theoretical modal analysis: The plinth of the record player was modelled in a CAD software, analysing the resonant frequencies to show the vibration shape of each resonant mode.
- Experimental modal analysis: Accelerometers were set up in a grid across the turntable to experimentally determine the frequency response and internal damping of the plinth, quantifying how vibrations travel through the material.
- Isolation design: Accelerometers were used measure the response of the turntable feet to external excitation. Several designs were tested - simple material slabs, rubber band (spring like) systems, and isolators inspired by earthquake dampers in buildings. This is to minimise the external vibrations entering the turntable.
- Acoustic analysis: Acoustic analysis was used to identify the main source of the audible noise heard without records playing. A frequency analysis was done on the makeup of this noise, and the sound pressure level (sound energy) was measured across the turntable surface to locate the source.

Results:

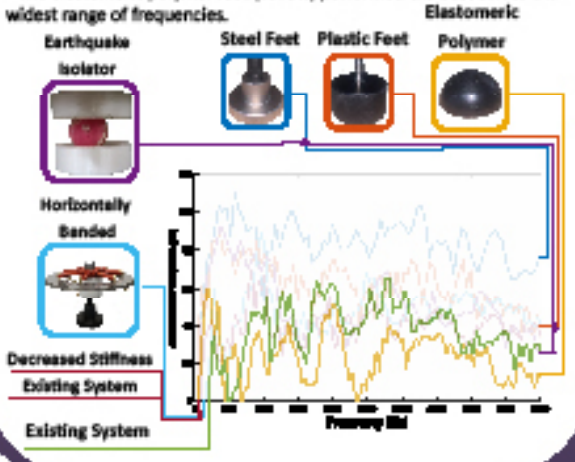
Theoretical & Experimental Modal Analysis

- Resonant Frequency at 200 [Hz]
- First Mode identified (See right)
- High internal damping >5%
- No amplification of vibrations within the range of human hearing



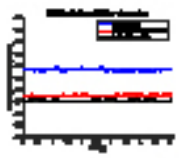
Isolation Design Summary

- The existing isolation feet (Green) work well, particularly at low frequencies (<500 [Hz])
- Steel feet (Dark Blue) performed the worst across all frequencies.
- The elastomeric polymer feet (Yellow) performed the best across the widest range of frequencies.



Acoustic Analysis

- Main acoustic noise present at 4 [kHz].
- Acoustic noise most prevalent directly above motor.
- Sound quickly falls into the noise floor.
- 35% reduction in audible noise by adding fibre-glass acoustic foam.



Conclusions and Recommendations:

- Minimal transmission of internal vibrations (see Theoretical and Experimental Modal Analysis).
- Utilize a combination of the elastomeric polymer and the existing isolation feet for further developments, including multiple tiers of isolation (See Isolation Design Summary).
- The main source of noise is the electric motor, and different insulation techniques have shown clear improvements in this. (See Acoustic Analysis).

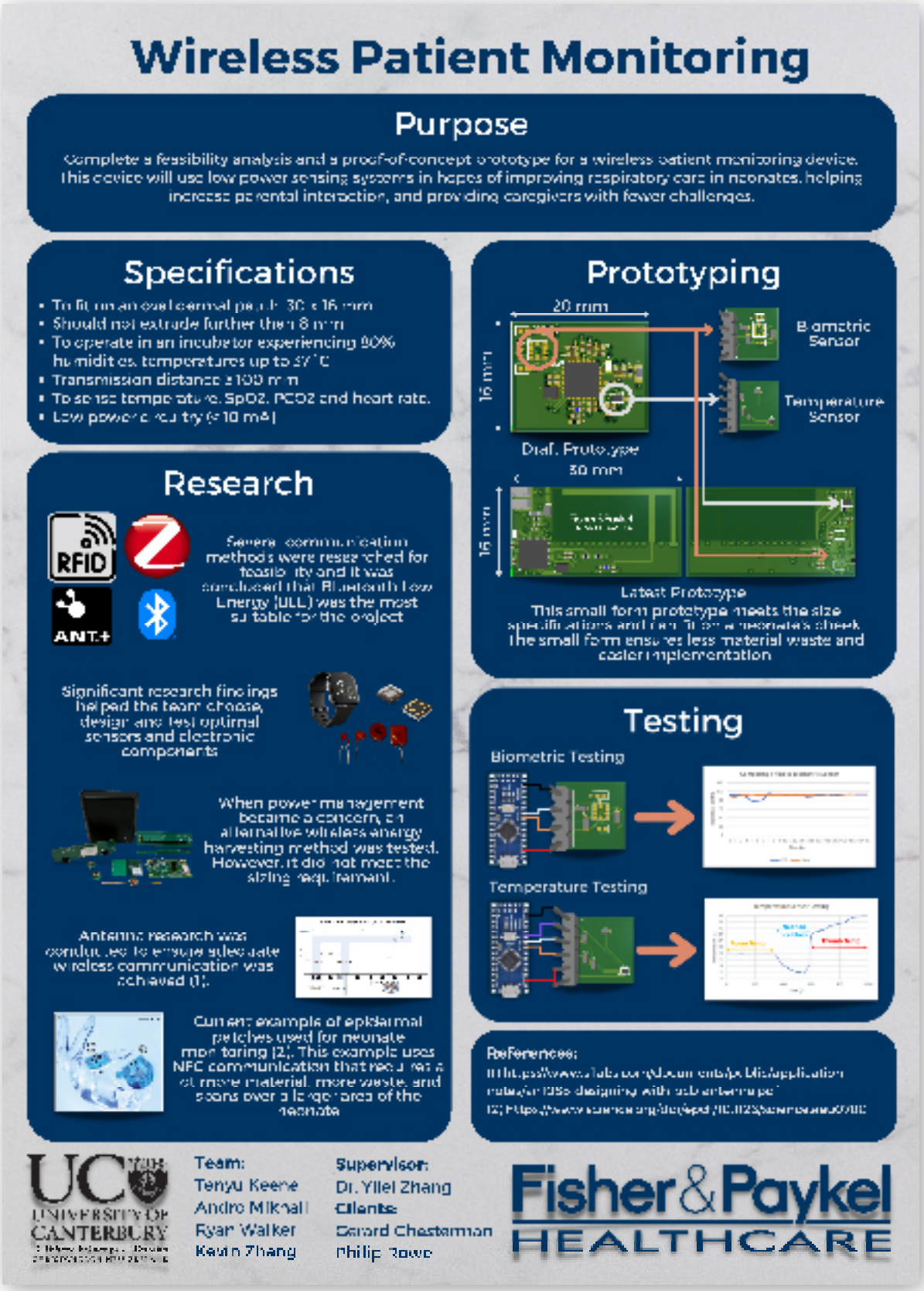
UC University of Canterbury

Team M01: Jack Ryder, Lewis Goldby, Liam Spring, Bea Smit

Supervisor: Prof. Stefanie Gutschmidt

Client & Mentor: Simon Brown

THE WAND TURNTABLE & TONEARM


Wireless Patient Monitoring
Purpose
Complete a feasibility analysis and a proof-of-concept prototype for a wireless patient monitoring device. This device will use low power sensing systems in hopes of improving respiratory care in neonates, helping increase parental interaction, and providing caregivers with fewer challenges.
Specifications
To fit on an oval epidermal patch (~ 30 x 16 mm)
Should not extrude further than 8 mm
To operate in an incubator experiencing 90% humidities, temperatures up to 37 °C
Transmission distance ≥ 100 mm
To sense temperature, SpO2, PCO2 and heart rate.
Low power circuitry (< 10 mA)
Research
RFID
ANT+
Several communication methods were researched for feasibility and it was concluded that Bluetooth Low Energy (BLE) was the most suitable for the project
Significant research findings helped the team choose, design and test optimal sensors and electronic components
When power management became a concern, an alternative wireless energy harvesting method was tested. However, it did not meet the sizing requirement.
Antenna research was conducted to ensure adequate wireless communication was achieved [1].
Current example of epidermal patches used for neonate monitoring [2]. This example uses NFC communication that requires a lot more material, more waste, and seems over a large area of the neonate
Prototyping
20 mm
16 mm
Biometric Sensor
Temperature Sensor
Prof. Prototype
30 mm
16 mm
Latest Prototype
This small form prototype meets the size specifications and can fit on a neonate's cheek. The small form ensures less material waste and easier implementation
Testing
Biometric Testing
Temperature Testing
References:
[1] https://www.ti.com/document-viewer/lit/html/sprabq5 Bluetooth application notes for RSS designing with sub-antennas
[2] https://www.science.org/doi/epdf/10.1126/scitranslmed.3010
UC
UNIVERSITY OF CANTERBURY
Team:
Tenyu Keene
Andro Mikhail
Ryan Walker
Kevin Zhang
Supervisor:
Dr. Yilei Zhang
Clients:
Gerard Chesterman
Philip Rowe
Fisher & Paykel
HEALTHCARE

Student projects: Mechanical Engineering and Mechatronics Engineering

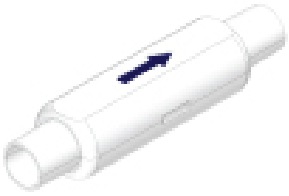
Simultaneous Ultrasonic Sensing of Flow Rate and Oxygen Concentration for Neonates

Fisher & Paykel HEALTHCARE

UC University of Canterbury

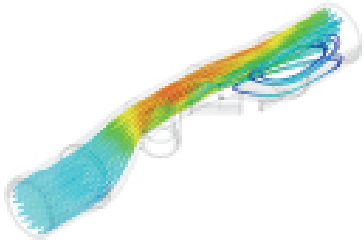
Students: Jessica Aitken, Katherine Ellis, Kimberly Lowe and Glan Padrutt **Supervisor:** Prof. Mark Jermy
Client Mentors: Jed O'Brien and Frederick Wright **Acknowledgements:** Scott Lloyd, Phil Bones, Bill Mohs and Philipp Hoff

Preterm birth is the principal cause of death for one million babies annually [1], requiring the ongoing need for effective respiratory therapies [2,3]. The purpose of this project was to develop an ultrasonic sensing system to simultaneously display oxygen concentration and flow rate, to ensure the correct delivery of known therapies.



REQUIREMENTS

- Accuracy to ±2%
- 95% Precision
- Oxygen concentration sensing between 20-95%
- Flow rate sensing between 2-40 LPM
- Pressure drop < 2 cmHO
- Temperature sensing capability



FLOW SIMULATIONS

Described a pressure drop of 0.54 cmH_2O at 40 L/m.

CALIBRATION

Flow rate was validated against TSI 4040 Air Flowmeter. O_2 conc. was validated against 0%, 21% and 99.5% O_2 conc. Correction factors are necessary to improve the accuracy and precision.

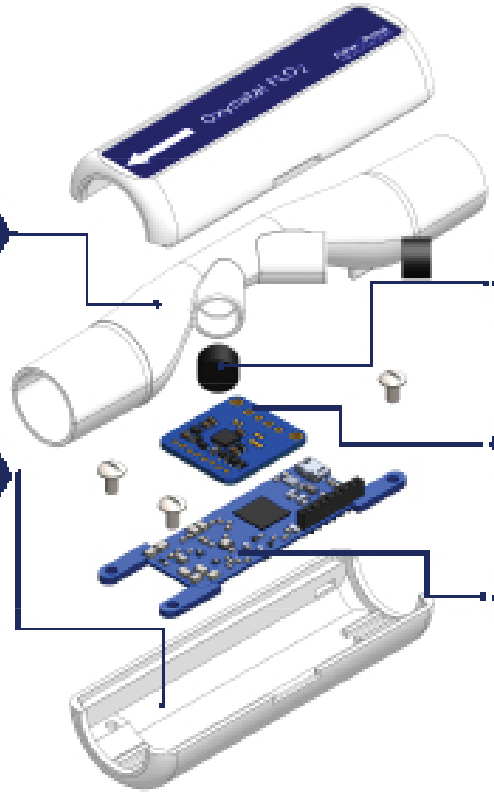
COST

For 1-100 units, 3D printing is most economical. For more units, injection moulding should be considered.

- $308 for 1 unit
- $151 for 100 units
- $128 for 10000 units

MODELLING SENSITIVITY

Modelling showed incorrect temperatures could cause high inaccuracies, so a temperature sensor was needed. Modelling also highlighted relative humidity sensing was unnecessary.



FLOW TUBE

22 mm male taper connectors, loft to the central tube. 2 secondary tubes locate the transducers. Ultrasound is reflected across the flow.

TRANSDUCERS

Two 300khz transducers which each transmit and receive an ultrasonic signal.

TEMPERATURE BOARD

PT100 temperature sensor with Adafruit MAX31865 breakout board.

OUTER HOUSING

Upper and lower parts fit within 35 mm diameter and 85 mm length.

- Opening clasp
- Minimal gaps
- Tight fit between parts
- Bosses for PCB fit
- Tabs for flow tube fit
- Outlet for power
- Flat top and bottom
- Directional flow arrows
- Finishing sticker

CUSTOM PCB

Based on Texas Instruments EVM430-FR6043.

- 5V Micro-USB connection
- 8-pin header instead of standard JTAG
- SPI connections for temp. breakout board

[1] Quinn J-A, Munoz FM, Gonik B, Frau L, Cutland C, Mallett-Moore T, et al. Preterm birth: Case definition & guidelines for data collection, analysis, and presentation of immunisation safety data. Vaccine. 2016;34(49):6047-56.
[2] Bailey N, Henry C, Garg S, Wagner N, Malhotra A, Valizer M, et al. The newborn delivery room of tomorrow: emerging and future technologies. Pediatric Research. 2022.
[3] Gupta S, Donn SM. Continuous positive airway pressure: Physiology and comparison of devices. Semin Fetal Neonatal Med. 2016;21(3):204-11.

Weeding Agricultural Robotic Solution

Plant Research (NZ) Ltd.

Background

Plant Research (NZ) Limited are plant breeders based in Templeton, Christchurch, specializing in peas, oats, wheat and triticale. Currently they employ seasonal workers to hoe the weeds between crop rows, at a large cost to the company. An engineering solution was desired to reduce this dependance.

Project Brief

Design and implement a robotic solution capable of autonomously navigating through crop fields, identifying weeds and spraying them with a herbicide. Previous teams have already completed the chassis, drivetrain and power componentry.

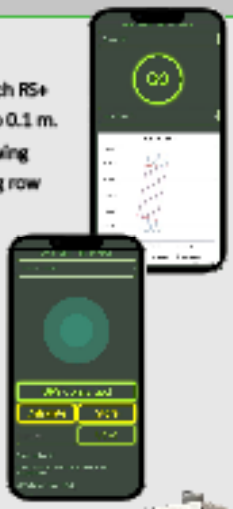
Robust Weed Detection

- Simple and effective colour detection algorithm using Open CV functions in Python.
- Features variable size spraying, cluster detection and a linear tracking algorithm.
- 70% detection accuracy during testing.

Raw 480p Image | Colour Segmentation | Tracking

High Accuracy Navigation

- GNSS positioning using an Emlid Reach RS+ provides a global position accurate to 0.1 m.
- Implements a generalized path following algorithm, with a focus on minimizing row deviation.
- Capable of following a path with a deviation of less than 0.1 m.



Intuitive User Interface

- Manually control the robot using a joystick on a local webpage.
- Create, store and execute new paths to follow.
- Receive operating information on robot position, path completion and GNSS position.

Obstacle Avoidance

- Detects obstacles using a single front facing Intel D435 stereo camera.
- Dynamically re-adjust paths to avoid obstacles in the row.
- Store obstacle image and location for the user to review.

Micro Jet Spraying

- Single degree of freedom servo operated positioning system.
- Micro dose solenoid actuated nozzle.
- Dynamically controllable dosage volume.
- Closed loop pump control regulates system pressure for greater accuracy.

2022 Team: Anton Musalov, Mark Gardyne, Sam Bain, Thomas Peterson
2021 Team: Luke Burke, Daniel Bowles, Tristan Weastell, Matthew Bertschinger
Client: Adrian Russell, Brian Kinney (Plant Research Ltd)
Supervisor: Dr Yilei Zhang Technicians: Julian Murphy, Dave Fanner

UC University of Canterbury

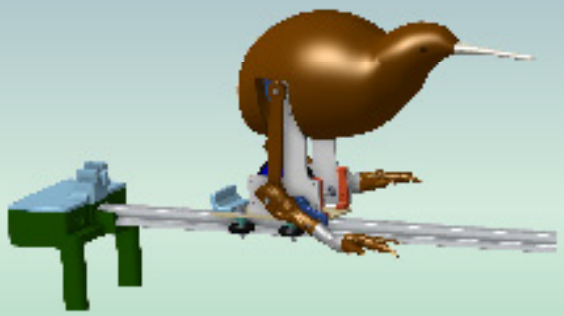
ANIMATRONIC KIWI

BACKGROUND

Seventy percent of reported kiwi mortalities are attributed to dogs. Kiwi aversion training is an effective technique for reducing kiwi deaths. However, current props are static and some have a limited lifespan. The animatronic kiwi is an attempt to improve upon current kiwi avoidance training props by introducing motion to capture the dog's attention. It needs to operate quietly and stimulate the dog with visual cues.

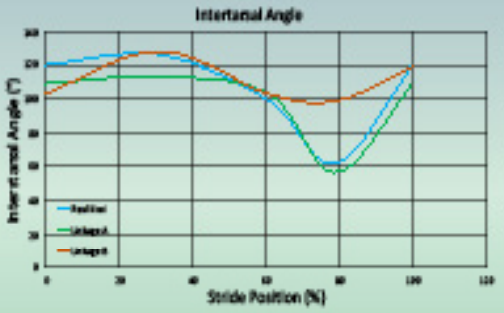
BODY MODEL

A model of a kiwi body was produced using both 3D scans and interpolated 2D images provided by the National Kiwi Hatchery and the University of Canterbury. The body was covered with patterned fur to emulate kiwi feathers.



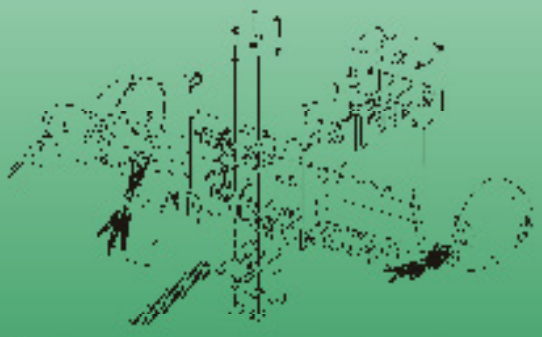
LOCOMOTION MIMICRY

Kiwi leg motion was replicated by comparing the joint angles of a real kiwi with the angles produced using two alternative mechanical linkages. The angles of the most realistic mechanism were then optimised using MATLAB software. Flexible silicone joints were used to allow the prop's legs to interact with the ground.



WIRELESS RELEASE

The prop is activated using a radio controlled relay that allows the trainer to release the prop from a distance of up to 30 m. A DC motor is used to actuate this mechanism. The mechanism is powered using rechargeable batteries for portability and sustainability

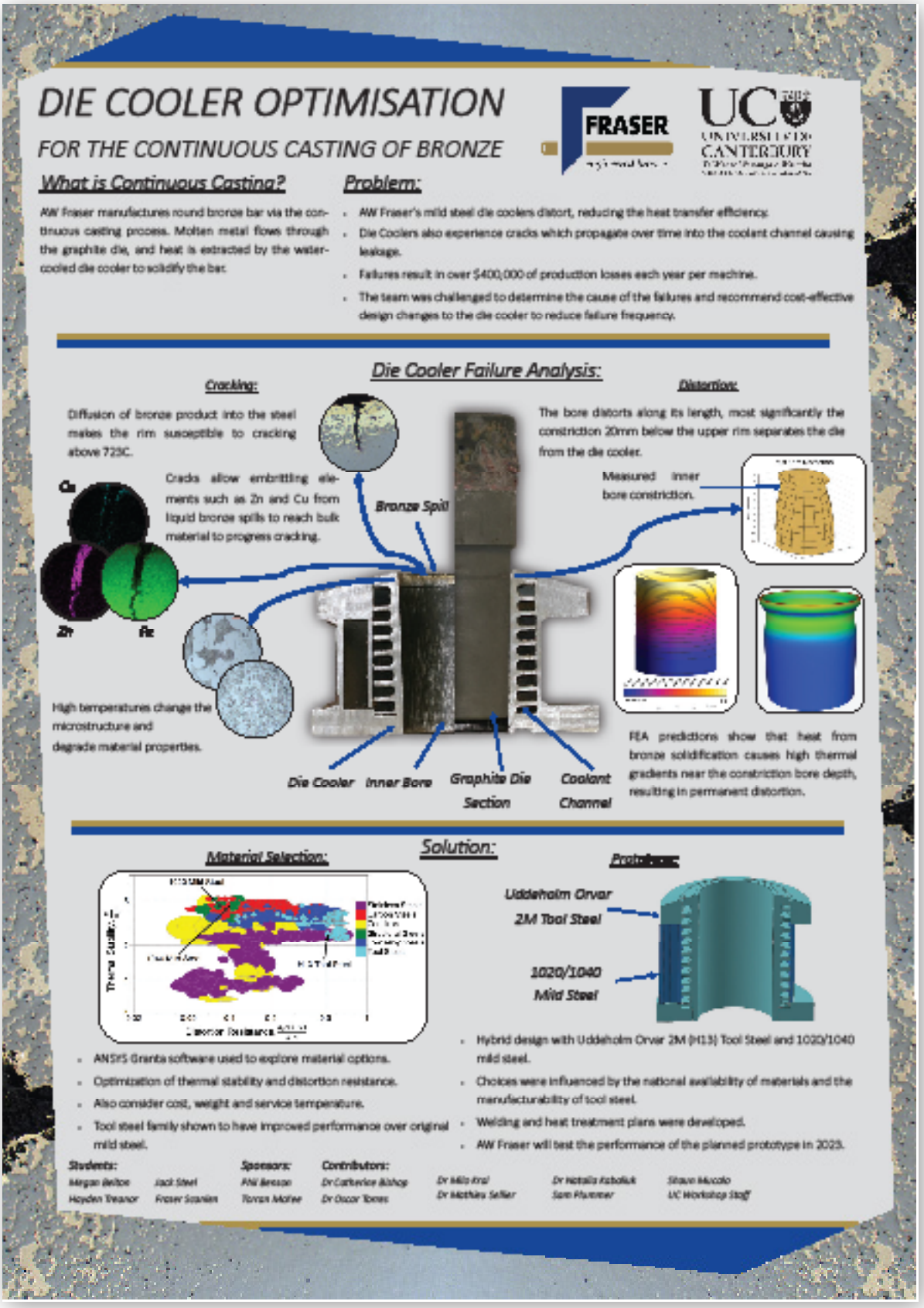


DRIVE SYSTEM

The kiwi is powered by a quill spring for its reliability, quiet operation, and repeatable slow release energy storage. The power from the quill spring is transmitted to the drive wheel and the leg linkage using toothed pulleys and belts. The drive wheel propels the kiwi along a rail.


The kiwi being tested in a realistic training environment.

Student Team: Matthew Bloomfield, Joost van Gorp, Samuel Schneider, and Josiah Duffield
Supervisor: Tim Gifftney
Client: Emma Bean
Project Mentors: Blake Cole, Karl Molving, Rob Whilton, and Marie-Joe Le Guen
Technicians: Julian Murphy, Julian Phillips, and Daniel Bishop


DIE COOLER OPTIMISATION
FOR THE CONTINUOUS CASTING OF BRONZE
FRASER
UC
UNIVERSITY OF CANTERBURY
What is Continuous Casting?
AW Fraser manufactures round bronze bar via the continuous casting process. Molten metal flows through the graphite die, and heat is extracted by the water-cooled die cooler to solidify the bar.
Problem:
AW Fraser's mild steel die coolers distort, reducing the heat transfer efficiency.
Die Coolers also experience cracks which propagate over time into the coolant channel causing leakage.
Failures result in over $400,000 of production losses each year per machine.
The team was challenged to determine the cause of the failures and recommend cost-effective design changes to the die cooler to reduce failure frequency.
Die Cooler Failure Analysis:
Cracking:
Diffusion of bronze product into the steel makes the rim susceptible to cracking above 723C.
Cracks allow embrittling elements such as Zn and Cu from liquid bronze spills to reach bulk material to progress cracking.
Cu
Zn
Fe
Bronze Spill
High temperatures change the microstructure and degrade material properties.
Distortion:
The bore distorts along its length, most significantly the constriction 20mm below the upper rim separates the die from the die cooler.
Measured inner bore constriction.
FEA predictions show that heat from bronze solidification causes high thermal gradients near the constriction bore depth, resulting in permanent distortion.
Die Cooler
Inner Bore
Graphite Die Section
Coolant Channel
Solution:
Material Selection:
ANSYS Granta software used to explore material options.
Optimization of thermal stability and distortion resistance.
Also consider cost, weight and service temperature.
Tool steel family shown to have improved performance over original mild steel.
Prototype:
Uddeholm Orvar 2M Tool Steel
1020/1040 Mild Steel
Hybrid design with Uddeholm Orvar 2M (H13) Tool Steel and 1020/1040 mild steel.
Choices were influenced by the national availability of materials and the manufacturability of tool steel.
Welding and heat treatment plans were developed.
AW Fraser will test the performance of the planned prototype in 2023.
Students:
Megan Belton
Jack Steel
Hayden Treanor
Fraser Scanlen
Sponsors:
Phil Benson
Torsen Mohrle
Contributors:
Dr Catherine Bishop
Dr Oscar Torres
Dr Milo Kral
Dr Mathieu Sellier
Dr Natalia Kabaliuk
Sam Plummer
Shaun Muccio
UC Workshop Staff

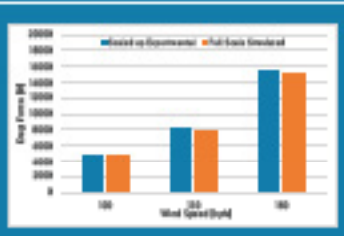
THE FARRA HIGH RISER

PROJECT GOALS

- Investigate historical wind speed data for a range of cities
- Review relevant wind and scaffolding codes
- Design and test aerodynamic cladding solutions for the original High Riser shape using Computational Fluid Dynamics (CFD) and a wind tunnel with the aim of allowing the High Riser to be used in extreme wind conditions
- Investigate a range of cladding materials and recommend the most appropriate solution
- Select appropriate horizontal restraints using testing results

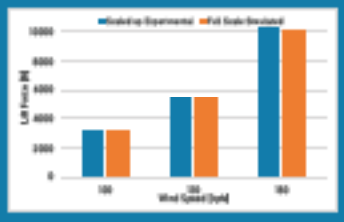
BASELINE CONCEPT: 45 DEGREE SHELL WITH TRUSSES

1:20 SCALE MODEL



DRAG FORCE ON THE FULL SCALE MODEL VS. WIND SPEED

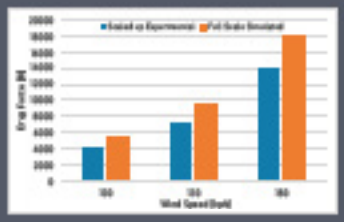
CFD PRESSURE MAP



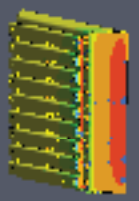
LIFT FORCE ON THE FULL SCALE MODEL VS. WIND SPEED

ADVANCED CONCEPT: INVERTED AEROFOILS

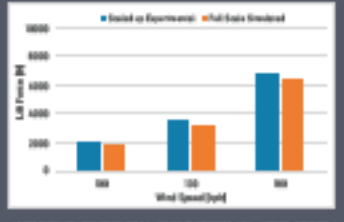
1:20 SCALE MODEL



DRAG FORCE ON THE FULL SCALE MODEL VS. WIND SPEED



CFD PRESSURE MAP



LIFT FORCE ON THE FULL SCALE MODEL VS. WIND SPEED

THE ORIGINAL HIGH RISER: Spencer on Byron Project (2017).

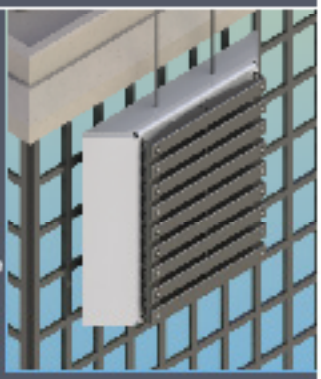
A modular building maintenance unit used for façade refurbishment

EXPERIMENTAL WIND TUNNEL TESTING: Our team manufactured 1:20 scale models of each aerodynamic cladding concept which we then tested in a wind tunnel at speeds of 60 – 180 km/h to determine drag and lift forces.

COMPUTATIONAL FLUID DYNAMICS (CFD): The aerodynamic performance of each concept was simulated using CFD to determine the drag and lift forces, alongside the drag coefficient. The models were validated by comparing the simulated results with the experimental results before scaling up the model to the High Risers full size.

THE FINAL CONCEPT

The final cladding concept uses a combination of inverted airfoils and a 45 degree shell. Compared to the original High Riser design the additional airfoils reduce the lift force pulling the cradle away from the building, and the 45 degree shell streamlines airflow over the cradle. Polyethylene was chosen as the cladding material as it was the most economical, low weight, and high strength option.



PROJECT OUTCOMES

- Our team provided concepts for the cradle shape, horizontal restraint system, and cladding material that will reduce the restraint loads and make the High Riser safer and more efficient than other scaffolding products on the market.
- Using advanced analysis such as wind tunnel testing and CFD, our team provided wind loading data for a range of complex cladding geometries that Wind Code Standards alone cannot provide.
- We also verified that using simple procedures such as following the New Zealand and International Wind Code Standards are valid methods for evaluating wind loading on a non-complex cradle shape.

GROUP MEMBERS: Katie Rata Gotlieb, Maurice Polz, Morgan Gibbons, and Jarrod Harrison
PROJECT SUPERVISOR: Professor Geoff Rodgers
CORPORATE SPONSOR: Thomas Schweitzer, Design and Innovation Manager of FARRA Engineering
SPECIAL THANKS TO: Bill Mahs, David Reid, Terry Doyle, Anthony Doyle, and David Fanner

Total Artificial Heart

Problem statement

There is a high incidence of heart disease and severe lack of available transplants. An artificial heart aims to prolong a person's life until a transplant is available, or possibly indefinitely.

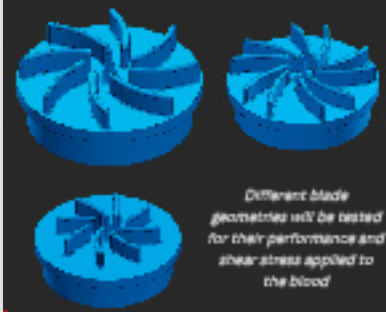
Our goal is to design a compact, implantable system that mimics the pumping action of the heart's left and right ventricles.

Requirements

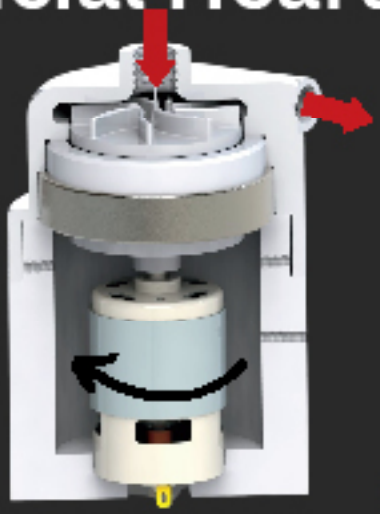
- 5-7L/min of flow
- Pressure equivalent to 120/80 [mmHg]
- Avoid damaging the blood cells

Pump design

The first prototype is a centrifugal pump with turbine blades designed to pump blood without damaging it. The pump housing is manufactured using 3D printed tough resin for precision and water-tightness. A modular design allows for quick switching of blades, for rapid testing.



Different blade geometries will be tested for their performance and shear stress applied to the blood



Our current prototype uses a DC motor to power a 3D resin printed blade.

Future plans

Future Heart Design

- Magnetically levitated
- Dual Chamber
- Electromagnetic motor

Future Control Design

- Measurement of body's impulses
- Adaptive flow output

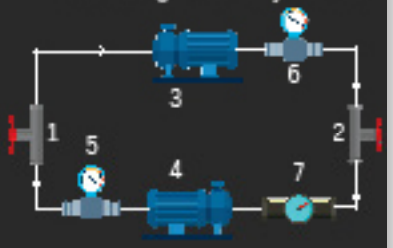
Future designs will use a dual-sided magnetically levitated turbine to emulate the left and right ventricles, transporting both oxygenated and deoxygenated blood.

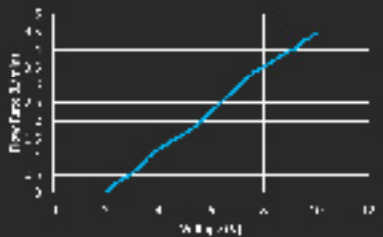
The Heart Hackathon

The Heart Hackathon is the world's first tertiary total artificial heart design competition. Student teams from around the world will compete to design and prototype a total artificial heart.

Testing station

The testing station allows for verification of the heart's output by simulating the systemic (1) and pulmonary (2) loads of the body. The left and right ventricles are represented by pumps (3, 4). The pressure (sensors 5 and 6) and flow (sensor 7) are measured frequently, allowing for a control system to adjust the pump's output according to the body's needs.





The testing station is capable of measuring a pump's pressure and flow output to verify the heart's performance

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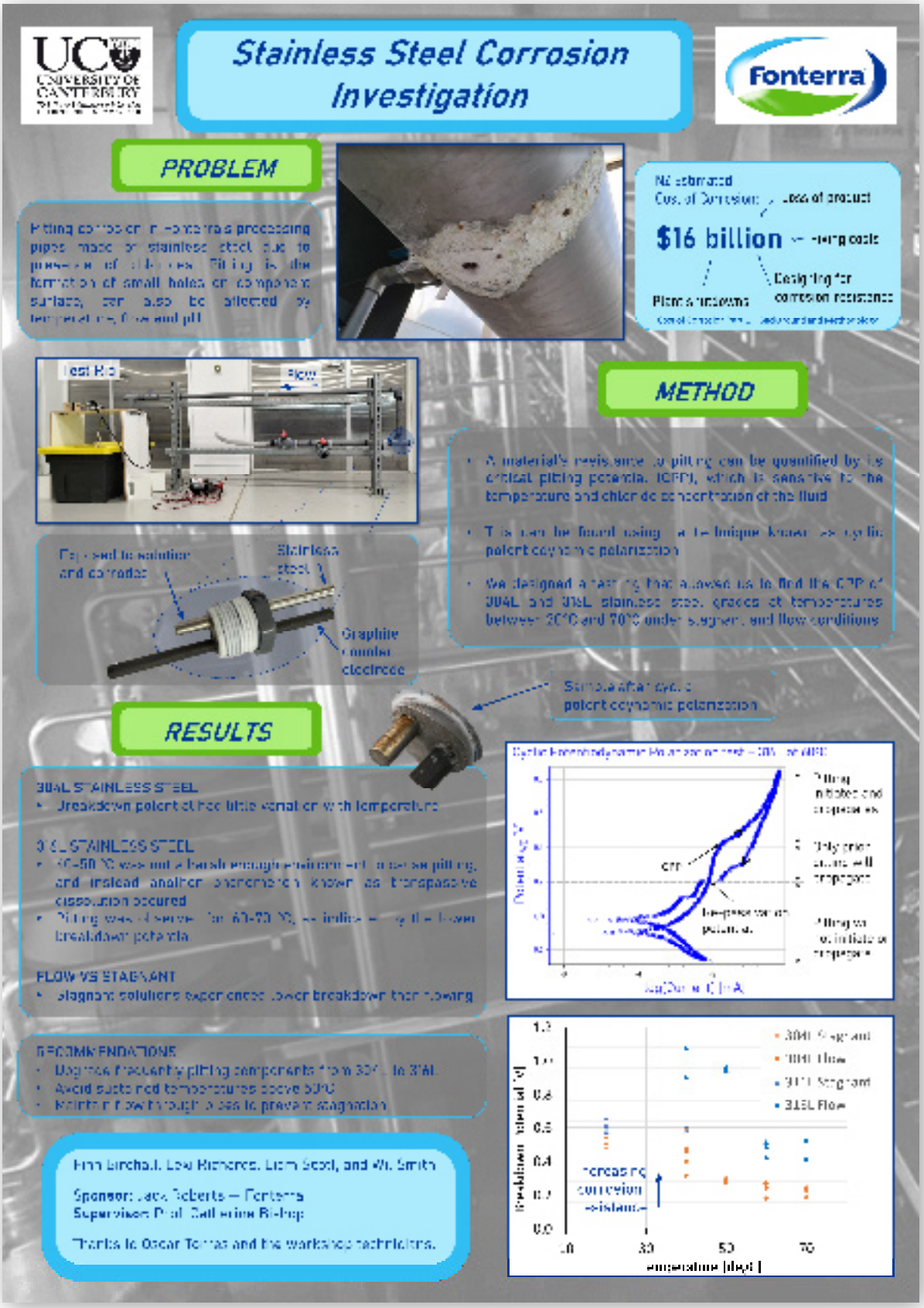
TEAM M10

Luke Forrester
Sarah Maclean
Harvey Morton
Anahita Piri
Christoph ten Houte de Lange

Dr Debbie Munro

Student projects: Mechanical Engineering and Mechatronics Engineering



Measurement of Heavy Vehicle Towing Forces

TRANSTECH DYNAMICS LTD
CONSULTING ENGINEERS

Purpose

The purpose of this project was to design a system which could attach to a truck trailer and measure the axial towing forces, trailer acceleration and location.

Specifications

- Battery powered - minimum life 24 hours
- Be able to measure in excess of the expected forces from NZS5446:2007
- Be equipped with GPS and an accelerometer
- Force measurement accuracy of +/-3%
- Be capable of withstanding life on a trailer

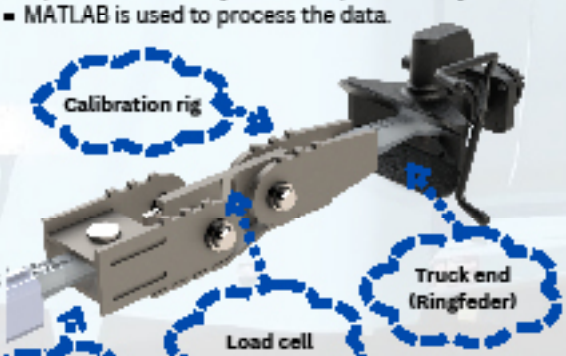
A trailer drawbar with the system installed

Solution

- Strain gauges are glued onto the drawbar to measure strain. These can be calibrated to output the force transmitted through the draw bar.
- A datalogger stores the strain measurements, location and acceleration from several modules.
- A power tool battery is used to power the system.
- MATLAB is used to process the data.

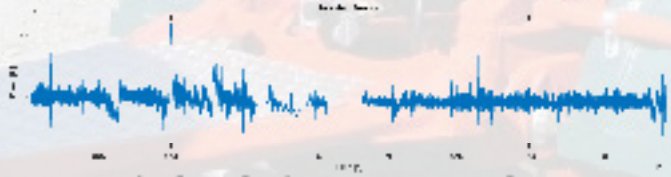
Calibration

- A calibration rig was designed to calibrate the strain gauges upon installation. This does not remain on the trailer.
- The rig is placed between the truck and trailer. The truck pulls forward and exerts a force through a calibrated load cell. This known force is used to calibrate the strain gauges applied to the draw bar.



Testing & Results

- The system was tested on a truck and trailer.
- A sample of the non-calibrated force measurements is shown below.



