RMITw

Digital Twin Step Up Plan

The RMIT University Digital Twins Network (RMITw)

RMIT UNIVERSITY

RMIT University acknowledges the people of the Woi wurrung and Boon wurrung language groups of the eastern Kulin Nations on whose unceded lands we conduct the business of the University. RMIT University respectfully acknowledges their Ancestors and Elders, past and present.

RMIT also acknowledges the Traditional Custodians and their Ancestors of the lands and waters across Australia where we conduct our business.

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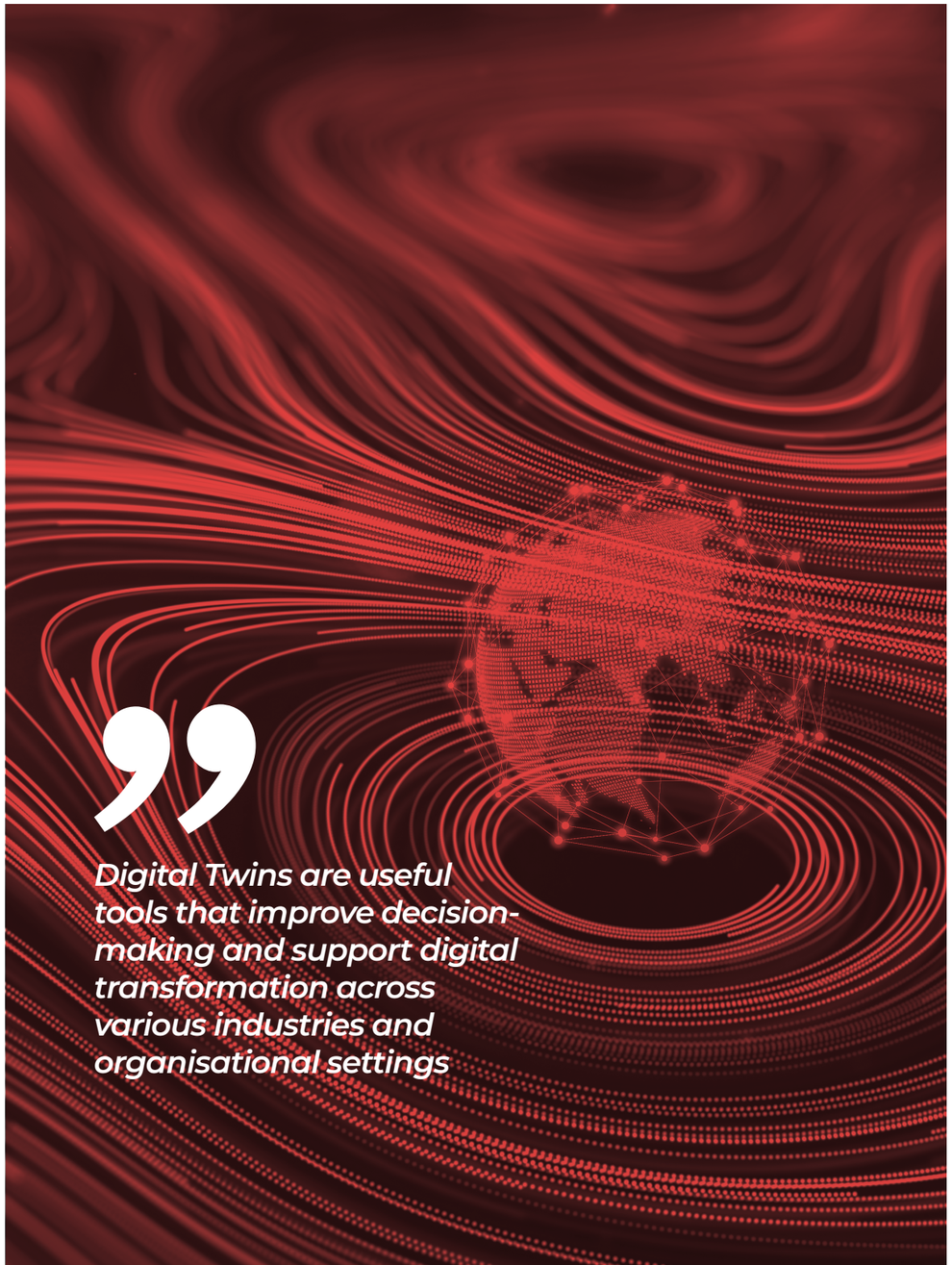


INTRODUCTION

Digital Twins are typically defined as "realistic digital representations of assets, processes, or systems in the built or natural environment" (the Gemini Principles, 2018). As an emerging technology, Digital Twins are unifying diverse domains to support better decision making and to enable digital transformation.

Digital Twins are an increasingly familiar concept today. Digital Twins (DTw) technology is becoming widely used in many areas of industry, including advanced manufacturing, civil engineering, property and construction, space and spatial technologies, emergency response, and many other applications.

WHY DIGITAL TWINS?

Digital Twins carry opportunities to facilitate better access to rich data and analysis. In turn, this can aid in better decision making, driving innovation, creating open dialogues, and developing new economic opportunities.

For example, Digital Twins are seen as especially important to our shared urban futures. Information and communication technologies promise to increase the sustainability and efficiency of the smart cities of the future, meet the diverse needs of citizens and industry, and help to improve quality of people's lives.

The technologies and policies that support Digital Twins are varied and fast-moving, and include visualization, AR, and VR; IoT, sensors, and data repositories; data analytics and simulation; data governance and cyber security and more. Hence, there exists significant potential for coordinated research in partnership to support and accelerate the impact of this emerging technology.

THE "STEP UP" PLAN

RMIT University today has a globally-significant breadth and depth of research capability connected with Digital Twins.

RMIT also has major operational capabilities connected with facilities and campuses. We have the scale and ambition to use these capabilities in research deployment and translation.

As a result, RMIT is building a leadership position as a trans-disciplinary, impact-focused research leader in Digital Twins. Supporting this growth, RMIT is developing an overarching narrative for driving research impact through collaboration and synergies.

This "Step-up" Plan was developed by the RMIT Digital Twins Network of researchers, with the support of the Information in Society EIP (Enabling Impact platform) and FrontierSI, to:

- provide a framework to facilitate interdisciplinary and inter-sector collaboration around a coordinated approach to Digital Twins; and
- support growth in research translation and research impact in RMIT's Digital Twins research activities.

WHY FOCUS ON DIGITAL TWINS?

