Manufacturing, Design, Entrepreneurship
New Zealand

MaDE2022: Manufacturing, Design and Entrepreneurship in NZ, looking beyond the horizon

25 - 26 JANUARY 2022

The Great Room, Cordis Auckland

MaDE2022 is presented by the University of Auckland's IMM Programme and proud to be partnered, sponsored and supported by our valued stakeholders.

THE UNIVERSITY OF AUCKLAND NEW ZEALAND — Innovative Manufacturing and Materials Programme

CONFERENCE PARTNER

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The New Zealand Manufacturing, Design and Entrepreneurship (MaDE) Conference Committee members are delighted to welcome you to our fifth national conference – MaDE2022: Manufacturing, Design and Entrepreneurship in NZ, looking beyond the horizon.

This event follows on from the successful and well-received MaD2017, MaD2018, MaD2019 and MaDE2020 Conferences. MaDE2021 was scheduled for mid-November and became MaDE2022 with having to postpone. We continue to focus on developing and enhancing valuable collaborations between researchers and industry to enable us all to synergistically work together towards an expanding and more prosperous future for the New Zealand manufacturing, design and entrepreneurship sectors, especially important as we look beyond the horizon towards post-pandemic recovery.

The MaDE Network is a cross-disciplinary community of New Zealand researchers in manufacturing, design and entrepreneurship that works in close collaboration with industry to envision and shape New Zealand's future manufacturing economy. The MaDE mission is to develop expertise and capability in translational research to grow New Zealand's high-tech manufacturing economy. The MaDE vision is for New Zealand to be recognised as a leading, technology empowered economy driven by innovative, high-value, niche manufacturing, design and entrepreneurship.

The Covid-19 pandemic and the geographical advantage of New Zealand, together with our innovative and world-leading reputation, continue to highlight the importance and necessity for us to further identify and capture new opportunities in the manufacturing, design and entrepreneurship sectors. An important aspect of MaDE2022 is to present innovative and strategically important research that can underpin this, as well as enabling us to work together to grow new knowledge and expertise accordingly. University-industry research linkages and collaborations are integral here. Through improving collaboration between Māori, researchers and industry, we aim to enable the innovation potential of Māori knowledge, resources and people.

We hope that you will enjoy the Conference and find both the content and networking valuable. We are very pleased with the support, interest and attendance of both the research and industry sectors from across the national MaDE Network, especially since circumstances have been so challenging for all our members across all sectors.

A full oral programme, split between industry organisations and researchers, all showcasing exciting research projects across a wide range of areas will be presented. We are pleased to be able to bring you five high-calibre key presenters who are leaders in their fields and have excellent insight into manufacturing, design and entrepreneurship, both locally and internationally. We invite you to engage and contribute during our two stand-alone Panel Discussion sessions, each led by a senior MaDE researcher, which will cover relevant and important topics. Please take the opportunity to review and discuss the research work being showcased in each of the poster presentations, spend time absorbing and interacting with the exhibition booth content, and network during the refreshment breaks. There is also a Student Innovation Showcase, sponsored by Auckland Unlimited, where postgraduate students will be presenting examples of their manufacturing and design innovations.

On behalf of the MaDE2022 Conference Committee, we wish to thank our conference partner (Auckland Unlimited), sponsors and supporters for acknowledging the significance of this event in our national manufacturing, design and entrepreneurial landscape; and especially for standing by with support for the event in challenging circumstances. Most importantly, thank you to all delegates for joining us.

Yours sincerely,

Professor Jim Johnston *MaDE2022 Co-Chair, Victoria University of Wellington*
Professor Olaf Diegel *MaDE2022 Co-Chair and MaDE Network Leader, The University of Auckland*
Dr Marcel Schaefer *MaDE2022 Co-Chair, Auckland University of Technology*

Contents

Venue WiFi

Network: Cordis

Username: MADE22

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MaDE Manufacturing, Design, Entrepreneurship New Zealand

MaDE NZ: Strategic Pathway for the MaDE Network

From its initiation in 2016 the MaDE Network has connected NZ researchers in manufacturing, design and entrepreneurship with each other and with relevant NZ industry. Spawned out of a strategic project of the Innovative Manufacturing and Materials (IMM) Programme at the University of Auckland, the MaDE Network positioned itself to apply for a Centre of Research Excellence (CoRE) in November 2019.

In May 2020, a formal announcement by the Royal Society Te Apārangi delivered the disappointing news that the MaDE CoRE had not been shortlisted through to the next stage of the selection process of Tertiary Education Commission funded CoREs. There was no context to this decision and no feedback has been provided.

The strategic thinking of the MaDE Leadership Team emerges from the premise that we have successfully established MaDE NZ – a significant and collaborative national network of researchers, industry stakeholders and government representatives crossing the disciplines and sectors of manufacturing, design and entrepreneurship.

Our **MISSION** of developing expertise and capability in translational research, to grow New Zealand's high-tech manufacturing economy still holds, as does our **VISION** for New Zealand to be recognised as a leading, technology empowered economy driven by innovative, high-value, niche manufacturing, design and entrepreneurship.

Whilst the pandemic continues to challenge us, with current funding, we have been able to successfully deliver **MaDE2022** – a physical conference, within NZ government COVID-19 regulations, in Auckland on **25-26 January 2022**.

Beyond these dates, our current project timeline and available funding will have expired and future MaDE NZ related activities will necessitate alternative funding sources, which will continue to be challenging in the post pandemic economic recovery phase. However, we believe that we have a strong value proposition and we are working hard to identify funding mechanisms as enablers to sustainably continue our pathway and build a track record whereby the ongoing connectedness and unification of our MaDE Network is upheld, the delivery of future MaDE conferences is enabled, innovative research across the MaDE disciplines is supported and with the possibility of developing a national, cross-disciplinary MaDE education programme, which produces industry-ready post graduates.

We hope that you and your organisations will continue to support MaDE NZ in whatever way you are able in the weeks, months and years to come.

Please make the most of the opportunities at MaDE2022 to engage with fellow delegates.

www.madenz.net

NZ’s Manufacturing, Design and Entrepreneurship (MaDE) Network

Our MISSION is...

To develop expertise and capability in translational research, to grow New Zealand’s high-tech manufacturing economy.

Our VISION is...

For New Zealand to be recognised as a leading, technology empowered economy driven by innovative, high-value, niche manufacturing, design and entrepreneurship.

MaDE CONFERENCE COMMITTEE

- Jim Johnston, Victoria University of Wellington (Co-Chair)
- Olaf Diegel, The University of Auckland (Co-Chair)
- Marcel Schaefer, AUT (Co-Chair)
- Mark Battley, The University of Auckland
- Claire Barnsley, The University of Auckland (Operations - until 3 Dec 2021)
- Stephanie Szmurlo, The University of Auckland (Event Manager)
- Amanda Wallace, The University of Auckland (Event and Conference Planner)
- Isobel Adamson, The University of Auckland (Event and Conference Planner)
- Rafilya Wilson, The University of Auckland (Event and Conference Planner)
- Jonathan Stringer, The University of Auckland
- Yuqian Lu, The University of Auckland
- Paul Woodfield, AUT
- Mike Duke, University of Waikato
- Rachael Tighe, University of Waikato
- Khalid Arif, Massey University
- Tim Miller, Victoria University of Wellington
- Don Clucas, University of Canterbury

MaDE DRIVER TEAM (STEERING COMMITTEE)

- Olaf Diegel, The University of Auckland (Chair)
- Kenneth Husted, The University of Auckland
- Simon Fraser, Victoria University of Wellington
- Mark Battley, The University of Auckland (IMM Programme Lead)
- Simon Bickerton, The University of Auckland
- Claire Barnsley, The University of Auckland (Operations)
- Marcel Schaefer, AUT
- Mike Duke, University of Waikato
- Don Cleland, NSC10 & Massey University
- Johan Potgieter, Massey University
- Shayne Gooch, University of Canterbury
- Debbie Munro, University of Canterbury
- Conan Fee, University of Canterbury
- Allen Guinbert, Fisher & Paykel Appliances
- Catherine Beard, ManufacturingNZ
- Dieter Adam, The Manufacturers’ Network

Tuesday 25 January 2022

8:00 AM - 9.00 AM	Registration Opens
9:00 AM - 9:30 AM	**CONFERENCE OPENING (GREAT ROOM 4)** **MIHI: TBC | OFFICIAL OPENING:** *Professor Jim Metson, Deputy Vice Chancellor - Research, The University of Auckland* **SESSION CHAIR:** *- Prof Olaf Diegel, MaDE2022 Co-Chair and Director of The University of Auckland's Creative Design and Additive Manufacturing Lab*
9:30 AM - 10:00 AM	**KEYNOTE SPEAKER: FRANCES VALINTINE CNZM (CEO AND FOUNDER, TECH FUTURES LAB)** **STEPPING INTO OUTER SPACES - A JOURNEY INTO UNCHARTERED FUTURES** **SESSION CHAIR:** *Prof Olaf Diegel* | **ROOM: GREAT ROOM 4**
10:00 AM - 10:30 AM	**MORNING TEA** (Great Room 1) - sponsored by University of Waikato Poster and Exhibition Viewing
10:30 AM - 12:30 PM	**CONCURRENT CONFERENCE SESSION 1**

	GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
	INDUSTRY 4.0 - NZ MANUFACTURING **SESSION CO-CHAIRS:** *- Nick Pickering and Kevin Marett*	**ADVANCES IN ADDITIVE MANUFACTURING** **SESSION CO-CHAIRS:** *- Jérôme Leveneur and Juan Schutte*	**COMMERCIALISATION AND VALUE-ADD** **SESSION CO-CHAIRS:** *- JIM JOHNSTON AND MIKE DUKE*
	INDUSTRY 4.0 REQUIREMENTS BEYOND THE PANDEMIC HORIZON *- Frank Phillips, LMAC New Zealand Ltd*	**INDUSTRY APPLICATIONS FOR MULTI JET FUSION – ENABLING THE BENEFITS OF HP MJF FOR ADDITIVE MANUFACTURING** *- Jonathan Zyzalo, EVOK3D NZ*	**FROM A BRIGHT IDEA, THROUGH R&D TO A COMMERCIAL COMPANY: THE JOURNEY OF INHIBIT COATINGS LTD.** *- Jim Johnston, Victoria University of Wellington*
	HORTICULTURE SYSTEM OF SYSTEMS IMPLEMENTING AN AUTONOMOUS SURVEY ROBOT AND ORCHARD DIGITAL TWIN *- Nick Pickering, University of Waikato*	**A SUSTAINABLE METHOD FOR CREATING 3D FORM UTILISING NATURAL SHRINKAGE AND THE PRECISION OF DIGITAL DEPOSITION** *- Nayanathara Kuruppuarachchi, Victoria University of Wellington*	**LEANING ON STRENGTHS AND PARTNERING FOR SUCCESS** *- Matt Bradley, Blender*
	INDUSTRIAL REVOLUTIONS - RISE OF THE MACHINES AND THE ROLE OF HUMANS *- Allan Orr, Aspect PT and Caleb Millen, Beckhoff Automation Limited*	**ADVANCED PLASMA STRATEGIES FOR SPATIAL ADDITIVE MANUFACTURING OF TENSILE STRUCTURES** *- Jérôme Leveneur, GNS Science*	**COMPANY GROWTH ...WITH A LITTLE HELP FROM INNOVATIVE SUPPLIERS!** *- Anne Staal, AUT*
	THE PHARMA INDUSTRY 4.0: BLOCKCHAIN APPLICATION IN UPSTREAM SUPPLY CHAIN *- Amirhossein Mostofi, Victoria University of Wellington*	**GENERATIVE DESIGN OF PROGRAMMED MATERIALS FOR CONTROLLED FREQUENCY RESPONSES** *- Wuxin Yang, AUT*	**OPPORTUNITY FOR AN AGRI-ROBOTICS INNOVATION ECOSYSTEM IN NEW ZEALAND** *- Mike Duke, University of Waikato*

	GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
	DEFINING AN APPROPRIATE PROCUREMENT MATURITY MODEL TO ASSESS AND IMPROVE INNOVATION PROCUREMENT IN FAST-GROWING/ FRONTIER FIRMS IN NEW ZEALAND *- Elizabeth McGill, AUT*	**AUTOMATING COMPLEXITY WITH nTOPOLOGY** *- Juan Schutte, CDAM Lab, The University of Auckland*	**MAKING MAKERS AND MAKING ENGINEERS: SEEDING THE NEXT GENERATION OF ENGINEERS THROUGH HANDS-ON SKILLS** *- Mark Jeunnette, The University of Auckland*
	DIGITAL TWIN-DRIVEN ONLINE ANOMALY DETECTION FOR AN AUTOMATION SYSTEM *- Huiyue Huang, The University of Auckland*	**HIGH PERFORMANCE CONTINUOUS FIBRE COMPOSITE 3D PRINTING: PROTOTYPING AND PROCESS CHARACTERISATION** *- Josh Hares, CACM, The University of Auckland*	**FOILING OR FAILING: IT'S A FINE LINE – UNIVERSITY / INDUSTRY ENGAGEMENT, HOW HARD CAN IT BE?** *- Graeme Finch, CACM, The University of Auckland*
	AUGMENTED REALITY AND IoT - DRIVING TRANSFORMATION AT SCALE *- Kevin Marett, LEAP Australia*	**ADDITIVE MANUFACTURE OF CEMENTITIOUS MATERIALS** *- Joel Epps, University of Canterbury*	**A CASE STUDY OF THE COMMERCIAL REALITIES OF POLYMER ADDITIVE MANUFACTURING PRODUCTION, AKA "TALES FROM A SERVICE BUREAU"** *- Derek Manson, Fi Innovations*
	HUMAN CAPITAL 4.0: THE NEW CONCEPT AND NEW COMPETENCE TYPOLOGY FOR THE WORKFORCE IN INDUSTRY 4.0 *- Emmanuel Flores, The University of Auckland*	**FUNCTIONALLY GRADED CORE MATERIAL AND HARD-POINT INTERFACES FOR COMPOSITE SANDWICH PANELS** *- Ben Murton, University of Canterbury*	**ADDING VALUE TO THE SAWMILL PROCESS THROUGH VISION SCANNING** *- Daniel Kulasingham, Sequal*
12:30 PM - 1:30 PM	**LUNCH** (Great Room 1) - sponsored by Fisher and Paykel Healthcare Exhibition Viewing		
1:30 PM - 2:00PM	**KEYNOTE SPEAKER: MATT DARLEY (RECOVERY SYSTEMS MANAGER, ROCKET LAB)** **TURNING ROCKET LAB'S ELECTRON ROCKET INTO A REUSABLE LAUNCH VEHICLE** **SESSION CHAIR:** *Professor Jim Johnston, MaDE2022 Co-Chair and Professor - School of Chemical and Physical Sciences, Victoria University of Wellington* **ROOM: GREAT ROOM 4**		

Tuesday 25 January 2022 (continued)

2:00 PM- 3:30 PM	**CONCURRENT CONFERENCE SESSION 2**		
	GREAT ROOM 2	**GREAT ROOM 3**	**GREAT ROOM 4**
	APPLICATIONS IN ADDITIVE MANUFACTURING **SESSION CO-CHAIRS:** - *Don Clucas and Troy Dougherty*	**DESIGN INNOVATIONS** **SESSION CO-CHAIRS:** - *Tim Miller and Craig Shannon*	**INNOVATIONS IN MANUFACTURING** **SESSION CO-CHAIRS:** - *Emilio Callius and Simon Bickerton*
	VAT-BASED 3D PRINTING OF ELECTROACTIVE POLYMERS - *Kyle Engel, The University of Auckland*	**A ROBOTIC 3D/4D PRINTING CONSTRUCTION METHOD TO CREATE SUSTAINABLE LARGE SCALE TEMPORARY STRUCTURES** - *Tim Miller, Victoria University of Wellington, School of Design Innovation*	**METAMATERIALS, ADDITIVE MANUFACTURING AND DESIGN IN MECHANICAL ENGINEERING** - *Emilio Calius, AUT*
	FDM PRINTING OF POLYLACTIC ACID: TENSILE TESTING OF STRENGTH CONFIGURATIONS FOR MECHATRONICS - *Benjamin Orwin-Higgs, Massey University*	**VIRTUAL REALITY AS A DESIGN TOOL** - *Ben Thomsen, Blender*	**MANUFACTURING RELATED DEFECTS IN CARBON FIBRE REINFORCED PLASTIC STRUCTURES – WHERE AND WHY THEY OCCUR, AND DO THEY MATTER?** - *Simon Bickerton, CACM, The University of Auckland*
	SCREEN PRINTING FOR ADDITIVE MANUFACTURING OF TITANIUM PARTS - *Don Clucas, University of Canterbury, Mechanical Engineering Department*	**INSOURCING VS OUTSOURCING AND BLENDED TEAMS - DELIVERING VALUE FOR PRODUCT DEVELOPMENT IN A CHANGING POST-COVID WORLD** - *Craig Shannon, Globex Engineering*	**A COST-EFFECTIVE HYBRID APPROACH FOR THE MANUFACTURING OF HIGH- PERFORMANCE INJECTION MOULD INSERTS USING THE LASER POWDER-BED FUSION PROCESS** - *Simon Chan, CDAM Lab, The University of Auckland*
	NOVEL COMPOSITE-METAL ADDITIVE MANUFACTURING - *Troy Dougherty, Nuenz*	**INNOVATION IN DESIGN AND MANUFACTURING WITH DIGITAL KNIT TECHNOLOGIES** - *Frances Joseph, AUT*	**RAPID PROTOTYPE ADOPTION AT FISHER & PAYKEL HEALTHCARE** - *Andrew Lee, Fisher & Paykel Healthcare Ltd*
	SELECTIVE LASER MELTING OF HIGH PURITY COPPER ON A LOW COST, LOW POWER 250-WATT MACHINE - *Tim Gordon, The University of Auckland*	**THE FUTURE OF DESIGN? BURGEONING DESIGNERS' EXPERIENCE OF 'ADVANCED' DIGITAL DESIGN TOOLS** - *Nicholas Emerson, University of Canterbury*	**RECYCLED TEXTILE FIBRE AS A PERFORMANCE-ENHANCING ROADING ADDITIVE**- *Deborah Crowe, Usedfully*
	SCREEN 3D PRINTING CELLULOSE GEL - *Hossein Najaf Zadeh, University of Canterbury*	**CREATIVE STEM PATHWAYS: 3D PRINTING AND DESIGN FOR PASIFIKA STEM EDUCATION** - *Lionel Taito-Matamua, Victoria University of Wellington, School of Design Innovation*	

3:30 PM - 4:00 PM	**AFTERNOON TEA** (Great Room 1) Poster and Exhibition Viewing
4:00 PM - 5.00 PM	**PANEL DISCUSSION 1** **TOPIC: SUSTAINABILITY AND THE CIRCULAR ECONOMY – LOOKING BEYOND THE HORIZON** **Room: Great Room 4** **ADJUDICATOR:** Marcel Schaefer (MaDE2022 Co-chair) | *Programme Director, BEngTech, Mechanical Engineering, AUT* **PANELLISTS:** Deborah Crowe – *Co-Founder, Usedfully* Jeffrey Seadon – *Senior Lecturer, School of Future Environments, AUT* John Kennedy – *Ion Beam Physics Research Scientist, GNS Science* Rachel Barker – *CEO, Plastics New Zealand* Rebecca Percasky – *CEO, The Better Packaging Co.*
5:00 PM - 5:30 PM	No activity planned
5:30 PM - 7:00 PM	**Student Innovation Showcase** (Happy Hour) - sponsored by Auckland Unlimited (Pre-function area)
6:00 PM - 7:00 PM	**PRE-DINNER DRINKS** (Pre-function area)
7:00 PM - 10:00 PM	**CONFERENCE DINNER** (Great Room 4) - sponsored by Beckhoff Automation Ltd. Dinner Welcome: Professor Jim Johnston
	KEY DINNER ADDRESS: *David Downs (CEO - The New Zealand Story)* **FROM NUMBER 8 TO GREAT! HOW NZ'S HISTORY AS AN INNOVATIVE COUNTRY HAS SET US UP FOR SOME SILVER LININGS**

CONFERENCE PARTNER:

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Wednesday 26 January 2022

8:30 AM - 9:15 AM	**Registration Opens**
9:15 AM - 9:30 AM	**INTRODUCTION OF DAY (GREAT ROOM 4)** **SESSION CHAIR:** *Dr Marcel Schaefer, MaDE2022 Co-Chair and Programme Director, BEngTech, Mechanical Engineering, AUT*
9:30 AM - 10:00 AM	**KEYNOTE SPEAKER: BRONWYN FOX, CHIEF SCIENTIST, CSIRO, AND PREV. DV-C (RESEARCH & ENTERPRISE), SWINBURNE UNIVERSITY OF TECHNOLOGY** **THE INDUSTRY-RESEARCH NEXUS IN THE ADVANCED MANUFACTURING SECTOR** **SESSION CHAIR:** *Dr Marcel Schaefer* | **ROOM: GREAT ROOM 4**
10:00 AM - 10:30 AM	**MORNING TEA (Great Room 1) - sponsored by University of Canterbury** Poster and Exhibition Viewing
10:30 AM - 12:00 PM	**CONCURRENT CONFERENCE SESSION 3**

GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
MANUFACTURING AND INNOVATION **SESSION CO-CHAIRS:** *- Holger Heinzel and Jyoti Kalyanji*	**MANUFACTURING AND DESIGN CIRCULARITY** **SESSION CO-CHAIRS:** *- Oliver McDermott and Putri Fraser*	**MATERIALS AND SURFACES** **SESSION CO-CHAIRS:** *- Maedeh Amirpour and Hamed Abdoli*
NOVEL ANTIMICROBIAL FILTER MEDIA MADE OF ELECTROSPUN NANOFIBRES PROTECTING AGAINST BIOLOGICAL OR NON-BIOLOGICAL AIRBORNE PARTICLES *- Fabrice Karabulut, Nanolayr Ltd.*	**CIRCULAR MANUFACTURING - BUSINESS MODEL INNOVATION** *- Oliver McDermott, Blender*	**THERMOGRAPHY INSPECTION FOR UNDERCOATING CORROSION** *- Larissa Kopf, University of Waikato*
ROBOTIC WELDING IN STEEL FABRICATION *- Holger Heinzel, HERA*	**DESIGNING FOR A LOW-EMISSIONS CIRCULAR ECONOMY** *- Rachel Barker, Plastics NZ*	**DEVELOPMENT OF COATING-FREE SUPER WATER-REPELLENT MICROPATTERNED ALUMINIUM FOR SPONTANEOUS DROPLET MOTION** *- Kirill Misiiuk, University of Otago*
UNDERSTANDING ASSUMPTIONS IN THE PRODUCT DEVELOPMENT PROCESS *- Abhishek Makker, Oasis Engineering*	**DESIGN FOR PURPOSE: DEMATERIALISING WELLBEING THROUGH DESIGN** *- Gabriela Baron, The University of Auckland, Design Programme*	**RATIONAL DESIGN OF GEOMETRY TAILORED LATTICES WITH APPLICATION IN HUMAN INTERFACES** *- Maedeh Amirpour, CACM, The University of Auckland*

	NATIONAL TESTING REGISTER *- Kenneth Ortega, NZPA and McDiarmid Institute*	**A DESIGN-BASED APPROACH TO UPCYCLING AGRICULTURAL PLASTIC WASTE** *- Danielle Patterson, Victoria University of Wellington*	**ACHIEVING A GOOD ADHESION BETWEEN DISSIMILAR MATERIALS UTILISING SIMPLE SURFACE TREATMENTS AND ENVIRONMENTAL-FRIENDLY ADHESIVE** *- Ardeshir Saniee, AUT*
	GREAT ROOM 2	**GREAT ROOM 3**	**GREAT ROOM 4**
	BEYOND WOOLLY JUMPERS: EXPLORING THE ADDITIVE FABRICATION CAPABILITY OF DIGITAL KNITTING TECHNOLOGY *- Jyoti Kalyanji, AUT*	**BREAKING THE CYCLE OF NITRATE POLLUTION: REDUCTION, RECAPTURE AND REUSE** *- Handayani Putri Fraser, Victoria University of Wellington*	**HYBRID COMPONENTS: ENHANCING BONDING STRENGTH BETWEEN 3D-PRINTED ALUMINUM SUBSTRATES AND CARBON FIBRE REINFORCED PLASTICS** *- Hamed Abdoli, CACM, The University of Auckland*
	DESIGN AND MANUFACTURING PROCESS FOR A PASSIVE-FLEXIBLE FLIPPER FOR MARINE TURTLES *- Nick van der Geest, AUT*	**ADDING VALUE: UPCYCLING PROBLEMATIC PLASTIC WASTE THROUGH DIGITAL CRAFT** *- Huy Tim (presenter Jeongbin Ok), Victoria University of Wellington*	**APPLICATION OF 3D DIGITAL PHOTOGRAMMETRY TO QUANTIFY THE SURFACE ROUGHNESS OF MILK POWDER** *- Wei Yu, The University of Auckland*
12:00 PM - 1:00 PM	**LUNCH (Great Room 1) - sponsored by Fisher and Paykel Appliances** Exhibition Viewing		
1:00 PM - 1:30 PM	**KEYNOTE SPEAKER: KAHL BETHAM (CEO, GALLAGHER)** **GALLAGHER SUCCESS STORY** **SESSION CHAIR:** *Prof Jim Johnston, MaDE2022 Co-Chair and Professor - School of Chemical and Physical Sciences, Victoria University of Wellington* **ROOM: GREAT ROOM 4**		
1:30 PM - 3:00 PM	**CONCURRENT CONFERENCE SESSION 4**		
	GREAT ROOM 2	**GREAT ROOM 3**	
	HEALTHCARE APPLICATIONS **SESSION CO-CHAIRS:** *- Paul Ewart and George Stilwell*	**INDUSTRY COLLABORATIONS AND COMMERCIALISATION** **SESSION CO-CHAIRS:** *- Thomas Borrmann and Mark Battley*	
	FISHER & PAYKEL HEALTHCARE EVORA NASAL MASK - A DESIGN JOURNEY *- Jordan Kimpton, Fisher & Paykel Healthcare Ltd*	**FROM THE LAB TO A PILOT PLANT – A GEOTHERMAL STORY** *- Thomas Borrmann, Victoria University of Wellington*	