Strain gauges being applied to a drawbar

Team: Caleb Emmens, Ethan Stewart, Jack Fairnaid, Matthew Emmett
Sponsor: TransTech Dynamics Ltd
Client mentor: Dr Tom Brooks
Supervisor: Dr Angus McGregor
Technicians: Oscar Torres, Julian Phillips, Julian Murphy, Zac Peraton, Tony Doyle, Antony Doyle, Garry Cotton, David Fanner
Special thanks: Special thanks to Frews Transport in Darfield for allowing us to test the system on one of their trailers.
CAD Models: CANedge2, CANmod.gps: https://csselectronics.com/ Battery: Grabcad - user: DS Measurement node: https://illiasystems.com/ Ringfeeder: TransTech Dynamics Strain gauge: https://www.tml.jp/

UC UNIVERSITY OF CANTERBURY

FYP Project M13
This project was made possible by the University of Canterbury

CYBER POTATO

MOTIVATION

Wyma Solutions are world leaders in innovative post harvest processing of fruit and vegetables. They are seeking a solution to reduce the damage occurring to their potatoes.

PROJECT AIM

To create a data acquisition device to identify impacts on a potato as it travels down a packhouse line. The data collected will help Wyma to accurately quantify and locate impacts occurring to a potato. This means their packhouse line can be modified to reduce bruising and wastage.

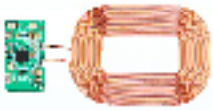
SOLUTION

ORIENTATION

Uses 9DOF IMU with sensor fusion to determine the impact orientation at a sample rate of 25Hz.

IMPACT ACCELERATION

Records impacts up to 500g at a sample rate of 3.2kHz.



WIRELESS CHARGING

Allows for waterproof charging of the device with a 4 hour battery life.

SHELL DESIGN

Urethane coated, 3D printed shell has a density of 1.08g/cm^3. This provides mechanical properties that mimic that of a real potato.

SOFTWARE

Wi-Fi user interface enables control of data acquisition and access to test results from any wireless device.

PROJECT TEAM
Azmansh Manipandthy
Amos Plumpton
Yazmin Shipley
Pravin Tangavelu

SUPERVISOR
Dr Chris Pretty

TECHICIAN
Julian Murphy

CLIENT
Wyma Solutions
Cory Smitheram

wyma
THE BEST FROM EVERY HARVEST

Vegetable Polisher Clean In Place System

Problem

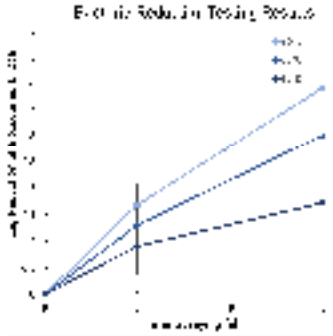
The Wyma Vegetable Polisher cleans produce post harvest. Over time dirt and vegetable debris build up on the interior walls and brushes which can hinder performance and potentially support bacteria growth. Currently, Wyma's vegetable polishers are manually cleaned which is highly time intensive and produces variable results.

Aims

- Remove vegetable debris from the interior walls and brushes
- Determine requirements for bacteria reduction
- Integrate into a built-in clean in place system

Bacteria Testing

- Log reductions of E. Coli on brushes were measured after simulated cleaning at 65–85°C.
- Implementing 5s spray @ 85°C for 1.5 log reduction based on reduction requirements and minimising water usage.



Log reduction 5s @ 85°C:
mean=1.68; std dev=0.34;

Brushes and Interior Walls Testing

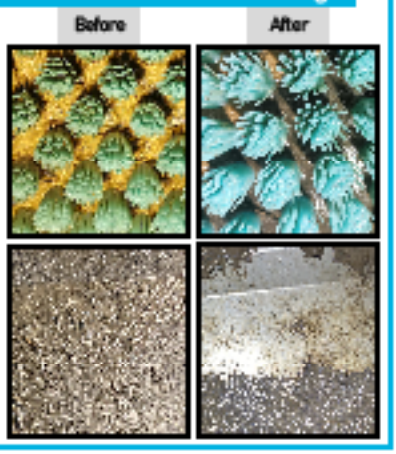
1m long spray bar @ 5 bar pressure with interchangeable nozzles

↓

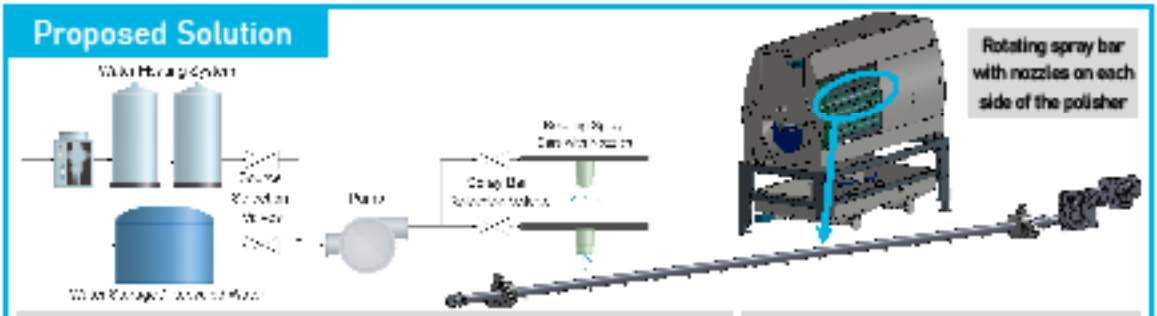
Bar in stationary position at set distance away for the test

↓

Apply water for set period of time (30–60s)



Proposed Solution



Daily Cleaning Cycle

Step 1: Clean Interior Walls:

- High pressure water flows through 65° fan nozzles at 5 bar, 7.7 L/s
- Two spray bars rotate sequentially to reach all interior walls surfaces
- Reaches distances from 90 mm to 1000 mm
- Total water usage: 2,500 L per cycle

Step 2: Clean Brushes

- High pressure water flows through 65° fan nozzles at 5 bar, 7.7 L/s
- One spray bar operates by remaining stationary as polisher drum rotates, 150 mm away from brushes
- Total water usage: 14,000L per cycle for a 14 brush shaft polisher

Weekly Cleaning Cycle

Bacteria Reduction Phase:

- Water heating system delivers 85°C water at 2.5 L/s
- Low pressure heated water flows through 65° nozzles on spray bar
- One spray bar is able to spray all brushes
- Total water usage: 1500L per cycle

University of Canterbury

Project Team Members:
Max Bowron
Nathan Pain
Stephanie Lee
Kate Wells

Supervisor:
Dr Angus McGregor

Client: Wyma Solutions
Dr Kent Stewart

Acknowledgements:
Rayleen Fredericks
Garry Cotton
A. S. Wilcox & Sons
Crozier Farms

wyma

VOLLĒ GOLF: GOLF SWING MACHINE

Cole Baker-Smith, Lewis Griffin, Sam Middelberg and Ben Remacha

Client Background

Vollē Golf was founded in 2018, launching New Zealand's first premium direct-to-consumer golf ball. It was a commercial success, and Vollē began looking ahead to new and continued product development.

Having been conducting their product testing with an independent company in the United States, they found the process to be expensive and cumbersome. So, the idea was born to design and build a test bed capable of replicating a golf swing through impact so Vollē can locally test new ball designs.

Proposed Solution

Design Criteria

To be a success, the design needed to meet these six criteria:

- **Consistent** — Must produce repeatable results
- **Interchangeable** — Can hit all major types of golf clubs
- **Adjustable** — Can change swing speed and impact angle (AoA)
- **Presentable** — Will become a marketing tool
- **Transportable** — Needs to be used for offsite testing and demo days
- **Simple UI** — Easy to modify swing parameters

Motor Platform

The motor platform provides a stable mounting point for a 3-Phase AC servo-motor. The motor can deliver swing speeds up to 110 Mph, and produces consistent swings every time. The shaft angle can be adjusted to suit the type of club being hit.

Ball Tracking

An off-the-shelf launch monitor can be set up and used to get real time data of every shot.

Rotating Arm

An aluminium arm reinforced with steel brackets provides a lightweight and rigid solution. The club is mounted in quick change clamps at the bottom of the arm.

Acrylic Shrouds

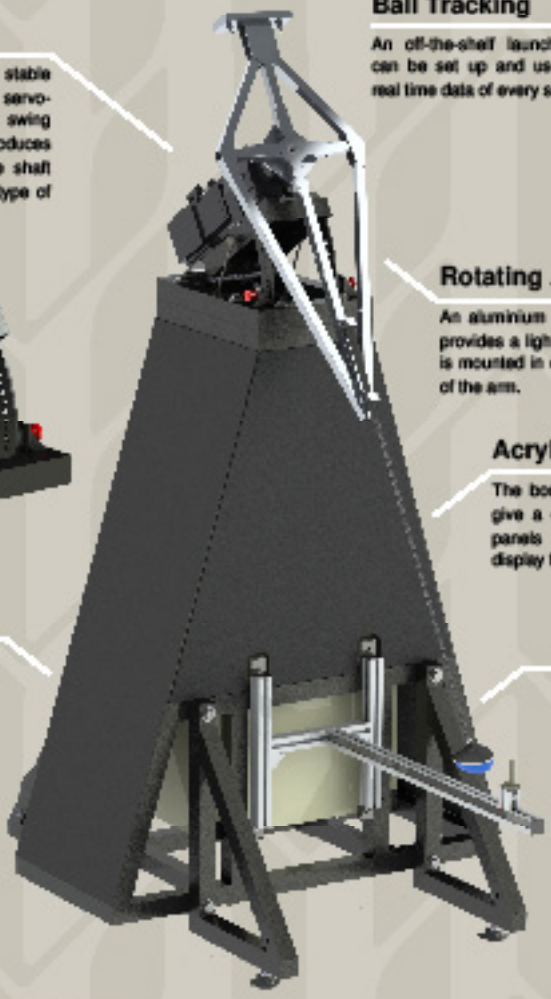
The body of the machine is shrouded to give a clean finish to the design. These panels can also be screen-printed to display the clients branding.

Transportable Design

The motor platform, tee box and legs can all be removed for transport. When disassembled, the machine can be transported using a standard sized trailer. Wheels are also mounted to the rear legs to make transport easier when fully assembled.

Tee Positioning

To be able to hit with different clubs, the tee is mounted to a cantilevered arm that can be moved and locked in place anywhere in the tee zone. This is also how the impact angle (AoA) is changed.



UC UNIVERSITY OF CANTERBURY

Special thanks to:
Tim Gilfrey (project supervisor), Tony Doyle and the UC Mechanical Workshop, Rodney Elliott, and all other parties who have helped us to achieve our project goals.

Vollē GOLF

Environmentally Friendly Hot Water Heat Pump

Project Brief

Our project tasked us to create a CO_2 heat pump to deliver hot water to an indoor fireplace. A gas fireplace can produce over 8 kW of heat output while an electric fireplace can produce 3 kW of heat output. The aim was to deliver a heat pump that could produce the heat output of a gas fire with the efficiencies and environmental safety of a heat pump. CO_2 was selected as it is an environmentally friendly refrigerant as it has a Global Warming Potential (GWP) of 1, compared to commonly used R290 (propane) refrigerant (GWP of 4) and R32 (GWP of 677).

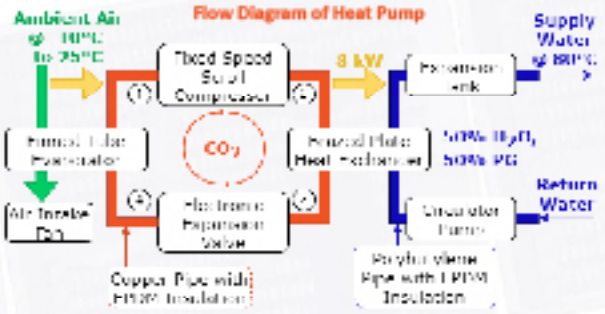
Specifications

- 80°C hot water supplying 8kW of heat energy
- COP higher than 3.5 at 15°C
- COP higher than 2.0 at –10°C
- Sound Pressure Level (SPL) of 40 dB at 1 m from unit.

Deliverables

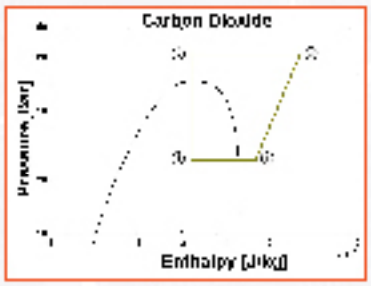
- Component selection and justification
- Component configuration and design layout
- Acoustic and thermodynamic analyses supporting our component selections.

Flow Diagram of Heat Pump



Thermodynamics

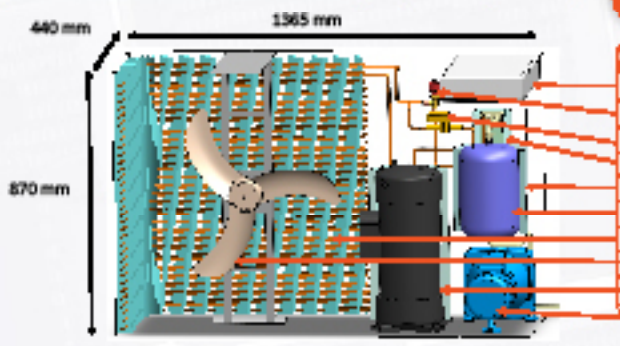
- Engineering Equation Solver (EES) was used to model the thermodynamics
- EES model informed component sizing
- Scope changes lead to comparison with propane.



Acoustics

- Suppliers chosen based off provided sound data
- Fan speed lowered at cost of increasing heat exchanger
- Fan simulated in Comsol to verify sound at 1 m
- Effect of aesthetic housing features compared

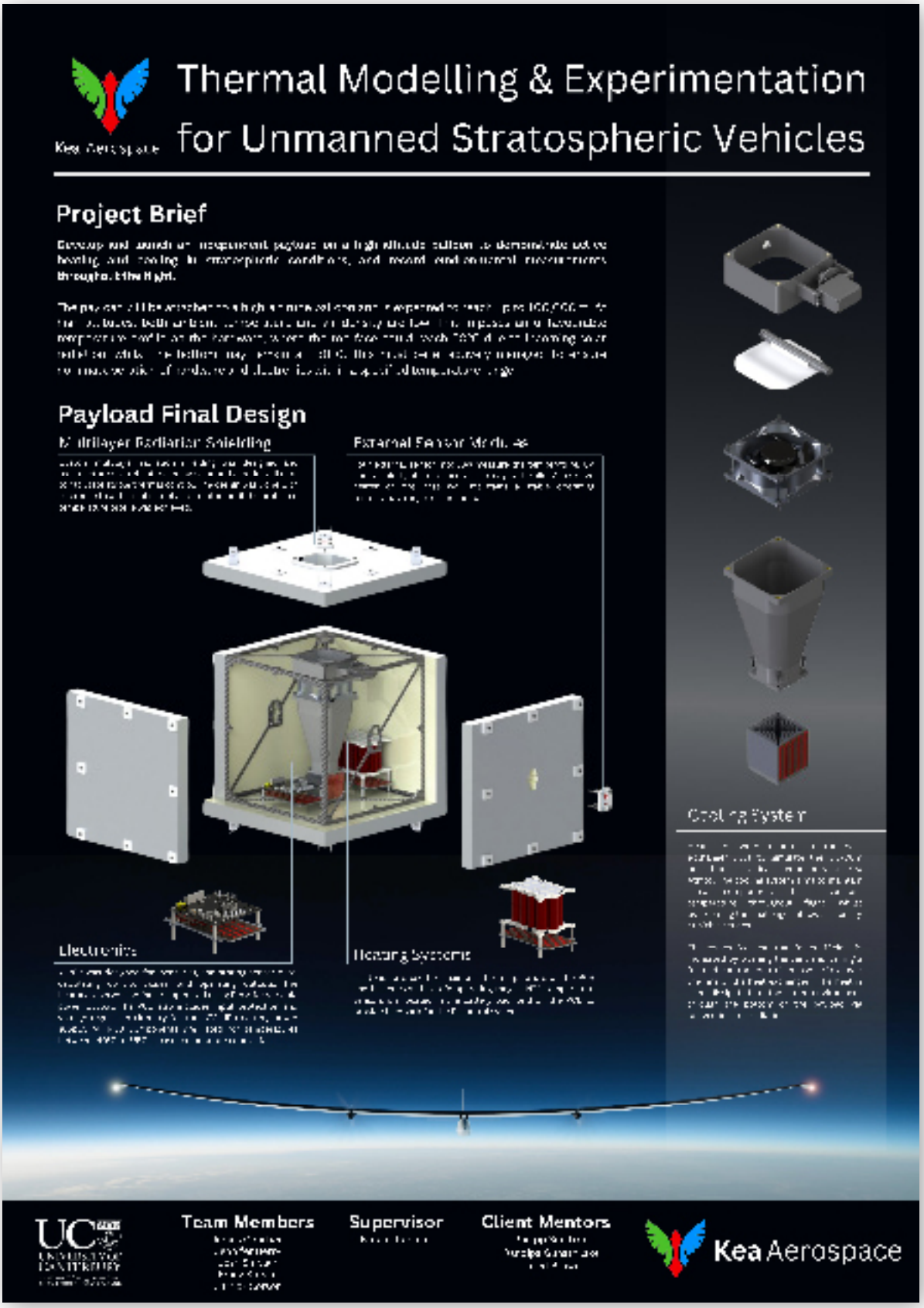
CO_2	Propane
Transcritical	Subcritical
80 bar min. operating pressure	30 bar max. operating pressure
High temp. output	97° max. temp.
Lower COP	Higher COP



Component	Component Sizing
Electronics Box	420x275x85 mm
Electronic Expansion Valve	140 bar max. pressure
Solenoid Valve	Used in defrost cycle
Brazed Plate Heat Exchanger	Surface area of 0.195 m^2
EPDM Insulation	1 inch - 2 inch thick
Water Buffer/Expansion Tank	Volume of 8 L
Fin and Tube Heat Exchanger	Surface area of 25 m^2
Axial Fan	630 mm in diameter
Scroll Compressor	15 cm^3 per revolution
Circulator Pump	10 m Pressure Head

Team Members: David Evans, Josh Stewart, Tim Smith, Jack Yates
Supervisor: Bill Mohs
Clients: James Fisher, Troy Jolly, Luke Davis

escea.


Kea Aerospace
Thermal Modelling & Experimentation for Unmanned Stratospheric Vehicles
Project Brief
Payload Final Design
Multilayer Radiation Shielding
External Sensor Module
Electronics
Heating Systems
Cooling System
Team Members
Supervisor
Client Mentors
Kea Aerospace

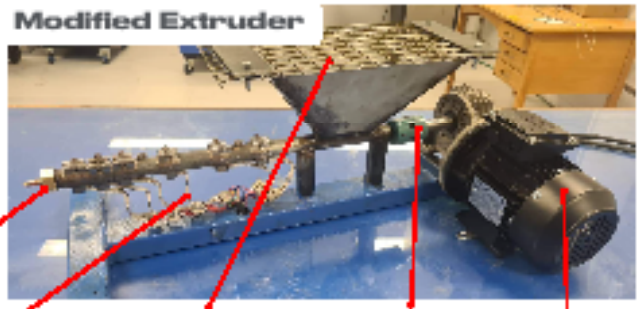
ECO-FRIENDLY REINFORCEMENT FOR CONCRETE

chiptech

OBJECTIVES

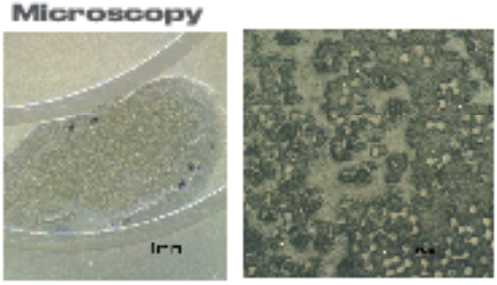
1. Develop a co-axial pultrusion machine capable of producing glass fibre reinforced plastic (GFRP) rods
2. Combine pultruded rods into a single 8 mm rebar
3. Determine the mechanical properties and examine microstructure of the GFRP rebar

Modified Extruder



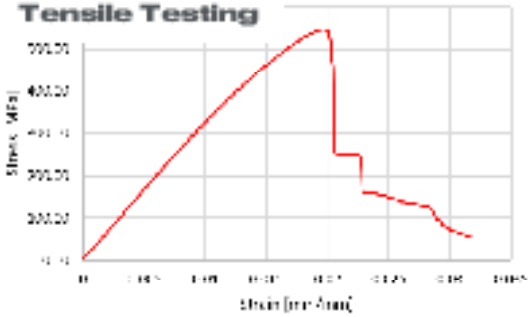
RESULTS

Microscopy



Optical microscopy was used to determine how the degree of impregnation changed with processing parameters

Tensile Testing



Tensile testing revealed that the GFRP rods have an ultimate tensile strength of 545 MPa

The highest quality GFRP rods were produced at a barrel temperature of 230°C with a screw speed of 20 RPM

Pull-out testing

The GFRP rebar with no surface treatment has a pull-out strength of 2.25 kN in concrete

Team:
Daniel Yu
Isambard McMinn
Logan Bigwood
Rousseau Rees-Baker

Supervisor: Prof. Dirk Pons
Client: Anton Good
Special Thanks:
Julian Murphy
Tony Doyle
David Read

UC UNIVERSITY OF CANTERBURY

UCM35

Adam Donaldson, Ryan Morton, Sam Coldicott and Sam Wells.

ELECTRIC LAND SPEED VEHICLE AERODYNAMICS

Project Brief:

Design and manufacture a streamlined and stable aerodynamic package for an electric land speed vehicle. The vehicle will compete in the Dry Lake Racers Association (DLRA) Speed Week and Bonneville Speed Week competitions with the goal to break the current EI class world land speed record.

Aerodynamics

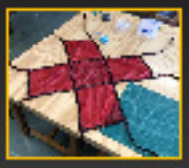
- Low Drag Coefficient: Cd = 0.133.
- Large tail produces restorative moment at all yaw angles.
- Balanced downforce creates stable pitch moment at all ride heights.
- Sharp fin along tail separates flow in yaw to reduce unwanted lift.
- Wedge nose design diverts flow around vehicle to reduce lift.
- ANSYS Fluent computational fluid dynamics (CFD).
- kw-SST turbulence model.
- 20 million element poly-hexcore mesh.

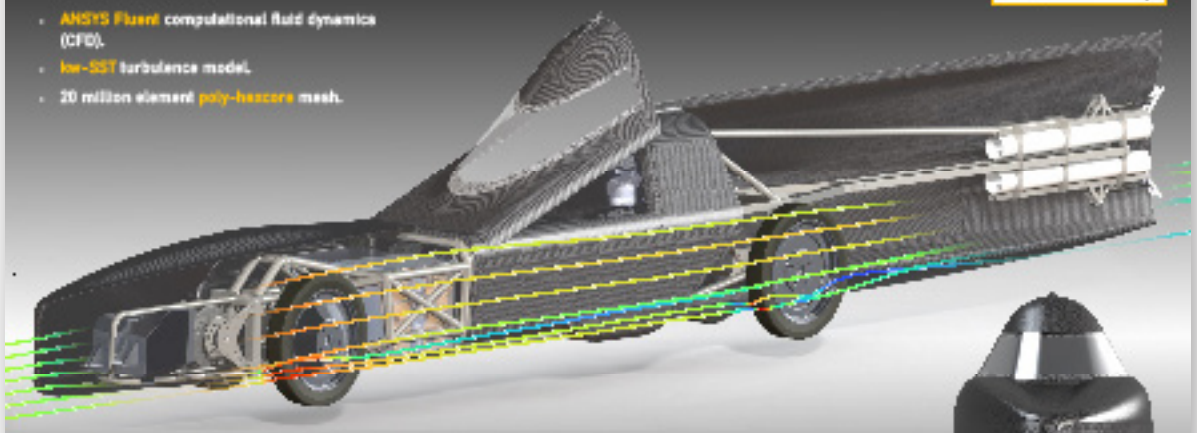
Canopy

- 4 bar linkage hinge mechanism with gas struct actuation.
- 3mm Polycarbonate windshield.
- Actuated from inside and outside for safety in case of rollover.

Parachute and Safety

- 1m diameter UCM made ripstop nylon crossform parachute.
- 0.5G peak deceleration.
- 2.4m commercial drag racing reserve chute.
- Pneumatic actuated release.
- Mechanical and pneumatic relief backups in event of failure.





Thermal Management

- Closed loop ice cooling system for motor and inverter.
- 20L Tank with internal baffle plate.

Composite Manufacture

Composite body panels created from a combination of carbon fibre, Kevlar® and Corecell™ to reduce weight, increase stiffness and produce a smooth surface finish to lower drag.

1. CNC Mould Prepped
2. Carbon fibre layup
3. Carbon fibre resin infusion
4. Finished part released.

UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

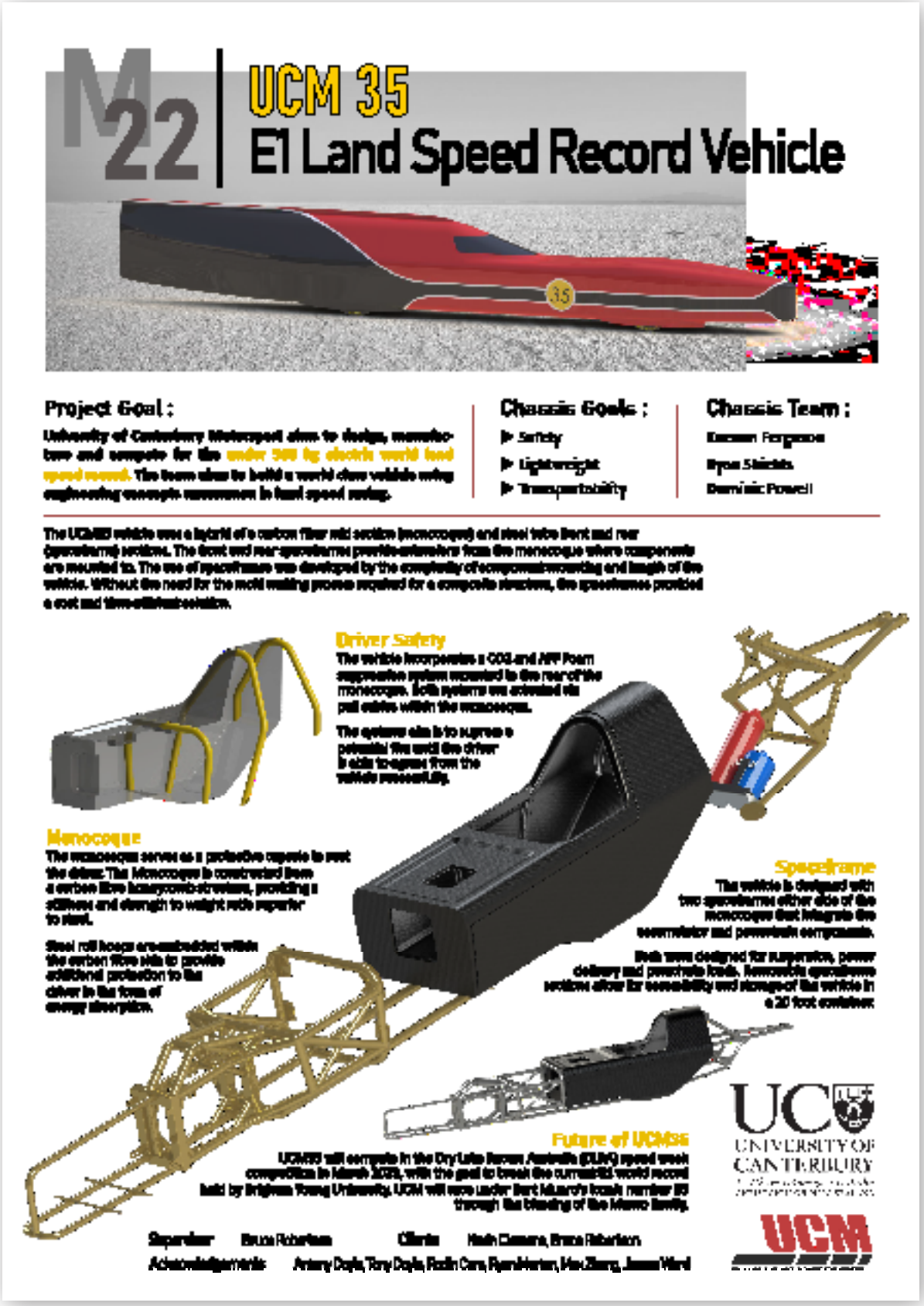
Clients:
Dr. Kevin Clemens
Bruce Robertson

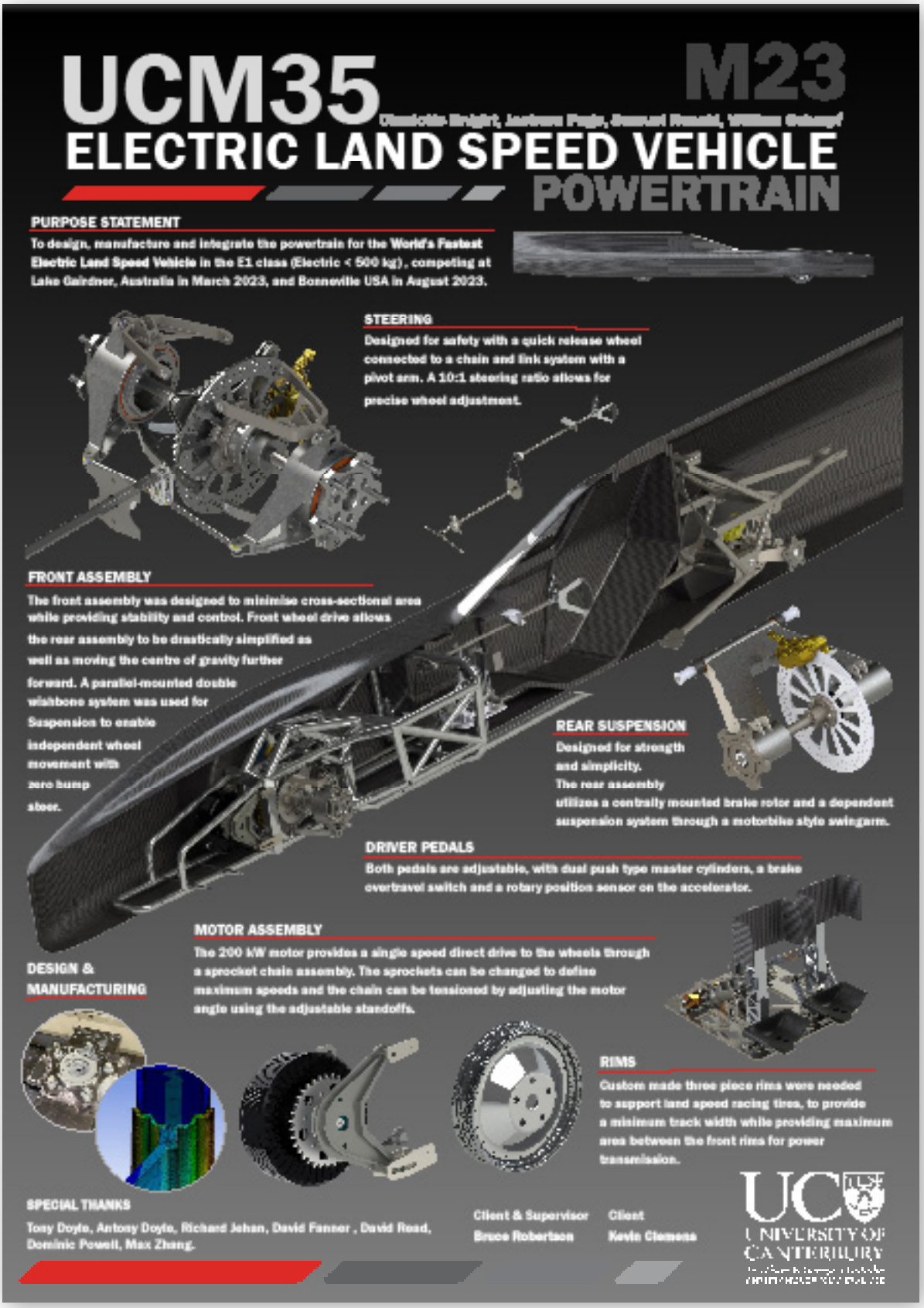
Supervisor:
Dr. Natalia Kaballuk

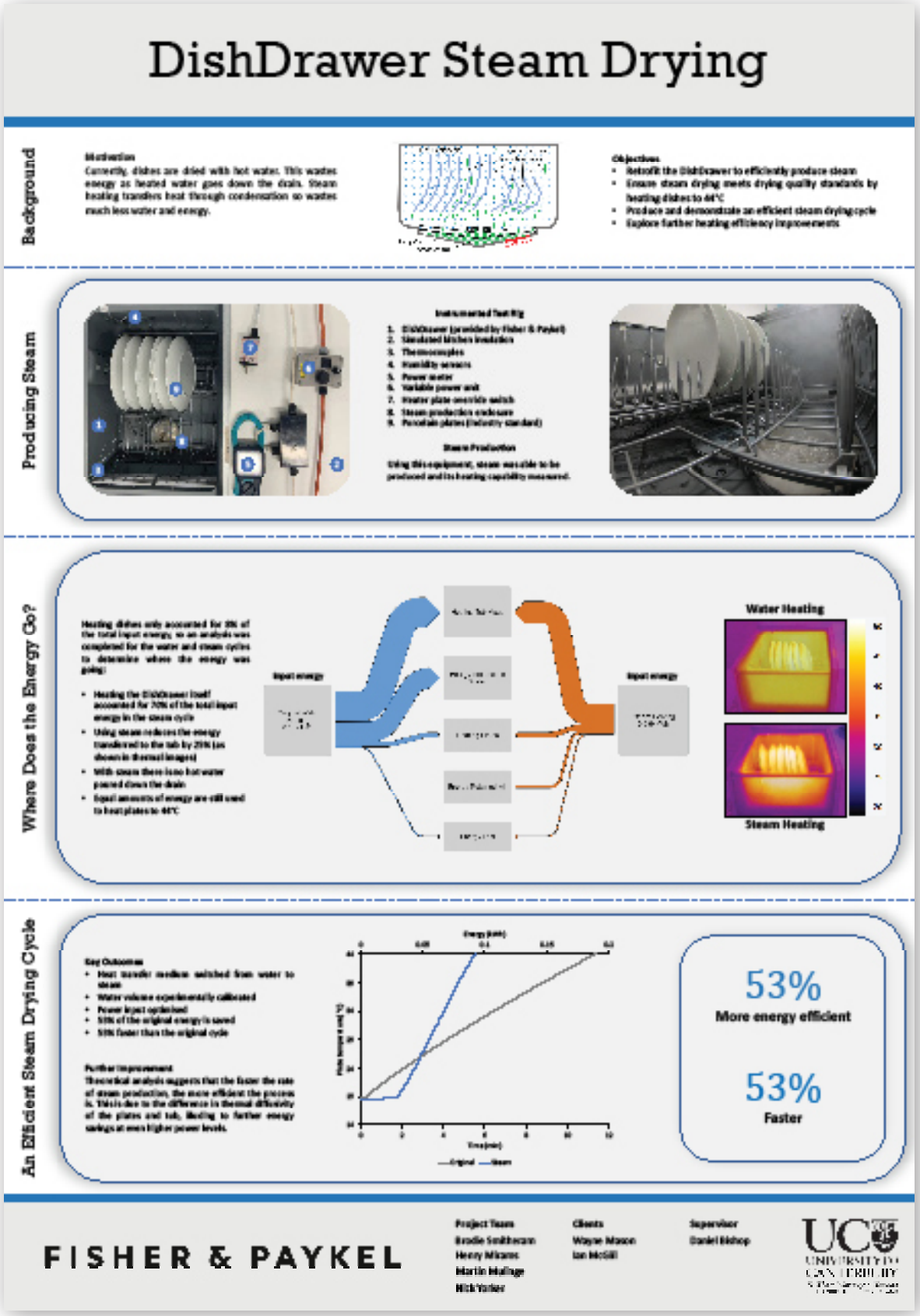
Special thanks:
Mechanical Workshop Staff
Professor Mark Jermy
Dr. Bill Mohs
Dr. Eva Hákansson
Dr. Lewis Clark

UC
UNIVERSITY OF CANTERBURY

Student projects: Mechanical Engineering and Mechatronics Engineering



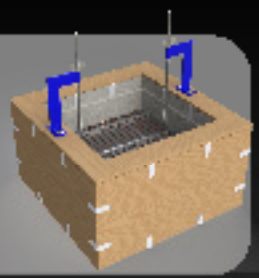

UCM35
M23
ELECTRIC LAND SPEED VEHICLE
POWERTRAIN
PURPOSE STATEMENT
To design, manufacture and integrate the powertrain for the World's Fastest Electric Land Speed Vehicle in the E1 class (Electric < 500 kg), competing at Lake Gairdner, Australia in March 2023, and Bonneville USA in August 2023.
STEERING
Designed for safety with a quick release wheel connected to a chain and link system with a pivot arm. A 10:1 steering ratio allows for precise wheel adjustment.
FRONT ASSEMBLY
The front assembly was designed to minimise cross-sectional area while providing stability and control. Front wheel drive allows the rear assembly to be drastically simplified as well as moving the centre of gravity further forward. A parallel-mounted double wishbone system was used for Suspension to enable independent wheel movement with zero bump steer.
REAR SUSPENSION
Designed for strength and simplicity.
The rear assembly utilizes a centrally mounted brake rotor and a dependent suspension system through a motorbike style swingarm.
DRIVER PEDALS
Both pedals are adjustable, with dual push type master cylinders, a brake overtravel switch and a rotary position sensor on the accelerator.
MOTOR ASSEMBLY
The 200 kW motor provides a single speed direct drive to the wheels through a sprocket chain assembly. The sprockets can be changed to define maximum speeds and the chain can be tensioned by adjusting the motor angle using the adjustable standoffs.
DESIGN & MANUFACTURING
RIMS
Custom made three piece rims were needed to support land speed racing tires, to provide a minimum track width while providing maximum area between the front rims for power transmission.
SPECIAL THANKS
Tony Doyle, Antony Doyle, Richard Jehan, David Fanner , David Read, Dominic Powell, Max Zhang.
Client & Supervisor
Bruce Robertson
Client
Kevin Clemens
UC
UNIVERSITY OF CANTERBURY


DishDrawer Steam Drying
Background
Motivation
Currently, dishes are dried with hot water. This wastes energy as heated water goes down the drain. Steam heating transfers heat through condensation so wastes much less water and energy.
Objectives
Retrofit the DishDrawer to efficiently produce steam
Ensure steam drying meets drying quality standards by heating dishes to 66°C
Produce and demonstrate an efficient steam drying cycle
Explore further heating efficiency improvements
Producing Steam
Instrumented Test Rig
1. DishDrawer (provided by Fisher & Paykel)
2. Simulated kitchen breakdown
3. Thermocouples
4. Humidity sensors
5. Power meter
6. Variable power unit
7. Heater plate override switch
8. Steam production enclosure
9. Porcelain plates (industry standard)
Steam Production
Using this equipment, steam was able to be produced and its heating capability measured.
Where Does the Energy Go?
Heating dishes only accounted for 8% of the total input energy, so an analysis was completed for the water and steam cycles to determine where the energy was going:
Heating the DishDrawer itself accounted for 70% of the total input energy in the steam cycle
Using steam reduces the energy transferred to the tub by 25% (as shown in thermal images)
With steam there is no hot water poured down the drain
Equal amounts of energy are still used to heat plates to 66°C
Input energy
Input energy
Water Heating
Steam Heating
An Efficient Steam Drying Cycle
Key Outcomes
Heat transfer medium switched from water to steam
Water volume experimentally calibrated
Power input optimised
53% of the original energy is saved
53% faster than the original cycle
Further Improvement
Theoretical analysis suggests that the faster the rate of steam production, the more efficient the process is. This is due to the difference in thermal diffusivity of the plates and tub, leading to further energy savings at even higher power levels.
Energy (kWh)
Time (min)
Original
Steam
53%
More energy efficient
53%
Faster
FISHER & PAYKEL
Project Team
Brodie Smitheram
Henry Mikaere
Martin Mullage
Nick Yorke
Clients
Wayne Mason
Ian McGill
Supervisor
Daniel Bishop
UC
UNIVERSITY OF CANTERBURY

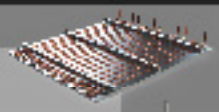
Insulation Testing Rig

Project Background and Objectives

- The ovens designed and produced by Fisher and Paykel Appliances use a 25 mm layer of fibreglass wool wrapped with aluminium foil for thermal insulation of the oven cavity. Fisher and Paykel aim to optimise this insulation to decrease oven energy consumption while protecting the oven electronics.
- This project aimed to build a testing rig which collects measurements of temperature and heat flux across various insulation samples. The results of the tests were used to inform the client about potential insulation alternatives for their ovens.