There are many different application areas of Digital Twins, and multiple reasons for an explicit focus on research impact and translation in connection with Digital Twins. For RMIT University, these motivations link directly to RMIT's strategic focus on leadership in emerging technologies, in smart and sustainable cities, on regional collaboration, and on social innovation.

EMERGING TECHNOLOGIES

Emerging technologies for Digital Twins are continually being developed and applied. Many of these technologies are new, but also include established technologies finding new applications.

Digital Twins connect emerging technology across domains. The technologies to support Digital Twins include visualisations, data creation, data governance, cyber security, simulation, AR and VR, AI, IoT, and more.

SMART AND SUSTAINABLE CITIES

A smart sustainable city uses information and communications technology to improve quality of life and efficiency of services, while ensuring that it meets the needs of present and future generations.

With Digital Twins facilitating better access to rich data and analysis, we will improve decision making, drive innovation, create open dialogues and develop new economic opportunities, while building more liveable and sustainable cities.

REGIONAL COLLABORATION

RMIT is an active and influential member of civil society, working to build trust and create shared benefit in the communities where it operates.

Digital Twins allow for us to manage our campus, but also to engage in collaborative initiatives with local and state governments, supporting better local, regional and state-wide outcomes.

SOCIAL INNOVATION

Social innovations are new social practices that aim to meet social needs in a better way than the existing solutions.

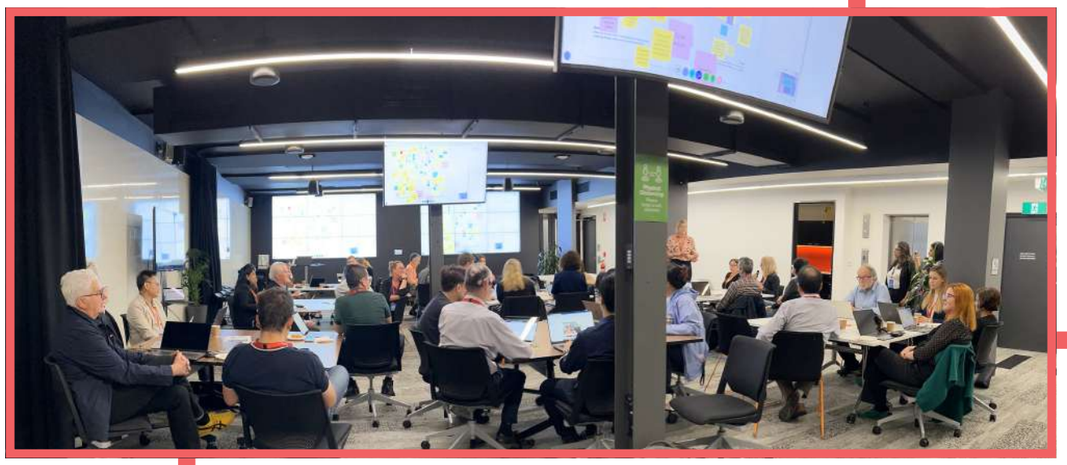
Digital Twins allow us to address complex social challenges. Evidence-based and participatory decision-making, supported by data and advanced analysis, makes it possible to consider system-wide drivers of our changing, unpredictable future.

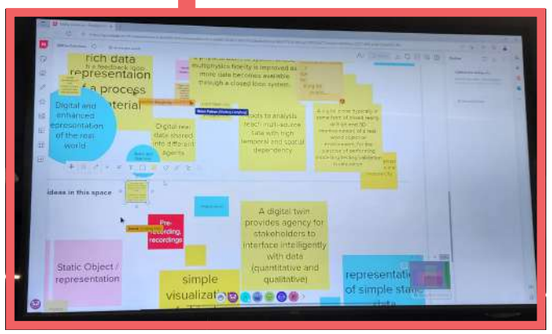
RMIT DIGITAL TWINS RESEARCH TEAMS

Supporting capability development, collaboration, and capability deployment, we bring Digtial Twins researchers and operational staff together in flexible, activity and outcome focused teams through the RMIT Digital Twins network (RMITw).

DIGITAL TWINS TEAMS

RMIT successfully held its first Digital Twins workshop in collaboration with FrontierSI on 30 November 2022. This facilitated workshop attracted more than 50 attendees with representatives from all three academic colleges (STEM College, College of Business Law, College of Design and Social Context) as well as from the Research and Innovation (R&I), Information and Technology Services (ITS), Policy, Strategy, and Impact, and the Operations Portfolios.





As part of the planning and collaboration process, researchers and professional staff co-designed the RMIT Digital Twin Step Up Plan, including generating a shared understanding of definitions, a gap and SWOT analysis, and the basis for growing RMIT Digital Twins research and innovation principles.

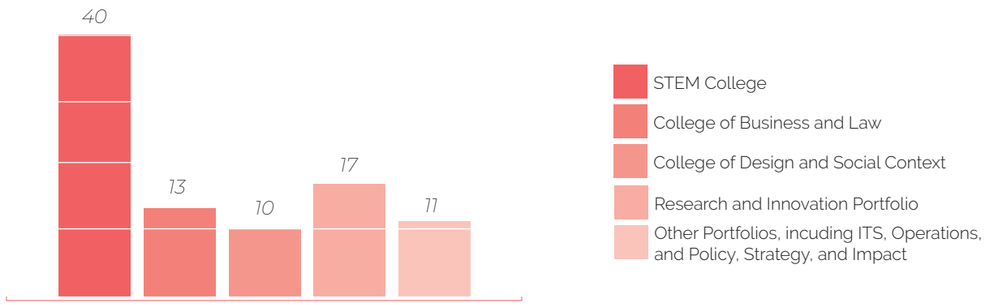
RMIT DIGITAL TWINS RESEARCHER NETWORK

Established through RMIT's Information in Society EIP (Enabling Impact Platform) in 2022, RMIT supports an active network of more than 80 researchers and professional staff with a direct interest in Digital Twins.