Wednesday 26 January 2022 (continued)

1:30 PM - 3:00 PM	**CONCURRENT CONFERENCE SESSION 4**	
	GREAT ROOM 2	**GREAT ROOM 3**
	HEALTHCARE APPLICATIONS **SESSION CO-CHAIRS:** - *Paul Ewart and George Stilwell*	**INDUSTRY COLLABORATIONS AND COMMERCIALISATION** **SESSION CO-CHAIRS:** - *Thomas Borrmann and Mark Battley*
	DESIGN OPTIMISATION OF AN INTRAOSSEOUS NEEDLE FOR TRAUMA AND EMERGENCY MEDICINE - *Lorenzo Garcia, AUT*	**GEOTHERMAL WELL OPTIMIZATION USING AN INTEGRATED BINARY PROCESS AND RESERVOIR MODEL** - *Brent Young, The University of Auckland*
	THE USE OF ENGINEERING THEORY AND SENSOR TECHNOLOGIES TO DEVELOP SPORTS EQUIPMENT TESTING TECHNIQUES - *Paul Ewart, Wintec Ltd*	**BETTER AND SAFER BOATS AND BUILDINGS THROUGH EFFECTIVE INDUSTRY-UNIVERSITY RELATIONSHIPS** - *Mark Battley, CACM, The University of Auckland*
	COMPARISON OF MULTIDIRECTIONAL ISOMETRIC STRENGTH FOR PEOPLE IN A SEATED POSITION USING A SIMPLE ANALYTICAL MODEL AND EMPIRICAL RESULTS - *George Stilwell, University of Canterbury*	**NZ PRODUCT ACCELERATOR: BRINGING TOGETHER NZ TO BUILD INNOVATION** - *Harshpreet Singh, NZPA*
	ARTIFICIAL MUSCLES FOR SOFT REHABILITATION SYSTEMS: A MANUFACTURING PROCESS OF TWISTED AND COILED POLYMERS ACTUATORS WITH NiCr RESISTANCE WIRE - *Alberto Gonzalez Vazquez, AUT*	**THE JOURNEY OF INNOVATION – HOW TO IMPLEMENT NEW INNOVATIVE TECHNOLOGIES IN YOUR COMPANY** - *Nathaniel McTaggart, Auckland District Health Board*
	FROM BENCHTOP TO BEDSIDE: A CASE STUDY ON COMMERCIALISING A MEDICAL DEVICE - *Deborah Munro, University of Canterbury, Mechanical Engineering*	**TITANIUM THERMAL PROTECTION SYSTEM FOR SMALL RE-ENTRY VEHICLES** - *Philipp Nieke, University of Auckland*

3:00 PM - 3:30 PM	**AFTERNOON TEA (GREAT ROOM 1)** Exhibition pack-down commences
3:30 PM - 4:30 PM	**PANEL DISCUSSION 2** **TOPIC: ADVANCED MANUFACTURING TRANSFORMATION IN NZ – THE INDUSTRY-RESEARCH NEXUS** **ROOM: GREAT ROOM 4** **ADJUDICATOR:** Rachael Tighe | *Senior Lecturer, Mechanical Engineering, University of Waikato* **PANELLISTS:** **Catherine Beard** – *Director of Advocacy, BusinessNZ* **Frank Phillips** – *Advanced Manufacturing Manager, LMAC Consulting NZ* **Hunter Nottage** – *Policy Director and Advanced Manufacturing ITP Lead, MBIE* **Johan Potgieter** – *Professor of Robotics, School of Food and Advanced Technology, Massey University Centre for Advanced Manufacturing* **Kahl Betham** – *CEO & Executive Director, Gallagher*
4:30 PM - 5:00PM	**AWARDS AND CONFERENCE CLOSING - sponsored by GNS Science** **SESSION CO-CHAIRS:** - *Professors Jim Johnston and Olaf Diegel*
5:00 PM	**POST-CONFERENCE COCKTAILS - sponsored by MaDE NZ** **VENUE: JADE ROOM, CORDIS AUCKLAND**

PRIZES AND AWARDS SPONSOR:

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Poster Presentations

RESILIENCE FOR NEW ZEALAND MANUFACTURING (FUTURE MANUFACTURING/BUSINESS MODELS)	**GENERATION OF BIOGAS USING FIXED-DOME ANAEROBIC DIGESTER FOR SMALL-SCALE INDUSTRIAL APPLICATIONS IN NEW ZEALAND** *- Jai Khanna, Waikato Institute of Technology (Wintec)*
UNIVERSITY, CRI, INDUSTRY R&D COLLABORATIONS	**(ACADEMIC LEADERSHIP + TECHNICAL SUPPORT) × STUDENT LEARNING OPPORTUNITIES = RESEARCH AND DEVELOPMENT TO INDUSTRY** *- Lauane Andrade, Waikato Institute of Technology (Wintec)*
	OPTIMISATION OF SENSORY FACTORS AND ENVIRONMENTAL PERFORMANCE OF FOOD PRODUCTS: A CASE STUDY OF A VEGETABLE-BASED PATTY *- Madison Franks, Massey University*
INDUSTRY 4.0	**A FLEXIBLE MONITORING SYSTEM FOR MACHINERY HEALTH MANAGEMENT IN INDUSTRY 4.0 FRAMEWORK** *- Minjung Kim, The University of Auckland*
INNOVATIONS IN MANUFACTURING AND DESIGN	**MEASURING MOISTURE INGRESS INTO HOUSINGS FOR LONG-TERM WIRELESS IMPLANTABLE SENSORS** *- Simon Blue, University of Canterbury*
	INVESTIGATION OF CONDENSATION-FROSTING ON COATING-FREE TOPOGRAPHIC WETTING GRADIENTS FOR HEAT TRANSFER SURFACE APPLICATIONS *- Chris Hughes, University of Otago*
	FINITE ELEMENT ANALYSIS METHODS IN SPINAL FUSION *- Sebastian Jones, University of Canterbury*
	MULTI-AXIS SPIN COATING ON CURVED SURFACES *- Finn Mcintyre, University of Canterbury*
	ARTIFICIAL INTELLIGENCE AND MULTI-MATERIAL 4D PRINTING IN PHYSICAL FILM DESIGN AND MANUFACTURE *- Andrew Roberts, Victoria University of Wellington*
	THE USE OF 4D PRINTING TO PRODUCE MYCELIUM ('FUNGI ROOTS') MATERIALS *- Deane Thomas, University of Canterbury*
DESIGN FOR MANUFACTURING	**DESIGN, MANUFACTURING AND MECHANICAL TESTING OF SMALL-SCALE WIRELESS CHARGING PADS FOR ROADWAYS** *- Kai-Yeung Li, The University of Auckland*
	CONCURRENT OPTIMISATION TOOLS FOR MULTI-PART COMPOSITE YACHT STRUCTURES *- Tobias Lorimer, The University of Auckland*

ADDITIVE MANUFACTURING AND DESIGN INCLUDING 3D AND 4D	**CREATING A LIVING 4D PRINTING PLATFORM** *- Chris Bainbridge, The University of Auckland*
	MATERIAL AND STRUCTURAL TAILORING WITH ADAPTIVE BIO-BASED MATERIALS AND ADDITIVE MANUFACTURING FOR ENHANCED COMFORT OF PROSTHETICS AND ORTHOTICS *- Dayna Cracknell, The University of Auckland*
	POST-PRODUCTION MECHANICAL PROPERTY MODIFICATION OF "LIVING" GELS VIA PET-RAFT *- Patrick Imrie, The University of Auckland*
	PLASTIC IN PRACTICE: AN EMPIRICAL APPROACH TO 3D PRINTED UPCYCLING IN NEW ZEALAND SCHOOLS *- Maddison Jessop-Benseman, Victoria University of Wellington*
	FAST HYDROLYTICALLY DEGRADABLE 3D PRINTED OBJECT BASED ON ALIPHATIC POLYCARBONATE THIOL-YNE PHOTORESINS *- Yimei Wu, The University of Auckland*
	APPLICATION OF PURE TITANIUM COATINGS FOR MEDICAL PURPOSES *- Hong Zhou, Waikato Institute of Technology (Wintec)*
MANUFACTURING PROCESSES AND TECHNOLOGIES INCLUDING ROBOTICS, AUTOMATION AND VIRTUAL	**REMOTE ACCESS AND CONTROL OF PLC LAB EQUIPMENT** *- Praneel Chand, Waikato Institute of Technology (Wintec)*
	DESIGN OF A LOW-COST SOIL DRYING OVEN *- Praneel Chand, Waikato Institute of Technology (Wintec)*

Student Innovation Showcase Presenting Students

#	First Name	Last Name	TEI	Email	Short Title
1	Heath	Ascott-Evans	Massey University	h.ascotevans@ massey.ac.nz	Smart bung
2	Nick	Barakat	The University of Auckland	nbar760@ aucklanduni.ac.nz	A study into the design and application of additive manufacturing for Formula SAE impact attenuation
	Liam	van Mechelen		lvan532@aucklanduni.ac.nz	
3	Simon	Blue	University of Canterbury	simon.blue@ pg.canterbury.ac.nz	Moisture ingress into implanted sensor housings through an epoxy bond
4	Gemma	Burnside	University of Canterbury	gemma.burnside@ pg.canterbury.ac.nz	Novel long-life semiochemical for New Zealand's Department of Conservation trap lures for rats, cats and mustelids
5	Nicholas	Childs	The University of Auckland	nchi730@aucklanduni.ac.nz	Binder jetting meat alternative products
	Justin	Tsoi		jtso068@aucklanduni.ac.nz	
6	Rahul	Dissanayake	Massey University	rahuldissanayake21@gmail.com	Polydimethylsiloxane (PDMS) 3D printer
7	Joel	Epps	University of Canterbury	jae59@uclive.ac.nz	Additive manufacture of cementitious materials
8	Tim	Gordon	The University of Auckland	tgor213@aucklanduni.ac.nz	Pure copper 3D printed heat sink demonstrator
9	Seb	Jones	University of Canterbury	sebastian.jones@pg.canterbury.ac.nz	Simulation of sheep spine for monitoring spinal fusion
10	Minjung	Kim	The University of Auckland	mkim332@aucklanduni.ac.nz	IoT-based real-time condition monitoring for asset management
11	Nayantara (Tara)	Kuruppuarachchi	Victoria University of Wellington	taraaz.dr@gmail.com	Digital smocking: Tailored to shrink
12	Callum	McGregor	University of Canterbury	callum.mcgregor@pg.canterbury.ac.nz	Contemporary design techniques to improve current design, manufacture and fit of assistive devices
13	Finn	McIntyre	University of Canterbury	finn.mcintyre@pg.canterbury.ac.nz	Spin coating on curved surfaces

14	Marcus	Michau	Victoria University of Wellington	marcus.michau900@hotmail.co.uk	3D printing variable-density diabetic orthotics to mitigate lower-limb amputations in New Zealand
15	Jean Henri	Odendaal	Massey University	j.h.odendaal@massey.ac.nz	The opportunity of steerable needles as a 3D/4D printing technique
16	Caleb	Philps	University of Canterbury	cap89@uclive.ac.nz	Harakeke composite using Māori weaving patterns
17	Andrew	Roberts	Victoria University of Wellington	andrewroberts2425@gmail.com	Artificial Intelligence and multi material printing for design and manufacture in the film industry
18	Brendan	Sanders	University of Waikato	brendan120300@gmail.com	Moray: The handheld apple thinning device
	Rahul	Jangali		rahul.jangali@waikato.ac.nz	
19	Sashin	Straker		sashin@straker.co.nz	Development and integration of apple fruitlet thinning end effector
20	Deane	Thomas	University of Canterbury	deane.thomas@pg.canterbury.ac.nz	The use of 4D printing to produce mycelium ('fungi roots') materials
21	Zhan	Widdison	Massey University	zwiddison@gmail.com	Water tank monitoring device
22	Zexuan	Zhu	The University of Auckland	zexuan.zhu@auckland.ac.nz	An Augmented Reality-assisted assembly workstation

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Student Innovation Showcase

SPONSORED BY AUCKLAND UNLIMITED

Happy Hour: Let's all talk together – students, industry, and academics
Tue 25 January 5.30 – 7.00pm
Venue: Pre-function space

This Pop-up exhibition provides students with the opportunity to explain their work through physical demonstrations, samples or exhibits; and also, to strike up conversations with and gain feedback from industry, academics, and fellow student delegates at MaDE2022.

It will be a show-and-tell form of conversational presentation, with delegates mingling freely in the conference exhibition area. Students whose Expressions of Interest have been accepted for this session will be bringing their demonstration/sample/exhibit (e.g., 3D print/object, etc.) to MaDE2022 and setting up in the designated exhibition area. Exhibits will be on display in the allocated demonstration space only for the session time.

Cash prizes are sponsored by GNS Science and there will be a single BEST Innovation Showcase Prize valued at $1,000 (including $500 cash and 3D printing credits to the value of $500) and three Highly Commended Prizes valued at $300 each (including $150 cash and 3D printing credits to the value of $150). 3D printing will be done at the University of Auckland's Creative Design and Additive Manufacturing Lab. All prizes will be announced during the MaDE2022 Closing Ceremony on Wednesday 26 January 2022.

Please note, all delegates are invited to cast a vote to help determine the BEST and Highly Commended Innovation Showcase prizes. The success of this event requires your participation and as a thanks, a spot prize for voting will be given to a lucky delegate. This prize will also be announced during the MaDE2022 Closing Ceremony on Wednesday 26 January 2022.

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AUCKLAND

MaDE2022 Prizes and Awards

The MaDE2022 Conference Committee is pleased to be offering the following awards and prizes which will be presented during the closing proceedings on Wednesday 26 January, 4.30 - 5.00pm.

Award/Prize	Sponsor	Value ($)
People's Choice Award Best Oral Presentation	GNS Science	500.00
Poster Presentation First Prize	GNS Science	500.00
Poster Presentation Second Prize		300.00
Poster Presentation Third Prize		200.00
Student Innovation Showcase First Prize	GNS Science, Auckland Unlimited & The University of Auckland's Creative Design and Additive Manufacturing Lab (3D Printing Credits)	1,000.00 (incl. $500 cash)
Student Innovation Showcase 3x Highly Commended Prizes		300.00 (incl. $150 cash)
Student Innovation Showcase Voting Spot Prize for lucky delegate	MaDE NZ Conference Committee	60.00

Delegate Feedback (Lucky Draw Prize)

Lucky Draw Prize Delegate Feedback	MaDE NZ Conference Committee	500.00

Your post-event feedback is important to us. Online feedback forms will be sent to all registered delegates immediately following MaDE2022.
To be eligible to win the Lucky Draw Prize of $500 you should include your contact details and your feedback must be:

- Submitted by the stated deadline
- Complete and of an acceptable quality

NOTES:


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Welcome to Auckland Unlimited – Tāmaki Makaurau Auckland's economic and cultural agency committed to making our region a desirable place to live, work, visit, invest and do business.

Nau mai ki Auckland Unlimited – te pokapū ōhanga, ahurea hoki o Tāmaki Makaurau e ngākau titikaha ana ki te whakarite i tō mātou rohe kia matenuitia ai hei wāhi noho, mahi, torotoro, whakangao pūtea, whakahaere pakihi hoki.

We're here for you. We work with businesses and a wide range of partners to grow Auckland's innovation culture, support the growth of businesses and key industries, and attract investment, events and visitors to the region.

We're the Government's Auckland partner for the Regional Business Partner Network (RBP), a gateway that connects businesses to the right advice, people, funding, and resources. Working together, we can help you strengthen and grow your business by connecting you with:

- Partial funding for training workshops, courses, coaching and other services that build the management capabilities of owners, operators and key managers
- Research and development options, primarily through Callaghan Innovation
- Advice, support and connections with the right programmes

We also consider opportunities and challenges for the sustainable development of Auckland's economy. Our Economic Insights Series is designed to stimulate discussion about the region's economic performance and future, and help decision-makers understand barriers and enablers of economic development.

We're here to enable your business and industry to innovate, be future-ready and sustainable.

Find out more at **aucklandnz.com/business**

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AUCKLAND

MaDE2022 Panel Discussions

MaDE2022 Panel Discussion Programme

Tuesday 25 January	
4.00 - 5.00pm	**1. Sustainability and the Circular Economy – looking beyond the horizon**
Wednesday 26 January	
3.30 – 4.30pm	**2. Advanced Manufacturing transformation in NZ – the industry-research nexus**

There will be two Panel Discussions, one on the afternoon of Tuesday 25 January and the other on the afternoon of Wednesday 26 January. Each Panel Discussion will be adjudicated by a senior MaDE researcher.

OVERALL AIM OF THE PANEL DISCUSSIONS:
To identify opportunities, challenges and strategies related to each topic so as to enable New Zealand's MaDE economy to retain and expand its global competitiveness.

THE PROCEEDINGS:

- The Adjudicator introduces the topic and Panel members. This should not take more than five minutes.
- Panellists introduce their insight into the topic for about two minutes each followed by an open discussion.
- Delegates will be invited to contribute to the discussions from the floor.
- Both Panel Discussions will be recorded.

RECAP OF THE SESSION AT THE CLOSING CEREMONY:
The outcomes and findings of the Panel Discussions will be summarised by the Adjudicators for presenting succinctly in the Closing Ceremony and in more detail for the post-event report.

Slido QR code for all Panel Discussions

https://www.sli.do/

CODE: #MADE2022

MaDE2022 Panel Discussion Topics

PANEL 1:

Sustainability and the Circular Economy – looking beyond the horizon

Tuesday 25 January, 4.00 – 5.00pm | Venue: Great Room 4

ADJUDICATOR:

Marcel Schaefer *MaDE2022 Co-Chair; Programme Director, BEngTech, Mechanical Engineering, AUT*

PANELLISTS:

- **Deborah Crowe –** Co-Founder, Usedfully
- **Jeffrey Seadon –** Senior Lecturer, School of Future Environments, AUT
- **John Kennedy –** Ion Beam Physics Research Scientist, GNS Science
- **Rachel Barker –** CEO, Plastics New Zealand
- **Rebecca Percasky –** CEO, The Better Packaging Co.

INTENDED OUTCOME:

The establishment of a more sustainable circular economy provides a prime opportunity for the merging of manufacturing, design and entrepreneurship. The broad concept of sustainability is evolving, and invariably spans environmental, social, and economic dimensions. In general, the vast majority of people with an interest in sustainability, whilst acknowledging the existence of these three sustainability pillars, tend to focus primarily on one of the pillars. For example, they may focus mainly on environmental sustainability, to the detriment of economic and/or social sustainability, or one of the other pillars.

The challenge is how, in the context of MaDE, do we develop a more inclusive approach, so that one sustainability pillar cannot be considered without incorporating its impact on the other two pillars?

This Panel will be an opportunity for industry and researchers across the MaDE disciplines to discuss the creation of a more sustainable future. It will be a forum for sharing of opinions, and experiences with sustainable technology and business developments. Also to debate the critical needs of industry that should be addressed by the MaDE Network, and how to better integrate the three foundation pillars of sustainability.

PANEL 2:

Advanced Manufacturing transformation in NZ – the industry-research nexus

Wednesday 26 January, 3.30 – 4.30pm | Venue: Great Room 4

ADJUDICATOR:

Rachael Tighe *Senior Lecturer, Mechanical Engineering, University of Waikato*

PANELLISTS:

- **Catherine Beard –** Director of Advocacy, BusinessNZ
- **Frank Phillips –** Advanced Manufacturing Manager, LMAC Consulting NZ
- **Hunter Nottage –** Policy Director and Advanced Manufacturing ITP Lead, MBIE
- **Johan Potgieter –** Professor of Robotics, School of Food and Advanced Technology, Massey University Centre for Advanced Manufacturing
- **Kahl Betham –** CEO & Executive Director, Gallagher

INTENDED OUTCOME:

Advanced Manufacturing encompasses an integrated approach to manufacturing centred around all advanced technologies. This includes digital design, computer simulation, industry 4.0 and IoT (internet of things), Blockchain and cryptocurrencies, additive manufacturing and manufacturing processes – all linked together through a digital thread.

In reality, however, when applied in industry we often see a disconnect between the manufacturing and the industry 4.0 practices, with manufacturing focusing on faster and 'conventional' automation of manufacturing processes, and industry 4.0 focusing on connected devices, IoT, and big data. However, the true advantages exist when there is a more synergistic integration of manufacturing and industry 4.0, wherein live data is intelligently used to inform the manufacturing process.

This Panel will discuss the opportunities that are opened up for New Zealand companies to better integrate advanced manufacturing, driven by industry 4.0 and big data, and will the challenges they may encounter, from both a business and an applied research perspective.

NOTES:

Key Presenters

Stepping into outer spaces - A journey into unchartered futures

FRANCES VALINTINE CMNZ

CEO and Founder, Tech Futures Lab

KEYNOTE ADDRESS: 9.30 – 10.00AM, TUESDAY 25 JANUARY

Frances Valintine CNZM is dedicated to pushing Aotearoa ahead as a global leader in innovation to build a stronger, more resilient future for all New Zealanders. A leader in her own right as an innovator, emerging technologies futurist and disruptor of traditional education, Frances founded Tech Futures Lab in 2016 to foster the capabilities and skills needed to develop a culture of innovation and agility critical to NZ businesses and individuals to thrive in this fast-paced technological advancement era.

Prior to this, in 2013 Frances founded The Mind Lab to empower students and educators to develop applied digital knowledge and capability.

Over the past 8 years across Tech Futures Lab and The Mind Lab, Frances has been instrumental in reskilling and educating 20,000 adult students in formal programmes, many thousands in short tech courses in software development and over 250,000 school aged students.

With an eye always on future horizons, Frances has worked with and advised over 250 organisations across every sector in New Zealand – from agriculture to finance, retail to law and has gained a reputation as an expert in leading digital transformation initiatives that bring positive impact.

A Companion of the New Zealand Order of Merit for her lifetime contribution to education and technology (2018), Frances has received numerous awards recognising her passion and commitment to supporting the young and more mature to seek opportunities and reach their potential. In 2020 Frances received the Outstanding Contribution to Technology and Business at the CIO Awards. Her past accolades also include:

2017: the NZ Flying Kiwi Award, inducted into the New Zealand Hi-Tech Hall of Fame and named one of the top 3 NZ Innovators of the Year at the NZer of the Year awards.

2016: named one of the top 50 EdTech Educators in the World by EdTech International; awarded a Sir Peter Blake Leader Award.

2015: awarded the Westpac New Zealand Woman of Influence (Innovation) and the Next New Zealand Woman of the Year (Education)

Driven by a strong sense of purpose to support positive growth for Aotearoa, Frances also sits on the boards of Watercare and Dilworth School Trust. She is also a selection adviser to EHF (Edmund Hillary Foundation), a judge on the Hi Tech Awards, a mentor to a number of female technology leaders (in NZ and India), and a Director to On Being Bold, a platform to support and encourage emerging female leaders and year 13 students to dream big.

She holds a Master of Education Management from the University of Melbourne.

Turning Rocket Lab's electron rocket into a reusable launch vehicle

MATT DARLEY

Recovery Systems Manager, Rocket Lab

KEYNOTE ADDRESS: 1.30 – 2.00PM, TUESDAY 25 JANUARY

With more than two decades of aeronautical engineering experience, he leads a dedicated team at Rocket Lab developing the world's first reusable small launch vehicle.

Matt's specialist skills in space systems engineering, Finite Element Analysis (LS-DYNA), Fluid Structure Interaction (LS-DYNA) and design, analysis and development of aerospace systems drives the advancement of reusable launch vehicle technology for orbital-class small rockets.

Prior to Rocket Lab, Matt was Systems Engineering Lead at Reaction Engines Ltd for the SABRE (Synergetic Air-Breathing and Rocket Engine) program, and Senior Systems Engineer at Vorticity Ltd, working on entry, descent and landing systems for European Space Agency missions and technology development projects. Matt is a Senior Member of the AIAA and a member of the AIAA Aerodynamic Decelerator Systems Technical Committee.

With both a hands-on and theoretical approach, Matt's work continues to enable Rocket Lab to increase production, lower costs and offer further flexibility and launch options for customers.

From number 8 to great! How NZ's history as an innovative country has set us up for some silver linings.

DAVID DOWNS

CEO – The New Zealand Story

GALA DINNER PRESENTER: TUESDAY 25 JANUARY

David Downs is a business leader, public servant, consultant, board director, speaker – and genetically modified organism. David is now CEO of The New Zealand Story, an ambitious government-funded organisation marketing New Zealand to the world.

Previously David was a General Manager at New Zealand Trade and Enterprise (NZTE) for 10 years, working with the Technology sector to help fast growing tech companies grow internationally. David has held various roles at NZTE, in the Services, Customer and Corporate Services teams, and led a cross-government project for the MBIE to help grow the Agritech sector.

David spent 13 years at Microsoft, in New Zealand and as regional director for South East Asia, and he has set up and run successful businesses of his own. David is a published author on New Zealand Innovation, with two highly successful books – 'No.8 Re-wired', and 'No.8 Recharged'.

In 2017/2018 David was facing a terminal diagnosis and given less than a year to live, but managed to beat cancer in a remarkable series of lucky breaks. After a year of chemotherapy, and staring a terminal diagnosis in the face, David got a literal lifeline, with the chance to get on to a clinical trial in the USA. Now a genetically modified cancer-killing machine, David's reflecting on the lucky series of events that saw him beat cancer, and on his new approach to life.

He's an ex-comedian, TV and Radio actor, semi-finalist for New Zealander of the Year, and a genetically modified optimist who documented his battle with cancer in the book A Mild Touch of the Cancer – now a documentary film. His charity project Down with Cancer helps raise funds to make the revolutionary CAR T-cell therapy available in New Zealand for those who need it.

A chartered member of the Institute of Directors, David holds a number of board positions, including as the chairman of The Icehouse, the Hi-Tech Trust, and the Well Foundation. He is part of the executive advisory committee to the CEO of DIA.

At the beginning of the Covid-19 lockdown, David co-founded sosbusiness.nz – a not-for-profit initiative to help bars, cafes and other small businesses sell vouchers. It quickly became a huge hit and to date has sold over $2 million in vouchers for over 2500 small businesses. All the money goes to the businesses. Based on that experience, he published a book about the innovation that happened during covid-19 in New Zealand, 'Silver Linings', published by Penguin RandomHouse.