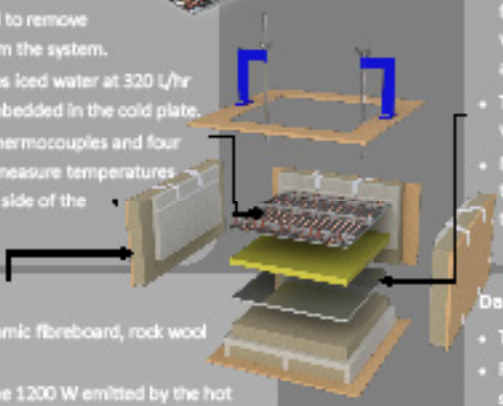


Final Design



Cold Plate

- The cold plate is required to remove up to 1200 W of heat from the system.
- A centrifugal pump pumps iced water at 320 L/hr through copper tubes embedded in the cold plate.
- The cold plate has nine thermocouples and four heat flux transducers to measure temperatures and heat flux on the cold side of the insulation sample.



Hot Plate

- Heat is supplied by four mica plates which heat the underside of two 5 mm aluminium plates.
- The mica heaters are powered by a controller which uses two 600 W power supplies.
- Nine thermocouples are embedded between the aluminium plates to measure temperatures on the hot side of the sample

Housing

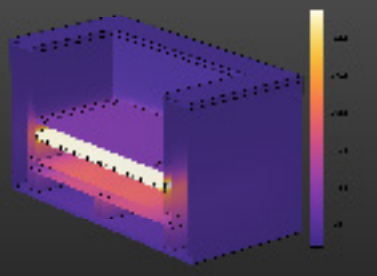
- Made from layers of ceramic fibreboard, rock wool and plywood
- Required to withstand the 1200 W emitted by the hot plate so that the external rig temperature does not exceed 50°C—the "safe to touch" temperature
- Height adjustment mechanism, attached to housing lid, controls the compression of the insulation sample.

Data Acquisition

- Type K thermocouples
- Four differential-temperature thermopile sensors measuring heat flux and temperature (Type T thermocouple)
- Calibrated to 5% accuracy
- LabVIEW software to record data and Excel software to process data

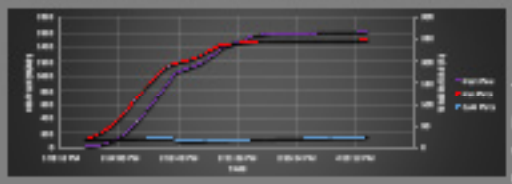
Thermal Simulation in COMSOL

- Time-dependent COMSOL studies were used to study:
  - Distribution of heat throughout the rig
  - Main heat transfer paths and housing heat losses
  - Time required to reach steady state operation



Results

The thermal conductivity was calculated from the data using Fourier's law, where q is the heat flux passing through the sample, T_H is the temperature of the hot plate, T_C is the temperature of the cold plate and L is the thickness of the sample.



$$q = -\frac{k(T_H - T_C)}{L}$$

The k value of this particular sample was determined to be 0.0358 W/m*K

Challenges

Controlling the power output proved to be a challenge when attempting to stabilise the temperature at a desired value. A written procedure will be developed to reduce this difficulty for future tests carried out by Fisher and Paykel Appliances.

Team: Charmi Patel, Diana Kommedal, Nick Corkery and Sam Bonthron
Supervisors: Mathieu Sellier and Daniel Bishop
Special thanks to Julian Phillips, Gary Cotton, Bill Mohs and the Workshop team

Client: Gabriel Castilho, Fleurine Barre-Debilly and Nick Chang

FISHER & PAYKEL

DESIGNING A SUSTAINABLE ALTERNATIVE TO POLYSTYRENE PACKAGING

PROBLEM

Expanded polystyrene (EPS) is commonly used in appliance packaging but is not consistently recycled. The Australian National Plastics Plan now requires companies to phase out EPS by July 2022.

OBJECTIVE

Design and validation of reusable spring dampers for use as appliance packaging. To perform protective duties, alongside being economically and physically viable.

REQUIREMENTS

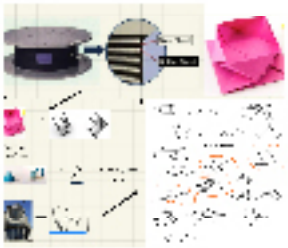
- Protect 45 kg oven from drop
- Stackable & modular
- Stampable & foldable
- Protected from yield for reuse
- Withstand cyclic loading
- Curb-side recyclable

CURRENT PACKAGING

- EPS is not commonly recycled - filling landfills
- Toxic trash exposed to humans and wildlife
- However, EPS is beneficial: lightweight, cheap, mouldable, optimum mechanical properties

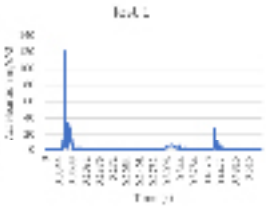
CONCEPT DESIGN

- Researched designs from existing earthquake dampers and complex origami for sheet metal folding
- Brainstormed potential concept designs & selected optimal design



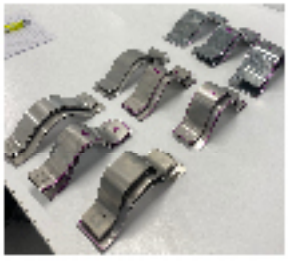
DROP TESTING

- Accelerometer was used to measure the impact of a 300 mm drop height (flat, edge, and corner drops)
- Impact magnitude, force, and impact time recorded for baseline comparison



PROTOTYPING

- Sheet metal bent and formed through press method
- Alterations of bend radii, thickness, width, length, and taper made to optimise design
- Yield preventer added

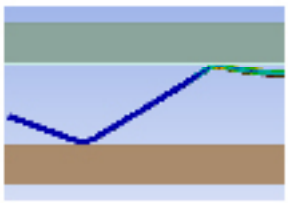


COMPRESSION TESTING

- Single and cyclic compression loading
- Max load, initial stiffness, energy absorbed, and yield extension extrapolated from data
- Designs rated to identify best performing concept

FINITE ELEMENT ANALYSIS

- Non-linear, dynamic, and frictional effects
- Allowed design optimisation by performing parameter studies



FINAL DESIGN

- Taper included for efficient material usage
- Folded ends used as yield preventer
- Optimised parameters chosen to maximise energy absorbed and yield strength

VALIDATION

- Tested in compression with single and cyclic loads
- Yield point identification - tune the yield preventer
- Substitute prototypes into oven packaging and drop test to validate protective performance

FISHER & PAYKEL

CLIENT: ANDRE STEYN, STEPHEN KIM

TEAM: CLAIRE JOHNSTON, CAELUM BETTERIDGE, JOBEN CHAHAIL

SUPERVISOR: MARK STAIGER

TECHNICIANS: BILL MOHS, OSCAR TORRES

UC UNIVERSITY OF CANTERBURY

PA-Kayak

Electric Power-Assist

Background

Power-assist electric bikes allow exploration of New Zealand for riders of all fitness levels.

Our vision is to harness this success into our new product, the power-assist kayak.

Deliverables

We have been tasked with the design and construction of an electric power-assist kayak prototype.

This prototype is to be tested with two drive systems, and we will discuss the advantages of each.

Mirage Drive

+ Can beach easily
+ Shallow water travel
- 1 : 1 gear ratio
- Difficult to implement power-assist

Propeller

+ Reliable
+ High gear ratio
+ Easy to implement power-assist
- Difficult to beach

Inspiration

The recent boom of electric power-assist bikes has allowed a far greater percentage of New Zealanders to explore all it's land regions.

Can this success be applied to a kayak?

BAFANG E-Bike Motor

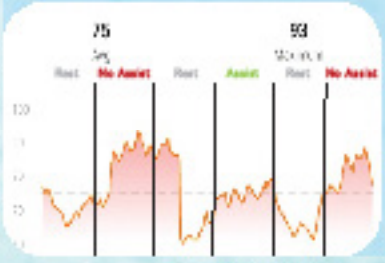
We have chosen a 750W BAFANG e-bike conversion kit to power our drive systems during testing.

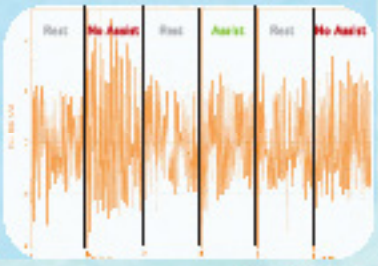
Construction

Major modifications were made to a fibreglass kayak. This involved making room for the drive systems while ensuring water-tightness. The Prototype was then tested at Lake Roto Kahatu, measuring the performance of the power-assist for each drive system.

Test Rig

A test rig was constructed to analyse the users heart rate (left) and breathing flow rate (right) with and without power assist. This testing confirmed that the rider exerted less energy when pedalling with power assist. The test rig also helped develop and validate the two drive systems.





FYP GROUP MZ9

Members: Ethan Roylance, Matt Boyles, Sam Davidge, Sam Garton

SPECIAL THANKS

Supervisor: Dr. Don Clucas

Tony Doyle and the workshop, Julian Phillips, Shayne Crimp

M30 ENZTEC

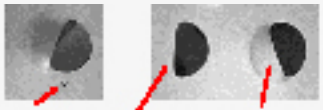
Automated Inspection of Acetabular Reamers

BACKGROUND

ENZTEC produces Acetabular Reamers for total hip arthroplasty. Their product is changing to be single use thus the production will increase. Checks for defects are completed manually but this will no longer be suitable due to the increased volumes.

Currently the most common defects are:

- Unformed teeth



- Dimples and black spots

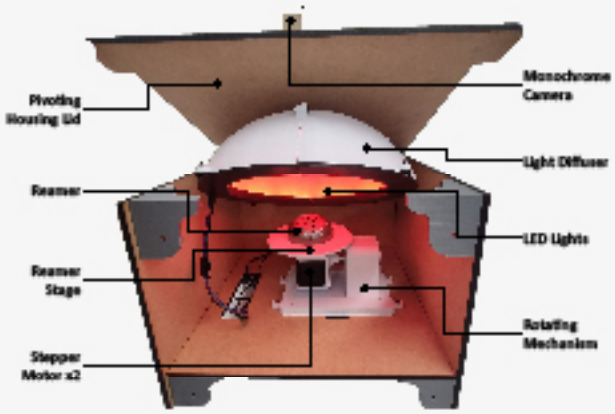
PURPOSE

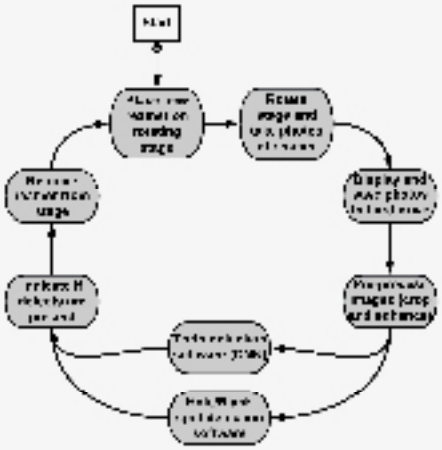
The Acetabular Reamer Inspection team aimed to design and build a device prototype. This prototype will detect the two main types of defects on the top surface of the Acetabular Reamer. The desired outcome was to provide ENZTEC with an automated prototype, validating evidence portfolios, and calculations to confirm the success of the prototypes design.

SCOPE

A proof-of-concept Computer Vision Device with focus on optimising the device for cost and image quality:

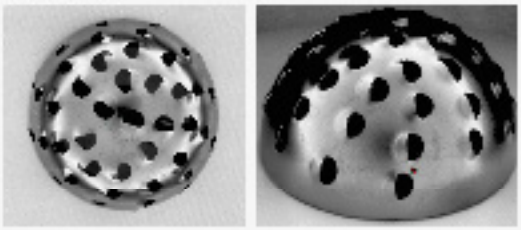
- 1 reamer checked less than 2 minutes ☑ >2 min
- Missing teeth, dimples & black spots ☑ 98%, 92%
- Dimples & black spots of 1 mm minimum ☑ 0.4 mm
- Reamer sizes: 50 to 65 mm ☑ 45 to 66 mm





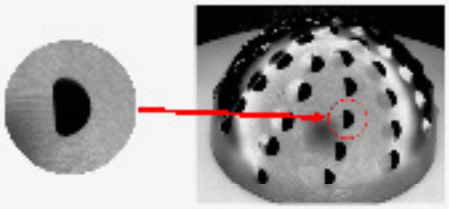
BLACK SPOT DETECTION

The black spot and dimple detection uses the OpenCV blob detection function. The parameters of the function were optimised for this application. They detection method outputs the number of dimples per image and outlines the location of the defect in red. The current accuracy is 98%, with plans to improve this in the future.



UNFORMED TOOTH DETECTION

The Unformed tooth detection method uses a ResNet Convolutional Neural Network with 4 layers to identify missing teeth from. The CNN was built using a dataset of 3493 photos of individual. The CNN was trained off 2788 images, validated using 522 images and tested on 183 images. The current accuracy is 98%.



UC University of Canterbury

Client: Dr Iain McMillan

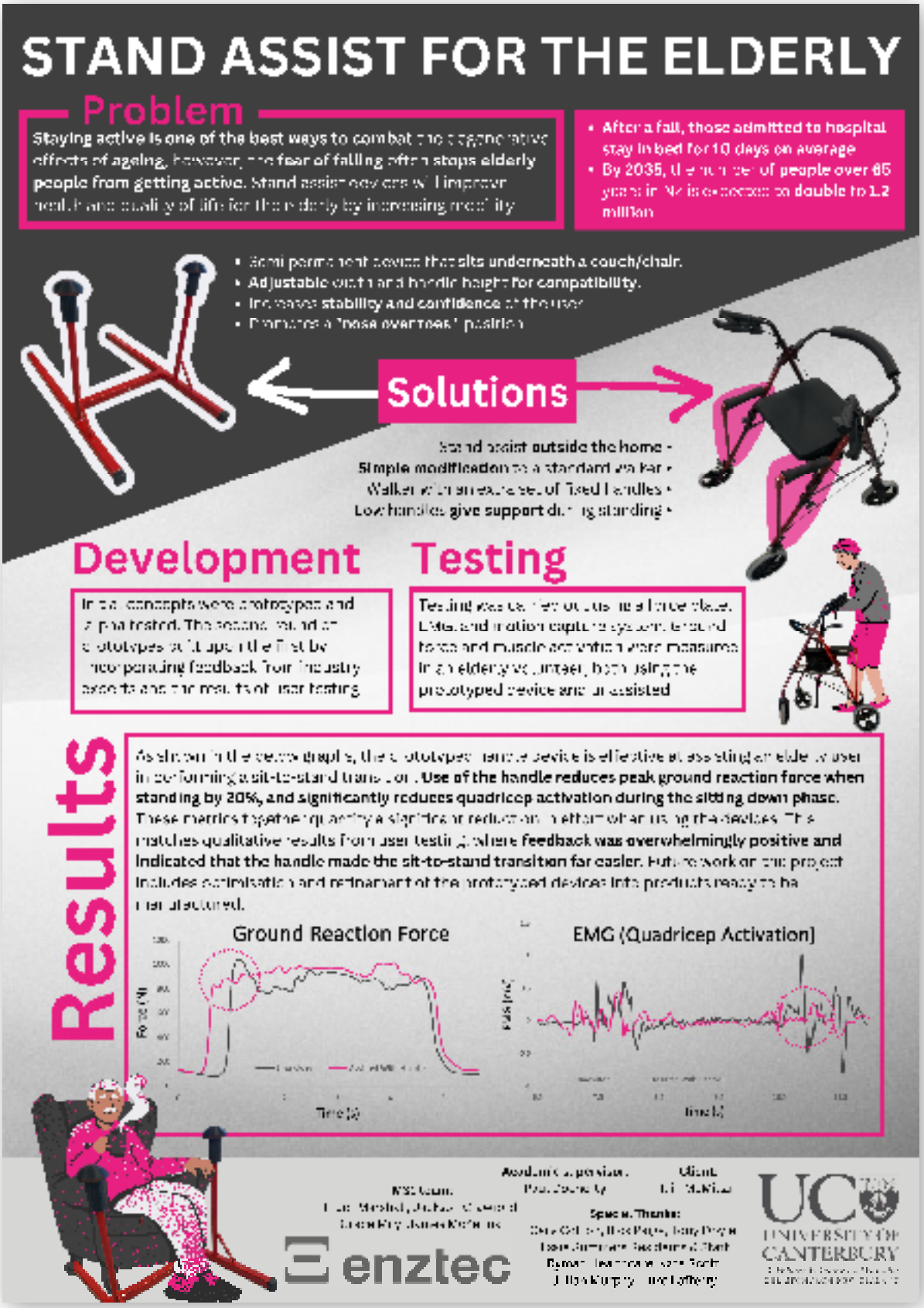
Supervisor: Dr Chris Pretty

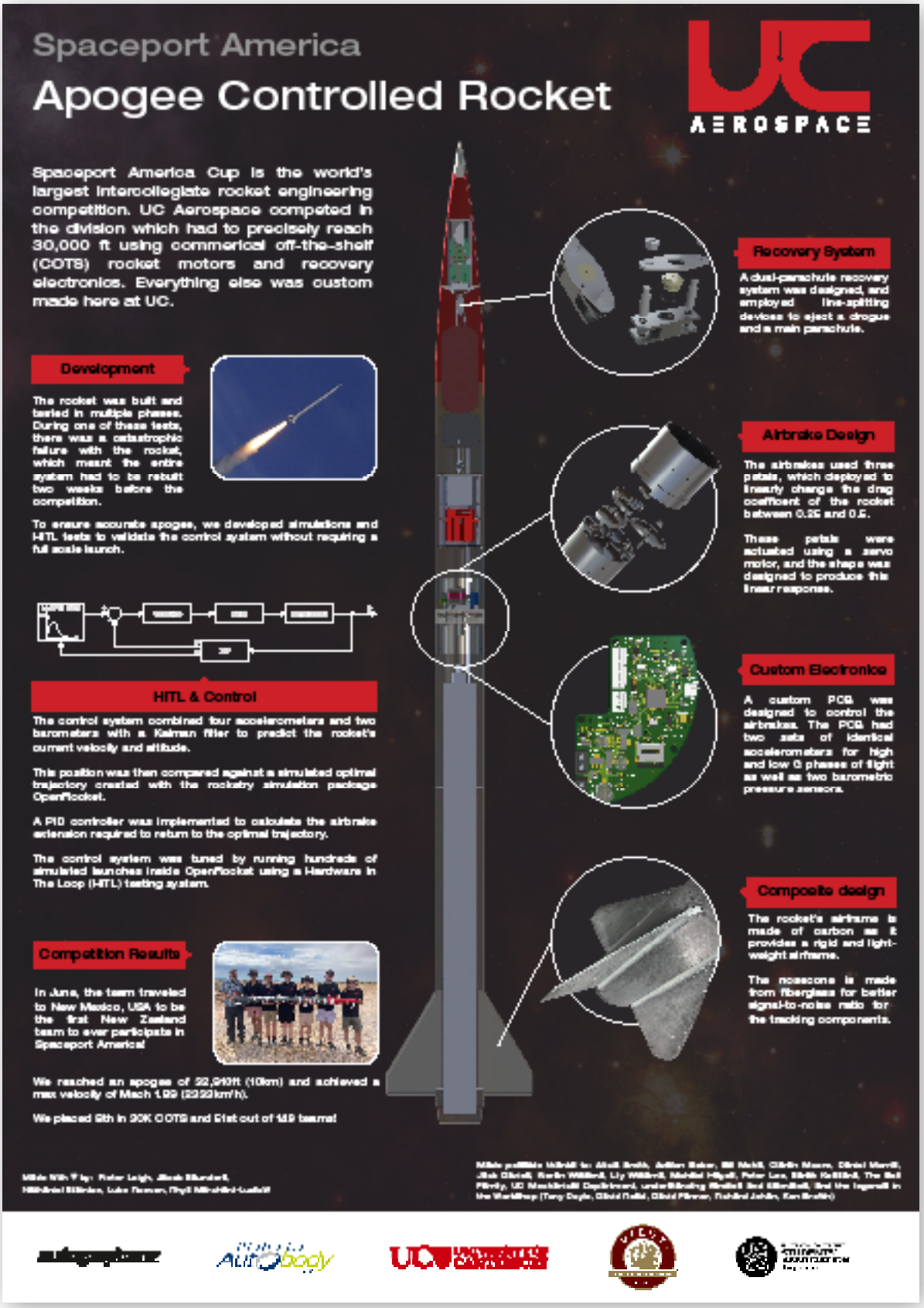
Special thanks to Rodney Elliot and Julian Murphy for their help with the project

Team members:

Daniel Foote
Rikl Drabsch
Amelie Rolfe
Margot Crenshaw

enztec


STAND ASSIST FOR THE ELDERLY
Problem
Staying active is one of the best ways to combat the degenerative effects of ageing, however, the fear of falling often stops elderly people from getting active. Stand assist devices will improve mobility and quality of life for the elderly by increasing mobility
After a fall, those admitted to hospital stay in bed for 10 days on average
By 2035, the number of people over 65 years in NZ is expected to double to 1.2 million
Solutions
Development
Testing
Results
Ground Reaction Force
EMG (Quadricep Activation)
enztec
UC
UNIVERSITY OF CANTERBURY


Spaceport America
Apogee Controlled Rocket
UC AEROSPACE
Spaceport America Cup is the world's largest intercollegiate rocket engineering competition. UC Aerospace competed in the division which had to precisely reach 30,000 ft using commercial off-the-shelf (COTS) rocket motors and recovery electronics. Everything else was custom made here at UC.
Development
The rocket was built and tested in multiple phases. During one of these tests, there was a catastrophic failure with the rocket, which meant the entire system had to be rebuilt two weeks before the competition.
To ensure accurate apogee, we developed simulations and HITL tests to validate the control system without requiring a full scale launch.
HITL & Control
The control system combined four accelerometers and two barometers with a Kalman filter to predict the rocket's current velocity and altitude.
This position was then compared against a simulated optimal trajectory created with the rocketry simulation package OpenRocket.
A PID controller was implemented to calculate the airbrake extension required to return to the optimal trajectory.
The control system was tuned by running hundreds of simulated launches inside OpenRocket using a Hardware In The Loop (HITL) testing system.
Competition Results
In June, the team traveled to New Mexico, USA to be the first New Zealand team to ever participate in Spaceport America!
We reached an apogee of 32,940ft (10km) and achieved a max velocity of Mach 1.99 (2323km/h).
We placed 6th in 20K COTS and 21st out of 149 teams!
Recovery System
A dual-parachute recovery system was designed, and employed line-splitting devices to eject a drogue and a main parachute.
Airbrake Design
The airbrakes used three petals, which deployed to linearly change the drag coefficient of the rocket between 0.35 and 0.5.
These petals were actuated using a servo motor, and the shape was designed to produce this linear response.
Custom Electronics
A custom PCB was designed to control the airbrakes. The PCB had two sets of identical accelerometers for high and low G phases of flight as well as two barometric pressure sensors.
Composite design
The rocket's airframe is made of carbon as it provides a rigid and light-weight airframe.
The nosecone is made from fiberglass for better signal-to-noise ratio for the tracking components.

Tadpole Mobility Scooter

The goal of this project was to design and build an electric mobility scooter with superior geometry and functionality. The client wanted a tadpole design, with one rear driving and two front steering wheels. This gives benefits of a backwards tip causing the user to land on their shoulder rather than head and having clear visibility of the widest point of the scooter with the two wheels placed in front of the driver.

The Client's Current Trike

The "Supa Scoota" has several target areas for improvement:

- Current scooter lacks stability
- Poor controls
- Poor display
- Limited manoeuvrability

Adjustable Prototype

An initial prototype was manufactured using steel for adjustability to test and optimise the scooter geometry. During this design, the team designed with these key deliverables in mind:

- Use of mountain bike components to improve the serviceability
- Better Ergonomics with single hand control and biomechanically designed seating.
- Increased performance of steering, stability, and scooter range

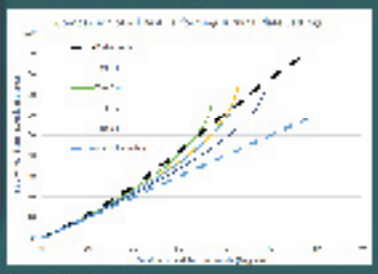
The Key Improvements in the Prototype are Shown Below

Rear Suspension

A single pivot mountain bike design was chosen to offer superior comfort and serviceability.

Ackermann Steering

Due to having two front turning wheels, a simple Ackermann system was a requirement for accurate steering. This was done by including an adjustable turning plate which turns the inside wheel a greater amount than the outside wheel. Optimum settings were found as shown below. These settings were tested on the first prototype, producing turning without slip across the full range.



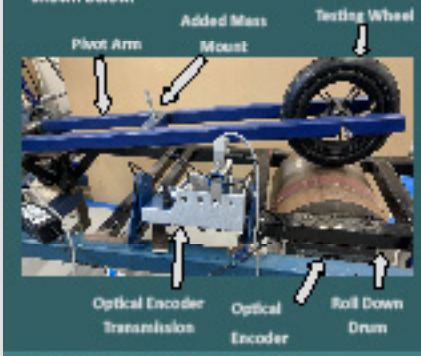
Wheels

To improve the battery life of the scooter, a study into rolling resistance is being conducted to reduce the tractive effort required as below

$$F_{Traction} = F_{RR} + F_D + F_{Inc} + F_G$$

$$\& \; F_{RR} = \mu N$$

To study which tyres have a low rolling resistance, a purpose built roll down dynamometer test rig was constructed, as shown below.



Electronics Design and Implementation

Display

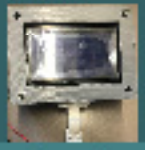
- Shows scooter speed, inclination, battery charge and time
- Enclosed in a weather-proof case

Control Box

- Teensy 4.1 Microcontroller
- MPU6050 IMU (speed and inclination)
- 4-36V Voltage Regulator
- XC4382 BE Bluetooth Module

Motor

- 48V Motor Controller
- 36V 350W Hub Motor
- Powered using a 36V battery



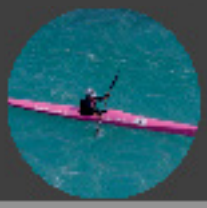
Student Team		Supervisors	Client	Special Thanks To
Max Goodwin	Jacob Clough	Shayne Gooch	Roland Matthews	Tony and the mechanical workshop staff, Edsel Villa, Phillip Hoffman, and Julian Murphy for all their help with the project.
Harry Zarifeh	Omar El-Zahar	George Stilwell		

FOOTPLATE RE-DESIGN

Conor Fuller, Hayden Bull, Tom Abbott, and Benjamin Mitchell

THE PROBLEM

Flow Kayaks current footplate design has poor adjustability and a shorter than expected lifetime. Customers have found cracks developing near the connections and hockey sticks which we aim to solve.

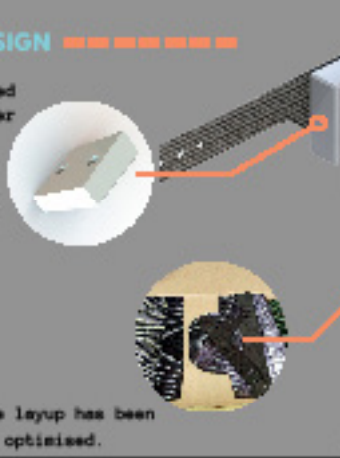


WHAT THIS SOLUTION WOULD ACHIEVE

Our solution targets increased performance from athletes, enhanced strength and durability, improved manufacturing technique and is adaptable to a wider range of multisport kayaks.

THE NEW DESIGN

We have designed 3D printed taper blocks that will allow our product to fit into both Flow Kayaks and competitors boats.



Use of existing parts such as the toe pedals allows our new product to be rapidly implemented into production

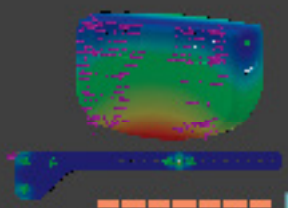
The carbon fibre layup has been computationally optimised.

Flat hockey sticks allow for faster manufacturing and a simplified load path, increasing strength

MECHANICAL TESTING

The team measured the loads exerted on the footplate by various athletes. We also conducted material testing to better understand the mechanical properties of the carbon fibre weaves used by Flow Kayaks.

Carbon Fibre Test Sample



FEA

Finite element analysis was utilised to optimise the carbon fibre layup weave, orientation, and geometry. It also serves as a quantitative gauge to determine the improvement on the original design.

MANUFACTURING

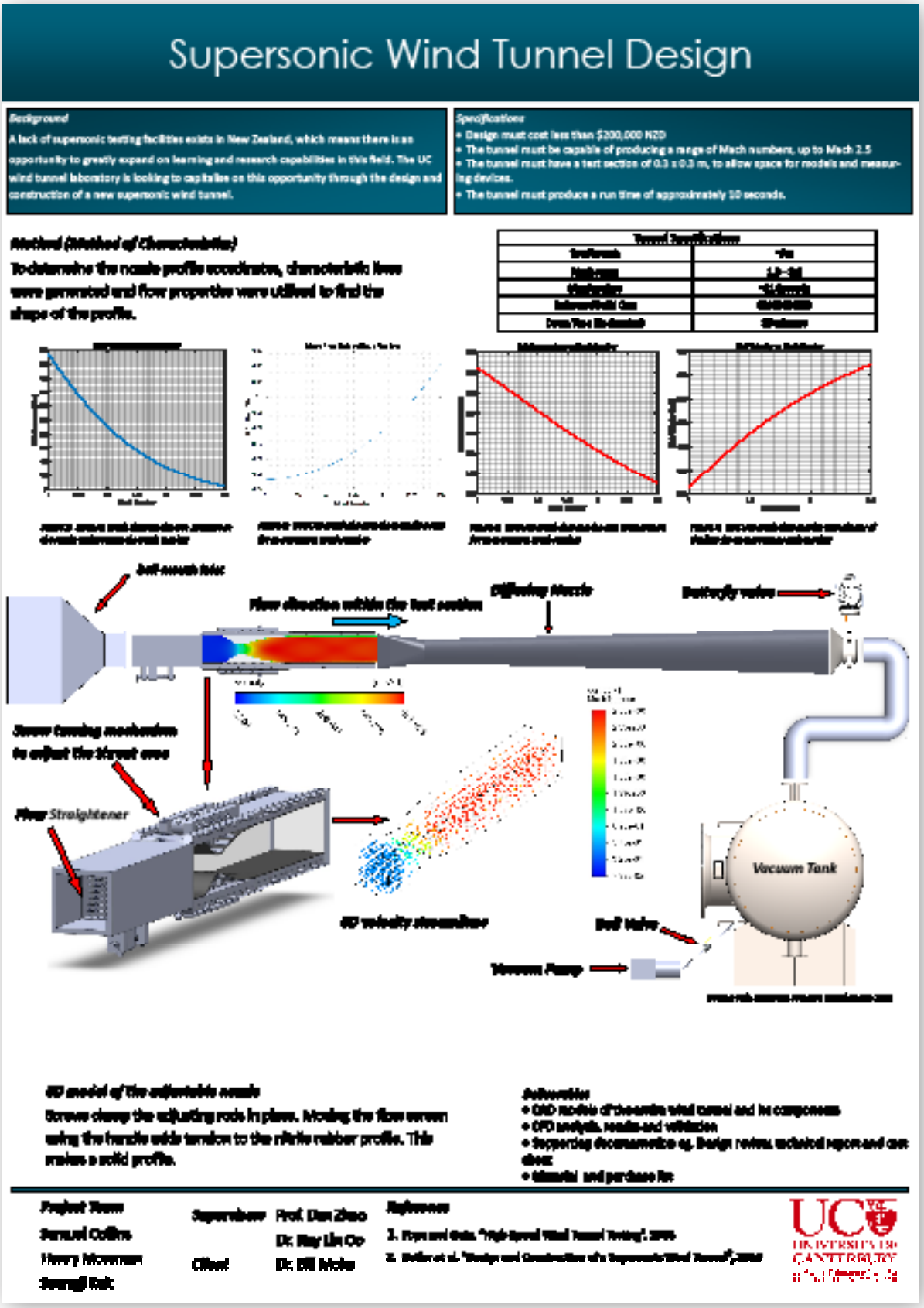
Using an industrial 3D printer the male plug for the footplate was produced, the surface was then prepared to facilitate Flow Kayaks in manufacturing a production mould.

Special thanks to:

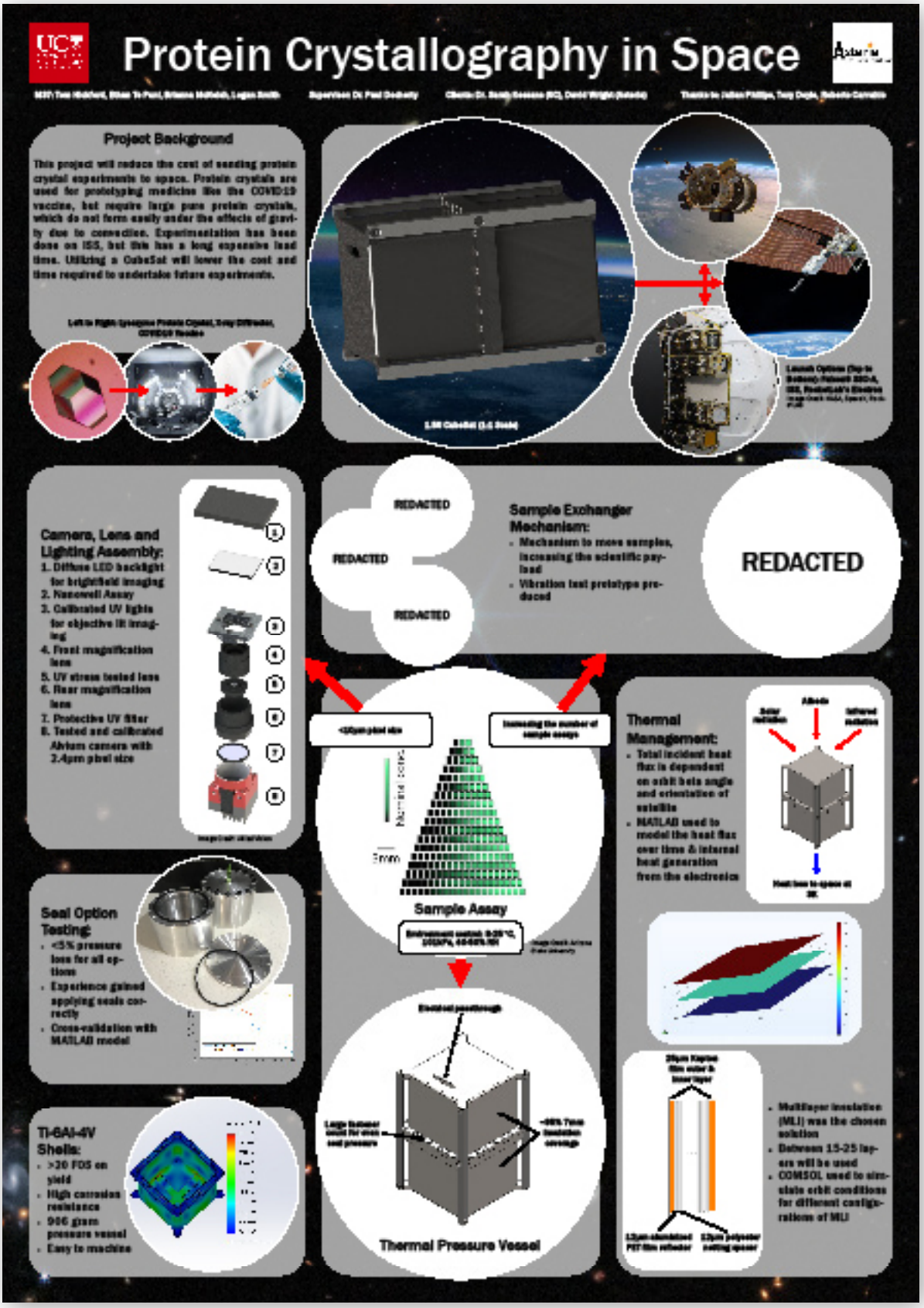
Keith Jessop, Chris Stagg, Oscar Torres and Mark Staiger

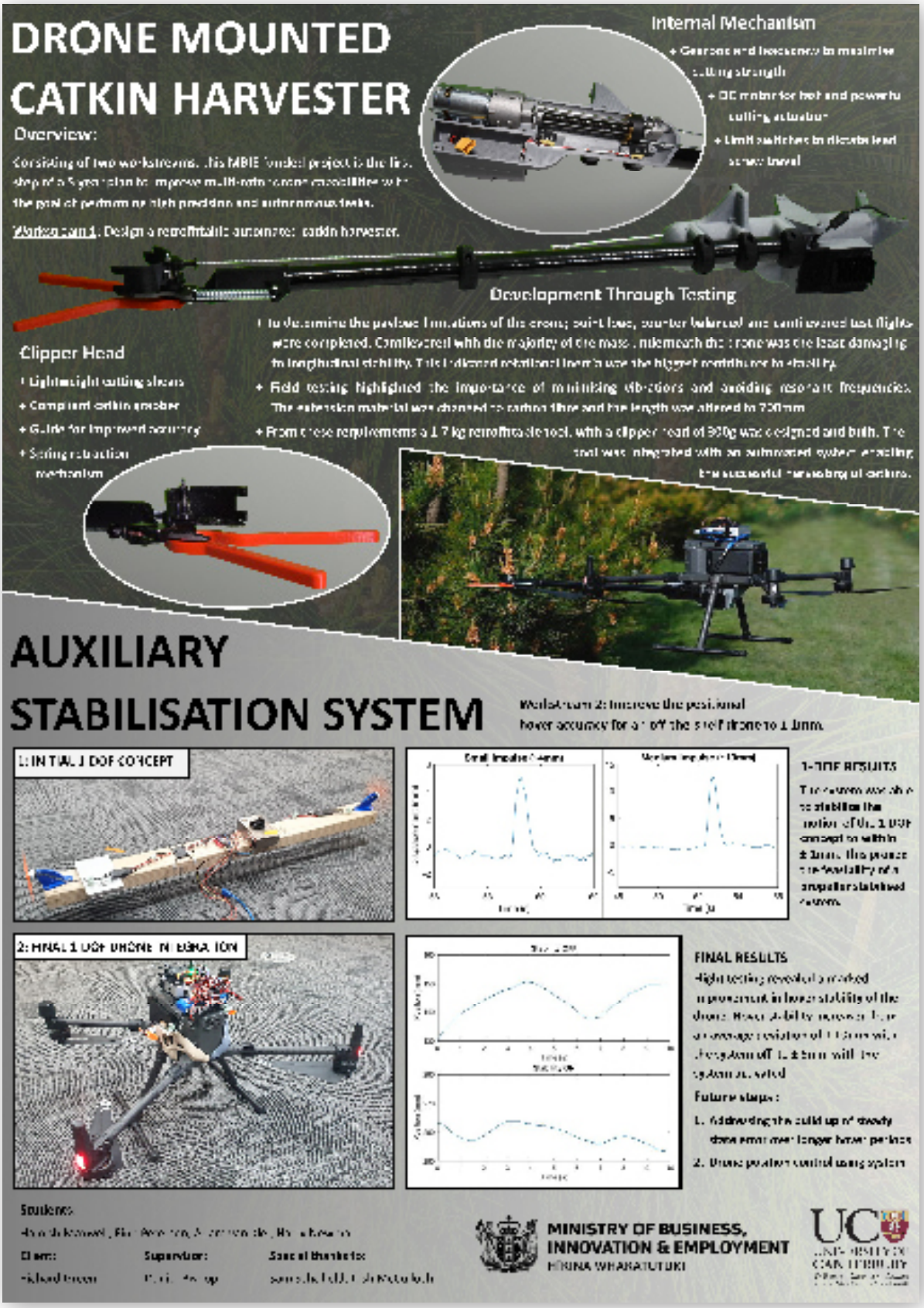
FLOW

Student projects: Mechanical Engineering and Mechatronics Engineering



Student projects: Mechanical Engineering and Mechatronics Engineering




DRONE MOUNTED
CATKIN HARVESTER
Overview:
Internal Mechanism
Development Through Testing
Clipper Head
AUXILIARY
STABILISATION SYSTEM
1: INITIAL 1 DOF CONCEPT
2: FINAL 3 DOF DRONE INTEGRATION
FINAL RESULTS
Future steps:
MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

UNIVERSITY OF CANTERBURY

Semi Automated Twin Head CNC Router

MOTIVES

The motivation for this project is to make the process of cutting Structural Insulated Panels (SIPs) semi automated, thus reducing labour requirements. This will ultimately increase efficiency and reduce costs. In doing so, this will promote SIP's mainstream popularity, bringing Formance SIP's into the affordable NZ housing market.

