IP4: Harnessing Disruptive Technologies for Earthquake Resilience

Our people

Project Co-Leaders: Nirmal Nair and Garry McDonald

Project Contact Person: Nirmal Nair (N.Nair@auckland.ac.nz)

Project Investigators: Nicola McDonald, Emily Harvey, Cecile L'Hermitte, Raj Prasanna, Hamish Avery, Juan Monge, Robert Cardwell, Nadia Trent, Kevin I-Kai Wang, Ho Seok Ahn, Minh Kieu, Pascal Cheon, Kristin Stock, Seosamh Costello, Liam Wotherspoon, Charlotte Brown, Brendon Bradley, Phil Mourot, Marion Tan.

Industry Affiliates: Andrew Renton, Stuart Woods, Paul Drummond

Project PhD students: Eric Sauvage, Shaila Arif, Rahul Chopra, Kitty Li, Sameeah Hameed, Chanthujan Chandrakumar

Previously participated PhD students: Rizki Rahayani, Xin Liu, Jason Ye

Project Research Assistant and Administration: Yuan Liu (Yuan.Liu@auckland.ac.nz)

Our inter-disciplinary programme

This programme will identify how transformational (i.e. order of magnitude) advancements in NZs infrastructure resilience can be achieved through strategic adoption of disruptive technologies, via government and market-led initiatives. A central hypothesis is that rapid adoption of several disruptive technologies (e.g. distributed solar power, autonomous transport, and a sensing society) will result in a significantly greater resilience gain than the conventional wisdom of incremental investment to improve existing asset classes (e.g. centralized transmission networks, physical logistics, significantly increased public awareness and preparedness).

The following key questions needs to be understood:

- What is the failure hierarchy of a renewable distributed energy system in seismic events?
- How should existing asset management investment occur to provide resilience during the transition to a renewable and distributed energy system?
- How can real-time sensing enable early detection of network degradation pre-event, and situational awareness in the immediate post-event environment for rapid restoration?
- How do individual utility networks develop resilience to externality risks and avoid contagion?
- How does the trade-off in electrification of transportation, reducing vulnerable reliance on liquid fuels, but increasing resilience requirements for electricity, play out over time?
- How will autonomous transportation modes function in a beyond business-as-usual environment? (e.g. physically damaged roads, disrupted electrical systems)

Research answers to the above will guide seismic-informed transformational analysis planned to be addressed as follows during the 7.5 years of th

- We will use novel approaches to capture behaviour when disruptive technologies change the business-as-usual structure of the economy beyond conventional socio-economic models that assume the future structure of an economy will follow the same pattern as it has historically.
- We will consider adoption pathways for several disruptive technologies (noted above), including temporal rates and depth of penetration, and the associated equity and well-being consequences of adoption.
- These adoption pathways will provide insight into the resilience gains (and potential pitfalls) of such technology adoption, and an evidence-base for just decision-making beyond the business-as-usual utility of these technologies.

Our project outline (July 2021 - December 2024)

Research Context

This Inter-disciplinary Programme focuses on three exemplary strands of disruptive infrastructure technologies under a range of plausible forward-looking scenarios to 2030, 2040 and 2050. We will investigate how these technologies may be harnessed to maximise not only economic objectives, but also to create seismic resilience co-benefits while minimising societal and environmental costs associated with increased inter-connectedness, ‘lock-in’ path dependencies and inequitable distributional impacts. Through these case studies we will develop novel integrated dynamic models, which sit at the convergence of data and system science, widening the investment evaluation lens to capture economic and wellbeing indicators through time for multiple stakeholders.

Key Objective(s)

We focus on the three key case study areas identified in the TEC proposal for this IP:

1) distributed infrastructure,

2) electrification and autonomous transport (particularly around physical IoT), and

3) sensing society through the IoT.

We also target research on developing the next generation of evaluation toolkit necessary that provides a more holistic assessment of the diverse impacts associated with the emergence of disruptive technologies in the above workstreams.

Finally, as part of our risk management approach, we keep open a potential fourth disruptive technology workstream for emergent challenges and opportunities.

Research Methodology

The research will be undertaken through several initiatives. These are outlined below. As a new programme within QC2 we are keen, in the initial 3.5 years, to have projects that provide breadth across our core case study areas, grow our community through emerging researchers, and to create opportunities for in depth by next generation researchers (PhD scholarships). Our leadership is also very keen on developing avenues for established and emerging researchers to undertake research with high levels of research excellence by facilitating and mentoring capability to leverage more targeted research opportunities.