David studied at Massey University, the University of Auckland and Stanford University, and regularly presents and gives talks on his cancer journey and on the power of positive thinking and optimism.

PROFESSOR BRONWYN FOX

Chief Scientist, CSIRO, and previously Deputy Vice-Chancellor (Research and Enterprise), Swinburne University of Technology

KEYNOTE ADDRESS: 9.30 - 10.00AM, WEDNESDAY 26 JANUARY

Professor Bronwyn Fox is the Deputy Vice-Chancellor (Research and Enterprise) at Swinburne University of Technology in Melbourne, Australia. She has been instrumental in positioning Swinburne at the forefront of manufacturing, building extensively on Australia's Industry 4.0 strategy. She has led a number of significant initiatives and global research partnerships through her former role as the founding Director of Swinburne's Manufacturing Futures Research Institute, including establishing a world's first Industry 4.0 Testlab for additive manufacturing of carbon fibre composites with Australia's national science agency, the CSIRO. Most recently, Bronwyn chaired an expert working group to write a ten-year horizon scanning report for Australia's Chief Scientist with the Australian Council of Learned Academies (ACOLA) on the Internet of Things.

She has demonstrated a sustained commitment to support the growth of the carbon fibre and composite industry in Australia through targeted research and was previously a co-founder of the Carbon Nexus facility at Deakin University, a core part of a $100 million dollar precinct in a regional community, Geelong. Carbon Nexus has acted as a catalyst for other companies to invest in production in the Geelong region resulting in a manufacturing precinct that supports around 1,400 new jobs. She is a Fellow of the Academy of Technology and Engineering (ATSE), a Fellow of the Royal Australian Chemical Institute and a Graduate of the Australian Institute of Company Directors. In 2018 Professor Fox was awarded the Global Congress on Manufacturing and Management (GCMM) Research Leadership Award. In 2020 she was awarded the Royal Society of Victoria Medal for Excellence in Scientific Research.

Gallagher success story

KAHL BETHAM

CEO, Gallagher

1.00 - 1.30 PM, WEDNESDAY 26 JANUARY

With a deep understanding of business strategy and strong business acumen, Kahl stepped up into the role as CEO for the Gallagher Group after holding the Deputy position for 2 years and many other senior roles within the company since 1997.

Kahl leads the Group Executive Leadership team comprising Security, Animal Management, Operations, R&D, IS, Risk, Finance, Legal and People & Brand.

A people focussed leader, Kahl is passionate about encouraging diverse thinking and customer focussed ingenuity, ensuring the pioneering spirit upon which Gallagher was built continues to thrive. His focus is on embedding a culture that nurtures a growth mindset, tapping into the collective potential of everyone and building a high performing organisation that cares about having a positive impact on their employees, customers and communities long into the future.

Kahl is a member of Gallagher's Board of Directors and a Director to the Gallagher Group entities.

The MaDE2022 Conference Committee wishes to thank the Abstract Management and Review Team. It is by virtue of their dedication and commitment that we have a detailed, interesting, broad, and structured conference programme.

ABSTRACT MANAGEMENT	
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Marcel Schaefer Jonathan Stringer	Programme Design
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Industry 4.0 requirements beyond the pandemic horizon

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In an effort to grow New Zealand's manufacturing expertise and capability in Industry 4.0 LMAC NZ have been working in deep collaboration nationally with Callaghan Innovation; the Employers and Manufacturers Association and internationally with the SIRI Institute and TUV SUD.

The Industry 4.0 Demonstration Network, that forms the basis of this collaboration, has permitted us to derive twenty case studies covering high-value and niche manufacturing businesses alongside developing a data driven heat map using the World Economic Forum accredited Smart Industry Readiness Index. This heat map highlights the Industry 4.0 priorities for manufacturers across eight different industries, six regions and ranging in size from ten employees to several thousand.

Using both the heat map and case studies this presentation aims to deliver a view beyond the horizon in terms of both time and geography of what Industry 4.0 technologies manufacturers in New Zealand will be prioritising to build their resilience and support growth post the pandemic.

The clear outcomes of this work will be explored, firstly showing that vertical and horizontal integration of business processes and the associated data are key to unlocking value opportunities in organisations. Before emphasising the need to precede this with a robust shopfloor intelligence of targeted data collection to be ultimately successful. Finally, the essential value of human capability development as a success driver of technology deployment will be investigated.

Ultimately the aim of this presentation is to deliver a holistic picture of where the manufacturing industry is heading in its requirements for technology. The value of this work is its ability to help shape research and development strategies for tertiary institutions/technology providers whilst assisting in providing direction for funding and grants for relevant organisations.

The presentation will be an interactive session designed to relate the audiences' experiences to real life examples and data.

Frank Phillips is the Advanced Manufacturing Manager at LMAC NZ Ltd, delivering Industry 4.0 consulting globally and delivering the Network of Site Visits, part of the Industry 4.0 Demonstration Network. The passion behind this research is driven by his desire to ensure manufacturers always get the most from their technology investments.

Horticulture system of systems implementing an autonomous survey robot and orchard digital twin

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Agriculture is facing a period of unprecedented change resulting from the requirement to feed c. 10 billion mouths by 2050, while operating in an environment of labour shortages and increasing sustainability expectations. To meet these challenges many are looking to industry 4.0 technology as a solution, specifically the combination of Artificial Intelligence (AI), Internet of Things (IoT), in-field and digital twins. Although there have been successful prototypes and promising start-ups, the complex nature of the horticulture growing and supply chain systems creates a significant risk of mass adoption failure due to the silo'd technology approach leading to usability, availability, viability and interoperability challenges.

A joint academia/industry project is working towards a collaborative System of Systems (SoS) through the use of a shared autonomous survey robot and digital twin platform. The programme has started with kiwifruit flower counting and canopy cover identification to support grower decision making on crop loading and labour allocation, with plans to expand the collaboration into the areas of pest/disease detection, fruit estimation and harvest optimisation. This presentation explains how Industry 4.0 and a SoS approach could assist the horticulture industry to accelerate innovation and scale adoption for research, industry and government partners to be better together.

Nick Pickering is a passionate technology leader & educator at the University of Waikato, who thrives on solving complex problems using a systems approach. Nick's career spans 20 years of international industrial experience within avionics, finance, logistics & manufacturing. Current research interests include Agritech, Smart cities, IoT & Digital Twins.

Industrial revolutions - rise of the machines and the role of humans

Presenting Authors

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Aspect PT has been involved in many factories across Australia and New Zealand, and has incorporated many Programmable Logic Controllers (PLC) into their manufacturing execution system. This presentation will expound the differences between Industries 2.0, 3.0, and 4.0 and the necessity of stepping from one to the next in order to increase productivity. For this progression, it is ideal to use a flexible and scalable system capable of covering the scope of Industry 2.0, 3.0 and 4.0.

Industry 4.0 is an appropriate goal, but achieving it in the average NZ factory is difficult, given the limited existing infrastructures and processes currently in use. Therefore, this presentation will also detail the path for many NZ/Aus factories that may utilise automation, but lack connectivity (Industry 2.0), to progress to Industry 4.0.

Implementing Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) systems at Industry 3.0 level may not have the flashy appeal of AI/machine learning, robots/cobots/AGVs but they are fundamental and provide vast benefits as an essential step before progressing to Industry 4.0. Consequently, this presentation will also discuss the different roles of automation versus personnel, repurposing staff for tasks they perform best.

To achieve this, Aspect has embraced the advantages of an industrial PC-based control architecture for their software solution. This allows the best of both worlds to be realised in a single package, Information Technology (IT) and Operational Technology (OT); a fundamental principle on which Industry 4.0 is based. Furthermore, it opens up possibilities for the controller to connect directly to the business server, cloud services, peripheral devices such as RFID readers, barcode scanners and a range of industry standard I/O interfaces, allowing for comprehensive network diagnostics and advanced data management. This is achieved using a Beckhoff platform; which is rated for industrial use and meets applicable standards and approvals.

Allan Orr previously owned and directed Production Logistics NZ Ltd, an Automation System Integrator established in 1989. He is currently the Founding Director of Aspect Productivity Technology Ltd, a NZ software company which has developed a world class "Manufacturing Execution System" installed by many Discrete Manufacturers throughout NZ and Australia.

Caleb Millen is a Massey University Master of Engineering (Mechatronics) graduate and has worked in several industries, focusing on product development and automation. He is currently an Application Engineer encouraging others to take advantage of Beckhoff technology by providing training, demonstrations and product and application support.

The Pharma Industry 4.0: Blockchain application in upstream supply chain

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High-quality standards, reliability, excellence in clinical science are among the top goals of every Pharmaceutical Supply Chain (PSC). Most of the leading pharma manufacturing companies in PSC try to be a pioneer by effective management of recall, reducing medical errors, and combating counterfeit products. However, one of the most important problems in the pharmaceutical industry is serialization and traceability. Blockchain in the supply chain defines transparent, reliable, and automated track and trace of physical goods while preserving the privacy of enterprise data.

Further, in the PSC, there are a lot of drivers for serialization and traceability which is the main challenge of the pharma blockchain. Serialization and Track & Trace are regulations being enforced by the governments to secure a high-quality in PSC including, the safety of patients, and local economical trading requirements. Most of Track & Trace operations focus downstream which is governmental driven, but we also need to ensure such operations upstream including tiers of suppliers to have an efficient and effective PSC.

The main research objective of this work is investing and implementing Track & Trace operations in the upstream supply chain and further to study the benefits of implementing such blockchain operations at upstream in a PSC. The supply chain upstream challenges can be categorized in supply chain performance, product sources, and quality of raw materials. Some of the promising advantages of blockchain technology in the upstream supply chain are the authenticity of raw materials, certification of raw materials, sustainability of manufacturing process, proof of the origin, and quality assessments.

With blockchain application, there is a possibility of going back far, for all-natural products which can be naturally based including plant-based and animal-based. The efficacy and intricacy of the work will be demonstrated on a real PSC.

Amirhossein Mostofi is a Ph.D. student of management at Victoria University of Wellington. His thesis title is the 'strategic alliance in pharmaceutical supply chains'. His research interests are supply chain management, optimization techniques, and applications of IT in supply chain management.

Defining an appropriate procurement maturity model to assess and improve innovation procurement in fast-growing/frontier firms in New Zealand

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Using the MFAT definition of SME, 97% of NZ businesses are of small or medium size, account for 29% of employment and contribute 28% to our GDP. Studies show that lack of appropriately skilled staff is one of the biggest challenges for SMEs.

The connection between the supply chain and shareholder value has been well made; organisations can spend more than two thirds of revenue on procurement so even a small cost reduction can have a big impact. Efficient supply chain management drives economic profit and thus shareholder value through its numerous inputs to both net income generation and asset management.

The output of this work will be a contribution towards advancing knowledge in the field of supply chain performance monitoring for SMEs. More specifically, the aim of the research is to develop a procurement & supply chain performance-management tool to be used as part of an improvement programme by innovative & entrepreneurial growth-oriented NZ SMEs.

Following a systematic literature review of existing academic procurement maturity models relative to fast-growing, innovative SMEs, it was found that:

- A systematic overview of such models has not been attempted.
- There is currently a gap in understanding to be filled relative to how fast-growing, innovative SMEs select and manage their key partners.
- Although many maturity models exist in the public domain these are geared to large companies and inappropriate for SMEs.
- Procurement in SMEs is a field to be explored; currently little research exists.

For the individual SME looking to innovate and increase economic value, procurement capability is key. A maturity / capability tool geared to resource constrained SMEs will allow better management of innovation procurement processes through improved identification of objectives, alignment with business needs, selection of partners, cultural fit, and management of supply chain relationships.

Liz McGill is a Fellow of the Chartered Institute of Procurement and Supply, SME Mentor and supply chain professional with industry experience in aerospace, construction, financial services and retail procurement and supply chains in Europe and Asia, currently embarking on a doctorate exploring innovative frontier firms' supply chains.

Digital Twin-driven online anomaly detection for an automation system

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Anomaly detection is a critical issue in detecting potential failures of the proactive maintenance schedule management of manufacturing systems. The equipment and operation process had more and more data generated, making transmitting the data collected from the system a challenge. Meanwhile, to achieve accurate detection results, both the historical and real-time data of the system need to be considered for anomaly detection, which is another challenging point.

Digital Twin technology is one of the enabling technologies of Industry 4.0 to implement the integration by providing a digital replica of the physical asset in the cyber world. It provides real-time data and historical data gathered from the physical system and reflects the current state of the physical system to the virtual world, which makes it suitable for the anomaly detection of the automation system.

This research proposes a Digital Twin-driven method for online anomaly detection for automation systems based on edge intelligence. A case study will be presented on a LiBr absorption chiller for the detection of anomalies at an early stage.

Huiyue Huang has received a BEng degree and a ME degree from Beihang University, China, and she is now pursuing her PhD at the University of Auckland. Her research focus is on Smart Manufacturing and Digital Twin technologies.

Augmented Reality and IoT - driving transformation at scale

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In a recent Aberdeen report Sarah Gaffney states "From product design to verification and testing, to maintenance, augmented reality has become a pillar of manufacturing – 63% of Best-in Class companies are already utilizing it, and 33% of Best-in Class companies are currently evaluating its benefits and planning to incorporate it into their production processes. AR seamlessly blends technology with real life, and in the manufacturing industry, technological assistance with physical challenges results in immense time and money savings."

Scaling for growth using advancements in Augmented Reality (AR) allow for the rapid creation of repeatable training instructions or step-by-step guides, capture process knowledge and scale your manufacturing and maintenance expertise throughout your organisation addressing:

- Widening skills gap leading to unfulfilled job positions
- High cost of downtime from unscheduled maintenance and changeover
- Safety and compliance adherence in a heightened regulatory environment

Examples will be shared of how fast and easy knowledge capture allows you to rapidly create step-by-step guides and scale your manufacturing expertise throughout an organisation.

Augmented Reality experiences can be created using existing product data, recordings, scanned data or other digital information to:

- Scale engineering excellence
- Improve quality and processes
- Boost front-line accuracy and efficiency
- Gain insights for continuous improvement
- Reduce the widening skills gap
- Reduce downtime
- Improve Safety and compliance adherence

Kevin Marett has worked for LEAP for over ten years, specialising in helping New Zealand manufacturing businesses to implement software solutions spanning design, engineering, manufacturing and service, in particular disruptive technologies such as PLM, Smart Connected Products & Smart Connected Operations.

Human Capital 4.0: the new concept and new competence typology for the workforce in Industry 4.0

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There is a clear need for a reform of the Human Capital concept and understanding, especially today, in the time of Industry 4.0. Past views of this concept saw the workforce only as an asset for job performance, nothing else. The only competency and skills taught to the workforce were unidimensional, that is, merely technical or job-specific, without the care or importance into other dimensions of upskilling, i.e. intrapersonal development. Research has shown that distinct and independent competences, such as soft skills or emotional intelligence, have a positive impact on the worker performance at the personal and professional level, reflecting such impact at the work place too. However, not enough emphasis had been given to that, at least until now. Today, between the disruptions of Industry 4.0 and Covid-19, they have highlighted the gap of the human resilience, not only at the personal but at the professional scenario. The lack of preparedness and resourcefulness in people to be able to cope with risks, uncertainty, and challenges has made more visible the need for enhancing the human aspect at the professional, but more so at the personal level.

In this study, we present a way to tackle such need and challenge. The proposed reconstitution of the Human Capital 4.0 aims at covering a more holistic, thus organic, way to perceive and care for the labour force. Shifting away from a mere job-based training to a more holistic and human-based upskilling, which in return will positively influence the job performance and business development. In addition, under the same ideology of the new concept, a novel competence typology is presented. This set of competency looks at the integration of the best competences and skills to embrace Industry 4.0 goals at the same time as to level up the upskilling of the future workforce.

Emmanuel Flores is wrapping up his Ph.D. at the University of Auckland in the Department of Mechanical Engineering. His research interests include Industry 4.0, Human Capital 4.0, Human wellbeing, Social wellbeing. He is an industrial engineer with years of experience in the manufacturing and service sectors. His expertise is on problem-solving focus.

Industry applications for Multi Jet Fusion – enabling the benefits of HP MJF for additive manufacturing

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Fast turnaround and material performance are key to seeing results in competitive environments. During the recent America's Cup, a partnership between HP NZ, EVOK3D NZ and Emirates Team NZ (ETNZ) saw them taking full advantage of turnaround times and functionality with HP Multi Jet Fusion 3D print technology.

HP Multi Jet Fusion (MJF) is a powder bed additive manufacturing technology that prints with polyamides in a set amount of time per layer, independent of the amount of part cross-sections in a layer. A unique benefit of MJF are parts produced having tough, isotropic properties in all three axes. ETNZ were able to use this advantage to rapidly deliver results. A couple applications were lightweight, strong part functionality, and the use of MJF as fibreglass mould tools for quick turnaround over traditional methods.

In one application, a sheave was needed to guide travelling hydraulic lines around a corner under a moderate pre-tension. The hoses required a large bend radius and ETNZ wanted to make a very lightweight sheave for its size. Additive manufacturing was the right choice for making a cost effective yet high performing part.

At the close of race finals, the team at ETNZ needed to urgently make padeyes for clipping crew members' safety lines to the deck. To stay within race rules, the padeyes had to be an integral composite part of the hull. Another requirement was having low drag aerodynamically for racing. Using the HP MJF printer, tooling was made overnight that allowed for direct lamination of the composite parts.

These are just two of the applications where MJF was used extensively to give ETNZ competitive advantage and speed in their successful defence of the 36th America's Cup.

Jonathan Zyzalo has been in the NZ additive manufacturing industry since 2001. Currently he is an Application Engineer for EVOK3D NZ. He specialises in successful implementations of polymer materials, particularly, HP MJF applications and business development for additive manufacturing.

A sustainable method for creating 3D form utilising natural shrinkage and the precision of digital deposition

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In the areas of architecture, industrial design and fashion there is a growing interest in Biofabrication, incorporating natural biological growing systems within manufacturing processes. From bricks grown from algae, 3D printed mycelium chairs, to substitute leather made from mycelium. These synergistic sustainable growing systems are often confined by digitally produced formwork or organic composites deposited through digital control.

The research presented here explores this relationship between digital deposition, in the form of robotic syringe printing of bio-composite materials, and two areas of natural change, mycelium growth and the reshaping of form through desiccation. Prospective biomaterials were identified, and iterative experiments were conducted to establish the most productive combinations of suitable growing mediums, fabric substrates, and a range of fungal cultures were explored, both commercial mushroom cultures and two New Zealand cultures. A series of 2D printed patterns were developed and tested to understand the relationship between digital placement, large-scale fabric substrates, mycelium growth and desiccation.

It was observed that contraction of the flat fabric during the drying process created undulating 3D forms. This was more pronounced on deposits of potato agar without mycelium and this material became the main focus of the study. The analysis of the shrinkage data informed the placement of lines and curves to create specific forms. Using a combination of parametric software, a range of 2D printed patterns strategies were refined to create 3D forms to fit the body through the developed shrinkage method. A final series of 3D haute couture garments were co-created through the symbiotic relationship of digital control and natural shrinkage.

This research was conducted in association with the National Science Challenge Additive manufacturing and 3D and/or 4D printing of bio-composites group.

Nayanathara (Tara) has completed a Design Innovation Masters student at Victoria University of Wellington. She previously graduated with a Bachelor's degree in fashion and textile design. Her research interests are the use of generative software to produce textiles through digital fabrication with a focus on sustainable innovative practices for fashion design.

Advanced plasma strategies for spatial additive manufacturing of tensile structures

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Spatial printing is a form of additive manufacturing where material, typically thermoplastic, is extruded directly in three-dimensional space producing, open spaceframe structures. Spatial printing gives designers and engineers improved level of control over material deposition, when compared to layer-based printing, resulting in economy in material usage and increases in print speed.

However, adhesion at the joints (nodes) in the structure are often weak as the initial deposition has time to cool-down before more material is connected. This leads to lower adhesion strength, decreased repeatability, and overall reduced mechanical integrity of the printed object. We showed previously that improvement in adhesion and strength can be gained through the introduction of plasma surface treatment and heat during the printing process.

Recently, further benefits of this strategy have been made by eliminating the thermo extrusion process and introducing a filament uncoiling method. Thus increasing speed by only introducing heat, via plasma, at the intersecting nodes. Unlike conventional additive manufacturing this technique has a focus on tensile structures and flexible filament. The custom-made uncoiler was developed for use on an ABB IRB 1200 Robotic Arm and has enabled the National Science Challenge 3D/4D printing researchers to conduct a range of spatial printing of tensile structures. A Tantec Plasma TEC-X OEM plasma torch was used and mounted alongside the uncoiling head. The resulting adhesion strength of the nodes were tested and compared to extruded parts.

This presentation illustrates the processes, experiments and research findings.

Jérôme Leveneur is a materials scientist and innovator at GNS Science. He received his PhD in Chemistry from the University of Auckland in 2013. His research focuses on the development and application of new ion beam processes and nanotechnologies (nanomagnetics, nanocomposites, magnetoelectrics) to solve energy efficiency challenges in industry.

Generative design of programmed materials for controlled frequency responses

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Designing structural forms to achieve pre-set frequency responses is an essential but complex task, given the multidimensional nature of the problem. However, limitations of the traditional manufacturing methods often force engineered components to be made of single material systems, which limits the freedom of design. With the advent of additive manufacturing methods, the point-by-point consolidation allows for a possible change of the material constitution within a given part domain. This will give rise to a plethora of new material and property options for the designers. A multi-material and generative design solutions using integrated with optimisation scheme of genetic algorithm (GA) is presented to find the optimal material distribution solutions achieving certain pre-set frequency response criteria. Accurate pre-set frequency response is obtained by the presented multi-material solution. However, the applicability of this solution is limited by their reliance on multi-material additive manufacturing. The current additive manufacturing methods only allow for the use of digitally mixed acrylic polymer options with limited mechanical properties. To enable more material options in the available additive manufacturing methods, a novel structured single-material solution is proposed. The problem domain is divided into several volume elements (voxels) each of which contains a structure whose geometrical form is altered to adjust its effective properties to desired values. The resulting continuous design spaces are searched using a modern evolutionary algorithm, the covariance matrix adaptation evolution strategy (CMA-ES). Correlations with the multi-material solutions show that the purposed single structured material approach is on par or better in some cases, even though the test domain was discretized into 80% fewer voxels than for the multi-material case.

Wuxin Yang obtained his BCIS and BS with first-class honors at Auckland University of Technology. He is a Vice-Chancellor's Doctoral Scholarship holder and currently he is in the third year of his PhD study in Engineering. His current research is related to the structural and topological optimization in material science.

Automating complexity with nTopology

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Growing capabilities of emerging software have major potential in the development of complex structures which can further leverage the potential of Additive Manufacturing.

nTopology is an example of such software and can be used to easily create advanced lattice-based features (such as the popular gyroid triply periodic minimal surface). While it's modelling interface is somewhat non-intuitive (akin to graphical programming), it is well equipped for mesh file modification and can create re-useable workflows capable of rapidly outputting complex parts.

This software is well suited to patterning features on complex surfaces/geometries allowing users to apply complex textures relatively easily. nTopology also allows for the tailoring of patterned features (namely quantities and scale) relative to inputs. This creates an interesting opportunity for advanced/rapid product development and Additive Manufacturing technology in which products/models can be optimised through data derived from Finite Element models or clinician consultation.

This presentation will discuss the Creative Design and Additive Manufacturing Lab's use of nTopology and will present developed workflows and case studies related to examples in prosthetics, wearables, food fabrication and healthcare technology.

Juan Schutte began his research career in the development of a novel Additive Manufacturing technology at Massey University and is currently a Research Fellow at the University of Auckland's CDAM Lab where, as a R&D Engineer, he consults with industry and academia on the opportunities of 3D printing.

High performance continuous fibre composite 3D printing: prototyping and process characterisation

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High-performance fibre reinforced plastics see widespread use across industries such as marine, automotive, and aerospace for lightweight, high strength and stiffness components. The manufacture of a component using current polymer composite manufacturing technology requires forming the part in a mould, as well as skilled manual labour to laminate the part onto the mould. Composite 3D printing of continuous fibre reinforced plastics is an emerging technology with the potential to both fully automate composite manufacture and remove the requirement of using a premade mould to form shapes. By incorporating continuous fibre reinforcement, significant improvements in mechanical properties are achieved relative to polymers printed including chopped fibres. The technology has the potential to offer additional benefits, such as full 3D fibre steering, for highly optimised lightweight structures.

A novel composite 3D printing process is being developed to have the ability to print carbon fibre thermoset polymers at a high fibre volume fraction, with mechanical properties comparable to traditionally manufactured composite materials. The approach used to develop this technology is based on fundamental process and materials science, which informs the ultimate design of the printing process. Fibre tows are infiltrated in-situ, minimising material costs.
A modular prototype printing head will be constructed to test a range of variations on the process, as well as to demonstrate the capabilities of the composite 3D printing technology.

The current progress of this research will be reported, including findings from investigating the underlying process and materials behaviour, and how this has informed the design of the proposed process. In particular, results of research on radial fibre compaction, in-line resin infiltration, and resin characterisation will be presented in relation to the design of the prototype printing device.

Joshua Hares is a PhD candidate in Mechanical Engineering at the University of Auckland's Centre for Advanced Composite Materials. His research is focused on the development of, and the process science surrounding a novel composite 3D printing process.

Additive manufacture of cementitious materials

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Internationally, additive manufacture using cementitious materials is gaining traction as a viable method of manufacturing large scale structures such as single dwellings and multi-storey buildings. The benefits include faster and potentially more economic construction along with producing less waste. However, there are several issues that are preventing wide-scale use such as the cost of the technology and the lack of design standards.

The purpose of this research is to investigate the current state-of-the-art of additive manufacturing technologies and applications for cementitious materials, evaluate viable applications for New Zealand, and produce a conceptual design for a comparatively low-cost, reliable and easy-to-use portable machine. At the University of Canterbury a bespoke Cartesian, linear xyz, machine with 1.5x1.5x1.5m build volume has been manufactured and is being used for development of control code and cementitious materials.

This presentation will report the international state-of-the-art, evaluation of applications and the concept design of a low-cost and portable machine. This machine could be manufactured in New Zealand and present opportunities for local and export markets.

Joel Epps is completing his final year of study towards a Bachelor of Engineering in Mechanical Engineering. He is currently researching cementitious additive manufacture as his final year project.

