MaD
Manufacturing and Design **NZ**

MaD2019: Future-proofing New Zealand's Manufacturing and Design Economy

20-21 May 2019
Cordis, Auckland

MaD2019 is presented by the University of Auckland's IMM Programme and proud to be sponsored and supported by our valued stakeholders

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

Innovative Manufacturing and Materials Programme

PLATINUM

Callaghan Innovation
New Zealand's Innovation Agency

GOLD

Nautech Electronics
specialised manufacturing solutions

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

SILVER

FISHER & PAYKEL

BECKHOFF
New Automation Technology

Fisher & Paykel
HEALTHCARE

BRONZE

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

AUT

GNS SCIENCE
TE PŪ AO

VICTORIA UNIVERSITY WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

SUPPORTERS

scion
FORESTS · PRODUCTS · INNOVATION

ifm

blender

ROCKET LAB

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Revolution Fibres
Extraordinary Nanofibre Ingenious Solutions

APL
WINDOW SOLUTIONS

uniservices
IDEAS TO LIFE

Kreon
The complete 3D scanning solutions

RAM3D

leap australia pty ltd

SEW EURODRIVE

The New Zealand Manufacturing and Design (MaD) Conference Committee and the MaD Driver Team are delighted to welcome you to our third national conference – MaD2019: Future-proofing New Zealand's Manufacturing and Design Economy

This event follows on from the successful and well-received MaD2017 and MaD2018 Conferences. MaD2019 has a focus on growing valuable collaborations between researchers and industry to enable us all to work together towards an expanding and more prosperous future for the New Zealand manufacturing and design sectors.

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.

In addition to fostering a collaborative future for the New Zealand manufacturing and design industry, an important aspect of MaD2019 is to identify strategic future research directions that can underpin ongoing product and process design and development, as well as enable us to work together to grow new knowledge and expertise. Through improving collaboration between Māori, researchers and firms 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.

Some 87 oral presentations, essentially evenly 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 four high-calibre keynote speakers 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 four Panel Discussion sessions, all led by experts in the respective areas, which will cover a selection of relevant and important topics. Please take the opportunity to review and discuss the research work being showcased in each of our ca. 30 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 where postgraduate graduate students will be presenting examples of their manufacturing and design innovations.

On behalf of the MaD2019 Conference Committee and the MaDE Driver Team, we wish to thank our partners, sponsors and supporters for acknowledging the significance of this event in our national manufacturing, design and entrepreneurial landscape. Most importantly, thank you to all delegates for joining us.

Yours sincerely,

Associate Professor Mark Battley *MaD2019 Co-Chair, The University of Auckland*
Professor Jim Johnston *MaD2019 Co-Chair, Victoria University of Wellington*
Professor Olaf Diegel *MaDE Network Leader, The University of Auckland*

Contents

Venue WiFi

Network: Cordis

Username: MAD19

*to log onto wifi please select the network CORDIS, when prompted please enter the access code MAD19. Be aware you may need to reconnect after 24hrs.

MaD2019 is a Programme Highlight event within Techweek19, New Zealand's festival of innovation that's good for the world.
20-26 May Techweek.co.nz

techweek2019 Official Event

Techweek is the world's only nationwide festival of innovation – inspiring and building the capability of all New Zealanders, and showcasing New Zealand as a place where solutions to some of the biggest global challenges are born. Techweek events vary from major conferences to small meetups on niche topics, hackathons, workshops and networking events.

Manufacturing and Design
New Zealand

A MaDE CoRE: Connecting and Powering NZ's MaDE Researchers

From its initiation in 2016 the MaDE Network has connected New Zealand researchers in manufacturing, design and entrepreneurship with each other and with relevant NZ industry. Born from a strategic project of the IMM Programme at the University of Auckland, the MaDE Network is positioning itself to apply for a Centre of Research Excellence (CoRE) in 2019. A CoRE is a multi-institutional collaborative research partnership, building upon research capability in areas of existing excellence, to develop outcomes important to New Zealand's future development.

Why a MaDE CoRE?

Manufacturing is a critical part of New Zealand's economy. We must continue to evolve from a nation relying largely on conventional manufacturing, to one of technological innovators and entrepreneurs to remain competitive in a world undergoing a digital-inspired manufacturing and design revolution. The MaDE CoRE will perform leading-edge, translational research that drives a technologically empowered and sustainable economy, and will educate technology and business savvy students to build it.

MaDE CoRE Vision:

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

Across the participating institutes, industry partners, our manufacturing regions and the Māori economy the MaDE CoRE will carry out world-class research and research-led education on design and manufacture, as well as the innovation processes from idea to commercial reality. Utilising leading expertise in the disciplines of science, engineering, design, business innovation and mātauranga Māori our research programmes will address fundamental science and emerging technologies that create and support industries, while our graduates will obtain broad skills and knowledge for highest impact in industry.

Please make the most of the opportunities at MaD2019 to engage with fellow delegates.

www.mad.org.nz | www.immprogramme.auckland.ac.nz

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

Innovative Manufacturing and Materials Programme

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 and design.

MaD DRIVER TEAM (STEERING COMMITTEE)

- Olaf Diegel, The University of Auckland (Chair)
- Kenneth Husted, The University of Auckland
- Mark Taylor, The University of Auckland
- Simon Bickerton, The University of Auckland
- Claire Reyneke, The University of Auckland (Operations)
- Enrico Haemmerle, AUT
- Mark Dyer, University of Waikato
- Don Cleland, NSC10 & Massey University
- Johan Potgieter, Massey University
- Simon Fraser, Victoria University of Wellington
- Shayne Gooch, University of Canterbury
- Debbie Munro, University of Canterbury
- Conan Fee, University of Canterbury
- Robert Blache, Callaghan Innovation
- Allen Guinbert, Fisher & Paykel
- Catherine Beard, ManufacturingNZ
- Dieter Adam, The Manufacturers' Network

MaD CONFERENCE COMMITTEE

- Mark Battley, The University of Auckland (Co-Chair)
- Jim Johnston, Victoria University of Wellington (Co-Chair)
- Claire Reyneke, The University of Auckland (Operations)
- Stephanie Szmurlo, The University of Auckland (Event Manager)
- Jonathan Stringer, The University of Auckland
- Xun Xu, The University of Auckland
- Marcel Schaefer, AUT
- 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
- Phil Anderson, Callaghan Innovation

Monday 20 May 2019

8:00am	**REGISTRATION OPENS:**
8:45am	**CONFERENCE OPENING:** GREAT ROOM 4
	Mihi, Nic Smith (Dean, Faculty of Engineering, University of Auckland), Vic Crone (CEO, Callaghan Innovation) **Session Chair:** Mark Battley (MaD2019 Co-chair, The University of Auckland)
9:30am	**KEYNOTE SPEAKER:** GREAT ROOM 4
	Göran Roos (Innovation Performance Pty Ltd) **NEW ZEALAND'S MANUFACTURING INTO THE FUTURE** **Session Chair:** Mark Battley (MaD2019 Co-chair, The University of Auckland)
10:00am	**MORNING TEA BREAK:** (GREAT ROOM 1) - SPONSORED BY UNIVERSITY OF CANTERBURY POSTER AND EXHIBITION VIEWING
10:30am	**CONCURRENT CONFERENCE SESSION 1**

GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
INDUSTRY 4.0 **Session Co-chairs: Robert Blache and Yuqian Lu**	**INNOVATIONS IN MANUFACTURING AND DESIGN** **Session Co-chairs: Simon Bickerton and Craig Shannon**	**THE LANDSCAPE OF ADDITIVE MANUFACTURING** **Session Co-chairs: Mike Fry and Tim Miller**
IMPLEMENTING INDUSTRY 4.0: THINK BIG, START SMALL, SCALE FAST - Robert Blache, Callaghan Innovation	**AULANA®: NANOGOLD COLOURED WOOL APPAREL AND BESPOKE RUGS FOR LUXURY MARKETS – A JOURNEY THROUGH DISCOVERY, DEVELOPMENT AND COMMERCIALISATION** - Jim Johnston, Victoria University of Wellington	**CURRENT STATUS AND DEVELOPMENTS IN 3D PRINTING TECHNOLOGIES FOR METAL** - Mike Fry, TiDA Ltd
THE INDUSTRIAL INTERNET OF THINGS FOR SMART FACTORIES - Gerrald Carlo Mateo, National Instruments	**IN-LINE THIN FILM DEPOSITION AND FUNCTIONALISATION OF INDUSTRIAL SURFACES** - Jerome Leveneur, GNS Science	**PRINT-ON PIEZORESISTIVE SENSORS FOR SOFT ACTUATOR CONTROL** - Giffney, Tim, The University of Auckland
INDUSTRY 4.0 HAS AN IDEA FOR NEW ZEALAND – CHALLENGES, OPPORTUNITIES AND CASE STUDIES - Yuqian Lu, The University of Auckland	**FORGET THE PLUG – A MULTI-DISCIPLINARY APPROACH TO WIRELESS CHARGING OF ELECTRIC VEHICLES** - Simon Bickerton, Faculty of Engineering, The University of Auckland	**ACRYLIC ADDITIVE MANUFACTURING** - Sarat Singamneni, Auckland University of Technology
INDUSTRY 4.0 IN ACTION ON THE SHOP FLOOR – A NEW ZEALAND CASE STUDY - Ivo Gorny, Callaghan Innovation	**REZOLUTION™ SUITE OF MINING CHEMICALS FOR SUBTERRANEAN STRATA STABILIZATION & BOLTING** - Hayden Nicholson, Polymer Group Ltd.	**THE ECONOMICS OF ADDITIVE MANUFACTURING IN 10 MINUTES** - Olaf Diegel, The University of Auckland
APPLICATION OF INDUSTRY 4.0 AND DIGITAL TWINS IN PROCESS INDUSTRY - Jan Polzer, The University of Auckland	**NEW SENSOR BASED SOLUTIONS FOR NEXT GENERATION SMART DISTRIBUTION TRANSFORMERS - A CASE STUDY FOR SUCCESSFUL INDUSTRY-UNIVERSITY COLLABORATION** - Arvid Hunze, Robinson Research Institute, Victoria University of Wellington	**3D PRINTING AND DISTRIBUTED UPCYCLING FOR MORE SUSTAINABLE FUTURES** - Simon Fraser, Victoria University of Wellington
HOW FOURTH INDUSTRIAL REVOLUTION THINKING INCREASES BY AN ORDER OF MAGNITUDE THE OVERALL PRODUCTIVITY OF THE FOREST PRODUCTS INDUSTRY - Tony Johnston, Wood Engineering Technology Ltd.	**LADIES SHOES AND DIGITAL TECHNOLOGIES. HELPING TO BRING THE CRAFTSMAN'S TOUCH BACK TO SHOE DESIGN WITH MODERN TECHNIQUES** - Craig Shannon, Globex Engineering	**A DESIGN-SCIENCE COLLABORATION: FREEFORM INTERFACIAL CONNECTIONS** - Tim Miller, Victoria University of Wellington
MANUFACTURER CHALLENGES AND MISCONCEPTIONS AFFECTING INDUSTRY 4.0 ADOPTION IN NEW ZEALAND - Reinaldo Silva, Facteon Global	**SMART IGNITION DEVELOPMENT PROJECT** - Dave Casey, Fisher & Paykel	**CONSISTENTLY ACHIEVING FULL STRENGTH METAL 3D PRINTING PRODUCTION PARTS** - Warwick Downing, RAM3D
CASE STUDIES IN APPLYING AUGMENTED REALITY TO HIGH VALUE MANUFACTURING PROCESSES - Kevin Marett, LEAP Australia	**SYSTEM INTEGRATION FOR A TURN-KEY GAS-SEPARATION TO LIQUID IN A MOBILE SOLUTION** - Jonas Meier, Fabrum Solutions Ltd.	**POWDER-BED FUSION ADDITIVE MANUFACTURING OF DIFFICULT-TO-WELD ALLOYS** - Zhan Chen, Auckland University of Technology

12:30pm	**LUNCH BREAK:** (GREAT ROOM 1) - SPONSORED BY FISHER & PAYKEL HEALTHCARE / POSTER AND EXHIBITION VIEWING
1:30pm	**KEYNOTE SPEAKER:** GREAT ROOM 4
	Fiona Cresswell (General Manager: Marketing Operations, Fisher & Paykel Healthcare) & Melissa Bornholdt (Product Development Manager: OSA Interface Industrial Design, Fisher & Paykel Healthcare) **CARE BY DESIGN** **Session Chair:** Jim Johnston (MaD2019 Co-chair, Victoria University of Wellington)

2:00pm CONCURRENT CONFERENCE SESSION 2

GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
ROBOTICS AND INDUSTRY 4.0 **Session Co-chairs: Marcel Scaefer and Reza Hamzeh**	**ADDITIVE MANUFACTURING APPLICATIONS** **Session Co-chairs: Jonathan Stringer and Yilei Zhang**	**SUSTAINABILITY IN MANUFACTURING** **Session Co-chairs: Florian Graichen and Oliver McDermott**
THE FUTURE OF MANUFACTURING - INDUSTRY 5.0 - Marcel Schaefer, Auckland University of Technology	**REACTIVE INKJET PRINTING: A ROUTE TO MULTIFUNCTIONAL 2D AND 3D PRINTING** - Jonathan Stringer, The University of Auckland	**TRANSITION TO A CIRCULAR BIOECONOMY – A UNIQUE OPPORTUNITY FOR NEW ZEALAND - SCION CASE STUDIES** - Florian Graichen, Scion
ROBOTS WORKING HARDER, STAFF WORKING SMARTER - Andrew Turner, Nautech Electronics Ltd.	**BIOLOGICAL INTER-DEPENDENCIES IN 3D PRINTING: LARVAE SCAFFOLD EXCAVATION OF HIGH FILIGREE CLAY STRUCTURES** - Derek Kawiti, Victoria University of Wellington	**THINK CIRCULAR TO SPARK INNOVATION AND COLLABORATION** - Barbara Nebel, thinkstep
INNOVATING TOWARDS A VIRTUAL POWER PLANT; DISTRIBUTED, SMART AND AFFORDABLE - Eric Pyle, Solarcity	**CUTTING-EDGE DESIGN: MACHINING METAL 3D PRINTED PARTS** - Cameron Mearns, Zenith Tecnica	**WHAT IS TRULY SUSTAINABLE PRODUCT DESIGN?** - Oliver McDermott, Blender Design Ltd.
A TECHNOLOGY SELECTION FRAMEWORK FOR MANUFACTURING INDUSTRIES IN THE CONTEXT OF INDUSTRY 4.0 - Reza Hamzeh, The University of Auckland	**EXPLORATION OF GEOMETRIC AUXETICS: PARAMETRIC COMPUTATION AND ADDITIVE TECHNOLOGY FABRICATION** - Brittany Mark, Victoria University of Wellington	**DEVELOPMENT OF COMPOSITE-BASED PLAYING SURFACE AS REPLACEMENT OF SLATE FOR COMPETITION POOL TABLES** - Shen Hin Lim, University of Waikato
ROBOTICS IN AGRICULTURE – DESIGN AS A CATALYST FOR RESEARCH AND INVESTMENT - Josh Barnett and Mike Duke, University of Waikato	**INFLUENCE OF LAYER THICKNESS SELECTION ON MECHANICAL STRENGTH AND LOADING RESPONSE IN 3D PRINTED ABS POLYMER** - Junior Nomani, Auckland University of Technology	**POWERFUL ANTIMICROBIAL ACTIVITY OF MANUKA HONEY INTO WOOL FIBRE** - Sami Aljohani, Victoria University of Wellington
LEANING IN TO INDUSTRY 4.0 AT TAIT COMMUNICATIONS - Dean Mischewski, Tait Communications	**HIGH SPEED 3D BIOPRINTING OF VASCULAR TUBES** - Yilei Zhang, University of Canterbury	**HIGH PRESSURE GROUND INJECTION FOR SUBTERRANEAN FREE-FORM STRUCTURES** - Tyler Harlen and Derek Kawiti, Victoria University of Wellington

3:30pm **AFTERNOON TEA:** (GREAT ROOM 1) - SPONSORED BY UNIVERSITY OF WAIKATO / POSTER AND EXHIBITION VIEWING

4:00pm CONCURRENT PANEL DISCUSSION SESSION 1

GREAT ROOM 2	GREAT ROOM 4
OPPORTUNITIES FOR INNOVATION IN DIGITAL MaDE **Lead Panellist: Olaf Diegel,** The University of Auckland **Panellists:** Göran Roos (Innovation Performance Pty Ltd), Robert Blache (Callaghan Innovation), Susan Lake (Core Builders Composites), Xun Xu (The University of Auckland)	**TOPIC: FUTURE-PROOFING THE NEXT MaDE GENERATION** **Lead Panellist: Juliet Gerrard,** Prime Minister's Chief Science Advisor **Panellists:** Dieter Adam (The Manufacturers' Network), Jim Johnston (Victoria University of Wellington), Mark Taylor (The University of Auckland), Melissa Bornholdt (Fisher & Paykel Healthcare Ltd)

5:00pm NO ACTIVITY PLANNED

5.30pm **Student Innovation Showcase (Happy Hour) - sponsored by Callaghan Innovation**

6:00pm **Pre-dinner drinks sponsored by Nautech Electronics Ltd.**

7:00pm **CONFERENCE DINNER (GREAT ROOM 4) - SPONSORED BY NAUTECH ELECTRONICS LTD.**
Dinner Welcome: Heather Deacon - GM: Research and Technical Services Operations, Callaghan Innovation
Key Dinner Address: Juliet Gerrard, Prime Minister's Chief Science Advisor

Tuesday 21 May 2019

8:30am	REGISTRATION OPENS		
9am	INTRODUCTION OF DAY: GREAT ROOM 4		
	Session Chair: Jim Johnston (MaD2019 Co-chair, Victoria University of Wellington)		
9:00am	KEYNOTE SPEAKER: GREAT ROOM 4		
	Peter Haythornthwaite (Design Consultant and award winning designer) CREATING AND IMPLEMENTING DESIGNED EXPERIENCES Session Chair: Jim Johnston (MaD2019 Co-chair, Victoria University of Wellington)		
9.45am	MORNING TEA BREAK: (GREAT ROOM 1) - SPONSORED BY UNIVERSITY OF CANTERBURY POSTER AND EXHIBITION VIEWING		
10:30am	CONCURRENT CONFERENCE SESSION 3		
	GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
	INNOVATION IN MANUFACTURING AND DESIGN **Session Co-chairs: Troy Dougherty and Mike Duke**	CASE STUDIES, EXAMPLES AND APPLICATIONS IN MANUFACTURING AND DESIGN **Session Co-chairs: Iain Hosie and Claude Aguergaray**	ENTREPRENEURSHIP AND NEW BUSINESS DEVELOPMENT OPPORTUNITIES OR CASE STUDIES **Session Co-chairs: Paul Woodfield and Dermott McMeel**
	HOW NEW TECHNOLOGIES ARE SHAPING THE INNOVATION LANDSCAPE IN NEW ZEALAND - Adrian Packer, IMS Projects	**NZ'S OPPORTUNITIES IN NANOFIBRE TECHNOLOGY** - Iain Hosie, Revolution Fibres Ltd	**SfTI STRATEGY FOR TRANCHE 2 FUNDING** - Don Cleland, Massey University
	ADVANCED COMPOSITE ADDITIVES IN NEW ZEALAND - Troy Dougherty, Nuenz Ltd	**THE CORE FUNCTION - REFRAMING YOUR PRODUCT SYSTEM** - Tim Allan, Locus Research Ltd	**DIAGRAMS FOR COMMUNICATING STRATEGY IN R&D ORGANISATIONS** - Laurence Gulliver, Fisher & Paykel Healthcare Ltd
	MAXIMISING THE MECHANICAL PERFORMANCE OF FIBRE-POLYMER COMPOSITES VIA A DEVELOPED UNDERSTANDING OF INTERFACIAL ADHESION AND AN ASSOCIATED TEST METHOD - Matilda Hayward, Victoria University of Wellington	**DIAL FEEL AND SENSORY DESIGN** - Fleurine Barre-Debilly, Fisher & Paykel	**SKILLS SHIFT IN MANUFACTURING – A NEW ZEALAND PERSPECTIVE** - Dieter Adam, The Manufacturers' Network
	PURGING SPACE JUNK THROUGH ADVANCED MANUFACTURING AND INNOVATIVE DESIGN - Erwin van Drunen, Rocket Lab	**THE EFFECT OF VACUUM CONDITIONS ON FEATURE QUALITY AND MACHINING EFFICIENCY FOR ULTRAFAST LASER MICROMACHINING** - Simon Ashforth, Faculty of Science, The University of Auckland	**EFFECTUATION BEHAVIOUR OF RESEARCHERS: EVIDENCE FROM A NATIONAL SCALE RESEARCH PROGRAMME** - Paul Woodfield, Auckland University of Technology
	BIO-INSPIRED DESIGN FOR DIGITAL FABRICATION: 3D PRINTED FUNCTIONALLY GRADED STRUCTURES - Maedeh Amirpourmolla, The University of Auckland	**DECORATIVE BLACK COATINGS ON METALLIC SURFACES BY ION BEAM ENGINEERING** - Prasanth Gupta, GNS Science	**AN EXPEDITION THROUGH THE VALLEY OF DEATH** - Greg Storey, Blender Design
	DISCOVERY AND APPLICATION OF THE DICHROIC EFFECT IN CUPROUS OXIDE PARTICLES - Emma Wrigglesworth, Victoria University of Wellington	**COOKING VESSEL TEMPERATURE SENSING** - Chris Green, Fisher & Paykel	**PLATFORM ECONOMIES AND BLOCKCHAIN. EVOLUTION? REVOLUTION? OR DO WE EVEN KNOW WHAT IS GOING ON?** - Dermott McMeel, Faculty of Creative Arts and Industries, The University of Auckland
	IDENTIFYING WINNING PRODUCTS – COMMITTING TO THE RIGHT IDEA - Daniel Faris, Locus Research Ltd	**RETRO-FITTING FOR DATA ACQUISITION AND ANALYTICS** - David Tomzik, The University of Auckland	**DISRUPTIVE PROCESS TECHNOLOGY ADOPTION BY SME MANUFACTURERS: INSIGHTS FROM AUSTRIA, AUSTRALIA AND NEW ZEALAND** - Kenneth Husted, Faculty of Business and Economics, The University of Auckland
	FREE AND OPEN SOURCE SOFTWARE FOR DESIGN AND MANUFACTURING - Jose Egas, University of Canterbury	**DESIGN FOR ART'S SAKE! AN ART-CENTRIC DESIGN PHILOSOPHY** - Angus McGregor, University of Canterbury	**DECISION MAKING PROCESS FOR ADOPTION OF NEW TECHNOLOGY IN MANUFACTURING SMEs** - Mohammad Torkaneh, The University of Auckland
	THE DOUBLE-EDGED NO. 8 WIRE OF NEW ZEALAND DESIGN - Haydn Jack, Blender Design	**OPTIMIZATION OF MULTI-PART PRODUCTION IN ADDITIVE MANUFACTURING FOR REDUCING SUPPORT WASTE** - Jingchao Jiang, The University of Auckland	**BEYOND 'SOFT SKILLS': ARTS AND HUMANITIES IN TECHNOLOGY-DRIVEN ORGANISATIONS** - Stefan Korber, The University of Auckland
12:30pm	LUNCH BREAK (GREAT ROOM 1) - SPONSORED BY BECKHOFF AUTOMATION LTD. POSTER AND EXHIBITION VIEWING		

1:30pm **KEYNOTE SPEAKER:** GREAT ROOM 4

Wendy Kerr (Director, Centre for Innovation and Entrepreneurship, The University of Auckland)
ENTREPRENEURSHIP 4.0
Session Chair: Mark Battley (MaD2019 Co-chair, The University of Auckland)

2:00pm **CONCURRENT CONFERENCE SESSION 4**

GREAT ROOM 2	GREAT ROOM 3	GREAT ROOM 4
3D PRINTING/ADDITIVE MANUFACTURING **Session Co-chairs: Ben Schon and Mike Duke**	**DESIGN, INNOVATION AND COLLABORATION** **Session Co-chairs: Debbie Munro and Paul Ewart**	**MANUFACTURING AND DESIGN FOR BIO APPLICATIONS** **Session Co-chairs: Maziar Ramezani and Lorenzo Garcia**
DEVELOPMENT OF A FIT FOR PURPOSE SYSTEM FOR 3D PRINTING OF FOOD - Ben Schon, Plant and Food Research	**APPLICATION OF NUMERICAL OPTIMISATION TECHNIQUES TO COMPLEX ENGINEERING DESIGN PROBLEMS** - Mark Battley, Faculty of Engineering, The University of Auckland	**BIO-COMPATABILITY OF PROSTHETIC EYES** - Keith Pine, NZ Prosthetic Eye Service
DIGITAL MANUFACTURING FOR IMPROVED BRA FIT - Xuxu Amoozegar-Montero, Victoria University of Wellington	**FUNCTIONAL COATINGS – COLLABORATIVE INNOVATION FOR HIGH-TECH MANUFACTURING** - Joshua Venter, Cirrus Materials Science Ltd	**TRIBOLOGICAL ASSESSMENT OF NANO-SILICA REINFORCED ALGINATE-POLYACRYLAMIDE HYDROGEL COMPOSITE AS ARTIFICIAL CARTILAGE** - Maziar Ramezani, Auckland University of Technology
ASSESSMENT OF BIO-BASED HYDROGEL 3D-PRINTING BY MICRO-EXTRUSION - Mathieu Loste-Berdot, Université Grenoble Alpes	**DESIGN A SQUARE PEG, BUILD A ROUND HOLE—DATA COLLABORATION TRAGEDY AND TRIUMPH** - Simon Hall, Caliber Design	**QUANTITATIVE STRENGTH CONSIDERATIONS FOR THE DESIGN OF DEVICES FOR PEOPLE WITH TETRAPLEGIA IN NEW ZEALAND** - George Stilwell, University of Canterbury
3D PRINTING NICHE NEW ZEALAND PRODUCTS FOR INTERNATIONAL MARKETS – OPPORTUNITIES AND THREATS - Sam Hodder and Mike Duke, University of Waikato	**TRANSLATIONAL RESEARCH & ENTREPRENEURSHIP IN BIOMEDICAL ENGINEERING** - Deborah Munro, Mechanical Engineering, University of Canterbury	**THE COLLABORATIVE APPROACH TO ADDITIVELY MANUFACTURED ARTIFICIAL LIMB PROSTHETICS** - Emily Allison, Callaghan Innovation
COMPLEX PARTS FROM METAL/POLYMER FEEDSTOCKS - Frederic Lecarpentier, Callaghan Innovation	**TECHNOLOGY ROADMAPPING IN NZ'S STEEL INDUSTRY** - Elisabeth Krull, The University of Auckland	**ANOTHER FACET OF BIOMECHANICAL DESIGN** - Lorenzo Garcia, Auckland University of Technology
DEVELOPMENT OF A MODULAR ADDITIVE MANUFACTURING TESTING DEVICE FOR BIOFABRICATION RESEARCH - Juan Schutte, Massey University	**A COMPARISON OF PROCESSING TECHNIQUES FOR PRODUCING PROTOTYPE INJECTION MOULDING INSERTS** - Paul Ewart, Wintec	**RESIDENTIAL AIR QUALITY IMPROVEMENT USING UV LIGHTS** - Mohammad Al-Rawi, Wintec

3:30pm **AFTERNOON TEA:** (GREAT ROOM 1) - SPONSORED BY CALLAGHAN INNOVATION **/ POSTER AND EXHIBITION VIEWING**

4pm **CONCURRENT PANEL DISCUSSION SESSION 2**

GREAT ROOM 2	GREAT ROOM 4
DIVERSITY IN MaDE **Lead Panellist: Debbie Munro,** University of Canterbury **Panellists:** Craig Shannon (Globex Engineering), Derek Kawiti, School of Design (Victoria University of Wellington), Troy Coyle (HERA), Wendy Kerr (Centre for Innovation and Entrepreneurship, The University of Auckland)	**COLLABRATION WITHIN MaDE** **Lead Panellist: Brian McMath,** NZ Product Accelerator **Panellists:** Allen Guinibert (Fisher & Paykel), John Kennedy (GNS Science), Mark Battley (The University of Auckland), Troy Dougherty (Nuenz Ltd), Vic Crone (Callaghan Innovation)

5pm **AWARDS AND CONFERENCE CLOSING -** SPONSORS: AUCKLAND UNISERVICES LTD, CALLAGHAN INNOVATION, MaD2019

5.30pm **POST-CONFERENCE COCKTAILS -** SPONSORED BY MaD2019

Panel Discussions

Panel Discussion Programme

Mon 20 May		
4 – 5pm	1. OPPORTUNITIES FOR INNOVATION IN DIGITAL MaDE	2. FUTURE-PROOFING THE NEXT MaDE GENERATION
Tue 21 May		
4 – 5pm	3. DIVERSITY IN MaDE	4. COLLABORATION WITHIN MaDE

There will be four Panel Discussions split across two one-hour sessions (one on the afternoon of Monday 20 May and the other on the afternoon of Tuesday 21 May). Each Panel Discussion will be led/chaired by an industry representative or a researcher.

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

THE PROCEEDINGS:

- The Lead Panellist is the Chair of the session.
- The Lead Panellist introduces the topic and Panel members. This should not take more than five minutes.
- Panellists introduce their insight into the topic for about three minutes each followed by an open discussion.
- Delegates will be invited to contribute to the discussions from the floor.
- All 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 Lead Panellists or their nominees for presenting succinctly in the Closing Ceremony and in more detail for the post-MaD2019 Conference Report.

Panel Discussion Topics

PANEL 1:

Opportunities for Innovation in Digital MaDE

Monday 20 May, 4:00 – 5:00pm | *Venue: Great Room 2*

LEAD PANELLIST:

Olaf Diegel *(Professor, Mechanical Engineering and Lead, Creative Design and Additive Manufacturing Laboratory, University of Auckland)*

OTHER PANELLISTS:

- **Göran Roos -** (MaD2019 Keynote Speaker; Founder and MD, Innovation Performance Pty Ltd.)
- **Robert Blache -** (Future Insights Manager, Advanced Manufacturing, Callaghan Innovation)
- **Susan Lake -** (Composite Structural Engineer, Core Builders Composites)
- **Xun Xu -** (Professor, Mechanical Engineering, University of Auckland)

Digital Manufacturing, in the wider sense, is about an integrated approach to manufacturing centred around 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. Digital Manufacturing, if applied for good reasons and in a suitable way, promises drastically shortened product development cycles and leads to better and more sustainable products and processes. However, for NZ companies that still rely on antiquated paper based drawings and stand-alone processes, many challenges exist in the 'Why', 'How' and 'When' to engage with digital manufacturing.

This Panel will discuss challenges and opportunities for NZ companies to render manufacturing more digital and will debate the challenges from both a business and an applied research perspective.

PANEL 2:

Future-Proofing the Next MaDE Generation

Monday 20 May, 4:00 – 5:00pm | *Venue: Great Room 4*

LEAD PANELLIST:

Professor Juliet Gerrard *(Prime Minister's Chief Science Advisor)*

OTHER PANELLISTS:

- **Dieter Adam -** (Chief Executive, The Manufacturers' Network)
- **Jim Johnston -** (Professor, School of Chemical and Physical Sciences, Victoria University of Wellington)
- **Mark Taylor -** (Professor, Chemical and Materials Engineering; Director, NZ Product Accelerator, The University of Auckland)
- **Melissa Bornholdt -** (Product Development Manager, OSA Interface Industrial Design, Fisher & Paykel Healthcare)

Our graduates and young innovative engineers, scientists and designers of today are our future for MaDE. Education and training in the respective discipline areas are necessary components. However these need to be coupled with wider graduate education attributes including business knowhow and personnel development. Research and development, innovation, team work, networking and cross-fertilization of ideas, together with harnessing the digital age are also key components in driving forward and achieving success in manufacturing and design businesses. Ongoing research and development identifies and opens up new opportunities, products and markets. University, Crown Research Institute and Industry research collaborations as well as the opportunity to source and secure research funding from both government and industry resources, are essential for positioning and maintaining a manufacturing / design business at the leading edge in the New Zealand and international marketplace. The Panel will variously explore and lead discussion on these aspects.

Panel Discussions continued

PANEL 3:

Diversity in MaDE

Tuesday 21 May, 4:00 – 5:00pm | *Venue: Great Room 2*

LEAD PANELLIST:

Debbie Munro

Senior Lecturer, Biomedical Engineering, University of Canterbury

PANELLISTS:

- **Craig Shannon -** (Mechanical Engineer, Globex Engineering Ltd.)
- **Derek Kawiti -** (Senior Lecturer, Interdisciplinary Digital Design, Victoria University of Wellington)
- **Troy Coyle -** (CEO, HERA – Heavy Engineering Research Association, Auckland)
- **Wendy Kerr -** (Director, Centre for Innovation and Entrepreneurship, The University of Auckland)

Attracting and retaining diverse talent in manufacturing, design and entrepreneurship is an ongoing issue for industry and academia. Being an under-represented person also places additional pressure and unique challenges on the individual. The Panellists will each provide an overview of their background and examples of the challenges they've experienced first-hand before opening an interactive discussion on how we can better support diversity in order to improve our workforce.

PANEL 4:

Collaboration within MaDE

Tuesday 21 May, 4 – 5pm | *Venue: Great Room 4*

LEAD PANELLIST:

Brian McMath

Business Development Manager, NZ Product Accelerator

PANELLISTS:

- **Allen Guinibert - R&D Collaboration Manager, Product Development, Fisher & Paykel**
- **John Kennedy - Principal Scientist and Team Leader, GNS Science**
- **Mark Battley - MaD2019 Co-chair and Associate Dean Research, Faculty of Engineering, The University of Auckland**
- **Troy Dougherty - Chief Technology Officer, Nuenz**
- **Vic Crone – Chief Executive Officer, Callaghan Innovation**

Effective collaboration is critical to achieving relevant and high-quality research and for ensuring effective uptake and implementation of new technologies by industry. The Panellists will discuss their experiences in achieving effective collaboration between researchers, across research organisations and between researchers and industry. The Panel will then open an interactive discussion on how we can facilitate and improve collaboration.