SCOPE

The project scope was to design and build a semi-autonomous CNC router prototype, to achieve Formance's technical requirements. Due to size constraints, a small scale prototype is being built to perform nested cuts on 1.2 x 1.5m panels of varying thicknesses from 115 – 305mm.

FUTURE STEPS

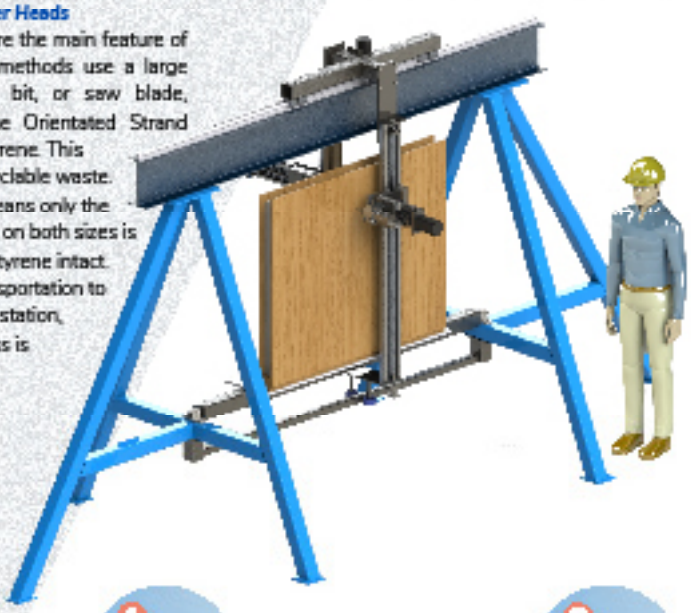
With the success of this project, Formance will be able to manufacture the rotator, modify electrical wiring and extend the I-beam length to accommodate their standard 7.2 x 1.2m roof panels. If the extended router meets expectations, it opens up opportunities for low-cost expansion throughout New Zealand.

Carriage

The carriage houses the x, y and z axis motion control. Motion of the x axis is achieved via a rack and pinion, while the y and z axis use linear ball and screw sliders. The y-axis sliders are chain linked as so their vertical motion is synchronised to increase accuracy.

Twin Router Heads

The twin router heads are the main feature of the project. Traditional methods use a large 50mm diameter cutter bit, or saw blade, which cuts through the Orientated Strand Board (OSB) and polystyrene. This creates excessive unrecyclable waste. The twin head design means only the Orientated Strand Board on both sizes is routed, leaving the polystyrene intact. This allows for easy transportation to the polystyrene hot wire station, where the cutting process is completed.



Electrical

The router is driven by a series of four closed loop stepper motors. These feature encoders which increase cutting precision. The router is controlled using Mach 3, a CNC controller software.

Rotating Mechanism

With the largest size SIPs weighing 150kg, a loading mechanism is implemented to minimise manual handling.

SIP is wheeled up to the router on a trolley, which is level with the rotator.

It is then slid over the rotating support block.

Using a pneumatic system, it is rotated 90° to the vertical position and locked in place.

The SIP is then ready for routing operations.

Team Members
Dylan Budge, Harry Dodd
Josef McBride-Wilson, Bob Letiu

Supervisor
Associate Professor
Don Clucas

Special thanks to
Tony Doyle
Anthony Doyle

Client
Nick Hubbard

FORMANCE

Formance.co.nz

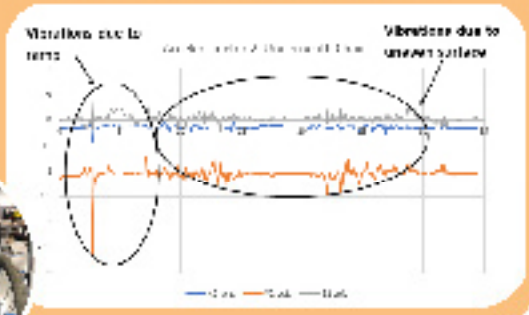
Wheelchair Retrofit for Use in the Australian Outback

Background

Standard wheelchairs are not fit for the Australian Outback terrain and extreme conditions. The aim of this project was to develop a kit-set such that diabetic amputees can retrofit their own wheelchairs for use in the Australian Outback. This project was run as a collaborative design competition with UNSW.

Vibrational Analysis

Wheelchair vibrations are known to be harmful to the wheelchair user and cause damage to the wheelchair over time. The analysis utilised two accelerometers and Arduino hardware/software to capture the vibrational data experienced by the wheelchair. Testing was conducted on an obstacle course that simulated the Outback terrain.



Stability Testing

A standard set of testing methods and criteria were required for both teams. A static stability testing device to measure critical tipping angles and a test dummy based on ISO7176 were used to determine these angles. The unmodified wheelchair indicated the least stable configuration was rearwards stability at 11.69 degrees.

Cushion

Quadruple density foam and gel cushion were used to increase comfort by reducing vibrations felt by the user. This mitigated the risk of pressure sores and kept the body cool by regulating body temperature in the humid environment.

Stability Plate

A rear wheel stability plate is mounted to the frame with a bolt through pre-existing holes on the side. This plate shifts the axle position backwards providing increased rearwards stability and lowered centre of mass. Static stability testing showed a 61.7% increase in rearwards critical tipping angle to 18.91 degrees.

Caster Suspension

The aim for this design was to incorporate suspension into the caster wheels. By manipulating the geometrical shape of the round-bar, it provides suspension to the wheelchair when subjected to vibrations caused by external loading.

Anti-tip

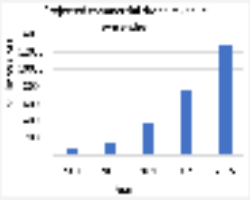
The anti-tip mechanism reduces the likelihood of tipping backwards, hence improving user safety. The design is simplistic, low profile and easy to manufacture. It has adjustable lengths with the use of a spring button and hole configuration.

Client: University of Canterbury & University of New South Wales
Supervisor: Dr Deborah Munro
Sponsor: University of Canterbury
Acknowledgements: Tony Doyle, A/Prof Lauren Kark & UNSW team
Project team: Adam Chung, Luke August, Oliver Hawker, Hannah Chatfield

Optimizing Separation Distance to Enhance Multi-rotor UAV Aerodynamics

1. Introduction and Objectives

- The aim of this project was to find the optimum separation distance between propellers of a quadcopter UAV.
- The optimum propeller separation will maximise thrust and minimise power output of a quadcopter UAV.



2. Methodology

2.1 Experiment:

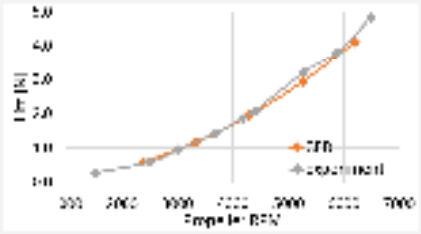
- Lift force data was measured with/without free stream velocity in the wind tunnel.
- Multiple flow profiles were conducted at different propeller conditions.

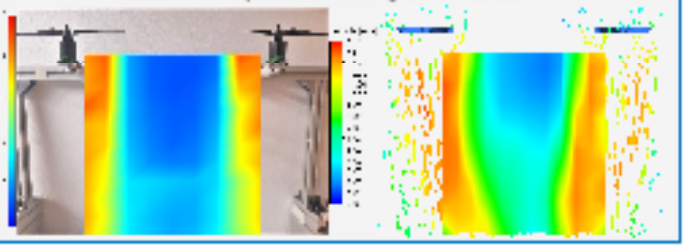
2.2 CFD:

- Conducted mesh sensitivity analysis to achieve reliability of model.
- Forces and flow properties are examined for a better understanding.
- Figure of merit (FM) and power coefficient was plotted to determine the optimum performance.

3. Validating CFD

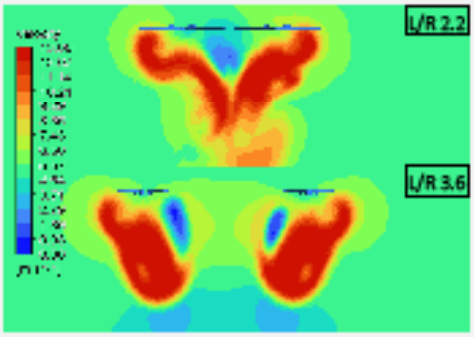
Lift plot and flow profiles show a good agreement between CFD and the wind tunnel experiment, validating the CFD model.

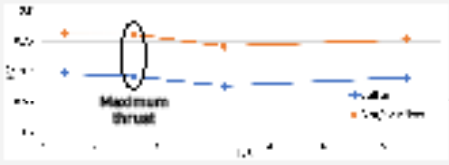


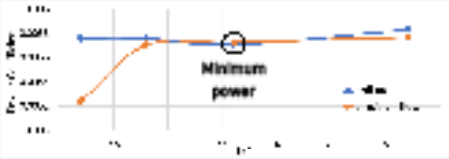


4. Results

The separation of adjacent quadcopter propellers was measured with the variable L/R, which was given by hub separation over propeller radius. As the separation of adjacent propellers increased, the amount of wake interaction decreased. The relationship between propeller separation and wake interaction is visualised below in the velocity contour, where a separation of L/R 2.2 has a visible wake interaction, and L/R 3.6 has none. The amount of propeller wake interaction effected performance metrics such as power coefficient and the figure of merit (FM).

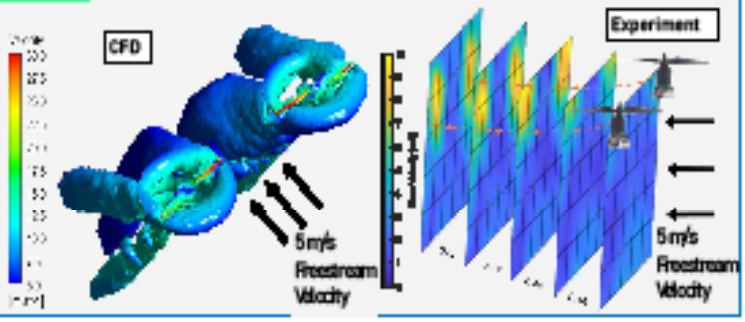






The two performance metrics were plotted against L/R separation, which shows that L/R 2.8 maximises thrust capacity and L/R 2.2 minimises power output.

The vortex core region (CFD) shows propeller wake interaction by visualising the high vorticity region of the wake. The 2D velocity contours from wind tunnel testing were stacked next to each other to show the agreement in the 3D flow profile of the propellers. From both experiment and CFD results, it is obvious that the freestream velocity (5 m/s) pushes the wake generated from the propellers downstream.



5. Conclusions

- After the consideration of structural weight, it was found that an L/R of 2.8 was the optimum propeller separation to maximise thrust capacity and minimise power output of a quadcopter UAV.
- Further research should investigate how changes in propeller speed and the addition of turbulence would effect the optimum separation of the propeller.

Team members:
Caleb Barr
Theo Nankivell
Sam Dougherty
Zara Goggin

Supervisors:
Prof. Dan Zhao
Dr. Ray Lin Ooi

UC
UNIVERSITY OF CANTERBURY

KIWICARE Alternative Trap Box

Project Aim

Rats and Mustelids (stoats, weasels and ferrets) pose a risk to many native species in Aotearoa. DOC200/ PCR200 traps are used to control these species. These are set in wooden housings which have many transport and handling issues.

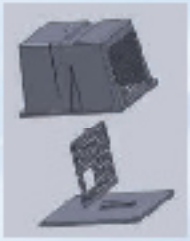
The aim of this project is to develop a lighter trap housing that is easy to transport, user-friendly and sustainable.

Current BT200 Trap Box

- Heavy (5.5kg+ per housing)
- Bulky (difficult to carry more than 2 housings)
- Prone to water damage
- Time consuming setup and use

Proposed Trap Box Design

- 10 boxes carried per person (+ 8 Boxes)
- 1.2kg net weight per box (4kg Lighter)
- 3 Piece - Injection moulded
- Recycled polypropylene
- UV resistant material
- Easy to assemble

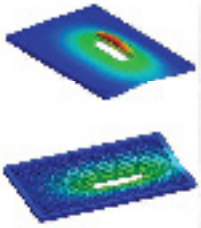


Easy 5 Step Trap Setting Method

1. Peg down baseplate
2. Slide trap on cleat
3. Set trap
4. Put lid on
5. Put strap on

Finite Element Analysis

A FEA analysis was done to ensure the baseplate would have the strength to withstand the force of loading the trap. The honeycomb structure performed the best as it had the greatest strength to weight ratio.



Fatigue Testing

Fatigue testing was done to the baseplate to replicate 5 years of solid use. This was done by manually loading and triggering the trap 130 times. No plastic deformation or damage was observed to the baseplate.

Next Steps

- DOC certification
- Finalise material filler
- Accommodate monitoring device and automated spray in design
- Integrate the feedback received from end users

Material and Sustainability

The trap housings will be made from recycled post-consumer waste polypropylene with a $CaCo_3$ filler and UV stabilisers. This material can easily be injection moulded and has a lower environmental footprint than virgin plastic.

A sustainability analysis found that they have 80g less CO_2e than the wooden traps when used in the backcountry.

UC University of Canterbury

Team
Kaden Gibbons
Alex Darling
Max Truell
Thomas Kain

Client
Dr. Peter Robinson

Supervisor
A/Prof. Sid Becker

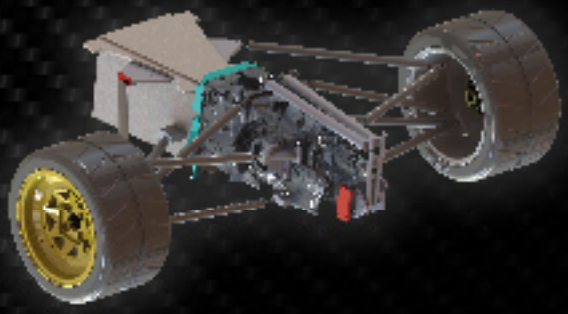
KIWICARE

FORMULA FORD M47

RODIN CARS

Project Brief: Rodin Cars have a 4-speed H-pattern Formula Ford. It is currently unsuited to their existing driver training program and they require a driver development vehicle which is cohesive with their existing platforms.

The Solution: A modified Formula Ford platform with a 6-speed paddle shifted sequential with improved driver ergonomics.

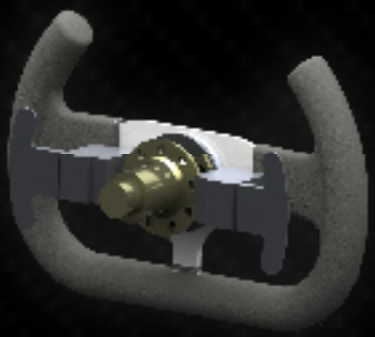


POWERTRAIN

- Transmissions have been investigated and the FTR-200 was found to be the best fit for ease, practicality and logistics.
- A new input shaft has been designed to fit this transmission.
- An adapter plate and new suspension mounts have also been designed.

ELECTRICAL

- Designed mounts to keep new hardware within existing bodywork.
- Repaired existing harness.
- Designed custom wiring loom for pneumatic paddle shift kit.
- These engineering solutions are adaptable and reversable.



ERGONOMICS

- A modified steering column with a new steering wheel has been fitted to the car.
- A paddle shifting unit has been designed and mounted to the wheel.
- A new ergonomic base frame in which the custom moulded seat insert is placed into.
- Modified and improved pedal box to allow for large adjustment of position.

Client: *Rodin Cars*
Supervisor: *Zac Perston*
Team: *Jordan S. Richard, Jessica Lee, Callum Bendall and Jack Noble-Adams*

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Blair's Trike Carrier

Scope: Design and manufacture a custom trike carrier that Blair can operate

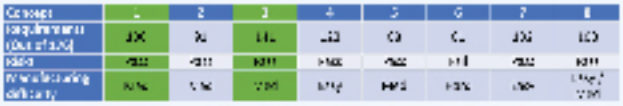
Background: Blair's cerebral palsy severely limits the motion in his legs and right arm. He frequently cycles in his custom electrically assisted trike, but this needs to be transported by someone else unless he wants to cycle from his house.

Specifications: Make a custom carrier that Blair can use by himself, so he has the independence to take his trike where he wants, when he wants, by himself. The carrier must meet NZTA legal requirements.

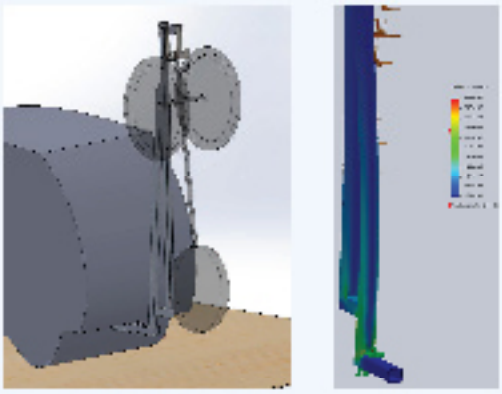
Concepts

Early concepts were roof mounted, rear mounted, or other. Most use some type of winch for assistance, as testing proved Blair can operate a winch. We filtered out the most improbable down to 8 designs, including the two shown below:

Design selection: We chose the final two designs by evaluating against constraints, considering risks, and considering manufacturing difficulty. Constraints include securing the trike, Blair being comfortable operating the carrier alone, meeting legal requirements, low risks posed to users, the ability to swap between cars, and an unoffensive design.



Design 1: Vertical Carrier

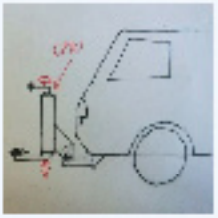


Design overview: Blair drives his trike up to the carrier, attaches the hooks onto the front of his trike and manually winches the trike up.

Design features: Attaches onto a hitch receiver on the back of Blair's car.

Design analysis: The structural integrity of this design was validated with a MATLAB script, hand calculations, and a Solidworks simulation. These used a maximum loading of 3x the trike weight to account for bumps, acceleration/deceleration, and wind. The calculations gave a Factor of Safety of > 3.

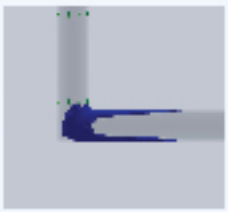
Design 2: Horizontal Carrier



Design overview: The horizontal design allows Blair to extend and retract the foot over the carrier. The connection point attaches to the centre of mass of the trike and is lifted into place by the stand.

Design features: Design includes as a tension line leading from the outer edge of the foot and extends to the top of Blairs car for extra safety.

Design analysis: The design was validated with hand calculations and in SOLIDWORKS analysis. Two separate designs were pursued; a larger square cross section design, and a smaller circular cross-section design. The square section exceeds the weight constraint, but allows Blair to ride directly over the connection point. The circular section has a greater FOS, but is more difficult to attach.



Clients: Blair Nevin, Sue and Carl Nevin

Client Liaison: Shayne Crimp

Supervisor: George Stilwell

Team members: Adam Finlayson, Jacob Heyblom, Nick Tuckey

Special Thanks:

Christine Products

Digby Symons

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HYDROGEN PRESSURISATION

PROJECT BRIEF:

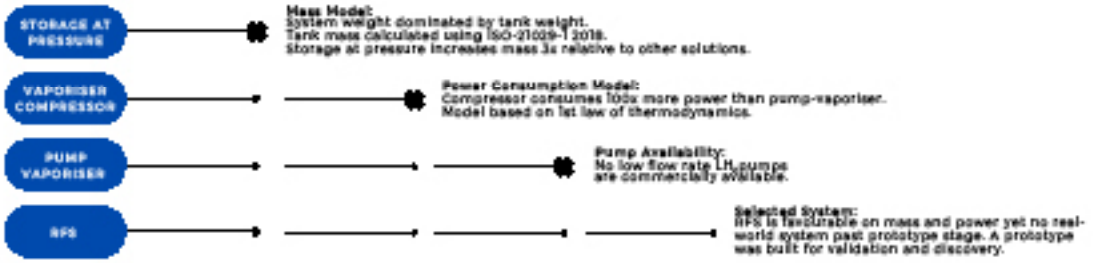
To evaluate traditional and novel methods of hydrogen pressurisation for mass sensitive aviation applications. The main focus is to model and experimentally test the concept of a reciprocating feed system.

MOTIVATIONS:

Growing environmental concerns have championed hydrogen as the fuel for the future. To have a competitive energy density hydrogen must be stored as a cryogenic liquid. Mass-sensitive applications require a low storage pressure to minimise fuel tank weight. Therefore hydrogen pressurisation systems are necessary when hydrogen is used as a fuel.

CANDIDATE SYSTEM EVALUATION

Four systems were evaluated using models to predict system mass, power consumption, and efficiency.



RECIPROCATING FEED SYSTEM (RFS)

A reciprocating feed system utilising the high volume expansion ratio of LH_2 presented the opportunity to design and build a lightweight and compact rapid pressurisation system.

Instrumentation

The Dewar and RFS tank each have pressure gauges and pressure relief valves.

Liquid Nitrogen

Liquid nitrogen is the best fluid in place of liquid hydrogen for its safety.

Dewar

120L vacuum insulated double skin pressure vessel.

Cryogenic Valves

2x globe valves provide control over the inflow of nitrogen and outflow of gas from the RFS tank.

RFS Tank

The RFS tank is a 600mL pressure vessel in which the fill/heat/pressurise/vent cycle occurs.

Heating Elements

400W heater at the bottom of the RFS tank delivers the heat for pressurisation.

Student Team: Mitch Davis, Mitch Radcliffe, Henry Knight, Sam Armitage
Supervisor: Mark Jermy
Mentor: Jonas Meier
UC UNIVERSITY OF CANTERBURY

LUNG MECHANICS

12 DEATHS/DAY
from lung dysfunction in NZ

Respiratory illness responsible for
2-3% OF NZ GDP

Personal healthcare expenses creating large
SOCIOECONOMIC GAP

SCOPE

Combine mechatronics and computational mechanics to optimise clinical outcomes including:

DIAGNOSIS | MODELLING | CARE | MANAGEMENT

Devices to simulate obstructive lung disease in healthy people

Endotracheal tube (ETT) cuffs for neonates

Simulating COPD

Chronic obstructive pulmonary disease (COPD) affects more than 200,000 New Zealanders. We are developing a device to induce symptoms of COPD in healthy test subjects, to enable safe, rapid evolution of new treatment devices and protocols.

Development DESIGN → TEST → IMPROVE → REPEAT

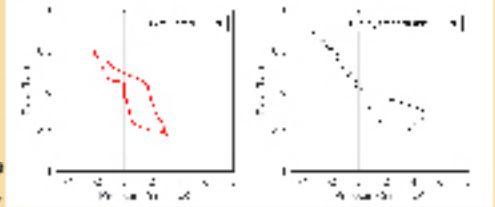
Final Design

The final design uses resistance filters and a volume-limited elastic expansion chamber (VLEX-c) to increase exhalation resistance.

Measurements from pressure sensors are used to calculate breathing volume, flow, and pressure.

Results

Simulated VS real COPD PQ loop →



Note the wide loop on inspiration is due to anti-Covid filters.

The device successfully simulates the effects of COPD in healthy test subjects. Results were validated by comparing pressure - flow (PQ) loops of healthy test subjects to COPD data.

ETT Cuffs for Neonates

Adult endotracheal tube (ETT) cuffs are inadequate for use in neonatal patients.

Goals
- Minimise/eliminate cuff contact on throat.
- Create turbulence in air flow past cuff to block flow.

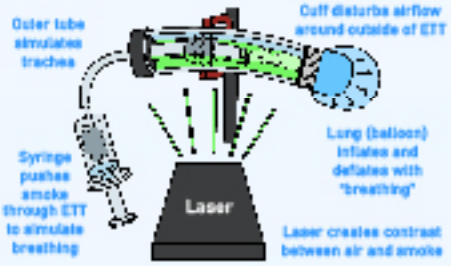
Cuff Designs

SLA printed with flexible resin.

Fins reduce cuff surface area pressing tracheal wall, ↑ turbulence in flow, ↑ resistance to escaping air.

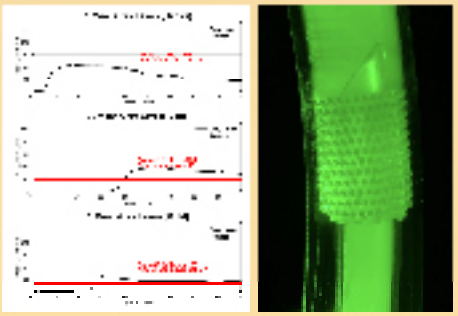
Testing

Smoke and green laser used to visualise airflow in simulated "trachea".



Results

Data analysed using colour processing functions in MATLAB (left), to compare smoke concentrations in trachea between test videos. The cuff was very successful blocking escaping flow during inspiration (right).



TEAM
Jaimey Clifton
Alexandra Edmonds
Elliott Wilkins
Chris Smith

SUPERVISORS
Dist. Prof. Geoff Chase
Ted Lerios
Ela Guy
Trudy Calje-van Der Klei

Measuring Sleep, Stress & Anxiety with Wearable Technologies

PROJECT SCOPE & BACKGROUND

- 3.6% of the world population affected by anxiety & chronic pain
- Current assessments are subjective
- Helius therapeutics wants an objective, readily available, long-term measurement for clinical trials of CBD products
- Our goal is to validate stress & HR metrics measured by wearable devices as an indicator of anxiety and pain.

DEVICE & ALGORITHM SELECTION

Considerations:

- Type/quality of sensors
- Biomarkers measured
- Metrics provided
- Data resolution
- Accessibility
- Cost/prevalence

Garmin Venu SQ was selected for validation testing

COLOUR-WORD-CONFLICT (CWT) & COLD PRESSOR TESTS

- Stroop effect is a delay in reaction time between controlled and automatic processing of information
- CWT induces anxiety by exposing subjects to conflicting stimuli.
- Cold pressor induces moderate pain by plunging hand/wrist in ice-water
- These tests are used to validate ability of a device's built-in stress metrics to measure wearers stimulus-response

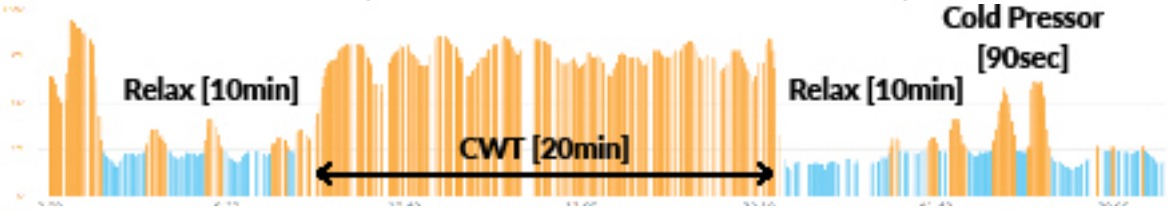
TEST PROCEDURE

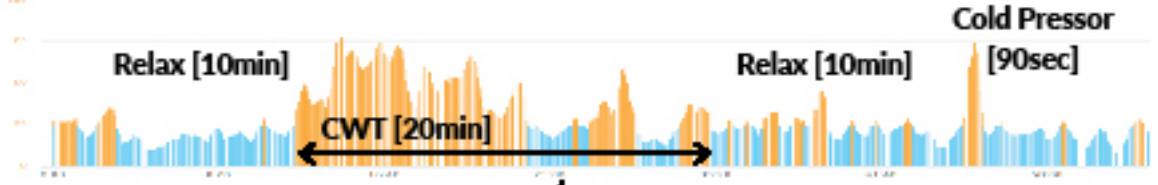
- 30 participants (15 male, 15 female)
- 10min relaxation to set a baseline
- 20min colour-word-conflict test
- 10min relaxation to reset a baseline
- 90sec cold pressor test
- 10min relaxation to reset baseline

RESULTS & CONCLUSIONS

- Garmin algorithm shows good resolution (measurements taken every 3sec)
- Response to stimulus is clearly measured by the Garmin Venu SQ
- Prelim. conclusions show this device/algorithm would provide good data for CBD clinical trials

"The stress is like trying to quit vaping during exams"





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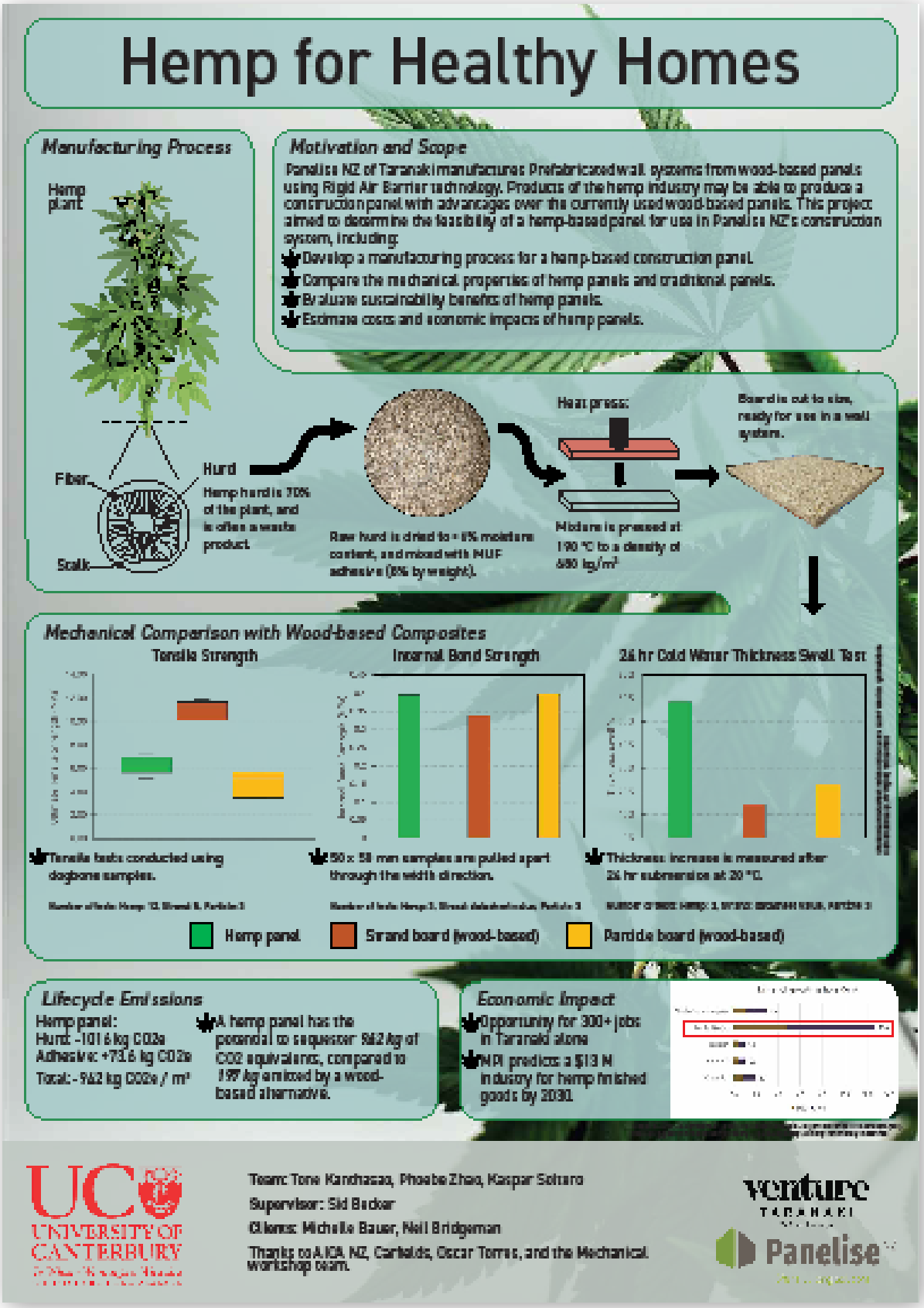
HELIUS

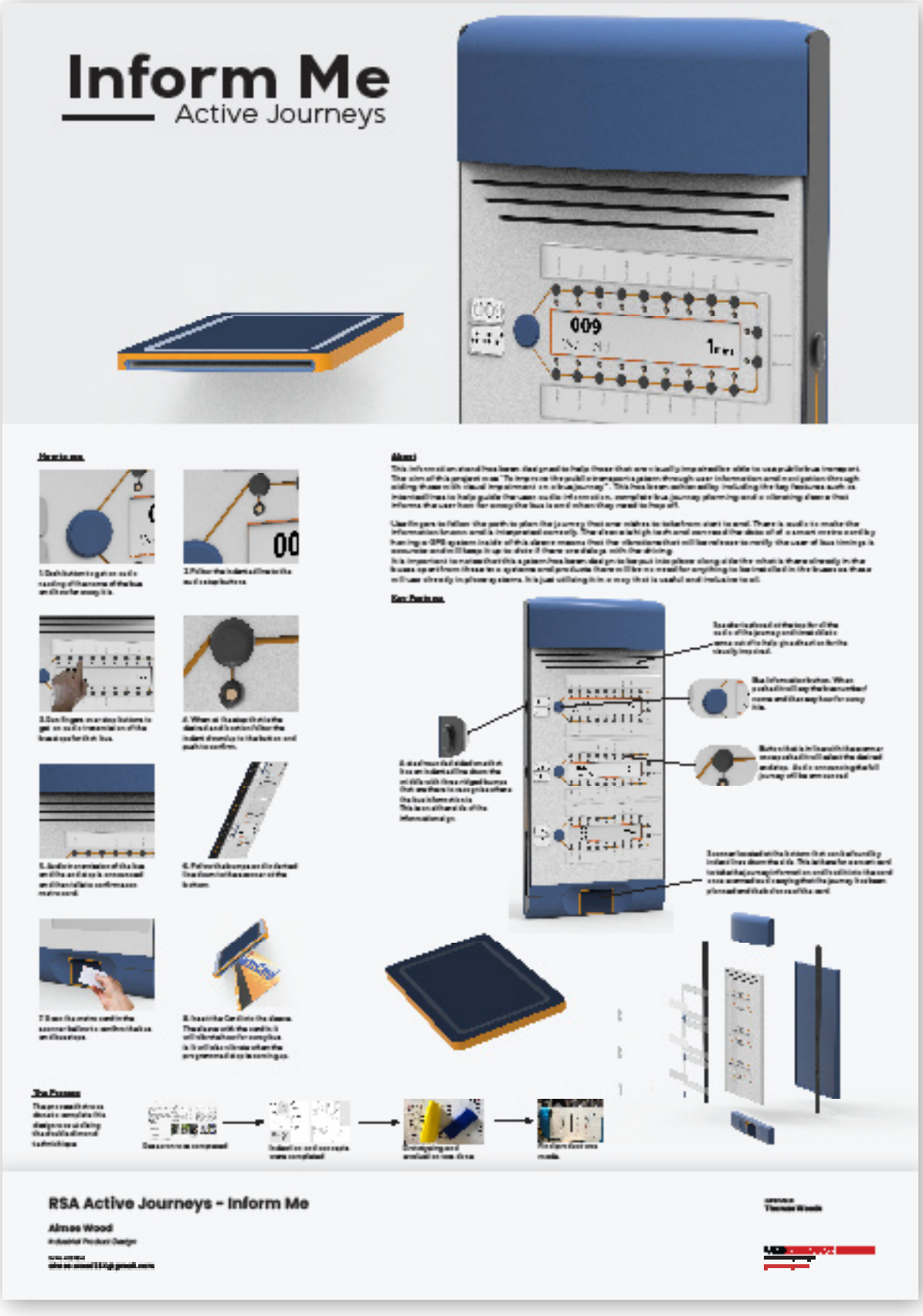
Team: *Wade Bennett, Isaac Flett, Harris Oon, Louis van Zyl*
Supervisors: *Dist. Prof. Geoff Chase, Dr. Tony Zhou, PhD Candidate Josie Dixon*
Special Thanks: *PhD Candidate Hamish Ferguson, Dr. Steven Su*


M53
REMOTE RELEASE CLAMP
Purpose
To design and produce a prototype remote release clamp for Cawthron's Shellfish Tower. The Shellfish Tower is a new form of cultivation technology that is submerged 10m deep for exposed bivalve (e.g. oysters and mussels) farming. The remote release clamp is to be attached to the top of the shellfish tower to remove unnecessary diving risks and improve harvest efficiency. Success for this project will be achieved with a working prototype.
Shellfish Tower
Inner Cones
80° angle on inner cone creates a self-locking mechanism uses the tower's buoyancy to clamp onto the mooring line
Moving inner cone piece up will release clamp allowing the tower to float to the ocean surface
Hydraulics
Twin, double acting cylinders provide 2.8kN of force at 210 bar
System includes directional control valve and an accumulator
FEA Stresses on Housing Section
Housing
Two symmetrical sections for easy assembly
Hydraulic cylinders sit at 90° parallel with the angle of the inner cones
Cones release mooring line as cylinders extend
Offset
Sectioned Clamp View
Jaws
Three methods to grip the rope were developed during the concept phase
Testing resulted in the final design containing large serrations, an offset of one rope diameter, and an angle of 90° in each jaw
Communication
Wireless communication is needed to facilitate release of clamp remotely (remove need for divers)
Traditional methods (Wi-Fi, Radio) unsuitable for underwater use.
Innovative system using Ultrasonic transducers created
System successfully tested in fresh and salt water (results shown below)
Transducer Receiving Signal
Polypropylene Mooring Line
Housing
Inner Cones
Ngā Punga o te Moana
CAWTHRON
UC
UNIVERSITY OF CANTERBURY