Functionally graded core material and hard-point interfaces for composite sandwich panels

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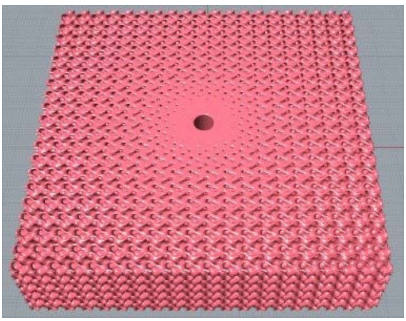
For high structural performance, sandwich panels with thin stiff composite skins and a thick but lightweight core material are used in many applications. Such panels have high bending stiffness at very low weight. Honeycomb core materials can be used for low curvature panels, but manufacture of complex geometries requires significant deformation or discontinuities of the core structure with resulting detriment to mechanical properties. Hard-points for connections present a further challenge: typically, the lightweight core is replaced with an area of much higher density material.

A novel technique combining cellular structures and additive manufacturing is proposed to create core material with variable geometry that can be adapted to suit the application. Using the Grasshopper plugin for the Rhino CAD system, Triply Periodic Minimal Surface (TPMS) cellular structures have been generated with functionally graded density. This enables a continuous transformation between a solid hard-point and low density lattice core material. TPMS structures have also been tested as substitute core in geometries where honeycomb core would require significant deformation or cutting. The research has focused on three main points: 1) Suitability of additively manufactured TPMS cellular materials as core structures; 2) Functionally graded interface of hard points and core materials; 3) Replacement of distorted or discontinuous honeycomb materials with conforming geometry TPMS structures. The Formula Student racing car at the University of Canterbury has been used as a case study to analyse performance of proposed structures based on load cases, geometries and manufacturing techniques used in the construction of the car.



Ben Murton is a PhD candidate in Mechanical Engineering. He has a BE(Hons) in Mech Eng from the University of Canterbury. His research interests include high performance energy absorbing structures, additive manufacture, product design and prototyping.

From a bright idea, through R&D to a commercial company: the journey of Inhibit Coatings Ltd.

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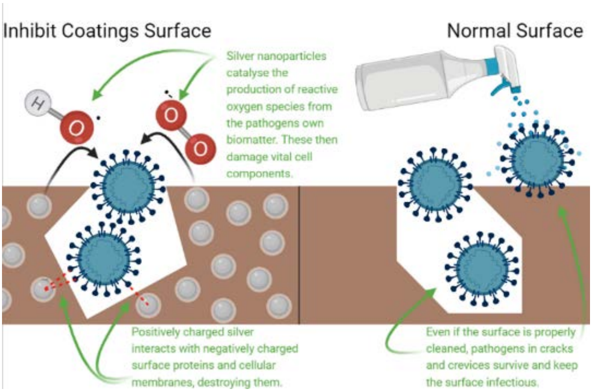
Inhibit Coatings Ltd was established as a spin-out company in November 2016 to commercialise the nanosilver-polymer composite antimicrobial and antiviral coatings technology, initiated and developed by Professor Jim Johnston and his former PhD student Dr Eldon Tate. Our industry partner, the Polymer Group Ltd, Auckland is the manufacturing arm. The R&D work was supported by the NZ Product Accelerator and the Polymer Group. Eldon went from a PhD graduate to the CEO of Inhibit Coatings.

The technology utilises the broad spectrum antimicrobial and antiviral properties of silver, with the nanosilver entities being tightly chemically bound to the polymer resin thereby providing high durability, whilst maintaining effectiveness. This provides the competitive advantage over other products in the marketplace.



Inhibit Coatings has developed and supplies highly effective and durable antimicrobial and antiviral coatings for food processing, healthcare, textile, architectural, transport interior and HVAC applications. The coatings kill over 99.99% of bacteria including Escherichia coli, Salmonella spp., Listeria monocytogenes and Campylobacter, and 99.9% of viruses including Sars-Cov-2 and Influenza A (H1N1), on the coating surface. The coatings maintain their activity after repeated wash cycles with no reduction in efficacy.

The journey from the bright idea through a collaborative university – industry research programme to develop and demonstrate the effectiveness of the nanosilver-polymer composite antimicrobial and antiviral coatings, prototype product development and demonstrating the effectiveness of the coatings in industrial applications, successfully raising investment capital and progressing the New Zealand and international commercialisation pathway, will be presented.

Professor Jim Johnston has a Personal Chair in Chemistry at Victoria University of Wellington. He is a Principal Investigator in the NZ Product Accelerator. His research in new materials, chemical technologies and product developments, is at the university-industry interface. He is a founding shareholder and Director of Inhibit Coatings Ltd.

Leaning on strengths and partnering for success

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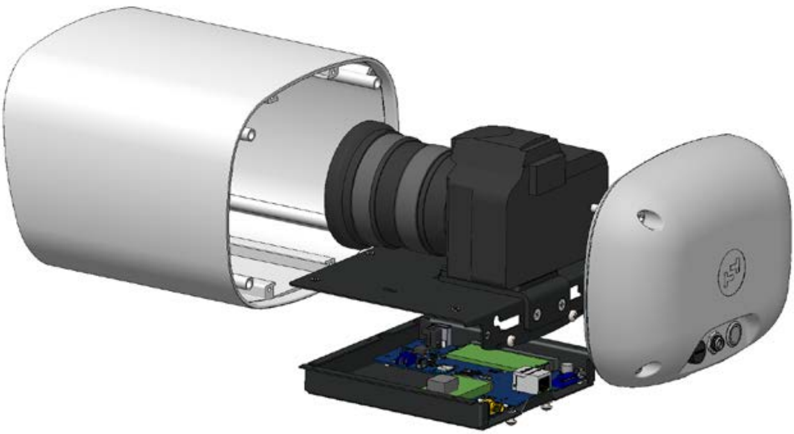
Small Businesses make up 97% of New Zealand businesses, most of these are highly specialised in their field. This creates a prime opportunity for collaboration.

Timescapes deliver high resolution, live, time lapse footage of construction projects in New Zealand and internationally. Their footage helps to monitor real time progress, security, and safety updates along with being a great marketing tool for construction companies.

At Blender we work as an Industrial and Mechanical design partner with Timescapes to supplement their Software and Electrical engineering teams. By leveraging our combined expertise we were able to develop a custom camera enclosure to enhance their product offering and support their ability to scale.

With partnerships like this, small businesses can generate the peripherals required for their products, while maintaining a lean team and continuing to focus on their core product offering.In my presentation I will talk about some of the techniques and tools used to collaborate and overcome the challenges of this process.



Matt Bradley is a Mechanical Engineer at Blender Design Limited. He has had 5 years of experience in the Product Development industry. His experience ranges across several product industries including medical devices, marine and industrial electronic applications.

Company growth ... with a little help from innovative suppliers!

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NZ frontier firms have growth-ambitions but have a relatively low productivity. Increasing their innovativeness is important for the NZ society. The recent report from the New Zealand Productivity Commission on frontier firms did not discuss benefits from engaging with suppliers. We reviewed 80 international academic articles on innovation & procurement (Full review available during MaDE).

Our Findings & Conclusions:

1. Most of the customer value and innovations in successful firms are sourced externally.
2. Good entrepreneurial procurement skills can increase productivity in NZ frontier firms.
3. Innovative suppliers can support frontier firms by providing and co-developing innovative offerings.
4. Academic literature discusses innovation procurement in large organisations. There is very limited research on innovation procurement in frontier firms.

Recommendations - company level:

- Leverage collaboration with key suppliers
- Leverage on procurement management capabilities
- Use webapps to scout & source technology and to optimise procurement processes.

Recommendations - industry level:

- Initiate procurement research on NZ frontier firms
- Develop easy-to-use digital innovation procurement tools for NZ
- Stimulate innovation procurement skills development.

Recommendations - policy level:

- Use public procurement to pilot innovative solutions with frontier firms
- Facilitate research funding.

Anne Staal is a senior lecturer specialising in innovation procurement & sustainable procurement. His PhD was on how construction companies manage innovative suppliers. He regularly blogs on his research and his early publication on the impact of COVID in NZ procurement ranks TOP 3% on ResearchGate.

Opportunity for an agri-robotics innovation ecosystem in New Zealand

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New Zealand, along with many developed countries, has recognised labour shortage as a critical problem for the agricultural sector, further exacerbated by Covid19. Growers and other stakeholders are looking for robotic solutions to harvest crops and perform labour-intensive tasks, but commercial robots are not yet available. Furthermore, commercializing the technology to solve these problems typically costs tens of $millions and several years. The few innovative NZ based agricultural robotics companies are already struggling to grow and have difficulty recruiting staff with the required skills. There is an opportunity for NZ to be an agri-robotics leader, but we need a better innovation ecosystem that is well calibrated to market demand. What does this look like?

One proposal is to establish an NZ Agri-robotics Centre. The Centre would collocate technology experts and researchers in all aspects of agri-robotics, ranging from artificial intelligence to mechanical engineering. There would also be project managers, investors and partnerships with engineering companies. End user problems would be screened and if successful passed into the Centre to start a stage-gated development process. The stage-gates would include, IP issues, proof of concept prototypes, financial viability studies and commercial prototypes. A successful project would lead to technology transfer from the Centre to the partner engineering companies for full, ideally, global commercialisation. IP issues will be managed by the Centre. The Centre's physical layout, size and location is important. It should have space for engineering laboratories, offices and meeting rooms and a large build space where robots are developed. It would also be essential to have the Centre in a major agricultural area where the robots can be tested with good interaction with end users. This will require collaboration between growers, robotics companies, applied researchers and investors for commercial success. Such a Centre does not currently exist in NZ.

Professor Mike Duke is the Dr John Gallagher Chair in Engineering. He works on applied agricultural engineering research with a number of companies. Mike believes the global robotics revolution in agriculture is underway and that a small country like NZ needs to focus its product development efforts if it is to become an exporter of agri-robots rather than an importer.

Making makers and making engineers: seeding the next generation of engineers through hands-on skills

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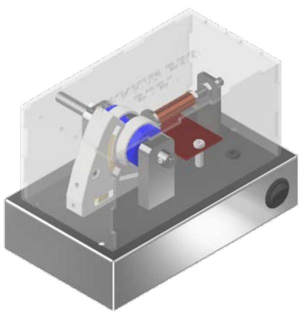
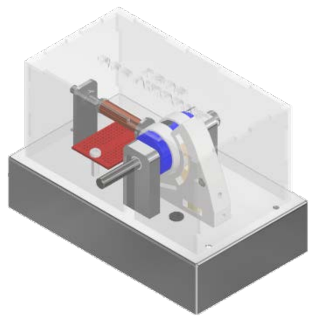
For decades, every engineering student at the University of Auckland has been required to complete a workshop practice course early in their academic career. ENGGEN 299 introduced students to mills, lathes, welding, and other basic metalworking tools over 4 full days of instruction. While engineering has never solely about making parts out of metal, the course failed to match the rapid expansion over the last few decades of the materials and tools available to engineers in industry, nor the more entrepreneurial mindset encouraged in student and graduate engineers alike.

The new version of the course, started in 2021, is centred around a brushless DC electric motor made by every student. Shown below, the motor incorporates rapid prototyping methods such as sheet metal folding, 3D printing, laser cutting, and basic circuit board soldering. For some students, for example, those specializing in mechanical engineering, the project also includes time learning to use a lathe and a mill.

This presentation describes a re-framing of the goals of ENGGEN 299 and a re-design of the course itself. Student feedback is included from an initial pilot and the first running of the course in 2021 with 650 students. The presentation ends with a request for input from MaDE 2022 attendees as we look to further improve the course.





Mark Jeunnette is the Director of Engineering Design and a senior lecturer in the Faculty of Engineering at the University of Auckland. His research interests include aerial remote sensing for agriculture, human-centered design in resource constrained settings, and engineering education.

Foiling or Failing – it's a fine line – university/industry engagement, how hard can it be?

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The benefits of meaningful collaboration between universities and companies is widely acknowledged – enabling companies to access specialist knowledge and facilities, leverage their inhouse capability and evaluate graduates, whilst for the university it provides focus, relevance and stretch for both its academics and students.

Whilst the aspirations of industry-university partnerships can be readily described, implementing an effective partnership is often a difficult and frustrating experience for both parties. In part, this is a reflection of the completely different cultures, time horizons and expectations of what constitutes success.

In this presentation I reflect on 30 years of experience in arranging collaboration between research organisations and manufacturing companies. There are a number of elements that are required in order to achieve a successful, collaborative partnership between researchers within a university or CRI setting and teams within a manufacturing environment. It's not that hard provided all the necessary ingredients are present but, almost impossible if one or more of the ingredients are missing – which is generally the case.

Several successful (and unsuccessful) examples will be used to outline the challenges and barriers that exist when developing and implementing a joint R&D activity.

Graeme Finch is the Business Development Manager for the University of Auckland's CACM. He has been involved in joint research projects with industry in both Crown Research Institute and University environments. With trade, science, and business qualifications, he is passionate about the gains that can be made when business and science objectives are aligned.

A case study of the commercial realities of polymer additive manufacturing production, aka “tales from a service bureau”

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Calmpipe is a Christchurch based start-up company which engaged Fi Innovations to manufacture their wellness product. The product consists of 9 additively manufactured components and is assembled with other common hardware. At the heart of the function is a patented twin chamber impellor design which is powered by the users own breath.

The product was initially manufactured using 2 different additive manufacturing processes, SLS using the Duraform ProX PA12 Nylon material and the Figure 4 DLP using the Pro Black 10 resin material.

Manufactured in batches of 40 and sold as a standalone product, this allowed for feedback to be received, processed and relevant design changes to be made in between batch runs.

The suitability of the additive manufacturing materials was analysed, and changes were made as required, but this was complicated by the limited selection of available additive materials.

With a retail price of $200 and a manufacturing cost per pipe just for the additively manufactured parts of $74.05 (excluding post processing, assembly and hardware) the margins were not sustainable. However, it did allow for revenue to be generated whilst gathering valuable customer feedback.

A hybrid manufacturing method has been identified as being the optimal solution by utilising injection moulding for some components and continuing to use additive manufacturing for the parts whose geometry is not practical for moulding.

Additive manufacturing has provided Calmpipe with a manufacturing methodology to launch, refine and validate a product whilst avoiding crippling start up costs. With the evidence gathered they have attracted investment into their company and are now designing their second-generation product.

Derek Manson is the Advanced Manufacturing Manager at Fi Innovations, based in Invercargill. He has been involved in the New Zealand additive manufacturing industry since 2006.

Adding value to the sawmill process through vision scanning

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Sequal is a Kawerau based sawmill that specialises in customised cut-to-order timber. Their customisation model allows them to access different markets and meet niche demand but also adds variability and complexity into their manufacturing system.

Sequal has been working with the University of Auckland to find opportunities for innovation and increase efficiency of their manufacturing processes. We found that the scalability of projects in other areas like the Digital Twin for production planning, was limited by the restricted trackability of boards during the cutting process. During the transportation and sorting of processed timber, there is little visibility of the movements of product. This project aimed to develop a solution that ensured the tracking of timber pieces through the production process.

As each board of timber is unique in its distribution of knots, we were able to develop an algorithm that identifies the location and sizes of knots using images of the boards directly after sawing (see Figure 1).
We can use this information to create a digital fingerprint that can uniquely identify a board and track its movement by comparing images taken throughout the sawmilling process.

Figure 1: Sample board with results of the knot detection algorithm

Furthermore, the distribution of knots in the product also dictates the value of a board. Using vision scanning, we can not only solve Sequal's tracking problem but also provide additional data on the product, transforming the way Sequal can market and sell in the future.This is a great of example of how industry and universities can work together on projects that are not only academically interesting, but also add value to business.

Daniel Kulasingham is Head of Technology at Sequal and is currently completing his PhD at the University of Auckland in planning optimisation for mass customisation manufacturing. Research interests: production planning, process optimisation, Digital Twins, mass customisation.

Vat-based 3D printing of electroactive polymers

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While Electroactive Polymers or EAPs are a rapidly growing field of research interest, there are difficulties in the integration of additive manufacturing techniques to produce ionic EAP complex objects. Other research groups, such as Carrico et al (2015), have made use of extrusion based additive manufacturing techniques. However, light based additive manufacturing of ionic EAPs remains a novel and exciting approach. Our research in the Newmarket Polymer Chemistry Laboratory has shown promising results in the vat-based additive manufacturing of these ionic EAP actuators. By combining vat-based photopolymerization techniques and synthetic polymer chemistry a novel ionomeric polymer network was synthesized from a liquid resin. Under photo-polymerisation this novel resin forms and ionomeric polymer network that undergoes cation exchange from a cation-chloride salt solution.

The coating of precious metal electrodes via surficial adsorption of the metal salt and the corresponding reduction to metal nanoparticles can be utilised to fabricate ionic EAP actuators. These ionomeric polymer networks facilitate cation motion through the polymer network under an electric field.

This novel photo-resin has shown printability in a commercially available Digital Light Processing (DLP) 3D printer. They were also controllably actuated via a sinusoidal waveform from a signal generator. As seen in Figure 1, a 3D printed Ionic EAP actuator displayed a displacement range of 16mm using a frequency of 0.01Hz and an amplitude of 10V. This research has shown that by merging the fields of polymer chemistry and materials engineering, newfound understanding in the additive manufacturing of ionomeric materials can be attained. Therefore, further advancing the fields of soft robotics and soft sensors.

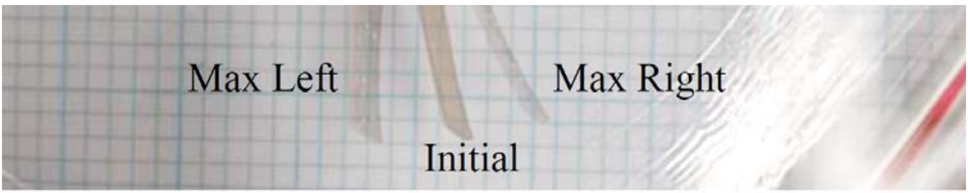

Figure 1: Vat-based 3D printed Ionic EAP actuator driven underwater using a sinusoidal wavefunction of 0.01Hz frequency and 10V amplitude

Kyle Engel is a PhD student under the supervision of Dr. Jianyong Jin and Prof. Olaf Diegel at The University of Auckland. His work is primarily focused on the fabrication of novel 3D printed ionic EAP actuators using vat-based additive manufacturing technologies.

FDM printing of polylactic acid: tensile testing of strength configurations for mechatronics

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Fused Deposition Modelling (FDM) 3D printing is seeing increases in use in engineering applications mainly due to aptitude for rapid prototyping. A 33 General Factorial design was conducted to test Ultimate Tensile Strength of 3D printed Polylactic Acid (PLA) specimens on the INSTRON 68TM-30 Tensile Testing Machine. An optimal regression model was formed to predict strong configurations of parts for applications in mechatronics and rocketry. It was hypothesised that higher Infill Percentage and more geometrically complex Infill Pattern would result in higher average UTS.

Specimens were subjected to three factors at three levels: Infill Percentage (25%, 50%, 75%), Infill Pattern (Gyroid, Triangles, Zig-Zag) and Colour (Red, Blue, White). Specimens were manufactured in two Blocks on two CREALITY Ender 3 Pro 3D printers. Printers were calibrated in Ultimaker Cura V4.7.1. Specimens were printed sequentially and kept in a cool environment to minimise effects of nuisance variables.

INSTRON tensile testing was conducted in a single session to minimise systematic error and operator bias. Results were processed with Minitab 19. Process analysis such as a Line Plot of Means and Quality Control were conducted to validate the study. Confirmation trials confirmed the optimal setting and the prediction accuracy of the final regression model.

Results aligned with hypotheses and corroborated with researched literature. A higher Infill Percentage and more geometrically complex Infill Patterns were found to improve parts' UTS. PLA with less pigmentation is generally stronger. Interestingly, results identified a significant two-way interaction between Infill Percentage and Infill Pattern, where Infill Percentage results in a different order of strength for Infill Pattern when 25% ≤ Infill Percentage ≤ 50%. More so, that the effect of Infill Percentage presents diminishing returns as it increases, with an optimum around 50-85%. This study's results were conclusive, providing avenues for improvement and exciting opportunities for future experiments.

Ben Orwin-Higgs is a 3rd Year undergraduate BE(Hons) Mechatronics student at Massey University, Manawatu. Ben is an intern Mechatronics engineer at Massey AgriFood Digital Labs, with aspirations to conduct research into exotic materials manufacturing and automation for applications in mechatronics, aviation and rocketry.

Screen printing for additive manufacturing of titanium parts

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Screen printing can be used to produce 3-dimensional moulds for manufacturing green bodies with complex shapes. It enables the economic manufacturing of a large number of precise and high-quality components. At MaDE 2020, we presented our developed technique of Screen Additive Manufacturing (SAM) wax moulds to cast cellulose hydrogel for chromatography purification. In the meantime, we have explored moulding other materials, such as metals and polymers.

The SAM process is similar to that of metal injection moulding (MIM). It involves forming, debinding, and sintering. A 3D CAD model of a part is sliced and each slice is used to make a screen. Through layer-by-layer screen printing of wax, a 3D mould is fabricated. Titanium alloy powder is mixed with additives (binders) to form a slurry, which is injected into the wax moulds to create green bodies. The wax mould and titanium slurry are dried in an oven for the sintering process. Once the samples were dewaxed and debound, they were sintered in a tube furnace under an argon atmosphere. A sintering profile, which includes time and temperature, affects the final part's quality, including shape fidelity, shrinkage, porosity and mechanical properties.

This approach seems particularly promising for making complex periodic structures, i.e. gyroid. In addition, we explored recycling discarded powder generated in Powder Bed Fusion (PBF) methods for producing less critical titanium parts using the developed AM method.

Don Clucas teaches Design and Manufacturing at the University of Canterbury and has twenty years of experience in product development and manufacturing industries. He established the Mechanical Engineering Advanced Design and Manufacturing Laboratory and his primary research interests are additive manufacture and small engines.

Novel composite-metal additive manufacturing

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Over the last two years, Nuenz and Auckland University of Technology have been prototyping new composite steel and aluminium metals for additive manufacturing. The focus has been on enhanced mechanical properties that apply to mainstream printing. Typically, printable metals are based on existing alloys compositions and are restricted to weldable compositions. This eliminates high-performance aluminium alloys, such as Al2024 and 7075, and tool steels. These metals are in high demand in industry, especially in aerospace and space systems, and heavy engineering for the rapid on-site inventory replacement.

The objective of the collaboration is to utilise Nuenz's advanced reinforcing additive, silicon nitride fibre, to develop and explore metal matrix composite material alternatives for the additive manufacturing industry. Additive manufacturing experts in North America have guided the research with feedback from consultants in the US, end-users in the US and Europe, and powder suppliers.

Metal matrix composite tensile test pieces

This presentation will discuss early work in metal matrix composite additive manufacturing and the results of both selective laser and binder-jetting printing methods for prototyping aluminium and stainless steels. Mechanical property investigation, including hardness, tensile strength and microstructure will be presented.

Troy Dougherty is the Chief Technology Officer at Nuenz. He developed the silicon nitride fibre production process and oversaw the scale-up from lab-scale to current pilot-scale production. He currently oversees all site operations at Nuenz, including production, R&D and customer engagement.

Selective Laser Melting of high purity copper on a low cost, low power (250W) machine

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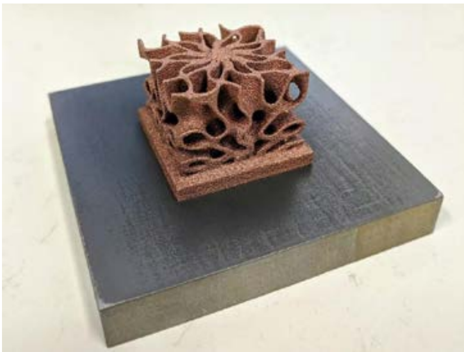
This work explores the feasibility of selective laser melting (SLM) of high purity copper on a low power, low cost SLM printer, namely, the Sharebot MetalOne. Due to the high reflectivity and high thermal conductivity of copper, stable melting of copper powder can be difficult with low power machines.

Copper's thermal properties make it desirable for heat exchanger applications. Additionally, the advanced geometry feasible with additive manufacturing (AM) enables optimisation of the heat exchanger performance.

10mm cube specimens have been printed using different process parameters (scanning speed, laser power, scanning strategy). The structure of each specimen has been analysed by means of scanning electron microscopy and the density measured using the Archimedes method. Marketable density of copper has been achieved with a laser power of 250W. The small scale, rapid iteration with the MetalOne has proved itself financially effective for experimentation.

SLM printers are typically costly and complex to maintain, hence, limited as experimental platforms. Proving the feasibility of copper with a low cost printer opens the door to more open-ended research on a financially viable platform.

Polished cross section of specimen



Advanced geometry demonstrator

Tim Gordon is an undergrad Mechanical Engineering (Hons) student at the University of Auckland. He is researching metal Additive Manufacturing processes in the Creative Design and Additive Manufacturing Lab and has international experience marketing applications of Polymer SLS AM.

Screen 3D printing cellulose gel

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Screen 3D printing can be an AM method for the production of small intricate parts with no waste and minimal machining cost. Using this method, a wide range of materials such as polymers, metals and ceramics can be manufactured. Hydrogels are among the materials that are most suitable for this AM method. They are hydrophilic polymer networks that are strong enough to absorb and retain a large amount of water. In our recent work, cellulose gel made from aqueous solutions of cellulose, sodium hydroxide and urea was used to form hydrogel parts.

Cellulose gel can be screen 3D printed due to its shear-thinning properties, and the formation of a secondary gel structure post-shearing, which allows the gel to regain most of its structural integrity. In this work, a study was performed to determine whether successive printing layers can be completed without delamination. Moreover, printing overhangs without support material were examined. Design of Experiments (DoE) was applied to optimise the screen 3D printer settings for printing cellulose gel. The optimum print settings were then used to print periodic structures with micro features and without the need for support material.

Hossein Najaf Zadeh obtained his PhD in engineering at the University of Canterbury and currently works as a post-doctoral fellow. He completed his M.Sc. and his B.Eng. in Mechanical Engineering at the University of Greenwich, England. His research interests are Additive Manufacturing, 3D printing of bio-based materials and product design and development.