Student Innovation Showcase

Sponsored by Callaghan Innovation
Happy Hour: Let's all talk together – students, industry and academics
Mon 20 May 5.30 – 7pm | 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 MaD2019.

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 MaD2019 and setting up in the designated exhibition area. Exhibits will be on display in the allocated demonstration space only for the session time.

There will be a single BEST Innovation Showcase Prize valued at $1,000 (including $300 cash and 3D printing credits to the value of $700) and three Highly Commended Prizes valued at $300 each (including $75 cash and 3D printing credits to the value of $225). 3D printing will be done at the University of Auckland's Creative Design and Additive Manufacturing Lab. All prizes will be announced during the MaD2019 Closing Ceremony on Tuesday 21 May 2019.

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 MaD2019 Closing Ceremony on Tuesday 21 May 2019.

PRESENTING STUDENTS

Callum	Allen	Victoria University of Wellington	allencall@myvuw.ac.nz
Maedeh	Amirpour	The University of Auckland	m.amirpourmolla@auckland.ac.nz
Josh	Barnett	University of Waikato	joshua.barnett@waikato.ac.nz
Patrick	Domett	Auckland University of Technology	patrickdomett@outlook.com
Jose	Egas	University of Canterbury	josegegas@gmail.com
Zhenan	Feng	The University of Auckland	zfen124@aucklanduni.ac.nz
Yejun	Fu	Victoria University of Wellington	junfyj@gmail.com
Tino	Hermann	The University of Auckland	t.hermann@auckland.ac.nz
Samuel	Hodder	University of Waikato	samuel.hodder@hotmail.com
Mailin	Lemke	Victoria University of Wellington	mailin.lemke@vuw.ac.nz
Vincent	McQueen	Victoria University of Wellington	mcqueenvincent@gmail.com
Hossein	Najaf Zadeh	University of Canterbury	hossein.najafzadeh@pg.canterbury.ac.nz
Maryam	Namini Mianji	Victoria University of Wellington	naminimary@myvuw.ac.nz
Kurt	Schmidt	Auckland University of Technology	kurtschmidt93@gmail.com
David	Tomzik	The University of Auckland	dtom077@aucklanduni.ac.nz
Christy	Wells	Victoria University of Wellington	wellschri1@myvuw.ac.nz
Emma	Wrigglesworth	Victoria University of Wellington	emma.wrigglesworth@vuw.ac.nz

MaD2019 Prizes and Awards

The MaD2019 Conference Committee is pleased to be offering the following awards and prizes which will be presented during the closing proceedings on Tuesday 21 May, 5-5.30pm:

Award/Prize	Sponsor	Value ($)
People's Choice Award Best Oral Presentation	Auckland UniServices Ltd	500.00
Poster Presentation First Prize		500.00
Poster Presentation Second Prize		300.00
Poster Presentation Third Prize		200.00
Student Innovation Showcase First Prize	Callaghan Innovation & The University of Auckland's Creative Design and Additive Manufacturing Lab (3D Printing Credits)	1,000.00 (incl. $300 cash)
Student Innovation Showcase 3x Highly Commended Prizes		300.00 (incl. $75 cash)

Delegate Feedback (Lucky Draw Prize)

Lucky Draw Prize Delegate Feedback	MaD2019 Conference Committee	500.00

Your post-event feedback is important to us.
Online feedback forms will be sent to all registered delegates immediately following MaD2019.
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

Key Presenters

NIC SMITH

Dean, Faculty of Engineering, The University of Auckland

OPENING CEREMONY SPEAKER

BIO

Nic Smith is Professor and Dean of Engineering at the University of Auckland. Before joining Auckland he was the Professor of Computational Physiology at the University of Oxford and Head of Biomedical Engineering at Kings College London. He is a fellow of the New Zealand Royal Society and Engineering New Zealand.

VIC CRONE

CEO, Callaghan Innovation

OPENING CEREMONY SPEAKER

BIO

Vic came on board as Chief Executive with Callaghan Innovation in March 2017. She has significant executive and governance experience in technology and innovation. She brings a strong customer focus, and a track record of leading and implementing strategy, and building organisational culture. Vic was previously the Managing Director of Xero, NZ and New Markets, following executive roles at Chorus and Telecom New Zealand. She has been an Independent Director on the Boards of a number of companies and organisations in the technology sector, including RedShield, Figure.NZ, Creative HQ and the Hi-Tech Trust.

HEATHER DEACON

GM: Research and Technical Services Operations, Callaghan Innovation

GALA DINNER WELCOME

ABBREVIATED BIO

Heather joined Callaghan Innovation in March 2018 as the General Manager of the Research and Technical Services Operations based in Wellington, New Zealand and was formerly the Director of NZ Operations at Airbus. She migrated to New Zealand with her family in 2006 from the UK where she had spent the previous 13 years working on aviation support contracts in the defence industry.

Heather studied Zoology at Liverpool University as an undergraduate and then achieved her Masters Degree from Cranfield University in Bio-Aeronautics. Heather started her career as a Flying Instructor and has worked for multi-national Defence Primes including Babcock, BAE Systems, Leonardo and Airbus.

In NZ, Heather took leadership of Safe Air and led its transformation from an Air NZ company to one owned by Airbus and now rebranded with that name. Heather was an Executive Director on the NZ Defence Industry Association Board until late 2018. She has a passion for innovation and creative thinking that generates novel solutions to meet the rapidly changing environment we all operate within both at work and at home. She is an advocate for a partnered approach working with syndicates or alliances to provide the optimum solutions for all parties but most importantly for the customer.

JULIET GERRARD

Prime Minister's Chief Science Advisor

GALA DINNER SPEAKER

ABBREVIATED BIO

Professor Juliet Gerrard trained at Oxford University, where she completed a First Class Honours degree in Chemistry and a DPhil in Biological Chemistry.

In 1993, she was appointed as a research scientist at Crop & Food Research, and as a Lecturer in Biochemistry at the University of Canterbury in 1998, where she became Professor and Co-Director of the Biomolecular Interaction Centre.

In 2014, she moved to the University of Auckland as a Professor in the School of Biological Sciences and the School of Chemical Sciences and was, until recently, the Associate Dean for Research in the Faculty of Science.

From 2012-2016 she held a Callaghan Innovation Industry and Outreach Fellowship (at 50% FTE) focussed on creating an integrated research programme across Callaghan Innovation and the Universities of Canterbury and Auckland. During this time she also founded a start-up company, Hi-Aspect Ltd, which went on to receive seed funding from a private investor in 2017.

Juliet has over 150 publications, as well as three books. She won a National Teaching Award for Sustained Excellence in Tertiary Teaching in 2004 and has served on FRST panels and domain reviews. She enjoyed her role as Chair of the Cellular, Molecular and Physiological Biology Marsden Panel and Deputy Chair of the Marsden Council prior to being appointed Chair in 2012 overseeing an increase in the fund from around $54 million to over $80 million by 2018. She steered the Marsden Fund Council through the creation of the Fund's first investment plan.

Juliet has had an increasing interest in governance and served on the Board of Directors of Plant & Food Research Ltd from 2013-2018.

KEYNOTE SPEAKER: 9.30 – 10.00AM, MONDAY 20 MAY

GÖRAN ROOS

Professor, Technologist, Author, Businessman, Advisor | Founder & MD: Innovation Performance Australia Pty Ltd

BIO

Göran Roos is a member of the board of the Global Centre for Modern Ageing and of Seeley International Pty Ltd. He is a Visiting Professor at Australian Industrial Transformation Institute, Flinders University; a Stretton Fellow appointed by the City of Playford at University of Adelaide; Visiting Professor at Tongji University, Shanghai; and Adjunct Professor at the Institute of Economics and Management of the Immanuel Kant Baltic Federal University. Göran is a fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) and of the Royal Swedish Academy of Engineering Sciences (IVA).

Göran is the founder or co-founder of several companies in many countries and is presently the Managing Director for Innovation Performance Pty Ltd. He has also worked as a consultant in more than 50 countries as well as having served in management positions in several European and US-based corporations and he has been supporting the Prime Minister's Taskforce on Manufacturing in Australia.

Göran is one of the founders of modern intellectual capital science and a recognised world expert in this field as well as a major contributor to the thinking and practice in the areas of strategy and innovation management as well as industrial and innovation policy.

NEW ZEALAND'S MANUFACTURING INTO THE FUTURE

This keynote presentation will cover the present paradigm shift in how value is created in the economy, the emerging digital and low resource footprint value creation logics, and a quick look at New Zealand's manufacturing industry with some reflections.

Notes

KEYNOTE SPEAKER: 1.30 – 2.00PM, MONDAY 20 MAY

FIONA CRESSWELL

GM: Marketing Operations, Fisher & Paykel Healthcare

BIO

Fiona Cresswell is an experienced B2B technical marketer and inspiring people leader with 18 years' experience in global medical device manufacturing at Fisher & Paykel Healthcare. Throughout this time Fiona has led teams of Clinical, Marketing and Operational professionals through numerous international product launches and transformation projects. Fiona has helped drive the growth of the organisation's sleep apnea business to a turnover of more than NZ$350 million. More recently, Fiona's focus has been on improving the efficiency and collaboration of marketing business-wide and leading a digital transformation of marketing systems, processes and practices.

MELISSA BORNHOLDT

Product Development Manager: OSA Interface Industrial Design, Fisher & Paykel Healthcare

BIO

Melissa Bornholdt is an accomplished Industrial Designer who has worked across the medical, marine and outdoor industries to transform products from undesirable utility to desirable necessity. In the relentless pursuit of emotionally connected design, Mel has worked on light weight kayaks and cost-effective jet boats to world-leading sleep apnea medical devices.

In her most recent role at Fisher & Paykel Healthcare she leads a team of talented Industrial Designers in the creation of multiple design projects. Her philosophy is centered on the user, which in turn drives her relentless pursuit to create and transform sleep apnea treatment into something that patients want, rather than need to use. Mel turns the undesirable into desirable and creates products people ultimately love.

CARE BY DESIGN

Fisher & Paykel Healthcare has always been driven by a single purpose; improving care and outcomes. This purpose isn't just a slogan that we put on the wall, it is something that guides us every day. There is an uncompromising way we do business at F&P. It is with ethics, integrity and care. It's care that is inherent in everything we do – our relationships, our decisions, our daily interactions with each other – at the end of the day it's our philosophy and our story. However, it's not by accident, this culture is intentional.

F&P Healthcare today, improves the lives of around 13 million patients every year and employs 4,200 people across 31 countries. This year we are Celebrating 50 years of business success and are on track to achieve $1B revenue.

Discover insights into how purpose remains at the heart F&P Healthcare and the importance of aligning people, culture, product design and brand.

Notes

KEYNOTE SPEAKER: 9.15 – 9.45AM, TUESDAY 22 MAY

PETER HAYTHORNTHWAITE

Design Consultant and award winning designer

BIO

Following his design education in New Zealand and the United States Peter worked in California and for Henry Dreyfuss Associates, New York. On his return to New Zealand he was a senior lecturer in design for 8 years at the University of Auckland. Between 1979 and 2000 he headed PeterHaythornthwaiteDesign, an internationally recognised design consultancy.

Peter is the recipient of many design awards. His work is included in various design collections including the Museum of Modern Art, and the Cooper-Hewitt. Strongly entrepreneurial Peter has established a number of design-based companies including arti-fakt-s, possibly NZ's first to compete internationally by design. As a partner of Equip he was a co-architect/deliverer of NZ's Better by Design program and the State of Victoria's Design to Business initiative. Peter continues to work as a design consultant to New Zealand and overseas-based companies.

He is an Adjunct-Professor of Design at Victoria University of Wellington, which recognised him with an Hon.D.Sc. He served two terms as President of the Designers Institute of New Zealand. In 2016 he was recognised with an ONZM for services to design.

Creating and implementing designed experiences

Over the past 20 years, people across all disciplines have ventured into design thinking. They have discovered that the way designers think and strategize can bring real value to their businesses. Tackling challenges and problems with a designerly open mind can work to reveal fresh insights and generate better outcomes.

Fundamental to design thinking is placing more attention on end-users and customers. Through applying an iterative, 'what if?' and 'how might we?' approach to observation, role playing, analysis, and so forth their needs, wants and desires can be better revealed. However, converting the mined 'gold' into practical and beautiful solutions, and then into brilliant businesses, often requires capability collaboration that is significantly dependent on design expertise.

Particularly recently, numbers of new organisations have flourished by delivering products and services that connect with the end user in Lego-like delight, ease and logic. What's more many have delivered them urbanely and harmoniously across all touch-points. Their successes go far beyond just designing a handsome 'answer'. They have cannily designed authentic, seamless experiences that consistently win hearts, minds, loyalty and preference. Customers, staff and partners get who they are and want to journey with them.

Markets are brimful with contenders. It's serious work for niche players to gain and sustain traction. Chinese companies are escalating the intensity as they shift from 3rd party makers to brand owners. New Zealand manufacturers and entrepreneurs, regardless of scale or area, must amplify their potential for success. But how? It's not magic, it's common sense: compete differently by fusing, across all end user and customer touch points, what you create, make and deliver with how you behave and communicate into an integrated designed experience. The touchstone of course is gaining the commitment and alignment of the team to achieve this objective. This takes commitment. But how?

Notes

KEYNOTE SPEAKER: 1.30 – 2.00PM, TUESDAY 21 MAY

WENDY KERR

Director, Centre for Innovation and Entrepreneurship, The University of Auckland

BIO

Wendy Kerr is Director of the Centre for Innovation and Entrepreneurship at the University of Auckland, where she aims to grow business savvy, entrepreneurially minded students. In her tenure there she has transformed the Centre, developing programmes and initiatives which have increased participation by 230% since 2015. Now, 5% of the University of Auckland student body are involved in the Centre's innovation and entrepreneurship programmes, including the recently launched incubator and the iconic innovation hub which was opened by the Prime Minister.

Over her career Wendy has been drawn to developing new ventures. An experienced General Manager she has global experience in leading technology and media start-ups with the Financial Times, Pearson and Quicken. In these roles she developed and executed the business strategy to grow successful ventures, and a record breaking tech IPO on the ASX.

For the last decade, while based in London, she has consulted to C-suite leaders of high growth, global technology companies helping them to thrive in challenging times of expansion and change. Long term clients included Expedia, Betfair, Fidessa, and LexisNexis across the UK, US, Europe and Asia.

Wendy is a Board member for the icehouse, an active angel investor, and mentors high potential start-ups. She is also a speaker in demand and a best selling author, having written two books on female led start ups, one of which got to number one on Amazon.

Entrepreneurship 4.0

We've all heard of Industry 4.0, but what does Entrepreneurship 4.0 look like?

This talk will explore the evolution of entrepreneurship and why Entrepreneurship 4.0 is a great model for New Zealand. We'll also examine the key elements of it and identify which are essential for your organisation. This model works very well for student start-ups, and we'll share some exciting examples coming from the University of Auckland.

Notes

OUR TOOLS:

- Tailored innovation advice
- R&D co-funding
- Access to advanced manufacturing and data engineers
- Lean productivity programmes and co-funding including Industry 4.0
- IP strategy and product development programmes
- Experience-base mentoring and advice
- Relevant network connections and collaboration
- Scale-Up NZ online platform

0800 422 552
Callaghaninnovation.govt.nz

CallaghanInnovation

New Zealand's Innovation Agency

We help ensure:

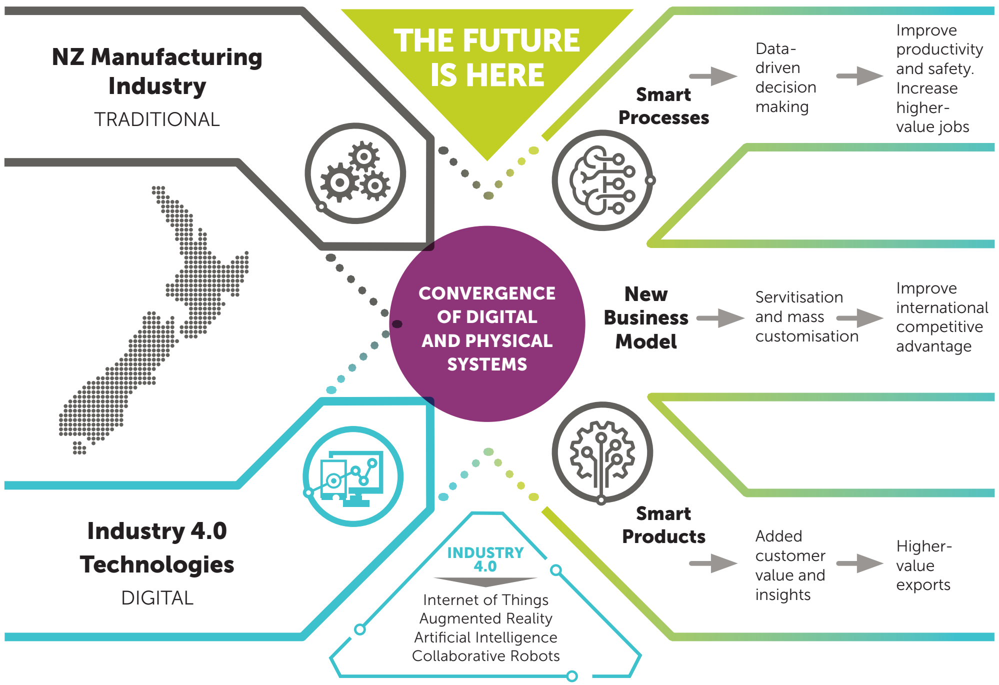
- manufacturers run lean, with accelerated, high-quality product development processes
- companies operate the best business models to exploit their competitive advantage
- businesses develop the most market-driven innovative products and services.

NZ's big challenges:*

- NZ manufacturing sector's productivity gain is only 0.2% between 2005 and 2015 – the worst in the OECD!
- 41% of manufacturers struggle to find skilled tradespeople.

NEW ZEALAND MANUFACTURING – THE BIG FIGURES:*

- **$36BN** IN EXPORTED GOODS
- MORE THAN **50%** OF TOTAL EXPORTS
- **11%** of NZ's workforce **employed in manufacturing**
- **12%** OF **TOTAL GDP**



*MBIE NZ Manufacturing sector report 2018, which includes food and beverage manufacturing.

AMS

Advanced Manufacturing Solutions: Opening our doors to industry

AUT

- Testing, forensics & analysis
- Independent advice & expert opinion
- Design, prototyping & production pilots

= Smart products, next generation processes

For further details, contact Andrew Hilton
andrew.hilton@aut.ac.nz

Engineering at Waikato

- Future-proofed, project-based learning in world-class facilities
- Fully accredited, internationally recognised programmes
- Quality work placements – organised by a dedicated team
- Work with world-renowned researchers and academics

For more information visit **sci.waikato.ac.nz**

SCIENCE & ENGINEERING
TE MĀTAURANGA PŪTAIAO ME TE PŪKAHA

Where the world is going

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

VICTORIA UNIVERSITY OF WELLINGTON IS PROUD TO SUPPORT MaD2019

VICTORIA UNIVERSITY WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

Visit our website to see how we're bringing together design and science to drive high-value manufacturing in New Zealand.

www.victoria.ac.nz/high-value-manufacturing

CAPITAL THINKING. GLOBALLY MINDED.
MAI I TE IHO KI TE PAE

Implementing Industry 4.0: Think big, start small, scale fast

BLACHE, ROBERT (PRESENTING AUTHOR)
Callaghan Innovation
robert.blache@callaghaninnovation.govt.nz

STANTIALL, NATHAN
Callaghan Innovation
nathan.stantiall@callaghaninnovation.govt.nz

ANDERSON, PHIL
Callaghan Innovation
Phil.anderson@callaghaninnovation.govt.nz

The Fourth Industrial Revolution – or Industry 4.0 – is expected to bring about productivity gains and new business opportunities, fuelled by digital technologies. Meanwhile, existing businesses along with their business models are threatened by disruption. Boundaries between industry sectors are likely to disappear, and entire industries might get redefined.

Globally, Manufacturing is at the forefront of this transformation; especially large corporates are embracing the new technologies. However, many smaller businesses, especially SMEs get overwhelmed by the abundance of new digital technologies developing at rapid speed.

When trying to keep up with these changes, businesses are at risk of aiming too high and getting caught in the complexities and unknowns of the new technologies. On the other hand, businesses that start with a simple technology approach may find that it doesn't deliver sufficient business value.

Here, we present a simple framework to combine business model thinking with small technology steps that – if successful – can be scaled quickly.

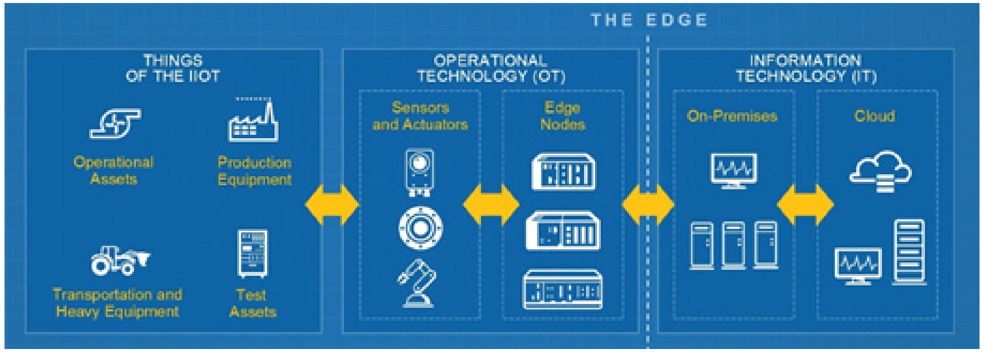
Further, we will showcase how interested businesses can get assistance on their journey towards implementing Industry 4.0.

Robert Blache is Callaghan Innovation's Future Insights Manager for Advanced Manufacturing. He is helping NZ businesses to understand the opportunities and challenges arising from global innovation trends, especially around Industry 4.0 and 3d printing.

The Industrial Internet of Things for Smart Factories

MATEO, GERRALD CARLO (PRESENTING AUTHOR)
Account Manager, National Instruments
gerrald.carlo.mateo@ni.com

The Manufacturing industry is evolving to become smarter and more connected using automation and data exchange, introduced by Industry 4.0. A key technology responsible for this transformation is the Industrial Internet of Things (IIoT) that enables use of data management and communication technologies to distribute decision making and manage quality across the supply chain. In this presentation, hear about the end-to-end solution addressing the three mandates for successfully managing the Internet of Things within the factory; Edge Nodes, Remote Systems Management, Data Management and how these enable transformation of Big Analog Data from the distributed systems into actionable information to make informed decisions. Also hear about how companies like Jaguar Land Rover, China Steel, and Duke Energy have adopted IIoT in fleet-wide deployments to maximize uptime, boost performance, and drive future product innovation.



Gerrald has extensive experience working with engineers and scientists for more than 7 years on a wide variety of industrial, academic and research applications. Currently based out of Melbourne as an Account Manager, he focused on building long-term partnerships with key industry, academic, and research institutions in Melbourne & Auckland.

Industry 4.0 has an idea for New Zealand – Challenges, opportunities and case studies

LU, YUQIAN (PRESENTING AUTHOR)
Department of Mechanical Engineering, The University of Auckland
yuqian.lu@auckland.ac.nz

Business competitions are becoming fierce than ever as we enter the ear of 4th Industrial Revolution (Industry 4.0) when advanced technologies are becoming ubiquitous. Companies today need to figure out how to stay competitive in the market via rapid technology innovation. This is particularly pressing for New Zealand businesses, who used to sustain via offering innovative products and services to targeted niche markets.

While New Zealand government agencies and companies start to embrace the vision of Industry 4.0, Industry 4.0 to many local companies remains a buzzy world. There are substantial challenges in understanding the benefits and implementation pathways of Industry 4.0.

The presentation will cover the business challenges that NZ companies are facing in the era of Industry 4.0, the opportunities and business strategies to move forward. Real examples of business transformation from local high-tech companies enabled by Industry 4.0 technologies will be discussed. The author will also summarise the learnings and recommendations gained from helping local businesses to transit towards Industry 4.0.

Yuqian Lu is a Lecturer at The University of Auckland. Before this, he worked with Compac Sorting Equipment and FRAMECAD Ltd focusing on business and product innovation. His focus is on developing smart industry systems using Artificial Intelligence and Big Data technologies, for applications in agriculture, manufacturing, and construction sectors.

Industry 4.0 in action on the shop floor – a New Zealand case study

GORNY, IVO (PRESENTING AUTHOR)
Callaghan Innovation
Ivo.Gorny@callaghaninnovation.govt.nz

MOLLEKIN, BEN
Mastip Technology Ltd.
Ben.Mollekin@mastip.com

This presentation shows the steps Mastip Technology and Callaghan Innovation took to implement an Industry 4.0 solution for measuring and displaying factory performance data at Mastip Technology's machine shop in Auckland.

Industry 4.0 and the Industrial Internet of Things are on nearly everybody's agenda in the manufacturing industry. The drivers for Industry 4.0 implementations are usually the necessity to increase the productivity, Health and Safety and/or quality improvements.

To deliver on these objectives, information about the business processes are needed. New digital technologies offer feasible methods to gather and process data. However, there is no straight forward, one-size-fits-all recipe available, how to get started. It requires an analysis of the production process to identify the pinch-points and then to decide, which information is needed.

Mastip Technology wanted to improve knowledge about setup-time, run-time and idle-time of twelve machines like CNC turning centres and machining centres. The time data must be associated to work orders and to machine operators. The datasets are used two-fold: they feed a dashboard display in the machine shop showing the performance of machines (value added time), and the information is used to understand how to plan machinery in the most efficient method.

The system allows for example, the family grouping of similar components, to choose the best machine for a job and to highlight where to focus continuous improvement actions. For Mastip Technology the overall visibly of throughput is achieved.

Ivo Gorny leads the Electrical Engineering Team of Callaghan Innovation in Christchurch. He is a Software Engineer with more than 30 years of experience in the development of hardware and software. His current focus are Industry 4.0 applications, microcontroller and industrial control systems.

Application of Industry 4.0 and Digital Twins in Process Industry

POLZER, JAN (PRESENTING AUTHOR)
The University of Auckland
Faculty of Engineering
jan.polzer@arcor.de

NEUER, MARCUS
VDEh-Betriebsforschungsinstitut GmbH
Germany
marcus.neuer@bfi.de

LOOS, MORITZ
VDEh-Betriebsforschungsinstitut GmbH, Germany
moritz.loos@bfi.de

This paper shows the industrial application of new Industry 4.0 concepts and digital twins in process industry. The developed concepts for decentralized production optimization are based on digital twins and autonomous agent communication. The digital twins give the product to be processed a certain "intelligence" and decision-making authority. Contrary to the conventional approach, the digital twins "say" the next process stage the optimal setup parameters for production. The paper also shows how such a system works in a real-world production environment. Furthermore the increase in productivity is to be seen.

Dr. Jan Polzer is Professional Teaching Fellow and Coordinator of Industrial Projects at The University of Auckland, Faculty of Engineering; research interests: Industry 4.0, digital twins, cross-process optimisation, closed-loop control, autonomous flying drones and applied research in industry

How Fourth Industrial Revolution thinking will increase by an order of magnitude the overall productivity of the Forest, Forest Products and Building Industries. A practitioner’s view

JOHNSTON, TONY (PRESENTING AUTHOR)
Wood Engineering Technology Ltd (WET)
tony.johnston@outlook.

Wood Engineering Technology Ltd. has successfully implemented the most advanced Industry 4.0 factory in New Zealand by being a conceptual innovator. In their factory a low utility debarked 1-meter length log enters a $20 million capital cost production system that 9 hours later, without a person touching any piece of wood or making a decision on what should happen to any piece of wood, a 6 meter length, highly consistent, high utility structurally engineered laminated wood building material in compliance with all NZ Building Code requirements, which can be configured to a specific sales order arising from a specific building construction job, is delivered into a packet of lumber, on the day that it is required.

The starting hypothesis of the 15-year journey to an operating factory, was that it would be possible to increase the productivity of the wooden building materials extended supply chain, by an order of magnitude. Achieved through bio mimicry and highly automated manufacturing technology, combing a discovered technique with state-of-the-art technology, to achieve a conceptual goal.

Delivering upon the initial concept required; Inverting the conventional lumber production process. Starting afresh and designing machines to perform specific tasks in new ways. Multiple iterations of the design of all 13 separate machine centres; Looking at the plant holistically within the whole supply chain from the standing tree through to the output products ultimate consumer; Getting everything to work together as one integrated process; Collection, mining and analysing large quantities of data; Replacing conventional individual machine operating systems with an overarching factory operating system; Developing decision criterion and algorithms that optimally controlled the process end to end. This has created the potential for mass customisation within a commodity business.

Tony has a BSC (Hons) from Otago. Founding Executive Director of WET. Previously; COO Tenon Limited; Executive Director LumberLink; President Fletcher Challenge Forests USA and others; 12 years in the meat industry. Married with 5 adult children

Manufacturer challenges and misconceptions affecting Industry 4.0 adoption in New Zealand

SILVA, REINALDO (PRESENTING AUTHOR)
Facteon Intelligent Technology Limited
Reinaldo.Silva@facteon.global

STOKES, KEIRAN
Facteon Intelligent Technology Limited
Keiran.Stokes@facteon.global

PURCELL, GREG
Facteon Intelligent Technology Limited
Greg.Purcell@facteon.global

For many businesses, making an operational upgrade can be particularly daunting. However, with the technological revolution and subsequent innovation levels unlikely to cease anytime soon, businesses need to work together to overcome perceived barriers affecting their adoption of Industry 4.0 technologies.

With any operational change, there are corresponding changes in both workplace processes and culture. It's one thing to adapt to newer automated software systems, but inspiring new streams of collaboration in the wake of these continues to challenge managers. It's no longer business as usual, but teamwork remains key to optimising operations.

There's also a misconception that modernising a factory means that it must be refitted with the latest machinery and this can be a significant, yet unnecessary, roadblock for many looking to start their Industry 4.0 chapter.

It doesn't have to be this way. Ultimately, the key to successful implementation of revolutionary technology is retaining an intrinsic focus on your business needs. Unless these are fulfilled, the application of multiple trending technologies is pointless.

Often, existing machinery can be leveraged to prevent unnecessary financial expense. The solution can sometimes be as simple as fitting sensors and Industrial IoT hardware to current operational assets.

This lack of education and understanding around such Industry 4.0 principles and the ways in which technologies can be applied meaningfully, is impacting the growth of New Zealand manufacturing. However, with the help of industry there's an opportunity for manufacturers to actively learn from solutions providers who have already navigated this journey and know how to successfully combine operational technologies with Industrial IoT tools, to provide the right Industry 4.0-aligned solution.

Only when we have improved collective familiarity with Industry 4.0 challenges and opportunities will New Zealand manufacturing truly be globally competitive.

Reinaldo Silva, Software Products Manager, Facteon. Reinaldo leads the development and commercialisation of Facteon's Industrial IoT product, COSMOline. In addition to researching the practical application of Industry 4.0 technologies, Reinaldo works closely with manufacturers to develop solutions specific to their operational challenges.

Case studies in applying Augmented Reality to High Value Manufacturing Processes

MARETT, KEVIN (PRESENTING AUTHOR)
LEAP Australia
kevin.marett@leapaust.com.au

Manufacturers worldwide are increasingly adopting Augmented Reality (AR) in their business to help tackle the inefficiencies associated with traditional approaches to the assembly process. Case studies will show how static documentation and instructions can be replaced with augmented digital overlays, also utilising the Internet of Things, to deliver critical information to workers when and where they need it.

Learn from case studies on how high-value manufacturers are avoiding costly mistakes and prolonged downtime by leveraging AR to empower their workers, resulting in greater efficiency, reduced waste and increased first-time quality, ultimately improving overall operational efficiency. Insights from a recent survey of NZ businesses readiness for AR will also be presented - helping attendees to gauge where their business currently sits in comparison with their peers.

With a long background in manufacturing both in New Zealand and overseas, Kevin Marett has been working for LEAP Australia for the past eight years providing software solutions to many of New Zealand's established and emerging manufacturing companies. LEAP have a long established reputation for successfully delivering solutions spanning design, engineering, manufacturing and service. Keeping pace with disruptive technologies, Kevin is providing companies with solutions around Design, PLM, Smart Connected Products, Smart Connected Operations and Smart Connected Service.

Aulana®: Nanogold Coloured Wool Apparel and Bespoke Rugs for Luxury Markets – A Journey Through Discovery, Development and Commercialisation

JOHNSTON, JIM (PRESENTING AUTHOR)
School of Chemical and Physical Sciences, Victoria University of Wellington
jim.johnston@vuw.ac.nz

Aulana® is a new technology and luxury nanogold-woollen product suite which is being developed. It innovatively combines the nanoscience of gold with wool fibres to produce nanogold-wool textiles in a boutique colour range for high value international luxury markets.

Aulana® captures the exciting and unique opportunity whereby the prestige and high value of gold are linked directly to the high quality of New Zealand wool through the use of nanogold as novel colourants in the wool, for the international high quality fashion apparel, luxury textile and rug markets. It is steeped in history. Since Roman times gold (nanoparticles) have been used to colour glass in pink, red and purple shades. In 1908 Gustav Mie explained this colour phenomenon through the resonance interaction of the light with the conduction band electrons confined at the surface of gold nanoparticles - localized surface plasmon resonance. Here, the colour depends largely upon the size and shape of the gold nanoparticles.

