



RMIT Wearables and Sensing Network

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Year 1 Report
September, 2020

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Welcome to W+SN Report

This report details the activities of the RMIT Wearables and Sensing Network (W+SN) in its first year. The aim of the network is to create collaborative partnerships across RMIT Schools and disciplines. We also seek to investigate new innovation models for developing wearable and sensing technologies that address big impact issues in health, ageing and sustainability.

W+SN coalesces cross-disciplinary clusters to develop work that is technologically and aesthetically world-leading. We combine expertise in nanoscale computer architecture, conductive materials, mechanical engineering, IoT systems and wearable sensors with cutting edge design thinking, co-design, product design and business knowledge. We seek to reframe how wearable and sensing technologies have been traditionally developed - privileging a technology push approach - by applying human centred design principals to high impact social, health and environmental issues.

The W+SN was launched in September 2019 with support from the Strategic Capability Development Fund (SCDF) and seed funding from the School of Design. As of September 2020 the network brings together over 75 researchers from 12 RMIT Schools. It is supported by 5 ECPs: Design and Creative Practice, Electrical and Systems (Engineering), Social Change, Advanced Materials, and Biomedical and Health Innovation.

In its first year the W+SN undertook a range of activities including market research, branding and collaborative events. Professor Swee Mak officially launched the network on Friday 13 September 2019 at an event at the RMIT Activator. During the launch we hosted two panels, one that invited our supporting ECP Directors to reflect on the megatrends the W+SN could explore, and another focused on impact, commercialisation and translation. During the launch event network members used a customised co-design toolkit to develop a 'megatrend mapping.' We used the data from this mapping to inform the creation of a data visualisation to guide the direction of the network.

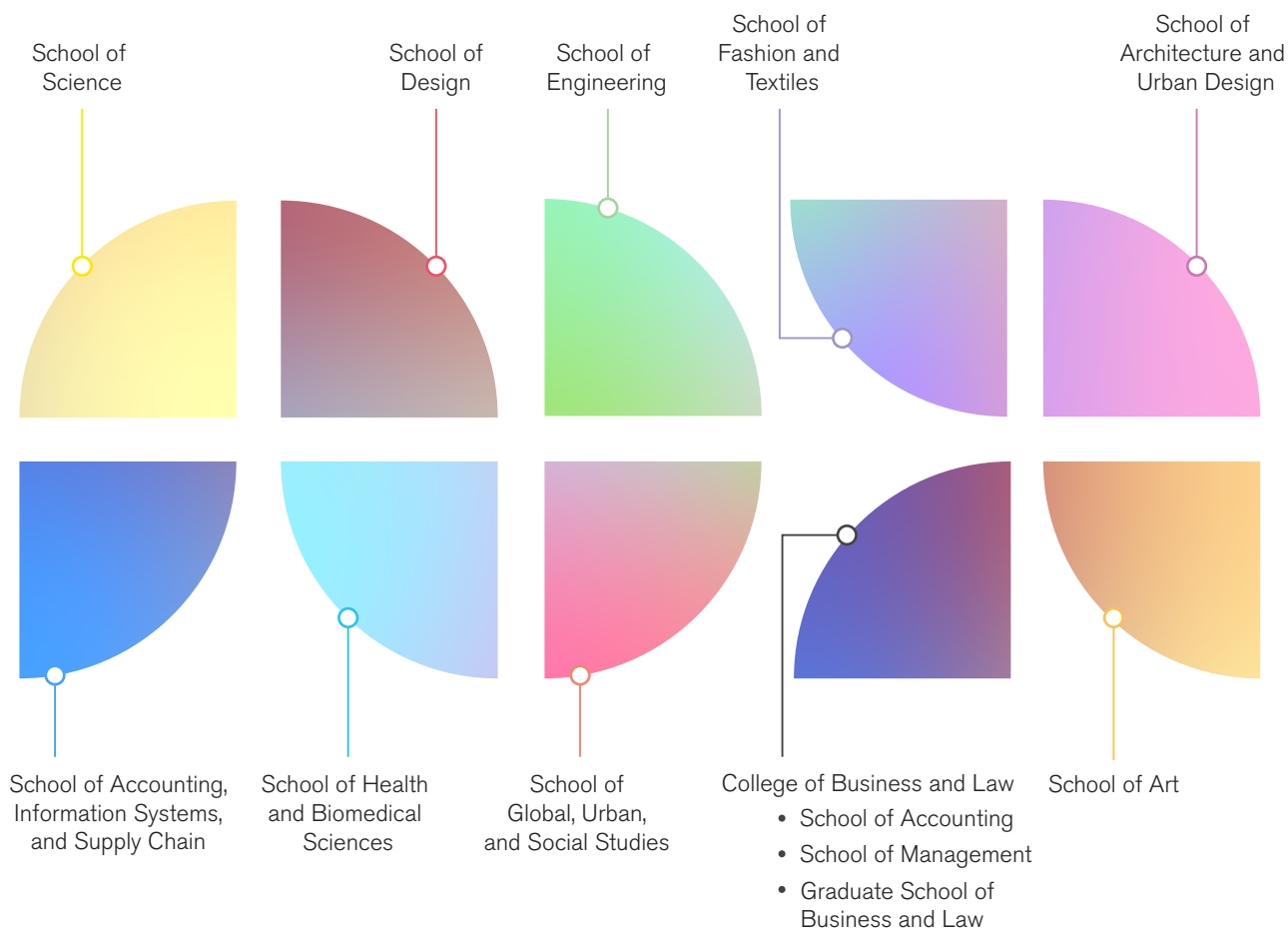


Diagram illustrating the twelve RMIT Schools that comprise the W+SN.

In November 2019 we hosted the Building New Languages event during which 10 research leaders shared their areas of expertise in 'lightening-fast talks.' Participants also took part in a giant capability mapping activity to identify skills, capabilities and partnerships across the network.

In parallel to these events we have undertaken a global review of existing research clusters and centres (both commercial and non-commercial) as a starting point for situating the W+SN within a local and global research context. This research is communicated in the 'Mapping Wearables and Sensing Report' available on the W+SN website under resources: www.ws-network.com.au.

COVID-19 and its impacts on RMIT in 2020 have shifted our focus from face-to-face events to virtual capability building activities. We have instituted a series of 'fireside talks' that will commence in September 2020 in addition to developing an archive of micro-interviews to showcase the abilities, skills and unique talents of our members. W+SN members are invited to participate in these micro-interviews and talks from September-December 2020 with the films being

hosted on the W+SN resources page. The aim of this work is to enable researchers to learn more about the capabilities of their peers and locate research partners when opportunities arise.

Our planned 2020 industry launch has been shifted to 2021 due to COVID constraints. However, our members are involved in a range of COVID response projects, from ethnographic studies through to monitoring approaches for aged care.

While our roadmap has realigned we are still committed to our goal of developing stronger interdisciplinary relationships between RMIT's researchers. RMIT's Research + Industry group outlines key directions for staff and students in the 'Directions to 2020' Roadmap document. Three key goals align with the W+SN strategic direction: 'Creating impact through collaboration', 'Industry and Enterprise embedded in everything we do' and 'Global reach and outlook'. Our W+SN 4-year roadmap ([page 5](#)) visualises the stages of our development from 2019-2022. This roadmap starts with coalescing the community and leads to thought leadership and large partnerships.

W+SN Co-directors



Dr Leah Heiss

Design and Creative Practice



Dr Judith Glover

Design and Creative Practice



Dr Olga Kokshagina

Business, Entrepreneurship

W+SN 4-year plan

The 4-year plan for the W+SN can be broken down into six phases. Each of these will ensure that the network continues to grow at a sustainable rate and lead toward longer-term goals including thought leadership and large-scale industry engagement.

2019

Create and Coalesce

The W+SN was evolved in mid-2019 and officially launched in September 2019. Activities for 2019 focused on bringing together researchers from across the University in a number of organised activities. The first of these was the W+SN Launch (see page 22) in which we introduced the network and engaged participants in a number of co-design activities focused on collaboration. As part of this event we conducted a megatrends mapping to understand the issues that were important for the W+SN to focus on. A subsequent data visualisation (see page 29) uncovered these to be health and wellbeing, data and sustainability.

A parallel activity throughout this period was to undertake an analysis of the landscape in which W+SN operates. This involved conducting an extensive market analysis of research and commercial labs in the wearables and sensing fields to identify potential collaborators. This information is collated in the 'Mapping Wearables and Sensing Report' available on the W+SN website under resources: www.ws-network.com.au.

The final task in this period was to develop an authentic and original brand and website to reflect the vision and purpose of the network. To this end we collaborated with Trampoline, a design agency who have created work for clients including Apple, Federation Square and ACMI. The visual identity for W+SN draws from triadic colours and provides a visual representation of the way seamless collaboration may occur across disciplines.

Connect and Collaborate

Our second event 'Building New Languages' (see page 31), focused on developing understanding between diverse disciplines in the network. At this event participants created a large-scale 'capability

map' to capture the research domains, skills and capabilities that were critical for researchers to do their best work. The data from the activity is being used to inform a series of capability visualisations to deliver back to W+SN members for further input.

2020

Understanding and communicating our capabilities

A central task for 2020 has been to revisit our capability map and conduct a gap analysis. This is a collaborative process that helps us to determine what capabilities have been left 'off the map' and sectors that require further examination. The first part of the activity is to distribute the 'first pass' of the visualisation (via this report) and invite feedback from our members. The visualisation will grow over time as we identify skills and capabilities across the network. The work is complemented by 2020 'fireside talks' and micro-interviews with W+SN members that help us to understand and communicate our skills and unique talents. A second activity is to analyse the global mapping and market analysis and determine the key partners to connect with prior to our industry launch in 2021. During 2020 a number of COVID projects are also happening across the network including COVID monitoring for aged care and ethnographic research for contact tracing.

2021

Engaging the Market

The W+SN is focused on strengthening RMITs capabilities in the market. Part of this is mapping the demand for our services. This will be undertaken through desktop research, industry engagement activities and an industry launch. Within our industry launch we will craft co-design challenges to connect our researchers to industry. The models may follow an IDEO-inspired design challenge format in which industry provide issues on which to focus. A parallel activity will be to understand what the capacity of researchers might be to take on larger-scale opportunities. This 'capacity analysis' is critical to coalescing teams to meet industry demand, as it occurs.