A robotic 3D/4D printing construction method to create sustainable large scale temporary structures

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With increased awareness of the environmental impact of synthetic materials, there has been an increase in research investigating more sustainable manufacturing methods and materials. A number of research projects use natural growing systems to produce materials with placement being defined by 3D printing or digitally fabricated moulds. These have been referred to as Hybrid Construction Systems, as both natural and manmade techniques are combined as a fabrication system.

This research investigates the opportunities and constraints of using mycelium-based composites in combination with spatially printed structures to dictate the form, materiality and areas of potential use. Mycelium offers many unique material qualities, it is a naturally occurring resource that can perform as a structurally sound material when used correctly. One benefit of it beyond removing the use of synthetic materials is that it can be composted, when it is no longer needed, which could offer sustainable design alternative for short-term products or for large temporary structures.

The research presented here, explores the creation of spatially printed 3D scaffolds and the synergies of materials, methods of growth and manipulation of mycelium based composites. Form, pattern, and structure of 3D printed objects were analysed along with application techniques to identify suitability for mycelium growth. Processes identified as successful were then applied to the design of large scale structures that highlighted the opportunities of the developed method.

The findings provide evidence that spatial printing could offer a scaffold for mycelium composites to grow, defining form and creating an alternative method and unique design opportunities to the traditional use of casting moulds.

A scenario of use was developed where furniture items and screens were designed for use at music festivals, the structures would be printed, grown on site, used and deconstructed to decay in the environment.

This research was conducted in association with the National Science Challenge Additive manufacturing and 3D and/or 4D printing of bio-composites group.

Tim Miller studied at Kingston University and UNSW and has many years of experience as an industrial designer, design consultant, educator and researcher. For the last 20 years he has focused on education and research that considers the design opportunities of emerging digital manufacturing technologies.

Virtual Reality as a design tool

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Virtual Reality is becoming more commonplace in our daily lives, we continue to see greater integration across platforms, increasing market spread and adoption. The market is rolling through hardware generations providing increasingly lower latencies with better visuals and intuitive controls making the experience even more user friendly and immersive.

At Blender we are leveraging VR as a tool to accelerate design reviews within our new product development process. With the latest design software integrations we are able to do this rapidly and repeatedly resulting in lower costs and shorter time frames when compared to traditional prototyping. VR provides a very engaging and contextual experience, even more so when we supplement the rendered environment with physical items and push the ability to gather key insights even further.

A partnership with amphibious boat manufacturer Sealegs has leveraged these VR tools to experience prototypes well before traditional practices would allow and accelerate development as a result. We could easily review aesthetics, ergonomics, visibility, and accessibility around the cockpit to make well informed design decisions to move the project forward. The process for refinement and testing in this way, and for this scale, is much less cumbersome than dealing with physical prototypes, and we were able to asses a range of solutions in a fraction of the time in a lean and easily repeatable cycle. This presentation will further detail the impact VR has had on our development process and the value it has delivered to projects within Sealegs and other key partners.

Ben Thomsen is a Founding Partner of Blender Design with a deep knowledge of design and manufacturing in New Zealand and internationally. Ben has a keen eye and technical focus with a unique problem-solving ability which has led to many successful and award winning products.

Insourcing vs outsourcing and blended teams - delivering value for product development in a changing post-Covid world

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Covid-19 has changed the way people are working across the globe. The biggest effect seen in New Zealand has been changing work locations (home/office) made necessary by multiple lockdowns. Overseas, this has been more pronounced with longer lockdowns producing even larger changes. From overseas data, one area that has changed noticeably is outsourcing and insourcing practices in various industries. Is New Zealand also going to see these changes with time?

Some of the noticeable changes that have been happening in New Zealand over the last 18 months due to Covid-19 or have happened independently at the same time are:

- An increased acceptance of remote working and video conferencing
- A reduction in skilled overseas migration to NZ
- A growing economy
- A more mobile workforce that is staying in jobs for shorter timeframes

Historically, the previous states of the above have steered C-suite executives not to outsource in NZ. Overseas, a willingness to use outsourcing alongside internal teams is becoming much more common. The drivers of outsourcing are cost, flexibility, speed to market and wider access to tools and skills.

When this is applied to product development in NZ, how can a company find a good balance between insourcing and outsourcing and when is it appropriate? How do you prepare a workforce for it so that it has a foundation to be successful from? Doing due diligence on a company's resilience, understanding if companies are the right partners, seeing if they will be a good cultural fit and having well defined contracts/scopes all help to ensure successful partnerships.

In this presentation, we will show trends, research and predictions about the above areas from both New Zealand and overseas to help people with their resource planning for the near future.

Craig Shannon is the General Manager at Globex Engineering. Since graduating from Auckland University with a BE Mech (hons), Craig has performed a variety of roles in and around product development, in both large and small organizations, in NZ and abroad. Craig is passionate about building product design capabilities in NZ.

Innovation in design and manufacturing with digital knit technologies

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Flatbed knitting technology has continued to advance steadily since the first seamless 'Wholegarment®' machine was introduced by Japanese manufacturer, Shima Seiki in 1995. These technological advances mean that flatbed machines are no longer bought solely to produce conventional knitwear; they have been adopted by manufacturers of footwear, sportswear, automotive products, medical and healthcare goods, and furnishings. Nike's 'Flyknit' range of knitted running shoes is one example of this approach, which offers advantages including minimal waste, reduced labour costs, design innovation and the benefits of localised production.

While many areas of textile and garment manufacturing in New Zealand reduced or closed down in the face of globalisation, New Zealand knit manufacturers were relatively quick adopters of seamless technology. As a result of the development of new luxury yarns like possum/merino, and knit technology innnovations, the country developed a buoyant industry, although heavily dependent on luxury knitwear aimed at the foreign tourist market. The recent impact of the pandemic on this sector has seen a shift in focus whereby manufacturers increased their online marketing activity, responded more openly to NZ brands that wished to source locally rather than face international supply chain delays, and by developing new types of knitted products.

The Textile and Design Lab (TDL) at Auckland University of Technology has a range of digital knit technologies including 'Wholegarment® intarsia and inlay machines. It engages with a wide range of industry partners for the purpose of research and new product development as well as generating opportunities for graduates. This presentation draws from recent research into the effects of the pandemic on the New Zealand Knit Industry and introduces case studies of projects developed at the TDL, that showcase innovation using new knit technologies, new materials and design innovation.

Frances Joseph is Professor of Material Futures in Huri te Ao, the School of Future Environments, and Director of the Textile and Design Lab at Auckland University of Technology. Her research is concerned with design and materiality including areas of intra-active textiles, facture and material ecologies.

The future of design? Burgeoning designers' experience of 'advanced' digital design tools

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Proponents of modern digital design tools have made claims about the roles these tools will play in creating the designs of the future. Many case studies show parts with mass reduction and improved stiffness, and combine this with optimisation for digital manufacture. Such tools depend upon a multitude of mathematical processes, sufficiently complex such that their theoretical analysis would be outside of the scope of a typical undergraduate degree. Much has been made to improve the usability of these tools, creating (in theory) advanced, yet highly useable digital design tools for design and optimisation. It is therefore pertinent to question how successful these tools are, and who they are most useful for.

This study considers the experience of a final-year undergraduate Industrial Design cohort during a digital design and manufacture course. The students were exposed to a structural design challenge using a repeated, iterative design framework allowing them to experience multiple design techniques and manufacturing processes in re-designing a single item. In the first iteration prototypes were created using 'established' subtractive design and manufacturing techniques (culminating in an assembly-based design produced via laser cutting or CNC). In the second iteration, learners re-designed the object for additive manufacture, using structural simulation methods and digital prototyping (culminating in a single-piece design produced via additive manufacture). In the final stage, learners used shape optimisation and 'Generative Design' methods to produce an 'optimised' design outcome (single-piece design produced via additive manufacture).

This oral presentation considers the preliminary findings, which appear to show that the students are capable of driving these tools successfully (presenting designs with more consistent structural performance), yet do so without fully grasping some of the core theories (as evidenced through reflection and exam performance). The outcomes of the study will be used to shape future education within this space, improving the process for future years.

Nick Emerson is a senior lecturer in the School of Product Design, teaching Engineering and Digital Design skills for Product Design students. He is engaged in the integration of engineering science, digital design, analysis, and manufacturing in the product design process and considering their impact on productivity and project outcomes.

Creative STEM pathways: 3D printing and design for Pasifika STEM education

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The advent of affordable 3D printers has precipitated the emergence of the "Maker Movement" where "physical making is the new frontier" and brings with it a "making-based model of education". The maker movement is not just about making things, "it is about developing agency, starting with the physical world, through the use of platforms and technology that make it easier to connect, learn and collaborate." (Deloitte Center for the Edge and Maker Media, 2014).

This has immediate relevance to Māori and Pasifika students and their predisposition to community based and tactile learning. To support these concepts, Master of Design Innovation graduate Lionel Taito-Matamua developed the Creative Pathways Outreach

(CPO) programme and launched it in 2015 at several secondary schools with high Māori/Pacific demographic in the Wellington region. The programme targets innovative approaches to teaching secondary school STEM subjects by linking practical tasks with 3D printing and creative design as a novel and engaging way to explore science, technology, engineering and maths. It has enjoyed considerable success and more than 20 teaching modules have been delivered over four years to six secondary schools as well as a number of community groups.

Recent funding from the Ministry of Pacific People's Toloa Kenese Fund will enable the team to build on these early successes and develop a teaching programme that is contextualised in a parallel educational impact research programme. The two programmes will inform each other and validate the pedagogical framework while allowing an evidence-based exploration of 3D printing and kinaesthetic learning for STEM education and Pasifika students.

Lionel Taito-Matamua is a Master of Design Innovation Graduate, an award-winning social entrepreneur, Awhina Facilitator and Pasifika Engagement Advisor for the VUW Pasifika Student Success Team.

Metamaterials, additive manufacturing and design in mechanical engineering

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Metamaterials are a 21st century development that, much like biological systems, blur the conventional distinction between material and device. They derive their properties from their internal structure or architecture rather than from their composition, enabling them to provide extraordinary mechanical, acoustic, thermal and electromagnetic properties. These unique capabilities interact powerfully with developments in additive manufacturing (AM) to open new horizons in the design of manufactured products.

Furthermore, varying this meso-structure from place to place within an object allows these properties to be spatially modulated, leading to potentially unprecedented functionalities. For example, varying the stiffness matrix through a structure can generate patterns of controlled, directional deformation. The structure becomes a device that internally transforms forces and motions between an input and an output, thus acting as a machine. Such metastructures can act as gearing systems or walking robots, modulate fluid flow or cloak objects from impinging acoustic waves, amongst many other possibilities.

The resulting enormous design and property spaces have a downside, however. Designing metastructures that provide the desired properties or functions becomes a considerable challenge given the dauntingly large number of design variables that are involved. While the design of metamaterials has generally proceeded in a forward fashion, meeting this challenge requires an inverse or generative design approach.

In this paper we identify emerging directions for the generative design of metamaterials and metastructures: machine-learning techniques and evolutionary computation. Evolutionary approaches can explore wide design spaces, outside the bounds of machine learning datasets. However, machine learning models can provide fast predictions and include nonlinear effects such as fracture and impact that are computationally difficult and expensive. We review progress to date and describe some applications, ranging from acoustic neural networks to extreme stiffness and strength. Enabled by progress in AM, these developments will in turn increase demand for AM.

Emilio Calius currently lectures in Mechanical Engineering at AUT where he leads research in the mechanics of metamaterials and metastructures. His previous experience includes spacecraft structures, composites, bio-inspired mechanisms, and smart structures. His present research focuses on non-periodic metamaterials and the applications of AI techniques in design.

Manufacturing related defects in Carbon Fibre Reinforced Plastic structures – where and why they occur, and do they matter?

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Fibre reinforced plastics, and in particular carbon fibre reinforced plastics (CFRP), enable significant improvements in the performance of racing yachts, and larger, higher more performance super yachts to be manufactured. CFRP materials have very high stiffness and strength to weight ratios, and can be constructed layer by layer, orienting the reinforcing fibres in the directions required to optimise structural performance. However, unlike homogenous materials the performance of CFRP structures is very dependent on the manufacturing quality, with any defects having the potential to significantly decrease product performance.

As part of a six-year MBIE Endeavour Research Program, the Centre for Advanced Composite Materials (CACM) and Southern Spars have collaborated closely on the “effect of defects” within high performance CFRP marine structures. A series of undergraduate and postgraduate research projects have addressed the following questions; where do defects come from, where are they, and when do they matter? Manufacturing process parameters influencing defect formation have been studied for two major processing techniques; autoclave consolidation of prepreg laminates and resin infusion. The position and size of defects (including wrinkles, voids) have been quantified using a range of destructive and non-destructive analysis techniques, while their impact on material and part performance have been assessed through detailed numerical simulations and mechanical testing.

An overview of this collaborative program of research will be given, highlighting the different types of student-staff interaction employed between Southern Spars and the CACM. The key technical outcomes will be summarised, some of which are currently being applied through technology demonstrators at the conclusion of the program.

Professor Simon Bickerton is a staff member in Mechanical Engineering at the University of Auckland, with a research focus on the manufacturing and application of polymeric composites. He is currently Director of the Centre for Advanced Composite Materials, and a previous Leader of the MaDE Network.

A cost-effective hybrid approach for the manufacturing of high-performance injection mould inserts using the laser powder-bed fusion process

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Metal additive manufacturing (AM) is a rapidly advancing technology allowing geometrically complex conformal cooling channels to be constructed for injection mould inserts to enhance mould performance. However, high manufacturing costs hinder the technology from being adopted in the mould-making industry. A cost-effective hybrid approach was developed for the laser powder bed fusion (PBF) process in which powder materials get additively deposited onto pre-machined substrates as a practical cost-reduction solution. Study on the bonding of maraging steel powder and wrought commercial-grade tool steels proving the hybrid-metal manufacturing concept is mechanically and metallurgically sound.

In this case study, a broken insert made of beryllium copper by conventional methods from an existing high-volume injection mould was replaced by a high-performance hybrid-steel hybrid-built alternative. The new insert, made of hybrid maraging steel/pre-hardened tool steel and designed with conformal cooling channels, was fabricated using the laser PBF process and finished with conventional mould making methods. In comparison with standard AM build practices, a 55% saving in time was attained with the hybrid-build concept. Results from the moulding test revealed a 62% reduction in cooling time and 27% reduction in overall cycle time, respectively. When considering the running cost of the moulding machine, the additional cost in using AM technology and the cost-saving per part moulding achieved, the cost break-even quantity was 20,000 pieces, an equivalent of 67 hours running time.

The overall result from this study demonstrates how metal AM technology, with the right approach, can be adopted in the plastic injection moulding industry to increase profitability.

Simon Chan is a PhD candidate from the Department of Mechanical Engineering at the University of Auckland and currently working as a R&D Engineer in the CDAM Lab. He has over 25 years of tool design and mould-making experience in New Zealand. His area of research interest is the application of additive manufacturing technology in injection mould fabrication.

Rapid Prototype adoption at Fisher & Paykel Healthcare

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The Rapid Prototype journey for Fisher & Paykel Healthcare started ten years ago with the purchase of a second hand FDM printer and the journey to date has been a roller coaster of successes and significant challenges.

This presentation is intended to capture the F&P RP journey to date and provide some insight into rapid prototyping for geographically isolated New Zealand companies.

The content is intended to share F&Ps collective experiences with:

- Purchase justification of 3D print platforms and technology
- Measuring internal customer values and expectations, and subsequent delivery to their requirements
- Managing workloads from emailed attachments to a dedicated rapid prototyping intranet portal in a rapidly expanding environment
- The pros and cons of supplying machines vs supplying parts to customers / staff
- Managing fast paced adoption of the technology
- Thoughts to consider when purchasing equipment
- The effect Covid has had on our 3D print operation
- Our H&S journey and findings in relation to 3D print materials
- A job description required to run a fast paced print bureau

Andrew Lee is a Toolmaker involved in various Mechanical Engineering industries over the last 40+ years, mostly involved within R&D within NZ and Mining/Hydraulics within Australia. An autodidact by nature; additional education has been in the form of various tertiary level papers in Engineering and Business.

Recycled textile fibre as a performance enhancing roading additive

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All types of textile fibres are resource intensive with high embedded environmental costs from the land, water, energy, and chemicals used in their production. In New Zealand, an estimated 220,000t of waste textiles end up in landfills each year. Employing a systems-wide approach Usedfully and research partners have designed and demonstrated a circular system for unwanted clothing and textiles.

Cellulose is currently imported for use as an additive in asphalt roading mix to stabilise it, reduce drain down and improve the strength of the road. Substituting imported cellulose with cellulose fibres from discarded textiles provides a circular pathway for unwanted textiles. It has the potential to divert 20,000t p/a of textiles from landfill, improve the performance and durability of roads, and reduce greenhouse gas emissions from decomposing textiles.

Usedfully has concentrated on system design, textile collection and recycling systems. Partners; Scion on fibre processing, testing, and material development; WSP Research NZ on roading material development and testing; and Waka Kotahi on road construction and future infrastructure requirements.

The path to commercialisation presents challenges faced by many in innovation, crossing the chasm from lab scale to commercial readiness. This presentation explores an innovation journey in the waste to value (cleantech) sector.

The research has been funded by Waka Kotahi, the Ministry for the Environment’s Waste Minimisation Fund, Ministry of Business, Innovation and Employment Pre-Seed Accelerator Fund and Usedfully.

Deborah Crowe has a BE (Electrical and Electronic) and a Graduate Diploma Design (Fashion). She co-founded mobile SMS company Run The Red which sold to Pushpay. She now applies her strong systems thinking and commercialisation skills in the cleantech sector converting textile waste into scalable industry solutions for New Zealand.

Novel antimicrobial filter media made of electrospun nanofibres protecting against biological or non-biological airborne particles

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In response to the worldwide pandemic, NanoLayr Ltd. focused on the development of functional filter media made of nanofibres that can detoxify itself. Electrospun nanofibre filter media have been successfully functionalised with antimicrobial additives. The different filtration mechanisms of nanofibres are particularly important when it comes to the filtration of viruses (such as COVID-19) and bacteria. Outstanding uniformity of nanofibres is shown by good correlation between pressure drop and basis weight across various test air velocities. Depending on the basis weight, the tested nanofibre filter media can pass the NIOSH 42CFR84 test method for N95 facemasks, for level 2 ASTM F2299 surgical facemasks, and ASTM F3502 test method with level 2 filtration efficiency and level 1 breathability, with level 2 breathability being achievable at lower basis weight. Resistance against different types of bacteria (Escherichia coli and Staphylococcus aureus), macrophage (PhiX174) and human coronavirus such as HKU1 and SARS-CoV-2 (COVID-19) has been demonstrated. An illustration of technical advantage between nanofibres filter media and other facemask competitor will be discussed. NanoLayr will be showcasing its advancements in air filter technology, manufacturing, and testing facilities to multiple international standards, in an effort to provide a NZ supply chain for PPE and pandemic preparedness.

Fabrice Karabulut completed his PhD in Chemistry at the University of Otago, where he investigated molecular catalyst for H2 evolution. In his current position as RD&I Scientist at NanoLayr Ltd. he is developing new functional nanofibers applied in range of application such as air filtration, sound absorption and smart textiles.

Robotic welding in steel fabrication

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Steel fabrication involves constructing structures from steel plates, sheets, and sections. Products are cut, shaped, precisely assembled, and securely connected to build complex-shaped and large products. The final products include buildings, bridges, boats, cranes, and industrial equipment. Items are often produced in small quantities, requiring flexible and adaptable production processes.

To connect metallic parts in a secure and lasting way, welding is a well-established method. Having access to skilled and trained workers has been a crucial aspect of achieving a high-quality outcome. Currently, our industry cannot meet demand for welders. In response, automation is being considered. Universal robotic arms have been used successfully for automated welding in mass production since the 1980s. In the context of steel fabrication, the aforementioned required flexibility is a major hurdle to robotic welding adoption, which necessitates fast robotic programming.

In our efforts to support the productivity of NZ's steel fabrication industry, we have investigated two major developments as they relate to robotic welding, namely cobot welding and offline programming.

Collaborative robots (cobots) can be programmed by manipulating its arm into certain positions. The robot controller can then calculate the movement based on these positions and some basic instructions.

A collaborative robot (cobot) can be programmed by physically manipulating the robot arm into the desired positions. The cobot controller calculates a path for the robot movement based on these positions and some basic instructions. We installed a cobot welder in our Fab 4.0 Lab recently and have begun testing the technology.

Through offline programming, the robot is programmed using computers away from the actual fabrication station. This software uses CAD models to identify locations of welds, set welding parameters, and analyse the movement required. We have implemented offline programming in our Fab 4.0 Lab and assisted our members in integrating it into their operations.

The presentation will report some key learning from this work. The HERA Fab 4.0 lab is open to member companies to trial new technologies.

Holger Heinzel graduated from the University of Stuttgart with a Master's in Mechanical Engineering. He is currently the Industry 4.0 lead at HERA. His research interests are around the productivity of welded steel fabrication, automation and Industry 4.0.

Understanding assumptions in the product development process

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The product development process, simple in theory, lends itself to significant room for error. Errors and things going wrong in the development of a product are part of the process. They are inevitable, and sometimes, unexpected. Sometimes they come at the worst possible times.

A strong product development process, therefore, aims to reduce the number of decision-making errors possible. The industry and the technicality of the development of the product itself do not matter, for the subject matter experts know this, and technical problems can be overcome with technical solutions. But how can we play upon existing knowledge to best reduce the possibility of errors occurring?

A short case study will be presented in regard to the development of a mechanical assembly unit, and what will be highlighted is how assumptions can lead to cascading errors if not properly identified early on in the design process.

The case study focuses on the importance of having a phase in your product development process that allows for the development team to identify, validate, and prove (or disprove) any assumptions before development even begins or during subsequent design reviews.

Sometimes assumptions cannot be validated until a prototype is tested but knowing that an assumption exists, and may be wrong, is a known quantity and can be planned for accordingly. Alternatively, a test can be designed to isolate, and test the assumption. This leads to an inherently more robust decision-making framework.

Abhishek Makker is a product development engineer working at Oasis Engineering. He holds a Master's degree in Mechanical Engineering from the University of Auckland.

National testing register

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The New Zealand Product Accelerator (NZPA) helps connect industry with research expertise, solves industry problems, builds productivity, and supports the transformation of the economy through diversification. They have broad capabilities from practical business skills to technology development and application expertise, as well as deep capability in materials and manufacturing areas. The core NZPA network consists of approximately 30 researchers and practitioners from New Zealand universities and government organisations, who frequently engage with a diverse range of experts in the wider R&D ecosystem on a project-by-project basis.

The NZPA is in the process of updating their directory of advanced testing capabilities and expertise available throughout New Zealand, called the National Testing Register.

This register is a key point of inquiry for companies looking to engage with the research community for their commercial R&D projects, while also benefiting researchers and their laboratories directly through increased visibility of their facilities, services, and equipment. The NZPA publicly hosts this information on their website, which also serves to foster new and strengthen ongoing relationships between companies and researchers.

This brief presentation will outline the desire for increased collaboration within the New Zealand R&D ecosystem as well as the NZPA vision for the register and how it could help facilitate these connections. Several case studies, highlighting how companies have benefited from the register and the information it holds, will also be presented.

Kenneth Ortega is currently undertaking a short-term internship with the New Zealand Product Accelerator and the MacDiarmid Institute. He completed his Doctoral studies at the University of Otago in 2021, working on the synthesis and characterisation of designer surfactants and nanoporous silicate materials.

Beyond woolly jumpers: exploring the additive fabrication capability of digital knitting technology

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Seamless digital knit technology emerged from radical technical innovation in the mid 1990's, enabling the fabrication of 3-dimensional knitted forms in a single machined process. The technology was developed specifically for the knitwear industry and it is largely within this sector that it has been adopted. However, it also has vast potential for advanced textile form and function beyond garment production. Access to and understanding of this potential is constrained by its positioning within the knitwear industry and the garment format of its proprietary design interface. As such, some 25 years later there remains limited recognition of its unique capability as a 3-dimensional textile fabrication tool and uncertainty of its attributes and parameters as an additive manufacturing technique.

This research engaged in a conceptual displacement of Shima Seiki's WholeGarment knit technology, repositioning it for the surface fabrication of 3-dimensional geometries. The research was guided by an architectural form-building approach, using performative operatives in the systematic fabrication of 3-dimensional cubic geometric forms; configurations commonly referenced across domains such as architecture, industrial design and engineering.

Through this process a knitted form-building system was established with fabrication of 3-dimensional cubic artefacts demonstrating previously unrealised capability through easily decipherable objects. The system is further supported by articulation of a cubic form-building domain through textual, symbolic and visual representations, and initial components for a 3-dimensional form library. Tools supporting the translation of 3-dimensional geometries into the knittable surfaces of the technology's 2-dimensional programming grid were also developed.

The research and its findings frame a space of possibility – of what could be – through new ways of approaching knitted form. Additionally, this alternative method of engagement allows seamless knit technology's extensive and complex additive fabrication capabilities to be accessed, understood and further explored by a broader range of practitioners.

3-dimensional knitted geometric form

Jyoti Kalyanji works as a research fellow with the Textile and Design Lab, and a lecturer with the School of Art and Design at AUT University. Her research investigates the potential of 3-dimensional knitted forms in fields such as industrial design, architecture and engineering.

Design and manufacturing process for a passive-flexible flipper for marine turtles

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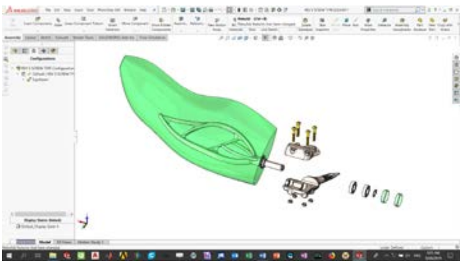
The world is home to seven species of sea turtle with all of them listed under the Endangered species Act. Sea turtles are known as a key stone species, this means if they are to become extinct this will negatively affect the environments in which they live. Huge numbers of sea turtles every year lose their flippers, this is mainly due to human factors such as ghost fishing nets. With only one pectoral flipper sea turtles are unable to nest or defend themselves from predators. This project focuses on this problem with the design, testing and manufacturing of a flipper prosthetic to help sea turtles once again swim normally. We develop swimming kinematics for common sea turtle swimming routines and optimise a flipper geometry and prosthetic assembly to maximise the propulsive performance. The assembly is manufactured using additive manufacturing techniques such as polymer casting and metal 3D printing procedures. Simulation results have been validated with a specially designed and built turtle fin dyno and Sea turtle robot. The design has been approved by The Centre for the Recovery of Wild Fauna in Tenerife Canary Islands as well as the Cairns Sea turtle rehabilitation centre in Australia for clinical trials. The implants are currently being trailed for bio compatibility in reptiles (A world first) as well as animal acceptance.