We synthesize and chemically bind the gold nanoparticles to the sulfur and nitrogen of the amino acids in the wool fibre proteins. Spherical nanoparticles of gold about 10-20 nm in size are pink-red in colour. Precise control of the nanoparticle size enables us to change the colour progressively through shades of pink, red, purple, blue-grey to grey. Nanogold colourants cannot fade or denature in sunlight and hence the nanogold coloured wool products exhibit excellent lightfastness.

The proprietary Aulana® technology and product suite have been developed on a laboratory scale and progressed to pilot scale trials and prototype products in luxury apparel, and bespoke rugs. Aulana® is a world first technology and product suite, which has attracted interest from UK, Italian and French fashion houses. The journey along this pathway from discovery, through laboratory and prototype development, together with the challenges of commercialisation are presented.

Aulana® scarf

Aulana® 'Midas' rug designed around a Royal pendant

Professor Jim Johnston has a Personal Chair in Chemistry at Victoria University of Wellington. He is a Principal Investigator in the NZ Product Accelerator. He works at the university-industry interface. He is recognised nationally and internationally for his research contributions in materials science and new chemical technology and product developments.

In-line thin film deposition and functionalisation of industrial surfaces

LEVENEUR, JÉRÔME (PRESENTING AUTHOR)
GNS Science
j.leveneur@gns.cri.nz

KENNEDY, JOHN
GNS Science
j.kennedy@gns.cri.nz

DAVIDSON, RYAN
GNS Science
r.davidson@gns.cri.nz

Controlling the surface properties of materials is often key to achieving high performance. For instance, it can be used to reduce ice or fouling build-up in heat-exchangers, reducing fouling in food processors, or designing better transparent windows and panels.

GNS Science has recently developed two unique ion beam surface modification prototype systems to apply physical surface modification processes over large areas. Ion beam surface modification (IBSM) processes involve atomic or molecular ions hitting a surface at high velocity. Because of the high energy involved in the process, IBSM can be used to largely alter the surface composition and properties of a material. For example, IBSM processes can: change the topography allowing smoothing or nanostructuring of a surface; affect the wetting properties – affinity or repellence of water or oils; or even to imbue antimicrobial properties to a surface.

The first prototype developed can modify large planar glass, metal, and plastic surfaces (currently modifying an area up to 15 cm × 200 cm). The second prototype extends these techniques to the modification of surfaces of small diameter pipes (< 1 cm) and fibres. This allows us to use surface modification techniques usually limited to the microelectronics industry, to the larger scale of industrial materials.

So far, our team has applied our prototypes to provide conductive surface treatments to polymer materials and glasses, as well as changing the wetting and ice adhesion properties of metal substrates. In our presentation, this platform technology will be further introduced, and the types of surface treatments obtained will be illustrated.

Dr 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 broad industrial challenges.

Forget the Plug – A Multi-disciplinary Approach to Wireless Charging of Electric Vehicles

BICKERTON, SIMON (PRESENTING AUTHOR)
CACM, University of Auckland
s.bickerton@auckland.ac.nz

AMIRPOUR, MAEDEH
CACM, University of Auckland
m.amirpourmolla@auckland.ac.nz

KIM, SEHO
Power Electronics, University of Auckland
seho.kim@auckland.ac.nz

LEVENEUR, JÉRÔME
GNS Science
J.Leveneur@gns.cri.nz

COVIC, GRANT
Power Electronics, University of Auckland
ga.covic@auckland.ac.nz

Forget the Pump. Forget the Plug. As car manufacturers rush to introduce an increasing number of Electric Vehicles (EVs), the ease and efficacy of battery charging is a central issue for their rapid adoption. Wireless transfer of electrical power via Inductive Power Transfer (IPT) has been pioneered in New Zealand, and charging of EV batteries will be a major global application of the technology. IPT is enabled by magnetically-coupled inductive coils, with power being transferred from a floor mounted primary “pad” to the secondary “pad” mounted in the vehicle. Commercial systems will be available from 2020/21 that utilise primary pads fixed on top of a floor surface (suitable for garages, and car parks). A current, multi-year MBIE funded research programme is developing IPT pad/pavement systems that will allow primary pads to be installed within our roads. The vision is for EVs to be charged with minimum effort and complication at roadside and taxi ranks, and in the longer term, as they drive quietly along our urban roads.

Development of IPT pads robust enough to survive internally for 10+ years within the harsh roading environment must address a broad range of technical challenges, requiring a truly multi-disciplinary approach. IPT pads will be flush mounted at roadsides to service parked cars and waiting taxis (semi-dynamic), and buried below the centre of lanes for charging while driving (dynamic). Complex and dynamic structural and thermal loads are applied, as well as environmental loads on both daily and seasonal cycles. Novel materials are being developed to address the complex multi-functional requirements; electro-magnetic, thermal, structural, as well as manufacturing considerations. Multi-physics simulations are key tools enabling detailed design of prototypes, which are being tested experimentally at multiple scales. An overview of progress is presented on this multi-disciplinary MaD project.

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 composites, and multi-functional materials. He is currently Director of the Centre for Advanced Composite Materials (CACM), and member of the MaD Network steering committee.

Rezolution™ Suite of Mining Chemicals for Subterranean Strata Stabilization & Bolting

NICHOLSON, HAYDEN (PRESENTING AUTHOR)
Managing Director, Polymer Group, East Tamaki, Auckland
nicholson@polymer.co.nz

The stabilization of underground mining operations has been a challenge since the Industrial Revolution.

Simple timber frames and sheeting eventually gave way to materials such as sprayed concrete, coupled with anchor bolts and mesh.

In the middle of the last century a revolutionary, rapid setting, chemical solution was developed by way of a two-component material, (inorganic segment plus organic segment) generically referred to as urea silicate.

Although manufactured by some of the world's largest multinational chemical companies this product category had a reputation for being unreliable (pure curing characteristics) during application.

Polymer Group began developing and evaluating urea-silicates five years ago and quickly experienced the same reported performance variability. An experimental programme was then designed based on data collected from 6 months of trials which subsequently revealed the key raw material properties required to eliminate the failure rate and enhance the reliability of underground application. The material was tested in the Swiss Hagenbach product-proving mine where it was evaluated as a rapid-setting grout for 3m long bolts typically utilized to retain mesh prior to spraying with concrete. The product exceeded the minimum 15 tonne pull test within 24hours of installation.

From this point the Australian market was explored and the products found ready acceptance with one of the Australian mining industry’s major suppliers.

With the reliability proven for injection into broken strata, and for the grouting of 3m long bolts, the company then began experimenting with a sprayable version. While injection products were not novel the successfully developed sprayable version, SILCRETE™, is unique in the industry. It has recently been accepted by Anglo American in Australia and is scheduled to become part of its revolutionary automated mining process coming on-stream in 2019.

Hayden Nicholson, Managing Director, Polymer Group, a company established on the Kapiti coast in 1978. Employing 15 staff the company is a vendor to New Zealand's energy generators, oil and gas, dairy and construction industries. The company specialises in providing locally manufactured products for protection of property assets and infrastructure.

New sensor based solutions for next generation smart distribution transformers

- a case study for successful industry-university collaboration

HUNZE, ARVID (PRESENTING AUTHOR)
Robinson Research Institute, VUW
arvid.hunze@vuw.ac.nz

DAVIES, MIKE
Robinson Research Institute, VUW
mike.davies@vuw.ac.nz

BADCOCK, ROD
Robinson Research Institute, VUW
rod.badcock@vuw.ac.nz

JANSSENS, STEFAAN
Callaghan Innovation
Stefaan.Janssens@callaghaninnovation.govt.nz

RAYMOND, SEBASTIAMPILLAI,
ETEL Limited
Sebastiampillai.Raymond@callaghaninnovation.govt.nz

JALAL, THAHIRA
Callaghan Innovation
Thahirah.Jalal@eteltransformers.co.nz

This presentation will discuss the development of an original, sensor based solution to enable monitoring of the next generation of smart distribution transformers. This project was done in collaboration between New Zealand's only manufacturer of distribution transformers ETEL Limited (Auckland), Robinson Research Institute (RRI), which is part of Victoria University of Wellington and Callaghan Innovation (CI).

Apart from the specific development, we will discuss our overall approach to implementing a successful collaboration between industry and university. The process starts by identifying and approaching possible industry partners and collaborators matching and complementing RRI's research background and experience. Next we specified the technical challenges together with the industry partner, resulting in a detailed project planning phase, secured funding and executed the project including patenting of crucial know-how and public dissemination of results in peer reviewed journal papers and conferences.

Together with ETEL, we identified a commercial need to develop the next generation distribution transformer by incorporating online sensor metrics and data intelligence to enable a step change for ETEL's customers (electricity distribution utilities) to manage their asset fleet. Although several commercial solutions for online and health monitoring of large and expensive power transformers exist, these solutions were not feasible for smaller less costly distribution transformer. Therefore ETEL decided to develop a unique cost effective sensor based solution, which can be integrated or retrofitted into existing products. After defining the technical and commercial metrics we reviewed available literature and patent landscape and identified new sensor concepts which fit the technical and economical requirements for implementation in distribution transformers. We will illustrate our approach by describing challenges and outcomes of developing an optical sensor to measure dissolved hydrogen within transformer oil and a capacitive sensor capable of determining the oil acidity and overall oil quality.

Arvid Hunze is a senior research scientist at the Robinson Research Institute, Victoria University of Wellington. His current research spans the full range of development of new sensor systems including materials advanced electromagnetic simulations, prototyping and sensor system deployment. His work is mainly targeting applied research for external customers and industry.

Ladies Shoes and Digital Technologies. Helping to bring the craftsman's touch back to shoe design with modern techniques

SHANNON, CRAIG (PRESENTING AUTHOR)
Globex Engineering
Craig.Shannon@globex.co.nz

JAMIESON, ROSIE
Ziera
Rosie.Jamieson@zierashoes.com

Ziera shoes has been working with Globex Engineering and Dicker Data to bring the design of shoes into the digital realm. By bringing specialists and their knowledge together in novel ways, we have been able to speed up design and to bring back the craftsman's touch to shoe design.

We have been working together on a ground up approach to the design process and made it into a completely digital process. Some examples of this have been

• Scanning feet to make the starting points of the shoe, starting with a digital base for design to improve fit.

• Novel computer added modelling techniques and software used to create organic models with designers

• Printing CJP parts for design iterations and communications with suppliers.

Ziera has had a strong vision throughout this change and have used digital technologies like Colour Jet Printing where they can have maximum effect. Some of the benefits to Ziera have been reduced design lead time, better quality communication with suppliers, reduced overall costs, better products for customers and enhanced brand strength. This has helped to bring back the core brand identity of unique fit and comfort that had been lost with the loss of local craftsman manufacturing close by.

In this presentation we will run through a few examples of the above to compare the historical processes to new processes and how Ziera, Globex and Dicker Data have achieved this together.

Craig Shannon is a Senior Manager at Globex Engineering. Since graduating from Auckland University with a BE Mech (hons), Craig has done 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.

Smart Ignition Development Project

CASEY, DAVE (PRESENTING AUTHOR)
dave.casey@fisherpaykel.com

ENGLISH, ROBERT
Fisher & Paykel Appliances
rob.english@fisherpaykel.com

LAMPEN–SMITH, JOSHUA
University of Auckland Summer Intern at F&P
jdlampensmith@gmail.com

Gas cooktops usually have one of two main ignition safety systems dependent on the market they are destined for. This is driven by regulation and customer perception of ease of use. Fisher & Paykel's project was to replace these 2 systems with a single smart system incorporating the best of both systems and allow further functionality improvements.

The 2 current systems are known as Flame Failure and Auto Re-ignition. Flame Failure will shut the gas off when no flame is detected but requires the customer to hold the dial down during lighting. Auto Re-ignition will relight any gas that flows if the flame goes out and requires no holding down of the dial. The 2 systems also require system specific burners. A single system would allow the use of a common burner, improved safety and functionality for the customer through the use of electronics.

Joshua Lampen–Smith a Summer Mechatronics Intern from Auckland University helped design and develop a working prototype incorporating an electronic controller and software of a system to demonstrate how this would work and feel for the customer. The system allowed to use of existing burners, valves and ignition but added smart control to their operation.

Functionality can further be improved through the use of timers and the integration of the system with other associated units such as fume extractors through connected appliance technology.

Dave Casey has worked as a Mechanical Engineer with Fisher & Paykel Appliances in Dunedin since 2008.

System integration for a turn-key gas-separation to liquid in a mobile solution.

MEIER, JONAS (PRESENTING AUTHOR)
Fabrum Solutions Limited
j.meier@fabrum.co.nz

Fabrum Solutions, in collaboration with Absolut System (France), have produced a range of large pulse tube cryocoolers. The cryocoolers are based on Callaghan Innovation's metal diaphragm pressure wave generator technology (DPWG) which has matured over the last 10 years to become a viable option for providing acoustic power to large pulse tube cryocoolers. The largest cryocooler, based on a 1000 cc swept volume DPWG, has demonstrated 1500 W of refrigeration at 77 K, from 24 kW of input power, was incorporated into a liquefaction plant to produce liquid nitrogen for an industrial customer and has been producing liquid nitrogen a rate of 12-15 litres per hour. Experience gained in operating the large cryocooler in an industrial environment for over three years has led to the development of an integrated turn-key gas separation to liquid system mounted in a mobile container. This presentation outlines the design and development of the turn-key system and test performance from the integrated liquefier, as well as identifying the variety of applications it has globally, and why it is a technology leader.

Jonas Meier is a Cryogenic Engineer at Fabrum Solutions. This entails the development of cryogenic refrigerators for cooling down to -200°C and below. And the integration of these cryogenic refrigerators into systems utilising this refrigeration, which include liquefaction of atmospheric gases and closed loop cooling systems for superconducting machinery.

Current status and developments in 3D printing technologies for metal.

MIKE FRY (PRESENTING AUTHOR)
TiDA Ltd
Mike.fry@tida.co.nz

This presentation will provide an overview of 3D metal Printing technologies currently in use and under development in NZ and provide a summary of international development trends illustrated by some specific case studies.

3D printing of metals is developing at an accelerating pace, emergent and evolving technologies are based on a wide range of principles; Binder jetting, Laser and electron beam processes, polymer bound-powder extrusion, Wire-arc and others - each seeking market opportunity and claiming advantages.

These technical developments are driven in response to market pressures to increase production volumes, reduce piece cost, and meet demanding quality assurance standards. A positive feedback loop is created as commercial pressure is intensified by the prospect of larger revenues from larger scale production becoming feasible. Resultant commercial activity in the metal 3d printing sector has the appearance of a feeding frenzy, with new market entrants and mergers announced on a near weekly basis.

We are now in the transition where 3D printed metal parts are progressing out of prototype/niche volume production and into low/medium and ultimately heading toward high-volume manufacturing.

The presenter's intent is to leave the listener better informed as to current technological progress and assist decisions around if, when and how to incorporate metal 3D printing into NZ projects and products.

Mike Fry is CEO of TiDA, a company specialising in; Titanium, Powder Metallurgy and metal 3D printing. After a PhD at UCL, Mike worked at Lotus Cars, progressing to Chief R+D Engineer for Cosworth Technology in the UK.

In NZ since 2007, Mike has 27 years experience leading commercial R+D.

THE LANDSCAPE OF ADDITIVE MANUFACTURING
Concurrent Conference Session 1 | Great Room 4

Oral Abstracts

Print-on piezoresistive sensors for soft actuator control

GIFFNEY, TIM (PRESENTING AUTHOR)
The University of Auckland
tim.giffney@auckland.ac.nz

TAN, SZE MUN
The University of Auckland
stan619@aucklanduni.ac.nz

In soft robotics the rigid structures of traditional robots are replaced with flexible, compliant designs fabricated from polymer materials. This flexibility and compliance has important advantages for applications including human-robot interaction and handling delicate objects. However, whereas in rigid systems the actuation occurs at defined joints, and deformation of the structure under normal loads is usually small, actuation in a soft robot is distributed throughout the structure and even small loads can lead to a significant change in shape. Therefore closed loop control is desirable to achieve precise motion of soft robots and repeatable positioning regardless of loads or orientation.

In this work, the direct extrusion printing of conductive carbon/silicone polymer composites that we have previously demonstrated is applied to create piezoresistive sensors directly on the surface of pneumatic bending actuators. Printing the sensors onto the actuator allows precise control of sensor geometry and the ability to create an array of sensors on the surface, allowing for multi-axis sensing. The extrusion method we apply is well suited to printing conductive traces with a high mass percentage of filler material (carbon) without requiring the addition and subsequent evaporation of solvent.

The choice of piezoresistive sensing simplifies measurement and allows for a compact, multi-channel external measurement circuit, which is easily integrated with the electro pneumatic valve to control the soft actuator.

Tim Giffney received his PhD degree in 2015 and is a lecturer at the Department of Mechanical Engineering, University of Auckland. One focus of his current research is on 3D printing of functional materials as a method to create "smart objects" with integrated sensing and actuation capability.

Acrylic additive manufacturing

SINGAMNENI, SARAT (PRESENTING AUTHOR)
Auckland University of Technology
Sarat.singamneni@aut.ac.nz

Poly (methyl methacrylate), PMMA, is a synthetic resin known for its toughness, rigidity, transparency, and stability in varied atmospheres. The widely varying characteristics make PMMA a popular choice for widely varying industrial applications. It has also been popular in biomedical applications and offers potential compatibilities with the human tissue. With controlled interconnected porosity characteristics, it is a good choice in bone repair and replacement tasks.

Macro and micro injection moulding, extrusion, chemical welding, thermoforming and different polymerisation techniques are common processing routes. In spite of the great application potential of PMMA in widely different applications, from aircraft canopies to the bone repair and replacement tasks, the processing limitations often limit the uses. Material modifications have been attempted to overcome some of these deficiencies in the past, though with specific limitations. Is additive processing a solution?

PMMA was proved to be suitable for processing by FDM, allowing for medical applications such as custom fabrication of craniofacial implants from medical imaging data and paving ways for better applications in medicine. However, FDM suffers from certain inherent limitations such as poor part definition, insufficient surface qualities resulting from stair-step effects, and the need to build support structures. Is it possible to process PMMA by the powder based methods, such as laser sintering? Ongoing research at AUT provided positive answers and quite interesting and promising outcomes. First, PMMA can be processed by laser sintering. Next, the material and process parameter combination needed an optimisation routine to converge on the best results. The osteoconductivity could be controlled by introducing ceramic fillers into the polymer matrix. Controlled connected porosities, though possible, proved to be quite challenging to closely craft, considering the complex interactions between experimental parameters.

The project outcomes attained international attention, industry involvement, and subsequent national and overseas collaborations.

Associate Professor Sarat Singamneni is at AUT and leading a team of researchers working on different aspects of additive manufacturing. The focus of the team is fundamental research in AM leading to process evaluation, enhancement, and development of materials alternatives and helping end users and the local industry with AM

The economics of additive manufacturing in 10 minutes

DIEGEL, OLAF (PRESENTING AUTHOR)
University of Auckland
Olaf.diegel@auckland.ac.nz

Many industries approach additive manufacturing (AM) as a drop-in replacement for conventional manufacturing technologies. This approach, however, does not fully utilize the unique possibilities that AM processes offer. When using AM for manufacturing it should also be noted that AM does not remove all manufacturing restrictions. It, instead, replaces them with a different set of design considerations that designers must take into account if they wish to add value to their products. Otherwise AM can easily become a slow and uneconomical way of manufacturing products or parts.

It is also of great importance to understand that, despite much of the marketing hype over the past decades, AM is not an “easy” technology that can make absolutely anything. It requires a good understanding of the different technologies and processes, and how to design for them. In fact, printing parts in metal, for example, can be downright hard, and the use of AM to manufacture metal parts should only be considered if the process truly adds value to the product.

Understanding what print factors influence the cost of an additively made part, and which of those factors can be directly influenced through the design of the part is of vital importance to the increased industrial adoption of AM. Many companies estimate that between 45% to 70% of the cost of an AM part can be in pre-and post-processing of the part. Understanding how good design for AM practices can minimize this cost is also of importance to industries wishing to adopt AM.

This presentation, through the use of real-world industry examples, explores some of the main controllable factors that can affect the cost of AM parts, and suggest some simple design techniques to both minimize these costs while, at the same time, improving the quality of the part.

Olaf Diegel is Professor of Additive Manufacturing and recently opened the University of Auckland’s Creative Design and Additive Manufacturing Lab. He leads the MaDE Network and is co-developer of the MaDE CoRE bid.

His research interests include design for AM, topology optimization and other light-weighting techniques, and the automation of AM post-processing. He is also interested in technologies that increase the speed/quality of the product development process.

3D Printing and Distributed Upcycling for more Sustainable Futures

FRASER, SIMON (PRESENTING AUTHOR)
Victoria University of Wellington School of Design
simon.fraser@vuw.ac.nz

BAGLEY,MARK; CAMERON,SOPHIA; GUY,BERNARD; JACK,BEN; MILLER,TIM; MOLLOY,ISABELLA; OK,JEONGBIN STEVENS; ROSS TAITO-MATAMUA,LIONEL
Victoria University of Wellington

marktonikkle@hotmail.com; sgccameron188@gmail.com; bernard.guy@vuw.ac.nz; Ben.Jack@vuw.ac.nz; tim.miller@vuw.ac.nz; molloy.isabella@gmail.com; jeongbin.ok@vuw.ac.nz; Ross.Stevens@vuw.ac.nz; l.taito_matamua@hotmail.com

The concept of distributed energy and distributed manufacturing refers to small scale grids or localised production facilities as opposed to large scale centralised models for the production of energy and products. The addition of distributed upcycling to the mix introduces the possibility of a more holistic approach to production and 're'production that is potentially capable of catalysing the systemic change necessary to achieve more sustainable forms of manufacturing, better suited to New Zealand's geographical location, market size and regional development.

This takes on a new imperative with China's 2018 ban on processing New Zealand's plastic waste which has initiated a national crisis in waste management. While New Zealand seeks alternative processing destinations the international shipping of plastic waste is not sustainable. 3D printing promises to play a key role in addressing this complex issue.

In response the MADE research programme at the VUW School of Design presents a range of design-led case studies as a tangible demonstration of how this might be achieved, including:

• materials research for localized, site-specific and practice-based up-cycling schemes;

• novel spatial 3D printing for material economy and energy efficiency;

• upcycling for high-value customised domestic products;

• 3D printing for distributed energy and customised manufacturing in remote communities.

These examples diverge from the many published case studies for upcycling which still mainly rely on the methods established for mass production, such as the pursuit of uniformity, centralized process and a "one-size-fits-all" approach, without active consideration and incorporation of unique aspects specific to the locations and local communities.

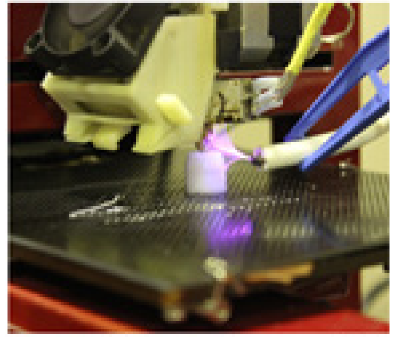
Simon has over 35 years' experience in practice based design research in industry and academia, through a variety of roles such as Assistant Design Director at the Porsche Design Studio, Head of School and Associate Dean of Research & Innovation at the VUW School of Design and affiliations with the NZ Product Accelerator and the MedTech CoR

A design-science collaboration: freeform interfacial connections

MILLER, TIM (PRESENTING AUTHOR)
School of Architecture and Design, Victoria University of Wellington (SOAD, VUW)
Tim.miller@vuw.ac.nz

LEVENEUR, JÉRÔME
GNS Science
j.leveneur@gns.cri.nz

BRUCE, CAITLIN
SOAD, VUW
caitlinbruce@outlook.com



Corona discharge plasma applied during 3D printing.

Digital fabrication technologies have opened avenues for fully integrated designs, optimising shape, functionality and production. Our team is particularly interested with the use of 3D spatial printing, or freeform 3D printing, which allows creating large self-supported structures to be built from the bottom up. This minimises materials usage and enables unique shapes and functionalities. However, the mechanical integrity of such structure is currently not optimum. The adhesion of joints in the structure are often weak as the initial layer has time to fully cool-down before more material is connected. This leads to lower adhesion strength, decreased repeatability, and overall reduced mechanical integrity of the printed object.

Surface treatment and environment control are well established for conventional manufacturing and other additive manufacturing. They remain a challenge with spatial printing where, usually, extrusion speed, temperatures, and cooling rates are the only parameters available. Recently, the team at Essentium presented a new FDM (fused deposition modelling) printer which uses RF discharge to enhance structural strength of the printed parts. Can we adapt similar approaches for 3D spatial printing?

The team, regrouping materials scientists and designers from the National Science Challenge - Science for Technological Innovation, took an original approach to answer this question. From the materials laboratory at GNS Science to the large industrial robotic arm at the VUW School of Architecture and Design in Wellington, we have taken an iterative stochastic approach to narrow down key operational parameters to optimise interlayer adhesion strength with plasma.

To specifically quantify the differences in interlayer adhesion strength at cross-over points tensile testing probes were design for both extrusion layer-by-layer printing and for free-from printing. These tensile probes provided a repeatability of 90%. In these conditions a significant (up to 30%) increase of the adhesion force was observed. Detailed results and discussions will be presented.

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

Consistently Achieving Full Strength Metal 3D Printing Production Parts

DOWNING, WARWICK (PRESENTING AUTHOR)
RAM3D
warwick@ram3d.co.nz

Metal 3D printing is gaining traction, not only as a technology for prototyping but also production. As a service bureau, production parts account for 80% of throughput. The key to successful production parts is a close collaboration not only during the design phase to ensure the best part is developed, and also in the production phase to ensure that the parts continually meet specification.

The process is repeatable, however unlike other technologies that mean once it is set up it will always run the same. The process requires constant monitoring where quality control is not just about the shape of the parts but also careful monitoring of all the variables to ensure they remain constant.

This talk will look at some of the process parameters that are important and the questions to ask your service provider. We will look at what you can expect with regards to mechanical properties that are achieved including the grain structures, heat treatment and features that you might be able to incorporate into your design to make the parts closer to final part.

Warwick Downing has been involved in metal 3D printing for over 10 years and together with the team at RAM3D has developed a depth of knowledge of the technology and the requirements to repeatedly deliver for the aerospace, defence, marine, consumer and industrial markets.

THE LANDSCAPE OF ADDITIVE MANUFACTURING
Concurrent Conference Session 1 | Great Room 4

Oral Abstracts

Powder-bed fusion additive manufacturing of difficult-to-weld Ni-based and Co-based superalloys

CHEN, ZHAN (PRESENTING AUTHOR)
Department of Mechanical Engineering
Auckland University of Technology
Zhan.chen@aut.ac.nz

The major metal additive manufacturing (MAM) technology is powder-bed fusion (PBF), either selective laser melting (SLM) or electron beam melting (SEBM). During PBF, the high energy beam fully fuses the powder in a selective path following part designer's instruction through CAD models, allowing geometrically complex parts to be manufactured. Thus, industrially, PBF should be widely applied but there are serious challenges. One is that many important industrial alloys, which are difficult-to-weld, are difficult to be PBF manufactured without hot cracking. This is readily understood as melting and solidification are two major physical events shared by fusion welding and fusion based MAM. Hot cracking occurs in dendrite grain boundaries and cracks are largely orientated along build direction (BD) during PBF. Two solutions to hot cracking are (a) solidification of equiaxed grains and (b) grain growth direction control during solidification. Both are, however, technologically highly challenging.

The two solutions will be discussed in this presentation. We will first briefly discuss the routes for equiaxed solidification, explaining solidification modes that are determined by PBF thermal quantities and the recent advance in grain inoculation. We will then present our grain growth control solution. Although it has not yet been well studied in literature, the shape of the PBF melt-pool plays a crucial role in relating PBF parameters to grain growth and thus to whether hot cracking can be prevented. This relationship will be briefly explained with our results from our experimentation using both Co-based and Ni-based difficult-to-weld superalloys. We will demonstrate how PBF parameters can be selected for desirable track profiles and for grain growth direction to highly deviate from BD. This will restrict the length of columnar grains resulting in hot cracking unfavourable.

The presenter is a materials engineer and a professor with the department of mechanical engineering at AUT. He currently is conducting research in the fields of metal additive manufacturing and friction stir welding. He teaches courses and supervises student projects and research on engineering materials and manufacturing technologies.

The Future of Manufacturing - Industry 5.0

SCHAEFER, MARCEL (PRESENTING AUTHOR)
Auckland University of Technology
marcel.schaefer@aut.ac.nz

Humanity is facing one of its greatest challenges of modern times: resource scarcity. The demands for materials followed an exponential growth during the last century and the demand for energy related to material extraction. While material intensity decreased, materials used per capita doubled. Throughout the last century, every year, material productivity improved at an average rate of 1%. The Intergovernmental Panel on Climate Change recommends a reduction of greenhouse gases by 2050 of 55-85% to prevent unwanted effects due to climate change. According to an optimistic projection, the target to reduce relative carbon dioxide emissions by 50% from the year 2006 to 2050 cannot be met by merely increasing efficiency in existing supply chains. In order to meet consumer demands, sustain economic growth, and prevent unwanted climate change different approaches to the so-called eco-efficiency strategy have to be developed. The eco-efficiency approach aims to minimize volume, velocity and toxicity of the material. This approach is also called "from cradle to grave" as products will be disposed of at the end of their lifecycle. Some products are recycled, but this often means only to delay their disposal. However, as stated above, emission targets cannot be met only by improving the efficiency of production systems and services.

A contrasting strategy to the conventional "cradle to grave" approach is named "cradle to cradle" approach. The core of the cradle to cradle methodology is to design goods and services that allow for maintaining the quality of resources. As a consequence, production processes produce no waste. This strategy is based on natures metabolism in which waste equals food. To eliminate waste, this concept has to be implemented at the very beginning of the design stage when products, packages and (manufacturing) systems are designed in the context of two distinctive discrete metabolisms. The first metabolism is related to the biological world were used materials are biological nutrients – they are biodegradable. The second metabolism is related to the technical world were materials are technical nutrients – all materials used are reusable for further applications without downgrading its quality.

The current manufacturing processes such as casting, joining shearing or machining have not changed significantly over the last decades. There are many publications on the fourth industrial revolution, and there will be an increase in productivity resulting from the implementation of Industry 4.0 processes and systems. However, it does not fundamentally challenge the way we manufacture goods. In order to meet the requirements based on a cradle to cradle manufacturing approach entirely new manufacturing processes have to be created.

Marcel is a Lecturer in the Department of Mechanical Engineering AUT. He completed his PhD and MSc at Rhine-Westphalia Institute of Technology (RWTH) Aachen University in Germany, where he worked as a lecturer and project manager and held the position as Deputy Head of the Department.

Robots working harder, staff working smarter

TURNER, ANDREW (PRESENTING AUTHOR)
Nautech Electronics Ltd
andrew.turner@nautech.com

COSTER, GREG
Nautech Electronics Ltd
greg.coster@nautech.com

Competing on the global market, innovation and quality have been the building blocks of Nautech Electronics over our 30-year history. However competing with international manufacturers with varying cost bases is a challenging environment. Without compromising our reputation for excellence, we have reviewed key areas for smarter production through robotics.

With the assistance of Callaghan Innovation we have successfully commissioned several automated robotic stations within our production and assembly lines.

One of the several robots Nautech has invested in has been configured for a large scale customer project. The scope of this job involves an assembly line where operators assemble and test a product, which is then placed on a conveyor, the cobot picks up the unit, places into a jig, installs 5 screws to a specific torque, then passes to the next operator for a final test and quality check. Utilisation of the robotic technology has enabled this project to run more efficiently and the ability to set the torque has also been an advantage to providing zero failure of the casings. As we build around 4000 of these units every month, installing 20,000 screws perfectly every time is a perfect job for a robot.

The capabilities of our robots allow for many functions such as milling, insertion, stripping, crimping, soldering, gluing and other repetitive processes. Wiring robot - we couldn't compete buying our pre-made wires locally and would have lost the work if not for the robot doing it for similar cost as importing from China and we can offer much better quality and consistency. By adopting the use of robotic technology we have redeployed human resource to concentrate on higher value tasks and thereby focusing on innovation and quality.

Reducing the manual labour content from production processes has been a successful initiative in achieving a profitable outcome for Nautech whilst providing an efficient solution for our customers. Future investment is planned to expand our capabilities even further.

Andrew is the Engineering manager and Managing Director of Nautech Electronics, Alitrax and Diver DACAD Systems. Nautech Electronics has now been in business for 30 years, started with just 2 staff and now employs 75 staff at its East Tamaki based manufacturing facility. The Nautech Group comprises several companies in New Zealand and Australia.

ROBOTICS AND INDUSTRY 4.0
Concurrent Conference Session 2 | Great Room 2

Oral Abstracts

Innovating towards a Virtual Power Plant (VPP): Distributed, Smart and Affordable

PYLE, ERIC (PRESENTING AUTHOR)
solarcity
Eric.pyle@solarcity.co.nz

BOOTH, ANDY
solarcity
Andrew.booth@solarcity.co.nz

WILLIAMS, GARETH
solarcity
gareth.williams@solarcity.co.nz

Solarcity in conjunction with Panasonic has developed an innovative home battery system that is much more than just a battery. It contains ICT that enables batteries and home appliances to be managed as part of the electricity system. Using this battery system a new era in power system management is enabled, for example, a virtual power plant (VPP) can be developed.

solarcity set out to develop a VPP capable of:

a) Servicing individual household load

1. Delivering demand response and grid support services

2. Operating as a whole or configurable sub clusters down to the individual unit level

3. Releasing the grid latent capacity to support further initiatives to electrify and decarbonise New Zealand's economy

In order to deploy its VPP solarcity has brought together three areas of innovation; (i) technical - an integrated battery, inverter and control system for household electrical circuits, (ii) financial - a "Netflix" type of financing model that eliminates the upfront capital cost to the property owner of a solar/battery system, (iii) use/management - the ability to enable power system managers to alter the way in which the power system is managed. Useful individually it is the marriage of the three strands that results in a product that will deliver a new era in power system management.

