

# Special Project 1: Spatially-distributed Infrastructure

**Leader:** Liam Wotherspoon  
**Deputy Leader:** Charlotte Brown

## Opportunity

---

The resilience of lifeline networks (electric power, transportation, telecommunications (ICT), potable water, stormwater/wastewater, and liquefied/gas fuels) and other distributed infrastructure (flood control networks) play a critical role in the ability of society to rapidly recover after a major disaster. The research in this project will be directed toward developing tools to assess the performance of spatially-distributed infrastructure networks subject to extreme natural hazards.

This research is funded under the both the Resilience to Nature's Challenges National Science Challenge (<http://resiliencechallenge.nz/>) through the Built programme and QuakeCoRE ([www.quakecore.nz](http://www.quakecore.nz)) through IP3: A resilient Aotearoa NZ transport system. Therefore, this research has a focus on a range of extreme natural hazards.

Working closely with relevant stakeholders we will develop methodologies to quantify system-level performance of nationally critical infrastructure when subject to natural hazards and cascading impacts, leading to improved resilience of communities through identification of multi-hazard related vulnerabilities in infrastructure critical for NZ society. Critical infrastructure asset owners do not currently have methods to fully quantify resilience of key components and trickle-down impacts of their disruption due to natural hazards. Nor are there consistent methods to measure and monitor infrastructure resilience within or across infrastructure types, organisations, or investment criteria to assess the merits of different options to improve resilience. System-level resilience methodology outputs will be based on local (or component) level quantification of vulnerabilities, and mechanistic models for the interactions between the components of the network system. [INFOGRAPHIC](#)

## Impact

---

Our goal is to develop an improved understanding of the resilience of spatially-distributed infrastructure networks to extreme natural hazards through new methodologies and application to New Zealand-specific critical infrastructure. In the face of New Zealand's unique natural hazard environment, and based on engineering science evidence, this project will enable New Zealanders to anticipate critical infrastructure vulnerabilities, and protect and transform the built environment to support thriving communities. The impact of this project will result from the robust quantification of infrastructure network resilience, and importantly, explicit insight into optimization of pre-disaster mitigation and post-disaster targeted repair strategies which will minimize the consequences of infrastructure network inoperability.

## Current Projects

---

### Overall research update - 2019

3 Waters Summary - [link](#)

Flood Defence Summary - [link](#)

Electricity Summary - [link](#)

Transportation Summary - [link](#)

Multi-Infrastructure Summary - [link](#)

### Direct Funding

- 23MCM - A multi-hazard scenario approach for developing network-based infrastructure criticality metrics across spatial scales (Lin - UA, Zorn - UA)
- 23FRH - Exposure of NZ infrastructure networks to fault rupture hazards (Daglish - UC, Stahl - UC)
- 23LMR - Development of a NZ logistics model for resilience intervention assessment (Stucki - UW, Trent - UW)
- 22THC - Characterisation of NZ transport hub components and system exposure (Li - UA, Wotherspoon - UA)
- 22FMC - Resilience of Fast Moving Consumer Goods networks (Wight - UC, Logan - UC)
- 22PSR - Prepositioning strategies for post-natural hazard event response (Shariati - UW, L'Hermitte - UW)
- 22NIR - Operational resilience of the North Island road transport network (Khadka - UA, Ranjitkar - UA)
- 21BFM - Development of seismic fragility models for the NZ bridge stock (Bal - UA, Stephens - UA, Hogan - UA)
- 21TFI - Infrastructure component fragility/vulnerability for tsunami wave impacts and currents (Kimpton - UA, Higuera - UA)
- 21MIS - Multi-hazard impact and operability of flood defence network components (Essuman - UA, Wotherspoon - UA, Crawford-Flett - UC)
- 21TER - Integrated telecommunications and electricity resilience assessments (Nair - UA)
- 21ALV - Volcanic ash impacts to electrical distribution system components (Mace - UC, Laphorn - UC, Wilson - UC)
- 21SRC - Interdependent System Resilience and Adaptive Planning in a Changing Climate (Brunner - UC, Logan - UC)
- 21ACI - Adaptation of coastal infrastructure in NZ (Whittaker - UA, Shand - UA)
- 21GLA - Integration of geospatial and focussed liquefaction tools for regional assessments (Orense - UA)
- 21RAM - Resilience through an Asset Management Long-term Planning Process (Hasanah - UA, Henning - UA)
- 21UFR - Quantification of urban flooding resilience and assessment of mitigation strategies (Al Riyami - UA, Shamseldin - UA)
- 21MHT - Multi-Hazard Assessment of Operational Impacts on the Road Transportation Network (Costello - UA, Ranjitkar - UA)
- 21IRM - Marae infrastructure adaptations and resilience planning (Vercoe - UA, Fa'au - UA)
- 21DMR - Developing a framework to decolonize managed retreat in Aotearoa New Zealand (Bailey-Winiata - UW, Gallop - UW)