Strategy for Deployment

By 2021 we will have a strong understanding of our capability and capacity in addition to the demand

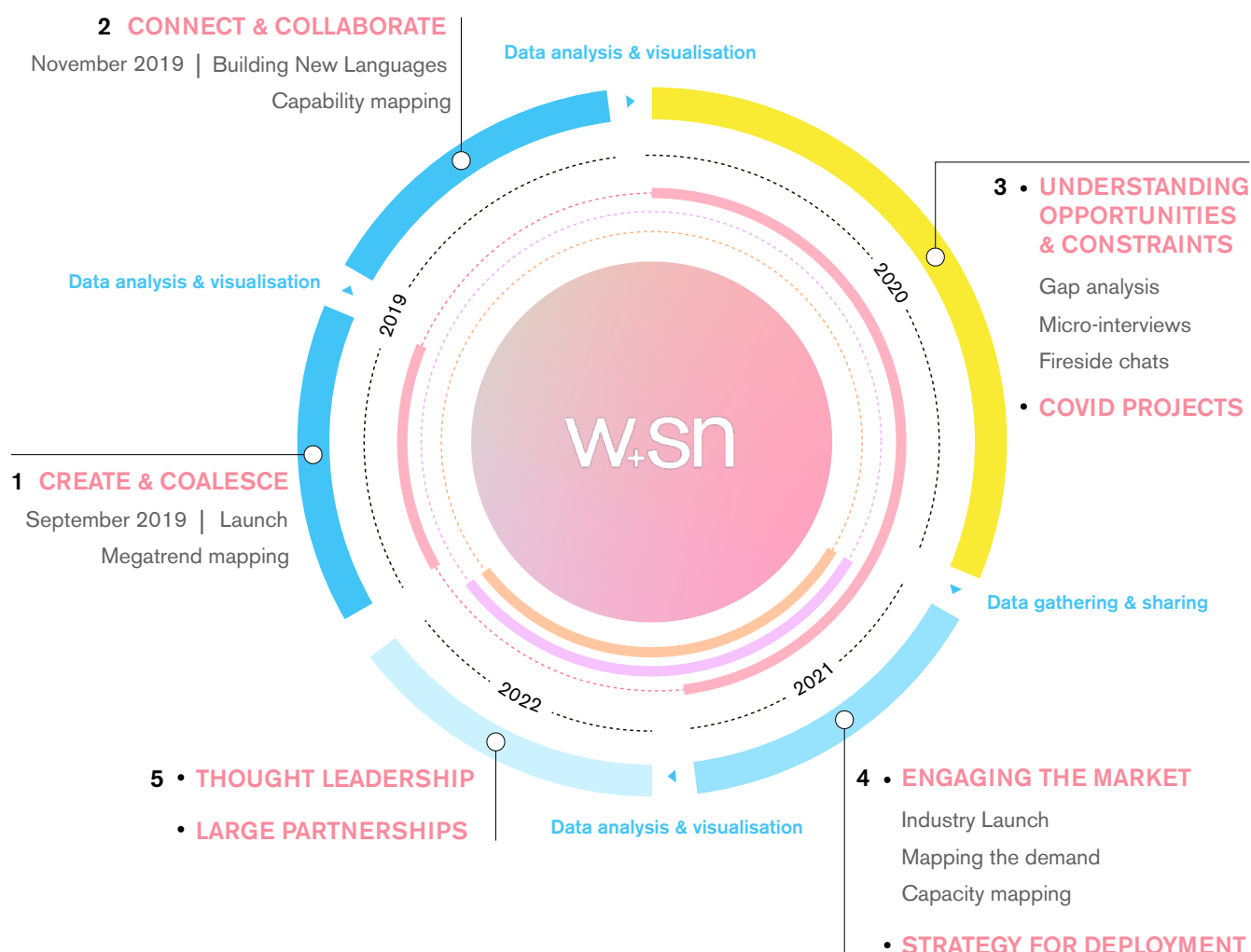


Diagram of the W+SN Growth Cycle over the four years.

for our services in industry. At this stage we will focus on developing a strategy for deployment that draws support from across R+I, including Research Partnerships and Translation, Research Strategy and Services and various SERAGS.

2022

Thought Leadership and Large Partnerships

One of the longer-term goals for the W+SN is to establish thought leadership in the area of wearable and sensing technologies, in Australia and also internationally. We seek to evidence this thought leadership through our large partnerships with domestic and international industry projects.

W+SN Members

School of Design



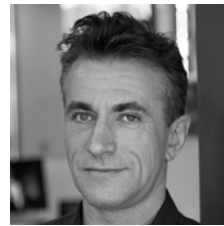
Dr Leah Heiss
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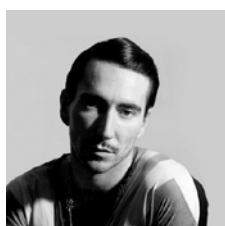
Dr Rohit Ashok Khot



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Dr Liam Fennessy



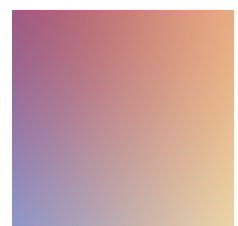
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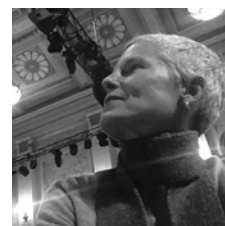
Dr Troy Innocent



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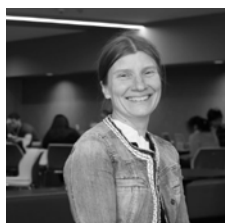


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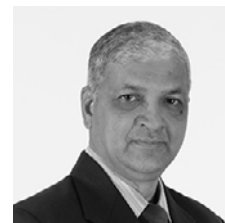
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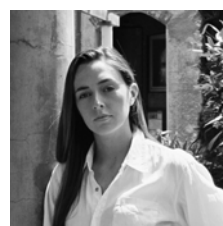
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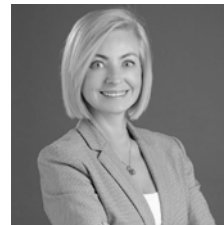
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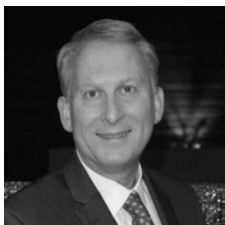


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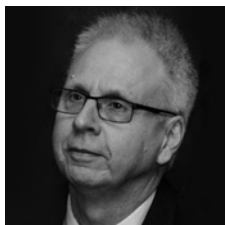


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Defining Wearables

**Jaki Pokrovsky and Dr Jude Glover,
School of Design**

Wearable and sensing technology within the health and medical industries are ubiquitous. The range of applications within this area alone range from implantable devices through to Personal Protective Equipment (PPE) and specialised equipment used within healthcare and medical practice.

Wearable technologies may include devices integrated into clothing and personal accessories, technologies that sit outside the body, as well as those that directly contact internal structures of the body (Slade Shantz and Veillette, 2014). These technologies are designed to sense specific parameters of various

diseases (EMBS, 2019d) or states and can exist and function unobtrusively within the user's life. The data generated from such innovations can be utilised in a number of ways; data can be transferred and stored remotely, generate alerts or response mechanisms to stimulate the patient to act, or the device may perform various functions based on the data received. In some instances, wearable and sensing technologies can be categorised as smart wearable sensing systems (SWSS) that are able to model and recognise user activity, present state, and the surrounding context as part of an ecosystem of objects and data processing components (Lukowicz, 2004). Within the scope of wearable technologies, there are a number of key categories can help us to imagine potential market applications.



The Smart Heart Necklace: A wearable cardiac monitor necklace to collect, store and remotely transmit cardiac data, in collaboration with St. Vincent's Hospital Melbourne, RMIT University, and the Nossal Institute for Global Health; funded by Gandel Philanthropy. RMIT Project team: Leah Heiss (Design), Keely Macarow (Art), Paul Beckett (Engineering). Photographer: Narelle Portanier.

Interoperability and Meaning

A universe of applications for W+SN Dr Olga Kokshagina, W+SN Co-director

Wearables and sensing technologies have great potential in a broad array of applications. They open up a universe of possibilities to find new meanings.

Wearables and sensing technologies are built on generic principles and can potentially be used to address many emerging opportunities. So, when designing your new diagnostic stick, low-cost wearable to detect loneliness, pedometers, new smart watches, etc. - try to think 'where else I can re-use the same principle?' Can it be that the device to detect loneliness can be used to help people with speech pathologies? Or be used instead of a handheld device for translation purposes? This is called 'repurposing existing solutions.' Think of designing a wearable from scratch to reflect the generic potential of the solution at hand. Would you design it the same way if you consider multiple applications?

When designing new wearable or sensing solutions, the user-driven approach is certainly crucial. Yet, for your wearable to be successfully used, try to also think how your device is changing the traditional value chain perspectives. Are there new stakeholders to bring on board? What is the value of your offering for a variety of stakeholders in the value chain? Perhaps, your device makes many traditional stakeholders offerings obsolete? If so, how?

By considering these elements from the beginning, you increase the chance of greater adoption and use of your solution. For example, one of the challenges we face today is cognitive overload: there are way too many

devices, notifications, interfaces that we have to cope with every day. The majority of these devices are not even interoperable. We need to build spontaneous flow in designing our solutions: making them compatible with other solutions people use every day. The inter-usability of solutions is critical to create value for the user and for stakeholders in the value chain.

Think for instance of a patient who comes to see the doctor because his smart watch indicates abnormal cardiac rhythm during his jogging. The doctor will have a hard time interpreting this data as base lines have not been established, different devices have different ways of measuring the cardiac rhythm and different error margins are built into the algorithm. We need to design by considering the ecosystem of possible usages and interfaces where we maximize the usability potential of the built solutions. Just think how many features of your smartphone or smartwatch you actually use.

Finally, this brings us to ethical design and ethical use of data. Wearables and sensing devices have great potential for better understanding different medical conditions and the needs of different users. They provide great opportunities in terms of customisation. However, they also involve responsibilities: how we use the data produced, who owns it, how to ensure data privacy and protection and avoid the risk of wearables 'hacking'.

Many other challenges and opportunities arise when it comes to the interdisciplinary field of wearables and sensing technologies and the W+SN network is committed to dealing with these in a systematic way by bridging different disciplines.



Dr Olga Kokshagina presenting a unique model of collaboration during her talk at the W+SN Building New Languages Event.

Meaningful collaboration across disciplines

Dr Leah Heiss, School of Design

W+SN brings together over 75 researchers from twelve RMIT Schools. Participants come from backgrounds as diverse as art, fashion, textiles, engineering, chemistry, biomedical sciences, design, business and psychology.

Many of our members have spent decades in a particular learning tradition, both as students and as teachers. They have honed the thinking skills of their fields, built and adapted the behaviours required to excel. Yet between schools and sectors there are notable differences in teaching and learning styles – from the structured creativity of engineering and science through to more flexible approaches in the practice of art, design and fashion. Beyond a specific learning style or model, mindsets¹ can also be very different. Despite differences in cognitive style, across the network we see a shared passion for innovation and a desire to collaborate in a meaningful way.

The goal of the W+SN is to encourage this collaboration across disciplines. Our mandate is to bring together people from different backgrounds and to help them to find common ground. It is through finding

commonality and empathising with each other that we can build trust, a precursor to meaningful collaboration.