DIGITAL TWINS SIG

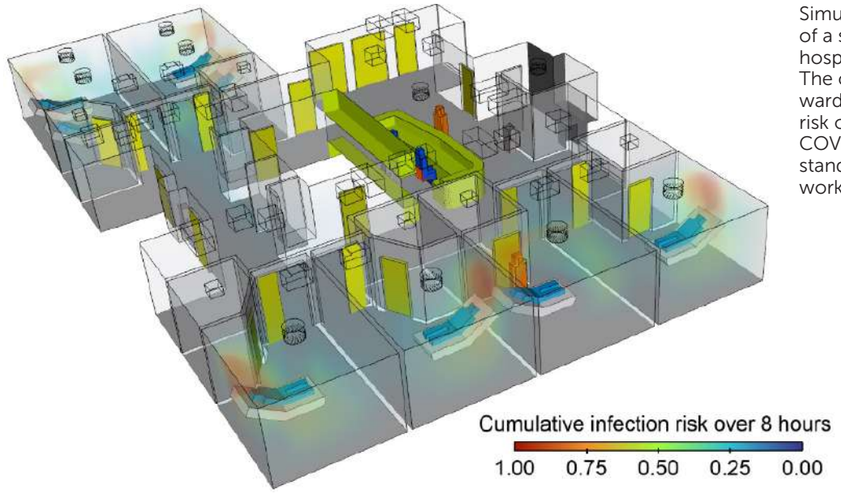
The RMIT Digital Twins Network connects research, professional, and technical expertise in Digital Twins from across the university. The group boasts representation from all major academic units, including all three RMIT Colleges and 14 Schools. The network also connects professional staff from major relevant portfolios, including ITS, Operations, and Policy, Strategy, and Impact (see below).

RMITw SIG MEMBERSHIP SUMMARY



CASE STUDY: Modelling Indoor Disease Transmission

Using Digital Twins to assist in modelling of indoor disease transmission — particularly defence against COVID-19 — is helping to create safer workplaces with detailed recommendations for specific workplaces and general recommendations to mitigate the risk of airborne pathogen transmission.



Simulation model of a section of hospital ward. The colours show ward occupants' risk of infection by COVID 19 after a standard 8 hour working shift

PROJECT APPROACH

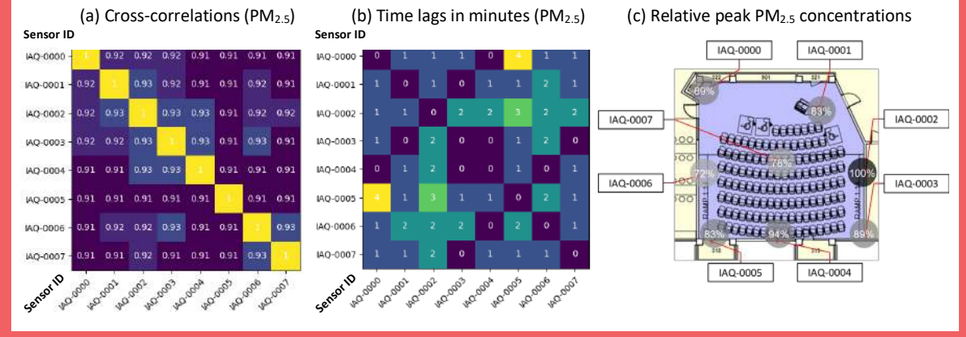
A recently completed a Victorian Higher Education State Investment Fund project aimed to identify COVID 19 hotspots in workplaces using Digital Twins & Industry 4.0 technologies. Sensor data on workplace airflow, climate conditions, and human movement were imported into digital-twin models of the workspaces.

Five anonymised Victorian workplaces were tested, including an open-plan office, factory "paint" room, section of a hospital ward, lecture theatre, and scientific research laboratory. The spread of aerosols — emulating COVID particles — was then simulated using computational fluid dynamics (CFD) using the Digital Twin models as a basis.

The RMIT team produced customised practical recommendations for each workplace to reduce COVID transmission risk, including using local air purifiers, physical distancing of at least two metres, well-fitting masks, and optimising the internal layout of each specific workplace.

An interactive dashboard that uses IoT sensors to capture and visualise continuous data streams from workplace environments, allowing for real-time monitoring and analysis.

A faithful digital replica of a scientific laboratory (above) including air vents (in blue) and sensors (in red); and using multiple sensors to estimate the speed at which airborne contaminants spread from their source throughout an indoor workplace (below)



Images courtesy Ivan Cole, Milan Patel, Ben Cheng

Contact ivan.cole@rmit.edu.au or milan.patel@rmit.edu.au for further information

RMIT's work on Digital Twin applications that assist modelling of indoor disease transmission — particularly defence against COVID-19 — is important to creating a safer working environment for indoor workers

Ivan Cole

RMIT DIGITAL TWIN PRINCIPLES

The RMIT Digital Twin research network embodies five principles that guide the development of impact-focused Digital Twins, and aligns with RMIT University's strategic plan to 2031. These principles also reflect the Gemini principles (right), whose core elements are purpose, trust, and function. More specifically, RMITw research and innovation aims to be:

BROAD BASED

- open and attractive to all researchers from across all RMIT disciplines, colleges, and units, with research and operational facets.

IMPACT FOCUSED

- planned around scalability, deployment, research translation, and pathways to impact.

COLLABORATIVE

- encourage active interdisciplinary and inter-sector collaboration within RMIT and with students, external industry, government, research institutions.

AT SCALE

- institution-wide, supporting large, long-term research initiatives that span multiple years and institutions.

SUSTAINABLE

- environmentally and financially sustainable, safe, and secure, ethical and inclusive, including building on existing initiatives, data and infrastructure.

THE GEMINI PRINCIPLES

The UK Centre for Digital Built Britain proposed the Gemini Principles in 2018 as a guide to the development of Digital Twin information management frameworks.

Purpose:
Must have clear purpose

Trust:
Must be trustworthy

Function:
Must function effectively

Public good Must be used to deliver genuine public benefit in perpetuity	**Value creation** Must enable value creation and performance improvement	**Insight** Must provide determinable insight into the built environment
Security Must enable security and be secure itself	**Openness** Must be as open as possible	**Quality** Must be built on data of an appropriate quality
Federation Must be based on a standard connected environment	**Curation** Must have clear ownership, governance and regulation	**Evolution** Must be able to adapt as technology and society evolve

The Gemini Principles set out values to guide the development and use of a national Digital Twin information management framework (UK Centre for Digital Built Britain)

CASE STUDY: RMIT Metaverse 1.0

An RMIT EIP (Enabling Capability Platform) Strategic Capability Deployment Funded (SCDF) project led by Dr Chayn Sun is helping showcase the potential of an immersive City Campus Digital Twin.