This presentation will outline the development of the battery system in conjunction with Panasonic and explain how the combination of innovation in technology, finance and grid management has created a package of innovation that will play a key role in the electrification and decarbonisation of New Zealand's economy.

Eric Pyle is Director, Public Affairs and Policy at solarcity. In the 2000s Eric led energy research policy at the Ministry of Research, Science and Technology. In a previous role Eric was Chief Executive of the New Zealand Wind Energy Association. Eric's interest has been in how renewable energy can contribute most effectively to the electricity system.

A technology selection framework for manufacturing industries in the context of Industry 4.0

HAMZEH, REZA (PRESENTING AUTHOR)
Mechanical Engineering Department
University of Auckland
reza.hamzeh@auckland.ac.nz

XU, XUN W.
Mechanical Engineering Department
University of Auckland
x.xu@auckland.ac.nz

ZHONG, RAY
Mechanical Engineering Department
University of Auckland
r.zhong@auckland.ac.nz

In the last decade, the emergence of Information and Communication Technology (ICT) and computer science significantly impacted different industries. Like other industries, manufacturing benefits increasingly from ICT and computer science. Advanced technological systems in collaboration with ICT and data analytics are transforming manufacturing to next generation which is called Industrial Internet of Things (IIoT). In Germany, this concept is called Industry 4.0 which aims to create smart factories by addressing challenges in current manufacturing systems.

One of the main characteristics of industry 4.0 is the impact of technology as an accelerant that allows individualized solutions, flexibility and cost savings in industrial processes. While understanding the potential of these modern notions, manufacturing organizations experience severe challenges in bringing ideas down to the shop floor. Problems occur mainly due to various perceptions about the nature of Industry 4.0, the expected impact on the strategic, tactical and operational level, the broadness and complexity of associated topics.

For a successful transformation toward Industry 4.0, it will be necessary to find the right mix of technological, social and business model innovations. Therefore, the main objective of this research is developing a decision-making framework for manufacturing technology selection incorporating technological, social and business considerations in a single decision-making loop.

Reza Hamzeh joined the Laboratory for Smart Manufacturing Systems (LISMS) in 2017 and since then he has been pursuing his Ph.D. in Mechanical Engineering under the supervision of Prof. Xu and Dr. Zhong at the University of Auckland. His research involves the Industrial Internet of Things, Operation Research and Technology Management.

Robotics in agriculture – design as a catalyst for research and investment

BARNETT, JOSH (PRESENTING AUTHOR)
University of Waikato
josh@mechlab.io

DUKE, MIKE (PRESENTING AUTHOR)
University of Waikato
dukemd@waikato.ac.nz

LIM, SHEN HIN
University of Waikato
hlim@waikato.ac.nz

In 2050, the population will have reached 10 billion but it is forecast that there will be fewer people to work the labour-intensive jobs required in many facets of agriculture. When also considering environmental factors, there is a strong push towards the development of robotics and automation within agriculture to future-proof the global food supply. Effective design adds value to this push by enabling robust, functional research platforms and prototypes. The University of Waikato is strongly involved with the design and hardware development for early-stage agricultural robots performing a variety of tasks across multiple crop types. Most notably, kiwifruit and apple harvesters and pollinators have been developed and trialled in New Zealand orchards which aim to address a prominent labour shortage. There are several challenges involved with developing a functional field robot, not least of which is the aesthetic component which plays an important role in appealing to potential investors and the general public. The challenges and strategies involved with effective early-stage robot design will be discussed including a case study on an asparagus harvesting robot recently developed by the University of Waikato which is destined for field trial in the USA.

Professor Mike Duke is the Dr John Gallagher Chair in Engineering at the University of Waikato and leads the Waikato Robotics, Automation and Sensing research group. His group extensively uses additive manufacture for a wide range of novel robotic devices, ranging from 3D printed titanium fruit picking mechanisms to complex silicon over moulds for soft grippers.

Josh Barnett is a mechanical engineer and University of Waikato graduate with a strong interest in innovative machine design. He has recently been involved with designing the hardware and motion control for kiwifruit and asparagus harvesting robots.

Leaning in to Industry 4.0 at Tait Communications

MISCHEWSKI, DEAN (PRESENTING AUTHOR)
Tait Communications
dean.mischewski@taitradio.com

In early 2018 the Tait Communications Manufacturing team began an improvement project to help reinvigorate our Lean Manufacturing program. It focused on the most high-tech, automated part of our factory, our surface mount technology (SMT) assembly lines, and doubled as a pilot project for Callaghan Innovation's promotion of "Industry 4.0" / "Lean 2.0" in NZ industry.

The project driver was that forecast demand by mid-year would exceed assembly capacity. The challenge:

"Increase SMT productivity by 20%, while maintaining flexibility and short lead times, without increasing inventory, while catering for an expanded range of products, without capital investment (and by the way, try to do it with fewer machines)."

The project went through these steps:

- Hardware Changes/Shuffling;
- Changeover Smoothing ("slow is smooth, and smooth is fast");
- Improve the Model;
- Visualise Run Time Data;
- Workload Balancing.

The project's most important part, and its connection to the Industry 4.0 theme, was our discovery of the value of process data which we had almost within reach the whole time. Much of our story was about finding ways to extract and visualise this data, and from that, gain insight into how to reduce setup times and increase production efficiency. Our results were:

- 37% productivity increase on the production line most under pressure;
- 21% increase in peak capacity overall;
- Roughly $250k in annual cost savings.

We learned that we didn't need to invest in exotic technology to gain a significant chunk of "Industry 4.0" benefits. Key learnings:

- Visualise data for useful insights;
- "It's OK to fail when we try something new";
- Improvement is iterative: learn and pivot;
- Dedicated software resource really helps;
- "Industry 4.0" / "Lean 2.0" / "IoT Interconnected Smart Factory" is the Next Big Thing… but using what you already have to be "smarter" can still be pretty good.

Dean Mischewski is Manufacturing Engineering Manager at Tait Communications. His undergraduate degree focused on Manufacturing and Industrial Technology, and he holds an MA in the Humanities. His current work concentrates on integrating electronics hardware design with manufacturing technology, to ensure design execution matches assembly capability and capacity.

Reactive inkjet printing: A route to multifunctional 2D and 3D printing

STRINGER, JONATHAN (PRESENTING AUTHOR)
University of Auckland
j.stringer@auckland.ac.nz

TEO, MEI-YING
University of Auckland
mteo748@aucklanduni.ac.nz

AW, KEAN
University of Auckland
k.aw@auckland.ac.nz

Inkjet printing, the patterned deposition of a multitude of identical droplets, has found extensive use in both home/office and industrial environments for the printing of graphics. This is primarily due to the fine resolutions (~10 µm), digital control of the pattern, ease of scalability, and the ability to deposit multiple different materials (as demonstrated by colour printing). These advantages have a large number of applications in other fields, which has led to an extensive array of research in using inkjet printing for biofabrication, printed electronics, smart packaging and 3D printing.

One inherent limitation in inkjet printing is that the ink that you print must be fluid enough, with a consistency not much thicker than water, and any material in the ink must be below a micron in size. While not too much of an issue for traditional graphics applications, this has presented a significant hurdle in other, more exotic, applications.

Reactive inkjet printing, where two or more inks consisting of chemical reactants are used, is an effort to circumvent this limitation. By mixing and reacting after printing of the inks, it is possible to print materials that would otherwise be difficult or challenging to print. A number of examples of devices fabricated using the reactive inkjet printing methodology will be presented. These will include high performance conductive polymer networks for sensing applications, three dimensional hydrogel structures for tissue engineering and microfluidics, and conductive polymer gel electrodes.

Jonathan Stringer is a lecturer in the department of Mechanical Engineering, University of Auckland. His research interests and experience are in inkjet printing, printed electronics, and the 3D printing of functional materials.

ADDITIVE MANUFACTURING APPLICATIONS
Concurrent Conference Session 2 | Great Room 3

Oral Abstracts

Biological Inter-dependencies in 3d Printing: Larvae Scaffold excavation of high filigree clay structures.

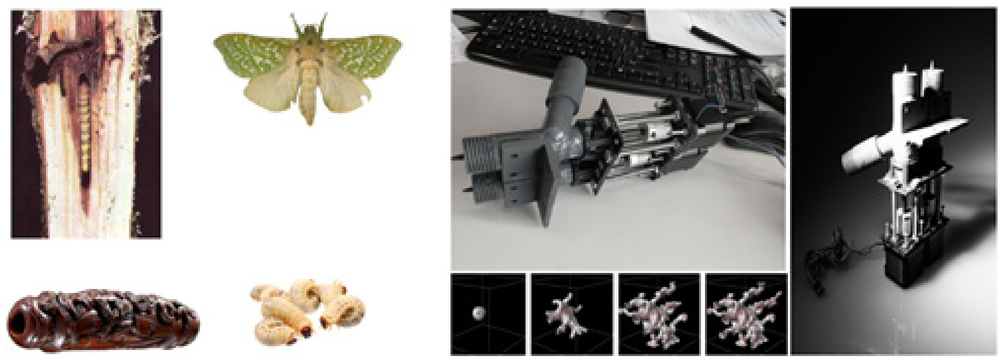
KAWITI, DEREK (PRESENTING AUTHOR)
Victoria University of Wellington
derek.kawiti@vuw.ac.nz

BAGLEY, MARK
Victoria University of Wellington
marktonikkle@hotmail.com

Hybrid inter-collaboration between biological and non-biological (machine) entities presents new challenges and opportunities in the sphere of manufacturing and design. This paper explores this relationship closely as a means to innovating low resolution 3d printing methods and technologies to produce high resolution outputs.

Drawing from the Māori (Ngāpuhi) use of the pūriri caterpillar in aiding the toolmaking process, the research seeks to develop a dual clay and bio material printer for printing high filigree clay objects. A range of insect larvae are co collaborators in the excavation and controlled curing of encased prints through the secondary scaffold consisting of edible bio matter and or cellulose solutions.

Keywords: biological orchestration, high filigree ceramics, indigenous materials, bio-tool paths, scaffold encasement



Senior Lecturer, Interdisciplinary Digital Design, director of multidisciplinary practice - CILOARC. Background in advanced parametric & procedural design methods, digital heritage, 'low' and 'high' tech' digital fabrication. Founder; collaborative research lab - SITUA (Site of Indigenous Technologies Understanding Alliance). Research collaborator, New Zealand Maori Arts and Crafts Institute of Te Puia, Rotorua. Research into new technical territories, indigenous hybrid fabrication practices and materials and additive manufacturing.

Cutting-edge Design: Machining metal 3D printed parts

MEARNS, CAMERON (PRESENTING AUTHOR)
Zenith Tecnica
c*ameron@zenithtecnica.com*

As Additive Manufacturing (AM) began to mature into a mainstream technology it became more critical to understand how to use this important toolset. While the capability of machines and optimisation techniques march forward it is likely that, for the foreseeable future, it will be necessary for many applications to machine metal 3D printed parts.

AM's limitations in dimensional accuracy, geometrical accuracy, and surface finish can limit the application of many designs and restrict printed components to 'near-net' shape. Finishing with machining can be critical for everything from mating surfaces to improving fatigue life.

We will explore examples when machining is necessary – and more importantly, not – as well as some tricks for design Additive parts for post-machining.

Cameron Mearns is a Mechanical Engineer working in the Production Team at Zenith Tecnica.

Exploration of Geometric Auxetics: Parametric Computation and Additive Technology Fabrication

MARK, BRITTANY (PRESENTING AUTHOR)
Victoria University of Wellington, School of Design
Brittanymark.77@gmail.com

MILLER, TIM
Victoria University of Wellington, School of Design
tim.miller@vuw.ac.nz

DAHM, KARL
Callaghan Innovation
karl.dahm@callaghaninnovation.govt.nz

Metamaterials are a synthetic group of materials constructed from repeated patterns of geometric structure with configurations that result in unnatural behaviour in response to applied force. As such, they are highly suitable for exploration using additive manufacturing and multi-material 3D printing. Our research here, surveys different structural configurations, illustrates the methods of manipulating geometry through software and considers potential applications.

One sub group is Auxetic Structures with a Negative Poisson's Ratio (NPR), where the structure becomes thicker or wider perpendicular to the applied force. The internal topology determines geometric deformation and behaviours such as orientation, size and void nature.

After surveying Auxetic Structures, a NPR Pyramid structure (US Patent US20100119792, Figure 5) was identified as having potential applications determined by controlling characteristic parameters. We used parametric modelling tools Rhino and plug in Grasshopper to generate a range of Auxetic Structures allowing adjustment of internal voids, cell size, density and geometric ratios. Our CAD model allowed for control of charge and decay which altered the rate cell density diminished across the points in the grid system.

We considered safety applications for snow sports athletes, particularly safety nets for athletes travelling at excessive speeds downhill as Auxetic materials have the potential to improve impact protection by increasing indentation resistance and energy absorption. Using a multi-material 3D printer, we have the opportunity to further develop our research by printing flexible joint and rigid struts allowing pragmatic explorations of a range of Auxetic configurations.

Our research starts to show that Auxetic Structures generated parametrically, allow customised material geometries. This is early research towards offering industry the potential of additively manufacturing responsive bespoke safety materials.

Mark Brittany is an Industrial Design master's student at Victoria University where she completed a BDI. She was awarded a summer scholarship undertaking research for Callaghan Innovation investigating Geometric Auxetic Structures through computational exploration and additive manufacturing. She has a passion for the outdoors and material knowledge, with the intent of developing a career designing sporting and outdoors equipment.

Influence of Layer Thickness Selection on Mechanical Strength and Loading Response in 3D Printed ABS Polymer

NOMANI, JUNIOR (PRESENTING AUTHOR)
AUT University / Mechanical and Manufacturing Dept
junior.nomani@aut.ac.nz

WILSON, DANIEL
Deakin University / School of Engineering
daniel.wilson@deakin.edu.au

PAULINO, DR MARIANA
Deakin University / School of Engineering
mariana.paulino@deakin.edu.au

MOHAMMED, DR MAZHER IQBAL
Deakin University / School of Medicine
iqy2004@hotmail.com

This presentation reports a detailed study on the influence of selection parameter, layer thickness or layer height in Fused Deposition Modelling (FDM) on the mechanical properties of printed ABS material. Selection of layer thickness is an important parameter in 3D printing. It impacts on factors such as printing time and print resolution. At present, there is contrasting agreement in the literature, of which selection of smaller or larger layer thickness would result in printed materials with greater strength.

Tensile and compression tests were conducted on standard ASTM samples printed at selected layer heights ranging between 0.2mm – 0.8mm, shown in Figure 1. This new novelty-method study found material printed at larger layer thickness to be significantly weaker compared to material printed at smaller layer thicknesses.

Experimental findings show mechanical properties of printed material may become geometry dependant and highlights the need for current mechanical testing standards such as ISO and ASTM, to be re-evaluated, accommodating more inclusive guidelines for the mechanical testing of 3D printed material.

Figure 1. ASTM type IV printed ABS tensile samples, printed at different layer heights ranging between (top) 0.2mm – (bottom) 0.8mm.

Junior Nomani is a Senior Lecturer at AUT University. His main research areas focus on the manufacturing of Stainless-Steel alloys by additive and subtractive means.

High Speed 3D bioprinting of Vascular Tubes

ZHANG, YILEI (PRESENTING AUTHOR)
Department of Mechanical Engineering, University of Canterbury, NZ
Yilei.zhang@canterbury.ac.nz

3D printing is an important technology in modern manufacturing system to satisfy customized and decentralized requirements by depositing materials layer by layer, which usually leads to low productivity. Efforts to remove the productivity bottleneck will be reviewed and discussed. For three-dimensional (3D) tissue engineering, vascular networks need to be incorporated into the tissue to provide sufficient nutrients for cell growth, proliferation, or differentiation. Here we introduce a high speed 3D bioprinting method for high aspect ratio structures, such as vascular tubes. Cell laden hydrogel will be printed using a UV laser Bessel Beam, which possesses several unique properties, such as self-healing and non-diffractive properties. As a result, the polymerization of a free-standing cell-laden fibre could be achieved from a single laser exposure. By manipulating the optical setup and laser power, fibres could be fabricated with desired diameters in the micron scale. Cell viability was high (>95%) and cells proliferated with time inside the fibres to self-assemble into endothelial cords with circular cross-sections. Compared to other techniques, the free-standing nature of the fabricated cords offers several advantages including the ability to be harvested and co-cultured with other cells. Potential applications of the high speed 3D bioprinting will be found broadly in regenerative medicine, tissue engineering and bio-manufacturing.

Yilei Zhang, senior lecturer in the Department of Mechanical Engineering at the University of Canterbury. His research focuses on bioprinting, Internet of Things (IoT), in vitro brain model and neurocomputing.

Transition to a Circular Bioeconomy – a unique opportunity for New Zealand - Scion Case Studies

GRAICHEN, FLORIAN (PRESENTING AUTHOR)
Scion
florian.graichen@scionresearch.com

New Zealand's and the world population is growing and this is affecting the environment. To ensure there's enough food, water and prosperity in 2050, we need to switch from a linear to a circular economy. That's why governments around the world are developing international programmes for Circular (Bio)Economies.

New Zealand is in a privileged position to enter the post petroleum era based on our climate, land availability and ability to produce significant amount of sustainably derived biomass. Without being constrained by industries from the post petroleum era we design or adopt new innovative infrastructure, manufacturing industries and products turning New Zealand into a Circular Bioeconomy.

Successful implementation of a Circular Bioeconomy will not only deliver the government priority goals but also significantly add to achieving the manufacturing target of 10x value increase over the 2018 target.

The "Circular Bioeconomy" is defined as the intersection of bioeconomy and circular economy and encompasses the following common topics:

- Improved resource and eco-efficiency
- Low greenhouse gas footprint
- Reducing the demand for fossil carbon
- Utilization of waste streams

This presentation will highlight several of Scion's activities – including new and re-design of infrastructure, processes and materials – targeting equal or better performing products that can be recycled, re-used or are biodegradable – all enabled by the use of sustainably derived biomass.

Examples will include:

- Biofuels/Bioenergy
- Bioplastics/biocomposites for targeted end of life solutions
- Distributed/additive processing and manufacture
- Packaging
- Recycling and biodegradation of customized products

Dr Florian Graichen is Science Leader for the area of Biobased Polymers and Chemicals at Scion - developing advanced biobased products through modification and engineering of biopolymers and chemicals. This includes agile, modular and mobile processing such as 3D printing and customized extrusion approaches.

Twitter: @FlorianGraichen | LinkedIn: https://www.linkedin.com/in/florian-graichen-42214a2b/
Scion: http://www.scionresearch.com/general/about-us/our-people/people/mb/florian-graichen

SUSTAINABILITY IN MANUFACTURING
Concurrent Conference Session 2 | Great Room 4
Oral Abstracts

Think circular to spark innovation and collaboration

NEBEL, BARBARA (PRESENTING AUTHOR)
thinkstep
barbara.nebel@thinkstep.com

Life Cycle Assessment (LCA), Cradle to Cradle®, Circular Economy, and Life Cycle Thinking are approaches that help to understand the full impact of a product over its life cycle. While they are often used interchangeably, there are some key differences between them, but they also complement each other well. In this presentation we will explore synergies and key differences between these concepts, based on real life industry examples.

A key element that all have in common is that they support product innovation without shifting burdens across the life-cycle or within supply chains from one stage to another. Combining the Cradle to Cradle® design concept with quantitative LCA assessments facilitates the move from "doing less bad to doing more good" with sometimes unexpected results that even might be counter intuitive.

In the session we will discuss ways to maximize product and service innovation, incorporating circularity, resource efficiency as well as resource effectivity and future-proof material compliance. Using New Zealand examples and case studies we will look at how a full life cycle approach can influence sustainable design.

Barbara's passion is to enable organisations to succeed sustainably. As CEO of thinkstep Australasia she often describes her job as a translator. Translating sustainability into traditional business language. Together with her team she delivers sustainability services from strategy and materiality assessments through to detailed Life-Cycle Assessments and CradletoCradle® projects.

What is truly sustainable product design?

MCDERMOTT, OLIVER (PRESENTING AUTHOR)
Blender Design Ltd
ollie@blender.nz

In 2019, one of the biggest issues facing the world is the health of the planet. We are living in a time of transition, where we are becoming more conscious of the impact that our decisions have on the environment.

Materials and resources are becoming scarcer and the impact of their use more evident. Designers and manufacturers have an obligation to themselves and future generations to care about how their decisions impact the world.

In the last decade, there has been an emphasis on the social and environmental impacts of materials. However, sustainable product design is bigger than just materials. Using recyclable or recycled materials isn't enough, mostly it's just greenwashing.

Trend cycles are also turning faster. Nowadays, it's standard to see perfectly good items thrown away. Shorter product life cycles set a faster pace for companies to churn out new products: using more resources just to keep up with trends.

Great design should solve problems, not create them.

So, what is truly sustainable product design?

Sustainability in design and manufacturing is doing better with less. It's embracing a broader view of the full lifecycle of a product and the impact it has, not only on business but on society and the environment.

The need to change how we create and consume products is urgent, and designers and manufacturers have a critical role to play. It's about time we de-coupled economic progress from environmental degradation and sought a positive return on our environment.

In my presentation I will address the challenges of the circular economy, focusing on the areas where designers and manufacturers can make an impact. I will share a new sustainability formula that I have developed and show some recent examples of how this has been applied successfully to new products and business models.

Oliver McDermott is the Managing Director of Blender Design. Oliver has over twelve years' experience as an industrial designer - involved in the creation of many successful products. Oliver is a national leader in looking for new and novel ways of designing and developing products that deliver big positive impact.

Oral Abstracts

Development of composite-based playing surface as replacement of slate for competition pool tables

LIM, SHEN HIN (PRESENTING AUTHOR)
School of Engineering, University of Waikato
hin.lim@waikato.ac.nz

BENSEMAN, DANIEL
School of Engineering,University of Waikato
dan.benseman@gmail.com

IBRAHIM, YAZDAN
School of Engineering,University of Waikato
yazdanibrahim@gmail.com

Currently, slate is the only acceptable material as the playing surface tournament quality pool tables. Due to the weight and fragility of the slate, construction and installation of pool tables require high craftsmanship and thus limiting production of these tables. This is also affecting the transportability of these tables. This paper presents the development of a composite-based playing surface that is lighter and can be mass produced to replace slate for competition pool tables.

Firstly, a study was conducted to determine a material that perform similarly to slate as the playing surface. In this study, the playing surface is constructed in three layered asymmetric sandwich composite configuration where the middle layer is an aluminium honeycomb core, the bottom layer is a thin sheet of aluminium and the top layer was the main tested material. Four materials were selected, which are a thin flexible slate veneer, aluminium, a synthetic stone known as Laminam and aluminium composite material (ACM) due to similar mechanical properties as slate. Two ASTM standard tests (ASTM G194-08 and ASTM F2117-10) were conducted to measure rolling friction and vertical rebound characteristics. Laminam is selected due to similar characteristics to slate and also its durability.

The construction process are bonding of aluminium sheet and Laminam to the expanded honeycomb core, waterjet cutting for pocket profile, rubber edging for cloth attachment. The total weight of the final design was 27.4 kg, which is less than a quarter of the slate weight of the same size. This design also reduced the requirement of high craftsmanship and has the potential to be mass produced.

Shen Hin Lim is a lecturer in School of Engineering, University of Waikato and his interest lies in design for agricultural and robotics applications. He is one of WaiRAS group members (https://sci.waikato.ac.nz/about-us/engineering/our-research/WaiRAS)

Powerful antimicrobial activity of manuka honey into wool fibre

ALJOHANI, SAMI (PRESENTING AUTHOR)
Victoria University of Wellington
sami.aljohani@vuw.ac.nz

JOHNSTON, JIM
Victoria University of Wellington
Jim.johnston@vuw.ac.nz

We present the novel use of New Zealand Manuka honey (MH) and its active ingredient methylglyoxal (MGO) as a natural non-peroxide antimicrobial agent in New Zealand wool and textiles. This has the potential to replace currently used synthetic antimicrobial agents as a way to meet the increasing demand for a more eco-friendly approach. New Zealand MH is well known for its unique antimicrobial activity and is strongly marketed accordingly.

We have characterised the uptake of MH and MGO by New Zealand wool fibres in loose top form, yarn and finished fabric. For this, the particular wool samples were soaked in dilute solutions of MH and MGO with concentrations of 50-250 mg L-1 MGO at temperatures of 20-80 oC and for times from 1 hour to 14 days. Increasing amounts of MH and MGO were taken up by the wool with increasing MH and MGO concentrations, temperature and time, e.g. at 70 oC, loadings of 5 wt% MGO and 4.5 wt% MGO in MH in the wool were achieved. Fourier-transform infrared spectroscopy and other techniques showed that the MGO was chemically bound to the wool fibres. As such the MGO treated wool showed negligible leaching of the MGO with washing, which desirably demonstrates the durability of the treatment.

The antimicrobial activity of the various MGO and MH treated wools and fabrics were tested against gram-negative Escherichia coli and gram-positive Staphylococcus aureus using a quantitative colony counting CFU procedure. This showed that for optimised conditions, treatments resulted in 100 CFU% bacteria reduction S. aureus and 99 CFU% against E. coli.

The research showed that Manuka honey and methylglyoxal impart durable, effective antimicrobial activity to wool fibres, yarn and fabric, in an eco-friendly approach. This opens new business opportunities to add value to New Zealand wool.

Sami Aljohani is a Research Assistant in the School of Chemical and Physical Sciences, Victoria University of Wellington. His MSc research, supervised by Prof Jim Johnston, investigated using Manuka honey and methylglyoxal as a natural antimicrobial agent in wool and polymers. His interests include material science and organic chemistry.

High Pressure Ground Injection for Subterranean Free -Form Structures.

KAWITI, DEREK (PRESENTING AUTHOR)
Victoria University of Wellington
derek.kawiti@vuw.ac.nz

HARLEN, TYLER (PRESENTING AUTHOR)
Victoria University of Wellington
tylerharlen@gmail.com

This paper investigates the re-application of the industry method of high pressure grouting used for ground injected water proofing for use as a means to create subterranean free form structures. The project carried out in conjunction with Ngāti Tukorehe, of Ōhau, Kāpiti utilises two approaches 'soft forming' and 'hard forming' to utilise ground based material as a pressurised 'scaffold' for the pressure injected form.

Three research outputs are presented; 1. Shallow rooted ground anchors to counter structural uplift in high wind zones. 2. Large scale free form injection to create excavatable structures for use as post disaster relief shelters. And 3. Free form injection for ground, erosion retention of shifting coastlines. Speculative testing of the method will be presented to show the application simulation and modelling.

Derek is a Senior Lecturer, Interdisciplinary Digital Design, director of multidisciplinary practice - CILOARC. Background in advanced parametric & procedural design methods, digital heritage, 'low' and 'high' tech' digital fabrication. Founder; collaborative research lab - SITUA (Site of Indigenous Technologies Understanding Alliance). Research collaborator, New Zealand Maori Arts and Crafts Institute of Te Puia, Rotorua. Research into new technical territories, indigenous hybrid fabrication practices and materials and additive manufacturing.

Tyler is an architectural graduate with a growing expertise in the use of digital tools, robotics and CNC based fabrication.

How new technologies are shaping the innovation landscape in New Zealand

PACKER, ADRIAN (PRESENTING AUTHOR)
IMS Projects
Adrian.packer@ims-projects.co.nz

Most modern innovation and product development processes state the importance of 'learning first' and retiring risk early. This is the key to failing fast and ultimately improving the economic return on innovation.

What can be missed is the importance of capturing the knowledge gained during the innovation process and a practical methodology for capturing and reusing that knowledge on subsequent projects. This is particularly true when projects fail.

This is changing. New technologies are available that enable innovators to capture knowledge quickly and to easily retrieve that knowledge when it is next required.

Rather than being clunky and challenging to use as was perhaps the case with previous knowledge management systems, new technologies are being released that are easy and intuitive to use and embedded into business processes. This means more people can be involved in innovation and overall employee engagement increases.

However, the real breakthroughs in innovation are being driven by systems that leverage powerful machine learning technologies. These systems allow the machine to estimate risks in the innovation project and help to close knowledge gaps with increasing pace and effectiveness.

In this discussion we will provide practical examples of how new technologies, supported by a structured innovation approaches, have enable New Zealand businesses to enhance their cultures and accelerate their innovation efforts.

Adrian has worked in business improvement for over 20 years. His areas of speciality include Lean, Innovation and performance coaching.

Adrian holds an MBA from Cranfield School of Management and a BSc Physics from Bristol University.

He is a Director in two NZ businesses: IMS Projects and Coherenz Consulting Ltd.

Advanced Composite Additives in New Zealand

DOUGHERTY, TROY (PRESENTING AUTHOR)
Nuenz Limited
troy.dougherty@nuenz.com

Nuenz manufactures advanced additives for composite materials. Today's ever-moving society is looking for new materials to solve challenges with fuel-efficiency, safety and improved performance across a wide range of applications. Nuenz is looking to market new additives technology into this space with our launch product, silicon nitride fibre, as well as other new innovative products. Over the last three years, Nuenz has established itself as a competitive technology provider in both aluminium metal composites and polymer composites.

Nuenz's proprietary silicon nitride fibre additive is a high-performance additive that can be used to improve the strength, stiffness and toughness of composites. Improved mechanical properties directly correlate to reductions in weight as less material is required in the product. Material reduction is important with current technology trends towards improved fuel efficiency.

Nuenz has carried out extensive work with metal composite, focusing primarily in aluminium metal composites. Aluminium is being used to displace ferrous metals in the automotive sector due to its high strength to weight ratio. Composites can help to increase the wear and further boost the mechanical properties without the need for exotic alloys. Nuenz has also recently been funded to progress this technology into the developing aluminium additive manufacturing space.

Nuenz has also developed proprietary polymer composite technology that allows rapid development of advanced additives into thermosetting polymers, such as epoxies, polyesters, polyurethanes and other industrial resins. Fast development allows us to rapidly formulate new composites with customers looking for improved performance, reduced costs or added safety.

This talk will cover the scale-up of Nuenz's silicon nitride additive, and discuss case studies of test studies involving metal composites, additive manufacturing and polymer composites.

Troy is the CTO at Nuenz Limited, overseeing R&D, production, IP, technical marketing. He obtained his PhD at the University of St Andrews, UK. Troy was a finalist in the 2018 Wellingtonian of the Year awards for his work in Science & Technology

Maximising the Mechanical Performance of Fibre-Polymer Composites via a Developed Understanding of Interfacial Adhesion and a Predictive Test Method

HAYWARD, MATILDA (PRESENTING AUTHOR)
Victoria University of Wellington
Matilda.hayward@vuw.ac.nz

JOHNSTON, JIM
Victoria University of Wellington
jim.johnston@vuw.ac.nz

DOUGHERTY, TROY
Nuenz
troy.dougherty@nuenz.com

The mechanical performance of fibre-polymer composites is largely determined by the strength of the interfacial adhesion across the phase boundaries. Typically, inorganic fibres and polymers are chemically incompatible owing to surface effects. The properties of fibre-polymer composites are, therefore, limited by the lack of strong interfacial interactions and the subsequent formation of interfacial voids.

Coupling agents (CAs) can be used to treat the surface of fibres to enhance interfacial adhesion and improve the composites' properties. The type of CA used has a significant influence on the composite performance and selecting a CA is a critical step in the design and optimisation of novel fibre-polymer composites. Appropriate selection of a CA is a current challenge facing the composites industry.

In this work, an in-depth understanding of the key processes involved in composite interfacial adhesion was developed. This knowledge was used to develop a proprietary test which can be used to predict which CA will onset the best interfacial adhesion in a composite and maximise the mechanical performance. The key features of the predictive test, which are necessary to make it applicable as an industrial standard, are that it is fast, cost-effective and accessible.

The predictive test was applied to a range of silane-based coupling agents (SCAs) to determine which onset the highest level of interfacial adhesion in Si3N4 fibres composites made with commercial thermoset polymer resins, including epoxies, vinyl esters and polyurethanes. The mechanical properties of the composites were tested to determine which SCA produced the composite with the highest mechanical properties for each polymer type. The results from the mechanical testing were compared with the predictions from the developed test to determine the accuracy of the new method. Using the techniques developed in this work, the mechanical properties of fibre-polymer composites were able to be improved by up to 40%.

Matilda Hayward is completing her PhD at Victoria University of Wellington. Her research focus is on quantifying and optimising interfacial adhesion in fibre-polymer composites with the aim of maximising the mechanical properties of novel materials.

Purging space junk through advanced manufacturing and innovative design

VAN DRUNEN, ERWIN (PRESENTING AUTHOR)
Rocket Lab
e.vandrunen@rocketlab.co.nz

The long-awaited era of dedicated small satellite launches has arrived, and with it, new challenges and responsibilities for launch providers. For years, the focus has been on providing a frequent and reliable service to space for small satellites. With this now a reality thanks to Rocket Lab's Electron launch vehicle, which completed three orbital missions in 2018, the question on the industry's mind is how to cope with the growing challenge of orbital debris, or "space junk", from high-frequency launch. There's now a rising cast of commercial launch players looking to provide a service to orbit for the burgeoning market. Given the number of satellites that will be put on orbit over the next several years, the safe and sustainable management of the domain must be a global priority.