We start from an understanding that collaboration is a learned skill – like a muscle it requires practice over time. There is a common assumption that collaboration is a continuous and close-coupled process in which individuals mindfully work together to realize a shared vision.² Yet the tidiness of this vision is misleading. Thomas Kvan positions collaboration as being *loosely coupled* with participants “*contributing what they can in different domains of expertise at moments when they have the knowledge*.”³ Such a ‘loose weave’ notion of collaboration is resonant with the purpose and approach of the W+SN. As a group we recognize the need for people to come together and build relationships, prior to embarking on meaningful collaborations. Once connected, participants will share expertise if and when conditions (projects or opportunities) permit.

In February 2020 at Melbourne’s PauseFest Steve Vamos, CEO of Xero, suggested that our potential is the sum of our intellect and our connections.⁴ All intelligence and no connections and our potential is limited. Conversely, no intelligence but all connections and we are similarly stymied. The middle ground is about having the smarts and the people to share them



Members collaborating during W+SN events.

with. This is where W+SN, and other such networks can play a meaningful role. We provide the opportunity for the smartest people in the room to come together and share their expertise with others from different backgrounds.

To encourage these conversations we scaffold events with co-design tools and methods that help us to break down what we know into communicable chunks of information. Much of this is about translating our tacit knowledge into explicit knowledge to be shared with others.⁵ To allow this communication to occur it is critical that events and experiences are social. As Mengis and Eppler suggest, we “*create, share, and integrate knowledge in social interactions.*”⁶ As we are seeking creative connection and meaningful engagement this needs to be designed into the experience. If the vibe is too corporate participants will stay in their silos, too casual and it will be deemed flaky.

Dealing with common ground between experts, Mengis and Eppler write that this “*includes the communicator’s background, their goals, values, but also their social and physical context and more personal attributes such as speech style or emotional state.*”⁷ Learning more about people from different backgrounds helps us to find this common ground.

Another factor in encouraging common ground between diverse experts is to recognise and understand the field from which people emerge. This field includes their educational trajectory, discussed above, but also the tools, techniques and approaches used within that domain. In his book “*Designing Engineers*”, Louis Bucciarelli suggests that when working on a project we each inhabit an ‘object world’ which encompasses “*the domain of thought, action, and artifact within which participants...move and live when working on any specific aspect, instrumental part, subsystem, or sub function of the whole.*”⁸

Within the W+SN we focus on helping individuals to share their ‘object worlds’ with those from outside the fold. One way of accomplishing this is through our series of ‘lightening-fast talks’, launched at the Building New Languages event in 2019, in which we invite experts from across the network to discuss the projects, tools, technologies, approaches, practices and facilities that distinguish their practice (in 7 minutes!). This format was successful in enabling people from other fields to understand complex ideas in a simple way. Professor Sharath Sriram demonstrated the capability of the stretchable sensor he had co-developed with Professor Madhu Bhaskaran and took the audience for a virtual



tour of the RMIT Micro Nano Research Facility; Dr Glenn Matthews showed us through the capabilities of the Surface Mount Device Laboratory to construct and prototype electronics for testing; Professor Margaret Lech articulated the potential of AI in speech processing for safety in public spaces; and Dr Tarryn Handcock's stunning visuals helped the group to understand the potential of fashion to craft and prototype 3-dimensional structures.

Another way to assist our experts to share their worlds is through the 2020 micro-interviews and 'fireside chats.' The aim of these is to create discrete bytes of content to share between researchers, thus improving our understanding of each other's expertise areas.

Such experiences make tangible the complexity of each other's practices. The challenge for experts is to simplify their vocabulary, both visual and verbal, and to replace context-specific jargon with plain language. This enables non-experts to begin the process of making connections between their own practices and those of people from other expertise areas. In the Steve Vamos model, the W+SN is focused on helping researchers to increase their potential by sharing their intelligence through their connections.



¹ Carol Dweck, *Mindset: The New Psychology of Success* (Great Britain: Robinson, 2012).

² Thomas Kvan, "Collaborative design: what is it?," *Automation in Construction* 9, no. 4 (2000): 409–415.

³ Ibid, 411.

⁴ Steve Vamos presentation, The Secret to Success is Pretty Obvious – Humans," presentation at PauseFest, Melbourne, 6 February 2020, <https://www.pausefest.com.au/>

⁵ Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation* (Oxford, New York: Oxford University Press, 1995).

⁶ Jeanne Mengis and Martin J. Eppler, "Seeing versus Arguing The Moderating Role of Collaborative Visualization in Team Knowledge Integration," *Journal of Universal Knowledge Management* 1, no. 3 (2006): 152.

⁷ Mengis and Eppler, 2006, 153.

⁸ Louis Bucciarelli, *Designing Engineers* (Cambridge: The MIT Press, 1996) 62.

Tactile co-design approaches to build connections

Dr Leah Heiss, School of Design

Central to W+SN events is the use of co-design methods to enable collaboration between participants from diverse backgrounds.

During the launch event in September 2019 we conducted a number of mapping activities – a ‘megatrends mapping’ and an ‘expertise mapping’; while at the Building New Languages event we created a large-scale ‘capability mapping’. Each of these experiences has dual goals. Firstly, they enable the network to collect data from participants in an engaging and immersive way. This data informs the creation of visualisations to aid decision-making and secure University and industry support. The second, and more important aim of these activities is to coalesce and cohere participants. The action of building a diagram together in a fun and haptic way loosens up the experience. We are no longer just experts at a symposium being asked to perform a job-related activity (using butcher’s paper, markers and sticky notes). Instead we are playing with bright, colourful shapes and building beautiful patterns. These patterns are not

merely aesthetic; they carry information about who we are and why we are here. The novelty aspect helps us to connect with the people we are sharing this experience with.

Another motivation for using the Tactile Tools™ toolkit in W+SN events is to facilitate a stronger sense of empathy between participants. Empathy is a critical tool for enabling teams to work together as it enables people from diverse backgrounds to understand the world from the perspective of another person, or discipline. As Evan Thompson suggests, “*Empathy... provides a viewpoint in which one’s center of orientation becomes one among others.*”⁹ When considered in the context of the W+SN we use tactile co-design methodologies to create the conditions for participants to empathise with each other and acknowledge multiple viewpoints – in the room, in the University and in their projects.

In the capability mapping activity at Building New Languages in November 2019 participants were asked to ‘build’ their expertise area, as part of a two-metre wide network map. This involved identifying domains of research and articulating the skills and capabilities that are critical to those domains. The activity encouraged conversations within research groups – “*What is it*



Tactile tools being used during the large-scale capability mapping.

that we actually do? What skills do we need to do this?"; but also permitted shoulder rubbing with other groups. By necessity, one part of the map connected with the areas at its boundary and negotiation at the interfaces was required. At these intersections the tiles became mechanisms to enable conversation between people from diverse backgrounds. When two adjacent groups used a tile, and both brought their own meanings to that tile, it could be considered a *boundary object*.¹⁰ Boundary objects are a specific type of artefact to which people bring their own meaning and that operate at the interfaces between disciplines.¹¹ The use of boundary objects helps to create common ground between people from diverse backgrounds or expertise fields. Islind et al. suggest "*An object becomes a boundary object when it serves as a device for transformation, translation, and negotiation at the professional boundaries.*"¹²

The toolkit developed for the W+SN co-design activities was adapted from the Tactile Tools™ methodology, a co-design toolkit that I developed through my PhD research to encourage collaboration in interdisciplinary contexts.¹³ The methodology references generative toolkits¹⁴ which are "*typically used in facilitated collaborative activities, and their results...can*

be analysed to find underlying patterns."¹⁵

Working with collaborator Marius Foley, I have tested the methodology with over 200 experts in a variety of contexts to solve complex problems. For example, to assist Bolton Clarke Aged Care to redesign the end-of-life experience; with Aurecon Engineering to encourage human-centred approaches; and with the Victorian Healthcare Association to understand the roadblocks to implementing Voluntary Assisted Dying in Victoria.

Building on these industry engagements, we adapted the toolkit to cater for W+SN priorities. Paramount of these was the need to understand the skills, desires and expectations of the network. One of the first activities at the W+SN launch in September 2019 was for participants to write on a set of tiles "*Why am I here?*", "*What do I bring?*" and "*What do I want to learn?*" These responses were then collocated with the tools of other people sitting at the table. The experience prompted a conversation to ensue about the skills we have to share, and what our hopes and dreams might be. A subsequent activity challenged participants to map the megatrends they felt the W+SN should focus on. This asked experts to arrange their interests in a cohesive structure with colleagues from



other backgrounds. The outcome of these mappings is a series of creative, open-ended diagrams. There is ambiguity remaining in these diagrams – an intentional

aspect of the activity as it provides an opportunity for discussion and creativity.

⁹ Evan Thompson, “Empathy and Consciousness,” in *Between Ourselves: Second Person Issues in the Study of Consciousness*, edited by Evan Thompson (Exeter: Imprint Academic, 2001), 19.

¹⁰ Geoffrey Bowker and Susan Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge, Massachusetts: The MIT Press, 2000).

¹¹ Susan Star, “The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving,” in *Distributed Artificial Intelligence: Volume 2*, edited by Les Gasser and Michael N. Huhns (Burlington Mass.: Morgan Kaufman, 1998), 37.

¹² Anna Islind, Tomas Lindroth, Johan Lundin and Gunnar Steineck, “Co-designing a digital platform with boundary objects: bringing together heterogeneous users in healthcare,” *Health and Technology* 9, no. 4 (2019): 476.

¹³ Leah Heiss, “Designing Emotional Technologies: Collaborating across design, health and engineering to humanise wearable health technologies” (PhD diss., RMIT University, 2018).

¹⁴ Elizabeth Sanders, Stephen Scrivener, Linden Ball and Andrée Woodcock, “Generative Tools for CoDesigning,” in *Collaborative Design Proceedings of CoDesigning*, edited by Stephen Scrivener, Linden Ball and Andrée Woodcock (London: Springer-Verlag, 2000), 6.

¹⁵ Elizabeth Sanders and Pieter Stappers, “Probes, Toolkits and Prototypes: Three Approaches to Making in codesigning,” *CoDesign* 10, no. 1 (2014): 7.



Tactile tools being used at the W+SN launch in September 2019.



W+SN Activities | Event 1

W+SN Launch

On Friday 13 September 2019, the RMIT Wearables and Sensing Network held a launch event that brought together researchers from across RMIT to connect and map out next steps for collaboration. The event was officially launched by Professor Swee Mak, Associate Deputy Vice Chancellor (Research Capability) and Professor of Innovation. Professor Laurene Vaughan (Dean of School of Design) provided an acknowledgement of country focusing on the living culture of indigenous innovation in which the W+SN is located.

ECP Panel - Directors from Design and Creative Practice, Advanced Materials, Information and Systems (Engineering) and Social Change

In the first of a series of panels, several of RMIT's ECP Directors body shared their ideas on possible megatrends within the realm of wearable health technologies.