PROJECT APPROACH

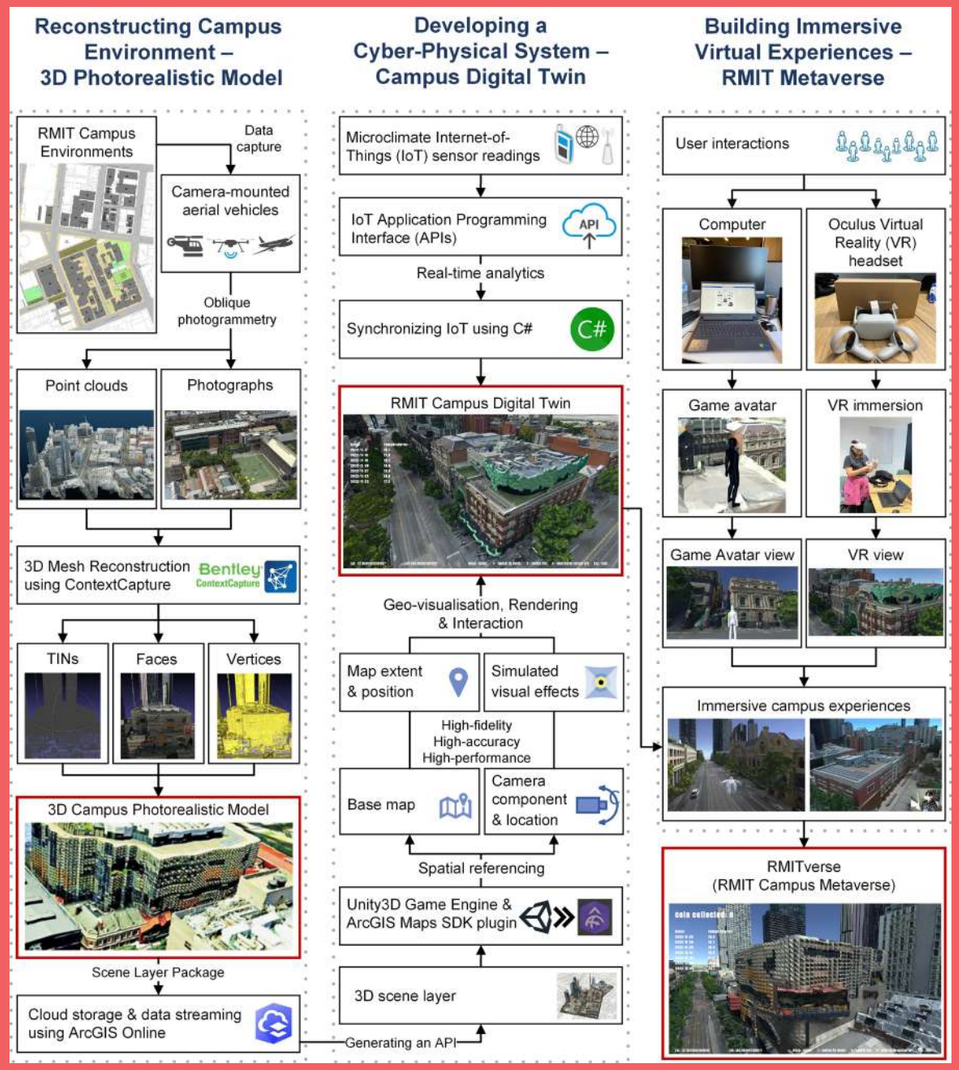
A detailed 3D campus model was created using context capture from LiDAR and oblique photogrammetry.

High-fidelity, high accuracy, and high performance were achieved by combining 3D mesh rendering using Unity gaming engine with ESRI ArcGIS to create a virtual campus from real GIS data..

IoT connections were also enabled to allow integration of near real-time micro-climate sensor readings from around the campus.

VR was used to allow a first-person view of the buildings, landscape, and campus furniture.

Ethan (avatar, below) guides the user in an immersive virtual campus experience (https://www.youtube.com/watch?v=UHAm7Idz-r0).



Images courtesy Chayn Sun, Athenee Teofilo

Contact chayn.sun@rmit.edu.au for further information

https://youtu.be/QbvLXJUTS18

The RMIT Metaverse 1.0 is a scalable, organic system Digital Twin, which can be used as a living lab to collect, store, and analyse data for state-of-the-art urban studies and interdisciplinary research.

Chayn Sun

AUSTRALIA AND NEW ZEALAND GOVERNMENT LANDSCAPE

Digital Twins are an especially active area for Governments across Australia and New Zealand looking to advance digital transformation. The figure below lists just some of the most prominent spatial Digital Twins in the government sector.

INTERNATIONAL GOVERNMENT-SECTOR DIGITAL TWINS

- *UK: Centre for Digital Built Britain National Digital Twin program*
- *Singapore: Virtual Singapore*
- *India: Amarvati, Andra Pradesh, ...*
- *Europe: Vienna, Zurich, Rotterdam, Flanders, Athens, Pilsen, Helsinki, ...*
- *USA: Boston, New York, San Francisco, ...*

AUSTRALIA-WIDE

- *ANZLIC Digital Twin Principles*
- *ANZLIC Framework for Spatially Enabled Digital Twins*
- *SSSI Spatial Digital Twin Special Interest Group*
- *Digital Twin Partnership*

QUEENSLAND

- *Queensland Digital Twin*
- *Brisbane Digital Twin*
- *Cross River Rail*

NEW SOUTH WALES

- *Spatial Digital Twin: Live.NSW*
- *Morriset (Lake Macquarie Council) Digital Twin*
- *Sydney Water Digital Twin Program*
- *UNSW Liveable Cities Digital Twin Research Project*
- *Bathurst Spatial Digital Twin*

VICTORIA

- *City of Melbourne Digital Twin*
- *Digital Twin Victoria (DTV), including, State-wide Digital Twin, Fishermans Bend Digital Twin Pilot, e-Comply planning demonstrator*

TASMANIA

- *Greater Hobart Digital Twin*
- *Launceston Digital Twin*

NEW ZEALAND

- *Digital Twin priority in National Infrastructure Strategy*
- *Wellington Digital Twin*
- *Flooding Digital Twin Research Project*

CASE STUDY: Digital Twin for Aircraft Sustainment

This Digital Twin approach to aircraft sustainment takes the hard work out of maintenance inspections and enables maintainers via MR-compatible devices (e.g., HoloLens) to visualise fatigue damage "hotspots" on the airframe.

PROJECT APPROACH

This innovative Digital Twin framework, called Mixed-Reality Non-Destructive Evaluation (MR-NDE), can bring maintainers new insights into aircraft health with the integration of in-flight Structural Health Monitoring (SHM) sensor data.