Hemp for Healthy Homes
Manufacturing Process
Hemp plant
Fiber
Hurd
Stalk
Hemp hurd is 70% of the plant, and is often a waste product.
Raw hurd is dried to <8% moisture content, and mixed with MUF adhesive (8% by weight).
Heat press:
Mixture is pressed at 190 °C to a density of 680 kg/m³
Board is cut to size, ready for use in a wall system.
Motivation and Scope
Panelise NZ of Taranaki manufactures Prefabricated wall systems from wood-based panels using Rigid Air Barrier technology. Products of the hemp industry may be able to produce a construction panel with advantages over the currently used wood-based panels. This project aimed to determine the feasibility of a hemp-based panel for use in Panelise NZ's construction system, including:
Develop a manufacturing process for a hemp-based construction panel.
Compare the mechanical properties of hemp panels and traditional panels.
Evaluate sustainability benefits of hemp panels.
Estimate costs and economic impacts of hemp panels.
Mechanical Comparison with Wood-based Composites
Tensile Strength
Internal Bond Strength
24 hr Cold Water Thickness Swell Test
Tensile tests conducted using dogbone samples.
50 x 50 mm samples are pulled apart through the width direction.
Thickness increase is measured after 24 hr submersion at 20 °C.
Hemp panel
Strand board (wood-based)
Particle board (wood-based)
Lifecycle Emissions
Hemp panel:
Hurd: -101.6 kg CO2e
Adhesive: +73.6 kg CO2e
Total: -542 kg CO2e / m³
A hemp panel has the potential to sequester 542 kg of CO2 equivalents, compared to 197 kg emitted by a wood-based alternative.
Economic Impact
Opportunity for 300+ jobs in Taranaki alone
NZIA predicts a $13 M industry for hemp finished goods by 2030.
UC UNIVERSITY OF CANTERBURY
Team: Tone Kandhasaa, Phoebe Zhao, Kaspar Soltero
Supervisor: Sid Becker
Clients: Michelle Bauer, Neil Bridgeman
Thanks to AJCA NZ, Carbiolds, Oscar Torres, and the Mechanical workshop team.
venture TARANAKI
Panelise

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



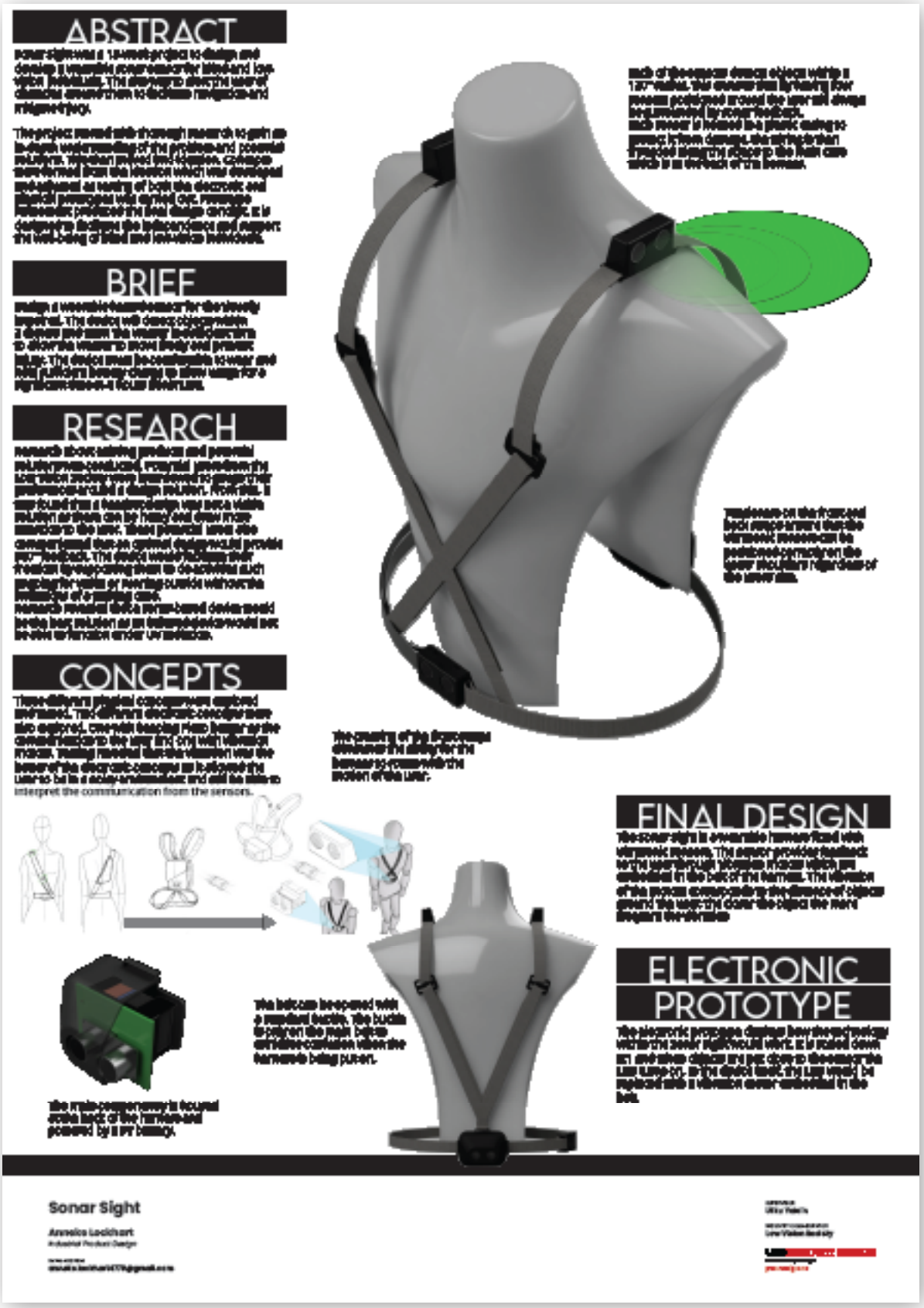

THE SPIN STOVE.
Project Aim.
To create a safe and highly efficient flatpack stainless steel woodfire stove for less than $16.40 NZD that can be assembled with basic tools with no fasteners.
Project Introduction.
Design Iterations.
Key Features.
ReliefAid
escea.
Tent Woodfire Stove
Alex Caldwell

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



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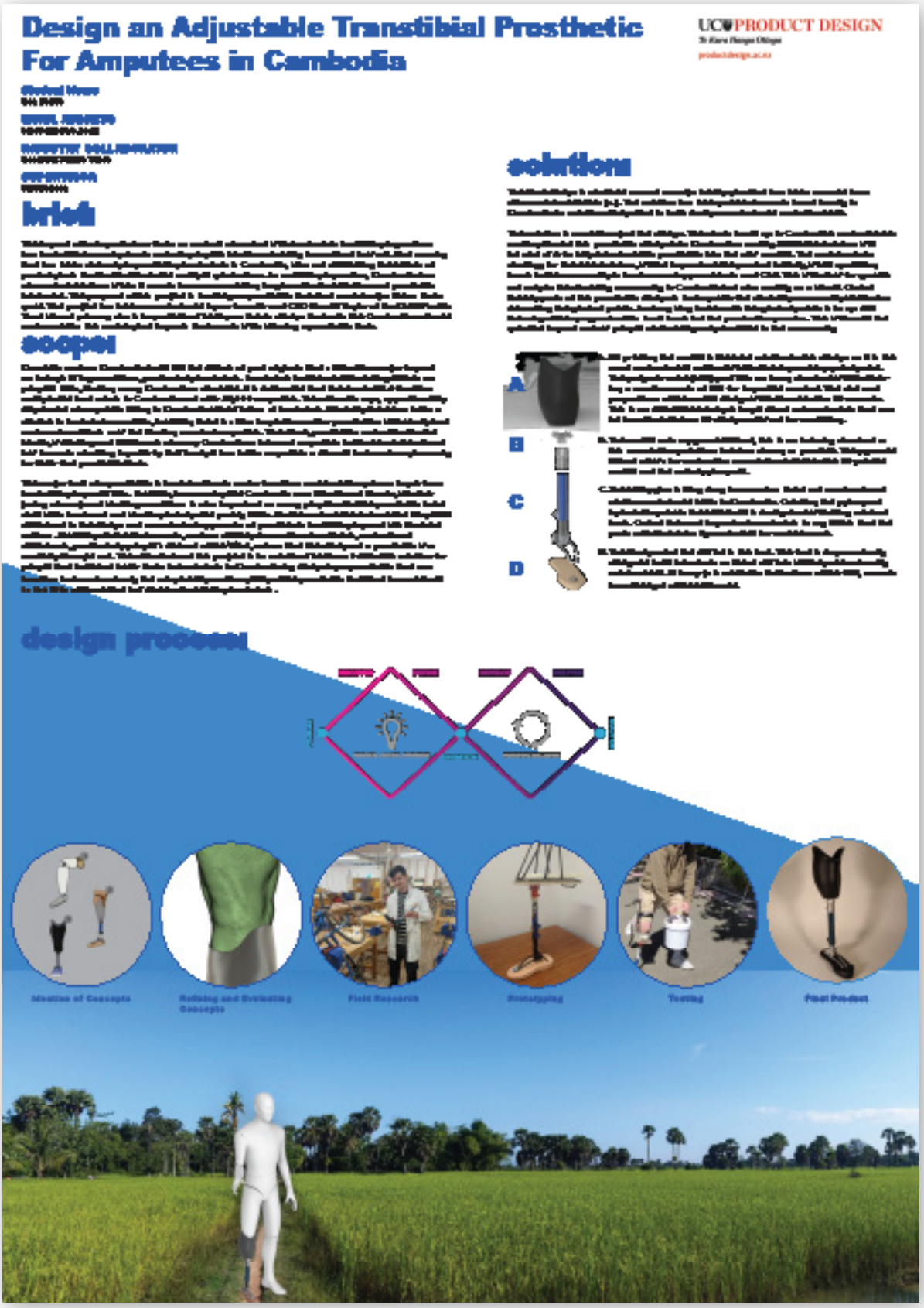


LoRa Pedator Tracking Collar

Introduction

Development

Brief

Aim

Concepts

Concept One Concept Two Concept Three

Research

Ideation

Exploded View

Final Design

Prototyping

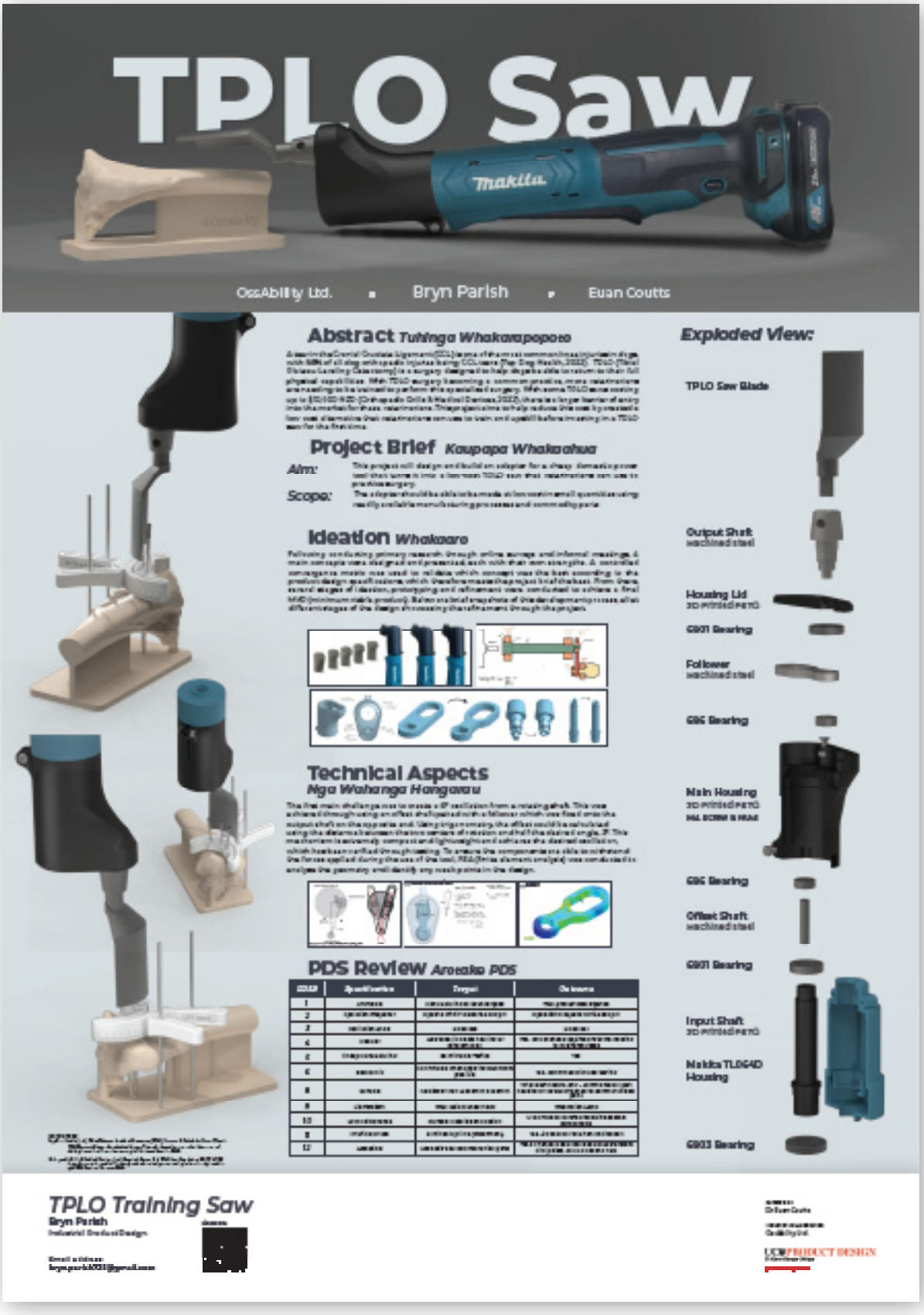
Simulation

Pen Testing

LoRa Predator Tracking Collar

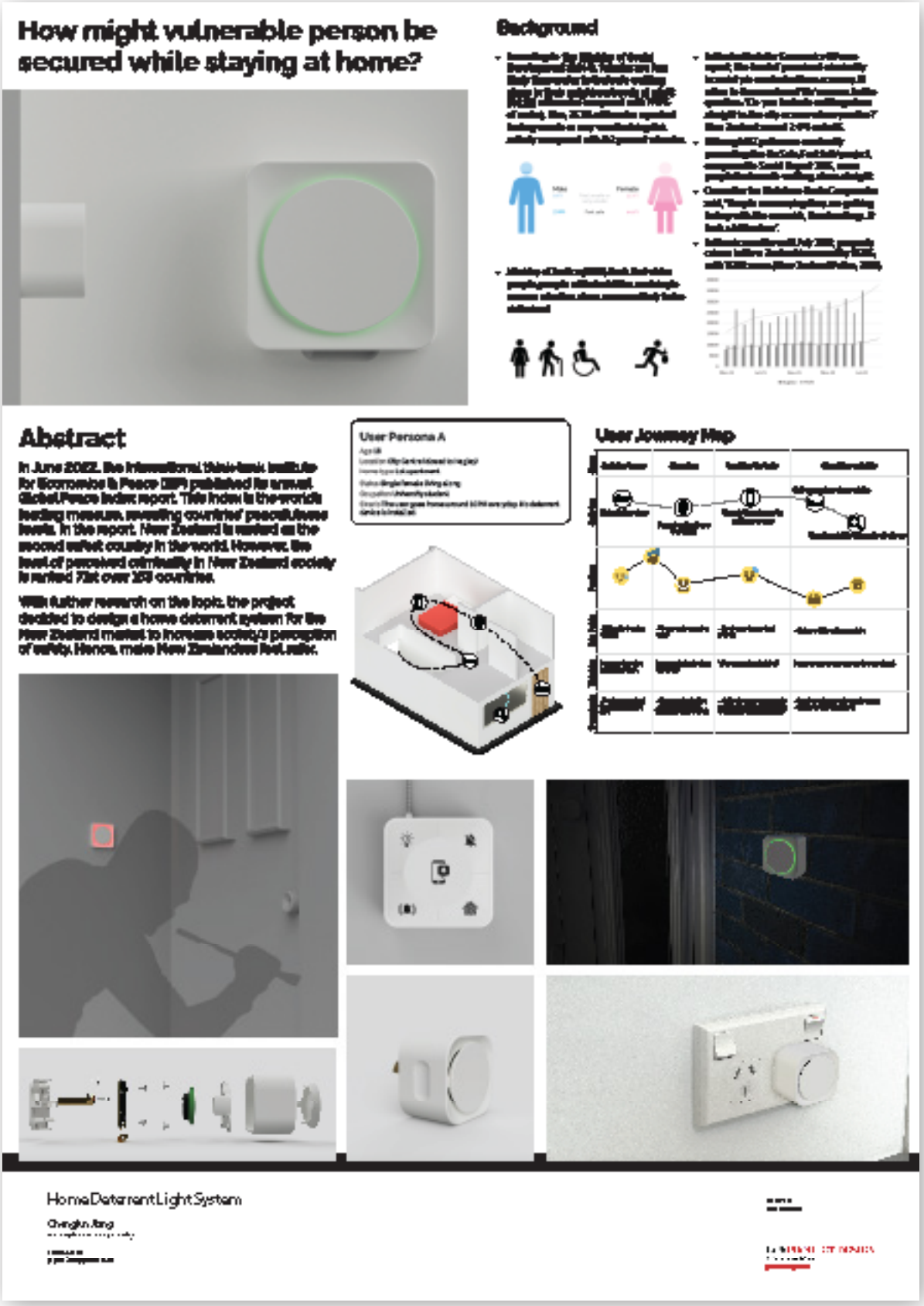
Ben Petrie

Student projects: Product Design - Industrial Product Design


TPLO Saw
Makita
OssAbility Ltd.
Bryn Parish
Euan Coutts
Abstract Tuhinga Whakarapopoto
Project Brief Kaupapa Whakaahua
Aim:
Scope:
Ideation Whakaaro
Technical Aspects
Nga Wahanga Hangarau
PDS Review Arotake PDS
Exploded View:
TPLO Saw Blade
Output Shaft
Housing Lid
6901 Bearing
Follower
6906 Bearing
Main Housing
6906 Bearing
Offset Shaft
6901 Bearing
Input Shaft
Makita TLD04D Housing
6903 Bearing
TPLO Training Saw
Bryn Parish
Industrial Product Design
UCW PRODUCT DESIGN

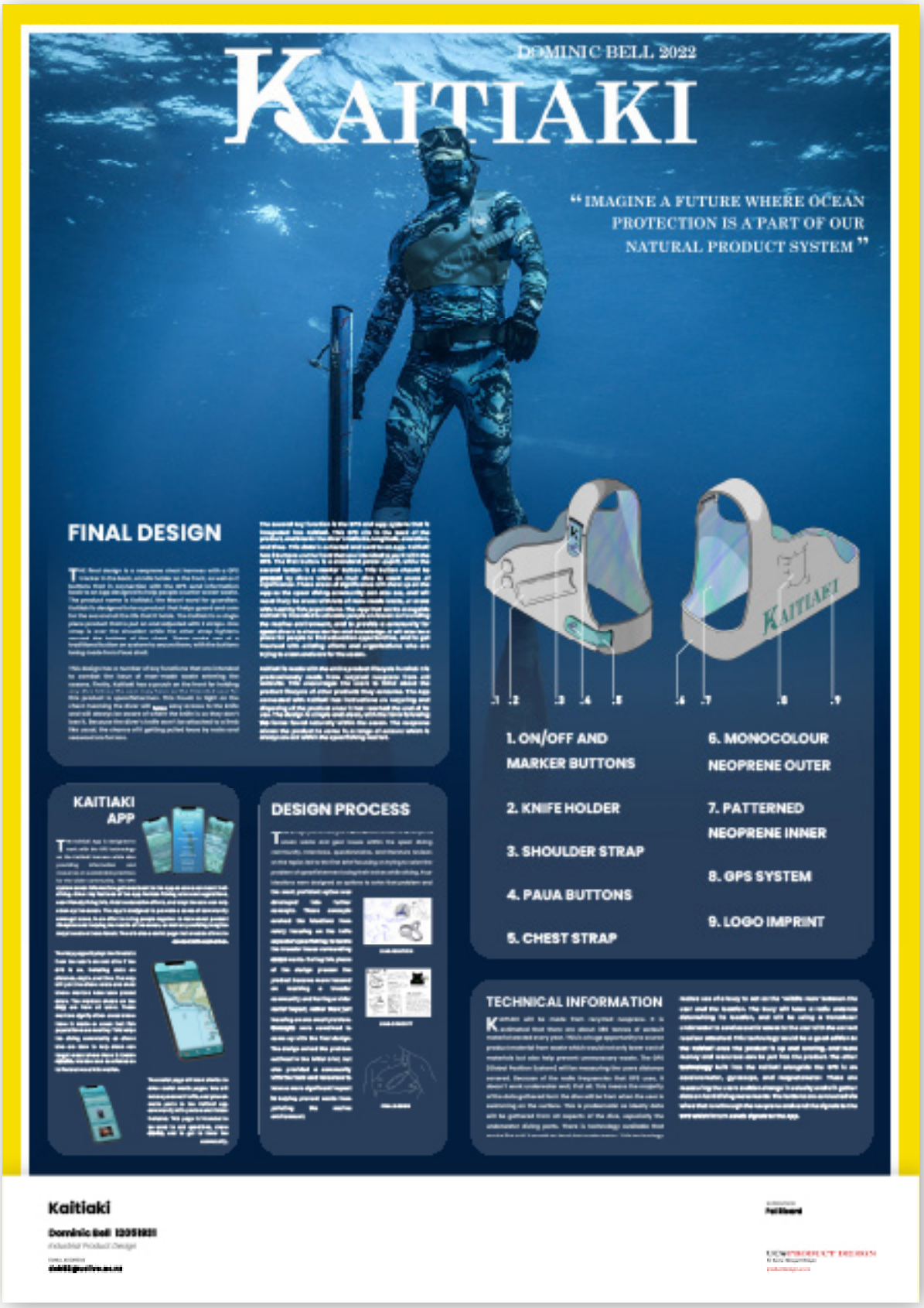
Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Student projects: Product Design - Industrial Product Design

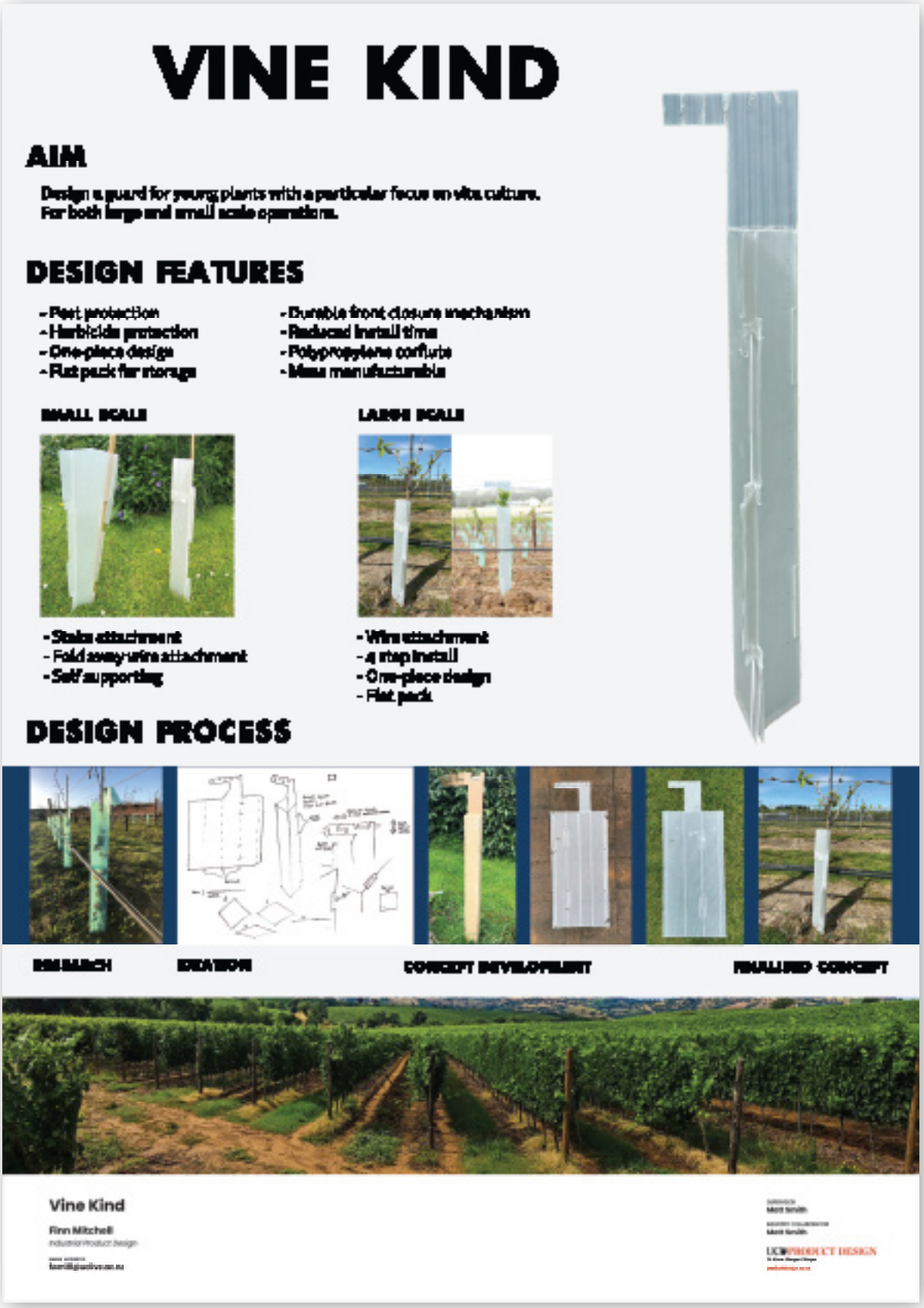
Student projects: Product Design - Industrial Product Design



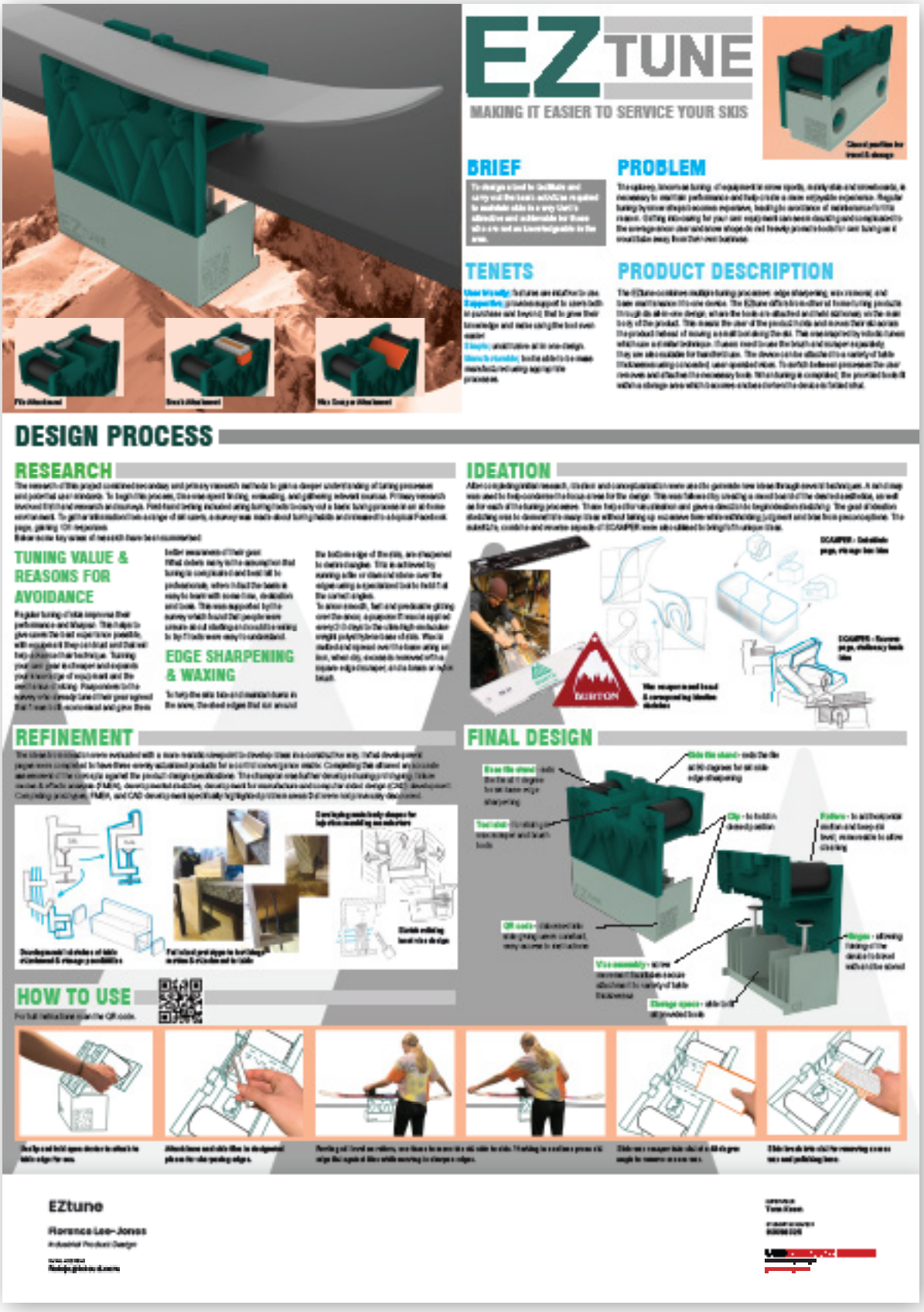

ADAPT ASCEND
Brief - Whāinga
To improve backcountry accessibility for adaptive skiers through enhanced interaction with rope tow infrastructure.
1 Apply Gripper
2 Contract
3 Ascend
Scope
The simple rope tow has long been an efficient means of alpine ascension. Commonplace throughout the club fields of New Zealand, skiers use a 'Nutcracker' clamping device to grip the rope, ascending the mountain via a tethered harness. This requires the use of both hands, which is problematic for adaptive skiers who use outriggers for stability. An opportunity was hence revealed to enhance rope tow accessibility for the adaptive community.
Tough PLA 3D print
Water jet cut aluminium plate
Stainless rivets
Hard stainless sheet steel
Nylon webbing
While sliding, the device is secured on the outrigger in its contracted state
Dual clutch cables pass through embedded channels
Single handed operation with integrated Ski Deployment
An ergonomic grip extension provides hand support on long rope tows
Outcome
Adapt Ascend is a rope gripping system designed to enable independent use of rope tows for adaptive skiers. The device is placed onto the rope using an outrigger, and gradual traction is applied via a hand actuated clutch for smooth acceleration. Where possible, the design incorporates bicycle parts which are easily sourced. Wear wearing components have been optimised for cost effective manufacture and open source accessibility.
If the rider releases their grip at any point, the device is safely ejected from the rope.
The skier gains traction using the clutch lever
Once up to speed, the outrigger is released and used as normal
The rider is hauled by a tether attached to the sit ski, or body harness
With the both outriggers on the snow the rider must maintain a gripping force through the hand actuated clutch.
Adaptive Backcountry Snowsports
Edward Parker
Ngā mihi
UC PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



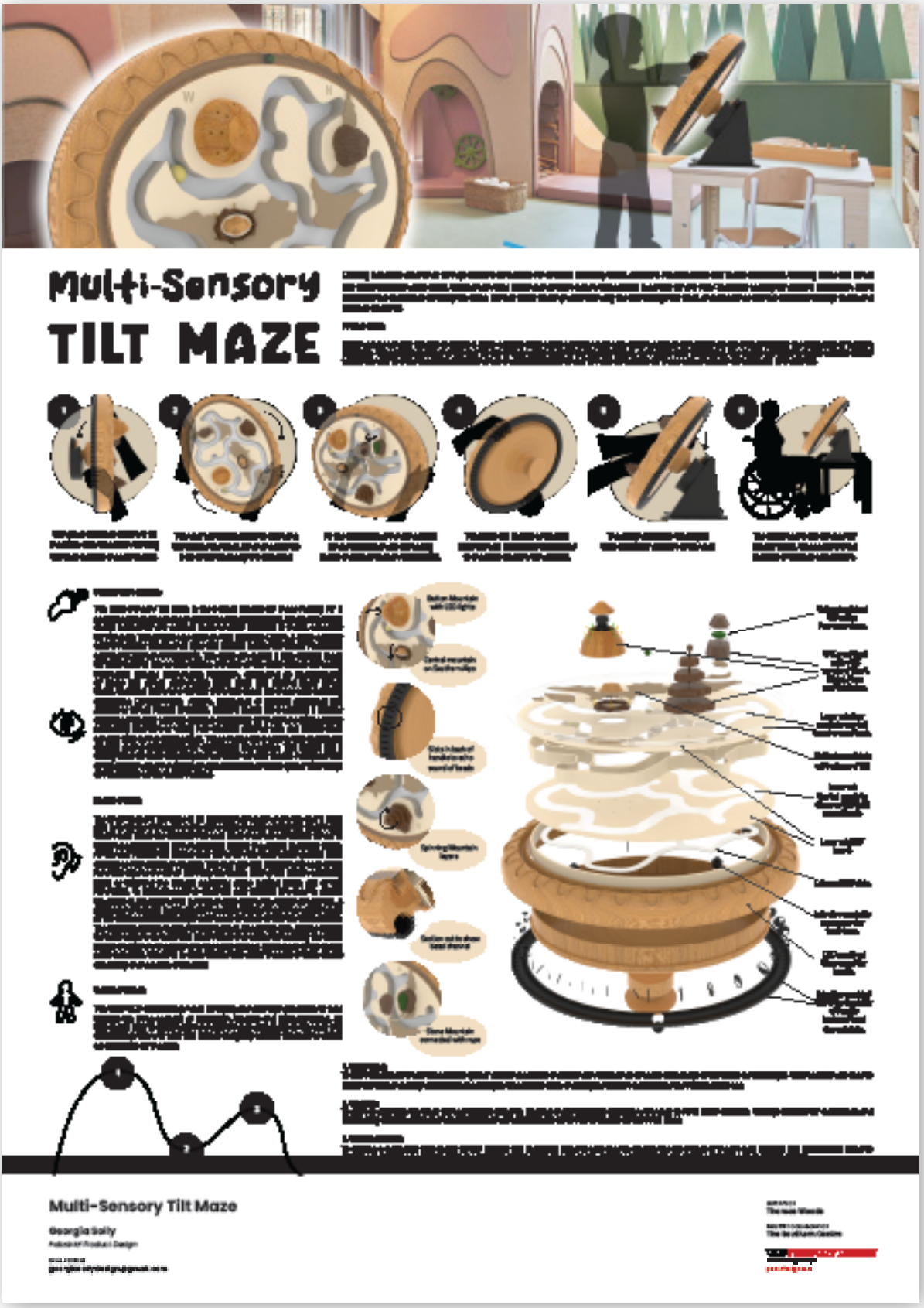
Student projects: Product Design - Industrial Product Design



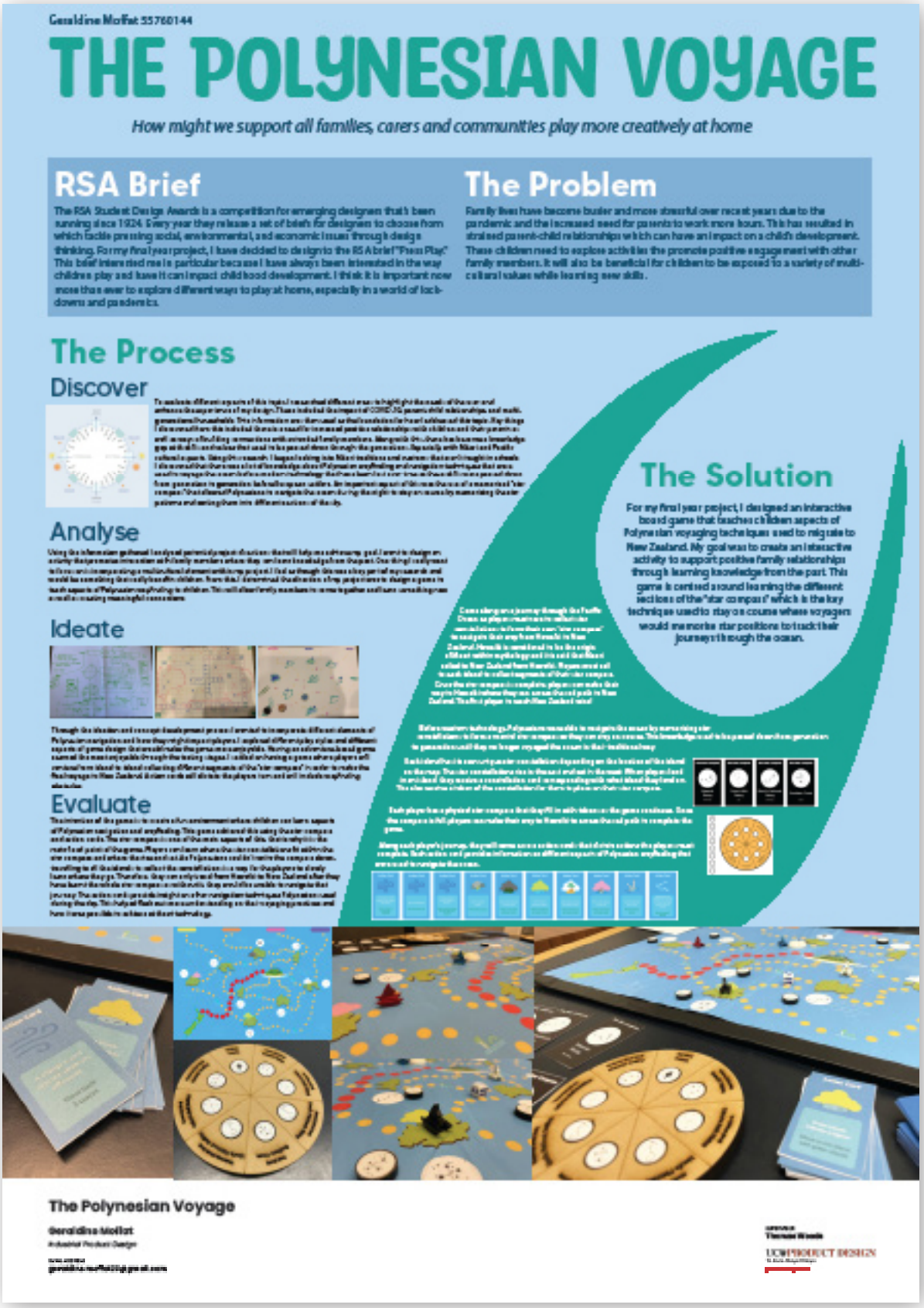
Student projects: Product Design - Industrial Product Design


maimoa
planet approved
maimoa
Problem
Product
Twist Release
Pry Release
Components of Collar
UC PRODUCT DESIGN
Te Kura Hanga Otinga
SCAN
for FOLIO