Regular attendance at online research wananga.

Meetings (1-2 hours) are scheduled for the wider IP4 team for the second Tuesday of each month. We are strongly committed to developing future research capability in this IP area – this will initially be driven by the networks of our established researchers. Each meeting will be followed by a planning session by the Research leads as well as other QC2 leaders. This iterative process is squarely aimed at enabling an agile programme of research.

Building capability and Strategic quick wins, that together help transition quickly to the post-COVID norm

We have provisioned on an average ¼ of the IP4 program funding p.a. towards seeding original research around the three disruptive themes, and remaining ¼ to our support modelling workstream.

Over the first 3.5 years we allocate three fully paid *PhD scholarships* to the following work streams of our programme

1) Renewable distributed energy

2) Autonomous transport

3) Modelling and evaluation.

Run quick win strategic ‘seeding’ workshops provisioned to be held-each year

The intent of the workshops is to develop research agendas around disruptive technologies under the three case study areas (through publishing in internationally peer-reviewed journals).

Specifically, these will focus on creating state-of-the-art impact-based evaluations of emerging disruptive technologies in the distributed infrastructure and sensing society areas.

The Year 3 workshops will focus on translating the most promising published agendas into proposal concepts for funding in wider research pools.

The workshops will cover research wnanga establishing agendas, stakeholder wnanga (if appropriate) to establishing needs, and for each case study area submission of at least one article – stress-testing the agenda through international peer-review.

Additional leveraged resources within and outside of QC

Involving University PhD scholarship holders mentored by our project investigators, aligned with IP4, towards contributing towards our work streams

Encouraging project investigators towards applying for annual QC RfP and scholarship calls for getting additional QC competitive funding

Engaging research students funded through other competitive science funding mechanisms of our investigators (aligned with IP4 work streams)

Exploring actively through future rounds of competitive science funding, based on ideas and problems generated/supported through our seeding projects

Supporting joint project applications for QC annual RfP with other QC DT/IP

Leadership commitment

Running monthly IP4 meetings that showcases emerging research on disruptive technologies in the seismic resilience space, facilitates delivery of the agenda-setting workshops, and actively encouraging participation in QuakeCORE activities including QCAM and the RfP rounds.

Establish agenda-setting workshops that not only produce internationally peer-reviewed research, but also translate idea concepts for wider research leverage

We will pay particular attention to

1) promoting QC2 core values,

2) science excellence,

3) science impact (where appropriate), and

4) areas of research health identified as through wider QC process i.e., growing women in science, growing Mori/Pacifika contributions, and encouraging leadership development

For our key disruptive technology case study areas, we have budgeted over the 3.5 years for regular workshop process. This is necessary investment to help attract co-leveraged funds to address the ambitious range of science questions that IP4 seeks to explore

Act as mentors/advisors for Grant writers

Risk mitigation

To avoid underwhelming or misaligned responses to our agenda-setting workshops we have selected well established researchers to facilitate and drive these processes. We believe this will help set the tone and culture of IP4 activities going forward – instrumental for the success of the programme.

Similarly, we have selected seasoned researchers to supervise PhD candidates ensuring a steady stream of quality research outputs to underpin future research efforts

Finally, we will adaptively manage our programme – this includes dealing immediate with any issues and potentially re-orientating funds to emergent disruptive technology challenges and opportunities.

Vision Mtauranga

We will be aligning ourselves to the overall QC2 VM strategy and seek every opportunity to engage with DT5 on projects and activities.

Expected Impacts

While our research is science excellence driven, it is also applied with the potential to have significant impact on future infrastructure investment decision-making.

Our 3 case study areas are clearly focused on understanding the impacts of harnessing disruptive technologies to address seismic events.

Our forward looking programme has a longer term lens, considering technologies that are likely to emerge and gain adoption at least one infrastructure management cycle from now i.e., to middle of this century

Developing theory, methods, and tools to understand the implications of future focused technologies will be of significant benefit to asset and infrastructure managers, planners and practitioners, and others who currently face having to make decisions with very limited supporting information. Our programme will help address this need from a seismic sciences perspective.