MR-NDE is intended for both defence engineers and maintainers. Having been developed on a RAAF Pilatus PC-9/A aircraft, it is now at a point ready for deployment to end-users to trial for robustness and move to a higher Technical Readiness Level (TRL).

The framework it is now evolving to make proactive condition-based maintenance possible at the maintainer level using mixed-reality to do more, such as hands-free damage assessment, digitalised documentation, and remote communication.

Images courtesy Michael Scott, Pier Marzocca and Wim Verhagen

Contact
pier.marzocca@rmit.edu.au
for further information

https://youtu.be/AvypdpcFA4U

The MR-NDE framework highlights the power of Digital Twins for combining multiple information sources in-situ, leveraging in-flight structural health monitoring (SHM) data, to enable maintainers to make better decisions on the ground and supplement general visual inspections.

Michael J. Scott

RMIT DIGITAL TWINS (RMITw)

The RMIT Digital Twins research network facilitates a range of collaborative activities, including workshops, seminars, and round tables. These activities bring researchers, practitioners, industry, and government together to collaboratively refine and develop foundational definitions, enablers, and principles behind the RMIT approach to Digital Twins research and research impact.

There already exist a number of widely-used definitions of Digital Twins. Among the most common is the UK Gemini Principles' definition already encountered as a "realistic digital representations of assets, processes, or systems in the built or natural environment".

Two more definitions appear at the bottom of this page: one adopting a more mechanistic, component-based definition (i.e., what does a Digital Twin consist of; the other adopting a more functional, purpose-based definition (i.e., what can you do with a Digital Twin).

RMIT Digital Twin network has together developed a shared understanding of Digital Twins. The resulting definition is below, combining both positive ("what it is") and negative ("what it is not") assertions about what Digital Twins means at RMIT.

RMIT SHARED DEFINITIONS

WHAT IT IS...

A Digital Twin is a digital and enhanced representation of the real world which provides insight, improves decision-making, changes your capacity to act, and can be applied across various industries and organisational settings.

WHAT IT IS NOT...

A Digital Twin is not a static dataset; it is not a recording; a monitoring system; a physical model; or a simple visualization of an object or space.

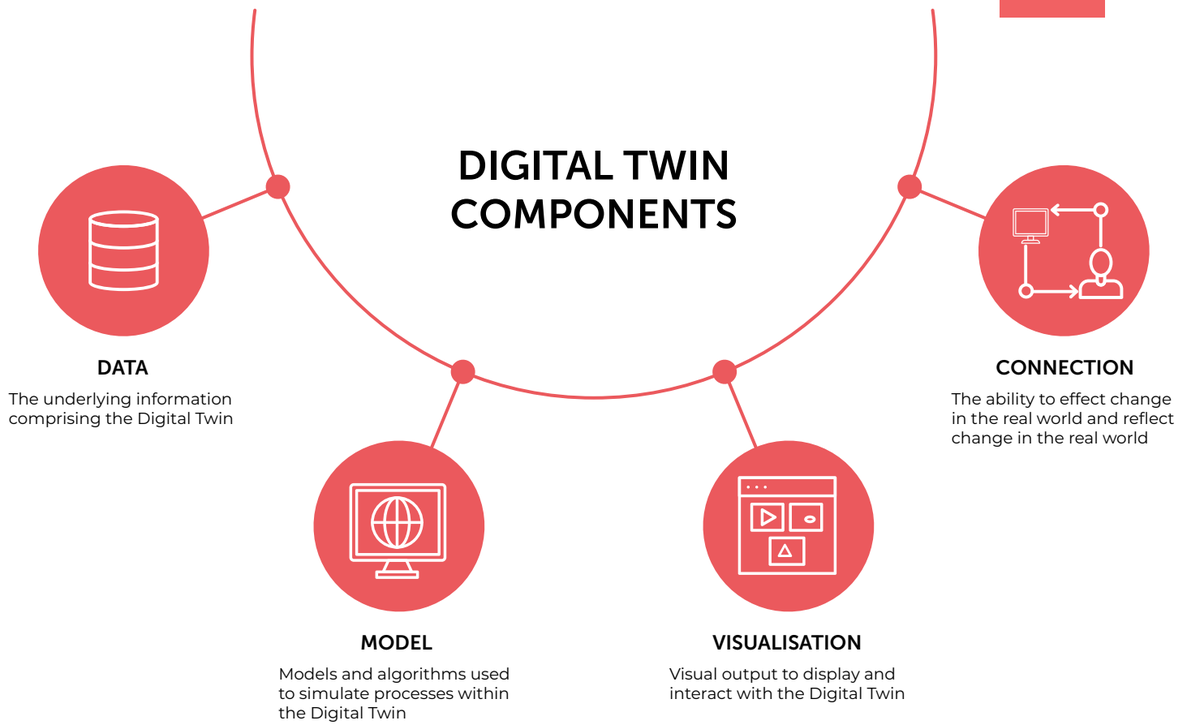
CONVENTIONAL DEFINITIONS

COMPONENT-BASED

A "dynamic digital representation of a real world object or system." (ANZLIC Principles)

PURPOSE-BASED

A "digital asset on which services can be performed that provide value to an organisation" (ISO 18101-1)

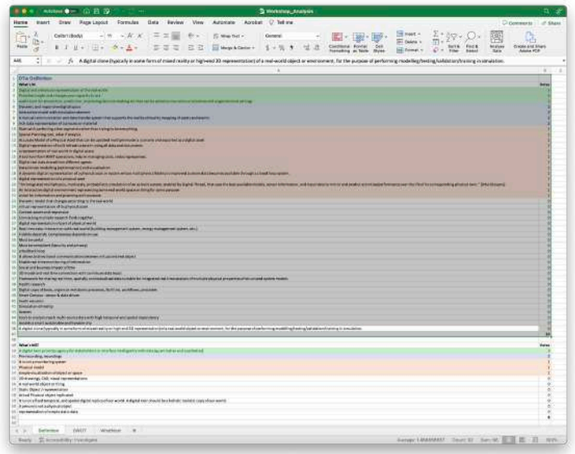


ENABLING CONCEPTS AND TECHNOLOGIES

- *Sensors and data update and capture*
- *Standards and ontologies*
- *Simulations and models*
- *Decision support, insights, and visualization*
- *Governance models and life-cycle management*
- *Participatory decision making*
- *Privacy, ethics and security*
- *Legal, IP and ownership*
- *Compute infrastructure*
- *Defined use cases and problems to be solved*

COLLABORATION

To arrive at shared concepts, definitions, and principles, the RMIT Digital Twins network collaborated on several different face-to-face and online activities, including SWOT analysis, gap analysis, presentations, and discussions.