Student projects: Product Design - Industrial Product Design



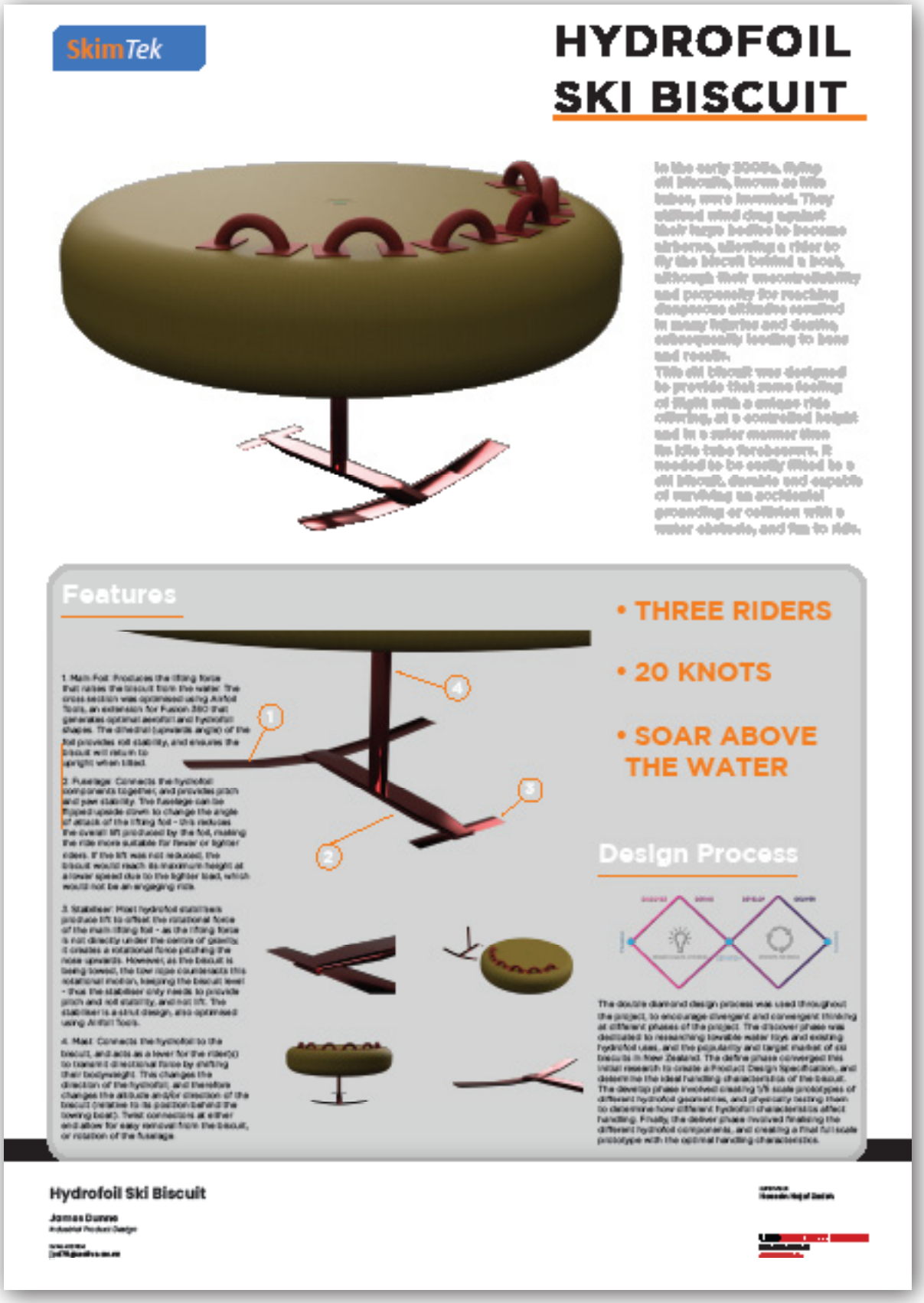
Student projects: Product Design - Industrial Product Design



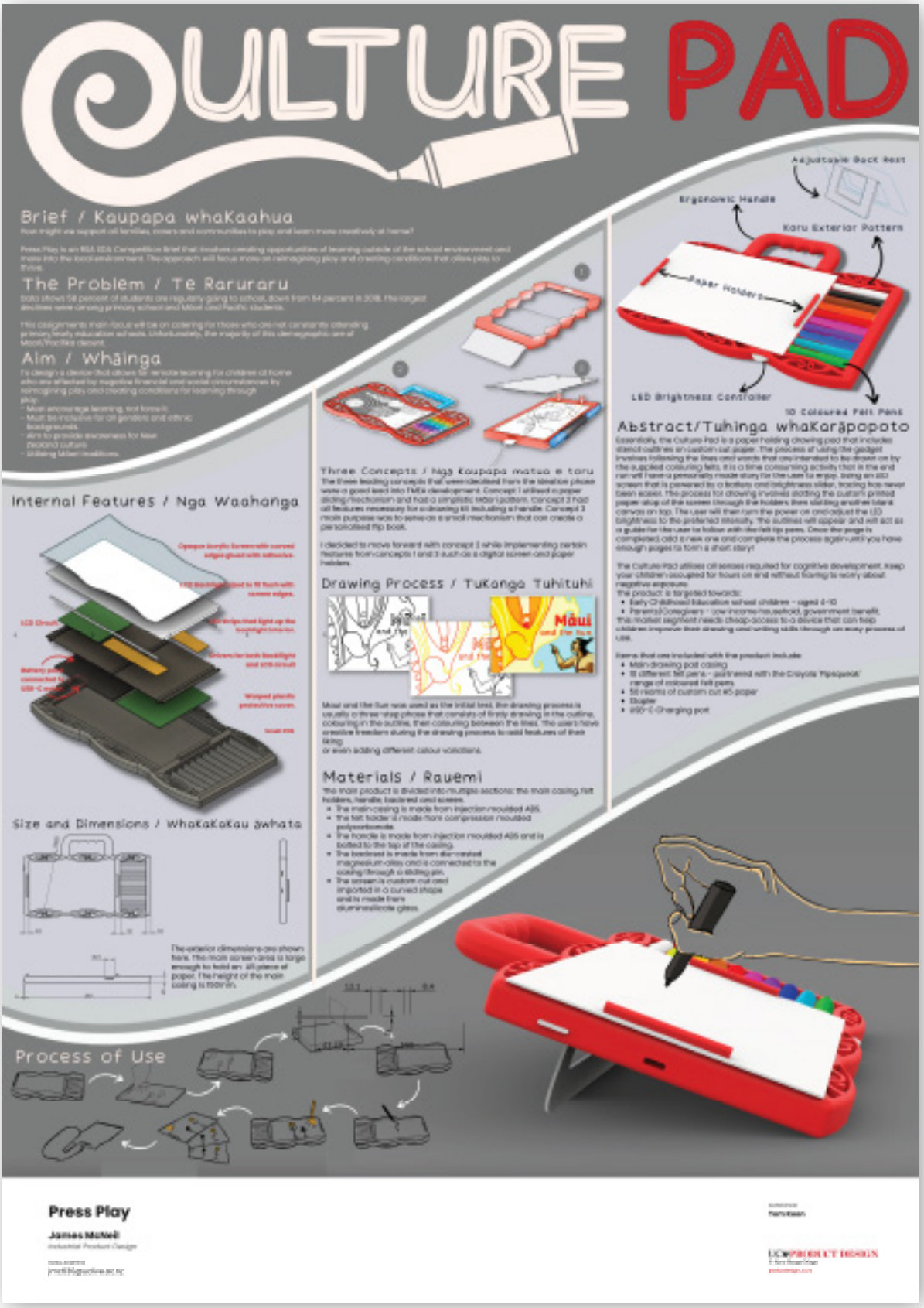
Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design


SkimTek
HYDROFOIL
SKI BISCUIT
Features
• THREE RIDERS
• 20 KNOTS
• SOAR ABOVE THE WATER
Design Process
Hydrofoil Ski Biscuit
James Dunne

Student projects: Product Design - Industrial Product Design



ERGOPRO BENCH

'Rigidity & Simplicity through design'

JN CONSULTANCY

Design process

Process

Project Abstract

Objectives

Embodiement in Design

ERGO FAT DAD

FAT FLAT DAD

DAD FRAME SUPPORT

2 X SQUARE SECTION ADJUST

CROSS BEAM FRAME

2 X ADJUST SIN SLOT WALL

2 X ADJUST SIN

HANDLE

H FRAME FOOT

H FRAME RUBBER PROTECTOR

2 X WHEELS

T FRAME FOOT

T FRAME RUBBER PROTECTOR

ERGOPRO BENCH

Jamie Nichols

Industrial Product Design

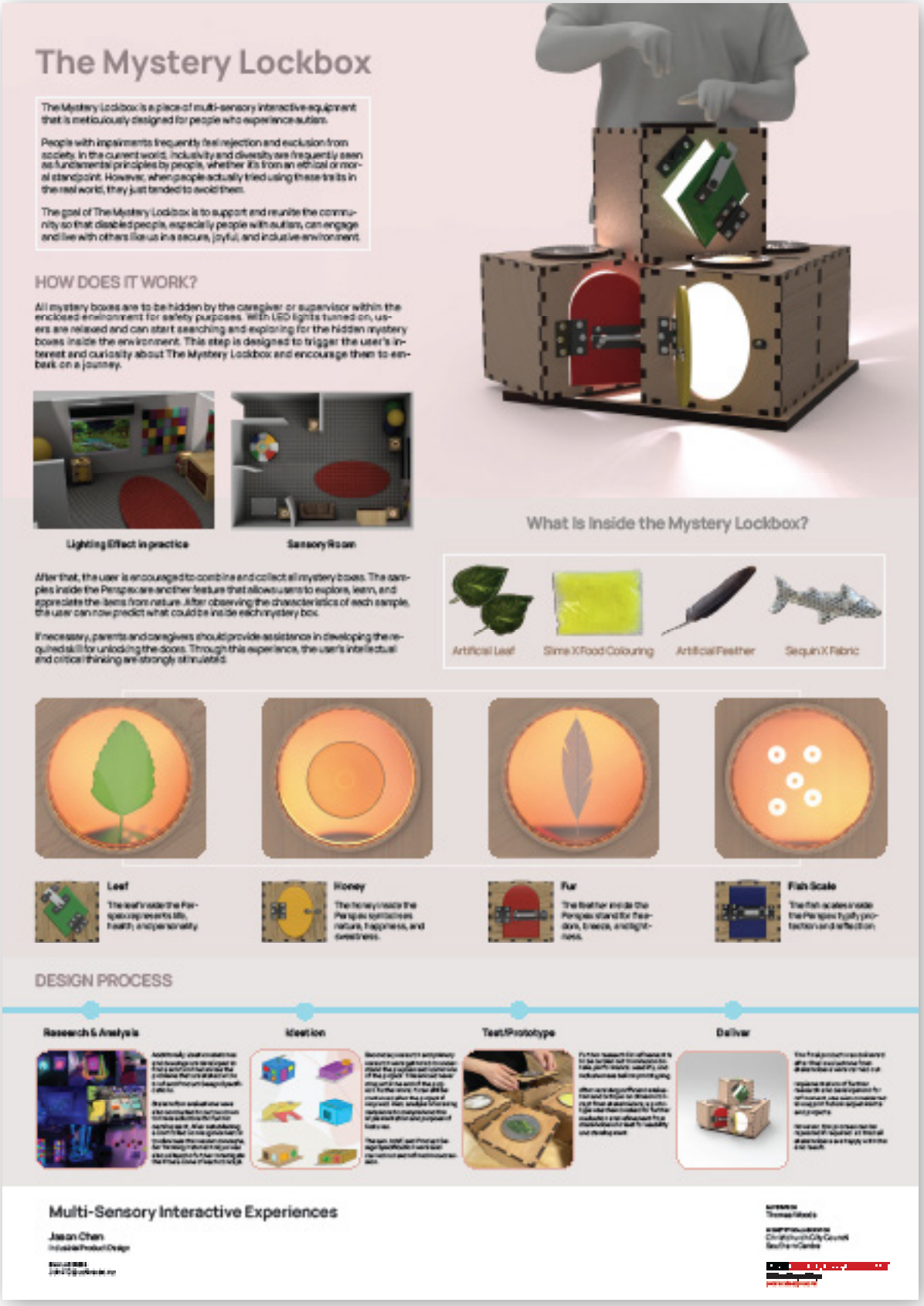
UC PRODUCT DESIGN

SUPERVISOR

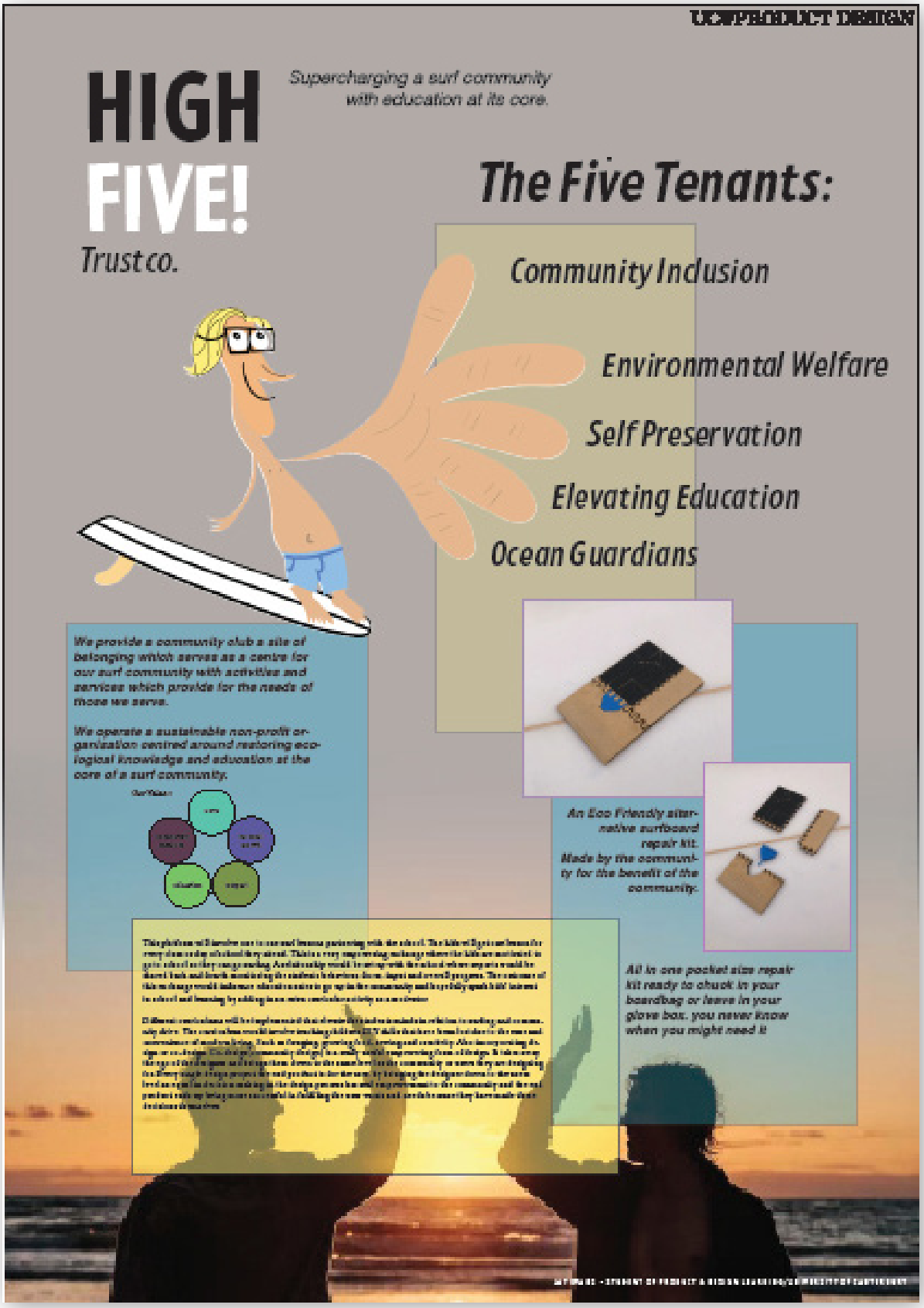
Tim Ewe

PROD314

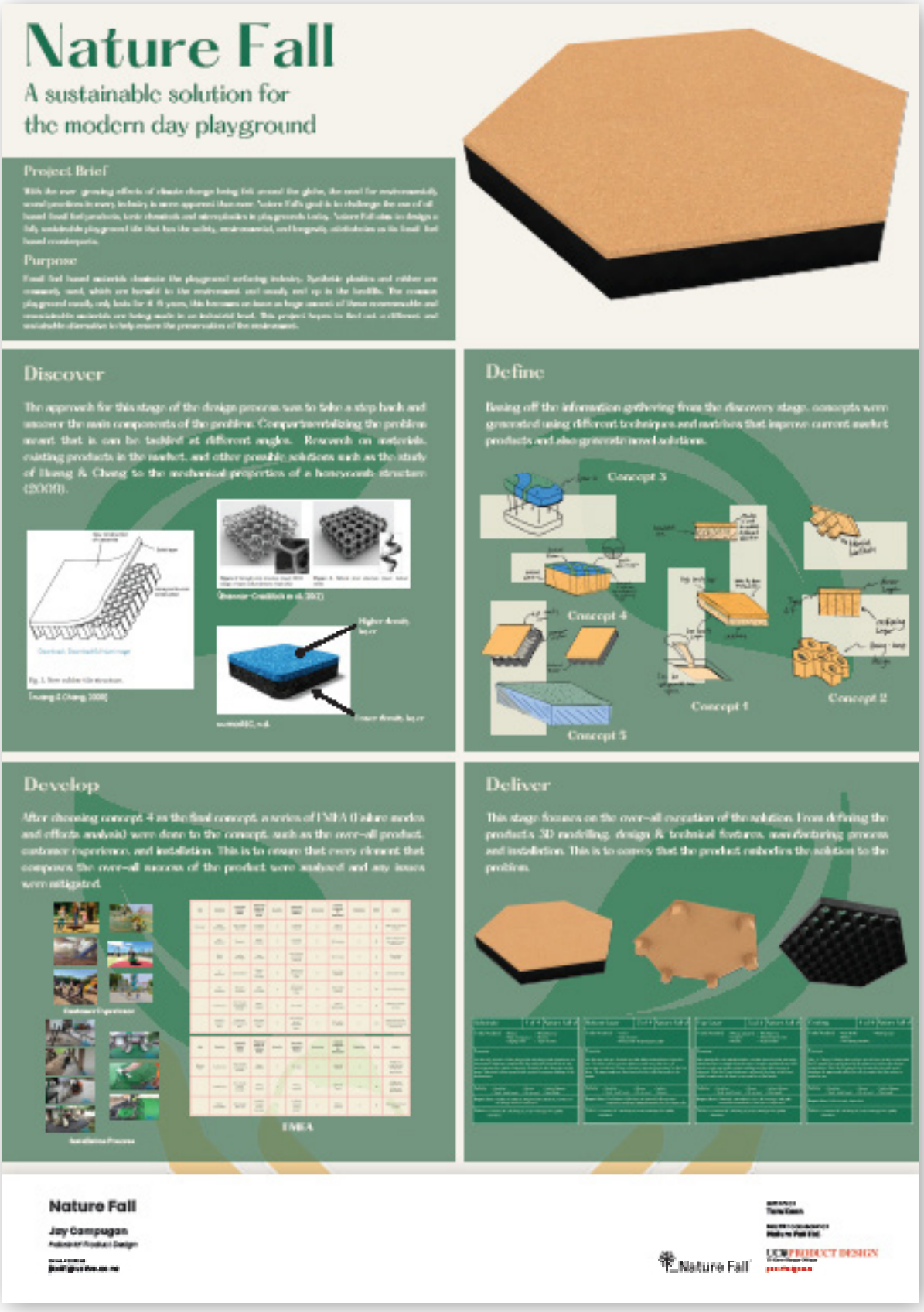
Student projects: Product Design - Industrial Product Design



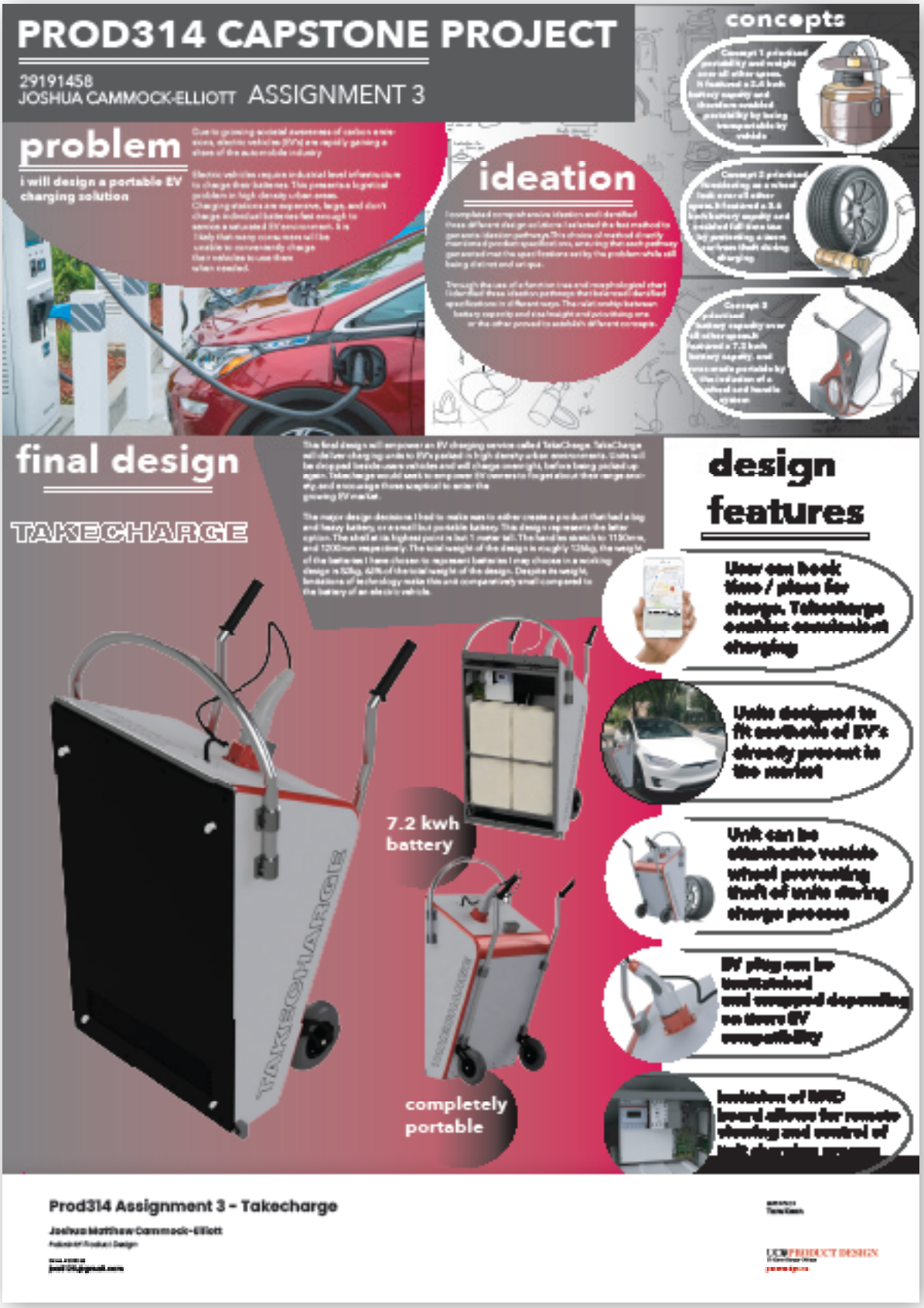
Student projects: Product Design - Industrial Product Design


UCT PRODUCT DESIGN
HIGH FIVE!
Supercharging a surf community with education at its core.
Trustco.
The Five Tenants:
Community Inclusion
Environmental Welfare
Self Preservation
Elevating Education
Ocean Guardians
We provide a community club a site of belonging which serves as a centre for our surf community with activities and services which provide for the needs of those we serve.
We operate a sustainable non-profit organization centred around restoring ecological knowledge and education at the core of a surf community.
An Eco Friendly alternative surfboard repair kit.
Made by the community for the benefit of the community.
All in one pocket size repair kit ready to chuck in your boardbag or leave in your glove box. you never know when you might need it

Student projects: Product Design - Industrial Product Design




Tu Ki Te Waahi
Stop in Place Snowboard Brake
Brief: Runaway snowboards have created a danger to all mountain users due to modern snowboard leashes becoming shorter and an ever-increasing number of snowboarders not using a leash.
The current market is made up of leashes that connect from your bindings to your boot, keeping your snowboard constantly attached to you. This is intended to prevent your snowboard from racing down the mountain without the user on it. However, this system is flawed as you are un-binded from your board before securing your leash, so when at the top of the mountain, you place the same risk of your board running away from you when placing your leash on as when you are putting your bindings on without a leash.
A solution must be implemented where runaway snowboards can be prevented without the need for a leash and that does not rely on user input. It is crucial that this solution will not hinder the edge of the snowboard or be of a significant weight that will disturb the balance and feel of the snowboard.
Aim: Develop a simple, easy to use and marketable product that ensures the users snowboard comes to a stop within five metres of the board being released from their control. In turn, this will increase the safety of ski fields and help bring an easier user experience to all snowboarders.
Final Outcome: Through testing a prototype at the Mt. Hutt ski field, the Tu Ki Te Waahi snowboard brake kept a static board on a 10 degree slope at rest. On a 20 degree slope, it stopped the snowboard at an average of 0.63m. Dropping a snowboard from a height of 1m while walking, the snowboard brake successfully stopped the board at an average of 1.4m on a 10 degree slope and an average of 3.94m on a 20 degree slope.
These results show that the Tu Ki Te Waahi snowboard brake successfully met the project's brief and aim and is a product that can serve a purpose in today's ski and snowboard market.
Brake Engaged
When the snowboard brake is engaged, the hook gets caught in the snow and brings the board to a stop. Through the use of a torsion spring, the brake can only be disengaged by the rider standing on the lever, in turn rotating the rod, and lifting the brake out of the snow.
Brake Unengaged
While the brake is unengaged, the snowboard rider is securely strapped to their board through their bindings. When the rider's foot presses down on the lever, the rod rotates, releasing the brake from the snow and off the ground, allowing the user to snowboard as they please.
Stakeholders Review
Scan to discover more of my design work:
Tu Ki Te Waahi - Stop in Place SnowboardBrake
Joe Robert
Industrial Product Design

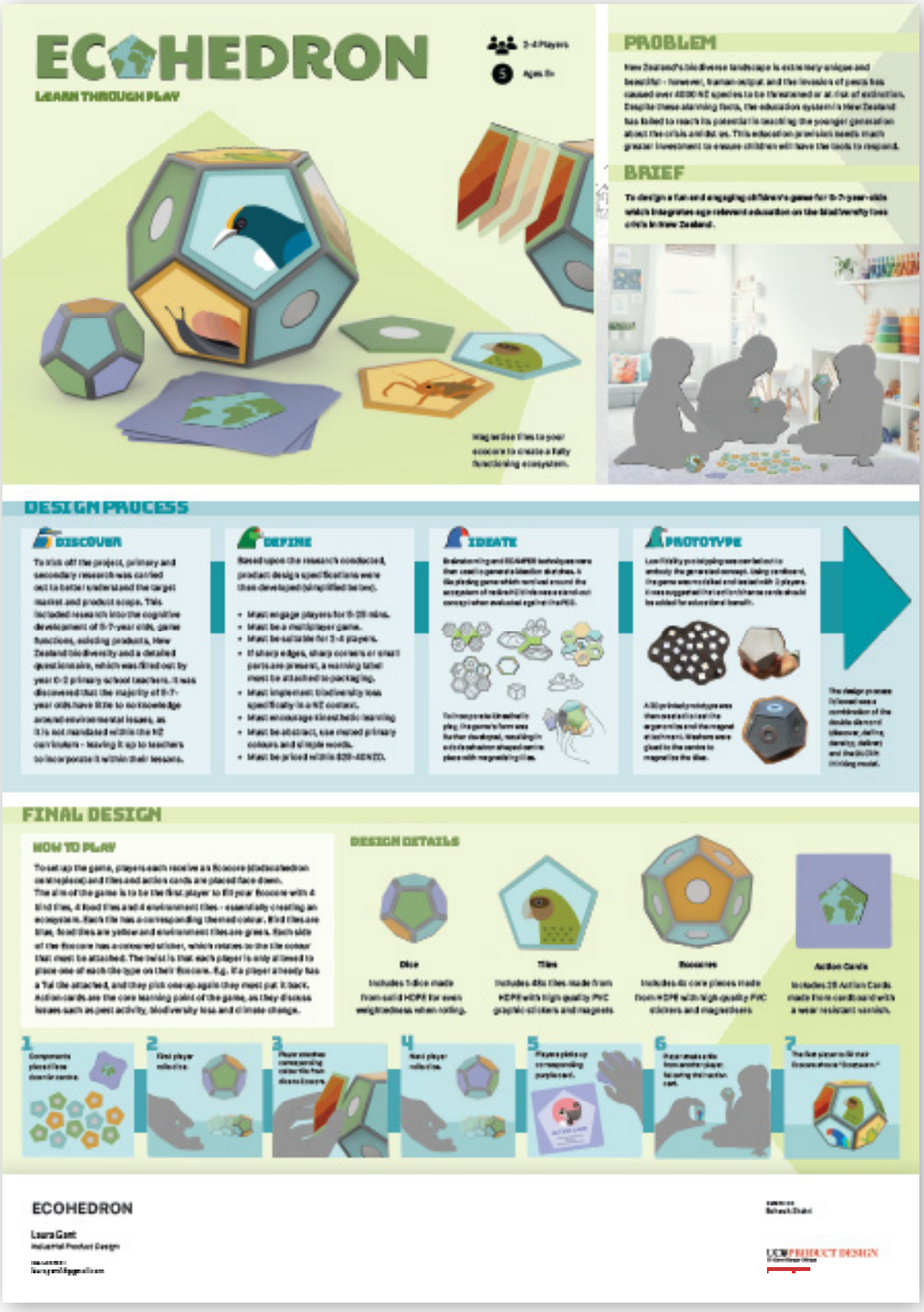

PROD314 CAPSTONE PROJECT
29191458
JOSHUA CAMMOCK-ELLIOTT ASSIGNMENT 3
problem
I will design a portable EV charging solution
ideation
concepts
final design
TAKECHARGE
7.2 kwh battery
completely portable
design features
Prod314 Assignment 3 - Takecharge
Joshua Matthew Cammock-Elliott

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Eco Core

High performance doesn't mean High environemental cost

The problem

Surfboard development has come a long way from the traditional solid planks of wood of the past, to lightweight performance based polystyrene boards. However, this evolution has come with its downsides in the form of environmental issues. These foam blanks produce a lot of waste. This project aims to re - design the internal core of surfboards, making them more sustainable, pushing the next step of surfboard evolution.

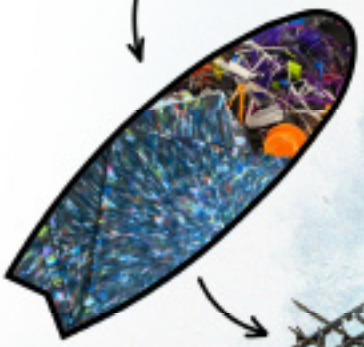
Design process

Initial ideation to explore different possible structures

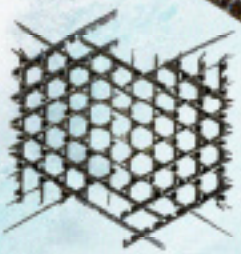
Physical prototyping to test feasibility of initial ideas

Material

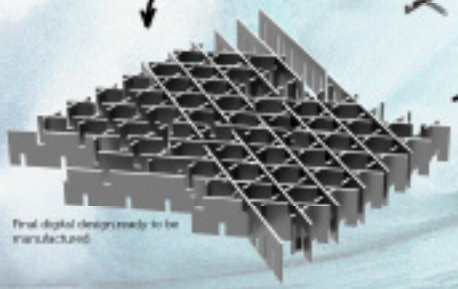
Through intensive research and prototyping a variety of different materials I found that polylactic acid (PLA) would be best suited for my core. PLA has great material properties that will perform similar, if not better than traditional polyurethane (PU) foam while minimising the footprint of surfboard manufacturing. This material is also very prominently used for 3D printing, leaving a lot of waste material which can be repurposed in the manufacturing of these cores.



Collection, shredding and formulation of recycled plastic sheets



Final digital design ready to be manufactured



Final solution

This design reflects on areas that I am very passionate about, both environmental issues and outdoor activities, trying to influence the next step of sustainable design in industries. Recycled PLA is used to create the modular surfboards eliminating PU foam creating a structurally sound surfboard that embodies all aspects of surfboard design

Project title

Lochiel Espiner
Industrial Product Design

Email Address
lochielespiner@gmail.com

SUPERVISOR
Nick Emerson

INDUSTRY COLLABORATOR
Individual Brief

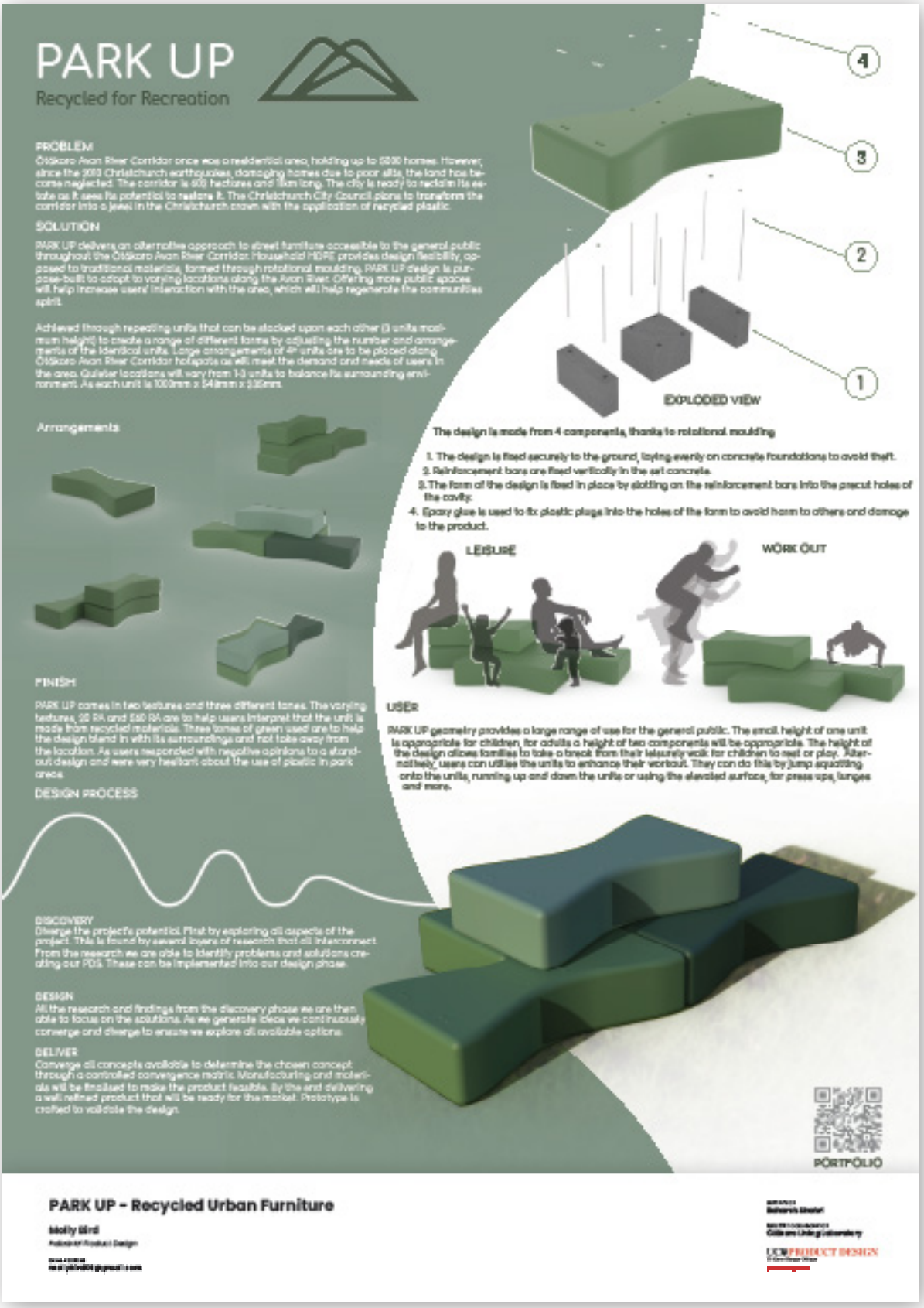
UCxPRODUCT DESIGN
Te Auru Hangai Oihaga

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



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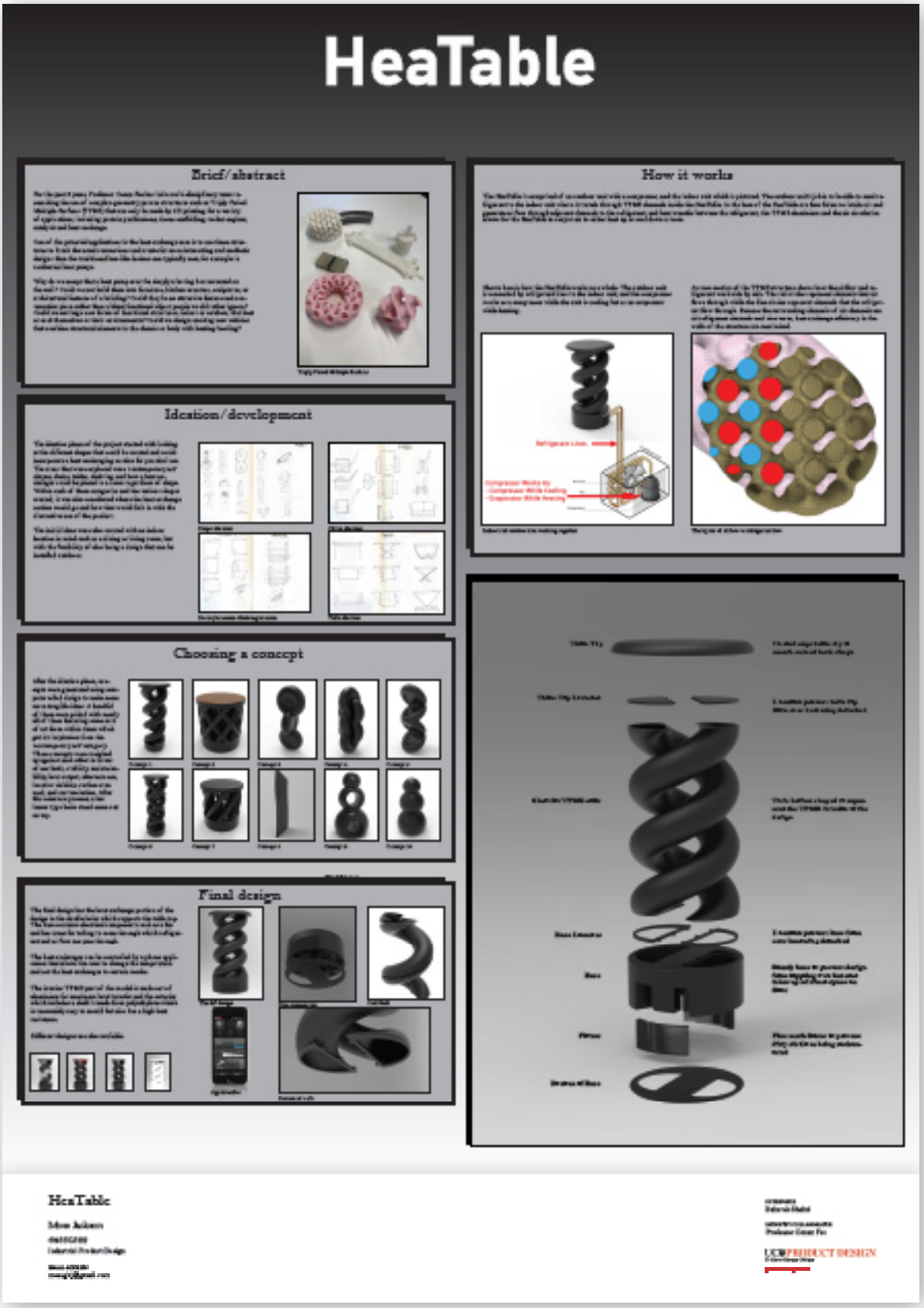