Rocket Lab has designed and manufactured the nimble but powerful extra stage on Electron, named the Kick Stage, to create an accessible, but sustainable future for the commercial use of space. The Kick Stage is designed to deliver small satellites to precise orbits, before deorbiting itself to leave no part of the rocket in space. Not only does it offer unmatched precision and flexibility of orbital deployment, but after payloads are deployed, the Kick Stage re-orientates itself and reignites its engine to perform a deorbit manoeuvre, enabling it to re-enter the atmosphere and burn up. This revolutionary architecture leaves nothing on orbit, but the customer satellites, reducing debris and protecting orbital access for future generations.

Erwin van Drunen is a Principal Design Engineer at Rocket Lab. Erwin was involved in the conceptual design of the Electron launch vehicle architecture and has been with Rocket Lab for more than five years. He has a Bachelor of Science and a Master of Engineering in Biomedical Engineering.

Bio-inspired design for digital fabrication: 3D printed functionally graded structures

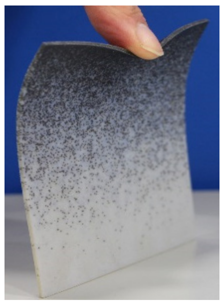
AMIRPOUR, MAEDEH (PRESENTING AUTHOR)
CACM, The University of Auckland
m.amirpourmolla@auckland.ac.nz

BATTLEY, MARK
CACM, The University of Auckland
m.battley@auckland.ac.nz

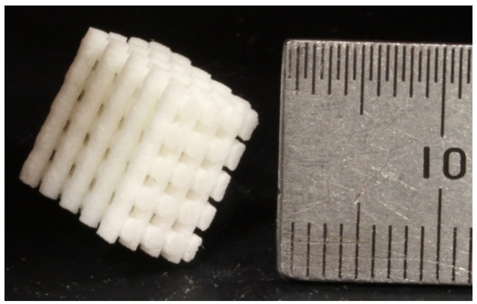
BICKERTON, SIMON
CACM, The University of Auckland
s.bickerton@auckland.ac.nz

Digital fabrication technologies such as multi-material additive manufacturing provide exciting opportunities to precisely control how and where material is distributed within geometrically complex structures, particularly for heterogeneous materials such as composites. Combining these with advanced structural analysis and design techniques provides opportunities to enhance product performance and durability through minimising failure issues such as stress concentrations and delamination.

Inspired by nature and biological systems, where form is characterised by heterogeneous compositions, the concept of functionally graded structures is introduced. Material composition and properties vary spatially in functionally graded structures to exhibit multiple functionalities within a single multi-phase and geometrically complex build. Examples include a functionally graded plate with continuous gradients of tailored properties (Figure 1.a) and a multi-scale cellular structure (Figure 1.b). Finite element simulation and experimental testing have been used to characterise the performance of these integrated functional components and refine their design to satisfy multiple functionalities such as structural rigidity and dynamic responses. The research will be beneficial for real life applications of functionally graded plates in engineering structures such as wing components, prosthesis, scaffold for biomedical applications and gradient alloys for carbon fiber composite for use in low-temperature spacecraft panels.



(a)



(b)

Figure1: Developed 3D printable functionally graded plate with tailored stiffness

Maedeh is a Research Fellow at Centre for Advanced Composite Materials (CACM), the University of Auckland. Her research interests are in the multi-physics simulation, design and computational modelling of advanced composite and multi-functional materials.

INNOVATION IN MANUFACTURING AND DESIGN
Concurrent Conference Session 3 | Great Room 2

Oral Abstracts

Discovery and application of the dichroic effect in cuprous oxide particles

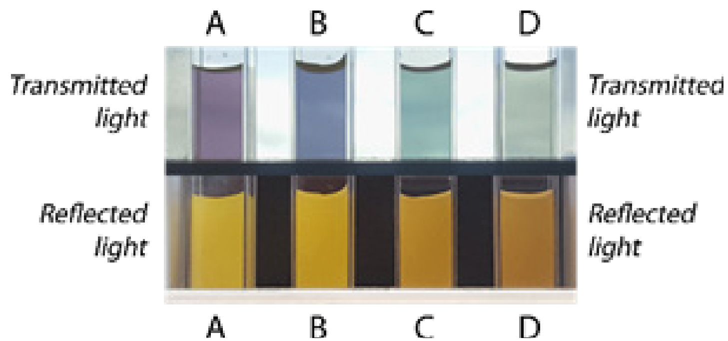
WRIGGLESWORTH, EMMA (PRESENTING AUTHOR)
Victoria University of Wellington
emma.wrigglesworth@vuw.ac.nz

JOHNSTON, JIM
Victoria University of Wellington
jim.johnston@vuw.ac.nz

When a material displays one colour in transmitted light, but a different colour in reflected light, it is known as the dichroic effect. Traditionally this effect has been observed and studied in metallic gold and silver nanoparticles, however further work is still necessary to determine what factors dichroism can be exclusively assigned to. It is therefore desirable to find alternative materials that display the effect to better understand it, whilst also increasing the colour range available for application.

We present the synthesis and novel application of non-metallic cuprous oxide particles that display the dichroic effect. By careful manipulation to control the particle shape and size we are directly able to control the colours displayed, producing samples that are bright yellow, orange or brown in reflected light but purple, blue or grey in transmitted light (see figure).

The colours produced have been characterised using absorption, reflectance and CloudSpecTM (MaramaLabs) spectroscopy and linked to the particle size and shape observed via electron microscopy. Combined with results from theoretical simulations this has significantly improved our understanding of the relationship between the observation of the dichroic effect and the particle properties. We have further incorporated the cuprous oxide into polymer systems with control of the particle size and shape and the polymer-particle interaction, effectively producing solid-state composites where the colour displayed depends on the direction of the light source. We foresee exciting potential applications for such materials in the areas of design and security.



Emma Wrigglesworth is in the final year of her PhD in Chemistry at Victoria University of Wellington. Her research is focused on the design and synthesis of nano- and micro-particles with unique optical properties, and their incorporation into polymers for application.

Identifying Winning Products – committing to the right idea

FARIS, DANIEL (PRESENTING AUTHOR)
Locus Research Ltd
daniel@locusresearch.com

ALLAN, TIM
Locus Research Ltd
timothy@locusresearch.com

No amount of hard work can make up for pursuing the wrong idea.

Developing new products and services is a challenging, and expensive undertaking. Before undertaking one of these projects, there are three critical questions that must be addressed up-front:

a) Have we identified a winning product idea?

1. Do we have the right ingredients for success?

2. Is our team seamlessly integrated across the project?

Identifying Winning Products sets out a practical framework for ensuring these three areas are configured to deliver exceptional products to market.

Idea

How to assess an idea's point of difference to ensure it addresses a real problem or opportunity that resonates with your audience. Choosing well what to invest yourself and your resources into is your most important decision.

Ingredients

The right resources, a well thought-out process and good decisions underpin the development of winning products. We can consider these elements the conditions necessary within the business for delivering a winning product.

Integration

Creating successful products means having an open an collaborative team. This means breaking down the division between the different stages of. It's all about collaboration and customer experience

Integrating these elements within the culture and structure of your business puts the right ingredients for success in place, for both yourself, your team, and those who use your products. This presentation will explore practical application of these structures with a view to delivering world-beating products.

Daniel Faris is CEO of Locus Research and Sustainable Design practitioner. A specialist in commercialisation, he drives complex, multi-disciplinary projects from strategy through to delivery, across diverse industries and subject matter areas. Daniel brings his deep appreciation for human-centred design to the practical and commercial realities of sustainable product development.

INNOVATION IN MANUFACTURING AND DESIGN
Concurrent Conference Session 3 | Great Room 2

Oral Abstracts

Free and Open Source Software for Design and Manufacturing

EGAS, JOSE (PRESENTING AUTHOR)
University of Canterbury
jose.egasortuno@pg.canterbury.ac.nz

CLUCAS, DON
University of Canterbury
don.clucas@canterbury.ac.nz

Traditionally, the development of Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and Multi Body Dynamics (MBD), has been led by software packages such as Catia, Solidworks, Ansys, PTC Creo, Adams, etc. To achieve stable operation, these software packages require immense development effort, demanding large teams of software developers and scientists in order to offer reliable products to be used in industry, research and education applications. One of the consequences is the high price of the software licenses, which may not be affordable for a large number of industries, Universities, and students around the world. This has catalyzed the appearance of software packages mantained by communities of people: students, engineers, hobbyists, but also companies and Universities, whose objective is promote the accessibility to these computational tools. CAD, CAE, CAM and MBD Free and Open Source Software (FOSS) packages, such as OPENCASCADE, Calculix, OpenFOAM and MBDyn, have appeared and are under constant development. They all share a common characteristic: their source code is under some form of Copyleft, so it is freely accessible for everyone. A group of international developers have undertaken the challenge of integrating some of these packages into a single, user friendly software called FreeCAD, which poses some advantages over private software, the main are:

Accessibility: FOSS is free of charge, thus, it is available for a much wider range of users; Flexibility: since the source code is available, FreeCAD can be adapted for a wider range of applications; Reliability: FreeCAD can be installed on GNU/Linux OS, which is more reliable and efficient than Microsoft Windows or macOS. Some of the weaknesses are: Stage of evolution: despite FreeCAD is evolving fast, it is at an early stage compared with private software. Lack of support: since it is developed by a community of people, FreeCAD does not offer any official support or warranty. We present a review of the development state and working methodology of FreeCAD. Its strengths and weaknesses are analyzed and compared to traditional (not open source) tools.

The Double-Edged No. 8 Wire of New Zealand Design

JACK, HAYDN (PRESENTING AUTHOR)
Blender Design
haydn@blender.net.nz

A personally recounted experience demonstrated contemporary approaches to product design in three different countries while studying consecutively in Auckland, Edinburgh and Eindhoven - consequently reflecting the stark contrast in the approaches of new designers internationally.

Studying in New Zealand placed a deep focus on a generalist mindset to learn a myriad of skills in designing and manufacturing processes. Design school experiences in Edinburgh endorsed industry specialization in conceptualization and communication, bypassing manufacturing voids to be assumingly handled by the much larger industry. Netherland's finest graduate projects at Dutch Design Week showed an astonishing ability to conceptualize the most absurd ideas, executed with ridiculous craftsmanship.

Two contrasting approaches to R&D between Europe and NZ have emerged. The highly resourced, specialist nature of Europe make it truly the factory of "new" ideas - professionals stick to their guns but do it well. Conversely, NZ designers are honed to be excellent generalists, see the bigger picture, and become "T-Shaped" people.

It is fair to say the No. 8 wire mentality is a double-edged sword in the world of manufacturing and design. We have the ability to solve problems with little resources and inspire hope in a new venture - but this doesn't guarantee the best result commercially. The problem is, resources are rarely available to truly commercialize an idea formed on a shoestring budget, otherwise, it wouldn't be the case.

Our size prevents us from hiring true specialists, so our designers, engineers and manufacturers all have expertise across disciplines - each is a T-shaped person with a specialization, yet is empowered to work in multiple facets. This needs to be capitalized on if we are to outplay Europe or China - a cohesive manufacturing and design unit will only leverage our No. 8 mentality. We need to emphasize what we're good at, but we need to do so collaboratively and stop trying to do everything ourselves!

Haydn Jack originally graduated from AUT as the Head of School, leading to his profession as an industrial designer and affiliated member of DINZ. Haydn currently operates at Blender Design and also represents BMW NZ as an ambassador amongst his other entrepreneurial and sporting pursuits.

NZ's Opportunities in Nanofibre Technology

HOSIE, IAIN (PRESENTING AUTHOR)
Revolution Fibres Ltd
iain@revolutionfibres.com

Revolution Fibres Ltd is a global leader in nanofibre production and advanced textiles manufacturing. Revolution Fibres already commercialize different products for various clients in areas like filtration, skin health, composites, acoustics, biotechnology and anti-allergy bedding.

Revolution Fibres has developed the most adaptable and robust electrospinning method in the world, allowing it to make non-woven textiles from a wide range of polymers and biopolymers, with functional bio-materials. Electrospun nanofibre technology has a vast innovation potential for many markets. In turn, NZ has a unique opportunity to exploit nanofibre technology in multiple global markets.

Revolution Fibres will present a range of case-studies where NZ and international firms have unlocked the technology potential of nanofibre, allowing us to fast-track innovation and product development and create large opportunities for the NZ manufacturing and bio economies. It will present a showcase of The Iguana, the world's largest electrospinning machine in the world (designed and made in NZ) which is devoted to collagen nanofibre production for cosmetic and healthcare applications.

For Revolution Fibres, electrospinning is not just about creating small synthetic fibres, but instead active fibres which do things like absorb sound, capture pollutants, sustain life, alter your skin appearance, and toughen the world's strongest materials. Revolution Fibres will present emerging market and technology trends that NZ can exploit through electrospinning – helping direct commercial, academic and funding activity in the years ahead.

Iain Hosie (Founder, CEO) co-founded Revolution Fibres in 2009, leading the company to become a global leader in nanofibre manufacturing. Iain is a scientist with a background in environmental health, government policy, product development and sales. Iain is a passionate advocate for nanofibre manufacturing and its commercialization in many sectors.

The Core Function – reframing your product system

ALLAN, TIMOTHY (PRESENTING AUTHOR)
Locus Research Ltd
timothy@locusresearch.com

The concept of 'Core Function' uses life cycle thinking to drive design breakthroughs by reframing your product system.

Life Cycle Thinking (LCT) is an effective tool for considering the sustainability of a product from resource extraction to end-of-life. However, a purely analytical approach has some limitations when we consider how product systems deliver value to the people who use them. Without expanding the scope of this approach, we risk limiting ourselves to making piecemeal changes to existing product systems, or, strictly technical changes that may 'break' the delivery of value to the end-user.

The approach discussed in this presentation takes a key building block of life cycle assessment (LCA) called the 'Functional Unit' and translates this into the 'Core Function' of a product. The functional unit provides an excellent mechanism for designers to look at the product system rather than the object. A simple example often used is comparing a glass milk bottle versus a plastic milk bottle. In this scenario, the functional unit is not the bottle, but 'the delivery 1000 litres of milk'.

While the functional unit is invaluable for analytical purposes, it does not provide design insight. By looking closely at what the user really wants, in this case 'convenient fresh milk', we dissolve the constraints and enable teams to find new pathways for delivering innovative new solutions. In this case, Convenient Fresh Milk becomes the core function of our product system. By focusing on the delivery of this core function, we are equipped to view the challenge from new and novel angles, prompting the development of deeply sustainable solutions.

This approach pushes designers to apply a new mindset to sustainable design; considering what a product system really means for the humans who use it, and innovating accordingly.

Timothy Allan is Founder of Locus Research. With more than 20 years' experience as an innovation and R&D leader, Tim has a wide range of experience in the development of new businesses, driven by disruptive products. He has proven ability heading complex product development projects and diversified design teams.

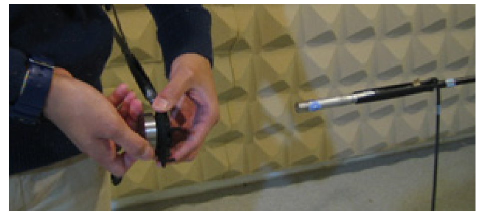
Dial Feel and Sensory Design
Bridging the gap between industrial design and mechanical engineering

BARRÉ-DEBILLY, FLEURINE (PRESENTING AUTHOR)
Fisher & Paykel Appliances
fleurine.barre-debilly@fisherpaykel.com

CHANG, GAWIN
University of Otago Summer Intern at F&P
chahu676@student.otago.ac.nz

Our aim is to understand the impact of every single mechanical parameter of a product on the perception of quality via analysis of the sensory perceptions of the user in order to capture, quantify and maintain consistent levels of perceived quality in our products.

Sensory Design approaches product development from the analysis of the impact a product has on its user's senses. Oven dials are the first point of physical contact between the user and the product and therefore influences the customer's perception of the overall quality of the product.



Our interest is to understand how each of the user's sense might affect the other. For example, how the sound of a dial will affect the user's perception of its feel.

The focus of Gawin's work has been to quantify a number of physical parameters in our new dial and develop a consumer testing method to help us understand how each parameter influences the user's perception of the product and how different parameters can together affect this perception. This involved a study of potential users ranking different dials in order of preference based on the sound and feel of the dials, both separately and in concordance.

This presentation will give an overview of our long term goals using sensory design, run through the testing method used for Gawin's sensory analysis of the dial as well as an insight into what might come next for sensory design at Fisher & Paykel.

Fleurine Barré-Debilly is a mechanical product development engineer specialising in Cooking Customer Interface at F&P in Dunedin.

The effect of vacuum conditions on feature quality and machining efficiency for ultrafast laser micromachining.

ASHFORTH, SIMON (PRESENTING AUTHOR)
aDepartment of Physics & School of Chemical Sciences, University of Auckland
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
s.ashforth@auckland.ac.nz

ARUL, RAKESH; MINNEE, THOM; AGUERGARAY, CLAUDE; BRODERICK, NEIL
aDepartment of Physics & School of Chemical Sciences, University of Auckland,
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
c.aguergaray@auckland.ac.nz

Ultrafast laser micromachining that utilises pulses on a femtosecond timescale is a rapidly growing area of research with applications in a wide variety of fields, from microelectronics to microsurgery. Often praised for their ability to perform precise cutting of materials through a 'cold-cutting' mechanism which avoids mechanical and thermal collateral damage to the surrounding material. However, the high precision and clean ablation features associated with ultrafast laser micromachining can be counteracted through the intense plasma in air that is generated at high pulse energies. The highly reflective plasma generated above the sample surface can result in a distorted beam profile at the target machining plane, producing machined features with reduced edge quality and accuracy. In addition, the highly reflective plasma results in underutilised portions of the incident pulse energy, therefore decreasing machining efficiency.

Using a femtosecond pulsed laser system (τ = 130 fs, repetition rate = 500 Hz, λ = 800nm) we present the ablation threshold data and trends for a variety of materials including undoped silicon and stainless steel whilst laser machined under vacuum and ambient conditions. Ablation features are analysed extensively to observe the impact of the ambient conditions (ambient air versus vacuum) on the resulting feature quality and machining efficiency

Simon Ashforth is Research Engineer of the Photon Factory at the University of Auckland and at Engender ltd. He is in particular focused on work within the micromachining area and using laser based technology to solve manufacturing issues. Simon recently completed his PhD at the University of Auckland, before accepting a role at a new company he helped develop, Engender.

Decorative black coatings on metallic surfaces by ion beam engineering

GUPTA, PRASANTH (PRESENTING AUTHOR)
GNS Science
p.gupta@gns.cri.nz

FANG, FANG
GNS Science
v.fang@gns.cri.nz

MURMU, PETER
GNS Science
p.murmu@gns.cri.nz

LEVENEUR, JEROME
GNS Science
j.leveneur@gns.cri.nz

FIEDLER, HOLGER
GNS Science
h.fiedler@gns.cri.nz

LOHO, THOMAS
University of Auckland
thomas.loho@auckland.ac.nz

KENNEDY, JOHN
GNS Science
j.kennedy@gns.cri.nz

New approaches to synthesize decorative black coatings on metallic surfaces are of significant research and commercial interest to manufacturing industries. In this work, decorative hard black coatings were deposited on a titanium surface by carbon ion implantation at ambient temperature. A 10 keV C+ beam was implanted on a Ti substrate to a fluence of 1 - 1.25 × 1018 C cm-2. Rutherford backscattering spectrometry and transmission electron microscopy results show that the implantation resulted in a multi-layered coating structure with a ~ 50 nm amorphous carbon layer at the surface followed by a ~ 50 nm amorphous titanium carbide intermixing layer deposited on top of a crystalline Ti surface. Raman spectroscopy confirms the formation of carbide intermixing layer and shows that the amorphous carbon layer has 15 – 20 % sp3 content. Nanoindentation measurements show that the surface hardness of the implanted surface has increased by 72%, from 3.7 to 6.6 GPa, upon carbon implantation. Scratch tests further demonstrate a reduction in coefficient of friction in the implanted surface by 25% signifying an improvement in wear-resistance of the coated materials. Colorimetry measurements reveal that carbon implantation reduces the luminosity of the Ti surface from 77 to 49 and chromaticity from 4.67 to 1.36 confirming incorporation of black colour on Ti surface. The results demonstrate that C implantation onto a Ti surface at high fluence results in a black coating with high surface hardness and wear-resistance that can be employed in decorative surface applications for manufacturing industries. In this presentation, the opportunities offered by ion beam engineering for producing decorative and hard coatings for metallic surfaces will be discussed.

Prasanth is an Ion Beam Scientist within the Materials team at GNS Science. His expertise lies in applying ion beam techniques for novel material fabrication, modification and testing. He is currently working on developing functional materials and coatings for magnetic sensors, decorative and surface protective applications.

Cooking Vessel Temperature Sensing

GREEN, CHRISTOPHER (PRESENTING AUTHOR)
Fisher & Paykel Appliances Ltd.
Christopher.Green@fisherpaykel.com

DIXON, GREG
Fisher & Paykel Appliances Ltd.
greg.dixon@fisherpaykel.com

FERNANDES, CALVIN
University of Auckland Intern, Fisher & Paykel
fernandes.calvin7@gmail.com

Cooking fires pose a danger to people and property. In New Zealand 25% of houses fires start in the kitchen. International standards agencies are working on establishing cooking fire regulatory guidelines. Several organisations have attempted to address this hazard by using sensors overhead the cooking surface or attached to the cooking vessels.

The goal of this project was to:

a) Review what cooking temperature monitoring technologies were commercially available, and to

b) Determine the most effective locations on and within the gas cooking surface for detecting cooking over-temperature for fire prevention.

Alongside a commercially available Safera Airis monitoring unit, Calvin Fernandes tested various likely sensor locations on a gas cooktop to determine their suitability for monitoring for over-temperature. This was done by measuring the temperature at various locations, in, on and around the cooking surface alongside the food load. The temperature profiles at each location were analysed for rate of change, and offset to the food load temperature.

Besides the food load, it was found that the trivet was the next best location that most closely followed the food load temperature. This location will be explored further as a potential solution in future projects.

Christopher Green is a Product Designer, working in the Surface Cooking team at Fisher & Paykel Appliances Ltd with 16 years' experience.

Retro-fitting for data acquisition and analytics in an Industry 4.0 setting

TOMZIK, DAVID (PRESENTING AUTHOR)
Laboratory for Industry 4.0 Smart Manufacturing Systems, University of Auckland
d.tomzik@auckland.ac.nz

XU, XUN
Laboratory for Industry 4.0 Smart Manufacturing Systems, University of Auckland
xun.xu@auckland.ac.nz

Successful implementation of Industry 4.0 can be associated with extensive investments. However, small steps can be made to get started. It is possible to retrofit existing machines and devices to feed data in a standardised manner to a remote cloud-based system.

This case study demonstrates the retrofit of a KUKA KR16 industrial robot and its KR C2 control system with a 10 $ WiFi-enabled chip to upload machine data into the university's research cloud. It provides the following functions:

a) Background monitoring: Custom software on the control computer runs in the background and sends machine data via the serial port to the connected chip. The chip connects to the wireless network and forwards the data via the internet using an IoT messaging protocol (MQTT). This method can work with limited hardware and software and does not interfere with the existing setup.

• Mobile visualisation: The data can be accessed and visualised with near real-time capability through a website. It is not limited to a local machine, application or specific platform.

• Storage and analytics. A database stores the received data. Historical data can be used to analyse the uptime or reconstruct the robots' movements if necessary (e.g. QA). Custom tools can be developed or available services used to connect to the database and performer further sophisticated analyses.

In the future, we can expect more devices with increasing computational power which can easily connect to existing devices and infrastructure. A growing amount of industrial software and applications will be sold a service. This will lower financial and technological obstacles for the transformation into Industry 4.0.

Prospective industrial applications are:

• Extension of an asset's lifetime

• Mobile and worldwide asset monitoring

• Optimisation of machine uptime

• Assessment of historical data for reconstruction and QA

David Tomzik is working on his PhD in Mechanical Engineering at the University of Auckland. His project centers on the development of a distributed cloud-based control system for use in manufacturing. He holds degrees from RWTH Aachen and Tsinghua University.

Design for Art's Sake! An Art-Centric Design Philosophy

MCGREGOR, ANGUS (PRESENTING AUTHOR)
University of Canterbury
angus.mcgregor@pg.canterbury.ac.nz

GOOCH, SHAYNE
University of Canterbury
shayne.gooch@canterbury.ac.nz

Producing kinetic artwork requires a collaboration between researchers and practitioners in engineering and fine arts. Engineers and artists generally have different approaches to creating physical artefacts, and engineers need a specific design framework to interface with artistic projects.

This paper concerns the modification of a well-known engineering design process to create an artist-centric approach to evolving an artwork. In doing so, the paper formalises bespoke methods used to develop several kinetic sculptures designed by artist Len Lye.

Following the death of New Zealand born artist Len Lye in 1980, the Len Lye Foundation was established to preserve Lye's work. Soon after, a collaborative relationship evolved between the Department of Mechanical Engineering at the University of Canterbury and the Len Lye Foundation. The union of conservation, engineering, and art is not new, but the University of Canterbury's work in developing new artworks places the onus on engineers to deepen the understanding of our involvement in artistic processes.

Typically, Lye's sculptures contain highly flexible vibrating elements which create unique audio-visual performances. These sculptures are often size limited by practical and economic limitations, and it is the responsibility of the engineer to provide a practical and technically feasible solution to build the artwork in accordance with the artists brief.

Prioritising an artist's aesthetic needs is critical to producing kinetic artworks. This process often requires negotiation between the engineer and the artist to establish a solution that meets artistic objectives and expectations. Increasingly, a considered approach to safety is required – particularly when exhibiting works in public spaces.

This methodology is verified by the art world's acceptance of posthumously completed Len Lye sculptures including Big Blade (1999), Wind Wand (1996), and Water Whirler (2006) and is a necessary attempt to answer the question: how do engineers ensure collaboratively designed art belongs to an artist?

Angus McGregor is a mechanical engineer and PhD student in the Mechanical Engineering Department at the University of Canterbury. He completed a professional engineering degree in 2015, and has worked alongside the Len Lye Foundation since 2015.

Optimization of multi-part production in additive manufacturing for reducing support waste

JIANG, JINGCHAO (PRESENTING AUTHOR)
University of Auckland
jjia547@aucklanduni.ac.nz

XU, XUN
University of Auckland
Xun.xu@auckland.ac.nz

STRINGER, JONATHAN
University of Auckland
j.stringer@auckland.ac.nz

Additive manufacturing (AM) is becoming increasingly popular because of its unique advantages. However, AM still suffers from support material waste during the fabrication process when overhanging features exist. Plenty of research has been carried out for minimizing support usage. However, former studies only focused on the optimization for a single part fabrication. In this paper, a four-step strategy of multi-part production for reducing support consumption in AM is proposed. When printing a group of parts in the same build vat or chamber, the proposed strategy optimizes the print orientation for each part, combines every two parts based on the geometries, proposes several possible multi-part combinations, and then selects the optimal part positions for fabrication. Two case studies are carried out for verification. The results show that the four-step strategy can significantly reduce the support waste and total fabrication time.

Jingchao Jiang received his Bachelor's degree in Marine engineering from Ningbo University, China. He is doing his PhD now at the University of Auckland in New Zealand. His research interest includes 3D printing and Additive manufacturing.

SfTI Strategy for Tranche 2 Funding

CLELAND, DON J. (PRESENTING AUTHOR)
Science for Technological Innovation and Massey University
d.cleland@massey.ac.nz

The Science for Technological Innovation (SfTI) National Science Challenge started in 2015. SfTI was recently awarded $73M over five years for its second tranche of funding starting in July 2019. In the first tranche, SfTI tested different approaches to mission-led science. SfTI created a project entitled “Building NZ’s Innovation Capacity” in which innovation and Vison Matauranga researchers studied the physical sciences and engineering researchers to better understand what methods and approaches were most effective. Other innovations included industry-led workshops to define future research direction, research team formation via collaborative co-creation processes and a ballot system for its competitive seed funding.

In the second tranche, the focus on stretchy and NZ-sticky research will continue. New spearhead projects underway or being developed include Atea (creating a learning environment for Maori communities), precision technology for aquaculture, adaptive learning robots to complement the human workforce, information exchange in the digital age, and clean water technologies. Further additionality is sought by changing behaviour of the NZ innovation system. SfTI will create further capacity development opportunities to increase the skills of our researchers including: how to connect with industry, Maori organisation and the wider research ecosystem; how to communicate with a range of stakeholders; how to collaborate for best outcomes; and how to incorporate commercial thinking into their research. A science quality review, further mission labs, and giving priority to emerging researchers in competitive seed funding will ensure that SfTI research remains relevant and cutting edge.

Don Cleland is Professor of Process Engineering in the School of Food & Advanced Technology at Massey University and the Theme Leader for Materials, Manufacturing Technology and Design in the Science for Technological Innovation (SfTI) National Science Challenge. His research interests are industrial refrigeration, heat pumping, energy efficiency and food processing.

Diagrams for communicating strategy in R&D organisations

GULLIVER, LAURENCE (PRESENTING AUTHOR)
University of Auckland / Fisher & Paykel Healthcare Ltd.
laurence.gulliver@gmail.com

Communicating strategy to employees is difficult. This presentation will help you communicate strategy using diagrams within your R&D organisation, by understanding how people engage with different diagram options.

There is no one way to innovate in R&D, and frequently project teams are given a flexible scope to help foster innovation. This incurs the risk of the R&D project team deviating from the overall intended direction of the R&D organisation.

Strategy diagrams are a simple way for R&D teams and employees to understand the connection between the idea/component/product/service they are developing and how it contributes to the organisation’s strategy.

How should you create a strategy diagram? The answer is (of course); it depends. But there are some guiding principles depending on your desired outcome. A quantitative experiment was conducted (in partnership with Fisher & Paykel Healthcare) to test different strategy communication methods.

The results yielded some interesting findings which will be discussed including that a bespoke approach was preferred and works best for engagement, but that an off-the-shelf approach (e.g. business model canvas) is as effective at communicating the key concepts as bespoke diagrams.

Laurence Gulliver has always had an interest in strategy, and completed an MBA thesis on the topic of communicating strategy visually in 2017. Laurence is employed at Fisher and Paykel Healthcare Ltd. as the General Manager of the Noninvasive Ventilation (NIV) part of the business.

Skills Shift in Manufacturing – a New Zealand Perspective

ADAM, DIETER (PRESENTING AUTHOR)
The Manufacturers' Network
dieter@themanufacturersnetwork.org.nz

ORMANDY, KIERAN
The Manufacturers' Network
kieran@themanufacturersnetwork.org.nz

Technology changes in manufacturing are accelerating, driven by a much wider application of digital and information technologies and increased adoption of automation. These changes are made to manufacturing processes as well as products and associated services. There are now a number of overseas papers attempting to predict how these technology changes will impact future skills requirements in manufacturing, referred to as Skills Shift.

New Zealand manufacturing is different from major manufacturing economies overseas in several aspects. We have high levels of direct exposure to global markets and, outside of food & beverage, hardly any larger manufacturing operations, and very little long-run manufacturing. New Zealand also has few (if any) substantial manufacturing industry clusters outside of food and beverage.

As part of the New Zealand government's Future of Work Forum initiative, we have undertaken research to understand Skills Shift in the context of New Zealand manufacturing. We interviewed manufacturing leaders and their employees, on how they see current skills shortages, and how skill sets will have to change to prepare leaders and employees for a future where manufacturing processes, products and services will evolve rapidly, driven by digital technologies.

We shall report on initial findings from our research and compare our results with overseas studies in the same area.

Dieter Adam has a Ph.D. in plant biotechnology and held academic research and teaching positions in Germany, Denmark and New Zealand, followed by senior management positions in the primary industry and at NZTE. Dieter took up his current role as Chief Executive of The Manufacturers' Network in May 2015.

Effectuation behaviour of researchers: Evidence from a National scale research programme

WOODFIELD, PAUL (PRESENTING AUTHOR)
Auckland University of Technology
paul.woodfield@aut.ac.nz

RUCKSTUHL, KATHARINA
University of Otago
katharina.ruckstuhl@otago.ac.nz

The effectuation process suggests that entrepreneurs utilise their various means including background, education, networks, and personal characteristics, to forge ideas into new products or developing ventures. Although the effectuation process has grown in prominence in relation to expert entrepreneurs, what is not well understood is how effectuation behaviour plays out in different settings. However, some precedent has been set for moving effectuation theory away from entrepreneurship toward R&D research.

Our paper attempts to bridge the gap between our current understandings of effectual behaviour with how large research teams of engineers and scientists develop effectuation practices. In doing this, we explore effectuation behaviour as part of the innovation process of a National mission-oriented research and innovation programme. This programme is tasked with growing a hi-tech New Zealand economy via the physical sciences and engineering, and through the integration of mātauranga Māori and western science.

We employ a qualitative multiple case study approach where we can reflect upon historic events whilst simultaneously focus on contemporary events. The context of the study is the New Zealand Science for Technological Innovation (SfTI) National Science Challenge. For our data collection and analysis we have access to about 300 researchers from nearly 40 organisations including five international organisations. These organisations include multiple universities, Crown Research Institutes and private research institutes, industry, and Māori stakeholders.

Our study extends innovation management literature through challenging traditional mechanisms used to develop innovation in the physical sciences and engineering context, by bringing into question effectual and causal logic processes. We reason that in mission-orientated research and innovation programmes, effectual logic is prevalent albeit not recognised. As such, we seek to close the gap in our understanding of how innovation is developed through large research teams with little or no pre-existing relationships. We suggest that following an effectual logic in garnering innovation activity can lead to a more engaged research team.

After a decade traversing the property industry in consulting, contractor, and engineering roles, Paul is now in the department of International Business, Strategy, and Entrepreneurship at AUT. He is also part of the National Science Challenge: Science for Technological Innovation, investigating "Building New Zealand's Innovation Capacity".