As described by the ECP panellists, their reasons for supporting the W+SN stemmed from the Network's ability to enable positive social change through interdisciplinary work. They noted that W+SN demonstrates a recognition of diversity and non-normative bodies and highlighted the network's potential to have significant social, health and environmental impact via human centred approaches. The multidisciplinary nature of W+SN also provides a positive way to coalesce expertise and interdisciplinary work that may lead to commercialisation.

Impact, Transformation and Commercialisation Panel with Amy Hunter, Anna Thomas and Matiu Bush

The second panel at the W+SN Launch event aimed to define Impact and tackle issues surrounding the commercialisation of outcomes. The panel featured guest speakers Amy Hunter, former Director of Research Translation RMIT; Dr Anna Thomas, Research Translation Manager RMIT; and Matiu Bush, former Deputy Director of RMIT Health Transformation Lab.

Identified as a key goal of W+SN, Impact can be created in varying degrees for various purposes through the development and planning of research projects. The university offers support through the provision of Intellectual Property and Research and Policy services that enable researchers to upskill in IP processes, policies and project management. To successfully achieve impact, Dr Anna Thomas identifies the utilisation of these services as a vital step in providing researchers with guidance. She suggested that identifying the desired impact and beneficiaries of research could exponentially improve the success of a researcher's work.

W+SN as a collaborative network has the opportunity to inspire impact and instil passion in its researchers to make a difference; a trait that coincides with RMIT's reputation for generating meaningful impact. Demonstrating impact means that researchers and their work can encourage changes within society by stimulating behavioural, economic, social and cultural shifts.



Professor Swee Mac
and Dr Leah Heiss.

Professor
Laurene Vaughan



Introduction by Dr Leah Heiss
and Dr Judith Glover.



Members collaborating in the second Tactile Tools activity.

Professor Larissa Hjorth and Professor Julian Thomas during the first ECP Panel discussion.



Members collaborating in the Tactile Tools activities during the W+SN Launch.



Megatrends Mapping

The Megatrends Mapping conducted during the W+SN Launch in September 2019 helped to initiate the collaboration process between participants in the network. Although participants came from different backgrounds, the activity encouraged them to share their knowledge and expertise with one another and establish common themes between the different disciplines.

Tools for Megatrends Mapping

The Tactile Tools toolkit was adapted to include a new rainbow shaped 'megatrends' tool. Participants were invited to annotate the tiles with sectors or areas of research that they felt were most important to address.

Mapping out the Megatrends

Interdisciplinary table groups were asked to identify and map what megatrends W+SN should aim to focus on. The methodology encouraged participants to collaboratively overlay, link, and cluster megatrends into themes and research domains.

Capturing the Data

After the event we transcribed all of the megatrend tools and sorted these into key themes. The themes were visualised as a sunburst map as this enables the viewer to see the primary and secondary themes in addition to

the individual responses. The map encourages W+SN members to consider their skillset and think about where they can best contribute.

Recurrent themes included health and wellbeing, sustainability, and data. Megatrends included mental and physical health, with a particular focus on disability and ageing 'towards in-home care'. A key megatrend here revolved around the use of 'med tech sensors' in the detection, prevention, and intervention stages of health issues.

Key megatrends around sustainability included an environmental as well as ethical concern in the production and disposal of technology due to its contribution to climate change. Participants noted that energy-efficient systems, bio-inspired materials, and 'holistic materials and sensors' were key trends relating to these concerns.

It was common to find megatrends around data and its usage in service design, 'personalisation and customisation of experiences' was seen as a key factor in this area, as well as the ethical concerns of its access through cyber security.

Presenting the Megatrends Mapping

We developed A0 posters of the Megatrends Map and early capability visuals and exhibited these at the Building New Languages event on 22 November. This provided participants with an opportunity to critique and respond to the work.



Presentation of the Megatrends Mapping at the Building New Languages event.



Megatrend tools being used in the Tactile Tools activity.



Rainbow shaped 'megatrends' tool

Collection of the annotated 'megatrends' tools from the event.

Megatrends Visualisation

The following diagram provides a snapshot of the megatrends identified in the mapping activity with key areas of health and wellbeing, data and sustainability foregrounded.

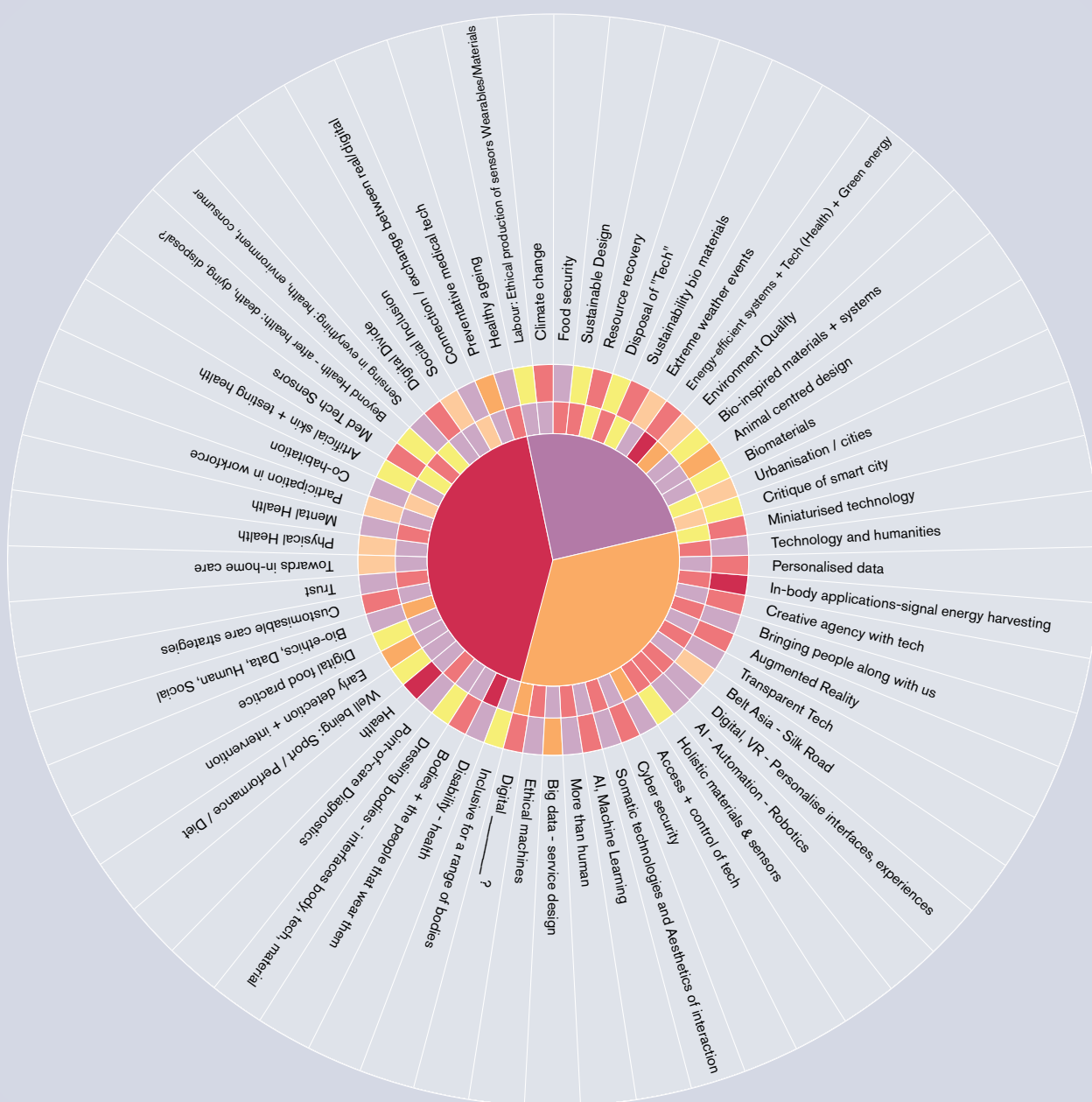
The Megatrends visualisation was a collaboration with Ally Crimp - a designer and Master of Design Futures graduate whose practice explores data humanism and participatory approaches to visualising the complexity of our data-driven world.

Primary Themes

- Health and Wellbeing
- Data
- Sustainability

Secondary Themes

- Health and Wellbeing
- Sustainability
- Data
- Technology
- Materials
- Humans
- Places





Health and Wellbeing

- Healthy Ageing
- Preventative medical tech
- Connection / exchange between real/digital
- Social Inclusion
- Digital Divide
- Sensing in everything - health, environment, consumer
- Beyond Health, death, dying
- Med Tech Sensors
- Artificial skin + testing health
- Co-habitation
- Participation in workforce
- Mental Health
- Physical Health
- Towards in-home care
- Trust
- Customizable care strategies
- Bio – Ethics (Data, Human, Social)
- Digital food practice
- Early detection + intervention
- Well being: Sport, Performance, Diet
- Health
- Point-of-care diagnostics
- Dressing bodies - interfaces between body, tech, material
- Bodies + the people that wear them
- Disability – health
- Inclusive for a range of bodies



Data

- Ethical machines
- Big data - service design
- More than human
- AI, Machine Learning
- Somatic technologies & Aesthetics of interaction
- Cyber security
- Access + control of tech
- Holistic materials & sensors
- AI - Automation - Robotics
- Digital, VR – Personalise interfaces, experiences
- Belt Asia - Silk Road
- Transparent Tech
- Bringing people along with us
- Creative agency with tech
- In-body applications-signal energy harvesting
- Personalised data
- Technology and humanities
- Miniaturised technology



Sustainability

- Critique of smart city
- Urbanisation / cities
- Biomaterials
- Animal centred design
- Bio-inspired materials + systems
- Environment Quality
- Energy-efficient systems + Tech (Health) + Green energy
- Extreme weather events
- Sustainability bio materials
- Disposal of “Tech”
- Resource recovery
- Sustainable Design
- Food security
- Climate change
- Labour: Ethical production of sensors/ wearables/ materials

W+SN Activities | Event 2

W+SN Building New Languages Event

On Friday 22 November 2019 we hosted the Building New Languages event at the RMIT Activator. The event was designed to bring the network together to connect and build collaborations. It was a three-part experience - 10 lightning-fast talks; building a giant capability map; and a collaborative lunch.

In the lightning-fast talks we invited 10 experts from across the network to share their research, approaches and facilities. Prior to the event Professor Vipul Bansal, Jude Glover and Leah Heiss developed a mapping of the network to understand what key research domains were represented. This mapping enabled the team to identify speakers that are experts in these domain areas. The 10 speakers, and their research domains were:

Professor Vipul Bansal

Biomarker discovery, Sensor platforms
(fluorescence, colour-based, weight-based, electrical)

Professor Sharath Sriram

Conductometric sensing

Dr Tarryn Handcock

Fashion and Textiles

Professor Margaret Lech

Software/AI

Dr Jacinthe Flore

The Ethics of Technology

Professor Olga Troynikov

Textile Materials, Material Assemblies, Garments,
Garment Systems



Associate Professor Flora Salim and Dr Wei Shao

Big Data and Data Networks

Dr Glenn Matthews

Embedded Systems/Microelectronics; Sensors &
Communications

Dr Olga Kokshagina

Business, Entrepreneurship

Dr Jude Glover and Dr Leah Heiss

Design and Creative Practice
(sound/product/VR/AR/Jewellery)

The speakers were challenged to provide a rich and diverse account of their research areas in seven minutes, with seven slides. The experience was enlightening for the audience and helped the network to understand the connections across and between research groups.