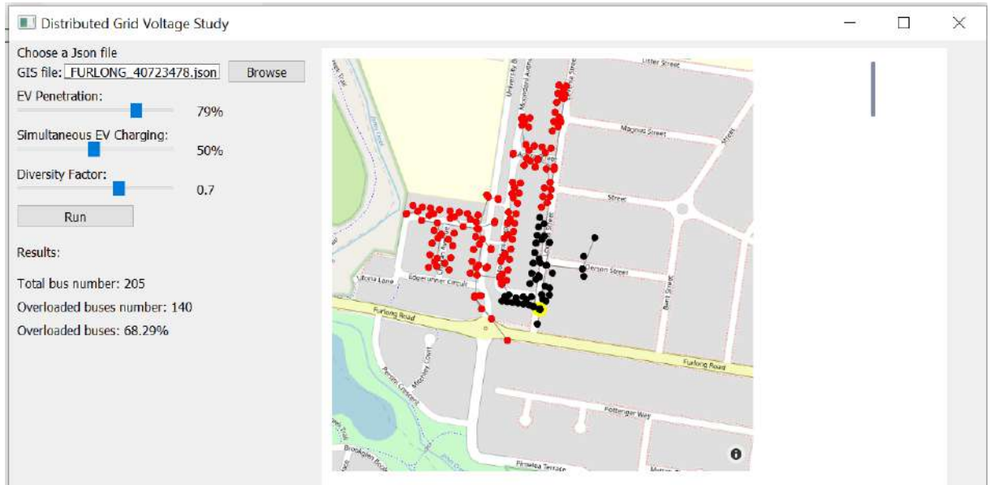
CASE STUDY: Digital Twins for Power Distribution Grids

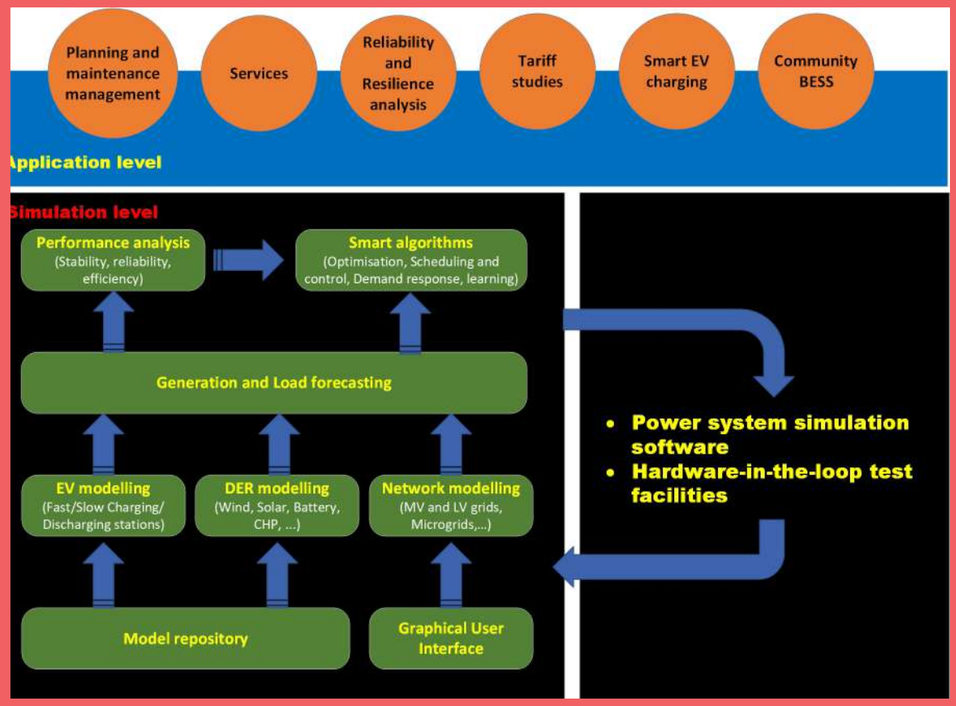
As part of a major investment in an RMIT-led Electric Vehicle Living Lab, the use of Digital Twins for analysis and insights to support reliable planning and operation of power grids in the presence of disruptive technologies, including electric vehicles.

PROJECT APPROACH

The RMIT EV Living Lab is developing state-of-the-art facilities to simulate different operational scenarios that may happen in a power grid in the presence of distributed energy resources and EVs. In collaboration with electricity distributors, the lab is developing a Digital Twin for power distribution grids using smart algorithms and advanced machine learning techniques.

The Digital Twin supports planning and operation of the power grid for Distribution Network Service Providers (DNSPs) under different levels of penetration of disruptive technologies, such as PV solar panels, batteries, electric vehicles and so forth. Using this approach, DNSPs can assess the readiness of their available assets to adapt to new technologies as they grow in use and to help design new parts of the network.





Images courtesy Ali Moradi Amani and Mahdi Jalili

Contact
ali.moradiamani@rmit.edu.au
or mahdi.jalili@rmit.edu.au
for further information

Digital twins will play a transformational role in enhancing the operation, resilience and reliability of tomorrow's integrated energy systems.

Ali Moradi Amani

STEP UP PILLARS

With support and facilitation from FrontierSI, the RMIT Digital Twin network activities in 2022 led to the development of three "step up" pillars to guide action and development into 2023 and beyond.

The three "step up" pillars identified by the network—flagship, local partnerships, and future workforce—have helped to shape the approach to network activities in 2023, 2024 and beyond.

Thank and acknowledgements are due to all the network members and Workshop participants, as well as the FrontierSI team (Kate Williams and Jess Keysers) for guiding the development process.

F

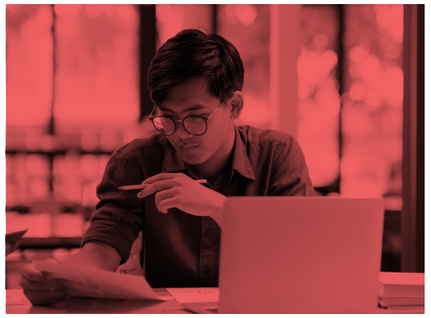
Flagship

We are investigating together the development of an inspiring flagship project that can to catalyse trans-disciplinary, impactful Digital Twins research. Candidate flagship projects include a Campus Digital Twin or an Emergency Planning and Response Digital Twin.