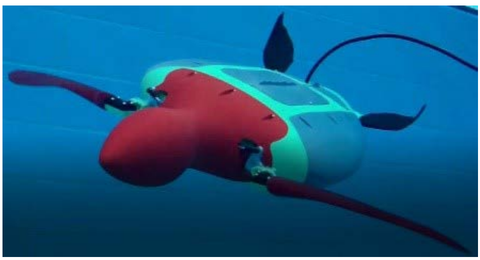


Figure 1 Sea turtle prosthetic (left), Sea turtle robot testing prosthetic (right)

Nick van der Geest is a PhD student in fluid mechanics at Auckland University of technology. Nick recently took 1st place in the Engineering New Zealand GT Murray design and research awards for this project during his undergraduate studies.

Circular manufacturing - business model innovation

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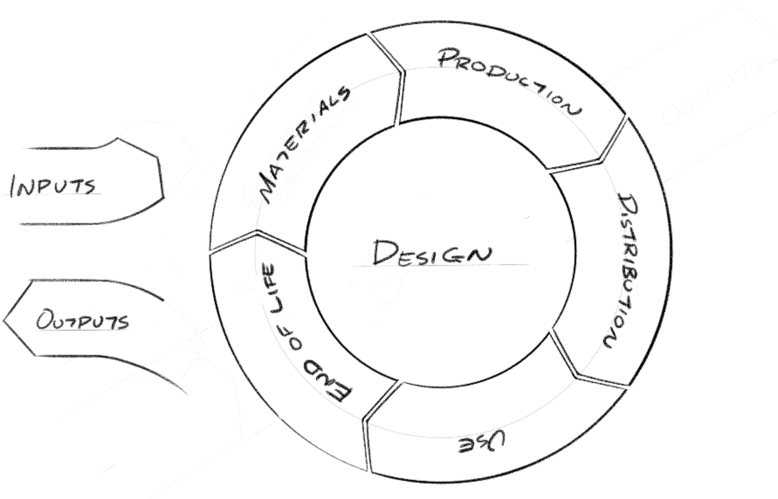
Manufacturing plays a central role in the transition to a circular economy, and yet there is no framework for transforming existing manufacturing business models to circular. Companies willing to become circular have to figure out how to adapt their existing business model or create new ones.

This important challenge presents a plethora of opportunities for innovation. But to make any meaningful impact we need to create a paradigm shift in the way manufactured goods are valued over their useful lifetime.

Talking from a product designer's perspective, I will share some novel ideas for how manufacturing business models can evolve from linear to circular. I'll also show some examples of companies that are already doing it.



Oliver McDermott is a Founding Partner of Blender Design and Board Member of The Designers Institute of New Zealand. Oliver is a national design leader in looking for new and novel ways of designing and developing products and business models that deliver big positive impact.

Designing for a low-emissions circular economy

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The impacts of our traditional take-make-waste economy on the planet have never been more apparent. Designers and engineers have a huge role to play in transitioning us to a circular economy. Eliminating waste, reducing resource consumption, and keeping those we do use in circulation, are critical for success. The biggest impacts can be achieved by designing products, and their packaging, to fit within circular systems. This involves careful consideration of the materials and assembly methods used, considering the full system the products are used and disposed in, and utilising recovered resources to drive circularity. A recycling economy is not a circular economy. To achieve real change, we must go much further than just designing for recyclability. We must understand the true costs of our decisions as we move through development.

This presentation will give you tips on designing for circularity, highlight some of the initiatives that Plastics NZ are undertaking, and how businesses can work with Plastics NZ to help realise a circular economy.

Rachel Barker is CEO of Plastics NZ, the industry association. With a strong technical background in product development, plastics processing and polymers, she has a passion for helping NZ transition to a circular plastics economy. Rachel believes that a collaborative approach, backed by strong science, is absolutely critical for success in this area.

Design for purpose: dematerialising wellbeing through design

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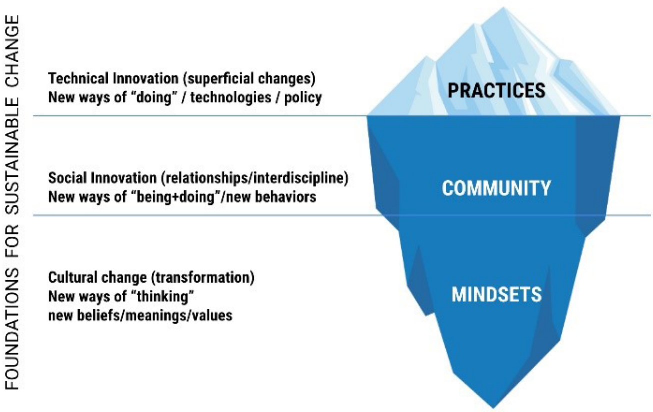
Dematerialization is to use less material, energy, water and land to achieve the same (or better) economic output. Through product and process re-design and Life Cycle Thinking, manufacturers, suppliers and designers are figuring out how to do more with less: use less material, extend the life of materials, use less energy-intensive processes to transform those materials, and utterly question if that material product is the best way to satisfy the need that demanded for it. In its deepest level, the concept of dematerialization leads to lesser consumption, and the consequent decrease in demand for material products.

When most marketable products are not only unnecessary, but materially unsustainable, what is the role of the Industrial designer? The answer to this question requires us to take a long, critical look at the traditional conception of our profession, with no disregard to the ethical consequences at stake.

In a pandemic struck world, environmental and social crisis have reached such depth, that people are seriously questioning the foundational belief that improved wellbeing depends on ever-higher levels of consumption. Design for purpose entails starting with the "why" as the guiding star of any design project, exploring the most genuine levels of collaborative design, shifting power dynamics, listening to communities as they re-define what wellbeing is from a self-determined perspective. Through a systemic approach, every Design for purpose project implies 3 levels of innovation. The technical solutions that focus in the product or service itself, the associate meanings that act at a socio-cultural dimension, and their influence in the mental-models of communities in their definition of wellbeing.



Design for Purpose: 3 levels of intervention for transformational innovation. Baron, G., 2021.

Gabriela Baron, PhD. is a Design academic, currently acting as Deputy Director of the Design Programme at the University of Auckland. She specializes in Design strategy at the intersection between people, their communities and their natural environment. Her methods foster collaborative, interdisciplinary and systemic approaches to addressing complex, global problems.

A design-based approach to upcycling agricultural plastic waste

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A combination of insufficient waste management resources and lack of specific data and local recycling has resulted in the growing severity and accumulation of plastic waste within New Zealand's agricultural industry. Given the crucial role that the agricultural and farming industry has towards the growth of the national economy, this research proposes a design-based system for the use of localised upcycling by exploring how plastic waste, emerging from New Zealand's agricultural sector can be reprocessed and upcycled to form the basis of a closed-looped system. The distributed nature of waste management facilities introduces the potential for 3D printing to offer a novel solution to onsite upcycling.

Initially, this research followed a research 'for' design approach to provide context for the project. This included conducting field research to establish current waste management practices and identified suitable material sourced from an agricultural waste processor specialising in on-farm recycling to be used for the basis of this study. This laid the foundation for the second phase of research using a research 'through' design approach. This included a materials-led investigation that entailed material sorting, granulation and unique filament production. The filament was used for 3D print testing which informed the design process and identification of potential products. This research demonstrates how localised 3D printing can contribute to the upcycling of agricultural plastic waste while demonstrating a successful closed-looped system.

This research uncovered new opportunities through the formulation of unique plastic filament combinations that showcased interesting material qualities and characteristics. The final design artefacts of this research demonstrate the capabilities of the new material ratios, generated from the combination of agricultural materials, for the use of potential industrial applications. These include the application of large-scale 3D printing, and proposed design applications relevant to the agricultural sector and distributed manufacture.

Danielle Patterson is a master's student at Victoria University of Wellington. Studying industrial design, she has focused on design-led practical solutions towards environmental and economic sustainability specifically through active utilisation of additive manufacturing.

Breaking the cycle of nitrate pollution: reduction, recapture and reuse

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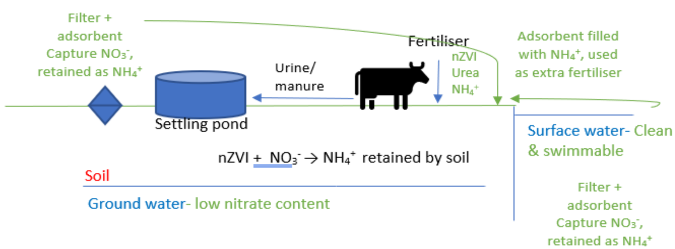
Excess nitrate in drinking and surface water is a major environmental challenge facing New Zealand, according to Ministry for Environment. Nitrate (NO3-) is difficult to remediate as it is a very stable and small planar anion. Capturing nitrate with a suitable membrane is difficult and expensive, and planting riparian strips is not very effective at capturing and containing nitrate. Nitrate forms soluble salts with all cations and cannot be precipitated from nitrate-containing waterways and removed as a solid. In pastoral/farming, aside from a substantial reduction in cattle numbers and the use of wider riparian planting strips which sacrifice productive land, little more is being done to mitigate the problem and nitrate still leaches from the soil to waterways.

Our solution is to address the problem at the source points and to remediate current polluted waterways. In our previous research, we developed a supported nano-zero valent iron (nZVI) composite material which has been shown to reduce nitrate into ammonium ions. Ammonium ions (NH4+), unlike nitrate, can be retained by the soil components and structure via hydrogen bonding. We are currently developing a nitrogen-based fertiliser embedded with nZVI to reduce the amount of ammonium oxidised to nitrate naturally in soil. This will minimise nitrate leaching from soil. Another point source for nitrate is animal urine and manure. We are developing an approach using a nZVI composite filter and adsorbent material to reduce this at source and for re-use as a fertiliser.

The combination of the two approaches will help break the chain of nitrate pollution, decreasing the environmental damage.



Putri Fraser is currently a Research Fellow in Chemistry at Victoria University of Wellington. Her main interest is in developing new methods and application in material science especially in relation to environmental chemistry. Currently, she is working with Prof. Jim Johnston on geothermal silicate, and in paint recycling.

Adding value: upcycling problematic plastic waste through digital craft

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The consequences of plastic pollution abundance and combination of its take, make, and waste practices linger within our environment and landfills, resulting in negative social, economic, and environmental impacts. With the current inadequate waste management infrastructure and without recycling restrictions on different types of plastics, this waste stream becomes complex and problematic. There are existing industry leaders who have successfully closed the loop for recycling certain plastic waste streams in NZ. However, field research revealed that even within such closed looped systems, some residual non-recyclable waste still remains. This research proposes to add new value to this low value and problematic waste in the form of highly crafted artefacts.

This research investigated 3D printed upcycling, and built its sustainable upcycling systems to include more low value and problematic waste streams. The upcycling of plastic waste materials typically follows and includes the process of collecting, cleaning, sorting, melting, granulating, formulating and 3D printing. After undergoing upcycling procedures, material and design experimentation follows to propose different design applications. A shift in perceptions and increased awareness around sustainable consumption and production is required alongside physical and tangible solutions. Bottle cap and sticker label waste are regarded as low value and problematic plastics, and offered a vehicle for this research. Without a market or use, these plastics stockpile and are relegated to the landfill. They are not widely used in real-world applications due to their recycling and processing difficulties. However, this research has demonstrated that the fine-tuning or crafting of both processing, and 3D printing, can make this possible and recover and reincarnate low-value materials like plastic into new valued products.

Jeongbin Ok is director of Industrial Design Programme at Victoria University of Wellington. His research interests span design and technology for sustainability, health and safety through adaptive integration of smart materials, additive manufacturing and digital processes. He is an inventor of more than 20 patented materials and products.

Thermography inspection for undercoating corrosion

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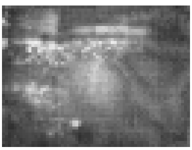
There have been incidents in which corrosion was the cause for catastrophic failure resulting in the loss of life. Visual inspection is almost impossible on coated samples but thermography has been identified as a suitable non-destructive evaluation technique to detect corrosion under coatings. In particular Pulsed Thermography (PT) has been shown to detect corrosion under coatings however requires further development.

In total 48 mild steel plate samples have been cut to size and 18 have been coated with corrosion resistant paint. All samples were left to corrode for three months in three different environments: an accelerated weathering chamber, a saline solution and outside in Hamilton, New Zealand. Samples have been periodically inspected using a PT setup using two camera flashes and an infrared camera. To investigate a known amount of corrosion under the coating, 27 samples were left unpainted with the intention of painting them at different stages of the study.

After five days, a sample from the accelerated weathering chamber (Fig. a) was coated. The coated sample was then inspected using PT (Fig. b). Areas of corrosion were identified as the lighter regions. Post-processing of the data, in particular background subtraction, was shown to have a substantial effect on reducing the noise in the image. To quantify the extent of corrosion the frame of interest was binarized using the Otsu method to determine a threshold (Fig. c). This allowed a percentage of defective to sound area to be found. Perimeter detection was employed on the binarized image and overlaid over the digital camera image of the uncoated sample (Fig. d).

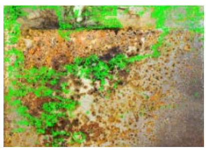
This work progresses thermography as a means of quantifying corrosion under coatings to make an informed assessment and aid in progression monitoring. Furthermore, this approach could be tailored to assess the quality of coating deposition.

(a)



(b)

(c)



(d)

Fig. (a). The uncoated mild steel sample exposed to the accelerated weathering chamber for two weeks (b) the thermographic image of the sample obtained using PT (c) the binarized image using thresholding (d) the perimeter overlaid over the digital camera image

Larissa Kopf is a first year PhD student at the University of Waikato. Her work is centred around improving quality assurance using thermography.

Development of coating-free super water-repellent micropatterned aluminium for spontaneous droplet motion

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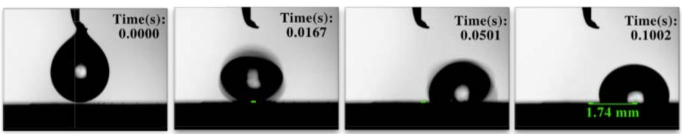
Nature has evolved a number of impressive water management solutions. The well-known example of the super water repellent lotus leaf is well documented and arises from its hierarchical structure: random microscale bumps with superimposed nanoscale hairs. Another important water management feature beyond water repellence is liquid transportation. Examples of even passive transport systems might be found in nature as well. The silk web of some spiders has surface tension gradients due to spindle-knot/joint couplings, resulting in spontaneous motion for sub-millilitre droplets.

Metals usually have hydrophilic behaviour, causing strong adhesion between droplets and the solid surface. The most general way to address this is to coat the surface with chemicals with lower surface energy. We aim to engineer surfaces, inspired by these natural examples using a gradient microstructure on the surface, imitating the lotus leaf's superhydrophobicity and implying the surface tension gradient driven motion via one-step industrial methods, such as, micromilling and laser ablation.

Such all-metal SHPB surfaces promote dropwise condensation over film-wise, improving surface water droplet removal. Such a surface can potentially be used for enhancing heat exchanger surfaces by improving the air-side heat transfer coefficient, and/or promoting delay (or elimination) of ice-/frost-formation under extreme weather conditions, which may be beneficial for wind turbine blades.

We will present a survey of micro/nanofabrication approaches (micro-milling and laser ablation) to produce microstructures with fixed- and variable-pitch, their resultant wetting properties and results which clearly demonstrate passive gradient-driven droplet motion on theoretically designed and micro/nanoengineered, all-metal, hierarchical superhydrophobic gradient surfaces.



Kirill Misiiuk is a PhD-student in the sub-wave optics laboratory of the University of Otago, working in the fields of surface science, microfluidics and thermodynamics.

Rational design of geometry tailored lattices with application in human interfaces

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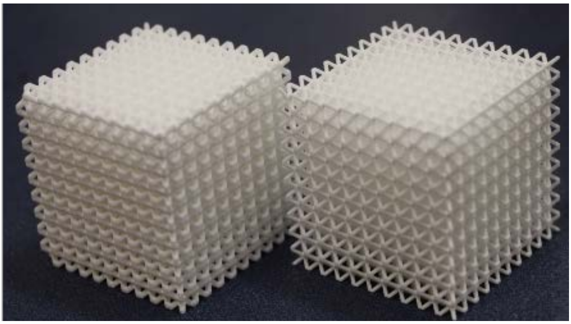
3D printing technology is enabling exciting opportunities to precisely control how and where the material is distributed within geometrically complex objects such as lattice structures. One important potential application of 3D printing technologies is in wearable human interfaces for products such as prosthetics and splints. By tailoring the architecture and geometrical features of the lattice structures with biocompatible and bioresorbable materials it is possible to enhance injury recovery and promote patient adherence in terms of wear duration and frequency. Due to the large number of design parameters, in situations where lattice structure designs must be optimised, the number of experiments required for trial-and-error optimisation is generally impractical. Therefore, computational modelling that enables control and optimisation of geometrical variation prior to 3D printing of filaments is essential to development in this field.

This study is focussed on investigating the physics and compressive behaviour of 3D printed lattice structures, and the development and validation of predictive computational models that enable rational design approaches for their printing. We developed and validated a modelling framework that enables us to tailor the properties and predict the compressive deformation of lattices. Then, a 3D-DIC technique was used to validate the compressive behaviour of 3D-printed lattices under experimental tests (as shown in the below Figure). Our computational models will be utilised to address how geometrical variations within such lattice structures made of bio-based filaments influence their mechanical performance. This will enable the development of exemplar products with tailored-flexibility to provide compatible interfaces and support to the human body surface, for products such as splints, prosthetics and orthotics.



Maedeh Amirpour is a lecturer at the Department of Engineering Science, University of Auckland and holding a Rutherford Fellowship from NZ Royal Society with specialising in optimisation of a range of advanced composite and multi-functional materials, 3D printing of bio-based materials for bio-medical applications and multi-physics computational simulation.

Achieving a good adhesion between dissimilar materials utilising simple surface treatments and environmental-friendly adhesive

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The significance of joining dissimilar materials in the structural frameworks using adhesives is growing in the manufacturing fields due to its superiority in comparison to other joining methods such as welding and fastening. Adhesively bonded joints still required more experimental and analytical results to escalate the level of trust among engineers to be considered for load-bearing components of the structural applications, especially when strength and durability are the main concerns. It is essential to treat the surface of the substrate to achieve good adhesion and select an appropriate adhesive to meet the requirements, both short- and long-term.

Surface treatment influences the surfaces' mechanical and chemical characteristics, such as surface roughness and chemical compositions. In most cases, some expensive and complex surface treatments are required to achieve adequate strength and durability. On the other hand, the usage of toxic materials needs to be minimised. Therefore, the challenge among researchers is to establish an adequate, simple, and cost-effective method of surface treatment promoting a good strength of the bond and provide acceptable durability.

In this presentation, we will discuss the results found in my research project about the effectiveness of selected surface treatments to alter the surface of aluminium alloys. The ability of each surface treatment to change the surface parameters such as surface roughness and surface free energy will be presented. In this study, an aluminium alloy 6061-T6 was treated mechanically, i.e., three different sandpaper grades followed by three different coupling agents after alkaline treatment. For the sake of comparison, the polished surface was taken as a benchmark in this research. Single lap joints were utilised to investigate the influence of selected surface treatments on the strength of adhesively bonded joints utilising environmental-friendly adhesive.

Ardeshir Saniee is a Ph.D. candidate in the Department of Mechanical Engineering at AUT. His research aim is to investigate the influence of surface treatments, on physio-chemical surface characteristics to identify the correlation between different surface characteristics with initial strength as well as durability of the adhesively bonded joints.

Hybrid components: enhancing bonding strength between 3D-printed aluminium substrates and Carbon Fibre Reinforced Plastics

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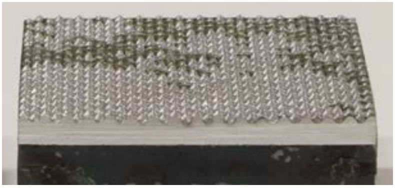
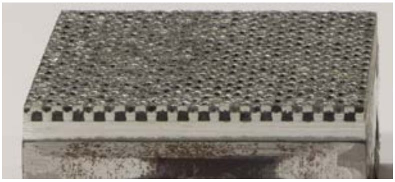
Composite materials are increasingly utilised across multiple industries due to their high strength-to-weight ratios, high stiffness, and corrosion resistance. Increasingly, Carbon Fibre Reinforced Plastics (CFRP) are being utilised as materials within hybrid components, in combination with plastics and metals. Although hybrid components provide a combination of advantages from the constituent materials, there are some challenges for the manufacture of high-quality hybrid components, such as weak interface bonding between constituent materials. Enhancement of interfacial bonding for hybrid laminates has been investigated regarding chemical and mechanical approached to bonding mechanisms.





This research focuses on utilising Additive Manufacturing (AM) technology to control a substrate's surface features to enhance the interfacial bonding, such as 3D-printed surface roughness and porosity. Interfacial bonding between aluminium and CFRP has been improved by controlling these features for flat hybrid plates. Preliminary results from short beam shear and flatwise tensile tests indicate that significant enhancements can be made to shear and normal tensile strength at the aluminium/CFRP interface by adding porosity and patterned surface features.

Hamed Abdoli is a PhD candidate in Mechanical Engineering at the University of Auckland, working on 3D printed hybrid composite components. He has a range of industrial and academic work experience. His research interests are related to manufacturing, testing and machining composite materials.

Application of 3D digital photogrammetry to quantify the surface roughness of milk powder

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The visual appearance of milk powder will vary depending on the manufacturing practice and/or the history of the packed powder. In extreme cases, it causes the customer to question the provenance of the powder. Furthermore, the surface appearance has also been identified as a critical quality attribute because the smoothness affects flowability and handling properties, and most importantly, the customer's perception of the product. However, the standard appearance tests using human sensory panellists are both subjective and time-consuming so, it is desirable to develop a quick, reliable and robust online appearance assessment tool.

This work proposed two strategies for assessing milk powder appearance and relative roughness using photogrammetry and 3D images. The milk powder sample was photographed at multiple angles. These images were then converted to a triangulated surface and subsequently analysed to obtain various geometric measures including surface normals, and contour slices, which are then further processed to quantify the surface roughness of milk powder samples.

One strategy relies on the area of a triangle formed by the three adjacent surface normal vectors of a rough surface. The second strategy uses the shape of the contour from the smooth-surface milk powder cone which is more circular than the shape of the contour for the rough-surface milk powder cone if the milk powder cone is sliced at a given altitude. From the first strategy, 75% area CDF (cumulative density function) values can be used to quantify the surface smoothness, and for the second strategy the energy (the integral of the absolute value of the FFT, a higher number indicates that the product has more large lumpiness) can be used to determine the roughness of milk powder. Therefore, combining, or even applied individually, these two strategies have proved useful in developing a quantifiable metric to characterize the surface appearance of milk powder.

Wei Yu is a senior lecturer at the Chemical and Materials Engineering Department, the University of Auckland, since 2012. His main research interests include digital twin development, data analysis using machine learning technology, process control and modelling.

Fisher & Paykel Healthcare Evora nasal mask- a design journey

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Obstructive Sleep Apnoea (OSA) is a disease that impacts patients with a breadth of implications from daytime sleepiness to increased risk of cardiovascular disease.

Patients face a multitude of barriers, physical and psychological, at the onset of their journey to treating their OSA, with more than one third of patients becoming non-compliant or abandoning treatment. More often than not, it's the mask that can make or break their success.

For the Evora Nasal design team it was essential to understand and meet the needs of patients at every step in the OSA journey – from diagnosis through to ongoing use in the home. Our development teams listened to extensive feedback from our customers and observed patients through multiple usability and clinical trials.
The Evora nasal mask aims to address some of the psychological barriers associated with fitting and wearing a mask through innovative comfort features, improved usability, and colour cues.

At every stage of the product journey the user was at the centre of any decisions made. Initial impressions, education, fitting, cleaning, disassembly and long-term use were an integral part of our design process giving purpose to every detail.

Early customer feedback highlights the simplicity and ease of fitting of the mask- essential characteristics for a product that needs to seamlessly fit into everyday life.

Jordan Kimpton is a Product Development Engineer at Fisher & Paykel Healthcare, where he was part of the team working on the Evora Nasal Mask. He has a Bachelor of Science, majoring in Physiology and a Bachelor of Engineering in Mechanical.

Design optimisation of an intraosseous needle for trauma and emergency medicine

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Intraosseous (IO) access provides access to a patient's venous system through highly vascular bone medullary cavity. When a medical situation arises, for instance, in emergency or trauma medicine, which requires quick administration of antibiotics, it is generally of significant importance that venous access can be rapidly acquired and fluid rapidly delivered to the patient, and this administration process is an alternative route. The benefits to IO transfusion include rapid set up times, fast absorption rates, non-collapsible insertion site and high success rates. IO transfusion has demonstrated success and is widely accepted as a viable alternative to traditional intravenous access. However, IO has significantly lower volume flow rates of fluid into the body. This viscous resistance is caused by the complex internal structures found in bone. This project aims to address this issue by redesigning and optimizing the EZ-IO needle, one of the most used intraosseous needle devices, for improved infusion rates, via the introduction of ports. Experiments were conducted on 8 swine tibias using the 45mm EZ-IO needles to establish an accurate control flow rate. The mean volume flow rate was determined to be 14.34ml/min using an applied pressure of approximately 40KPa. Computational Fluid Dynamics (CFD) analysis was then conducted on the same needle giving a volume flow rate of 4.38ml/min. The same boundary conditions were then used in CFD analysis of the new concepts. The CFD results suggested all the new designs had significantly improved flow rates compared to the control. The maximum volume flow rate determined using CFD of the new concepts was 24.4ml/min.