Following the talks participants spent one hour creating a giant map of the W+SN research domains, skills,

capabilities and partnerships using Tactile Tools. The activity helped the group to understand more about the diversity of research sectors and the significant skills and capabilities required within each of those areas. The data gathered from the mapping activity informs the data visualisation on [page 39](#). We welcome input into developing this visualisation further.

Top right: Dr Leah Heiss and Dr Judith Glover presenting a draft mapping of the Design and Creative Practice domain during their lightning-fast talk.



W+SN members engaging with one another to create the Capability Mapping.



Members viewing a prototype mapping developed by Vipul Bansal, Jude Glover and Leah Heiss.

W+SN Lightning-Fast talks

In the lightening-fast talks, experts from sensor development through to fashion design were challenged to share their research, ideas, technologies and labs - in 7 minutes!



Professor Vipul Bansal starting off the lightening-fast talks with his presentation.



Biomarker discovery, Sensor platforms (fluorescence, colour-based, weight-based, electrical)

Professor Vipul Bansal

School of Science

Vipul shared the exciting work he and his team are doing in the Ian Potter NanoBioSensing Facility. The team is working in biomarker discovery and a range of sensor platforms (fluorescence, colour-based, weight-based, electrical). Projects include colorimetric sensing for UV, vaginal health and a range of other applications.



Conductometric sensing

Professor Sharath Sriram

School of Engineering

Sharath provided an excellent overview of the conductometric work of the Functional Materials and Microsystems group. At the Micro Nano Research Facility researchers are able to 'print' and 'pattern' structures a few atoms in size. Sharath reported on the use of stretchable sensors for healthcare, aged care and environmental monitoring.



Fashion & Textiles

Dr Tarryn Handcock

School of Fashion & Textiles

Tarryn introduced us to fashion as an expanded field of research that traverses material knowledges; 3D prototyping and design; understanding bodies and sites of dress; inclusive design; and, reimagining bodies and dress.



Software / AI

Professor Margaret Lech

School of Engineering

Margaret engaged the crowd with her explanation of the role of wearable sensors in AI, speech and image processing, and decision making. Her projects include the detection of calls for help (sound, urban safety monitoring); prediction of trust in politicians (speech, twitter, and images); and, diagnosis and prediction of clinical depression (speech).



The Ethics of Technology

Dr Jacinthe Flore

School of Global, Urban, and Social Studies

Jacinthe highlighted the critical importance of understanding the ethical implications of our technologies. Her research has analysed the ethical, societal and emotional impacts of a range of wearable technologies, including devices to treat depression and sensors to detect and modify emotion. She exposed us to some of the critical thinking approaches we need to bring to our technology developments as researchers.



Textile Materials, Material Assemblies, Garments, Garment Systems

Professor Olga Troynikov

School of Engineering

Olga reported on her many exciting projects across textile materials and apparel systems, with industry partners from sport and exercise science, protection and health and safety. Her projects in functional materials included textile interfaces and microclimate sensing for sleep monitoring; sports apparel and workwear; as well as biomechanical audits of construction workers.



Big Data and Data Networks

**Associate Professor Flora Salim
and Dr Wei Shao**

School of Science

Wei discussed the cutting-edge work of the Context Recognition and Urban Intelligence (CRUISE) group and the Centre for Information Discovery and Data Analytics (CIDDA). CIDDA's work traverses time-series data mining, context-aware situational awareness and user behaviour analysis. They are working in the areas of Smart Cities/Health/Buildings/Farm; Agritech; Activity recognition and Waste Analysis.



Embedded Systems / Microelectronics; Sensors & Communications

Dr Glenn Matthews

School of Engineering

Glenn gave us a great virtual tour of the Surface Mount Device (SMD) Laboratory where they fabricate Printed-Circuit Board (PCBs – including flexible substrates) and associated hardware. The lab allows researchers to take conceptual designs to functional prototype stage using CAD (Altium) to develop schematics and PCBs for fabrication. The facility also provides pick and place machinery and automatic soldering via a 7-stage reflow oven.



Business, Entrepreneurship

Dr Olga Kokshagina

Graduate School of Business and Law

Olga presented a unique model of collaboration at the intersection of innovation, management and entrepreneurship; engineering; and, design as a systematic process. She discussed Phenomena, Processes, Contingencies, Interventions and Organisational Structures and described her toolkit, which includes action based research, ethnography and semantic analysis. Her research targets cancer, climate change, energy transition and food scarcity.



Design and Creative Practice (sound /product / VR / AR / Jewellery)

Dr Jude Glover and Dr Leah Heiss

School of Design

Jude and Leah provided an overview of design and creative practice disciplines. They divided this into 6 areas: 3D product development, interaction, sustainability and social innovation e.g. Food Waste; Communication: visualisation, strategy, experience; Digital: Web, AI, VR, data viz, games; Human centred design: service design, participatory methods; and, Art and Jewellery: digital processes and hand making.

Capability Mapping

During the W+SN Building New Languages event, participants spent one hour creating a giant map of the W+SN research domains, skills/capabilities and partnerships. For the activity Leah adapted her Tactile Tools toolkit to provide new ways to map our collective efforts.

The activity helped researchers from across the RMIT Schools to bring their diverse ideas and skills to the

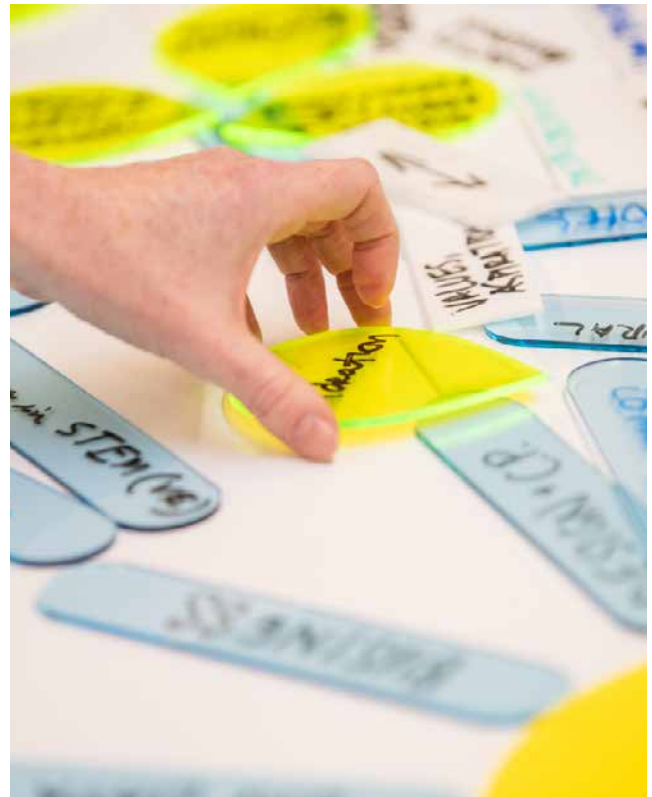
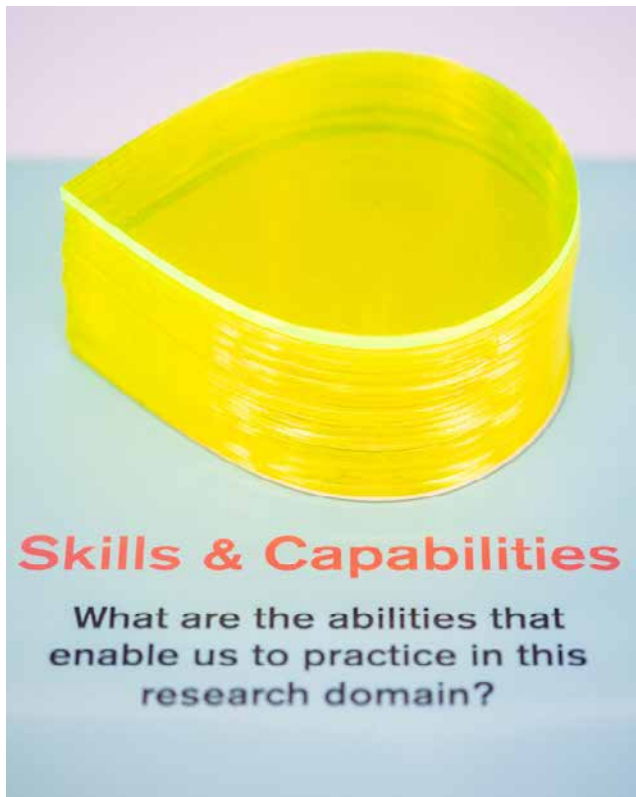
table. It also enabled researchers from different areas to identify areas of overlap and connection.

Tactile Tools for Capability Mapping

For the Capability Map Leah Heiss and her collaborator Marius Foley devised a series of new tools - the blue sticks are research domains, the yellow leaves are skills and capabilities and the pink puzzle pieces are partnerships. White pathway tiles were used as 'spacers' that could either be connectors or links to satellite research domains.



Tactile Tools displayed for use at the Building New Languages event.