P

Local Partnerships

We prioritise collaboration for impact with local partners, including government (e.g., Digital Twin Victoria, City of Melbourne) and our established local industry partners.. In 2024, RMIT University was announced as one of the Innovation Partners for Victorian Government's Digital Twins Victoria.



W

Future Workforce

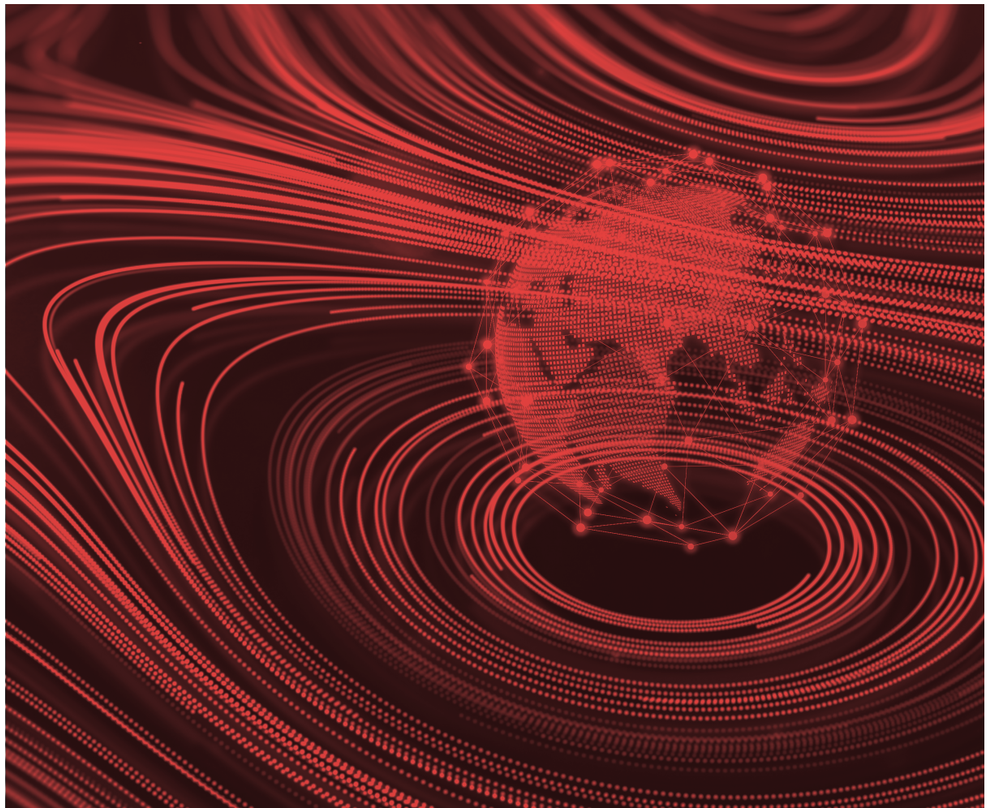
We aim to. develop lifelong learning opportunities to up-skill the existing workforce, and future workforce with the skills needed to support Digital Twins across multiple domains.

GROWING COLLABORATION

A key mechanism for achieving the desired "step up" in capacity is to connects across RMIT and the wider community to create meaningful impact through trans-disciplinary, problem focused research.

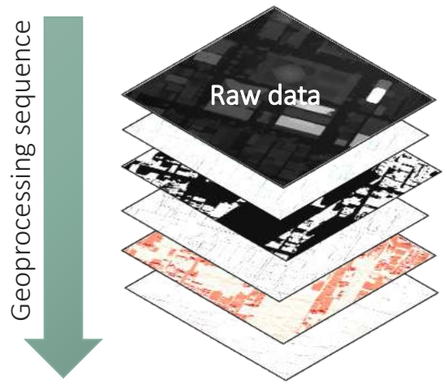
ACTIVITIES

- *Supporting pilot, test-bed, and flagship project development, such as RMIT Metaverse*
- *Organising showcase presentations and round table discussions*
- *Developing data sharing agreements with relevant partners, such as through AURIN*
- *Identifying and nurturing multi-School and cross-unit initiatives*
- *Supporting the RMIT Digital Twins network as a Community of Practice*
- *Developing opportunities for research and collaborative Digital Twin use cases*
- *Fostering new Digital Twins teaching opportunities*
- *Exploring future workforce micro-credentialling*
- *Promoting student engagement and virtual campus through Digital Twins*
- *Strengthening industry and community partnerships*



CASE STUDY: Urban Digital Twins for Emissions Targets

Solar Energy Application Lab at RMIT School of Property, Construction and Project Management has been utilising digitalisation and geospatial analysis for urban renewable energy resources mapping, simulation, and techno-social-economic analyses.



Urban DSM data

Angular layer

Roof shading layer (Hourly)

Façade shading layer (Hourly)

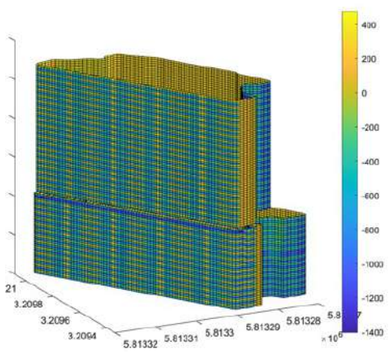
Roof irradiance layer (Hourly)

Façade irradiance layer (Hourly)

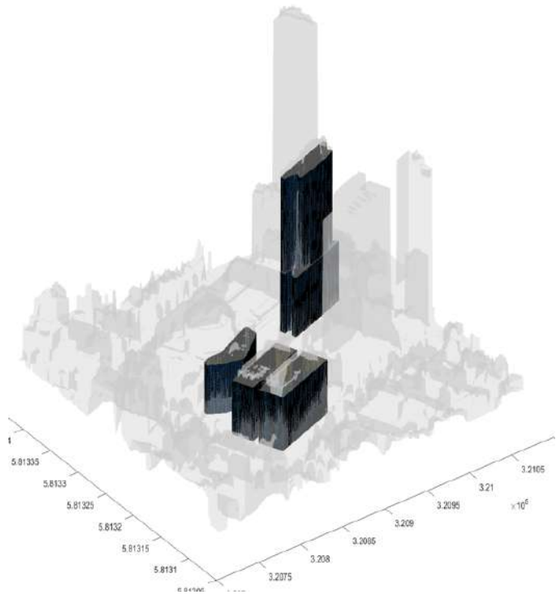
Photomesh image recognition of building elements

PROJECT APPROACH

Combining urban-level solar energy digitalisation and simulation, resources mapping, and techno-social-economic analyses, the approach constructs efficient workflows for solar simulation, building element-wise.