Lorenzo Garcia is a Lecturer at Auckland University of Technology, with a background in applied physics, mechanical engineering and biomedical engineering. As a BioDesign Engineer, he specialises in musculoskeletal biomechanics, technology transfer, innovation management, and the design of medical and bio-inspired devices.

The use of engineering theory and sensor technologies to develop sports equipment testing techniques

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The growth and acceptance of sports engineering as an academic discipline has been steady since 2000, as sports management, coaches and the athletes acknowledge the performance gains made through the research investigating their sports. This mahi work is based on the principles of kinetics and kinematics and investigates impact forces and their effect on the equipment and ultimately the user. The overarching motivation being based on the ethical imperative to prevent injury and safeguard life.

The projects include the well-known but far from mainstream sport of equestrian polo, where opposing teams of players, mounted on ponies, use wooden mallets to drive a ball past their opposition into a net. To develop new materials for the mallets it is essential that the welfare of both pony and rider is considered, as such, the properties and performance of the traditional materials need to be understood. The other study of contact forces is an investigation of martial arts, this looks at the resultant impact loads on the practitioner during free sparing and breaking objects. The aim being that with a deeper understanding of the forces involved we could inform, equipment manufacturers, players/athletes, coaches/managers, and instructors in ways to reduce injury and improve performance.

In conjunction with standard universal testing instruments, bespoke testing equipment (Fig 1-2) has been designed and built that allows replication of and measurement of both material and dynamic properties during activity.

This presentation provides an overview of the equipment, the testing, the sensors used in measurement, and the subsequent data collection (Fig 3) and analysis methods.

Figure 1: Load testing.

Figure 2: Swing rig.

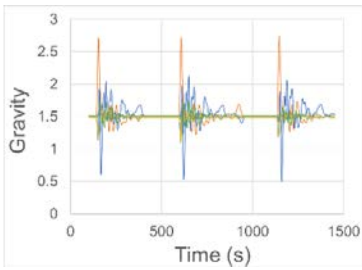

Figure 3: Sensor response signal.

Paul Ewart, Phd (Materials Science), is involved in undergraduate teaching and research for the Centres' of Engineering and Industrial Design, and Post Graduate supervision with the Design Factory, at Waikato Institute of Technology, Te Pukenga. His key interest areas are advanced materials and processes, sports engineering, and transdisciplinary research methods.

Comparison of multidirectional isometric strength for people in a seated position using a simple analytical model and empirical results

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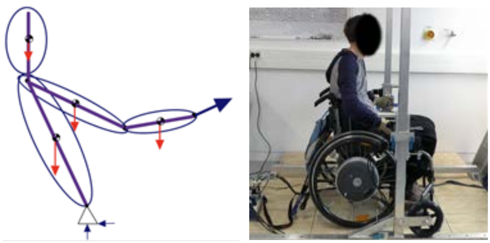
Tetraplegia is a condition that causes a decrease in the sensory and motor function of the torso and all four limbs. The condition is caused by illness or an injury sustained in the cervical region of the spine. In New Zealand, traumatic injuries account for 67% of new spinal cord injuries (SCI). Of these traumatic injuries, cervical injuries causing tetraplegia are the most frequent. Although this population have a reduction in function, they have a strong desire to lead full, active and independent lives where they can complete daily living tasks independently.

Isometric testing is a common method used to evaluate human strength characteristics. Empirical testing using a purpose built test rig has highlighted a clear difference in multidirectional isometric strength patterns for non-disabled participants and participants with C4-C7 tetraplegia in a seated position. This study has developed a simple biomechanical analytical model to enable upper body strength characteristics to be evaluated. The free body diagram and test rig are shown in Figure 1. Static equilibrium equations are used to determine the limiting factors responsible for the difference in strength patterns for non-disabled and SCI participants.



(a) FBD used in model *(b) Test rig used during testing*

Figure 1: Side view of FBD and test rig

Results from this study give insights into the impact factors such as wheelchair setup have on the stability of the user in their wheelchair and the multidirectional isometric force they can produce. This will be useful to for designers to understand the seated strength capabilities of people with tetraplegia and the limits of force they can produce. This knowledge will be useful in the design and configuration of new devices for people with tetraplegia.

George Stilwell is a PhD candidate in the Mechanical Engineering Department at the University of Canterbury. George's research looks at understanding and modelling upper body strength for people with C4-C7 tetraplegia.

Artificial muscles for soft rehabilitation systems: a manufacturing process of twisted and coiled polymers actuators with NiCr resistance wire.

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People with a physical disability with conditions like cerebral palsy, stroke or muscular dystrophies face reduced quality of life due to limited mobility and independence. Rehabilitation robots have the potential to aid people with a physical disability with their movements.

In recent years, artificial Muscle (AM) actuators have been explored to develop small, lightweight, and discrete devices. Examples of AM are shape memory alloys, pneumatic AM and twisted and coiled polymers actuators (TCPs). TCPs are becoming viable for rehabilitation robots due to their high power to weight ratio, linear behaviour, and considerable strain. TCPs are made of inexpensive polymer fibres such as fishing lines.

However, during the fabrication process and to activate TCPs, it is necessary to apply heat. Therefore, as they are made from polymeric fibres, they required an external heating source. The TCPs can be heated by different means, like hot water, hot air or joule heating. Nevertheless, with the first two methods is hard to control their activations. Contrary, joule heating is convenient as heat generates depending on the current applied to a heating element. Joule heating has been employed by using silver-coated fibres. However, this decreases their lifespan since the silver coat begins to oxidize and peel. Hence, a recently introduced method to applied joule heat is to use a TCP with an embedded resistance wire.

This work proposes a manufacturing method to consistently elaborate TCPs with embedded NiCr wires using a semi-automated device that allows the twist and coiled and the annealing processes within the same device. Furthermore, it allows fabricating in a simple manner TCPs of different lengths, made from different sizes of polymers fibres and NiCr wires that are both accessible and inexpensive materials. The elaborated TCPs were able to reach strains of 14% and forces up to 8 N.

Alberto Gonzalez received a bachelor in Electronic Engineering from Instituto Tecnologico de Morelia and a master's degree in Biomedical Engineering from Politecnico di Milano. He is currently a PhD student at Auckland University of Technology, New Zealand. His research interests include wearables, artificial muscles and soft robots applied to rehabilitation.

From benchtop to bedside: a case study on commercialising a medical device

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In the beginning, there was an idea. An orthopaedic surgeon had a problem he wanted to solve and engaged my knowledge as an engineer to solve it. This required lots of ideation, testing, animal studies, more testing, meetings with contract suppliers, capital equipment purchases, fabrication, patenting of IP, and more testing. Naively, as an academic, I thought this was the hard part, or at least the majority of the work. However, this barely the beginning of what would be required to translate this idea from the lab to the market for use in actual patients.

Commercialisation of an idea for a medical device is not for the faint of heart, and it requires a different skill set than what academics, engineers, or clinicians have knowledge or experience in doing. So, this journey began with recruiting mentorship and support for tackling this new frontier. I was able to get support from my university's Research & Innovation commercialisation team, the Centre for Entrepreneurship, and ThincLab, all of whom provided sage advice and options on how to proceed.

The key steps towards a goal of commercialisation were: 1) applying for seed funding to gather evidence the medical device idea was promising, 2) entering translational research competitions to get publicity, 3) forging relationships with potential suppliers and investors, 4) gathering commercialisation information: market validation, freedom-to-operate (FTO) patent analysis, market size, market entry strategy, capitalisation tables, budget needed for next stage, exit strategy for investors, etc and 5) seeking the next round of funding and what types of funding were available in New Zealand, including an understanding of equity stakes.

This presentation will discuss my spinal fusion sensor's commercialisation journey, successes and pitfalls along the way, lessons learned through the process, next steps for this device, and the launch of Munro Medical.

Deborah Munro is a Senior Lecturer at UC. She has spent most of her career in industry, working for NASA Ames Research Centre as a design engineer, then creating robotic dinosaurs for the Jurassic Park Ride at Universal Studios. She has been working in orthopaedic design for twenty years.

From the lab to a pilot plant – a geothermal story

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Silica is the biggest issue facing energy generation from wet geothermal resources. In geothermal reservoirs rocks containing silica dissolve at high temperatures and pressures in water. When the geothermal water is transported above ground and energy is extracted as steam or heat, the silica is supersaturated. Supersaturated silica precipitates to block production equipment and reinjection wells forming a hard, intractable scale. Removal of the scale is costly and requires frequent downtime. Current preventative methods lead to corrosion issues or a loss in efficiency and energy extracted. They also only delay the issue and cannot prevent it.

Nanostructured calcium silicate hydrate (CaSil) is the solution to the silica issue. It forms very rapidly and removes reactive silica from solution. Thereby, more energy can be extracted, and downtime and costs can be prevented. Even better, CaSil is a product that can be used in environmentally beneficial applications. Through these applications and by enabling the extraction of more renewable geothermal energy CaSil offers a unique opportunity to move towards a low carbon economy.

Starting in the 1998, we have developed CaSil. We started with laboratory and field work aimed at producing fine chemicals to be used as fillers and pigments in paper and paints. In 2008 we changed direction towards geothermal applications. This presentation will take you on the journey of realising the geothermal potential of the CaSil technology. Key decision-making steps will be outlined regarding the progress from the laboratory, through field work, a proof of concept plant, a pilot plant to a demonstration plant (in planning).

Thomas Borrmann is a Senior Research Fellow working with CaSil since 1999. He has a broad range of knowledge in chemistry and toxicology that has served him well in the design, building and operation of laboratory, proof-of-concept and pilot plants. He is the science leader of the geothermal CaSil project.

Geothermal well optimisation using an integrated binary process and reservoir model

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Industry 4.0 has been implemented in geothermal drilling, ground power plant production and automation. However, there is little effort to integrate the ground power plant and geothermal reservoir since the simulations/information are conducted separately, with data manually passed between the different simulators. Delays in the modelling process and the inability to efficiently model effects that reservoir changes over the asset's lifetime have on the plant could lead to poor investment decisions and a lack of optimisation. Integrating both reservoir and process simulators would enable accurate prediction of both reservoir and plant issues. A proof of concept demonstrated in this presentation may extend the industry 4.0 to cover an entire geothermal process from the reservoir to the ground power plant. The reservoir simulator AUTOUGH is integrated with the process simulator VMGSim using Python and PyTOUGH. This presentation aims to compare the effects of integrating reservoir and plant models on predictions of reservoir and performance versus conventional, unintegrated approaches, where data are passed manually and infrequently to test plant performance.

Geothermal fluid mass flow, pressure and temperature data are passed between AUTOUGH and VMGSim, where the wellbore and plant are simulated. Brine injection data are passed back to AUTOUGH. The well optimization is done by generating new well hydraulic tables to optimize plant production. The method of optimization is Sequential Quadratic Programming (SQP) using the python package SCIPY. Optimization of plant pressure by well choking allows for a much longer production plateau and delay in drilling additional wells. Optimization of wellheads is required to mimic real-life scenarios to which more accurate resource estimation can be deduced. From the results, a balance of well temperature, pressure and mass flow is required for optimal plant performance, and sometimes more flow is not always better, a result not predicted using the conventional unintegrated approach.

Brent Young is a Professor in Food and Process Systems Engineering at the University of Auckland. He is a Chartered Engineer and Fellow of IChemE and ENZ. Brent's research, teaching and practice focus on digitalisation, modelling, and control applied to the development and optimisation of food and energy process systems.

Better and safer boats and buildings through effective industry-university relationships

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Designing and building high performance composite sailing boats such as the America's Cup and F50 foiling catamarans for the SailGP Grand Prix is challenging and a sector where NZ is world leading - and would like to stay that way. Modern composite material systems also create excellent opportunities for improved building structures – but meeting requirements of consenting processes based on traditional materials can be challenging. Good engagement between industry and universities provides opportunities to address these types of opportunities and challenges but developing and maintaining effective industry-university relationships is not always easy. Key aspects are developing and maintaining long term relationships and each party developing a good understanding of the environment and constraints that each other operates in.

This talk will present case studies of different types of engagement and projects between Core Builders Composites and the Centre for Advanced Composite Materials at the University of Auckland. These examples will be used to show some of the different types of engagement that are possible, how they can be funded and how these benefit the company and the researchers.

Project types include commercial consulting, collaborative R&D projects, student interns and sponsored Masters and PhD postgraduate degrees, with examples including:

Cross-sector projects to investigate building code compliance processes and address flammability performance of composite materials and building panels.

Determining static and fatigue strength of materials and structures such as joints between carbon fibre and titanium wing mast components.

Non-destructive approaches to determine as-built quality and in-service damage monitoring for carbon-fibre composites hydrofoils and rudders.

Investigating through thickness stresses and failure processes for thick composite corners in carbon-fibre composite hydrofoils.

Improving crashworthiness of high-performance sailing yachts to protect crew safety and enable timely and cost-effective repairs.

Mark Battley is an Associate Professor in Engineering Science, Deputy Director at the Centre for Advanced Composite Materials and Associate Dean Research for Engineering at the University of Auckland. His research areas include computational modelling, design and experimental characterisation for advanced materials and structures, particularly for fibre reinforced polymer composites.

NZ Product Accelerator: bringing together NZ to build innovation

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NZ Product Accelerator (NZPA) is a national network of researcher's project directors, commercial enterprises, and NZ partner companies. It drives collaboration by bringing together its research network and partner companies to progress technologies that accelerate product development, create new market opportunities, and grow exports.

NZPA identifies and delivers the "Missing Science/Technology" needed in manufacturing, materials, and design of products for innovative manufacturing companies to enable them to compete and grow their markets. Our purpose is the development of technology platforms for maximum economic benefit to New Zealand. This is achieved using a novel enterprise engagement model based on pull science.

In summary, the NZ Product Accelerator brings together the best science teams from Universities and CRI's available to address the needs of New Zealand enterprises. Our portfolios include Sensing and Automation, Design Innovation, Manufacturing Systems, Materials and Surfaces, Soft-Materials, Bioprocessing and Recycling, and the latest one is Energy and Emissions. We are building technology platforms around our research portfolios based on market needs.

NZPA was allocated baselined funding in the 2019 Government budget under the Industry Futures initiative. In this talk, we will present the model and give examples of collaborative research with New Zealand enterprises.

Harshpreet Singh obtained his Ph.D. in Chemical and Materials Engineering from the University of Auckland. In his current role, Dr. Singh is involved as a Project Director for commercial projects at NZ Product Accelerator to develop innovative technologies for New Zealand businesses.

The journey of innovation – how to implement new innovative technologies in your company

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Implementing new innovative technologies into a business, particularly with additive manufacturing can be particularly challenging. The endeavours start with optimism, positive naivety and sometimes a sense of intimidation, to the task at hand, then often don't start, or get cut short because of challenges along the way.

A first-hand journey will be discussed, as well as experiences starting and running the 3D technologies facility at Auckland City Hospital. During the journey, a number of strategies were developed to overcome several common challenges and to begin the transition to a company culture of innovation and change.

One of the many common challenges encountered is people not realising the potential for new technologies, for instance, having the mindset that 3D printing is just for making toys and trinkets. Knowing how to change these perspectives and opening their minds into the real-world applications is crucial to implementing new technology and innovation within a company. On the other hand, managing expectations for what the technology is capable of and knowing how to explain that just because you can, doesn't mean you should, is a must-have skill that will be used often. Acquiring the required skillset and knowledge for implementing additive manufacturing can be challenging, but is crucial for a project's success.

When starting an initiative, often the biggest challenge will be having limited resources to work with, and it can be difficult to get the ball rolling. New Zealand has the major advantage of Whanaungatanga, the close connection between people and community. This makes networking and collaborating one of our best free resources for innovation. Using this resource effectively was an enabler to get the ball rolling and to begin a journey to transition to a company culture of innovation and change.

Nathaniel McTaggart is a biomedical design engineer at Auckland DHB and is studying part time, pursuing a master's degree in technological futures. He established the in-house 3D technologies facility at Auckland City Hospital in mid-2018, where he creates 3D models for presurgical planning and custom parts for medical equipment.

Titanium thermal protection system for small re-entry vehicles

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The number of miniaturised satellites such as CubeSats has increased more than tenfold in the last 10 years. However, to date not many systems exist to recover these small vehicles or their payloads. The challenge is the severe aerothermodynamic heating during re-entry into the Earth's atmosphere. We propose the concept of a thermal protection system (TPS) based on a combination of a lightweight titanium structure and a protective thermal barrier coating. Titanium is a promising candidate for TPS material due to its low density, low thermal conductivity, and relatively high melting point. However, titanium may not be able to provide adequate thermal protection given the high temperatures >1000 °C encountered during the re-entry of small re-entry vehicles. In addition, titanium is highly reactive above 400 °C, which could cause failure of the TPS. Therefore, it is imperative to use thermal barrier coatings for titanium TPS to take full advantage of this material. In this project, we study titanium sandwich structures with porous cores manufactured by electron beam melting. We use a convective heating device to investigate the relationship between the effective thermal conductivity and the relative density of the sandwich core. Moreover, we examine a common thermal barrier coating, manufactured by atmospheric plasma spray, for its potential use for titanium TPS. The coated samples have been characterised using scanning electron microscope and X-ray diffraction. Based on the results, a TBC encapsulated titanium TPS can be designed.

Philipp Nieke started his PhD at the University of Auckland in November 2019. In his previous role at the University of Bayreuth, Germany, he worked on a novel coating technology. Parallel to his studies, he gained experience at various applied research institutes in the fields of metal foams and high-temperature materials.

Generation of biogas using fixed-dome anaerobic digester for small-scale industrial applications in New Zealand

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Climate change is clearly becoming perceptible by its adverse effects to the environment. New Zealand is an agriculturally focused nation, it has the capacity to

generate a large amount of organic animal and farm waste (e.g., wood, crops, and food waste) to produce renewable energy resources such as, Biogas. Biogas is a sustainable substitute for a range of small-scale industrial applications such as, Natural Gas for cooking, electricity generation and fuels (Biodiesel) for Diesel Engines.

Biogas is generated from Anaerobic Digestion that consists of five stages of organic matter breakdown, disintegration, hydrolysis, acidogenesis, acetogenesis and methanogenesis. The organic waste gets fed to the digester at the disintegration stage, which breaks down organic polymers such as lipids, carbohydrates, and proteins. In the hydrolysis stage, organic polymers from disintegration are hydrolysed (depolymerised) by various enzymes. The carbohydrates, proteins and fats are then converted to their respective monomers such as, sugar, amino acids, and lipids. In acidogenesis, group of microorganisms converts monomers to a mixture of alcohols, volatile fatty acids, and other organic compounds. In acetogenesis, volatile acids produced are transformed to acetic acid, carbon dioxide and hydrogen by a group of acetogenic bacteria. Lastly, methanogenesis stage consists of methanogenic bacteria that munches on the organic matter in a desperate search of oxygen, which breaks down the complex structures to its simplest form, resulting in the formation of Biogas (composed of methane and carbon dioxide).

A single-phase fixed-dome digester is chosen due its cost and ease of maintaining the mesophilic temperatures bands from 25°C to 45°C and pH scale from 5 to 7. The sizing of the digester was computed using the Organic Loading Rate, Hydraulic Retention Time, and Volume of Farm Dairy Effluents formulas. From the calculations, it was found that the digester produces approximately 55% of CH_4 and 45% of CO_2.

Jai Khanna is a Senior Academic Staff Member at the Centre for Engineering and Industrial Design, Wintec Hamilton. He is currently conducting research in the fields of developing innovative cross-disciplinary projects for learners' engagement and enhancing engineering education. Other research areas include material science, manufacturing & design, and Energy Engineering.

(Academic leadership + technical support) × student learning opportunities = research and development to industry

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The Waikato Institute of Technology has been providing engineering courses to the community for almost 100 years. Originating in 1924 as the Hamilton Technical College it was a combined secondary, night, and trade training school. In 1968 the Waikato Technical Institute was established, on the same site, to better meet the needs of employers, and train people with skills to succeed in the workplace. Most recently Wintec has become part of Te Pukenga, the New Zealand Institute of Technology which has merged all Polytechnics, ITPs, and private training organisations across the country. The merger also enables equitable realignment of educational practice on a national scale to meet the mandates of the original partnership between Europeans and the kaitiaki original inhabitants of Aotearoa when they first sought to colonise the country. It also shows the organisations strong commitment to providing technical training needs to the workforce of New Zealand today and tomorrow.

Wintec house (1924)

Wintec Trades and Engineering (2014)

This poster provides an overview of the academic and technical resource provided to todays' diploma, degree, and postgraduate students in support of industry projects across several academic centres. Examples include the use of transdisciplinary design methodologies, advanced materials testing, and manufacturing processes seeking to develop commercial opportunities.

Lauane is on the Master of Applied innovation program with Design Factory NZ. She completed her Bachelor's Degree in Product Design in 2016 at Universidade Estadual Paulista (Unesp, Brazil) after a year of exchange at Politecnica di Milano where she was introduced to Design for All, which generated great interest in developing inclusive designs. Her research focus is currently investigating and evaluating current tools for augmented communication through transdisciplinary research.

Optimisation of sensory factors and environmental performance of food products: A case study of a vegetable-based patty

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In sustainable food production manufacturers must consider the environmental impacts of their products from grower to consumer as well as understanding what influence's consumer's food choices. However, the tools and techniques available for use within the product development process to assess the environmental performance of products are typically not design orientated providing limited decision support during product development. Contrastingly, there are many effective tools and techniques that are used to incorporate consumers' input into a food product, an important one being formulation optimization through sensory analysis, where a product is optimized for sensory performance. This optimisation stage also provides an opportunity to integrate environmental considerations into the product development process by evaluating the relationship between carbon and water footprint and sensory performance.

This research presents the results of a case study of the environmental optimization of an existing plant-based meat alternative product. Environmental consideration (including water and carbon footprinting) has been embedded in the sensory optimization step with the application of Design of Experiments (DoE). The study has provided a new generalizable methodology and experimental design that allows for the integration of environmental considerations into the sensory optimization step that can be applied in the product development process.

Madison Franks is a 4th year student at Massey University completing a Bachelor of Food Technology with Honours, majoring in Food Product Technology. This project corresponds with the 4th year food technology industry project: An original investigation of a food industry problem or opportunity completed under academic supervision.

A flexible monitoring system for machinery health management in Industry 4.0 framework

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Machine and system failures afflict both large and small organizations, leading to unexpected downtimes that eventually result in significant capital and productivity loss. Industry 4.0 has created new opportunities, increasing the ability to collect and analyse data and including "smartness" to provide relevant machine health information to alleviate such losses. This new industrial paradigm takes adoption and integration of advanced technologies like sensors, embedded systems, and networking technologies into existing systems and machines as prerequisites. However, 99% of all businesses in New Zealand (according to OECD), including sole operators and self-employed, comprise of Small and Medium Enterprises (SMEs), which struggle to adopt these technologies due to cost, specialized equipment and knowledge, and difficulty in changing existing plant set-up. Therefore, they are not able to reap the benefit of extensive research work and such new technologies.

To cope with this difficulty that SMEs are experiencing in adopting new industrial changes, this work discusses a smart machinery monitoring system that is easily re-scalable, configurable, and deployable into existing industrial systems or machines, incorporating it in the Industry 4.0 framework. The system facilitates the architecture of distributed sensor nodes that carry out data acquisition and data pre-processing by utilizing edge-devices and computing to extract information that is indicative of monitored machines' health status. In conjunction with this, it also exploits cloud-computing for further data analysis that is computationally intensive, and provides users a convenient remote access to the analytic results. The ultimate objective of our work is to develop a monitoring platform that is flexible such that the monitoring platform can be applied to a variety of machines and still perform with its best competence without needing to change its set-up such as analytic algorithms according to connected machines and available sensorial measurements.

Minjung Kim is pursuing his PhD in the area of condition monitoring and predictive maintenance at the University of Auckland.

Measuring moisture ingress into housings for long-term wireless implantable sensors

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Current packaging choices for implantable devices are limited and usually consist of a welded, titanium canister, because the human body is a harsh environment. Bodily fluids are conductive and contain compounds that are harmful to implanted electronic sensors, so a watertight canister is necessary for long-term implants. However, this prevents their use with wireless applications.

Polymeric canisters, or lids on titanium housings, might overcome this use limitation. A polymer can be injection-moulded and is transparent to electromagnetic waves. This allows for the transmission of wireless signals and/or power to an external device. However, polymers still have some limitations preventing their adoption for long-term applications. Although polymers like liquid crystal polymers (LCP) have low moisture absorption rates, they are never zero, because water molecules can travel from the body through the polymer, increasing the humidity and affecting the operation of the implanted electronics.

Our goal is to modify an LCP polymer to increase its usable lifetime for implanted sensor, so we first needed to understand the rate of moisture ingress into an electronics' housing. To measure this, we conducted tests using titanium housings with clear, acrylic lids. The lids were adhered to the housings using medical grade epoxy (MasterBond EP40Med). Inside the sealed housings, we placed humidity-sensitive paper (cobalt chloride) that changed colour from blue to pink with increasing humidity. We tested in a heated water bath, comparing photos of the colour of the paper for the submerged samples with a control housing that was not submerged. The results showed the humidity levels in the housings did not exceed a predetermined safe threshold of humidity for a period of three months. We have purchased off-the-shelf humidity sensors with digital displays and are now repeating the experiments to correlate the colour shade to an exact humidity level.

Simon Blue is a PhD student conducting biomaterials research with Dr Deborah Munro, Mechanical Engineering Senior Lecturer at the University of Canterbury and the Lead for the Minor in Biomedical Engineering. They are investigating the use of polymers for encapsulating wireless, implantable sensors.

Investigation of condensation-frosting on coating-free topographic wetting gradients for heat transfer surface applications

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Condensation is a common phenomenon across various heating, ventilation, air conditioning (HVAC) systems. Surface coverage by condensation or frost can present a resistance to heat transfer between the surface and the surrounding air, often an integral component of the system's operation. Condensation on hydrophilic surfaces tends to form as a film, and as droplets on hydrophobic surfaces. Dropwise condensation results in greater heat transfer than filmwise, and the energy expenditure resulting from a decreased need to defrost and/or remove condensation from working surfaces reduces among other things, the operational cost of the system. As such, the development of working surfaces with superhydrophobic and anti-frosting qualities has become an area of interest.