An expedition through the valley of death

STOREY, GREG (PRESENTING AUTHOR)
Blender Design
greg@blender.net.nz

The valley of death phrase has traditionally been used to describe the period of expenditure between initial investment and revenue generation for a new enterprise. Drawn graphically the descent down the valley is expenditure whereas the ascent is revenue on the other side - this creates an image of a valley. Without sufficient revenue an enterprise cannot be sustained.

The concept can be extended to other facets of a new enterprise such as with the development of new technology. The viability of a new technology is unknown initially and can often fall short of what is required in a successful product. In the valley of death scenario the technology must be viable and fit for purpose to enable revenue generation. Otherwise it will languish as a novelty.

In 2010 I co-founded a company called Eyejusters in the United Kingdom to commercialise adjustable focus eyewear where the power of each lens can be adjusted by the user. During our product development journey my colleagues and I had to find ways to unlock and improve on the technology and expertise in academic institutions and in industry. Our currency was a combination of ambition, ideas and altruism. To gain access to the expensive equipment and knowledge of academia and industry we needed to offer fresh ideas and the opportunity for mutual development. This gave us access to equipment and knowledge that would have otherwise been out of our reach without significant capital investment that we did not have at the time. These experiences are the story that I have to tell.

Greg Storey is a Senior Development Engineer with Blender Design. In the past he co-founded a start-up technology company to manufacture adjustable focus eyewear from the concept phase through to production. Through this venture he has learnt a great deal about the challenges of developing technology for commercialisation.

Platform economies and blockchain. Evolution? Revolution? Or do we even know what is going on?

MCMEEL, DERMOTT (PRESENTING AUTHOR)
University of Auckland. Faculty of Creative Arts and Industry
d.mcmeel@auckland.ac.nz

The 21st Century has been dominated to date by the emergence of ‘platform economies’ like Uber and AirBnB. They becomes central to connection and exchange of things of value between services providers and service users. A feature of these companies is they use their digital platforms to reorganize or connect physical assets. This is a departure from earlier platforms which centred on the digitization of things, such as music, videos or personal data which got moved around. This shift has seen digital economies emerge and come to dominate sectors—such as rental and taxi—that would have historically been considered insulated from digital platforms as the value they provide involves things (cars, rooms) that cannot be digitized. Are manufacturing and design susceptible to this disruption? Uber and AirBnB entered and dramatically disrupted established sectors through the implementation of a digital platform for connecting people who provide a service to people who need it. Incumbent stakeholders in these sectors, as yet, have not able to provide a response to these start-ups. This type of disruption does not favour existing stakeholders; it provides greater convenience for the service users but it is often associated with greater uncertainly for the providers. It redistributes wealth, power and the platform—and thus algorithms—become the main mediator of the service, not people. We are only starting to understand these technologies also reveal new things of value with a business or process and thus new opportunities for new services or entire new business opportunities. In this presentation I will summaries some of the background to the research, then report on a BRANZ funded project, using design research we are working with businesses to help them understand and explore the hidden implications of blockchain and the platform economy and think about how they might redesign their business.

Dermott McMeel is a lecturer and researcher in Design and Digital Media at the University of Auckland. He has degrees in Architecture from the Queens University in Belfast (1995, 1999) and a PhD (The Artistry of Construction) from the University of Edinburgh (2009). His research focuses on the social, organizational and cultural disruption that technology causes in the built environment. He has sustained a critical inquiry into how architecture, public space and design processes are influenced by various communication technologies through a variety of installations, funded research, journal articles and conference publications.

Disruptive Process Technology adoption by SME manufacturers: Insights from Austria, Australia and New Zealand (paper)

HUSTED, KENNETH (PRESENTING AUTHOR)
University of Auckland
k.husted@auckland.ac.nz

EL SAHN, ZIAD
Northumbria University
ziad.elsahn@northumbria.ac.uk

CALLAGHER, LISA
University of Auckland
l.callagher@auckland.ac.nz

KORBER, STEFAN
University of Auckland
s.korber@auckland.ac.nz

SIEDLOK, FRANK
University of Auckland
f.siedlok@auckland.ac.nz

Extant innovation theories and studies of Industry 4.0, robotics and artificial intelligence assert that adoption of such potentially disruptive technologies requires discontinuous changes to internal processes, close interaction with technology providers and considerable support and coordination with external networks. Yet, we only have a limited research-based knowledge about how these changes are initiated and embedded in small to medium sized firms (SMEs).

We explored the process of SME adoption of potential disruptive technologies through case studies nine Austrian, Australian, and NZ SMEs, finding:

• The companies did not have formal processes to identify, assess and implement new technologies. They largely relied on individuals with an interest in new technology and the position to advocate for technology investment

• Companies with some technology scanning and assessment processes were more likely to consider the benefits and challenges related to the technology prior to the adoption, suggesting that developing such processes should be part of the work associated with the adoption of the technologies themselves

• When technology searching, the NZ and Australian companies relied predominantly on international (Europe, US) trade shows to identify relevant technologies and identify potential suppliers. They reported that local re-sellers and government agencies provided limited input into the search processes

• All were passive users of the new technology. Only one company developed parallel processes to automate internal processes after the adoption; there was little evidence of engaging as lead users, beyond visiting other companies to see the technologies in operation

• Few companies considered new technologies as direct replacements for existing processes. Rarely, were the wider gamut of opportunities (e.g. business model innovation) considered. This highlights that, at least for SMEs, additive manufacturing is (mis)conceived as a cost-saving investment only and opportunities for further utilization are not seen

• The companies made few organizational adjustments for the new technology, beyond machine training provided by the suppliers.

As Professor of Innovation and Research Management, Kenneth Husted is co-developer of the MaDE CoRE bid. His research concerns R&D collaboration, science and innovation policy, innovation in low and medium tech industries, and knowledge management and governance.

ENTREPRENEURSHIP AND NEW BUSINESS DEVELOPMENT OPPORTUNITIES OR CASE STUDIES
Concurrent Conference Session 3 | Great Room 4

Oral Abstracts

Decision Making Process for Adoption of New Technology in Manufacturing SMEs

TORKANEH, MOHAMMAD (PRESENTING AUTHOR)
The University of Auckland
mtor012@aucklanduni.ac.nz
hammed@masterequipment.co.nz

Small to Medium Sized Enterprises (SMEs) in the manufacturing sector, play a critical role in the economy. As a group they are responsible for majority of employment and value add in the OECD countries. They are also one of the most vulnerable sectors of the economy due to limitations of financial resources, managerial knowhow and manpower. Due to the ongoing and rapid changes in the world economy manufacturing SMEs are finding it difficult to compete and prosper. Advanced manufacturing technologies and Industry 4.0 generate new opportunities for SMEs. However, research shows that in spite of the existence of many government initiatives around the world to encourage manufacturing SMEs to take up new technology, their uptake has been very slow.

Analysis of literature indicates that this problem has not been addressed in a comprehensive manner from a decision-making perspective. The decision making literatures in SMEs indicates owner-managers are the key factor and main decision maker in their organization when it comes to strategic decisions such as adoption of a new technology. Therefore, this research has focused on owner manager and relevant strategic decision-making processes that firms undergo to reach the adoption or rejection decision.

This paper presents a summary of the findings from in-depth analysis of literature in the areas of evolution of manufacturing technology, the characteristics of SMEs, diffusion of innovation, decision-making and strategic sense-making. A theoretical model is synthesized and presented based on the results of this analysis. This model identifies the role that strategic sense making can play in the adoption process of a new manufacturing technology in SMEs.

Author is a PHD student at university of Auckland, having over 25 years of experience in manufacturing management. Currently owner and managing director of Master Equipment and Services.

BEYOND 'SOFT SKILLS': ARTS AND HUMANITIES IN TECHNOLOGY-DRIVEN ORGANISATIONS

KORBER STEFAN (PRESENTING AUTHOR)
University of Auckland (Business School)
s.korber@auckland.ac.nz

SMITH PETER
UoA (Business School)
p.smith@auckland.ac.nz

FRANK SIEDLOK
UoA (Business School)
f.siedlok@auckland.ac.nz

Interdisciplinarity, in organisational settings and academic research, is widely believed to result in innovative solutions that address the complexity of contemporary problems. Although the importance of interdisciplinary integration is acknowledged by practitioners and academics, most existing research remains focused on examples where disciplines are relatively close to one another. In turn, academics have long recognised a widening divide between disciplinary fields, and the sidelining of the humanities, arts, and social sciences (HASS) in favour of the natural sciences. At the same time, there is an increasing appreciation that solutions solely developed within the Science, Technology, Engineering and Medicine/Mathematics (STEM) paradigms often misfit social realities or fall short of tackling large, wicked problems. However, this 'broader' or 'wider' gap dividing STEM and HASS remains largely unbridged. Our MaD-IMM seed-funded project puts systematic attention on this 'wider' gap. Our findings integrate existing theory and 25 interviews with informants who hold non-STEM and non-business degrees (e.g., English literature) but work in organisations that are predominantly STEM-driven. The framework developed offers systematic insights into the benefits of HASS integration and mechanisms through which such integration is accomplished. We find that most organisations utilise HASS-based skills and knowledge in a selective, instrumental and often superficial way. However, some firms bridge the gap between social and natural science in a more purposeful and strategic manner. In these organisations, the integration of HASS-based knowledge and practices has become a core part of organisational identities and a fundamental element of its competitive advantage. Using empirical data, we problematise the view that reduces the value of the humanities and arts to transferable 'soft' or 'vocational' skills. In turn, we argue that the fundamental value of HASS lies in other facets: fostering critical thinking, making sense of complex information and helping to reframe and interpret problems and solutions.

Stefan Korber is a lecturer at the University of Auckland Business School. His research interest includes Professional Service Firms, inter-disciplinary collaborations, and the influence of shared values and taken-for-granted assumptions on individual behaviour.

Development of a fit-for-purpose system for 3D printing of food

SCHON, BEN (PRESENTING AUTHOR)
Plant and Food Research
Ben.Schon@plantandfood.co.nz

NIJDAM, JUSTIN
Plant and Food Research
Justin.nijdam@plantandfood.co.nz

PATEL, PURAK
Plant and Food Research
Purak.patel@plantandfood.co.nz

PINFOLD, JAMES
Plant and Food Research
James.pinfold@palantandfood.co.nz

MORGENSTERN, MARCO P.
Plant and Food Research
Marco.morgenstern@plantandfood.co.nz

OLIVER, RICHARD
Plant and Food Research
Richard.oliver@plantandfood.co.nz

Additive manufacture and 3D printing of food hold promise for producing personalised foods, prototyping of food, and as a tool for investigating the interactions between food structure and food materials. It is, however still relatively in its infancy in comparison to other areas of 3D printing.

One of the reasons for this is the lack of availability of suitable equipment to develop complex 3D food structures. 3D printed foods have a specific set of requirements that are unique to food and the types of materials present. There is also the opportunity to assess a range of pre-existing food materials for their use as inks, in addition to the need to develop a wider range of food materials suitable as printable inks.

We identified some specific requirements that were not met by currently available equipment. We therefore designed and built custom extrusion-based FDM printers that met these specific requirements for use with food inks; utilising off-the-shelf components where possible.

Characterisation of the materials in order to design appropriate equipment, in addition to a systematic approach, meant the design and build were successful. This enabled us to produce a capable, multi-material extrusion-based 3D printer for food.

Ben Schon is a Scientist within the Materials Science & Technology Team at Plant and Food Research. His current research interests include 3D printed food, electrospinning technologies and applications, and bio-based materials.

Digital Manufacturing for improved bra fit

AMOOZEGAR-MONTERO, XUXU (PRESENTING AUTHOR)
Victoria University of Wellington, New Zealand
amoozeariy@myvuw.ac.nz

RODRIGUEZ RAMIREZ, EDGAR
Victoria University of Wellington, New Zealand
edgar.rodriguez-ramirez@vuw.ac.nz

This research focuses on developing an overall system for a more accurate bra fit and design. Due to the symbiotic relationship between bra fit and bra design, a parametric system was designed to digitise the measuring process, and adapt to both physical and personal desires of different types of bra wearers. Individuality will not only be in the form of taste, attitude, and aesthetics, but also through one's inherent breast shape, contours, and asymmetry.

Unlike traditional bra fitting methods, this system utilises advanced technologies such as 3D scanning, to consider additional factors that are not currently recognised, like the breast outline. This research also investigated the role of 3D knitting to fill the gap of customisation and individualisation at a mass production level, as well as serving as an innovative approach responding to bra design issues. The data accumulated helped influence unique bra designs to ensure better individual bra fit, while also acting as a medium to give the bra wearer a better understanding of their breast measurements, and how the bra fits on them.

Finally, the research compares, contrasts and identifies gaps within current methods for bra fitting and bra design, a parametric modelled measuring system, and final designed bra prototypes. Overall, it resulted in an effective parametric measuring system, which can adapt to individual 3D scans. The 3D knitted prototype bra offered improved alternatives to a traditional bra, such as a seamless knitted underwire, which provides a more comfortable and flexible fit. Furthermore, we hope to increase consumer engagement and awareness about their breasts and individual bra fit. After all, by providing the necessary information to the consumer regarding how to achieve a good bra fit, then this could help the consumer's ability for self-selecting better bra fit and enhance the satisfaction they receive from all bras.

Xuxu is a multi-disciplinary designer passionate about the interconnectedness of fashion and technology. After working in the Haute Couture industry at Iris van Herpen in Amsterdam, she is now studying towards her doctorate furthering her investigation in the role of parametric design and digital manufacturing for individualised bra fit.

Assessment of bio-based hydrogel 3D-printing by micro-extrusion

LOSTE-BERDOT, MATHIEU (PRESENTING AUTHOR)
Univ. Genoble Alpes, FR
mathieu.loste-berdot@lgp2.grenoble-inp.fr

BRAS, JULIEN
LGP2, FR
julien.bras@grenoble-inp.fr

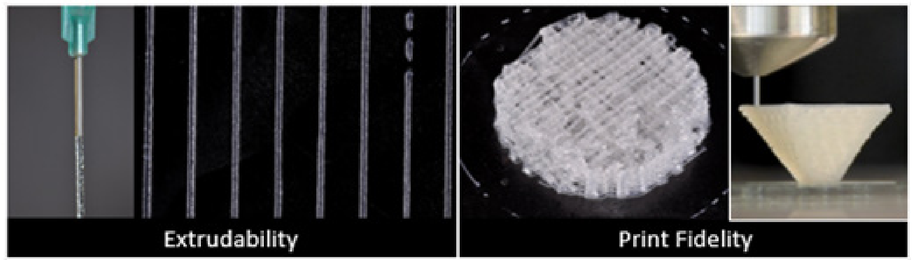
DENNEULIN, AURORE
LGP2, FR
aurore.denneulin@grenoble-inp.fr

LE CORRE-BORDES, DEBORAH
Plant & Food Research Ltd., NZ
Deborah.LeCorre@plantandfood.co.nz

BENEVENTI, DAVIDE
CNRS, FR
davide.beneventi@grenoble-inp

Our team aims to develop better bioinks for better bioprinting by improving on existing materials and developing processes that suit these materials. Matching the material to the printing process and investigating how the printing process can be tailored for a specific material is one of the underlying challenges addressed in this project. Our work explores the potential synergies between a few selected materials, and how they can relate to the formulation and printability of hydrogels. In particular, we have been inspired by the natural composition of the extracellular matrix present in organic tissues, and are developing new formulations by combining colloidal and chemical interactions between collagen and bio-sourced polysaccharides. Extensive efforts are put into linking the rheological properties with the printability properties of the studied gels.

This presentation will focus on the issues encountered during extrusion-based hydrogel printing and their possible fixes through both material and process optimization.



The presenting author has a double engineering degree in pulp and paper sciences (GINP, FR) and in bio-fiber chemical engineering (KTH, SW). The Ph.D. project is a collaboration between France and New Zealand institutes following a six months master thesis on collagen printability assessment.

3D Printing Niche New Zealand Products for International Markets - Opportunities and Threats

HODDER, SAM (PRESENTING AUTHOR)
University of Waikato
samuel.hodder@hotmail.com

DUKE, MIKE (PRESENTING AUTHOR)
University of Waikato
dukemd@waikato.ac.nz

Additive manufacturing in New Zealand for overseas markets can disrupt traditional manufacturers and their processes, giving agile companies a competitive advantage in niche markets. Offering the customer choice, by focussing on their particular requirements, needs a continuous design and development process. One advantage of this is that each new design is added to the product catalogue and can be re-produced by 3D printing, for many customers, with no additional tooling costs. This enables agile companies to quickly develop a portfolio of hundreds of digital products that can be purchased on line and quickly manufactured to order. However, although there are great opportunities for NZ companies, there are several threats ranging from intellectual property protection, cybercrime and distance from market. Furthermore, there are concerns that entrepreneurial New Zealanders, their businesses and revenues will move permanently overseas. These issues are discussed and possible solutions offered.

Professor Mike Duke is the Dr John Gallagher Chair in Engineering at the University of Waikato and leads the Waikato Robotics, Automation and Sensing research group. His group extensively uses additive manufacture for a wide range of novel robotic devices, ranging from 3D printed titanium fruit picking mechanisms to complex silicon over moulds for soft grippers.

Sam Hodder is an engineering graduate with a start-up company that designs and 3D prints niche products for the US market.

Complex parts from metal/polymer feedstocks

LECARPENTIER, FREDERIC (PRESENTING AUTHOR)
Advanced Materials, Research & Technical Services, Callaghan Innovation.
Frederic.Lecarpentier@callaghaninnovation.govt.nz

Combining metallic powders with polymer binders allows complex “green” parts to be shaped by injection moulding (MIM) and a number of emerging additive manufacturing (AM) techniques. Once the green bodies have been generated, they are subjected to chemical and thermal processes to remove the binders and to obtain fully dense metal parts. These shaping techniques offer greater design flexibility than traditional machining, require lower capital investment and are safer than other powder-bed AM systems.

We will discuss Callaghan Innovation’s in-house capability developed to fabricate dense metal parts from metal/polymer feedstocks: MIM; additive assisted injection moulding and fused filament fabrication (FFF).

MIM is a cost-effective net shape process for medium-to-high production volume of components with properties equivalent to those of cast and other powder metallurgy products. One downside of the high pressure MIM process is the need to fabricate expensive and complex injection moulds, especially when first prototypes or low volumes are required.

We have investigated a complementary process based on specially designed feedstocks compatible with a low temperature/low pressure injection moulding technique. This allows the use of additively manufactured plastic inserts and sacrificial templates. Stainless steel 316L parts were produced with properties exceeding the minimum MIM industry standards and complexity not easily achievable with traditional injection mould tools. This technology gives New Zealand companies the ability to trial a wide range of materials while validating the design of their product at the prototyping phase with little upfront tooling investment.

Low-cost 3D extrusion printing of metal/polymer feedstocks for rapid prototyping has recently become an active area of R&D. Our investigation has concentrated on the desktop FFF printing and thermal processing of MIM compatible filaments developed by overseas suppliers. Dense 316L metal parts were fabricated and characterised to evaluate differences in properties with those obtained by other powder-based methods.

Frederic Lecarpentier is a Senior Scientist in Callaghan Innovation’s Advanced Materials Group with 20 years research experience in the development of innovative products, from early prototyping through to production.

His current interest is the fabrication of complex parts using powder-based manufacturing processes, including metal injection moulding and emerging AM techniques.

Development of a modular Additive Manufacturing testing device for bioprinting technology evaluation

SCHUTTE, JUAN (PRESENTING AUTHOR)
Massey University, Auckland.
j.schutte@massey.ac.nz

POTGIETER, JOHAN
Massey University, Auckland.
j.potgieter@massey.ac.nz

ODENDAAL, JAY
Massey University, Auckland.

The development of Additive manufacturing technology provides a pathway for the generation of new methodologies of controlled fabrication such as 3D Printing. This capability is highly desirable within fields of biofabrication (in which the material is highly susceptible to processing parameters/environments). Whilst this has led to the development of many various forms of bio-material based 3D printing (known as bioprinting), there exists a strong desire for the ability to easily evaluate different types of manufacturing utilising different materials and processing methodologies. One of the biggest limitations a researcher in this field might experience is the inability to easily trial or develop mechanisms for/within currently available technology. This is typically due to the restrictions derived from proprietary software or electro-mechanical restrictions. Thus this research seeks to develop a modular testing device capable of performing additive manufacturing process evaluations in which novel materials and techniques may be implemented without the limitations of the proprietary material, software or mechanism restrictions of commercial machinery. Additionally the modular nature of the device will allow for an ease in the variation of testing/processing mechanisms incorporated e.g. the addition or removal of elements such lithographic, extrusion, jetting based technologies. Presented work related to this project consists of a developed modular additive manufacturing machine with modules related to lithography and extrusion based studies. Results depicted will be derived from initial experimentation utilising expired 3D Systems photo-curable resins, used Nylon 6-6 laser sintering powder, Keratin solution and Lignin solution materials.

Juan Schutte is finalising his PhD at Massey University's Auckland Engineering department. His research interests include innovative developments within technologies related to healthcare, bettering the quality of life, and additive manufacturing. Currently, his research activities include investigations into nanoscale 3D Printing technologies for the development of new methods for biotechnology.

Application of numerical optimisation techniques to complex engineering design problems

BATTLEY, MARK (PRESENTING AUTHOR)
University of Auckland
m.battley@auckland.ac.nz

KENT, DANIEL
University of Auckland
dken654@aucklanduni.ac.nz

HEALY, LEIF
University of Auckland
leifhealy@gmail.com

Coupling numerical optimisation techniques with performance simulation tools such as Finite Element Analysis (FEA) offers significant potential to the design engineer. Setup a parametric analysis model with relevant design variables, define performance constraints on responses such as allowable deformations and stresses, and setup an objective function to define what an optimal solution means. Then push solve, and, in principle, the optimisation algorithm will iterate away until an optimal solution is found.

However, what happens when the design problem is so complicated that thousands of iterations are required to cover the design space, or the complexity of the physics means that each iteration takes many hours to solve? Can optimisation still be a useful tool for a designer?

Two case studies will be presented and discussed. The first relates to high performance sailing yacht masts. In addition to having multiple objective functions, the responses are functions of both the cross-sectional geometry and the composite layup of the mast, meaning that the design space is very large. A solution approach is presented that builds an approximate model from parametric FEA models of the mast, then undertakes the multi-objective optimisation study using a weighted sum function approach to select designs based on trade-offs between different objectives.

The second case study relates to impact responses of sandwich composite automotive body panels. Complexity of the impact physics means that solution times for accurate explicit FEA modelling are very long, so it is not practical to use these within optimisation routines. Approximate models are developed and validated that enable optimisation techniques to be efficiently used to explore the design space.

In both cases, the results demonstrate that optimisation driven simulation is a powerful tool to inform design decisions, but engineering judgement is still essential to maximise the end user value of the final designs.

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

Functional coatings – collaborative innovation for high-tech manufacturing

VENTER, JOSHUA (PRESENTING AUTHOR)
Cirrus Materials Science Limited
Joshua.venter@cirrusmaterials.com

REYNOLDS, BRETT
Mastip Technology Limited
Brett.reynolds@mastip.com

GAO, WEI
The University of Auckland
w.gao@auckland.ac.nz

Mastip Technologies is a leading designer & manufacturer of hot runner injection moulding equipment & solutions to the worldwide plastic industry. Cirrus Materials Science is an advanced materials and coatings design specialist. Together with the Faculty of Engineering at the University of Auckland the collaborators set out to design and produce an advanced coating with superior wear and erosion resistance, and reduced maintenance cycles.

Copper beryllium(CuBe) tips are used to extrude polymers in injection moulding machines. Tips are coated electrolessly with Nickel Phosphorous (ENiP) to withstand a range of temperatures, polymers & moulding applications while maintaining the precise geometry required for accurate injection moulding. Existing ENiP coatings function adequately for commodity polymers; however ENiP coatings erode rapidly when injecting engineered or reinforced polymers. Mastip approached UoA researchers and Cirrus engineers to develop a new, nano-composite ENiP coating that reinforced the precision coating with alumina nano-particles. The technology, known as Cirrus Dopant™, is in development with several global manufacturers as a route to advanced performance coatings and new materials for use in harsh environments.

Following initial trials at UoA in 2016 / 17, Cirrus finalised the new coating design for Mastip to trial in real-world tests in 2018. As the industry partner, Mastip had originally sought to increase the erosion resistance of the ENiP coating layer by 40%; however end results showed Cirrus nano-composite ENiP performed 10x better than the existing precision coatings.

In this oral presentation Cirrus will discuss this collaborative project, the potential of the Cirrus Dopant™ technology, and the innovative nano-composite coating that will be introduced to Mastip's global customers later this year.

Joshua Venter, Business Development Manager for Cirrus Materials Science Ltd, is involved in establishing the commercialization of Cirrus advanced coatings & hard gold electroplating for New Zealand & Australian customers. Previously, Joshua has had six years of all-round hands on experience with a previous NZ leader in electroplating.

DESIGN, INNOVATION AND COLLABORATION
Concurrent Conference Session 4 | Great Room 3

Oral Abstracts

Design a square peg, build a round hole—data collaboration tragedy and triumph

HALL, SIMON (PRESENTING AUTHOR)
Caliber Design
simon.hall@caliberdesign.co.nz

We've come a long way since the first wheel was built from a cave painting depiction. Just as that painting may have been ambiguous, our contemporary digital and analogue design data can be too. From saving work to rework to "doesn't work", electronic design tools have delivered us many benefits but are also responsible for many headaches as we reinvent processes and formats. With some upfront thought, planning and setup though; we can achieve tremendous results.

This presentation will discuss some of the pitfalls of translating design data into physical things and offer suggestions on how to reliably turn the model on your screen into parts that fit and function as intended.

The examples, learnings, and wisdom that form the foundation of this presentation come from the collective knowledge of our team at Caliber Design. We're a mechanical design consultancy that provides project-based design engineering services throughout New Zealand.

We work with some of New Zealand's most well-known and successful businesses, working on innovative projects across multiple industries, including aerospace, materials and food handling, packaging, marine, agriculture, and medical. As a team, we have a breadth and depth of knowledge about contemporary design tools, collaboration, and making things work—including how many facets are needed to fit a square peg into a round hole.

Simon Hall is Design Manager at Caliber Design. He has worked in mechanical design roles for Fisher & Paykel, Compac Sorting Equipment, Advanced Aerospace, Tru-Test, PTL, and Rocklabs. Simon gives back to the industry through his active involvement in Engineering New Zealand (formerly IPENZ).

Translational Research & Entrepreneurship in Biomedical Engineering

MUNRO, DEBORAH (PRESENTING AUTHOR)
University of Canterbury / Mechanical Engineering
Debbie.Munro@canterbury.ac.nz

Biomedical engineering is an important sub-discipline in mechanical and mechatronics engineering, and thus the Department of Mechanical Engineering has a long tradition of postgraduate study and research in the biomedical engineering and medical device fields. There is also the Bioengineering Centre, which aims to be an internationally recognised interdisciplinary research centre of excellence, dedicated to servicing the biotech/bioengineering industry in New Zealand and throughout the world, and the University of Canterbury has considerable research expertise (of international standing) in areas which could provide significant advances in the biomedical and bioengineering areas.

The Department of Mechanical Engineering currently has some undergraduate courses that focus on biomedical topics, as well as multiple faculty conducting in-house research in this field. A new Minor in Biomedical Engineering, launching in 2019, will materialise research-based teaching at the undergraduate level and will provide mechanical and mechatronics engineering students a holistic education in bioengineering to develop a local and global awareness of health-related issues.

In order to solve some of the "Grand Challenge" problems of the 21st Century, New Zealand has made it a national objective to grow the health research sector of the economy. To achieve this objective, it is important that research be conducted in partnership with industry in order to successfully translate it into new products as well as new start-up companies in the healthcare space. Thus, the emphasis of the new minor in biomedical engineering will centre on product development, translational research, and entrepreneurship.

This talk will discuss the concept of translational research and the related processes, skills, and structures that allow student and academic research to be taken up by entrepreneurs or implemented by industry. It will also cover the unique challenges of translational research in the medical device field, with its necessary emphasis on safety, efficacy, and regulatory compliance.

Deborah Munro is a mechanical engineering faculty member at the University of Canterbury who leads the development of their new minor in biomedical engineering. Over half of her career has been in industry, designing orthopaedic implants and medical devices. Her current research is focused on fracture healing.

Technology roadmapping in NZ's steel industry

KRULL, ELISABETH (PRESENTING AUTHOR)
University of Auckland
e.krull@auckland.ac.nz

HUSTED, KENNETH
University of Auckland
k.husted@auckland.ac.nz

HABIB, BOAZ
Heavy Engineering Research Association
boaz.habib@hera.org.nz

Technology roadmapping (TRM) is widely used for strategic and innovation planning at product-, firm-, industry- and policy-levels. Motorola Inc.'s former chairman Rob Galvin described the approach as "an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of the change." In this paper we examine the applicability of TRM to a mature, traditional industry: the New Zealand steel and heavy engineering industry. Being geographically isolated, to date no significant disruptions affected the industry at large. However, globally, changes in the wider steel industry are on the horizon. These include, for example, slowing global steel demand growth paired with overcapacity, alternative materials, and the rise of technologies such as digital platforms enabling increased supply chain efficiencies.

TRM is used to support a focus group of industry participants to develop a collective understanding of the evolution of the industry and potential areas of disruption. We present an application of TRM to create a first-cut, holistic picture of the movement of the industry and investigate to what extent the activity of TRM impacts the way firms prepare strategically for disruptions.

As part of a wider initiative to improve innovation activities in the New Zealand steel industry through a collaboration between the Heavy Engineering Research Association (HERA) and The University of Auckland Business School, we designed a 1-day strategic roadmapping workshop. The motivation for the TRM was primarily around understanding the current and future strategic landscape at the industry level with the aim to identify potential innovation opportunities for individual member firms and how these would shape the firms' strategic direction and appetite for further strategic planning. The approach was largely modelled on the S-Plan TRM methodology, which was developed at the Institute for Manufacturing (IfM) of the University of Cambridge.

Eli is a Research Fellow in the Department of Management and International Business at the University of Auckland Business School. Her PhD research examined the coordination of heterogeneous knowledge for innovation during technology roadmapping projects. Eli's research interests include cross-functional and interdisciplinary knowledge management, innovation and TRM.

A comparison of processing techniques for producing prototype injection moulding inserts.

EWART, PAUL (PRESENTING AUTHOR)
Centre for Engineering and Industrial Design
Waikato Institute of Technology
paul.ewart@waikato.ac.nz

ZHOU, HONG
Centre for Engineering and Industrial Design
Waikato Institute of Technology
Hong.zhou@waikato.ac.nz

This project involves the investigation of processing techniques for producing low cost moulding inserts used in the particulate injection moulding (PIM) process. Prototype moulds were made from both additive and subtractive processes as well as a combination of the two. The general motivation for this was to reduce the entry cost of users when considering PIM.

PIM cavity inserts were first made by conventional machining from a polymer block using the pocket NC desktop mill. PIM cavity inserts were also made by fused filament deposition modelling using the Tiertime UP plus 3D printer.

The injection moulding trials manifested in surface finish and part removal defects. The feedstock was a titanium metal blend which is brittle in comparison to commodity polymers. That in combination with the meso-scale features, small cross sections and complex geometries were considered the main problems.

For both processing methods fixes were identified and made to test the theory. These consisted of a blended approach that saw a combination of both the additive and subtractive processes being used.

The parts produced from the three processing methods are investigated and their respective merits and issues are discussed.

Keepa.NZ- easyti-concept

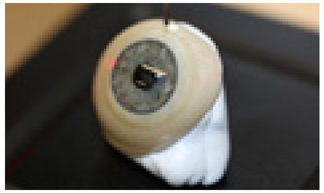
Paul Ewart. PhD materials and processing science (UoW 2015). He is research leader at Centre for Engineering and Industrial Design, Wintec. Recently received an Erasmus grant for European collaboration investigating project-based learning in processes research and education.

Interests include, prototyping processes, pre-production manufacturing, mechanical dynamics for health and well-being.

Bio-compatability of prosthetic eyes

PINE, KEITH (PRESENTING AUTHOR)
New Zealand Prosthetic Eye Service
keith@keithpine.co.nz

DE SILVA, KARNIKA
Product Accelerator , UoA
k.desilva@auckland.ac.nz



Measuring the surface hydrophilicity of a prosthetic eye

The eyelids are important structures for the successful wearing of a prosthetic eye as they retain the prosthesis in the socket and distribute tears and socket secretions during the action of blinking. The conjunctival lining on the inside surfaces of the eyelids bears directly upon the surface of the prosthesis and the interaction between the eyelids and the surface appears to cause permanent physiological change which impacts on eyelid health. These physiological changes impact the wearing comfort of prosthetic eyes and promote mucoid discharge associated with prosthetic eye wear.

Prosthetic eyes are made from (poly) methyl methacrylate (PMMA) which is hydrophobic and previous research by Dr Pine suggests that a more hydrophilic surface is likely to result in a more comfortable prosthetic eye.

A partnership was established between Dr Pine and Dr Karnika De Silva and Fengqian Zhang of the NZ Product Accelerator and Department of Chemical and Materials Engineering, and a research plan was developed. A number of potential solutions was discussed before the team focussed on working with various mixtures of PMMA and ethylene glycol dimethacrylate derivatives.

The project was successful and a new material was developed. This new material has the working properties of PMMA, but has a more hydrophilic surface than the PMMA currently used for prosthetic eyes. The next steps involve completing in-vivo testing to compare the new material with the current PMMA material in terms of wearing comfort and long-term socket damage. Approval for this research has recently been obtained from the UoA Human Participants Ethics Committee.