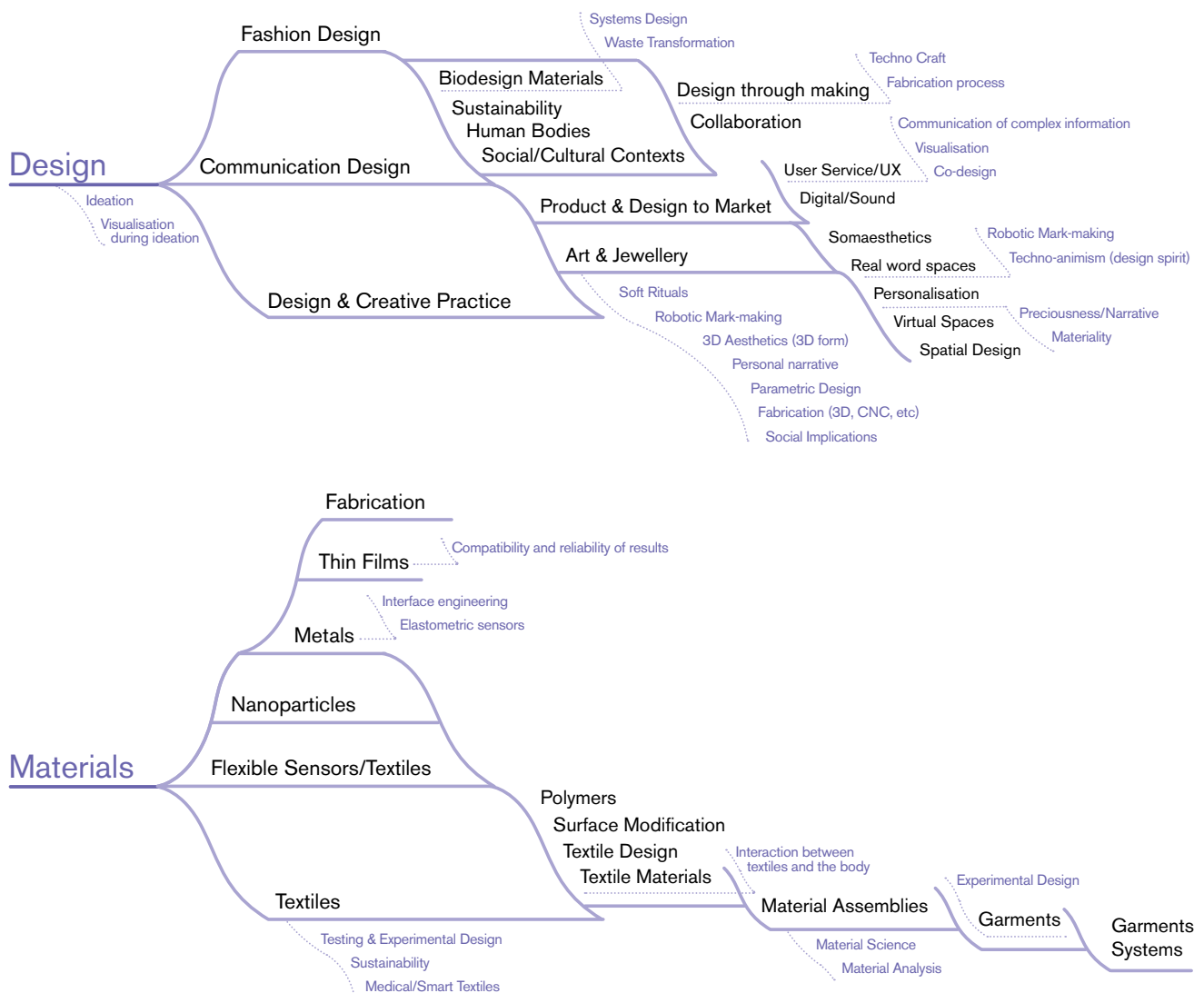
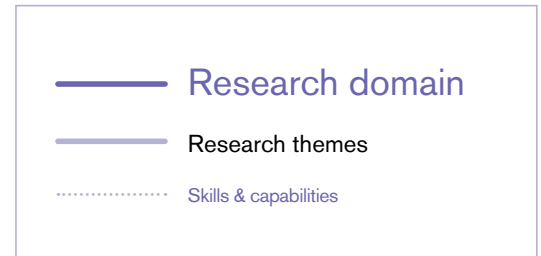
'Skills and Capabilities' tool used in the activity.

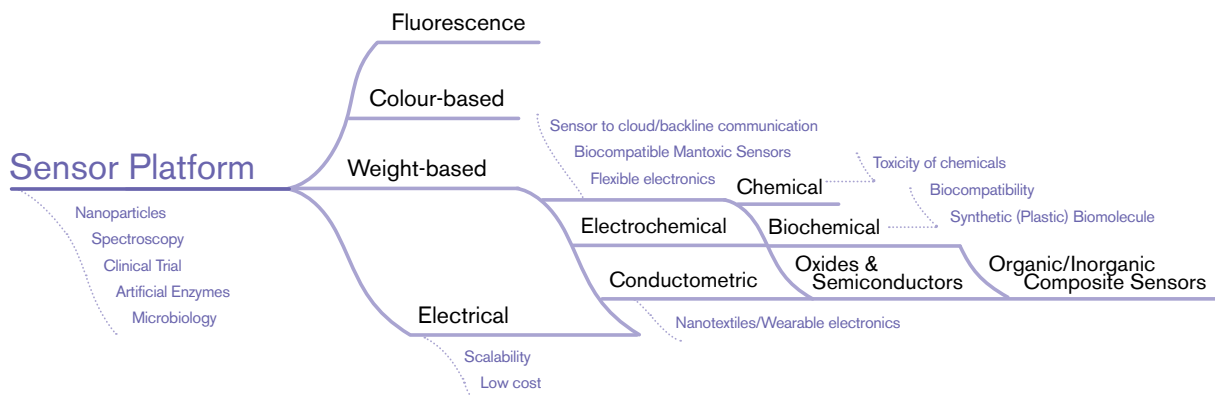
W+SN members engaging with the tools to create the Capability Mapping.

Capability Visualisation

The following diagrams provide a snapshot of the skills and capabilities of the network under different research domains. They are being expanded over time with the input of W+SN researchers.

The Capability visualisation was developed in collaboration with Ally Crimp - a designer and Master of Design Futures graduate who is exploring data humanism and participatory approaches to visualising the complexity of our data-driven world. We welcome feedback on this initial visualisation to ensure it reflects the range of capabilities in your expertise area.





Bioconjugate Chemistry

Chemistry
Biochemistry
Biology
Bio interfaces
Surface Engineering

Sensor Networks

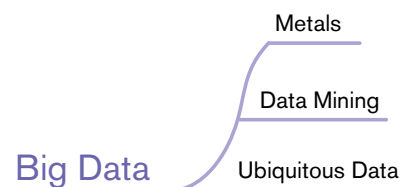
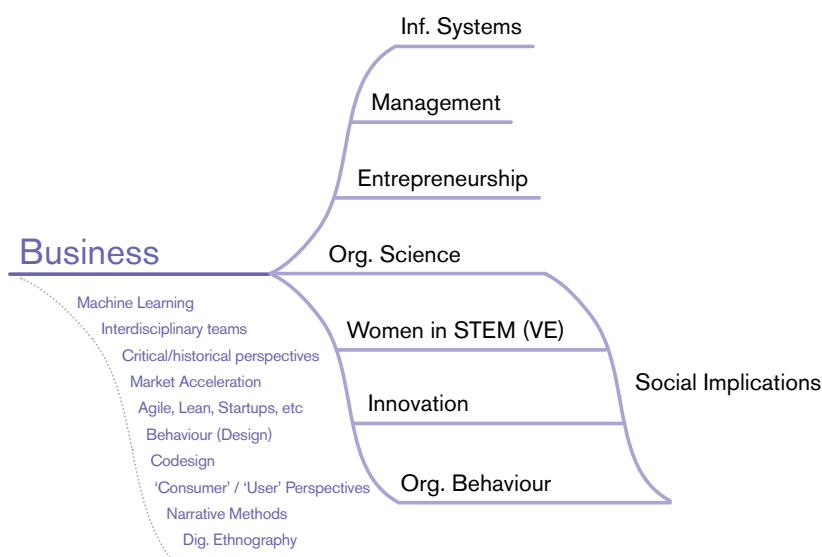
Optimisation
SG Signal
Physics

Mobile Tech
Wireless Communication
Device Free

Embedded Systems/Microelectronics

Analytics

Sensors & Communications



Collaboration in action

W+SN case studies

Case Study 1 | Smart Gyroid Sole

Developing a novel technique to create digital models of bespoke shoe inserts based on the 3D images of a user's feet.

RMIT

Dr Toh Yen Pang

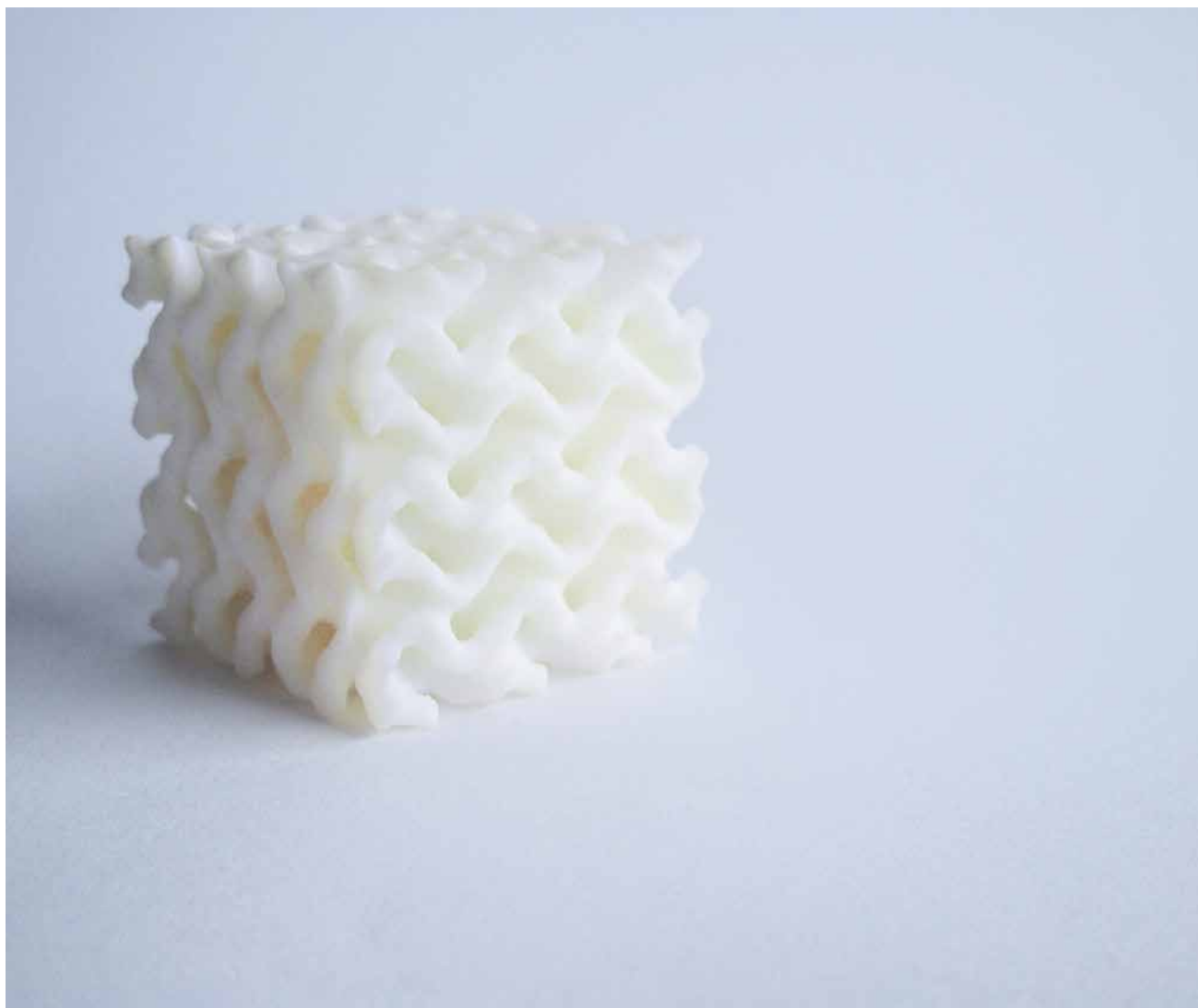
Professor Peter Dabnichki

Caitlyn Parry

Dr Leah Heiss

Inappropriate shoe-wear and foot deformities can cause discomfort and tend to discourage the aging from adopting healthier lifestyles, e.g. by limiting mobility. This project focuses on developing a novel technique to create digital models of bespoke shoe

inserts based on the 3D images of a user's feet. The bespoke insert will be able to provide additional arch support and redistribute some of the pressure on the ball of foot, which may alleviate the discomfort and pain in the ball of the foot.