Building elementwise solar simulation on 3D object



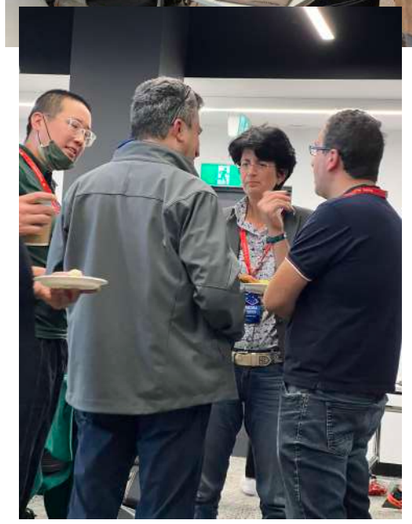
Images courtesy
Rebecca Yang

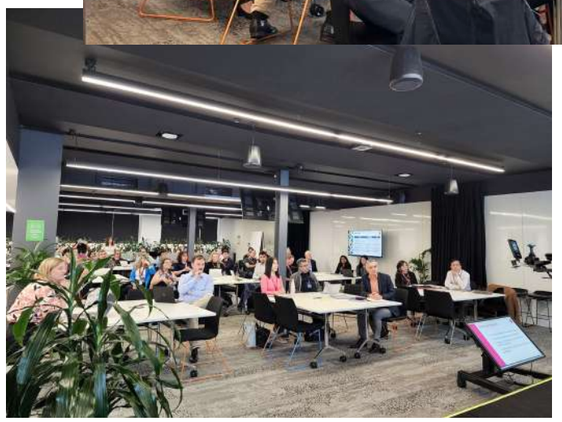
Contact
rebecca.yang@rmit.edu.au
for further information

We are investigating renewable energy potentials in the urban environment using innovative Digital Twins technology to assist in achieving zero emissions targets.

Rebecca Yang

RMIT DIGITAL TWINS NETWORK ACTIVITIES





With Special Acknowledgements to

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Prag Sapkota (Communication and Event Assistant, RMIT University)
Kate Williams (Chief Business Officer, FrontierSI)
Jessica Keysers (Analyst and Project Manager, FrontierSI)

RMIT Digital Twins SIG Members (January 2023)

Sadaf Afrashteh (Finance & Governance)
Michael Anderson (Operations Portfolio)
Alisa Andrasek (DSC)
Ehsan Asadi (STEM)
Yuntian Bai (STEM)
Jack Belcher (STEM)
Cees Bil (STEM)
Tania Binos (CoBL)
John Bonacci (R&I Portfolio)
Jodi Brown (ITS)
Paul Brown (STEM)
Jennifer Buhagiar (R&I Portfolio)
Kerryn Butler-Henderson (STEM)
Wayne Chan (Operations Portfolio)
Ben Cheng (STEM)
Suelynn Choy (STEM)
Ivan Cole (STEM)
Justyna Dabrowska (CoBL)
Shinjita Das (STEM)
Melanie Davern (DSC)
Ashton De Silva (CoBL)
Barbora deCourten (STEM)
Henrique Delamanha Mendonca (Finance & Governance)
Matt Duckham (STEM)
Nicole Eaton (Operations Portfolio)
Ruwini Edirisinghe (DSC)
Michael Fairbairn (CoBL)
Brian Falzon (STEM)
Mohammad Fard (STEM)
Lisa Given (DSC)
Malka Halgamuge (CoBL)
James Harland (STEM)
Lei Hou (STEM)
Catherine Itsiopoulos (STEM)
Pari Jafari (STEM)
Mahdi Jalili (STEM)
Leila Karimi (STEM)
Karlheinz Kautz (CoBL)
Mohan Krishnamoorthy (STEM)
Charles Lau (CoBL)
Annie Liang (STEM)
Chengyang Liu (DSC)
Karen Livesay (STEM)
Tianyi Ma (STEM)
Alexia Maddox (CoBL)
Mojtaba Mahmoodian (STEM)
Pier Marzocca (R&I Portfolio)
Tim McLennan (R&I Portfolio)
Nadia Mecoli (Policy, Strategy & Impact)
Urs Meier (R&I Portfolio)
Anne-Laure Mention (R&I Portfolio)
Alemayehu Molla (CoBL)
Jules Moloney (DSC)
Ali Moradi Amani (STEM)
Xavier Mulet (R&I Portfolio)
Humza Naseer (CoBL)
Michelle Nicolo (R&I Portfolio)
Caroline Northwood (R&I Portfolio)
Ian Peake (STEM)
Konrad Peszynski (CoBL)
Lisa Pigot (ITS)
Magdalena Plebanski (R&I Portfolio)
Priya Rajagopalan (DSC)
Lauren Rickards (R&I Portfolio)
Gerard Roe (R&I Portfolio)
Gary Rosengarten (R&I Portfolio)
Matthew Rotstein ()
Clare Russell (R&I Portfolio)
Mark Sanderson (STEM)
Prag Sapkota (R&I Portfolio)
Sujeeva Setunge (STEM)
Katrina Simon (DSC)
Dhirendra Singh (STEM)
Andy Song (STEM)
Michelle Spencer (STEM)
Naomi Stead (DSC)
Andrew Sun (Operations Portfolio)
Chayn Sun (STEM)
Yaguang Tao (STEM)
Athenee Teofilo (STEM)
John Thangarajah (R&I Portfolio)
Michael Tulip (ITS)
Michael Vlcek (Planning & Resources)
Monica Wachowicz (STEM)
Ron Wakefield (DSC)
Kaige Wang (STEM)
Matthew Warren (CoBL)
Naomi Whiteside (CoBL)
Deborah Wyatt (R&I Portfolio)
Rebecca Yang (DSC)
Toh Yen Pang (STEM)
Fabio Zambetta (STEM)
Kevin Zhang (STEM)

For further information

matt.duckham@rmit.edu.au
michelle.nicolo@rmit.edu.au

bit.ly/ISE-EIP
bit.ly/ISE-EIP-internal (RMIT staff)