Dr Keith Pine BSc (Psych), MBA, PhD (Optom), MIMPT specialises in ocular prosthetics through the New Zealand Prosthetic Eye Service. Dr Karnika De Silva, PhD works with the Product Accelerator , UoA as a Senior Technologist with a background in Polymer technology and composites.

Tribological assessment of nano-silica reinforced alginate-polyacrylamide hydrogel composite as artificial cartilage

RAMEZANI, MAZIAR (PRESENTING AUTHOR)
Auckland University of Technology
maziar.ramezani@aut.ac.nz

ARJMANDI, MOHAMMADREZA
Auckland University of Technology
marjmand@aut.ac.nz

The advent of orthopaedic prostheses and their widespread applications have helped millions of patients worldwide to be relieved from pain and gain their mobility. However, they are still not suitable for young or middle-aged patients suffering from localised cartilage damage, due to the limited life span of these load-bearing devices. All available remedies for those patients are temporary and some of them might result in regeneration of tissues with different properties to the existing one, and hence limited functionality and durability. Therefore, an alternative way should be investigated to prevent further tissue degeneration through replacing damaged regions of the tissue and preserving the remaining healthy portion. This will result in prolonging the tissue functionality, and further postponing the total joint replacement.

Different hydrogels have been studied extensively as potential cartilage replacement candidates, as they are biocompatible and can mimic the lubrication mechanisms found in cartilage tissue. Alginate-Polyacrylamide (ALG-PAAm) hybrid hydrogel was suggested as an orthopaedic prosthesis due to their biocompatibility and promising properties. However, their friction and wear performances remained under-explored. Thus, the current study focused on ALG-PAAm and in an attempt to improve its mechanical performance, silica nanoparticles (Si-NPs) were introduced to the interpenetrating polymer network (IPN) hydrogel matrix as a reinforcement and the mechanical and tribological characteristics of the resultant nanocomposite was investigated.

Dr Maziar Ramezani is a Senior Lecturer in Department of Mechanical Engineering, Auckland University of Technology (AUT). He is the founder and director of Tribology and Surface Engineering Lab in AUT. His research activities can be broadly divided into four main categories: tribology, additive manufacturing, metal forming and composite materials.

MANUFACTURING AND DESIGN FOR BIO APPLICATIONS
Concurrent Conference Session 4 | Great Room 4
Oral Abstracts

Quantitative strength considerations for the design of devices for people with tetraplegia in New Zealand

STILWELL, GEORGE (PRESENTING AUTHOR)
University of Canterbury
george.stilwell@pg.canterbury.ac.nz

GOOCH, SHAYNE
University of Canterbury
shayne.gooch@canterbury.ac.nz

SYMONS, DIGBY
University of Canterbury
digby.symons@canterbury.ac.nz

Tetraplegia is a condition that causes a loss of function effecting 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 spinal cord injuries. Nearly half of all newly acquired spinal cord injuries are accounted for by males aged between 15 and 29 years old. This young population have a strong desire to lead full, active and independent lives.

Products that are typically developed for people with tetraplegia to use are of high value and are manufactured in low quantities. Improving the knowledge of the strength capabilities of people with tetraplegia will allow designers of such devices to develop products that can be used more effectively.

This study has established a new methodology for establishing multi-directional arm strength data for people with tetraplegia while in the seated position. Tests are conducted using a purposely-designed test rig, which incorporates two three-axis load cells. Isometric strength is measured for each arm over a 1.3m by 1.5m grid of points parallel to the sagittal plane using 100mm increments.

Initial results of this study indicate that areas of strength can be identified using characteristic strength profiles for each injury level. The information in these strength profiles will be of interest to designers of assistive devices and medical professionals and practitioners. Future testing on people with tetraplegia using this method will enable greater insights into strength capabilities of this population.

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 C5-C7 Tetraplegia.

The Collaborative Approach to Additively Manufactured Artificial Limb Prosthetics

ALLISON, EMILY (PRESENTING AUTHOR)
Callaghan Innovation
Emily.Allison@callaghaninnovation.govt.nz

HAY, CAMILLE; MCQUEEN, VINCENT; GUY, BERNARD; FRASER, SIMON
Victoria University of Wellington
Haycamille23@gmail.com, Mcqueenvincent@gmail.com, Bernard.guy@vuw.ac.nz, Fraser.simon@vuw.ac.nz

JOHNSTON, AARON; GRAY, SEAN
New Zealand Artificial Limb Service
Aaron.johnston@nzals.co.nz, Sean.gray@nzals.co.nz

The collaborative efforts between many a University and Industry has brought to the world several helpful discoveries over the years- and has subsequently shown that these efforts are a powerful source of innovation.

A project has been undertaken by two students selected as part of a summer research scholarship between the New Zealand Artificial Limb Service (NZALS) and Victoria University of Wellington School of Design. NZALS aim to build their capability in additive manufacturing technologies to enable their patients to achieve independence by delivering leading prosthetic, orthotic, and rehabilitation services. The School of Design are leaders in additive manufacturing design, education, application and technology. The AddLab at Callaghan Innovation has provided support by offering a 3D printing facility, materials, design, and engineering knowledge for these students to develop the skills necessary for this project. The AddLab aims to provide benefit to industry by enabling the students to gain a greater understanding of designing for additive manufacturing specifically in preparation for entering the workforce.

This presentation will showcase a successful collaboration between an Industry, University, and a CRI which has provided new opportunities in design and manufacture of New Zealand-made lower limb prosthetics. The adoption of additive manufacturing applications and technologies provided multiple benefits to these students who are entering postgraduate study and a new world of making. This approach will provide numerous physical and emotional benefits to the recipients of additively manufactured prosthetics in the future.

Emily Allison is an Application Development Engineer from the AddLab at Callaghan Innovation. She has a background in mechanical engineering, 3D printing technologies, designing for additive manufacturing, and engineering education in New Zealand.

Another facet of biomechanical design

GARCIA, LORENZO (PRESENTING AUTHOR)
Auckland University of Technology
lorenzo.garcia@aut.ac.nz

Biomechanical Design is a specialization of engineering design and it could be defined as the procedure to find solutions that allow the biological and mechanical systems to function together. Another facet of biomechanical design is to investigate biological systems.

In this project, biomechanical design principles were applied to determine the drag coefficient of different design shapes which consist of insect bodies and see the effects the shapes have in the insect biological behaviour and characteristics.

In many engineering applications, insects have created new ideas of inspiration for building and designing new products, technology and research. As insects have had major inspirations in robotics, the aerodynamic study of them has also been a major area of interest in fully understanding their locomotion through the air and land. Previous research has mainly focused on the aerodynamics of airborne insects and it motion of flight, but little to no emphasis has been made on how aerodynamics behaves on land insects where only an insignificant wind tunnels test have been conducted.

Literature review and research were done on understanding the boundary layer, effects of drag in general and to three-dimensional shapes such as cylinders and spheres, and how wakes and vortexes are formed from them. Biological research was done on selected samples such as the Alpine Grasshopper, Ground Beetle and Large Earth Bumblebee and how methods in micro-CT scanning were previously implemented on these insects.

Computer Fluid Dynamic (CFD) was used in conjunction with key techniques in mesh manipulation to ensure the samples were able to be analysed.

Three tests of CFD were conducted such as the experimental one which used similar parameters to literature review, habitat which simulated the insects living conditions and lastly extreme test which determined the lowest drag coefficient possible. From the results of these test, we found that the trend in drag coefficient was equivalent to literature review data, which allows validating the CFD procedure.

This work extend the scope of what engineering design means by applying his principles to living organisms.

Lorenzo Garcia is a Lecturer at Auckland University of Technology since 2016. His research area is centered on medical devices and biomechanical design. Previously, from 2003 to 2016, he worked as Invention Manager where he specialized in Intellectual Property Management, Patent Searching, and Business Model Generation.

Residential Air Quality Improvement Using UV Lights

AL-RAWI, MOHAMMAD (PRESENTING AUTHOR)
CEID/Wintec
Mohammad.Al-Rawi@wintec.ac.nz

SMITH, CALLAN
CEID/Wintec
callansmith100@gmail.com

KHANNNA, JAI
CEID/Wintec
Jai.khanna@wintec.ac.nz

Many New Zealand homes suffer from poor indoor air quality (IAQ). Cold, damp and mould-ridden homes can cause serious respiratory health problems. Poor IAQ can arise due to poor insulation and ventilation, and compounded when residents cannot afford heating. The main aim of this paper is to describe the process and results of modifying an existing dehumidifier to include ultraviolet germicidal UV lights. The modified device was designed to improve thermal comfort by removing moisture and perform UV filtration of the air to address mould and bacteria growth. To achieve these we combined the properties of a dehumidifier with germicidal lights (UV). The device was designed with the purpose of reducing humidity, increasing room temperature and purifying the air. Testing has shown that the modified dehumidifier with UV lights works as planned, with petri dishes showing a reduction in mould growth in most samples taken. Humidity was reduced where the device was used, and approximately 2L of water was removed in a 24-hour period. The temperature was increased where the device was used. The results show that the device reduced mould growth and increased room temperature.

Mohammad AL-Rawi is a Senior Academic Staff Member in Wintec's Centre for Engineering and Industrial Design. He's current research is on improving air quality in residential environments. He designs and builds a residential air quality improvement system in order to prevent the negative health consequences associated with living in damp.

IoT and Data Analytics from Beckhoff

RUSH, STEVE (PRESENTING AUTHOR)
Beckhoff Automation Limited
s.rush@beckhoff.co.nz

MALHERBE, ANDRIES
Beckhoff Automation Limited
a.malherbe@beckhoff.co.nz

Beckhoff Automation provides the foundational technologies and tools needed to implement Industry 4.0 concepts and IoT connectivity, all via PC-based control.

TwinCAT engineering and control software are available for the creation of applications such as Big Data, data mining, pattern recognition as well as condition or power monitoring, in addition to traditional control tasks – which can sustainably increase production and engineering efficiency as a result.

BECKHOFF Automation and EtherCAT, being PC-Based control have been ready for Industry 4.0 for the last 25 years. The convergence of IT and automation technologies will allow for better implementation of PC-Based control into the Smart factory concept. At the heart of this concept will be secure communication from the field devices all the way to CLOUD BASED COMPUTING.

With the addition of EtherCAT P to the Beckhoff Automation portfolio, it makes bringing Industry 4.0 digital transformation to your factory floor simple and cost effective. No power, communication backbone or enclosures required to deploy with ease and expanding the EtherCAT P network at your own speed and budget.

A system that has the ability to be vendor agnostic to connect all your machines to a fast deployment power and communication network on ONE CABLE to existing machines and work stations. Smart factories should not have to be complicated to configure and deploy.

Steve Rush is the Technical Sales Engineer for Beckhoff Automation ltd New Zealand. With over 30 years of experience in the Engineering and Automation sector.

Lean and Industry 4

Using machine learning to remove supply chain waste

PACKER, ADRIAN (PRESENTING AUTHOR)
IMS Projects
Adrian.packer@ims-projects.co.nz

Lean has long been the improvement methodology of choice for manufactures, a focus on lead time enables previously unseen wastes to be identified and systematically removed.

Today, New Zealand companies are using big data and machine to drive further wastes reductions along their supply chain.

In this frank and open discussion, we will discuss one New Zealand company's ongoing efforts to use knowledge graph (machine learning) technology to ingest relevant data sets, including customer store sales data, historical sales patterns, weather data, and ERP data to inform inventory strategy and production planning.

The aim of this initiative is to go beyond simply removing waste from the sales to cash value stream; the intent is to use insights and machine learning to predict consumer demand; including delivering new products to market more efficiently.

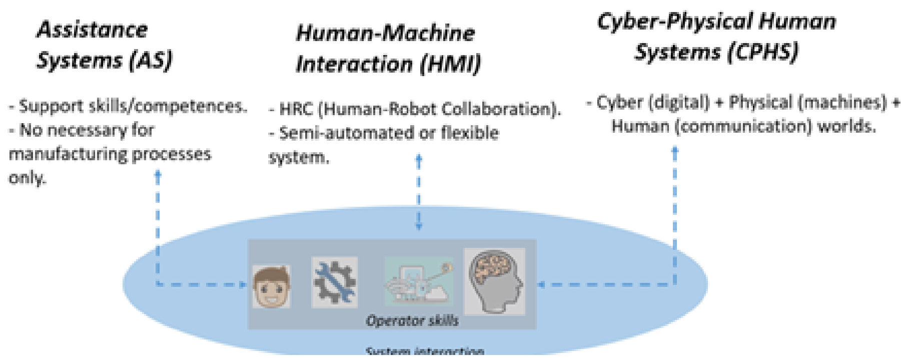
Adrian has worked in business improvement for over 20 years. His areas of speciality include Lean, Innovation and performance coaching. Adrian holds an MBA from Cranfield School of Management and a BSc Physics from Bristol University. He is a Director in two NZ businesses: IMS Projects and Coherenz Consulting Ltd.

Operator 4.0: A human perspective for Industry 4.0

FLORES, EMMANUEL (PRESENTING AUTHOR)
University of Auckland
ntor030@aucklanduni.ac.nz

XU, XUN
University of Auckland
xun.xu@auckland.ac.nz

Industry 4.0 promises to increase productivity and efficiency by achieving better utilization of manufacturing resources. It also offers the possibility to individualize products according to the specific requirements from customers. Nevertheless, Industry 4.0 also promises a better inclusion of workforce aspects, such as better job satisfaction, longer career development and a balance between personal and professional lives. However, for this commitment there is still ambiguity on how to achieve such challenge of the human capital inclusion with a seemingly technology-driven drive. This research sheds some light on the first steps to be considered to appreciate the need of, and understand the true meaning of, Operator 4.0, the human aspect in this new Industrial Revolution. This comprises the identification of a skill-set required from the workforce, plus the identification of systems working with humans in context of Operator 4.0 (see figure below). The ultimate goal for these first steps is to support how technologies on manufacturing systems could be implemented in order to allow a harmonious integration among the two entities, workforce and Industry 4.0 systems.



Emmanuel is pursuing a PhD at the University of Auckland, under the supervision of Prof. Xun Xu, in the Department of Mechanical Engineering and his research interests include Industry 4.0 and Operator 4.0 with an aim to study the inclusion of the human aspect into the new Industrial Revolution.

The architecture for smart manufacturing devices Digital twin implementation

HUANG, HUIYUE (PRESENTING AUTHOR)
The University of Auckland
hhua920@aucklanduni.ac.nz

Industry 4.0 and smart manufacturing are current hot topics in the field of manufacturing. At present, there are some problems in the manufacturing process, such as lack of flexibility, lack of effective data exchange between different manufacturers, which results in inefficient collaboration, and difficulty in meeting the needs of personalized manufacturing because of less intelligence. All these lead to a demand for intelligent manufacturing systems, in which each individual entity needs to have the ability of self-perception and self-decision-making to support smart manufacturing. The key enabler for such kind of manufacturing style to be realized is Digital Twin, the cyber presentation of its physical twin, which works as the brain of the device. With the implementation of Digital Twin, which contains the whole information of its physical counterpart and entire manufacturing process, it will bring up greater flexibility, smoother collaboration and fewer bottlenecks that may interfere manufacturing flow that relate to different vendors. An architecture of Digital Twin is proposed in this paper for its implementation, according to the analysing of functional requirements of Digital Twin. The architecture consists of several modules, including resource access module, service module, management module, and network module. Resource access module takes responsibility of data management of a Digital Twin, which can be helpful to history data management of a product. In service module, simulation and intelligent algorithm can be performed for a better production process. Management module is responsible for the stable operation of Digital Twin, and network module enables information exchange among Digital Twins and other applications. Although there many architectures proposed by other researchers, the architecture presented here is more focus on the implementation and deployment, which provides guidance for the practical application of Digital Twin.

Huiyue Huang has received the B.Eng. degree and M.E. degree from Beihang University, China, and she is now pursuing her Ph.D. degree in the University of Auckland. Her research focus is on smart manufacturing, cyber-physical systems and digital twin.

Intelligent Machine Window for Machine Tools

ZHU, ZEXUAN (PRESENTING AUTHOR)
The University of Auckland

zzhu827@aucklanduni.ac.nz

XU, XUN
University of Auckland
xun.xu@auckland.ac.nz

Industry 4.0 is considered to be the fourth industrial revolution, which is mainly based on smart manufacturing. Under the revolution in manufacturing, the evolution of machine tools is also moving forward. Today's CNC machines are well designed and developed to include with many features and capabilities. However, these new features and capabilities have made the operating tasks and programming tasks more and more difficult to achieve. In order to help machine operators to manage all the tasks and information under complicated manufacturing environment, most machine companies choose to place additional displays around the machine to show the information. However, the fact that attention needs to be distributed to additional displays with inconsistent user interface. It is also hard for the operators to focus on the multiple displays at the same time, some useful information may be ignored by operators during the operation. Based on the current situation, there has been a need of intelligent machine window (iWindow) based on augmented reality for the machine operator to dominate the product changes and start-up phases faster and more accurate. Apart from these, the intelligent machine window should also have other added-value services, such as: real-time machine control, high-fidelity machining simulation, real-time data communication, prognostic and health management, safety control process, functionality to cooperate with other machines and mobile devices, etc. Therefore, an intelligent machine window based on Augmented Reality has been developed. The developed system allows the operator to monitor and control the machine tool at the same time, but also enables to interact and manage the Digital Twin data simultaneously, which provides an intuitive and consistent human machine interface to improve the efficiency during the machining process.

Mr Zhu pursued his PhD study at the University of Auckland since 2018. He joined the LISMS research group under the supervision of Professor Xun Xu in Mechanical Engineering. His research areas include smart manufacturing, Augmented Reality in manufacturing, Cyber-physical system and Digital Twin.

Cyber-Physical Machine Tool based on STEP-NC

KUBOTA, TSUBASA (PRESENTING AUTHOR)
University of Auckland
Tkub556@aucklanduni.ac.nz

XU, XUN
University of Auckland
xun.xu@auckland.ac.nz

One of the main concepts of industry4.0 is to connect the physical machine tools with the digital domain using Internet of Things (IoT) technologies to allow communications between the machines regardless of its manufacturers. Cyber-Physical Machine Tool (CPMT) is one of the main concepts in industry 4.0 that integrates the physical machine tool with its digital twin modelled in cyber space. Integration of the digital twin allows CPMT an advanced computation and networking capabilities with other CPMT in the manufacturing environment. Standard for the Exchange of Product data compliant Numeral Control (STEP-NC) defines a machine independent bi-directional data standard for Computer Numerical Control (CNC) machines. STEP-NC is capable to deliver richer machining process information compared to conventional G-codes by containing "What" should be machined rather than "How" it should be machined. At present, the machine tool in the manufacturing field is only focused on the physical characteristics of the machine tool however, it is not correlated with the actual process data. This paper presents the framework which correlates the real time machining data with its corresponding process data to establish a practical machining knowledgebase. The machining knowledgebase will be utilized for both offline and real-time machining parameter optimizations within the CPMT.

Tsubasa is a Master's research student at the University of Auckland. His research area is in the field of cyber-physical machine tool and STEP-NC.

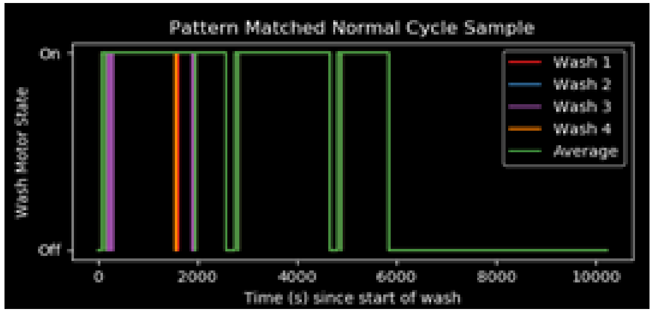
Dish wash comparison tool

HUTCHEON, ANDY
Fisher & Paykel Appliance
Andy.Hutcheon@fisherpaykel.com

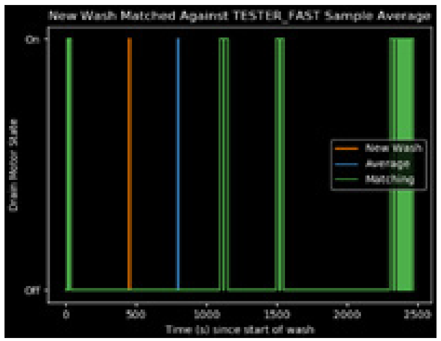
MCGILL-SMITH, SOPHIE
University of Canterbury
mcgillsmithso@gmail.com

To speed up the development cycle automated testing is valuable to ensure that updates do not have unintended consequences. Firmware changes can introduce behavioural changes elsewhere in a system.

For a dishwasher such as DishDrawer, exhaustive testing comparing actual wash performance results is expensive and time consuming. This testing is done during wash cycle development, but is prohibitive to repeat frequently (such as when user interface changes are made during production). Detailed logging is a routine part of wash cycle development testing, so the behaviour of the various system components is available for later examination.



The operation of a wash can be characterised by the timing and ordering of operation of the physical components (heaters, pumps etc.) that make up the DishDrawer. To enable regression testing, pattern matching software was created that could identify a wash 'fingerprint' for a given cycle and use this to determine whether an updated DishDrawer still behaved as expected. The matching tool can be trained using the set of washes previously run during cycle development (which allows normal variation between cycle to be characterised), and washes run under the control of new firmware compared to ensure that the behaviour remains equivalent.



Andy Hutcheon is an embedded software engineer at Fisher & Paykel Appliances Product Development site in Dunedin. With more than five years' experience developing DishDrawer software his interests include automated regression testing of incremental software updates.

Tailoring the properties of soft magnetic composite: example of inroad inductive power transfer

LEVENEUR, JÉRÔME (PRESENTING AUTHOR)
GNS Science
j.leveneur@gns.cri.nz

TROMPETTER, BILL; KENNEDY, JOHN
GNS Science
b.trompetter@gns.cri.nz

CHONG, SHEN; HUNZE, ARVID; SHARMA, VAIBHAV; LONG, NICK
Victoria University of Wellington
s.chong@vuw.ac.nz

KIM, SEHO; COVIC, GRANT
University of Auckland
Author's email

There has been a steadily increasing demand for magnetic materials in devices and charging systems over recent decades. Soft magnetic materials, in particular, are needed in our power electronic devices, motors and generator, where they play a key role in the energy efficiency of the system.

Soft magnetic composites (SMC) materials are materials that combines at least one magnetic filler within a matrix. While they usually exhibit lower magnetic permeability, they offer the flexibility to optimise their properties by controlling the matrix composition, magnetic materials and size fraction of the magnetic filler. This way, resulting materials can have better mechanical and thermal performance compared to other soft magnetic materials (such as ferrites). In addition, they often exhibit lower eddy current losses in their operating range.

A possible application of SMC is inductive power transfer (IPT). In some cases, such as for future inroad charging systems, there is a pressure in designing magnetic materials that have robust mechanical properties at low cost. Better, non-brittle, and affordable magnetic materials are required so that vehicles can run over charging pads built into the road without destroying them. This requires innovative solutions and new magnetic material sources to meet these needs in an economically viable way.

Our investigation aims to identify ideal size fraction and composition of a soft-magnetic composite that can be applied for inroad IPT systems. We have first investigated the magnetic permeability and losses for a range of materials to identify the potential of SMCs for this application. We have also scoped NZ's natural magnetic materials and their ability to be included as viable magnetic material for our roads. By integrating our findings with novel IPT system and road designs, with optimisation of the magnetic, mechanical and thermal properties, we hope to deliver an effective solution for this emerging opportunity.

Dr 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 broad industrial challenges.

Microfluidic System for Water Quality Monitoring

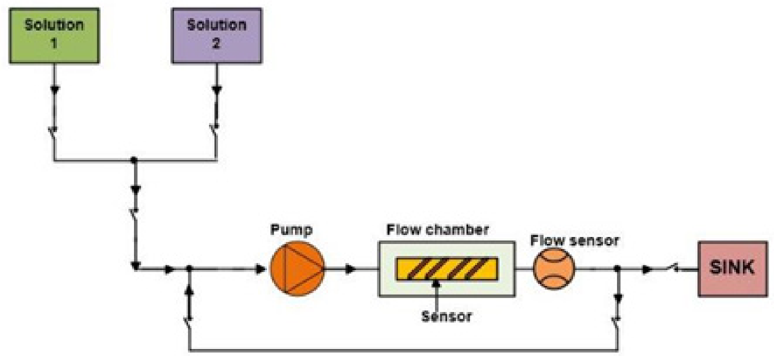
JAYWANT, SWAPNA (PRESENTING AUTHOR)
Massey University, Auckland
s.jaywant@massey.ac.nz

ARIF, KHALID
Massey University, Auckland
k.arif@massey.ac.nz

We present a fluidic system integrated with a novel sensor. The sensor makes use of unique surface modification technique to detect metallic contamination of water by measuring the diffraction intensities induced by laser illumination. This approach involves usage of self-assembled patterns of thiol compounds on the gold-coated glass. These self-assembled patterns are obtained through a micro-contact printing procedure. We demonstrate the potential use of Au-S to produce self-assembled thiol patterns that can be used for detection of metallic contamination.

An automated fluidic system has been developed using 3D printing and off-the-shelf components. This fluidic system is used for circulation of water or reagents during water quality monitoring. The major components those are used in the system are pump, valves and flow sensor. Hence, the fluidic components in the system are computer interfaced to operate the assay sequences in an automated fashion. The system is providing high throughput.

Currently, we have focused on the detection of dissolved arsenic in the water. However, our findings recommend that this method can also be used for detection of pathogenic contaminants like E.coli for water quality monitoring.



Presenting author, Mrs. Swapna A. Jaywant is currently pursuing PhD at the School of Engineering, Massey University Auckland. Her areas of research interest include sensing technology, microfluidics, and bioinstrumentation.

POSTER
INNOVATIONS IN MANUFACTURING AND DESIGN
Poster Presentations

Laser beam shaping for optimised industrial laser micro-machining and surface patterning.

LOW, JEFFERY (PRESENTING AUTHOR)
aDepartment of Physics & School of Chemical Sciences, University of Auckland
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
jeffery.low@auckland.ac.nz

BARBER, LIAM
aDepartment of Physics & School of Chemical Sciences, University of Auckland,
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
lbar915@aucklanduni.ac.nz

AGUERGARAY, CLAUDE
aDepartment of Physics & School of Chemical Sciences, University of Auckland,
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
c.aguergaray@auckland.ac.nz

BRODERICK, NEIL
aDepartment of Physics & School of Chemical Sciences, University of Auckland
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
n.broderick@auckland.ac.nz

Ultrafast (femtosecond) laser micro-machining is an established processing method with a variety of novel applications and advantages. The short pulse duration of ultrafast lasers minimises the thermal effects involved, allowing for precision cold cutting. However one of the hurdles slowing the adoption of ultrafast laser micro-machining across industry is the speed at which it processes material.

A liquid crystal on silicon spatial light modulator (LCOS-SLM) can be used to dynamically manipulate the laser beam allowing us to create multiple focal points for parallel machining. Parallelisation is a key strategy in upscaling to large surface areas (m2)

Complex calculations, involving phase analysis and mapping of the beam, are required to create the desired beam shape, Existing iterative methods, such as the Gerchberg-Saxton algorithm, can be used to create the necessary output (a phase mask) that will approximate the desired shape, however the quality of the recreated shape is often not satisfactory for high quality machining.

In this work, we have implemented the Gerchberg-Saxton algorithm and a series of its derivatives as well as explored other phase mask generation methods. The suitability of these methods for spatial beam shaping of ultrafast laser pulses for industrial micro-machining was assessed in terms of calculation time, efficiency and shape error.

Jeffery Low is a research engineer in the Photon Factory at the University of Auckland, where he also completed his bachelors in Mechatronics Engineering. As a member of the Photon Factory's machining team his work is focused on using laser based technology to provide solutions for manufacturing challenges.

Semiconductor platforms for enhanced Raman Spectroscopies

ARUL, RAKESH (PRESENTING AUTHOR)
aDepartment of Physics & School of Chemical Sciences, University of Auckland
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
raru090@aucklanduni.ac.nz

YE, JASON; DONG, JUNZHE; BUCHANAN, REBECCA; ROSALIND-BETZ, HAZEL; WEST, CLAIRE ; NIEUWOUDT, MICHEL; XIANG, LIQIN; GAO, WEI; SIMPSON, M. CATHER
aDepartment of Physics & School of Chemical Sciences, University of Auckland
bPhoton Factory, MacDiarmid Institute for Advanced Materials and Nanotechnology & Dodd-Walls Centre for Photonics and Quantum Technologies
cDepartment of Chemical and Materials Engineering, The University of Auckland
dDepartment of Applied Physics, Northwestern Polytechnical University, People's Republic of China
c.simpson@auckland.ac.nz

Raman spectroscopy is a powerful tool for the detection and characterization of chemicals in complex mixtures (e.g. melamine in milk). However, Raman spectroscopy is a very inefficient process and not very sensitive. Surface Enhanced Raman Spectroscopy (SERS) using nanostructured noble metal surfaces can enhance the sensitivity of Raman spectroscopy by 6 orders of magnitude. More recent studies suggest that semiconductors, in addition to and in place of noble metals, can be used for Raman enhancement via the Photo-Induced Enhanced Raman Spectroscopy (PIERS) effect. This has the opportunity to revolutionize the field of enhanced Raman spectroscopy, as semiconductor nanomaterials are cheaper and more inert than the standard metal nanoparticles used. We explore metal oxide nanostructures as a platform for SERS and increase the Raman enhancement by crystal phase engineering and heterostructuring with metal nanoparticles. Hybrid TiO_2 and silver nanostructures were synthesized via laser treatment to induce dewetting of silver nanoparticles and crystallization of TiO_2. This resulted in an order-of-magnitude improvement in detection senstitivity over the regular, state-of-the-art in SERS, and the mechanism of enhancement is investigated in detail. We also investigated electrochemical and sol-gel synthesized pure and doped semiconductor systems (TiO_2, ZrO_2, WO_3) to replace the use of expensive noble metals in SERS. This technology could be used to detect trace contaminants in wastewater, and is benchmarked by testing low concentrations (down to tens of femtomolar) of dye contaminants in water.

Rakesh is currently a research engineer in the Photon Factory in the University of Auckland and recently finished his MSc in Chemistry at the University of Auckland and BE(Hons) in Chemical and Materials Engineering. His research interests in material science involve using laser-based processing to improve the photonic and chemical properties of engineered nano-surfaces for sensing trace contaminants in wastewater and other industries using Raman spectroscopy.

An AR-enabled collaborative prototyping system

LIN, YUAN (PRESENTING AUTHOR)
University of Auckland
ylin797@aucklanduni.ac.nz

XU, XUN
University of Auckland
xun.xu@auckland.ac.nz

Prototyping is an iterative process involving design, fabrication and evaluation. To reduce the total iteration count and therefore avoid wasting resources, it is crucial to enable manufacturing engineers and end-users to validate the initial design before making any physical prototype, especially when product developer, manufacturer and target market are distributed in different area.

As an effective approach to present the digital model in physical surroundings, Augmented Reality (AR) can eliminate the misconception during design verification, particularly when multiple users can examine the same model during discussion. However, the implementation of such collaborative AR environment often relies heavily on expensive equipment or complex setup that are not widely accessible. Therefore, this study aims to provide a low-cost solution for this problem.

The client software of proposed system is capable of remotely loading CAD models and synchronize its updates at runtime. The comments for design improvements can be shared across every user instantly. The user can join the discussion using various devices including AR/VR goggles, smart phones and any other device has web browser with WebGL support.

The outcome of this study can also bring convenience to other applications, such as remote maintenance and investment negotiation.

Yuan Lin has received a bachelor's degree from Central South University in 2013, and a master degree from Harbin Institute of Technology in 2016. Currently, he is a PhD student from the University of Auckland. His research interests are computer vision and human-machine interaction.

Seat design for a novel head-only MRI scanner

WELLS, CHRISTY (PRESENTING AUTHOR)
School of Design, Victoria University of Wellington
christywells1996@yahoo.com

LEMKE, MAILIN
School of Design,
Victoria University of Wellington
mailin.lemke@vuw.ac.nz

EDGAR, RODRIGUEZ-RAMIREZ
School of Design,
Victoria University of Wellington
Edgar.Rodriguez-Ramirez@vuw.ac.nz

PARKINSON, BEN
Robinson Research Institute,
Victoria University of Wellington
Ben.Parkinson@vuw.ac.nz

Magnetic resonance imaging scanners use strong magnetic fields to obtain images of the human body. This medical technology is used worldwide in clinical practice, however, current devices are expensive to manufacture and require the user to be situated in a supine or prone position while undergoing the scanning procedure. A new kind of head only MRI scanner is currently being developed by a team of world-leading experts in the field of MRI and allows decreasing the overall footprint of the system by placing the patient in an upright position. We report on the design of a seat that is developed as part of the multi-site research and design project. Our seat design can be used as part of this novel MRI system that places the user in the correct position inside the magnet. We followed a human-centred design methodology based on the development of multiple design concepts and user testing sessions to evaluate the usability of the chair. The designs were influenced by human factors which secure that the intended population will be able to use the system as well as factors that enable a comfortable user experience and a high level of perceived comfort. Our iterative design process led to two full-scale prototypes which were tested by participants. Participants indicated that the chair needs further refinement to increase the user experience but provides sufficient support for a 20-minute scanning procedure. Our results suggest that the chair should be similar to a lounge chair and provide a leg rest and footrest to secure a sufficient level of comfort and support while being placed inside the scanner. Further studies are required to validate our initial results and confirm the usability of the system in clinical practice.

Christy Wells is enrolled as a student in the 'Master of Design Innovation' program at VUW. Her research focuses on the development of a new kind of MRI system which allows an upright position during the scanning procedure and creating a comfortable user experience.