■ Model prototype of the Smart Gyroid Sole

Case Study 2 | Using wearable sensor technology to advance entrepreneurship research

Around the world entrepreneurs create change and add value to society and the economy.

RMIT

Professor Pia Arenius
Andrew Brough
Imran Ture

Nauman Aslam
Vural Aksakalli

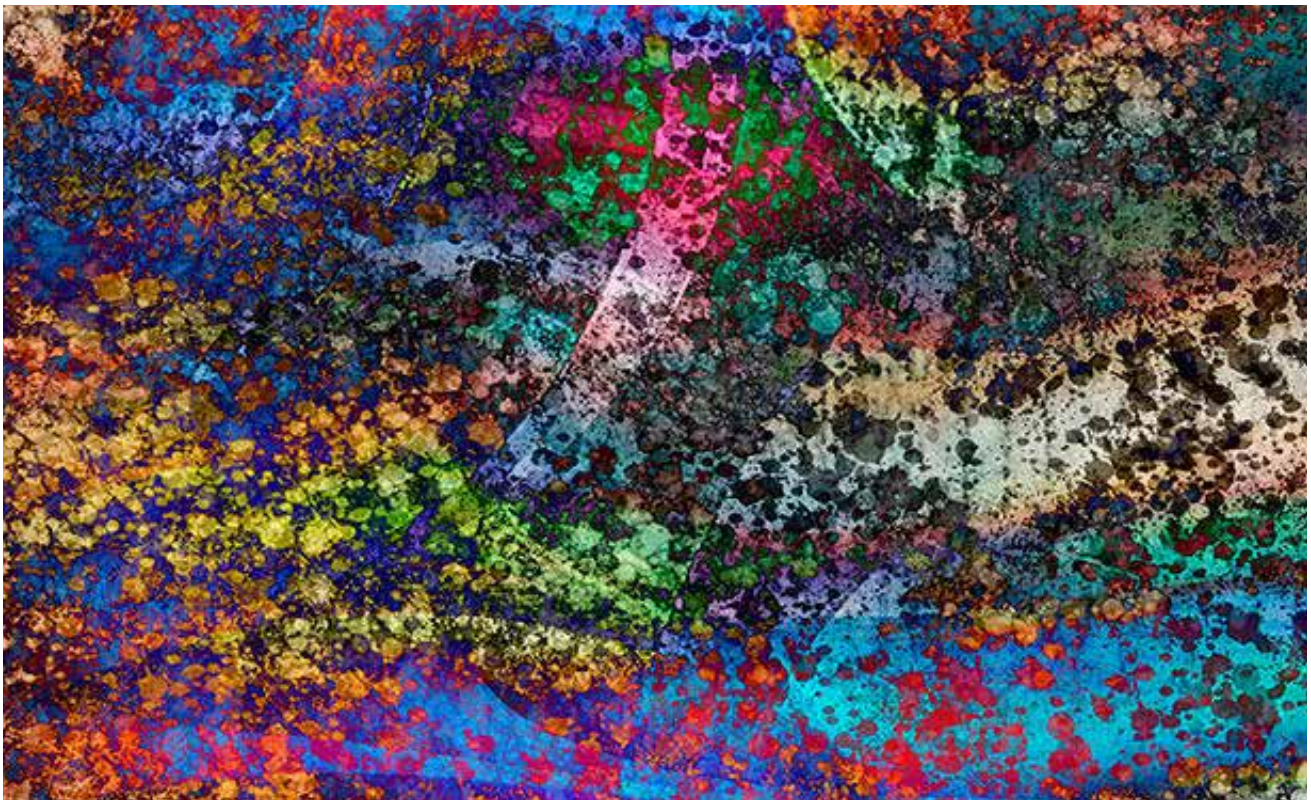
Around the world entrepreneurs create change and add value to society and the economy. If entrepreneur's performance and wellbeing can be improved this can be of great benefit to the individual and society as a whole. We aim to deliver insights that drive better decisions, actions and innovative outcomes.

How can we help people learn to become better entrepreneurs? Can we help entrepreneurs to understand better their emotions and behaviours to improve their performance and wellbeing?

We are answering these questions using advances in wearable sensors and data analysis to gain insights into

entrepreneurs' behaviours and emotions, to increase our understanding of how entrepreneurs make decisions, sustain action and manage emotions through the day to day mental and physical demands of life and to support greater wellbeing and performance for more sustainable and reflective entrepreneurial action.

In the coming years wearables and intelligent data analysis will become part of our daily lives in how we work, live and play. This project will influence our understanding of entrepreneurial performance and wellbeing and enable solutions to be translated to support better learning, support and investment in entrepreneurs in our society.



Case Study 3 | CaT Pin

A wearable to detect loneliness.

The CaT Pin is a discreet, low-cost wearable to detect loneliness. In the form of a lapel pin or brooch. The form can be customised to the style and aesthetics of the wearer by imprinting its surface with cherished jewellery, medals or textiles. Thus the CaT Pin becomes a treasured possession that is also a mnemonic device, reflecting the wearer's personal identity.

RMIT

Dr Glenn Matthews

Dr Leah Heiss

Emma Luke

Associate Professor Paul Beckett

Industry Partner

Bolton Clarke

Matiu Bush



■ Model prototypes of the CaT Pin

Case Study 4 | Salient Sounds

The use of interactive sounds to enhance motion awareness and motivate human movement.

This project seeks to explore the use of interactive sound to enhance motion awareness and motivate human movement. It is as yet unknown the extent to which the audio-biofeedback from the perspective of sound has a capacity to inform human movement. The interrelationship between sounds texture and interactive transition can influence body movement and mindful awareness. To design and develop for these interrelationships, appropriate models of sensor data

extraction and sound synthesis are needed to “feed” back the salient qualities in bi-pedal walking and standing to the person moving.

This project is at proof of concept stage to explore and examine the appropriate data extraction and sound synthesis methods to enable study on this unique movement to sound perception context.

RMIT

Dr Toh Yen Pang

Dr Frank Feltham

Professor Peter Dabnichki



■ Model of sensor data extraction and sound synthesis

Case Study 5 | The Drone Chi Project

Direct manipulation of a drone by the body to cultivate an awareness of breath, balance and co-ordination.

The past decade has seen an increased number of guidelines and programs developed to improve the assessment and treatment of falls risk. Drone Chi employs direct manipulation of a drone by the body to cultivate an awareness of breath, balance and co-ordination. Aesthetically inspired by Tai Chi, the drone

responds to small changes in movement, breath and balance, the working system has been demonstrated numerous times most notably at the International Conference of Human-Computer Interaction (Glasgow) and the CISCO x RMIT Health Transformation Lab Launch.

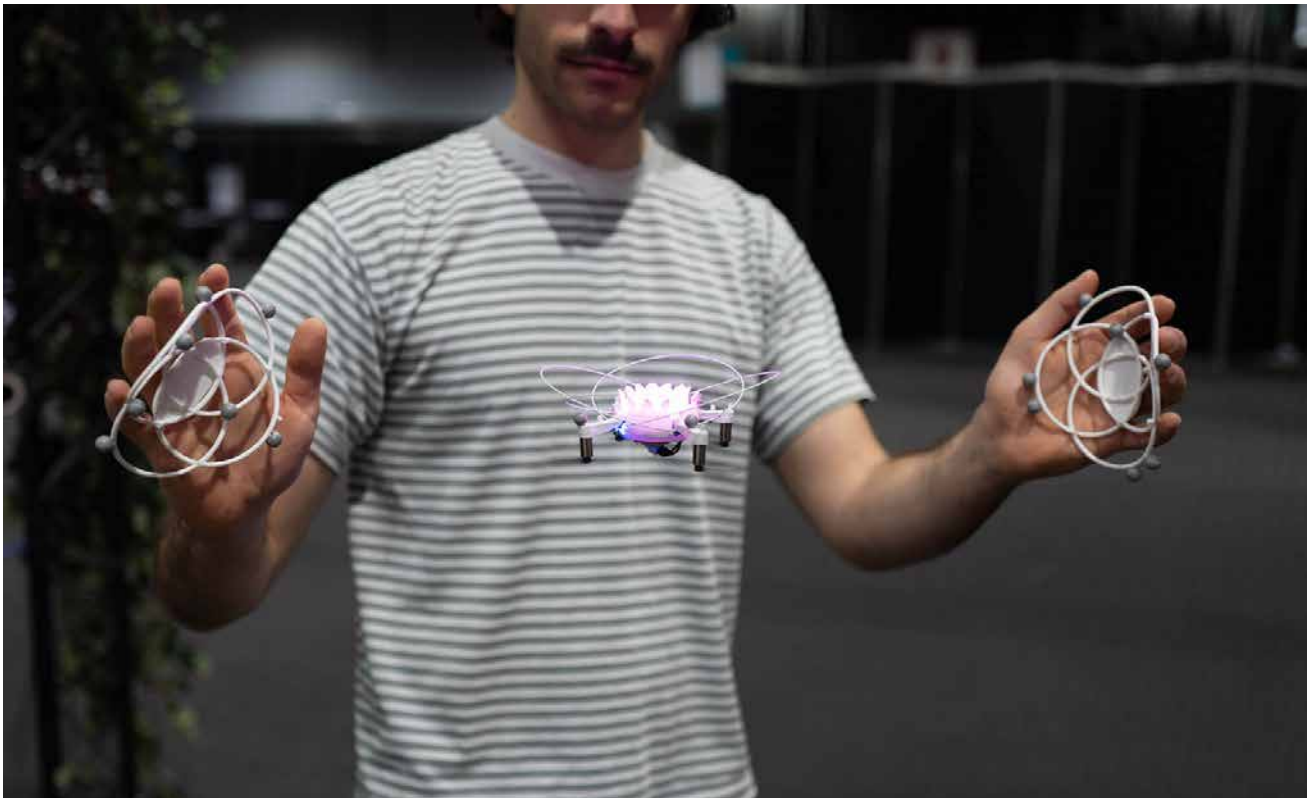
RMIT

Joe La Delfa
Emma Luke

Advisors

Professor James Harland
Dr Ian Peake

Matiu Bush
Dr Abdulghani Mohammed



■ The Drone Chi Project

Case Study 6 | Smart Heart Necklace

The Smart Heart necklace was a two year collaboration with St. Vincent's Hospital Melbourne, RMIT University, and the Nossal Institute for Global Health; funded by Gandel Philanthropy.