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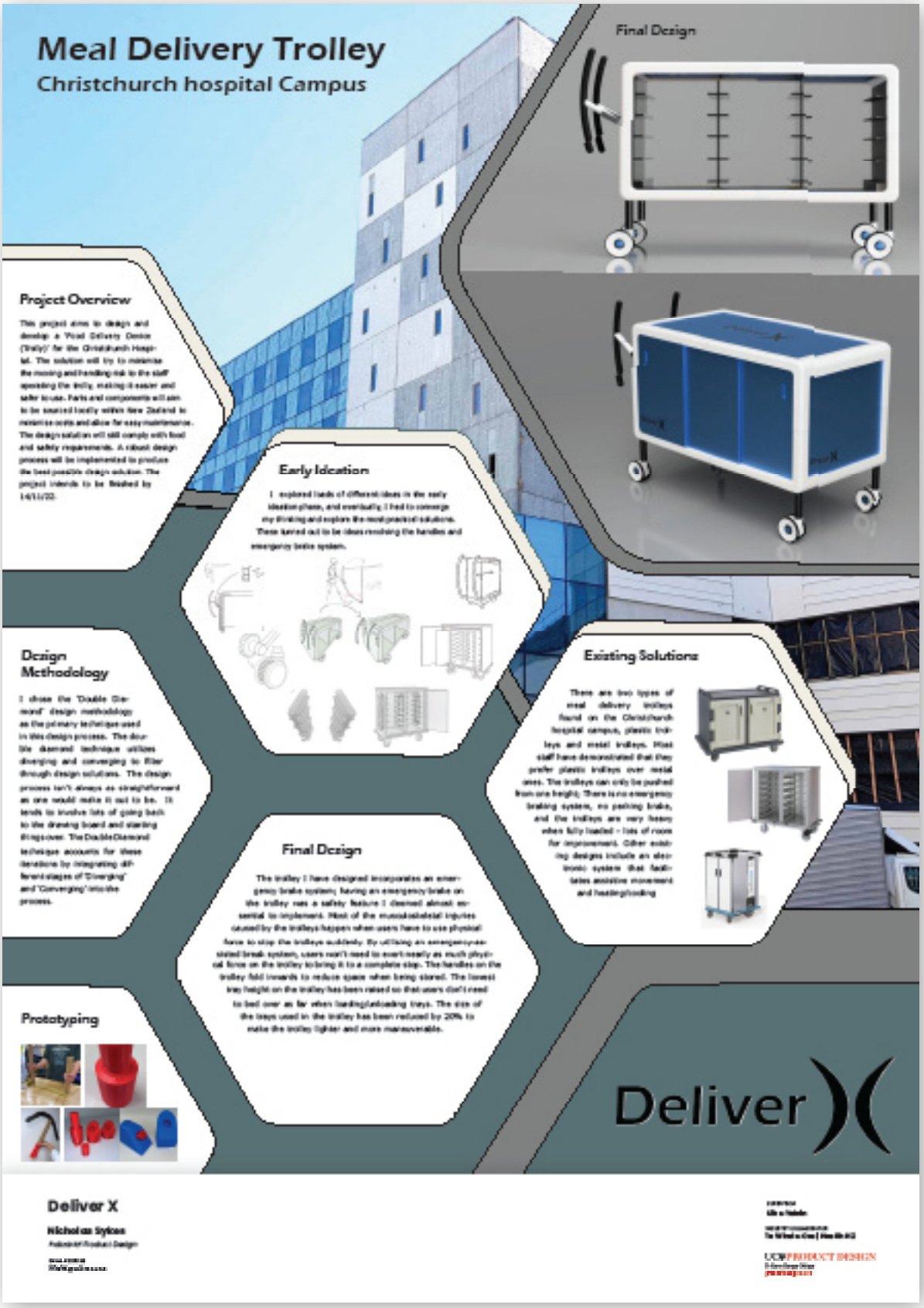
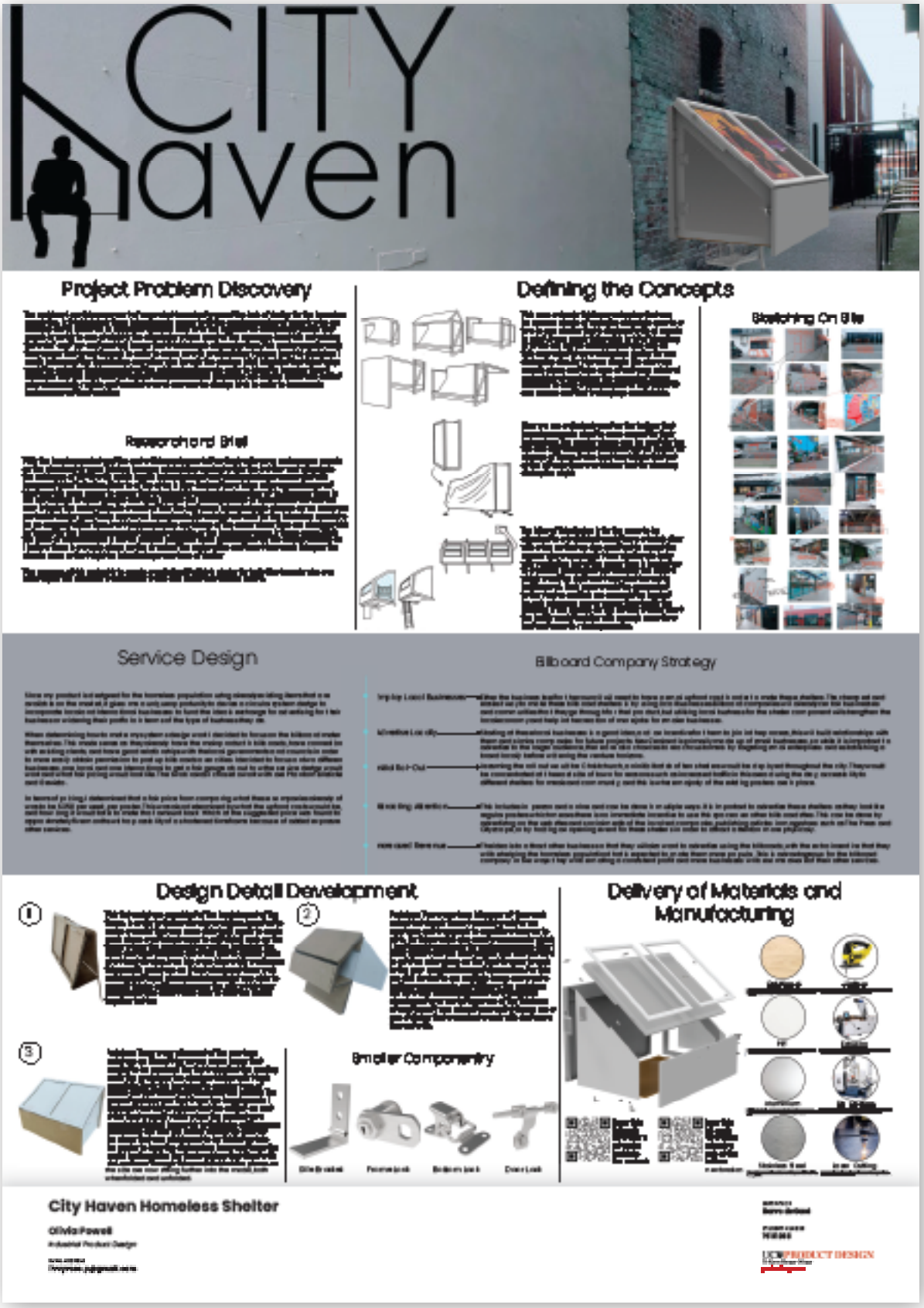


Student projects: Product Design - Industrial Product Design



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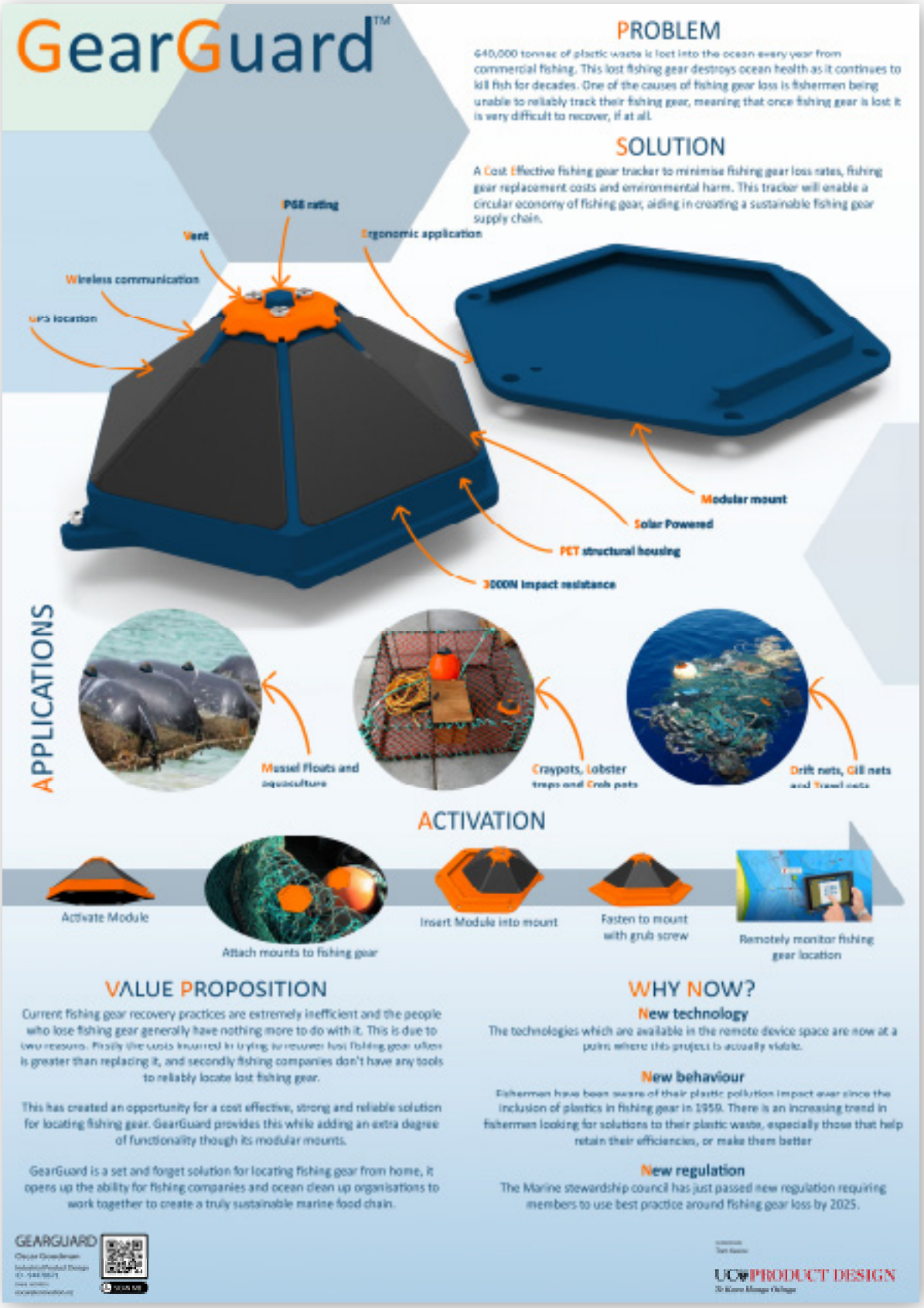
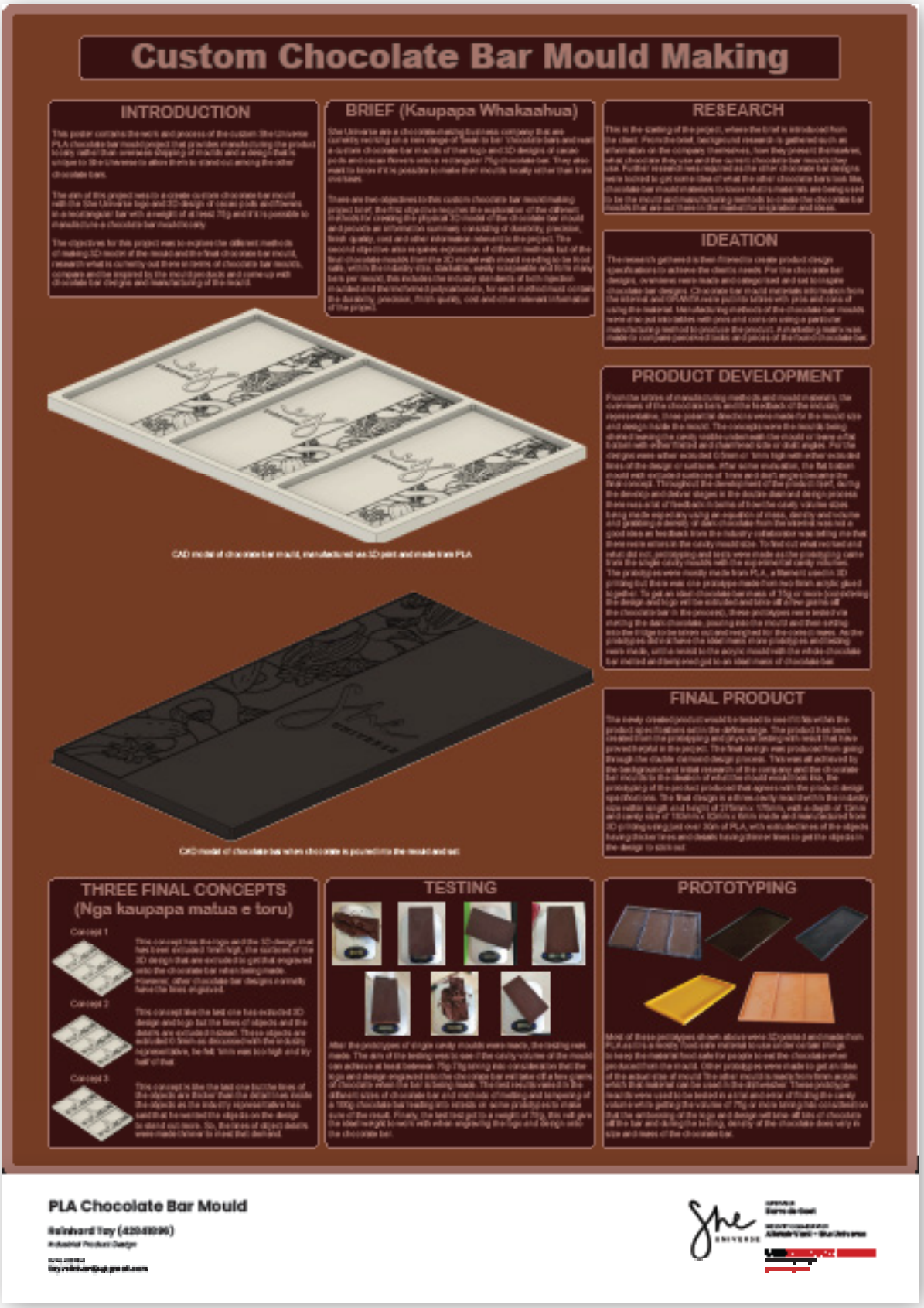



PACK-IT
JACKET
Wearable Luggage
The Pack-it Jacket is designed specifically for the traveller who always seems to have overweight bags. The jacket has a total of sixteen pockets for storing excess luggage, creating a puffer-like jacket when filled with items and can fit around slings. It can be worn in two different lengths as well as having the ability to zip off the sleeves to create a vest. Simply fill the jacket with items and wear it on the airplane to avoid additional luggage fees.
Design Features
Minimalistic
Durable
Sustainable
The Process
Pack-it Jacket
Poppy Fallon

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



ESCAPADE

Outdoor Comunications Device

BY REUBEN BEARPARK
ID: 43788627

AIM

Develop a simple, easy to use and marketable product that allows users to communicate easily and have on demand location data on group members when needed, all without the use of traditional Infrastructure such as cell networks or internet.

BRIEF

Currently there are only a few products on the market that combine two-way communication paired with OnDemand location tracking of users, for outdoor adventure use. One common and very popular example of this is the Garmin in-reach mini. However, this device is very expensive, costing around $650 making it less accessible to its users. The primary use of the InReach mini is to notify outside parties about the wellbeing and progress of its users.

While this is important it's also critical to have a cheap, reliable communication and location link with people you may have along with you, in case of separation or if members wish to explore individually.

As This product is intended to be used by the Adventurer, it should be usable in a variety of situations and weather conditions. Being able to withstand being dropped, and exposure to elements such as hash sun, rain, snow and dirt.

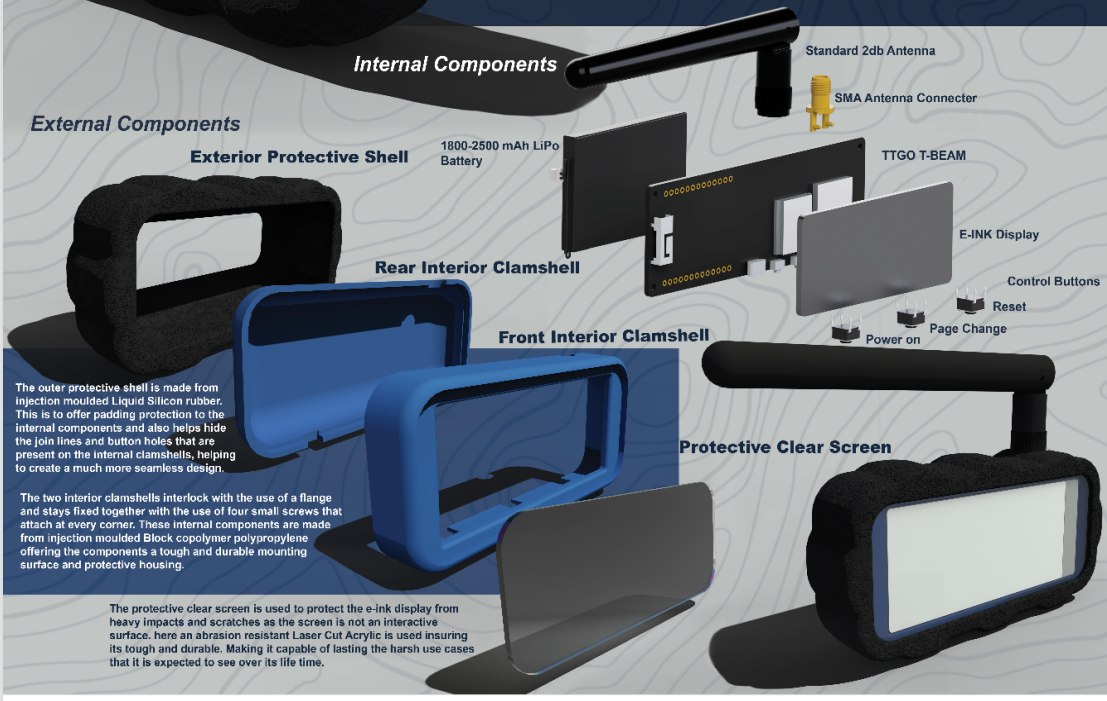
It's important that this device is easy to use, small and light. As a large bulky device will more likely be left behind and won't suit anyone trying to go outdoors.

Product Features

- •10 - 20 KM Messaging (LORA technology)
- •Accurate location tracking piggybacked off phones GPS.
- •long battery life (multiple days)
- •small, lightweight and portable
- •IPX4 water resistance.
- •Tough and Durable (Tested to MIL-STD-810)
- •Easy messaging though app on phone.
- •Different colour options available
- •Easy to use
- •Cheap and accessible
- •NO cost to message
- •Replaceable antenna
- •Replaceable components
- •Sunlight readable E-ink display
- •Aesthetically pleasing.

Internal Components

External Components



The outer protective shell is made from injection moulded Liquid Silicon rubber. This is to offer padding protection to the internal components and also helps hide the join lines and button holes that are present on the internal clamshells, helping to create a much more seamless design.

The two interior clamshells interlock with the use of a flange and stays fixed together with the use of four small screws that attach at every corner. These internal components are made from injection moulded Block copolymer polypropylene offering the components a tough and durable mounting surface and protective housing.

The protective clear screen is used to protect the e-ink display from heavy impacts and scratches as the screen is not an interactive surface. here an abrasion resistant Laser Cut Acrylic is used insuring its tough and durable. Making it capable of lasting the harsh use cases that it is expected to see over its life time.

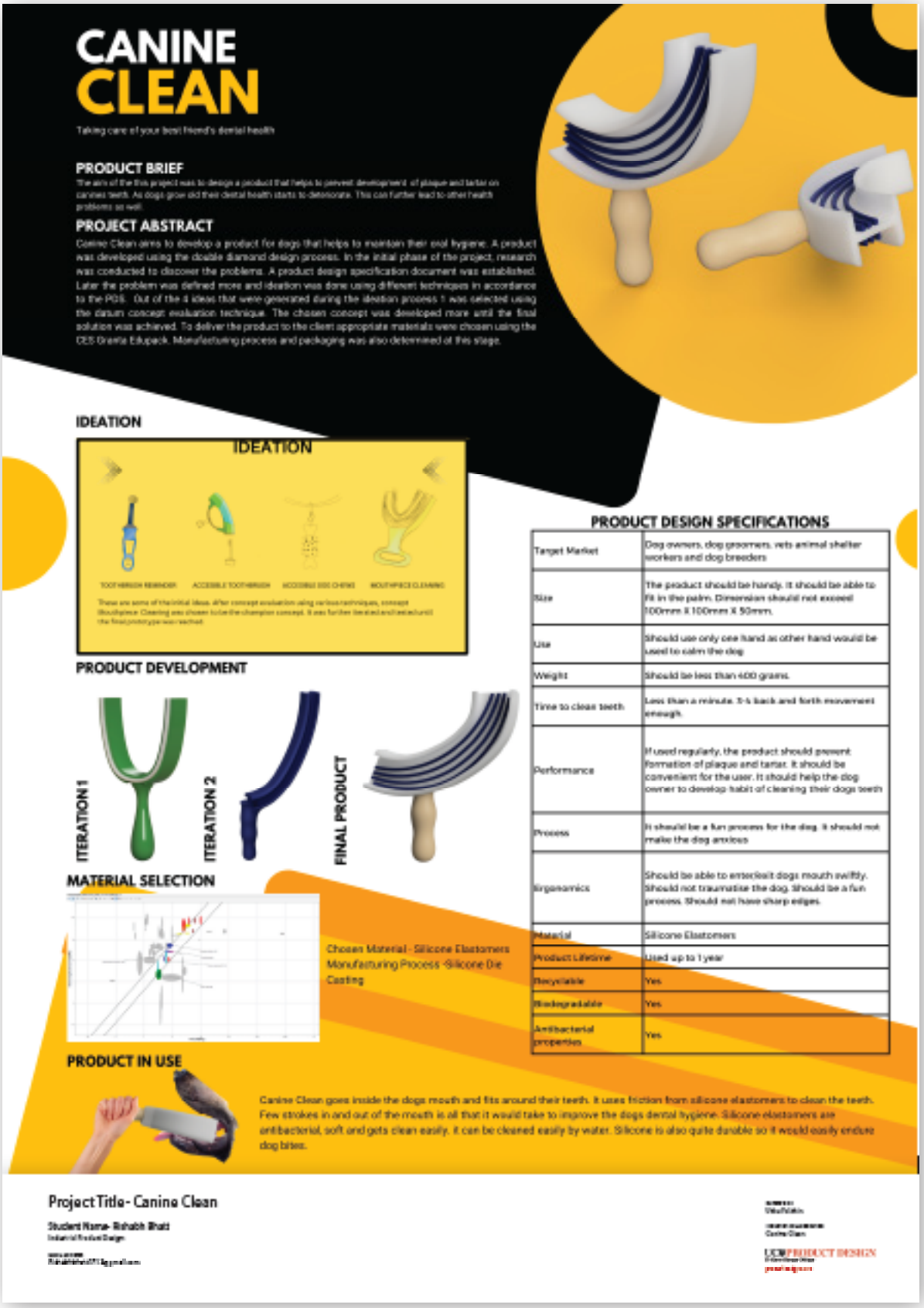
ESCAPADE Outdoor Comunications

Reuben Bearpark
Industrial Product Design
EMAIL ADDRESS
rab224@uclive.ac.nz

SUPERVISOR
Euan Coutts

UC PRODUCT DESIGN
productdesign.ac.nz

Student projects: Product Design - Industrial Product Design



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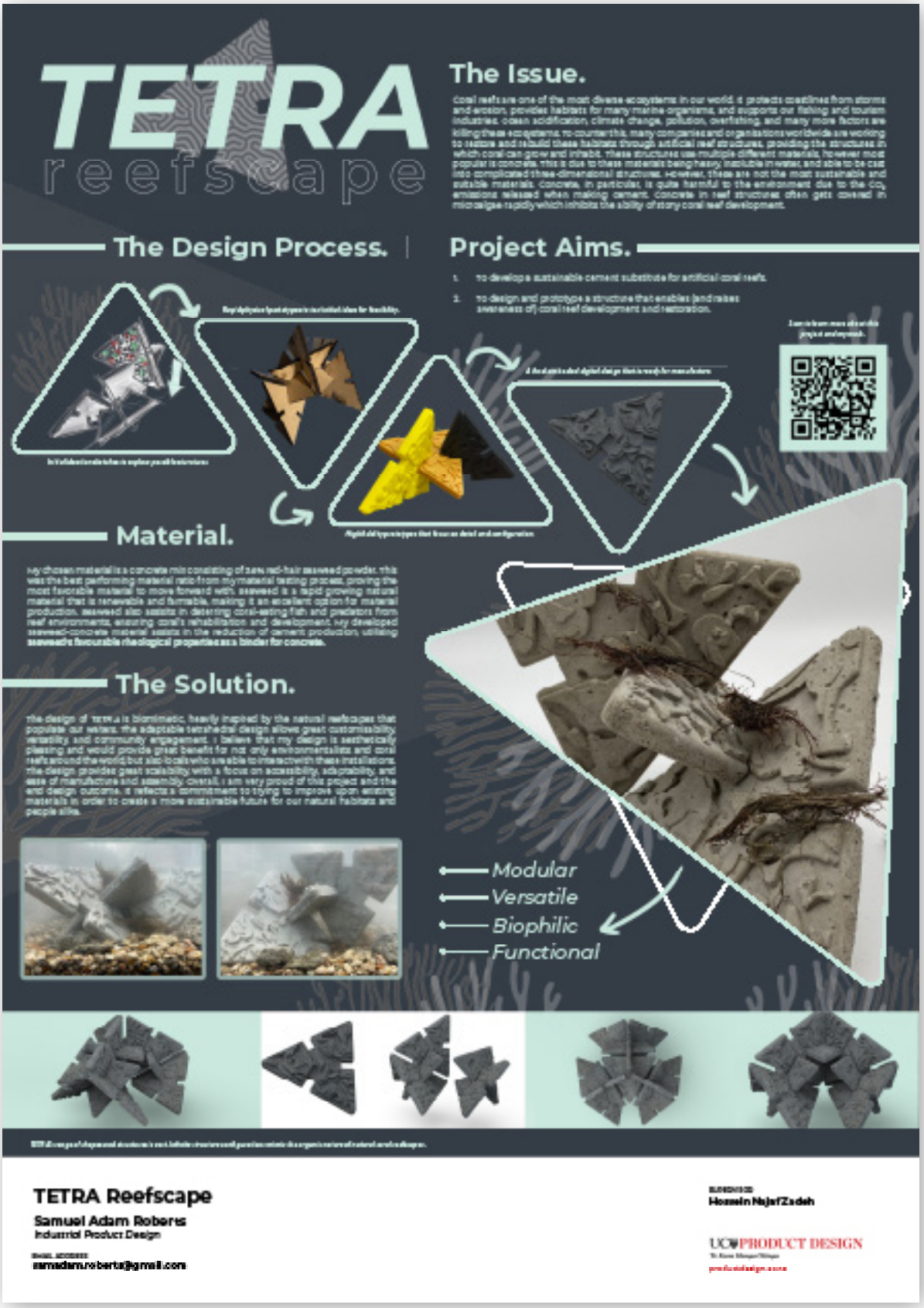
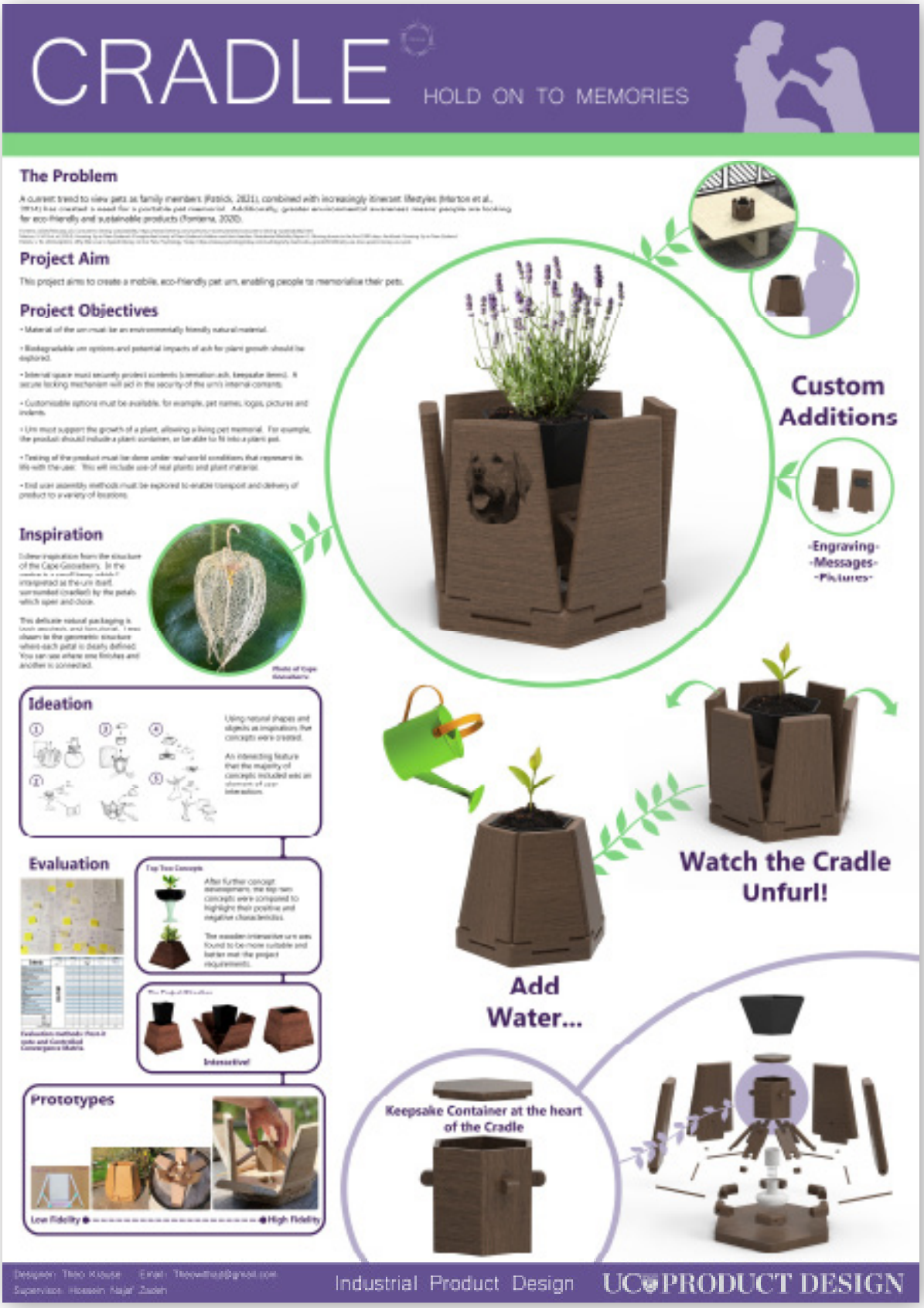
Student projects: Product Design - Industrial Product Design




Automatic Lego Brick Organiser
Purpose
Details
Prototype Testing
Avalible Filter Sizes
Scan Me!
UC PRODUCT DESIGN
Te Kura Hanga Otinga
Lego Brick Organiser
Scott Syder


COBRA
Collapsible Electric Guitar
Animation
Design Process
The main goal I wanted to achieve was for the guitar to fit inside an everyday backpack. The design process started around the folding of the neck and the tensioning of the strings as this was the biggest hurdle to overcome. The neck needed to be rigid one in the playing position which meant a stable hinge system and the strings needed to be tensioned and detensioned easily. The collapsing of the body came after the neck system. I wanted to find a good balance between the body being small and compact and it looking good and being comfortable.
Lower Prototype
Hinge Prototype
Body Prototype
Design Details
Neck
The neck folds through the use of a concealed hinge. To lock the neck in place bolts are threaded through the two facing plates. A lever system above the neck allows the strings to be tensioned for playing and de-tensioned for travel
Body
The body consists of a center piece and two wings that can fold in and out through metal bars. The body can be locked into the out position the through spring loaded pins
Features
- Headless design
- Two humbucker pickups
- 3 way selector switch
- Volume control pot
- 24.75 inch (628.65mm) scale length
59%
size reduction
Cobra Collapsible Electric Guitar

Student projects: Product Design - Industrial Product Design



EcoRoll

Hard Cable Cover

Thomas Hughes 07544513

The Brief

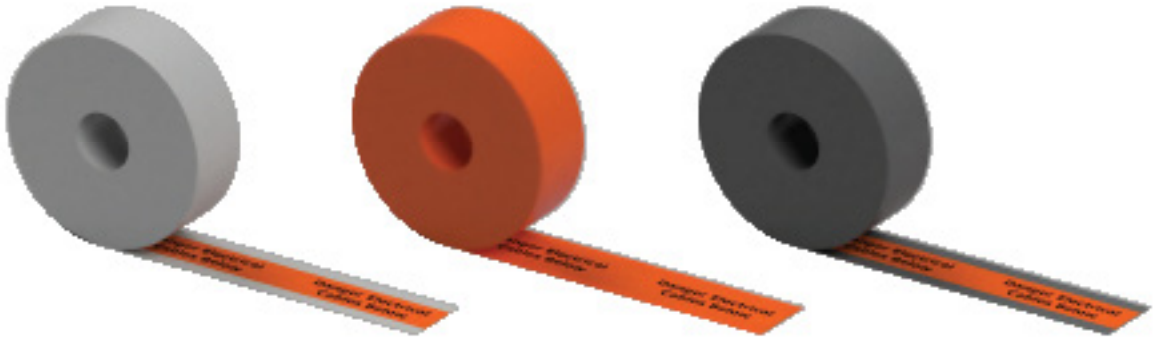
To redesign polymeric hard cable cover into a lighter, thinner and sustainable product to use and install.

The Problem

Protective cable covers are vital in preserving electrical services buried underground. They protect buried cables and prevent expensive damage to them by excavation equipment. These covers need to last for years underground without degrading. In Australia and New Zealand they must meet the AS4702-2000 standard for Polymeric Cable Protection Covers.

High Density Polyethylene(HDPE) is the preferred choice for current products due to its low price and good mechanical properties. However, at 5mm thick it does not meet the standard and causes the weight of a 200m roll to be quite heavy. This can be hazardous to people in transportation, handling and installation.

The challenge was to find a new material which meets the standard yet is lighter and costs no more than the current product.



The Solution

The EcoRoll is a hard cable cover made from Nylon 66 designed to be lighter, thinner and safer to install. The EcoRoll still meets the AS4702-2000 standard at 3mm thick.

- Safer to install - lighter & smaller, reducing risks of crushing/serious injury.
- Easier to install - no large machinery required.
- Easier to transport - weight savings means less loads and lower emissions.

The EcoRoll comes in 200m long rolls at 300mm wide however these can be varied where needed.

Nylon 66 belong to the polyamide family and

- Has very good hardness
- Is wear resistant
- Has high mechanical strength
- Is easily machined
- Has low electrical conductivity

Installation sites can vary in size so the EcoRoll offers flexibility in how it is installed.

For larger sites it can be installed as demonstrated on the left. Here the end has been fixed in the end and it is walked along by the machinery. For smaller sites it can be walked out by hand.