In the present work, aluminium surfaces (alloy 5052) are fabricated with coating-free topographical wetting gradient micropatterns, to investigate the microdroplet mechanisms, frost wavefront propagation and condensation heat transfer coefficient, compared to fixed-pitch and polished control (flat) surfaces. Previous work with the gradient surfaces has found that in-plane forces acting on droplets with diameters below the capillary length result in spontaneous droplet motion. It is thought that this will enhance the water management ability of the surface by removing condensation droplets at smaller radii and hindering the propagation of a frost wavefront across the surface. The surfaces can therefore be important for applications such as heat exchanger technology.

We will present the experimental systems for investigating condensation and frost-formation, including parameters such as condensation growth, and the velocity of the ice wavefront on sub-cooled surfaces. We will also present the image processing methodology that allows generation of growth curves which track average droplet radius as a function of time for our various surfaces: polished control aluminium; fixed pitch structures; and gradient pitch structures.

Chris Hughes is currently studying towards a Master of Science (MSc) in Physics at the University of Otago. His current areas of research interest are thermal engineering, micro/nanofabrication, and microfluidics.

Finite Element Analysis methods in spinal fusion

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Although sheep are often used as a first choice for animal studies of the human spine due to their structural similarities, no simulation models of sheep exist for spinal fusion studies. The goal of this research is to produce a computer model that can be used for the estimation of loads and strains within the spine to assist in the design of implants for human spinal procedures. This simulation model's data output will be used with a wireless implantable spine sensor under development by Dr Debbie Munro.

Diagnosis of spinal fusion is typically achieved using x-rays. CT scanning is occasionally employed, but it is expensive and reserved for suspected complications. Research has shown that bone is structurally stiff enough to support physiological loads several weeks before the same bone is mineralised enough to be seen with x-rays. A sensor to monitor changes in spinal stiffness would reduce patient rehabilitation times and improve quality of life. It would also allow practitioners to better predict when fusion has occurred and to know immediately post-surgery if any issues have arisen (e.g., non-union of bone). There is further potential to reduce costs by shortening disability payments and eliminating the need for x-rays.

This research involves building a finite element analysis (FEA) model of the sheep lumbar spine under normal spine loading. This model was obtained by meshing CT scan images and was then revised to include material properties of the various tissues. Muscle and ligament attachments were then added to better represent the sheep spine. Future work includes simulating fusion to show the increase of bone stiffness over time. This work will be correlated with the output from physical testing of the spinal sensor in vitro to provide a complete picture of what is happening in the healing spine following fusion.

Sebastian Jones is a current Master of Engineering Student at the University of Canterbury under the supervision of Dr Debbie Munro. He has interests in biotechnology, medical engineering, and numerous action sports. Previous back injuries have partially inspired Sebastian to take up research into spinal fusion and bone growth.

Multi-axis spin coating on curved surfaces

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Technological advancements experienced throughout the last century have been enabled through continual developments of key manufacturing processes. Spin coating is a common technique that produces thin film layers used to create essential devices such as electronic circuit boards, sensors, displays and data storage disks. The process is ideal for the manufacture of uniform films on the scale of micro or nanometers due to its low-cost and effectiveness. Spin coating involves the deposition of a liquid onto a substrate which is then spun, thereby dispersing the fluid through centrifugal forces. This creates a very thin, uniform film which cures, becoming a solid layer.

One key drawback to this process is the requirement for a flat, rigid substrate, restricting the design of devices to simple, planar geometries. For spin coating to become a viable process for the manufacture of curved, thin films, a system for controlling the fluid flow must be developed to produce a uniform coating. This research investigates the hypothesis that the coating distribution can be controlled through the implementation of optimized motion kinematics of the curved substrate.

A unique system has been developed where a multi-axis rotational manipulator is used to apply complex motion to a curved substrate throughout the coating process. Fluid dynamics models have been used to analyze the optimal control of the substrate and investigate the implications of varying operational parameters such as geometry, material and kinematics. The prototype machine has then been used to validate results through experimental analysis of the thin film manufacturing method.

The manufacturing process developed through this research has significant disruptive potential for coating industries both in New Zealand and overseas. Applications such as rotational molding and consumable packaging would benefit from this technology, where the method of controlling fluid flows over complex surfaces could improve process quality and efficiency.

Finn McIntyre is a mechanical engineering graduate of the University of Canterbury where he is now working towards the completion of a research master's project. He has been involved with a variety of projects where areas of interest have included mechanical design, fluid dynamics, energy systems and controls.

Artificial Intelligence and multi-material 4D printing in physical film design and manufacture

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This research paper focuses on the marriage of Artificial Intelligence (AI) and Multi Material Printing (MMP) in the film industry. This paper proposes the combination of the latest tools in machine learnt design, in particular Contrastive Language–Image Pre-training (CLIP) and MMP through the Stratasys J850 can create never before seen character designs for the physical film industry. This research takes advantage of liquid and air support to create synthetic organisms with efficient manufacture and remarkable on-screen performance. This work will aim to bring into question the potential of AI in artistic practice and its ability to reshape our understanding of iterative design and manufacture within the physical film industry, but perhaps design as a whole.

Figure 5 : Personal CLIP A.I. Experimentation

Traditionally in film character design, an arduous process has been used between director and artist to create the most desirable results, however, there are often subliminal cognitive barriers that surpasses the human mind and it's 'mind's eye'. This thesis proposes the idea that perhaps the best way of achieving compelling film designs is to utilise AI tools and the way organic life uses artificial mechanisms to simulate itself and evolve. To manifest these ideas in a world that is real, multi material printing will serve as the gateway between their digital conceptions and their physical birth. Due to the highly refined abilities of MMP in both voxel and flexible mediums, the Stratasys J850 will help transform the children of the AI system into objects that exert synthetic biological qualities. Furthermore, 3D printing allows for high customisation and rapid production, ideal for the fast-paced film industry. This research seeks to use MMP to advance the argument of physicality in film and its design processes. These tools will aim to aid even the most untrained 'mind's eye' in its creativity.

Figure 2 : Personal 3D render of A.I. generative

Andrew Roberts is studying his Master's of Design Innovation at Victoria University of Wellington. He tutors third year industrial design students in Professor Simon Fraser's Capstone course at the Te Aro Design Campus and previously worked as a 3D artist at Weta Workshop.

The use of 4D printing to produce mycelium ('fungi roots') materials

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An increase in environmental pollution and scarcity of natural resources is encouraging the transition towards materials which promote a circular economy, and away from traditional materials sourced largely from fossil fuels and raw materials.

A potential solution can be found in materials composed of mycelium which can grow on a substrate of low-grade agricultural waste (such as potato skin, coffee grind, just to name a few) to create a material that is biodegradable after use. After a period of growth, the mycelium digests the substrate, and a mycelium-based composite remains with varying mechanical properties depending on substrate, fungal species, and final processing techniques.

Currently, the main fabrication process for mycelium-based composite is moulding. The mould provides the structure in which the substrate is packed into and inoculated with mycelium. The mycelium grows into the substrate, and once the desired shape is achieved, the material is dehydrated to prevent further growth generating a rigid composite.

A less common method for generating mycelium-based composites is via 3D-printing. The application of 3D-printing technologies can allow more complex shapes to be obtained. Additionally, 3D-printing allows for infill pattern control which could potentially have an advantage over using moulds for making mycelium-based composites since this will increase the surface-area ratio and potentially lead to enhanced mycelial growth.

Deane Thomas graduated with a BSc, majoring in biological sciences and statistics at University of Canterbury. She is currently studying a Masters in Product Design focusing on a project that aligns closely with her personal interests and values.

Design, manufacturing and mechanical testing of small-scale wireless charging pads for roadways

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The aim of the research is to develop an improved design and manufacturing methodology for small-scale wireless charging systems for roadways. These systems, which are referred to as 'IPT pads' (inductive power transfer), have the potential to promote the mainstream uptake of electrical vehicles (EV's) by increasing their effective range and reducing their battery size. These systems consist of a coil and ferrite arrangement potted in a thermosetting resin. It is Lid imperative that the mechanical response of these systems under wheel loading is well understood, particularly its ferrite magnetic core, which is a brittle Ferrite ceramic. Consistent and reliable manufacturing is crucial to achieving this goal, however, this proved difficult with the current IPT pad design, shown in Coil Figure 1. A new design (Figure 2) and manufacturing process was created to improve its manufacturability, and thus increase the predictability of ferrite behavior. Casing A finite element model of the improved design was developed and validated through a series of mechanical tests. The validated finite-element model provides a tool for predicting the structural behavior of new designs in the future, as well as larger-scale systems which are difficult to test experimentally.

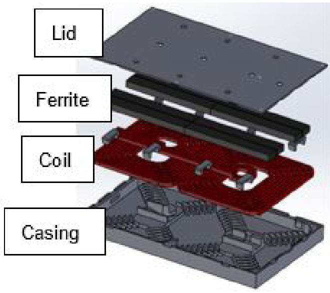

Figure 6: Original IPT pad design. All components potted in one go – hard to control consistency

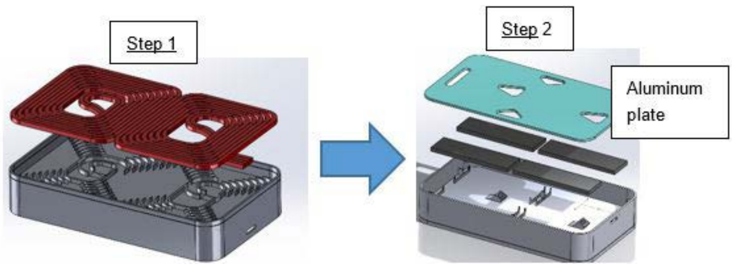

Figure 7: Improved design. Coil and ferrite bars potted in separately, which increased manufacturing reliability and consistency.

Kai-Yeung Li received a Master's degree in Mechanical Engineering in 2018, and is currently pursuing a PhD at the Centre for Advanced Composite Materials at the University of Auckland. His research interests include composite materials, finite-element analysis and structural design.

Concurrent optimisation tools for multi-part composite yacht structures

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Composite racing yachts are tending towards more lightweight and innovative designs. Studies have shown that it would be helpful if the designers of loaded structures could eliminate the pitfalls of contemporary yacht design processes such as self-restriction and convergent design. Designers need to be able to create structurally efficient structures, which means they are both strong and light. Optimisation schemes are agreed upon as the best method for maximising the efficient use of composites in structural design. These materials are often used in complex composite structures such as those employed for the internal structure of high-performance yachts. The sequential nature of their approach still limits current design processes and optimisation schemes. A sequential approach limits a structural response's potential efficiency by prohibiting system-wide optimisation. Components of a structure optimised one after the other cannot reach a system-wide optimum as late-stage optimisations are restricted by those undertaken earlier. This work details the preliminary development of a digital concurrent multi-component optimisation scheme. The tool arranges laminate architecture and structural geometry to maximise plate laminates' strength and stiffness to weight ratios. Concurrent optimisation is achieved using a genetic algorithm, and the Tsai-Wu failure criteria are employed to measure laminate performance.

Tobias Lorimer is a University of Auckland Graduate (2019) with a degree in Mechanical Engineering. Tobias is in is second year of a PhD. focusing on the effects of optmisation approach in carbon fibre structure design and is supervised by Tom Allen and David Wynn.

Creating a living 4D printing platform

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4D printing is often recognised as one of the pillars of the 4th industrial revolution. Current 4D printing techniques allow us to produce a variety of actuators, sensors, self-assembling objects, and shape-memory structures. While these are each great at their own jobs, these abilities are rarely combined into a single object, as it dilutes the effectiveness of each component. To this end we have endeavoured to merge reversible addition-fragmentation chain-transfer (RAFT) polymerisation with 3D printing to create a living 4D printing platform.

Since 2019 we have conducted world-leading research demonstrating the use of visible light RAFT polymerisation in a standard digital light processing (DLP) 3D printer. After printing the structure we are able to use simple photo-catalysed polymerisation techniques to induce an array of different 4D transformations. These include, environmental response, mass and size growth, physical property modification, self-healing, and growth-induced bending. Due to the use of RAFT polymerisation, the transformations are not restricted by the polymer composition, giving us a large amount of freedom to perform multiple transformations on objects of varying composition and properties. Examples of such transformations from our published works can be seen below in figure 1.

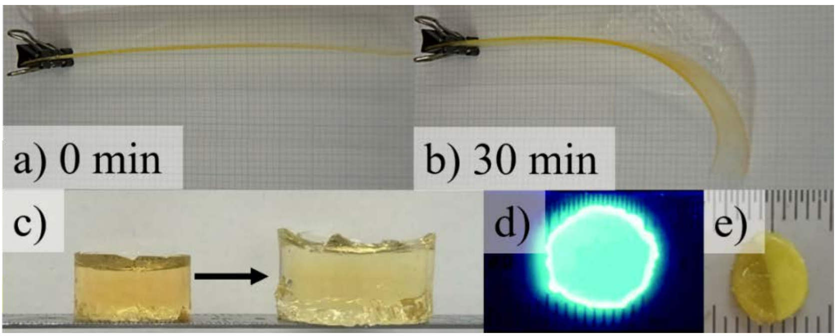

Figure 1. Showcase of different 4D transformations using RAFT polymerisation: (a, b) Growth-induced bending. (c) Mass and size growth. (d) Fluorescence functionalisation, responding to UV light stimulus. (e) Photo-welding.

Chris Bainbridge is a PhD student in the Jin Polymer Chemistry group at UoA, his current research areas are living polymer networks, 4D printing, and advanced laser fabrication techniques such as two-photon polymerisation.

Material and structural tailoring with adaptive bio-based materials and additive manufacturing for enhanced comfort of prosthetics and orthotics

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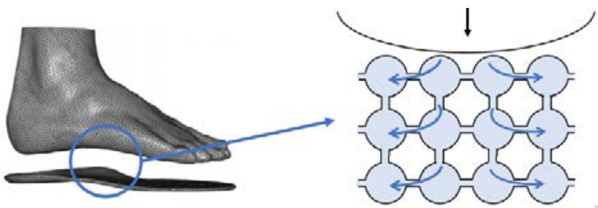
Orthotic insoles are a component in the footwear system that is in direct contact with the plantar surface of the foot. Orthotics assist in treating biomechanical problems or diseases such as diabetes, but conventional manufacturing processes are labour intensive and only provide limited ability to tailor the performance. Additive manufacturing creates the opportunity for more complex design concepts that would not be possible with traditional manufacturing methods.

Conceptually, there are great benefits of developing an insole that has a responsive functionality allowing it to adapt while the wearer is walking and standing. Manufacturing a temporally responsive insole could be achieved with four-dimensional (4D) printing, which is the additive manufacturing of responsive materials to create a responsive structure that adapts when exposed to an external stimulus. In the case of orthotic insoles combining biomaterials, 4D printing provides the opportunity to create a responsive product that can address comfort dynamically.

This project uses multi-physics and multi-scale numerical modelling and static and dynamic experiments to investigate the tailorable responses of a regionally controlled, fluid-impregnated, interconnected cellular structure. This uses a combination of tailored structural stiffness and fluid viscosity to provide a responsive functionality that can redistribute pressure over an irregular topology both statically and dynamically to maximise user comfort. A coupled fluid-structure analysis methodology is described, and results presented demonstrating how the choice of materials, fluid viscosity, and tailoring of the cellular geometry can be used to achieve the required control of pressure distributions and adaptive performance.



Dayna Cracknell is a doctoral candidate in Department of Engineering Science at the University of Auckland. She recently finished her undergraduate degree in Mechanical Engineering and is interested in research that integrates healthcare and additive manufacturing to encourage innovative medical devices.

Post-production mechanical property modification of “living” gels via PET-RAFT

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Controlled Radical Polymerisation (CRP) techniques can be used to create “living” gel networks. Unlike ordinary polymers, these “living” networks have the ability to continue growing in size and mass by inserting new monomers into their polymer chains. By carefully choosing which monomers are inserted, the properties of the “living” network can be tuned in the post-production stage. Our group has previously demonstrated the post-production modification of “living” parent gels into daughter gels with new properties, including enhanced surface energy, temperature-responsiveness and fluorescence.

In this work, we use the CRP technique Photo-Electron Transfer Reversible Addition-Fragmentation chain Transfer (PET-RAFT) to modify the mechanical properties of “living” gel networks. This mechanism depends on special “RAFT agent” active sites in the “living” network where new monomers can be inserted. We demonstrate the effects of RAFT agent symmetry and choice of monomer on the mechanical properties of the daughter network by running compression tests on the gels.

This world-leading research investigates a new frontier of smart materials technology. This study provides valuable information towards the development of 4D printable smart polymers which can be customised and repurposed after printing.

Patrick Imrie is currently working towards his PhD in Chemistry under Dr Jianyong Jin and Prof Olaf Diegel at the University of Auckland, which he expects to complete in 2024. His research is in the field of polymer 4D printing.

Plastic in practice: an empirical approach to 3D printed upcycling in New Zealand schools

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Plastic has become an integral material in our society due to the broad range of applications it can be used for, however, it is having a detrimental effect on our environment. In addition to more efficient waste management systems, a cultural shift through education is fundamental for more effective management of plastic waste. Although the New Zealand National Curriculum currently teaches students about sustainability, the method of teaching remains conventional and does not explore the empirical, tactile learning opportunities that 3D printing provides. This research proposes the application of an education programme which focuses on plastic waste, upcycling and 3D printing in New Zealand intermediate and secondary schools. It explores how tangible learning can engage students more effectively with sustainability and STEAM (science, technology, engineering, arts and maths) subjects. The research consisted of two phases. The first phase involved the development of a 3D printing filament made from upcycled plastic waste. Multiple dairy waste plastics such as milk bottles and yoghurt containers were explored for potential 3D printing applications.

The second phase consisted of participatory research methods, collaborating with students and teachers across three New Zealand schools. An education programme proposal focused on 3D printed upcycling was developed, with goals, values and desired outcomes being identified using the input of students and teachers. The final output of this research consists of an education programme proposal, as well as a series of projects which could be integrated into the programme engaging students with various STEAM subjects. The proposed programme takes a holistic approach in educating students of the various aspects of 3D printed upcycling, from the collection of plastic waste through to the designing and printing of tangible outputs.

Custom cookie cutters.

Modular spinning tops.

Classroom planters.

Maddi Jessop-Benseman is an industrial designer based in Wellington. She has completed both a Bachelors and Master's degree in Design Innovation at Victoria University of Wellington. During her undergraduate study, Maddi was particularly interested in sustainable design, and specifically designing for children with an educational context.

Fast hydrolytically degradable 3d printed object based on aliphatic polycarbonate thiol-yne photoresins

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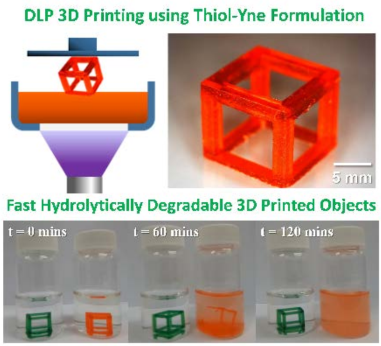
Like the thiol-ene addition reaction, the thiol-yne addition reaction can be initiated thermally and photochemically. The latter route therefore can be utilized for vat photopolymerization-based additive manufacturing (AM). In this work, the following is reported (1) the synthesis of an aliphatic polycarbonate oligomer with a pendant alkyne functional group as a hydrolytically degradable “yne” component; (2) a new thiol-yne photoresin formulation that has been applied in digital light processing (DLP) 405nm 3D printing to print objects with high resolution (50 μm layer thickness); and (3) the successful demonstration of fast hydrolytic degradation of a 3D printed object in aqueous alkaline solution. Therefore, the incorporation of an aliphatic polycarbonate alkyne component and ester thiols in the photoresin formulation is effective for imparting the ability to do fast hydrolytic degradation of 3D printed objects.



Yimei Wu is a 4th-year PhD student in the University of Auckland. She is supervised by Dr. Jin and Professor Simpson. Her research interest is to investigate novel photopolymers for additive manufacturing, including degradable resins, visible-light printable resins, and electrically conductive polymers.

Application of pure titanium coatings for medical purposes

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Titanium is a mature material for medical purposes due to its excellent compatibility with the human body. Furthermore, titanium is extremely resistant to corrosion from body fluids, and is compatible with bone and living tissue. Meanwhile, titanium has a relatively low modulus of elasticity, which reduces the differences in stiffness between the human bone and the implant. This is important to the traditional application of titanium alloys as hip implants and knee joints, but also to bone fracture plates and screws. A good and lasting connection of the implant with the bone tissue is possible when there are sufficient conditions for the bone to grow into the pores of the material. Therefore, the use of a porous implant with titanium coating may be helpful in solving this problem.

In this paper, shrouded plasma spray was used to lower the cost and produced low oxide containing titanium coatings as titanium is a very reactive metal at high temperatures. A solid conical shroud was designed for plasma spray. The titanium powders and coatings were assessed by X-ray diffraction, scanning electron microscopy and optical microscopy. An analysis in microstructure had been carried out, as shown in figure1-3. The results showed that the shroud attachment played an important role in protecting the titanium particles from oxidation in flight during the process of plasma spraying. An enhanced microstructure in the titanium coatings plasma sprayed with the shroud were observed, as indicated in figure 2. The reduction in air entrainment with the shroud resulted in better heating of the particles and increased in deposition efficiency and coating thickness. The dominant phase in the titanium coating with the shroud was α-Ti, as presented in figure 3.

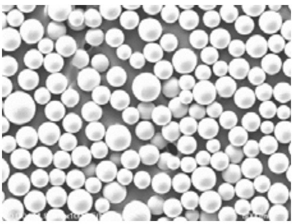

Figure 1:
SEM image of Titanium powder

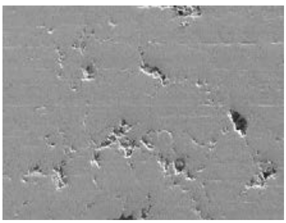

Figure 2:
SEM image of Titanium coating

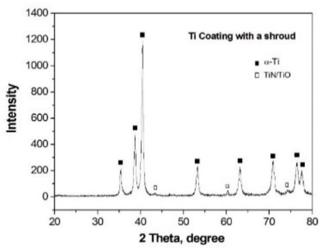

Figure 3:
XRD pattern of the Ti coating

Hong Zhou is a material researcher and a senior academic staff at the centre for engineering and industrial design, Waikato institute of technology. He is also an editorial board member for Sustainability, and a reviewer board member for Coatings. He currently is conducting research in the fields of surface engineering and thermal spray technology.

Remote access and control of PLC lab equipment

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Covid-19 has presented challenges and opportunities for higher education. Blended and online delivery of courses has become increasingly relevant during lockdowns and physical distancing requirements. In many cases, labs and projects have become simulation based, replacing interaction with real physical equipment. This research project investigates the development of a remote lab set up for Wintec's PLC Programming 1 course. The main factors considered for the development are low cost and familiarity (similar set up to the existing classroom environment). Using screensharing software on a remote PC, students can access a lab computer which in turn allows the selection and operation of experiments through a microcontroller thereby enabling them to operate the lab equipment.

The student's remote personal computer gets access to the lab computer using TeamViewer software. All software to perform the practical work are installed in the lab computer. This includes SoMachine software to program and run the PLC, and a Visual Studio Graphical User Interface (GUI) to select and power the experiment hardware. The commands from the GUI are executed with the help of an Arduino microcontroller which makes use of relays to do the task. Part of the GUI also displays a live feed of the hardware via a real-time webcam placed inside the lab.

A prototype system has been successfully constructed and tested to work as required. To improve the effectiveness of the design, the remote system could be modified to accommodate more experiments from other automation related courses. A rotating camera could be purchased instead of a fixed one, allowing the users to view only the selected experiment which will provide a much better viewing angle.

Praneel Chand is a Senior Academic Staff Member in the Centre for Engineering and Industrial Design (CEID) at Wintec. He holds a PhD in Electronics and Computer Systems Engineering from Victoria University of Wellington. Praneel's research focuses on the design and development of electronic and computer systems for control, automation, mechatronics, and robotics problems.

Design of a low-cost soil drying oven

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Soil drying ovens are used by civil engineers to test suitability of ground conditions for roading and construction projects. These ovens are required to meet the industry standard NZS 4402: 1986 – Methods for testing soils for civil engineering purposes. Commercially available ovens can be expensive. Hence, this project investigates the in-house design of a low-cost soil drying oven. The main specifications of the oven required a capacity of 250-500 L, single phase 230 V AC supply, and temperature regulation between 105°C and 110°C with a readable accuracy of 1°C. Major influencing factors included: low-cost, locally available (NZ) parts, and easy assembly and portability.

Engineering students from mechanical and electrical disciplines have worked in two teams to develop solutions. Both teams utilised Arduino microcontrollers to implement PID temperature regulation. The teams had variations in the number of heating elements and temperature sensors used in their designs. Other electrical control features implemented included a setpoint potentiometer, LED indicators and an LCD display. For the mechanical design, the teams utilised an angle iron frame with stainless-steel sheet metal. Glass wool insulation was used between the exterior and interior cavity to increase thermal insulation. Integrated removable trays were designed to house the electrical control system.

The estimated total cost for materials was approximately $900 for one group and $1200 for the other group. The oven has not been fully fabricated yet due to CoVID-19. However, parts of the design have been tested functional in simulations. Future work will include fully constructing the ovens and testing them in the lab.

Praneel Chand is a Senior Academic Staff Member in the Centre for Engineering and Industrial Design (CEID) at Wintec. He holds a PhD in Electronics and Computer Systems Engineering from Victoria University of Wellington. Praneel's research focuses on the design and development of electronic and computer systems for control, automation, mechatronics, and robotics problems.

NOTES:

Presenter Index

The MaDE2022 Conference Committee thanks our partner, sponsors and supporters for acknowledging the significance of this event in our national manufacturing, design and entrepreneurial landscape; and especially for standing by with support throughout the pandemic.

Most importantly, thank you to all delegates for participating in MaDE2022. Following our Closing Proceedings in Great Room 4 at 4.30pm on Wednesday 26 January, please join us for post-event nibbles and networking from 5.00pm.

Also, your post-event feedback is important to us.

Please complete the DELEGATE FEEDBACK form provided and deposit it in the labelled receptacle at the Registration Booth.

Alternatively, online feedback forms will be sent to all registered delegates immediately following MaDE2022.

There is a Lucky Draw Prize of $500.

To be eligible to win you should include your contact details and your feedback must be:

- Submitted by the stated deadline
- Complete and of an acceptable quality

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