The project is a wearable cardiac monitor necklace with the capacity to collect, store and remotely transmit cardiac data collected over an extended period for analysis by medical professionals. The neckpiece is aimed at patients who have recently suffered a heart

attack or who are experiencing heart rhythm problems and aims to replace the bulky cardiac holter monitor with something that is more integrated into people's daily lives.

RMIT

Dr Leah Heiss
Associate Professor Keely Macarow
Associate Professor Paul Beckett

Industry Partner

St. Vincent's Hospital Melbourne
The Nossal Institute for Global Health



■ Smart Heart Necklace. Photographer: Narelle Portanier.

Mapping Wearables and Sensing Report (excerpt)

Jaki Pokrovsky and Dr Jude Glover, School of Design

In order to understand the commercial and research environment in which W+SN is located we have undertaken an extensive mapping of labs and research centres. This research is brought together in the 'Mapping Wearables and Sensing Report' available at ws-network.com.au/resources.

The research is helpful in enabling us to identify potential collaborators and to understand what our unique offerings might be. We provide here a short excerpt of the report and encourage readers to visit the W+SN website to download the full document. On the following pages we include visual mappings of the research. These are also available on the W+SN website for download. We invite feedback on these mappings and suggestions for research and commercial labs that we have missed. Please forward this information to Leah Heiss, leah.heiss@rmit.edu.au.

Wearable and sensing technology within the health and medical industries are ubiquitous. The range of applications within this area alone range from implantable devices through to Personal Protective Equipment (PPE) and specialised equipment used within healthcare and medical practice. To best understand the growing market of wearable and sensing technologies, major categories of the sector have been defined. These categories include:

- Microtechnology & Nanotechnology
- Biosensors
- Biomedical Signal Processing
- Diagnostic & Therapeutic Systems
- Telemedicine & Telehealth
- Implantable Technologies
- Genomics
- Brain Computer Interface
- AI + Datafication, VR
- Mechatronics
- Health & Performance Monitoring
- Smart textiles
- Biomaterials

The industry is expansive, and constantly developing through the endeavours of research institutions and commercial industry on a global scale. This section will discuss and outline the scope of research and development in the area of

wearable and sensing technologies in both commercial and institutional settings. The examples provided demonstrate the dynamic nature of the industry and allow the identification of trends occurring in the market.

Broken down into two broader categories of Commercial Labs and Research Labs, each company or institution is classified according to the most prominent aspect of their product and research outcomes. The categories are:

- Material Innovation & Fabrication
- Devices and SWSS
- Sensors
- User Centred Design
- Nanotechnology
- AI, Machine Learning & Datafication

Key trends surrounding sustainability are emerging, largely involving ethical and environmental concerns around the production and disposal of technologies. Not only does the production of these technologies entail significant energy expenditure across product manufacture and life cycle, its use phase also requires energy, and options for disposal are limited, resulting in greater contribution to waste streams and climate change as a whole (Artem Golev, 2019; Manjula Shantaram, 2014).

In some respects, these sustainability trends are beginning to be addressed by investigations into alternate power sources, energy harvesting, as well as biomaterial alternatives. There appears to be a distinct need for further development in this area, to enable wearable health technologies to achieve optimal performance with minimal social impact.

Machine learning and the potential for AI integration into health technologies also presents as a growing trend. The development of data processing methods and translation may lead to more efficient and effective feedback mechanisms with the potential to create more user-friendly experiences for users and medical practitioners alike.

Conversely, trends around data are largely becoming focused on user centred design and by integrating such approaches to design, the user experience can be tailored and personalised to provide better or more holistic outcomes. More significantly, Datafication, a by-product of the growing market, presents as a gap in the market that is only beginning to gain warranted attention. In particular, data collection mechanisms, automation, data security and data management that have become an inherent component

of wearable health technologies now appear at the forefront. With wearable technologies on the rise, it is evident that further development of data systems will be required in future to enable the utilisation of health devices and ecosystems.

Additionally, these developments in data handling will call for investigation and deeper understandings of the ethical dimensions that exist around technologies developed in the wearable technology paradigm. Therefore, ethics and regulation present as upcoming trends that are progressively gaining traction.

Datafication also poses a risk of becoming an “asocial” form of technology, describing the loss of control of our data through various avenues as it is continuously compiled and gathered through devices and new sensing technologies. Not only does this lead to issues surrounding privacy and data ownership, but it also questions the value of data and how that concept alone could impact users’ lives. Insurance structuring in the future, data platforms or aggregators, legal and operational hurdles surrounding the use of prospective wearable and sensing technologies, all

require regulation and infrastructure in a relatively new and developing sector.

On a global scale, there is considerable innovation occurring in materials and fabrication technologies. This trend often pairs with the development of novel devices and SWSS that address broad themes of health and wellbeing, data, and sustainability in the market.

In terms of health and wellbeing, areas beginning to come to the forefront of wearable and sensing technology development include disability, mental health, and ageing as our global population ages. Coupled with human-centric methodologies, the need for responsive and inclusive technologies that tackle critical areas such as health and ageing is evident. This encompasses technologies capable of detection, prevention and intervention or action to improve health outcomes and morbidity status.

Overall, the wearable and sensing market has the potential to generate massive impact within the global community in all facets of healthcare and wellbeing.

Continued at ws-network.com.au/resources.



■ A closeup of lady's hand using a smart watch. Photo by Solen Feyissa on Unsplash.

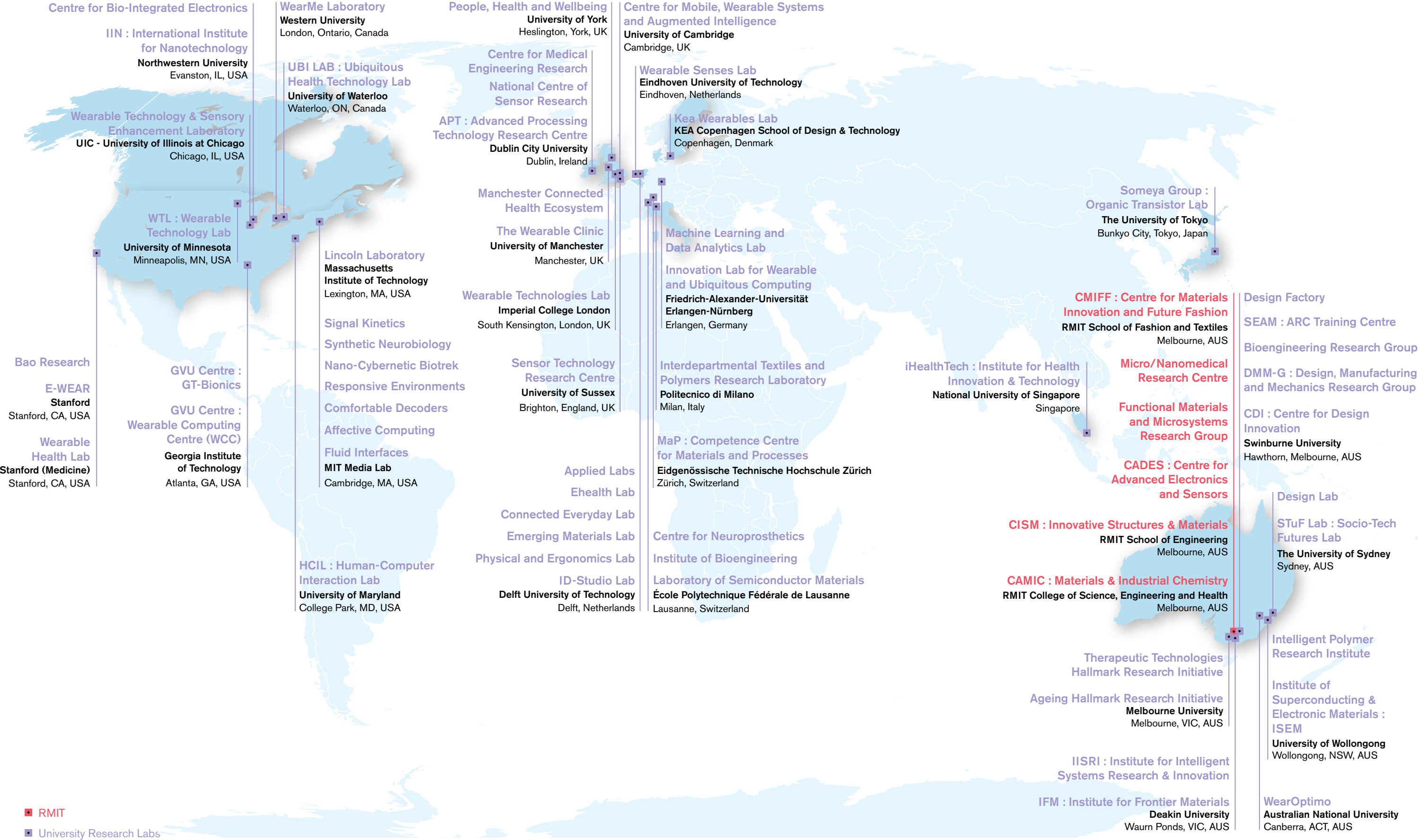


Figure 1: University Research Labs Mapping

This map provides a snapshot of Universities worldwide that are conducting research into fields that fall within the wearable health technology space. The visualisation is available at ws-network.com.au/resources. We welcome your input to this mapping to ensure it is up to date.



This map provides a snapshot of developments and research into wearable technologies within the commercial space. This encompasses marketed products and services in addition to commercialised research bodies. The visualisation is available at ws-network.com.au/resources. We welcome your input to this mapping to ensure it is up to date.

Acknowledgements

Thank you to Professor Swee Mak, the Strategic Capability Development Fund and the following ECPs for ongoing support: Design and Creative Practice, Social Change, Advanced Materials, Biomedical and Health Innovation and Information and Systems (Engineering).

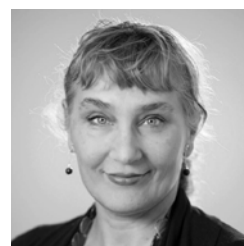
Thank you to our research assistants for their amazing help: Hatoun Ibrahim, Iliyanna Ibrahim, Jaki Pokrovsky, Amelia Warman, Mikayla Borrello and Dana Swieca.



Professor Swee Mak
Associate Deputy Vice
Chancellor
Research Capability



Professor Rachel Caruso
ECP Director
Advanced Materials



Professor Magdalena Plebanski
ECP Director
Biomedical and Health
Innovation



Professor Mark Sanderson
ECP Director
Info and Systems
(Engineering)



Professor Julian Thomas
ECP Director
Social Change



Professor Larissa Hjorth
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Business,
Entrepreneurship

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For more information about W+SN please contact Leah Heiss, Jude Glover or Olga Kokshagina. For any enquiries about the Tactile Tools™ methodology and toolkit please contact Leah or see tactiletools.com.au.

All photographs of W+SN events and Tactile Tools activities by Adam R Thomas and James McPherson.