EcoRoll: Hard Cable Cover

Thomas Hughes

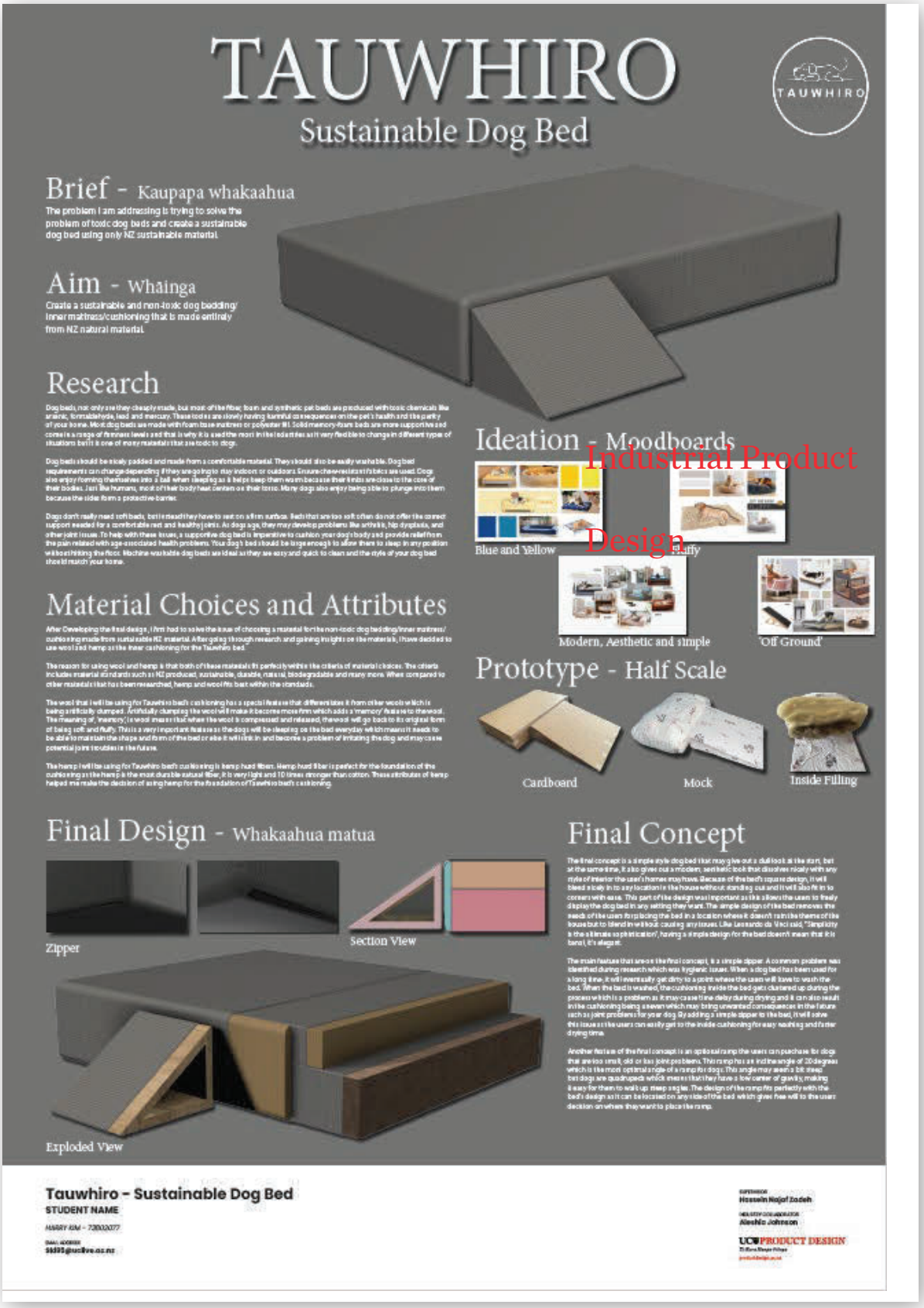
UCW PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

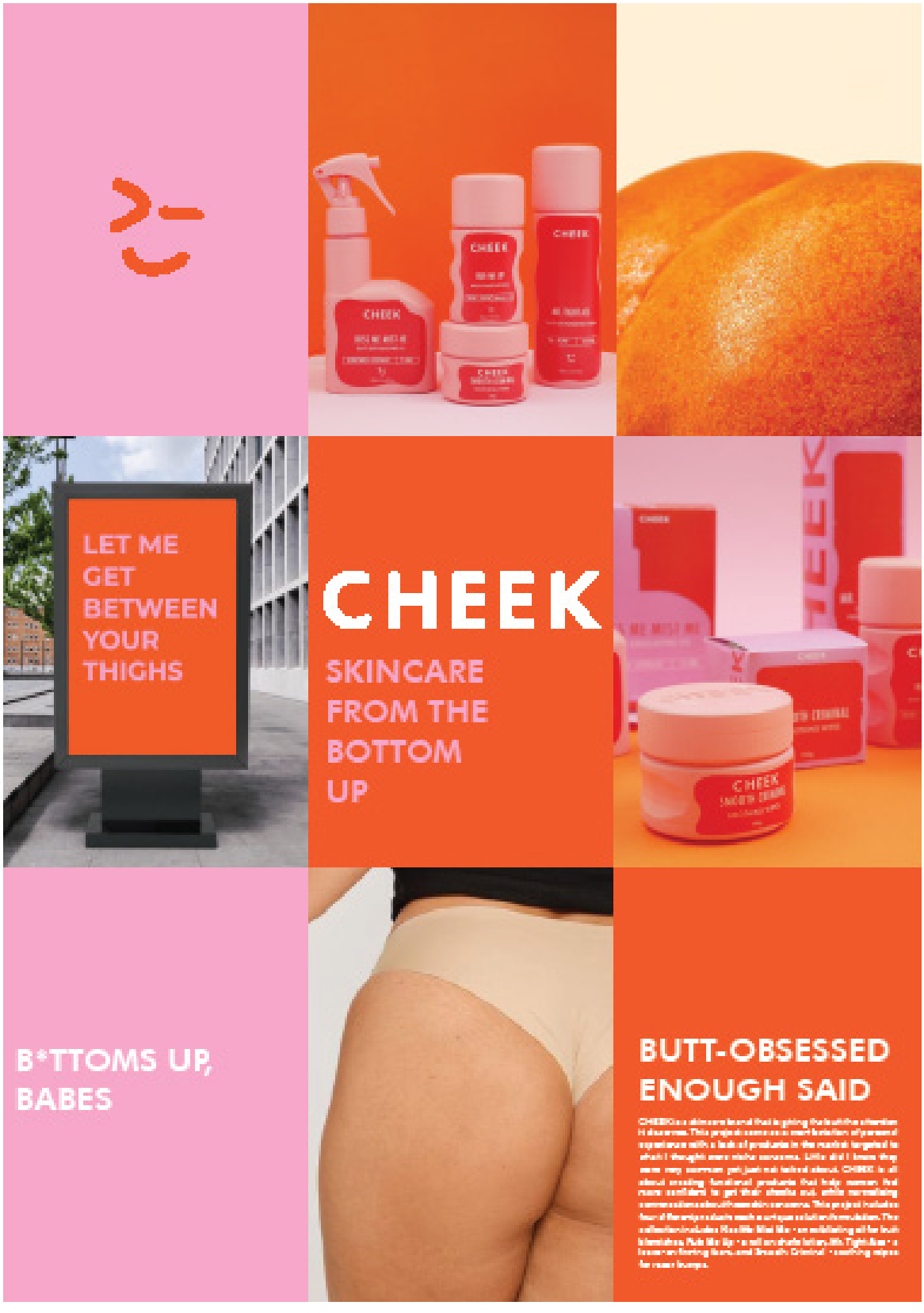
Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design



Student projects: Product Design - Chemical Formulation Design

E D E N

Plant Care

EST. 2022

EDEN is a luxurious houseplant agrochemical company designed to

'Preserve Nature's Beauty'.

The brand mission statement is to produce high-quality household products that care for your plants and protect our environment. Striving to provide consumers with effortless and sustainable alternatives to household agrochemicals that they will be proud to display with their plants, EDEN wants to educate consumers not only on how to care for their plants but our planet as well. Valuing Sustainability, Reliability, and Safety, all ingredients are highly researched and backed by science, are 100% renewable, and have a minimalistic design to fit into most interior design styles.

EDEN's target market are women aged 25-55 who are looking for luxurious, easy ways to care for their houseplants. We want to differentiate from our competitors by creating a desirable product that has value beyond its function alone. Some houseplants can cost around $500 to purchase, so providing a luxury plant care option that fits into the desires and needs of this market is exactly what EDEN has done.

Plant Protectant

Solid Fertiliser

Tiana Pink

ASCEND TRAVEL CARE

THE PROBLEM

THE SOLUTION

THE BARRIER PROTECTING CREAM

THE REHYDRATION TABLET

THE TRAVEL SUPPORT CAPSULES

ASCEND,
YOUR TRAVEL CARE ESSENTIALS

student of

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

Rae

The Problem

In New Zealand the combination of our laid back 'she'll be right attitude' and the hole in the ozone layer being directly above us, has meant that our melanoma rates are the highest in the world. Each year 350 New Zealanders die from melanoma. The way sunscreen is being applied by the consumers differs greatly from its recommended application and from the way SPF testing is conducted.

The Target Market

As sun burn is more common among people aged between 18-29 this will be Rae's target market. Rae products aren't limited to those who frequent the beach. Instead, Rae is designed to be used every day by anyone exposed to the sun. A typical consumer would be a New Zealander who is looking for sun care products that make use of New Zealand native plant extracts or are looking for products that are made in New Zealand.

The Proposal

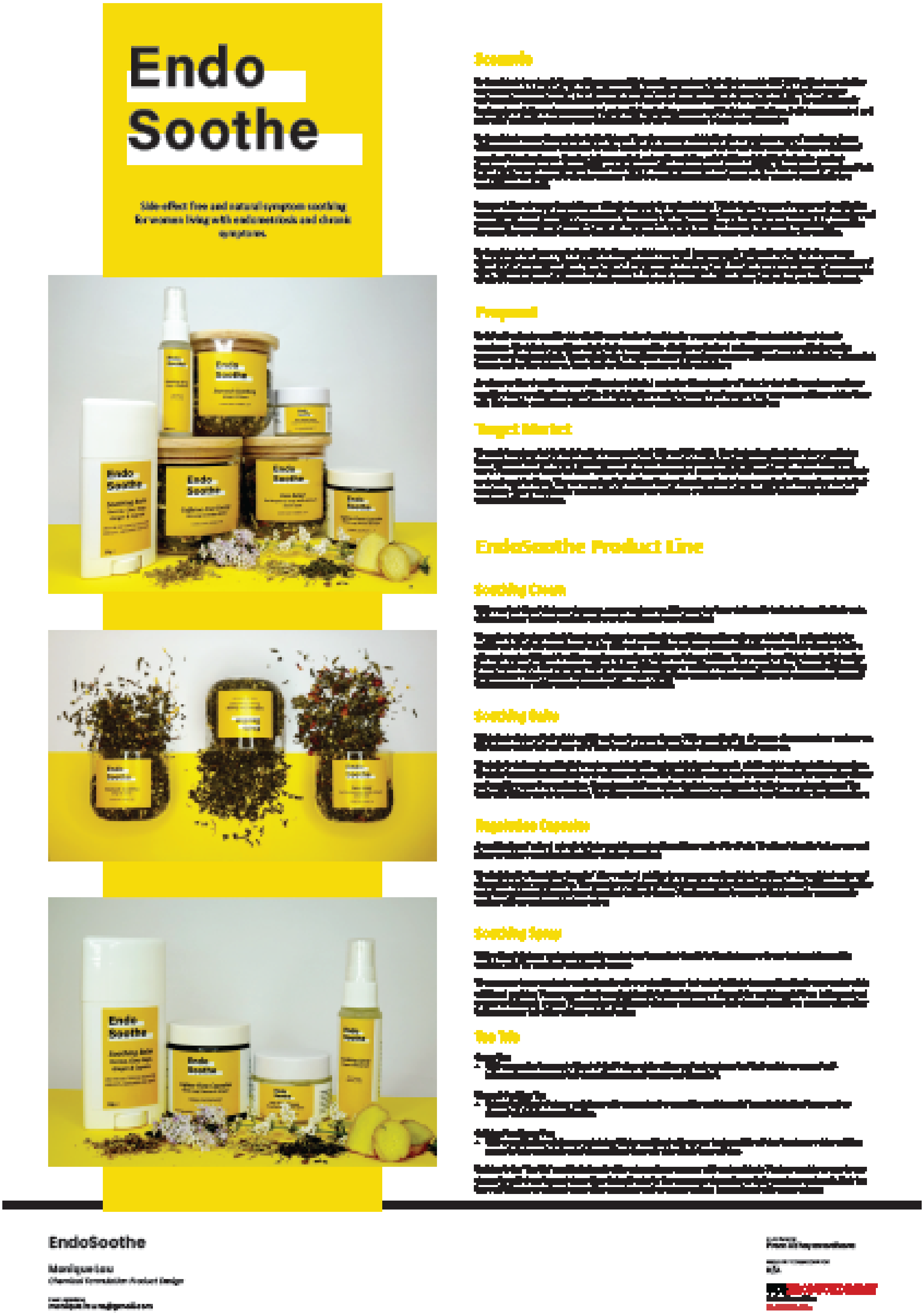
We want to educate consumers about the best way to use sun care products in order to get the most protection. Our line will have a focus on changing the way the sun care market is viewed, with an aim to get kiwis into a habit of protecting their skin every day. Rae wants to provide solutions that are simple and effective, making the margin of error with application of sun care products smaller. Rae will highlight New Zealand throughout the line with the use of native flora. The concept for this product was born out of the concern that consumers weren't applying enough sunscreen. The idea formed to try to find a way to regulate the amount of sunscreen consumers used to ensure they are being properly protected. The desired product would be a SPF that consumers want to use, that didn't feel like a chore when being put on. The ingredients in the after sun product provide the skin with much needed moisture after a long day in the skin. They also have soothing properties allowing some relief to the painful symptoms that sunburn can cause.

Mineral Facial SPF Pods

This is a mono-dose facial sunscreen pod. These are meant to be squeezed into the consumers hands and then rubbed on their face, neck and ears. The pod is an oil based butter encapsulated in a carrageenan based shell. The hero ingredient of this product is harakeke seed oil. Harakeke seed oil is packed with vitamin E, anti-oxidants, phytosterols and omega 6 fatty acids. This will help soothe and moisturise the skin while regulating oil production and encouraging cell turnover. By nature mono-dosing often means excess packaging, so it was important to me to solve the issue of having a regulated dose

After Sun Cooling Spray

This product is an after sun mist. It is designed to be spritzed on the face after being exposed to the sun. The mist provides a cooling and refreshing feel, helping to re-moisturise and replenish the skin. The mist has two hero ingredients, kanuka honey and harakeke gel. Kanuka honey has anti-inflammatory properties, helping to repair the skin when exposed to UV rays. Harakeke gel soothes and cools the skin, while also providing moisture back into the skin. Other key ingredients in the mist include sodium PCA and panthenol which are humectants, providing moisture to the skin by locking it in and drawing



Endo
Soothe
Side-effect free and natural symptom soothing for women living with endometriosis and chronic symptoms.
Target Market
EndoSoothe Product Line
EndoSoothe
Chemical Formulation Product Design

Student projects: Product Design - Chemical Formulation Design

ocean & botanicals

ROSE COAST

New Zealand sea salt skincare in
plantable wildflower seeded boxes

Proposal:

Rose Coast aims to deliver a modern and sophisticated skincare product line that puts the beauty and health of ourselves and the planet first. The product line combines the healing properties of the ocean through Marlborough flaky sea salt blended with natural flower botanicals. The use of natural ingredients tie together the overall brand image and focuses on ingredient alternatives that work. The cardboard box contains wildflower seeds that can be planted after purchase. The products are targeted towards eco-conscious women aged 20-40 years old, who care for natural products that benefit themselves and the planet. These women want to implement change by putting things into action and make a difference.

The Problem:

Ever since the pandemic, people are looking more towards products to take care of their personal well being. The environmental problem is that the skincare/beauty industry produces more than 120 BILLION units of packaging globally. We currently see a market filled with recyclable packaging and 'green-washing'. People put it in the bin and don't know if it get recycled or what difference they contributed towards. The Rose Coast products are packaged in recycled cardboard boxes that have small wildflower seeds throughout the cardboard. The boxes can be planted and will create an abundance of wildflowers when germinated.

Sea Salt Infused Acne Patches

The hydrogel patches have been designed to begin the recovery process of breakouts by reducing redness, inflammation, killing bacteria, soothing and healing the skin. The patches are a light blue clear colour and are rounded in shape to easily cover breakouts. The product contains only plant based gums and is New Zealand Made and Cruelty Free. The acne patches contain Liquid Tolarol as a powerful certified organic bioactive anti-acne ingredient. This ingredient is new to the skincare market and acts as a natural alternative to chemicals commonly used in acne patches. The flower botanical blend is also featured in this product but to a lower percentage.

Sea Salt Scalp & Body Scrub

This scrub gently exfoliates the scalp and body while hydrating the skin and adding shine and luster. The product contains no sulfates (SLS or SLES) or parabens and is Cruelty Free. The scrub represents quality New Zealand ingredients and is proudly New Zealand Made. The delicate crystals of Marlborough Flaky Sea Salt is the key ingredient, not seen before in skincare products on the market. This salt is made using a special NZ process of solar evaporation. The flower botanical blend of Rose Hydrosol, Hibiscus Flower Extract and Calendula Flower Extract to enhance the skin and scalp benefits and create a natural aroma.

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Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

EST. 2022

SKINFUEL

Full coverage skincare for men

The Problem

When thinking about the cosmetic industry there is one thing that is certain, that it is always discussed and marketed at women and women only. The cosmetic industry is a highly saturated market that has little to no gaps in the market as most has already been created and tested out, as new makeup trends are always on the rise. It has always been designed for the use of women, but over the past few years the industry has spiked the interest of men more and more. Skinfuel wants to create a line of full coverage skincare for men. The goal is to break the social stigma of men wearing make-up. Who says men shouldn't feel 300% confident in their own skin with a little help of makeup. The aim is to create a natural mineral full coverage skincare line that has care for the male skin by adding sun protection and pigmentation to help with future damages and restore past ones. Skinfuel's target market are millennial working men any age above 30, who want to protect and regain confidence of their skin and appearance. Skinfuel has found a niche gap in the market for New Zealand men and wants to pick up the growing trend of men using full coverage skincare.

The Solution

Skinfuel's philosophy is to provide inclusivity, natural and long-lasting full coverage skincare that works to create products that are easy to use. Skinfuel wants to create the most subtle look that can be provided for the men's grooming and skincare. This brand is all about entering a new era for cosmetics and skincare and unleashing your inner confidence onto the surface of your skin and appearance. The formulations are designed to make the skin feel great and create protection at the same time. Men are stereotypically known not to have a skincare routine and not care too much about their appearance. Most of the time this is due to the social stigma that has been created through the marketing targeted at females. Skinfuel offers products that are easy to use, include natural ingredients and locally sourced ingredients from New Zealand. It has included sun protection and is easy to take on the go.

The Products

Scalp & Beard fill powder

This scalp and beard fill powder is the new and upcoming product that will solve the issues of a sparse beard and hair loss in the scalp area. Feeling insecure about your hairline or crown? Just use a dab of the scalp and beard fill powder and you are starting the day with a confidence boost. It is long lasting and stays on the skin for the whole day.
It will come with a sponge that can be used in a versatile way, either as a beard powder to fill in a patchy beard or to touch up on the scalp, as many males struggle with hair loss at an early age. The ingredients are partially New Zealand sourced and use a new technology which includes wool powder that has keratin to stimulate the hair growth and natural pigmentation. At the moment there is no product out on the market in New Zealand that uses New Zealand made ingredients. caffeine is a proven hair growth stimulant and titanium dioxide powder can be used to protect the skin and scalp from the sun.

Mattifying solid concealer

The concealer is in a solid clay form. The user experience of the product is different compared to other concealers that are used for men on the market. It has SPF protection and uses mineral ingredients to absorb oil. The concealer can be used just to cover a simple spot or treat acne at the same time due to the bentonite clay, whereas the titanium dioxide will provide sun protection. Skinfuel's concealer will provide an awakening effect due to the extracted caffeine and hemp seed oil and hyaluronic acid to nourish the skin. This product will appeal due to the active ingredients providing benefits that are missing in the market.

Skinfuel - Full coverage skincare for men

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UCOL PRODUCT DESIGN

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echo

Sheryl Webber

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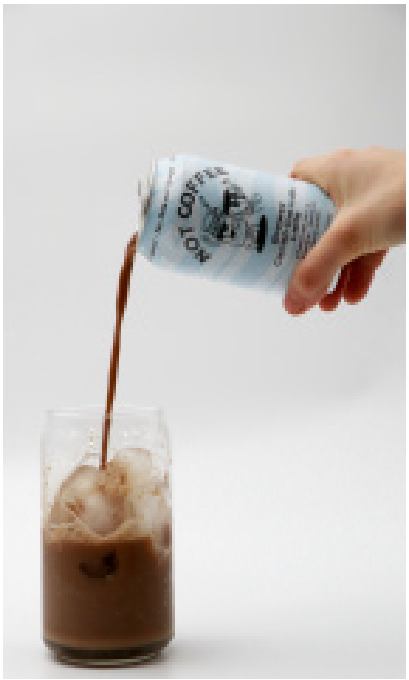
Soular

Skyla Murray
Chemical Formulation Design

NOT COFFEE

It's NOT COFFEE, It's Better, It's Cacao!



The Products

Brewed cacao oat-milk Latte

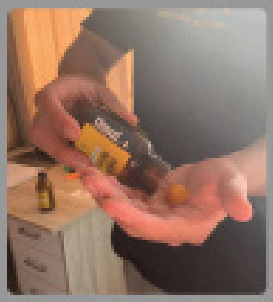
Cacao oat-milk Latte powder

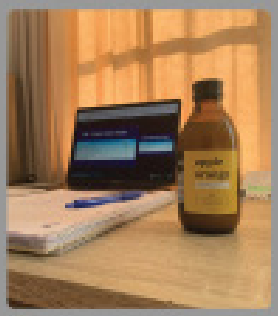
Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

Umood.

you matter





Our mission at Umood is to advocate for your mental health through proven beneficial extracts that will allow you to flourish, because you matter.

Umood's products are aimed at consumers wanting juice or gummies with immunity and mood-boosting benefits, both backed by science. Umood has a company philosophy that "you matter", which emphasises that an individual's health is our main concern. We recognise that when you are physically sick, your mood is also affected, and this is often what prevents you from doing everything you want to and being your best self.

We have two products that brilliantly incorporate our functional extracts. These are a "Vitalising juice" and "Vitalising gummies", both have a full dose of saffron extract and beta-glucan for your daily mental boost and immunity support. Our vitalising juice has a base of cold pressed Hawkes Bay apple and Gisborne orange juice, 200ml in size, so you can enjoy the delicious fruits alongside our extracts. Our vitalising gummies are best for people wanting to get the benefits of our extracts every day in an easy to consume and enjoyable chewy treat. You can have one gummy in the morning then one at night to get the full dose.

Our target market is young New Zealander's who want to take control and live their best life. Busy and bustling people like teachers and students who are trying balance their work, social life, and exercise, but are often held back by sickness.

In the future, we would like to further characterise the effects of our combined extracts through clinical trials and optimise our formulations for improved shelf-life and sensory properties.

Tom le Fleming
[redacted]

Chemical Formulation Design,
School of Product Design

Supervisor: Sarah Kessans

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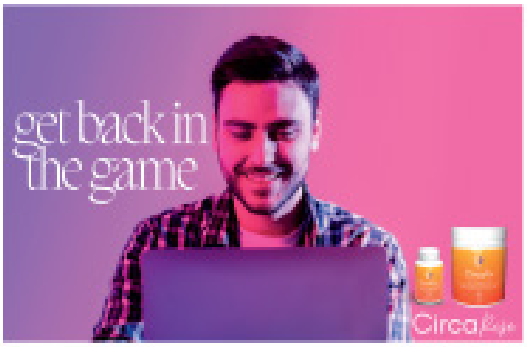
Circa



TARGET MARKET

Gen Z

- Ages between 17 to 28
- Low to middle income - recent graduates and students
- Strong values and senses of justice
- Online purchasing behaviour
- Beginning to acquire more purchasing power
- Have a strong digital footprint and consume social media often
- Ability to make well informed purchasing decisions
- Most aware of ethical consumers

THE PROBLEM

Burnout & Vegetarians/Vegans

- Gen Z is reporting some of the highest rates of burnout in the workplace
- Gen Z is struggling with the worst stressors
- Lack of power, financial instability, normalisation of hustle culture, inability to unwind
- Lower workplace capital
- Constant screentime makes it difficult to switch off at night
- Burnout is a state of emotional, physical and mental exhaustion
- As stress continues, interest and motivation is lost
- More severe effects such as depression and anxiety can occur
- Younger generations are looking for food options that are healthier and more ethical - these features are associated with plant-based options
- Social media is key in the development of plant-based lifestyle trends and environment conscious behaviours
- There is a risk of becoming deficient in key vitamins and nutrients that are difficult to obtain from a plant based diet, due to low bioavailability
- Deficiencies can cause effects such as weakness, fatigue, impaired brain function, irritability and even depression.

CIRCA RISE & REST

Circas mission is to support and encourage young individuals in their attempts in changing the world. Circa's product line aims to help restore the rhythm to busy, burnt out individuals aged 17 to 28. This target market is also one of the most likely to be vegetarian and vegan as Circa will also target their products at supporting vegans and vegetarians.

Circa Rise, is formulated with ingredients to help boost energy and cognitive function as well as provide stress support. Designed to help consumers rise in the mornings and tackle the busy day ahead.

Circa Rise Latte is a functional powdered instant beverage formulated with actives ginkgo, ginseng and Rhodiola mixed with a creamy oat milk base.

Circa Rise Capsules are a more pharmaceutical approach, with amino acids L-Theanine and L-Tyrosine, iron, and vitamin B12.

Circa Rest, is formulated with ingredients to help promote a restful sleep and help with relaxation as well as stress management. Designed for the generation who never sleeps, Circa Rest can help to quieten a busy mind ready for the next day. 1cc Rest Latte is a functional powdered instant beverage formulated with actives Reishi, Ashwagandha and Passionflower with a creamy oat milk base.

Circa Rest Capsules are a more pharmaceutical approach, with amino acid L-Tryptophan, minerals Magnesium and Zinc and Vitamin B6.

Student projects: Product Design - Game Design

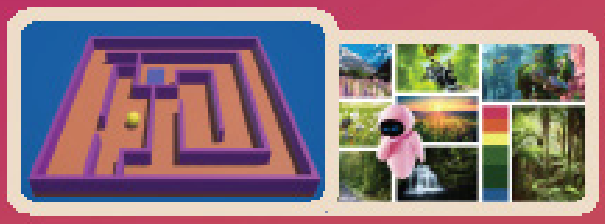
Mr. Marlow's Manor of Mayhem

Student projects: Product Design - Game Design

Trimble Virtual World UI

Felipe Andres Garcia Pereira

A game to support mental health treatment

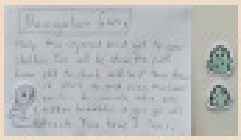


Project Brief

oVRcome is a Christchurch based start-up that uses virtual reality to make mental health treatment more accessible. We were tasked to explore the use of VR gaming as a fun way to engage users of their mild depression program.

How did we make a game for depression?

'Working memory' is the brain's ability to remember a small piece of information and use it to complete a task. Depression tends to weaken working memory, so we have designed a maze navigation game that could help players improve their working memory.



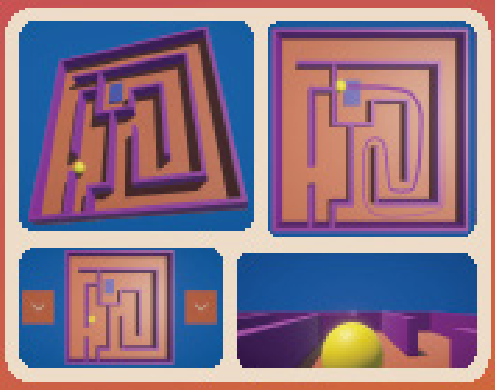
We looked at game ideas based on different brain exercises and areas of depression treatment and prototyped our concepts. For user engagement, we also brainstormed several narrative designs for our prototypes.

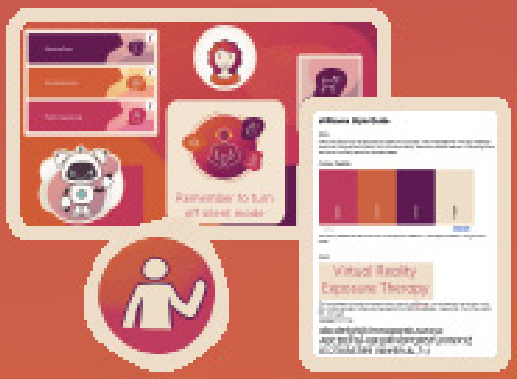
Our VR game challenges a player's ability to correctly remember a path through a maze and retrace that path backwards. The player is shown a path through the maze, then must use guide a ball backwards on that path.

What did we achieve?

To find the most satisfying way to play the game, we developed four ways to guide the ball through the maze using gaze control:

- Tilting the board to roll the ball
- Tracing a path for the ball to follow
- Rotating the board to let the ball drop
- Turning corners in first-person view





We provided several Narrative Design and User Engagement recommendations including:

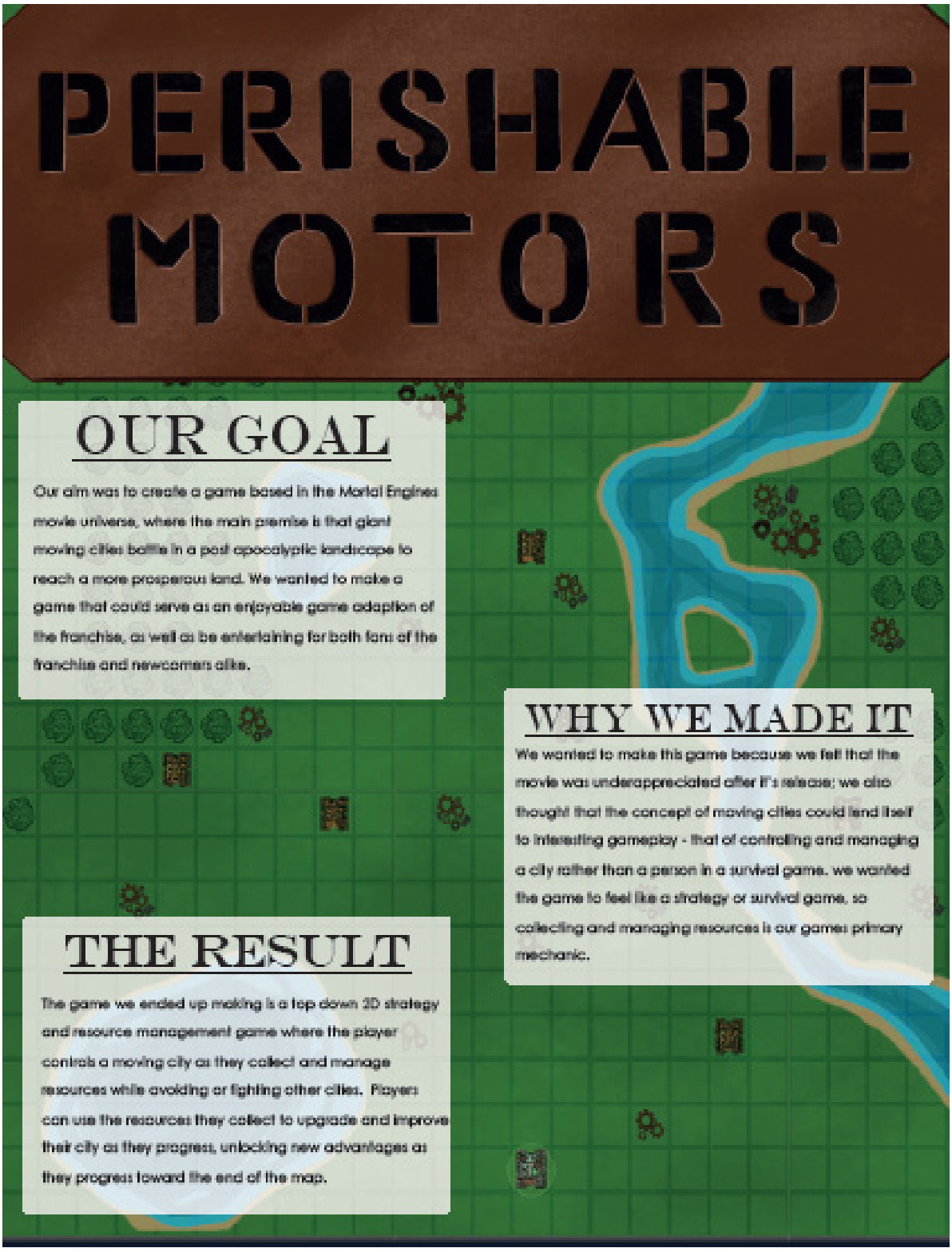
- An oVRcome Style Guide
- Character/companion ideas and user journies
- Using 360° videos as the environment

These features would achieve oVRcome's goal to retain their subscribers in a fun and engaging way.

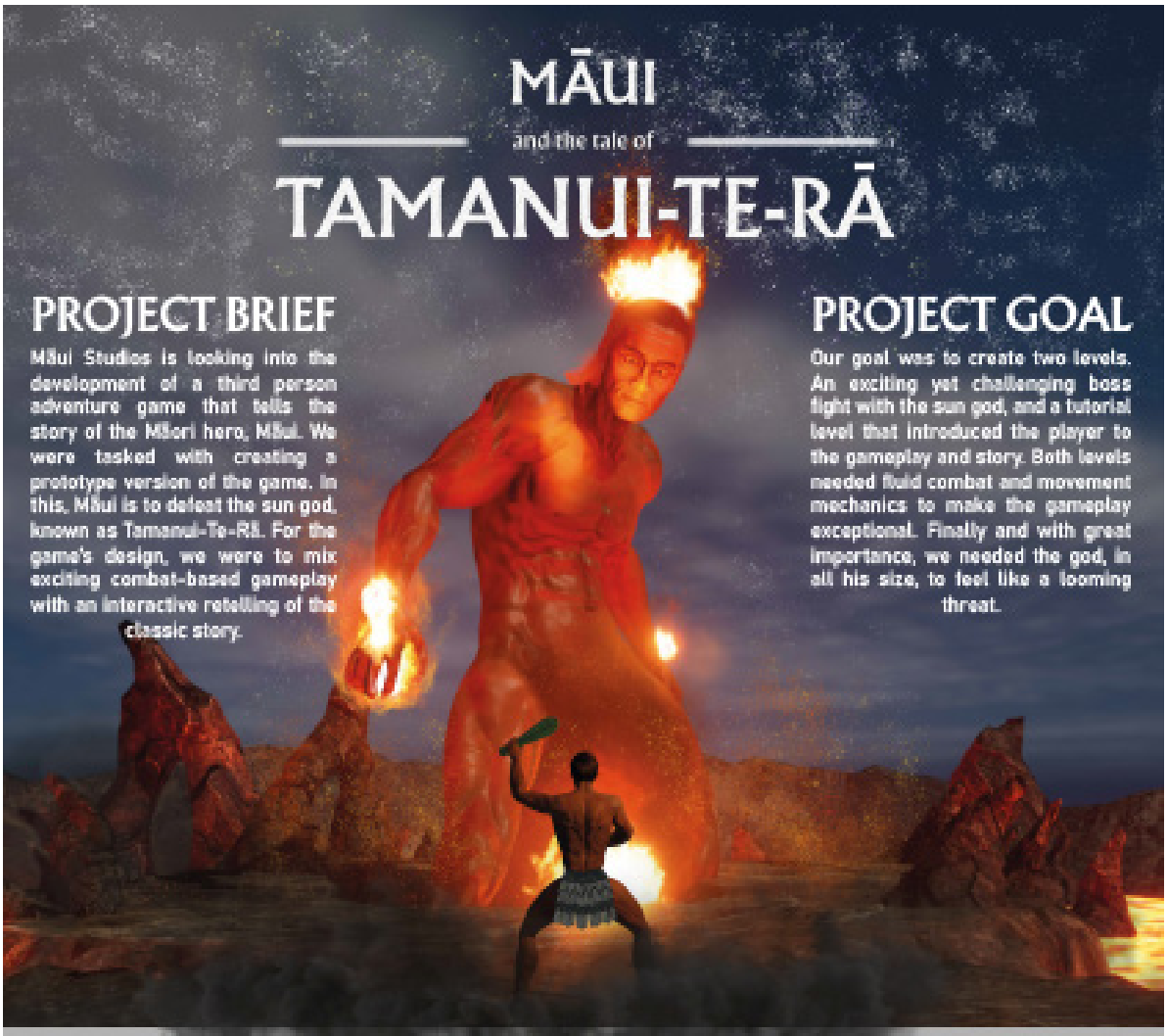
oVRcome: A game to support mental health treatment

Cara Kruger | Nikki Le-Bas
Applied Interactive Game Design

Student projects: Product Design - Game Design



Perishable Motors


MĀUI
and the tale of
TAMANUI-TE-RĀ
PROJECT BRIEF
Māui Studios is looking into the development of a third person adventure game that tells the story of the Māori hero, Māui. We were tasked with creating a prototype version of the game. In this, Māui is to defeat the sun god, known as Tamanui-Te-Rā. For the game's design, we were to mix exciting combat-based gameplay with an interactive retelling of the classic story.
PROJECT GOAL
Our goal was to create two levels. An exciting yet challenging boss fight with the sun god, and a tutorial level that introduced the player to the gameplay and story. Both levels needed fluid combat and movement mechanics to make the gameplay exceptional. Finally and with great importance, we needed the god, in all his size, to feel like a looming threat.
BOSS DESIGN
Fighting a sun god is not easy. Tamanui-te-rā comes equipped with devastating attacks to destroy Māui.
Magma Eruption: Fire is torn from the lava and hurled at Māui, leaving a lingering ball of fire.
Colossal Fist: Tamanui Slams his fists on Māui, dealing massive damage but draining the gods energy, leaving him open to attack.
Solar Breath: Fire spews from the Gods mouth.If Māui gets set on fire, his best bet is to Stop, Drop, and Roll.
COMBAT
TAIAHA: Its long wooden body allows quick precision attacks while the sharp greenstone tip cuts through gods.
PATU: The close distance club weapon, carved from greenstone and decorated with war kowhaiwhai is perfect for subduesing an angry god.
Each weapon has a unique moveset that can be utilised against Māui's foes in different ways.
MĀORI THEMES
In order to appropriately represent Māori culture, and tell this story, we mix fantasy with history. Our self driven research and consultation with Māui studios, helped us in this regard.
The levels are influenced by native Aotearoa landscapes and Māori Pa for Māui's village in the tutorial level.
The weapons are all based on real Māori weapons with a slight twist.
Māui and Tamanui-te-rā, both wear traditional Piu-Piu skirts.
Māui vs The Sun

202

Submit a project for next year

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:

- 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.

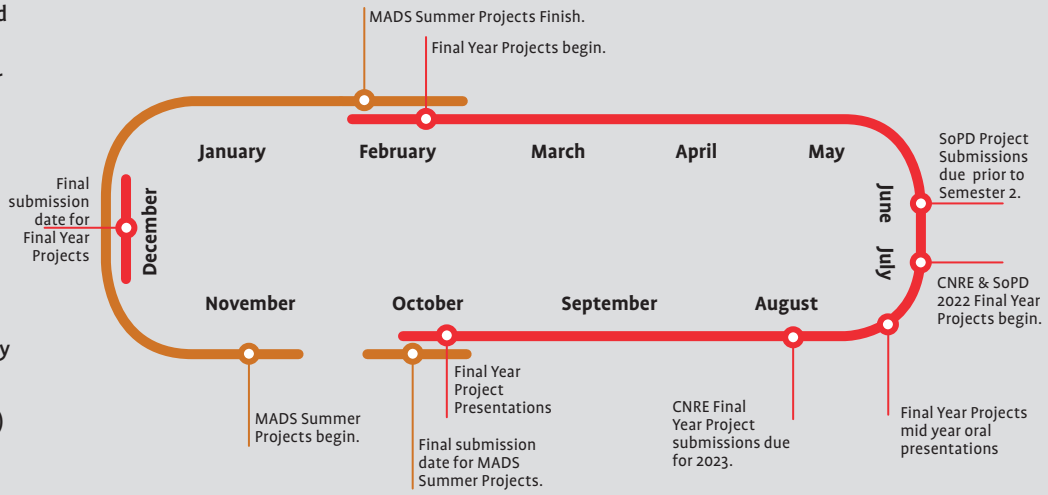
PROJECT TIMELINE:

With exception of Civil & Natural Resource Engineeering (CNRE) and School of Product Design (SoPD) the preferred submission date for an idea for a Final Year Project is: December for projects to be started the following February.

For CNRE it is **mid-August, for projects to be started the following July.**

For SoPD, FYPs run in Semester 2 only with submissions required by end of June.

Master of Applied Science (MADS) Summer Project final submission date for a project is the end of September, for projects to be started in November..



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

industry Engagement Team

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