Reducing risk in pre-production investigations through undergraduate engineering projects.

EWART, PAUL (PRESENTING AUTHOR)
Centre for Engineering and Industrial Design
Waikato Institute of Technology
paul.ewart@waikato.ac.nz

KIM, CHAN
Centre for Engineering and Industrial Design
Waikato Institute of Technology
chan.kim@waikato.ac.nz

AL-RAWI, MOHAMMAD
Centre for Engineering and Industrial Design
Waikato Institute of Technology
mohammad.al-rawi@waikato.ac.nz

This poster is the culmination of final year Bachelor of Engineering Technology (B.Eng.Tech) student projects in 2017 and 2018. The B.Eng.Tech is a level seven qualification that aligns to the Sydney accord for three year engineering degree and hence is internationally benchmarked. The enabling mechanism of these projects is the industry connectivity that creates real world projects and highlights the benefits of the investigation of process at the technologist level.

The methodologies we use are basic and transparent, with enough depth of technical knowledge to ensure the industry partners gain from the collaboration process. The process we use minimises disconnect between the student and the industry supervisor while maintaining the academic freedom of the student and the commercial sensitivities of the supervisor.

The general motivation for this approach is the reduction of the entry cost of industry to enable consideration of new technologies, and thereby reducing risk to core business and shareholder profits.

The poster presents several images and interpretive dialogue to explain the positive and negative aspects of the student process.

Paul Ewart. PhD materials and processing science (UoW 2015). He is research leader at Centre for Engineering and Industrial Design, Wintec. Recently received an Erasmus grant for European collaboration investigating project-based learning in processes research and education.

Interests include, prototyping processes, pre-production manufacturing, mechanical dynamics for health and well-being.

Representing and reasoning about the quality of preliminary design information in engineering product development

BRINKMANN, JENS
(PRESENTING AUTHOR)
University of Auckland
Jbri364@aucklanduni.ac.nz

WYNN, DAVID
University of Auckland
d.wynn@auckland.ac.nz

SHEKAR, ARUNA
Massey University
a.shekar@massey.ac.nz

In the early stages of a design project many important issues are unknown or only known in an imprecise manner. In current practice the iterative maturation of design information is not explicitly captured alongside that information; for example, many design modelling tools require parameter values to be entered in a precise manner even if the quality of the information is known to be poor. This can cause problems in which downstream consumers of the information waste effort on tasks that are not yet justified. If the status of the information – the Quality of Preliminary Design Information (QoPDI) – could be made explicit, this could help to avoid such problems, potentially leading to reduced rework and to better designs.

QoPDI has numerous facets such as ambiguity, uncertainty etc.

To facilitate communication of QoPDI between designers that are potentially from different departments, companies or located around the world, a common vocabulary is necessary. Therefore, a taxonomy – with 107 entries - clarifying and relating the facets of QoPDI has been developed. Building on this taxonomy an integrated framework has been established that operationalises several of these terminologies found in literature.

By eliciting and expressing the QoPDI in a given situation and QoPDI for tasks of several sophistication levels, guidance in task-selection and effort-allocation can be provided in a rational way.

For this MaD-funded project 15 practitioners from 5 companies shared their experience and thoughts about using preliminary information in 18.5 hours of conversation.

By combining the insights from literature with these real-world needs, a concept demonstrator for matching the available information quality and task-needs for QoPDI was created. As next steps, the further analysis of the conversations as well as the evaluation of the concept demonstrator will continue.

Jens Brinkmann is a PhD candidate in Mechanical Engineering at the University of Auckland since October 2017. After gaining experience at different consulting companies in Chile and Germany where he most recently organised virtual assembly meetings for Volkswagen, he decided to proceed in academia and moved to New Zealand.

Thermal Power Stirling - Green Heat Engine

AL-RAWI, MOHAMMAD (PRESENTING AUTHOR)
CEID/Wintec
Mohammad.al-rawi@wintec.ac.nz

MYLARAPU, AKHIL
CEID/Wintec
Akhmyl05@student.wintec.ac.nz

PAUL, EWART
CEID/Wintec
Paul.Ewart@wintec.ac.nz

Primary energy consumption growth averaged 2.2% in 2017, up from 1.2% in 2016. Natural gas accounted for the largest increase in energy consumption followed by renewable energy and oil. Global oil growth averaged 1.7 million barrels per day, natural gas consumption rose by 96 million cubic metres and coal consumption increased by 25 tonnes of oil equivalent and power generation rose by 2.8%. This caused the Carbon emissions to grow by 1.6% after little or no growth from 2014 to 2016. Carbon emissions pose a great threat to the planet as they are the main contributors to greenhouse effects and global warming. To minimise this, a great deal of money and research is being put into renewable and green sources of energy. One of these renewable sources of energy is solar energy. A Stirling engine provides a cheap and easy way of converting this solar energy into electrical energy while also providing a higher efficiency than gasoline or diesel engines. The aim of this project is to design and build a Stirling Engine which produces electricity using sunlight as the main source of heat energy. The working fluid for this project would be air at atmospheric pressure and the electricity generated would be sufficient enough to do some useful work and would present this system as an alternative form of environmentally friendly electricity generator.

Mohammad AL-Rawi is a Senior Academic Staff Member in Wintec's Centre for Engineering and Industrial Design. His current research is on improving air quality in residential environments. He designs and builds a residential air quality improvement system in order to prevent the negative health consequences associated with living in the damp.

Reproduction of a 1928 AJS cylinder head

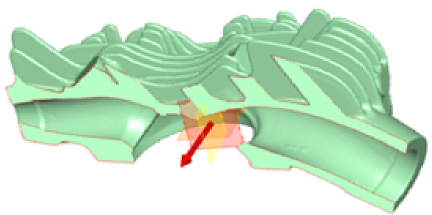
GLASSON, NEIL
Callaghan Innovation
neil.glasson@callaghaninnovation.govt.nz

A client recently wanted to reproduce an overhead cam cylinder head for a 1928 AJS motorcycle. They had borrowed an original head and wanted to produce an exact replica. Reproducing the original patterns would have been laborious, expensive and cost prohibitive for producing only one or two finished heads. The use of 3D printing in PLA to produce one-off or short-run investment castings has become commonplace and this was deemed to be an attractive option.

The main challenge with this project was to find a cost-effective way to generate the 3D model from the original head. Optical scanning is cheap and readily available but is limited to only being able to scan what can be clearly seen. For this part, optical scanning could not adequately model the depths of the cooling fins, nor the internal geometry of the ports. More advanced CT scanning could be accessed overseas to enable modelling of all geometry (including internal), but this was deemed to be excessively expensive and unacceptable with a borrowed original part.

A hybrid approach, using a combination of optical scanning, silicone molding, templating, CAD modelling and mesh refinement enabled an accurate 3D model to be produced. Machining and shrinkage allowances were added to the model before the part was 3D printed, vapor polished and investment cast in iron. The original 3D scan data also enabled production of drawings to aid final machining. The finished casting has been a success and the client is now looking to produce more heads for sale to help fund the rest of the restoration.

Neil Glasson is a Lead Research Engineer with Callaghan Innovation and has an interest in finding meaningful and practical applications for 3D printing and 3D scanning. Neil has recently been part of the development team realizing a prototype microfabrication machine – 3D printing on the micron scale: (https://micromaker3d.callaghaninnovation.govt.nz/)



Synthesis of Conductive Ink for Printed Sensors

REHMANI, MUHAMMAD (PRESENTING AUTHOR)
Massey University
m.a.a.rehmani@massey.ac.nzl

ARIF, KHALID
Massey University
k.arif@massey.ac.nz

Printed flexible electronics has opened the doors for many household and commercial applications due to its advantage of being a two-dimensional device with flexibility to be integrated onto the curved surfaces. However, the fabrication process requires substantial capital investment and is more suitable for mass production. Moreover, customization of processes and design is still a challenge.

Recently, inkjet printing has provided some control over the customization and drop-on-demand fabrication process. Inkjet process often requires intricate setups, special inks, printhead and suitable post processing of substrate. Moreover, the existing printing methods are not suitable for high aspect printing.

In our previous research we devised a facile method for printing of electrodes on thin films which provided a low-cost solution as well as control over the design customization.

In this research, a method is proposed to synthesize the high viscosity tin-lead (Sn-Pb) ink for screen printing suitable for high aspect ratio printing. The ink is curable at a temperature below 185 degrees centigrade. Due to the nature of ink to fully cure at low temperature the synthesized ink can be used on various flexible substrates such as polyamide. A low-cost Sn-Pb precursor and simple processes for synthesizing the ink make this approach attractive for printed electronics applications. The proposed methodology along with the facile templating method can be used to batch fabricate printed sensors at a very low cost.

Muhammad Rehmani is currently pursuing PhD at the School of Engineering, Massey University Auckland. He holds a master's degree in Mechatronics from Jeju University, South Korea and more than 10 years of industry experience in different roles. His research interests include sensing technology, printed electronics, 3D printing and instrumentation.

Effects of moisture degradation on poly lactic acid in fused deposition modelling

HARRIS, MUHAMMAD (PRESENTING AUTHOR)
Massey University, Auckland.
m.harris@massey.ac.nz

POTGIETER, JOHAN
Massey University, Auckland.
j.potgieter@massey.ac.nz

ARIF, KHALID
Massey University, Auckland.
k.arif@massey.ac.nz

Additive manufacturing (or 3D printing) is rapidly evolving as the dominating technology to manufacture complex geometries with precision. Fused deposition modelling (FDM) is the most common form of additive manufacturing due to the affordable access enabled by the open source 3D printers with a range of known polymers, i.e., Acrylonitrile butadiene styrene (ABS), Poly lactic acid (PLA), Nylon and Polycarbonate.

FDM structures have inherent porosities at the point of contact between two beads that make the structure weak. These porosities are also vulnerable to moisture adsorption that can lead to moisture degradation of internal structure.

This research reports the effects of moisture degradation on PLA ASTM D638 Type IV dog-bones manufactured by FDM and injection moulding. The dog-bones were immersed in water for 30 days to allow the water to adsorb into the porosities. The research includes the tensile testing of dog-bones to analyse the effects on the tensile strength and elastic modulus. It also reports the Fourier transform infrared spectroscopy (FTIR) to co-relate and explain the effects on tensile strength with moisture degradation of chemical groups in PLA.

The research is aimed at assisting the research community to understand the stability of FDM structures against the most important environment factor, i.e., moisture.

Muhammad Harris is a PhD student in the School of Food and Advanced Technology, Massey University Auckland. Harris holds a BE (hons) and an ME in Manufacturing Engineering from UET Lahore. His research is supported by Food Industry Enabling Technologies (FIET) program.

Extrusion system for 3D printing of pelletized plastics

VOCKERODT, NATHAN (PRESENTING AUTHOR)
Massey University, Auckland.
nmvockerodt@gmail.com

ARIF, KHALID
Massey University, Auckland.
k.arif@massey.ac.nz

The purpose of our extrusion system is to research and develop a method to utilise a broader spectrum of solid material consistencies ranging from powders to plastic chips. This ultimately results in a cheaper 3D printing process as the production of spooled plastic filament can be completely skipped. The production of filament usually entails melt down of pelletized plastics and extrusion through a nozzle. The extruded plastic is then pulled through a series of cooling baths and sponges until finally wound on a spool.

Our 3D printing solution subverts this step entirely by using the pelletized materials directly in the 3D printing process. An auger (extruder screw) is used to drive the pellets from a storage hopper into a heated chamber where melting occurs. The extruder pushes pellets into the heated chamber resulting in the prior melted material to extrude out of a nozzle. A cartesian based movement system is then used to move this extruder in accordance to a generated 'g-code' file.

A pellet extrusion printer allows for easier mixing of materials and colours as opposed to the typical FDM (Fused Deposition Modelling) printing method. It may be possible to create a system which deposits and mixes coloured pellets in different ratios in order to create a large variety of colours similar to what typical ink-jet printers do with their colour cartridges using the CMYK (Cyan, Magenta, Yellow, Black) spectrum. This makes it possible to print in any single colour. It is also possible to customise the strength and/or flexibility of the final product by mixing with additives. Pellet extrusion allows for greater freedom of useable material as compared to typical FDM printers; it is possible to print materials that are not typically spooled which may include glass, wax, sugars, sand, PVC, etc.

Nathan Vockerodt is a 3rd year BE (hons) student in Mechatronics Engineering at Massey University. He is currently involved in a range of additive manufacturing research/development projects. His research interests include industrial robotics, additive manufacturing and aeronautics.

Thermographic evaluation of additive manufactured materials

LEMERCIER, BAPTISTE (PRESENTING AUTHOR)
University Clermont Auvergne, Sigma-Clermont Engineering School
baptiste.lemercier@waikato.ac.nz

TIGHE, RACHAEL C.
University of Waikato
rachael.tighe@waikato.ac.uk

Additive manufactured (AM) materials are known to suffer from manufacturing defects such as porosity. To increase assurance of AM parts and further enable their application in structural roles a complete understanding of the mechanical properties of the materials produced is required. A study is carried out assessing the feasibility of using thermographic techniques for this purpose. Currently, mechanical properties are assessed by destructive testing of a test specimen. This approach gives an indication of bulk material properties but gives little understanding about how properties may vary through the part. Where properties vary or defects are found, stress concentrations may be created which can lead to premature failure. Thermoelastic stress analysis (TSA) is an existing technique that gives information about surface stress distributions. To inspect using TSA the component is cyclically loaded at a low load (well below yield) to create a small thermoelastic signal. Using an infrared detector this signal is recorded and the thermal response is correlated to the applied load to reveal stress distributions. The study aimed to assess the use of TSA to ascertain the impact of process parameters on stress concentrations created during the manufacturing process. If the parameters influencing stress concentrations are better understood and informed then the reliability of AM parts can be improved. Initial work has focussed on the implementation of TSA on polymers including ABS, Figure 1, where there is a push towards using such material for increasingly structural parts. Work progresses towards implementation on metallic AM components that are prone to similar manufacturing defects.

Baptiste Lemercier: Master's student in mechanical and dynamics engineering, in Sigma-Clermont, France. Intern in the University of Waikato, working on using infrared thermography to inform on additive Manufacturing.

Dr Rachael Tighe: Lecturer of Mechanical Engineering at the University of Waikato. Research interests include developing non-destructive evaluation and materials characterization using imaging based approaches.

A study of the influence of ambient temperature and humidity on fabricated parts by Fused Deposition Modelling (FDM)

AMEER, ADEL (PRESENTING AUTHOR)
University of Waikato
aaa45@students.waikato.ac.nz

CHIKIT, AU
University of Waikato
chikit.au@waikato.ac.nz

CARSON, JAMES
University of Waikato
jkcarson@waikato.ac.nz

Fused Deposition Modeling (FDM) is becoming mainstream in additive manufacturing (AM) techniques. The FDM procedure begins by forming layers of semi-molten thermoplastic filament which is heated and extruded through a nozzle to build a desired model. In this paper, experiments were performed to identify the influence of ambient temperature and humidity on FDM parts to enhance mechanical properties. It turns out that ambient temperature and humidity have not been experimentally tested with the use of a 3D printer. Layer thickness, raster angle and fill pattern were identified to have the greatest effect on the quality of FDM components. A series of FDM specimens with raster angle of 0°, 45° and 90° were manufactured at ambient temperature between 23°C and 40 °C, using the MK3 3i Prusa (3D printer) which is placed inside an insulation chamber. The insulation chamber employs an electric heater and a heat exchanger to maintain the ambient temperature and humidity. Samples were subjected to a uniaxial universal tester for evaluating the tensile strength. Results showed that parts fabricated at higher ambient temperatures had significantly higher tensile strength compared to the components fabricated in a normal environmental condition. The 45° raster angle produced the sturdiest specimen with average magnitude of 43.04 MPa at high ambient temperature. The weakest specimen average magnitude of 37.53 MPa at low temperature.

This research positively impacts NZ design and manufacturing processes. 3D printing has great potential in medical filed particularly in human orthopaedics, dentistry and surgery procedures.

Adel Abdulhamed Ameer is a PhD student in Mechanical Engineering, Waikato University. His areas of research are Manufacturing of Modelling, CAD and Additive Manufacturing.

Full field displacement measurement for 3D printed parts using digital image correlation

ARIF, KHALID (PRESENTING AUTHOR)
Massey University, Auckland
k.arift@massey.ac.nz

MATTHEWS, STEVEN
University of Auckland, Auckland
s.m@auckland.ac.nz

We present the application of 2D Digital Image Correlation (DIC) technique to parts produced using a Selective Laser Sintering (SLS) 3D printer. In SLS, tiny particles of plastics are fused together through heat produced by a high-power laser. The tensile strength of the SLS printed part varies considerably depending on the orientation of printing, speed of scanning, and time allowed for the part to be cured. Mechanical strength can be measured by conventional tensile tests, however, with so much variation in the maximum stresses, it raises questions about the behaviour of the tested part, which 1D test such as in tensile testing machine cannot solve. These tests do not take into account material non-uniformities, heterogeneity of parts and non-isotropic properties – which are evident from different failure loads obtained during testing.

On the contrary, DIC can accurately measure complex displacements at the surface of the object under any kind of loading, providing greater understanding of stresses and strains across the entire sample surface (Fig. 1).

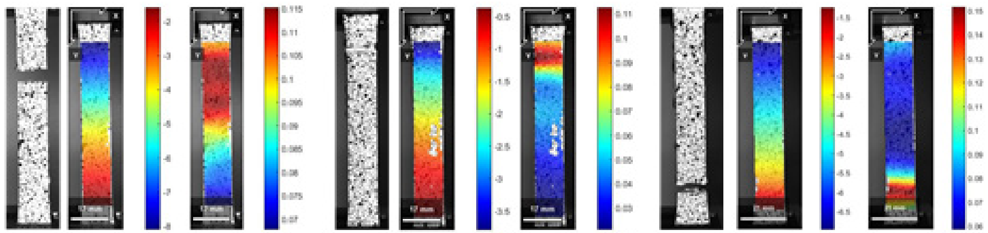


Fig. 1 - Displacement and strain plots for samples tested in Instron 5967 with the DIC setup.

Several crucial parameters such as DIC setup, pattern generation and image processing are discussed with respect to their application against 3D printed polymer parts. Accuracy of measured displacements are heavily dependent on the quality of imaging, speckle pattern and subset size. Imaging and pattern requirements for 3D printed parts are different from other materials due to the surface texture of SLS printed parts and their highly non-isotropic properties as a function of build geometry. The surface texture of SLS printed parts, in particular, dictates the type of spectral pattern and subsequently the subset size yielding most accurate results.

Dr. Khalid Arif is a Senior Lecturer in Mechatronics and Robotics at Massey University Auckland. His research interests include Sensors, Robotics, and Additive Manufacturing.

Thermomechanical Performance of Bobbin Tool Design as an innovative variant for Friction Stir Welding

TAMADON, ABBAS (PRESENTING AUTHOR)
University of Canterbury
Abbas.tamadon@pg.canterbury.ac.nz

CLUCAS, DON
University of Canterbury
don.clucas@canterbury.ac.nz

PONS, DIRK
University of Canterbury
dirk.pons@canterbury.ac.nz

Bobbin Friction Stir Welding (BFSW) is a new class of solid-phase joining, whereby a symmetrical rotating spool, consisting of two shoulders connected by a fully penetrating pin, ploughs through the interface of the two plates. A fully penetrated bond is achieved by the generated heat and stirring. This welding process is suitable for joining sheet aluminium alloys. The thermomechanical performance of the joint is complicated by the stirring action and requires more elucidations. A comparative study of the microstructure of the weld region was performed by applying metallographic measurement using OM, SEM, and AFM. Experimental work was conducted on AA6082-T6 aluminium plates. To optimize the quality of the weld, understanding the performance of the welding parameters is required. By characterization of the weld structure, we can evaluate the flow-based features in the microstructure, where the failure of flow regimes can cause some specific defects, such as tunnel voids or micro-cracks. Moreover, the effect of the dynamic recrystallization (DRX) was observed as a consequence of severe plastic deformation through the BFSW weld texture. The consequent fine grain size formed in the weld region compared to the base metal results in a homogenized distribution of the equiaxed grains which can enhance the strength of the joint by work hardening. After better understanding of the weld parameters using the empirical model, we have addressed the main objective of this research; interaction between the welding variables including tool design, FSW processing, and the workpiece. BFSW has achieved high potential for industrial applications, where a rapid, full penetration, clean, and economic weld is required.

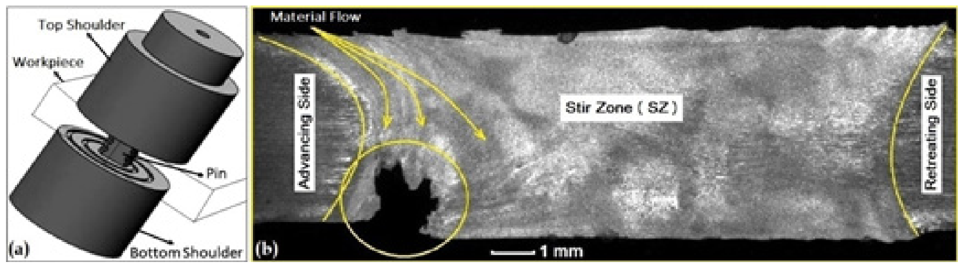


Figure 1. (a) Schematic of bobbin tool, (b) Macroetched cross-section of the BFSW Aluminium weld.

Abbas Tamadon is a PhD student in the Department of Mechanical Engineering, University of Canterbury. With a strong background in Metallurgy, his main research interest is Welding Processing and Manufacturing.

Mass personalisation enabled sustainable development in the context of Industry 4.0

AHELEROFF, SHOHIN (PRESENTING AUTHOR)
The University of Auckland
Shohin.aheleroff@auckland.ac.nz

LIANG, JOHN
The University of Auckland
johnliang1113@gmail.com

XU, XUN
The University of Auckland
xun.xu@auckland.ac.nz

ZHONG, RAY
The University of Hong Kong
zhongzry@hku.hk

Industry 4.0, as the fourth Industrial Revolution, comprises a variety of technologies resulting in cost reduction and efficiency improvement. Industry 4.0 changes the way that value creation and globalisation are transformed towards sustainable development. Industries and business sectors have faced challenges to save the environment and society while there is a continuously growing demand for products worldwide. There are limited studies about how Industry 4.0 could bring significant values to sustainability as much as it has on production. Affordable mass personalisation has offered to address sustainable development in manufacturing. This study has proposed mass personalisation by emerging Industry 4.0 technologies including Internet of Things (IoT), CMfg (Cloud Manufacturing), AM (Additive Manufacturing) and ICT technologies such as AI (Artificial Intelligence). This work investigates how personalisation at scale, in the context of Industry 4.0 would achieve the highest customer satisfaction ensuring sustainable development and economic dimensions. Mass personalisation eco-system along with the required technologies, architecture, and framework have been studied. Subsequently, an overview of opportunities and impacts in different industries for sustainability through mass personalisation is given. An IoT-enabled case study as a specific opportunity for sustainable development in Industry 4.0 has been presented. Finally, challenges and future perspectives have been identified and discussed. This study leads to a sustainable development approach when developing smart products and services (P&S) through mass personalisation as a service.

Shohin is a PhD student in mechanical engineering at the University of Auckland. His research topic is product personalisation in the context of Industry 4.0. Shohin has a proven track record of enterprise projects for +20 years in energy and telecommunications and willing to empower business to operate smarter.

Research for Development – driving breakthrough products

FARIS, DANIEL (PRESENTING AUTHOR)
Locus Research Ltd
daniel@locusresearch.com

ALLAN, TIM
Locus Research Ltd
timothy@locusresearch.com

The right approach to research is what unlocks us to create products with a lasting point of difference.

This presentation outlines a framework for undertaking research with the express intent of unlocking insightful and innovative product development opportunities. Ultimately this is where the core value of a product is created. Doing this effectively has implications for how we plan and scope our research, and for how we document and use what we learn.

Plan

Research for Development begins with planning our research around uncovering insight and not just the gathering of research data. This generally requires the use of multiple types of research, both qualitative and quantitative, in order to generate a three-dimensional picture of the subject. It also requires a thoughtful process of synthesis to translate the facts into meaningful insights.

Scope

The investment into research should be proportionate to the degree of change that you are driving for. For fundamental breakthroughs, a large research base would be desirable to maximise your chances of uncovering new insights and developing breakthroughs. Conversely, even a short/targeted research phase will increase a small project's success, if managed and used effectively.

Document and Use

Formalising the outputs of your research must be done in a format that preserves the key insights throughout the development journey. Done well, this helps ensure that the core promise of the product is not diminished on its journey to commercialisation. This means aligning your research outcomes with the constraints and specifications required to complete the product. We'll show you how we compile this within a single document called a Product Development Specification (PDS).

Timothy Allan is Founder of Locus Research. With more than 20 years' experience as an innovation and R&D leader, Tim has a wide range of experience in the development of new businesses, driven by disruptive products. He has proven ability heading complex product development projects and diversified design teams.

Design and implementation of a robot-assisted trimming system for rotationally moulded plastic

CHEN, WEIHUA (PRESENTING AUTHOR)
Massey University, Auckland.
chenweihua00@gmail.com

ARIF, KHALID
Massey University, Auckland.
k.arif@massey.ac.nz

NOBLE, FRAZER
Massey University, Auckland.
f.noble@massey.ac.nz

Most of the products produced in rotational moulding need to be trimmed. There are two reasons requiring trimming of parts: 1) the flash on some parts caused by the mould must be cut off so that they become qualified products, and 2) some products should be chamfered which is a necessary process in the whole manufacturing.

The existing technique of the trimming generally involves workers with hand operated tools. This method is inefficient, inconsistent, and expensive because workers are not easy to concentrate on the work continuously and result in numerous substandard products. Therefore, an automatic, consistent, and efficient cutting system will help rotational moulding industry to improve their product quality and reduce costs.

We propose to use a six-axis industrial robot equipped with one or more shape recognition sensors to automatically trim the moulded parts. When a moulded part is placed in the working area of this system, the sensor identifies the shape of the part and compares it with the expected shape. Then the system calculates the cutting path and the robot automatically completes the cutting work (Fig. 1).

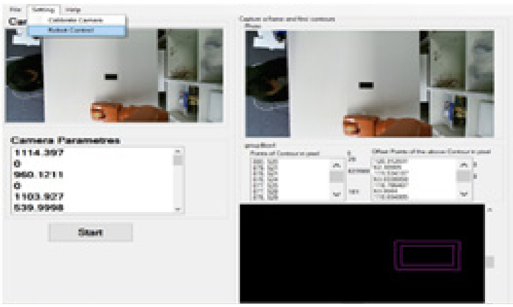


Fig. 1 – User interface for the robot assisted trimming system

According to the results of several experiments, this system can detect the contour of the parts accurately, computes offset points precisely and generates instructions for controlling the robot. Further testing and enhancement of the system is in progress and is shortly expected to result in a fully functional system.

Weihua Chen is a Masters student in the School of Food and Advanced Technology, Massey University Auckland. His research interests include robotics, automation, image processing and 3D printing.

Vibration-based Fault Detection for Non-Stationary Signals in Industrial Drivetrain Systems

CHOUDHURY, MADHURJYA DEV (PRESENTING AUTHOR)
The University of Auckland
mcho491@aucklanduni.ac.nz

RASHID, YOUSEF
The University of Auckland
yras331@aucklanduni.ac.nz

TEAL, PAUL
Victoria University of Wellington
paul.teal@vuw.ac.nz

DHUPIA, JASPREET
The University of Auckland
j.dhupia@auckland.ac.nz

Manufacturing processes involve transportation, processing, and assembly of raw materials, which are extensively carried out through drivetrain assemblies comprising of motors, generators, geared mechanisms, etc. Any failure in such systems result in loss of capital and reduced productivity. Thus avoiding premature machine failures in order to ensure system availability is of utmost importance to the economic health of the manufacturing sector, which alone contributes around 12-15% to New Zealand's annual GDP. Condition-based health monitoring via processing of measured vibration signal can play an important role in improving machine reliability/availability. However, inherent fluctuations in the machine operating speeds result in non-stationary nature of the measured signals that challenges practical implementation of these techniques. An advanced fault detection algorithm, which forms the basis of online condition monitoring software that is widely applied for condition-based machinery maintenance is proposed in this work. The detection algorithm combines adaptive signal decomposition (ASD) and dynamic time warping (DTW), to extract reliable fault information from the measured vibration signals. First, an ASD algorithm is used to decompose the measured signal into its various constituent intrinsic modes (IMs). This adaptive decomposition overcomes the challenge of manually selecting and tuning a band-pass filter to process the measured vibration signal. Thereafter, the IM containing the relevant fault information is selected for spectral analysis. The DTW method performs an "elastic" stretching and compression along the time axis of this IM, which removes the spectral smearing. The measurements processed with the proposed algorithm contain rich fault information, which allows for robust machinery failure detection. The effectiveness of the algorithm has been validated both by simulated and experimental data obtained from industrial gearboxes.

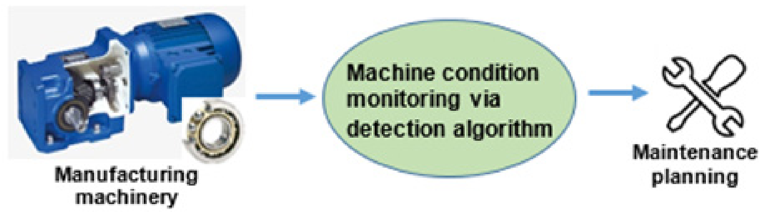


Figure 1. Steps involved in a machine's health management.

Madhurjya Dev Choudhury is pursuing his PhD in the area of condition monitoring and fault diagnosis at the University of Auckland.

Real-time prediction of sanitary sewer blockages and overflows using RFID sensor modules

TATIPARTHI, SUNDRA (PRESENTING AUTHOR)
The University of Auckland
Stat604@aucklanduni.ac.nz

GREGORY DE COSTA, YASHIKA
The University of Auckland
ydec845@aucklanduni.ac.nz

ZHUANG, WEI-QIN
The University of Auckland
wq.zhuang@auckland.ac.nz

ZHONG, RAY
The University of Hong Kong
zhongzry@hku.hk

WHITTAKER, COLIN NICHOLAS
The University of Auckland
c.whittaker@auckland.ac.nz

Ageing urban drainage networks and changes in domestic wastewater inflow have severely affected sewer network performance, leading to failures and overflows. These issues are mainly attributed to the disposal of kitchen food into the sewer network, rising levels of fats, oil and grease and installation of low flush toilets. These factors further affect sewer velocities, causing a fall below low flow conditions (<0.6 m/s), and an accumulation of sediment. During dry weather conditions, these deposited solids eventually change their properties and form fatbergs which cause sewer blockages, corrosion, and abhorrent odour problems. Therefore, failure to regularly manage and maintain these infrastructure networks leads to significant economic investments for water utilities and governments. Furthermore, overflows also cause pathogenic microorganisms' contamination in both aquatic and terrestrial environments, which has received increased attention in New Zealand recently.

This study aims to identify potential sewer blockages and overflows through affordable, real-time smart sensor modules using such as Radio Frequency Identification (RFID) and the Internet of Things (IoT). Data transmission and cloud computing play essential roles in this study, whereby manufacturing and design industries involved in additive tools can co-develop to design and develop models towards sustainable water management for water authorities. So far, this study has measured surface velocities in open flow channels, under various flow conditions, through sensor modules. The Manning's formula was used to compute flow characteristics in open channel. Preliminary results have revealed a good correlation between measured and calculated velocities from sensor modules and design flows. Although this technology is yet to be tested in the field, in the longer term, this study aims to provide new models to predict sewer corrosion and enable real-time assessment of sewer pipe networks. These modular sensor approaches will ultimately assist both water authorities and asset managers to make decisions and identify adverse locations for cost controlling in sewers and extend their asset lifetimes.

Sundra Tatiparthi is a PhD candidate from the University of Auckland under the supervision of Dr. Wei-Qin Zhuang. Their research interests are in Smart Wastewater and Stormwater networks.

Manta and Cactaceae

LEMKE, MAILIN (PRESENTING AUTHOR)
School of Design, Victoria University of Wellington
Mailin.lemke@vuw.ac.nz

RODRIGUEZ-RAMIREZ, EDGAR
School of Design, Victoria University of Wellington
Edgar.Rodriguez-Ramirez@vuw.ac.nz

ROBINSON, BRIAN
Graduate School of Nursing, Midwifery and Health, Victoria University of Wellington
Brian.Robinson@vuw.ac.nz

Stroke causes persistent damages to the brain affecting commonly one side of the body. The preferential use of the less affected arm and hand can contribute to a so called 'learned nonuse' which can be overcome by restraining the movement of the unaffected side and promoting a behaviour change. The design of everyday objects for people with stroke has a strong focus on compensating the lost motor abilities rather than contributing to an initiation of use of the affected arm and hand and therefore facilitating rehabilitation. This study followed a 'research through design' methodology to develop design concepts for everyday objects which encourage the use of the affected arm and hand by restraining the movement and therefore contributing to the rehabilitation process. We focused on the design of an object which can be used with a smartphone based on our previous results investigating essential everyday objects post stroke. Two design prototypes were evaluated by four people with chronic stroke. Our formative usability evaluation indicates that the design prototypes evoke an initiation of use but require further refinement to increase the usability of the designs. Long-term studies should investigate the anticipated behaviour change that our design prototypes aim to evoke in daily activities.

Mailin Lemke has completed a PhD at Victoria University of Wellington focusing on everyday objects for people with a chronic stroke which aim to contribute to the rehabilitation process. Mailin currently holds a post-doc position at the School of Design focusing on the development of an MRI scanner.

Presenter Index

Presenter Index continued

Notes

Manufacturing and Design **NZ**