- 21IIB - Integrated built environment assessment of resilience and recovery strategies (Lan - UA, Zorn - UA)
- 20HCM - High Impact Weather infrastructure component fragility models from NZ case histories (Wotherspoon - UA)
- 20GMS - Ground motion simulation of subduction zone earthquakes in NZ (Bradley - UC)
- 19EDF - Embankment systems for flood detention and routing: management strategies and impacts (Wallace - UC, Crawford-Flett - UC)
- 19SLI - Sea-Level Rise, Groundwater Dynamics and Impacts on Infrastructure Systems (Bosselle - UC, Hughes - UC)
- 19HWE - Power System Resilience Enhancing Techniques for Pre, During and Post-HILP events (Lakshita - UA, Nair - UA)
- 18196 - [Understanding evacuation and travel behaviour under emergency situations in Auckland, New Zealand](#) (Thakur - UC, Ranjitkar - UA) **Journal 1**
- 17143 - [Characterising long-term ground deformation impacts on Christchurch City's buried high voltage electricity network since the start of the Canterbury Earthquake Sequence](#) (Rehman - UA, Nair - UA)
- 16SMS - Technical resilience of stormwater management systems to flooding (Valizideh - UA, Shamseldin - UA) **Conference 1** **Conference 2** **Journal 1**
- 16UTM - [Assessing the resilience of an urban transportation network](#) (Afzal - UA, Ranjitkar - UA, Costello - UA) **Conference 1** **Conference 2**

#### Aligned from other programmes

- [Infrastructure disruption from coastal flooding](#) (Paulik - NIWA, Zorn - UA)
- [Flood risk to the built environment](#) - Increasing flood resilience across Aotearoa (Paulik - NIWA, Zorn - UA)
- [Transportation Research Centre](#) - University of Auckland
- Quantifying infrastructure levels of service for a post-event response and recovery context (Mowll - Mas, Becker - Mas, Johnston - Mas, Wotherspoon - UA) **Journal 1**
- [Geospatial hazard exposure tools for infrastructure networks](#) (Lin - UA, Wotherspoon - UA, Blake - UC) **Conference 1** **Conference 2** **Poster 1**
- Seismic fragility models for New Zealand bridges (Lew - UA, Wotherspoon - UA, Al-Ani - OPUS) **Conference 1** **Poster 1** **Journal 1**
- Characterisation of failure modes for New Zealand stopbank construction (Ting - UA, Melville - UA, Shamseldin - UA, Whittaker - UA)

## Completed Projects

- 18ADP - [Critical infrastructure impacts & adaptations in small towns following earthquakes](#) (McKibbin - UC, Blake - UC, Wilson - UC, Wotherspoon - UA, Hughes - UC) **Journal 1**
- 18TRA - [Assessing Transient Populations Exposure to Disaster Risk](#) (Darling - UC, Wilson - UC, Orchiston - UOtago, Bradley - UC)
- 18198 - [Assessing the impact of undocumented stopbanks on flood routing and catchment performance](#) (Wallace - UC, Crawford-Flett - QC, Wilson - UC, Shamseldin - UA) **Thesis**
- 18202 - [Tsunami vulnerability of key infrastructural assets](#) (Whittaker - UA, Melville - UA, Wotherspoon - UA) **Journal 1**
- 18201 - [Seismic resilience for fast-changing telecommunication networks](#) (Bertelli - UCL, Giovinazzi - UC, Wotherspoon - UA, Rossetto - UCL)
- 18TEL - [Framework for dynamic reconfiguration of wired and wireless communication systems following natural hazard events](#) (Latif - UA, Austin - UA, Nair - UA)
- 17123 - [Tsunami loading characteristics on power poles](#) (Whittaker - UA, Melville - UA)
- 17GIS - [Integrating Geographic Information Systems and Building Information Modeling to Characterise Urban Resilience](#) (Jones - UC, Hughes - UC, Horspool - GNS)
- 17RES - [Effective Power Restoration Practices following extreme natural hazards](#) (Maina - UA, Nair - UA, Liu - UA)
- 17MIC - [A Framework for Islanded Microgrid Operation after Hazard Events](#) (Deh Kohnneh - UA, Nair - UA)
- 17EPD - [Electric power distribution system resilience modelling toolbox](#) (Liu - UA, Nair - UA) **Journal 1**
- 17MOT - [Data and decision making in the transport system following the Kaikoura earthquake](#) (Wotherspoon - UA, Blake - UC, Trotter - OPUS, Ivory - OPUS, Stevenson - ResOrgs) **Workshop Report** **Final Report** **Journal**
- 17CRN - [Criticality of road networks in Auckland](#) (Rebello - UA, Jaggi - UA, Costello - UA, Blake - UC, Oo - AT, Hughes - T&T, Egbelakin - Mas) **Journal 1**
- 17KAI - [Impact of the Kaikoura Earthquake on Infrastructure Networks](#) (Various authors) **3 Waters Journal** **Transportation Journal** **Electricity Journal** **Telecommunications Journal**
- 16RTN - [Operational resilience assessment of a rural road network](#) (Aghababaei - UA, Costello - UA, Ranjitkar - UA) **Conference 1** **Journal 1** **Journal 2** **Journal 3**
- 17145 - [Characterisation and screening of New Zealand stopbank networks](#) (Rodger - UC, Crawford-Flett - QC, Shamseldin - UA, Wotherspoon - UA) **Conference 1**
- 17104 - [Framework for integrated 'end to end' impact assessment of infrastructure networks under natural hazards](#) (Uma - GNS, Prasanna - Mas, McDonald - ME, Horspool - GNS) **Journal**
- 16018 - [Resilience of Distributed Transportation Infrastructure Workshop](#) (Costello, Ranjitkar - UA): **Workshop Report**
- 16071 - [Performance of the Telecommunication Network during the Canterbury Earthquake Sequence](#) (Giovinazzi - UC, Nayyerloo - GNS, Esposito - ETH Zurich)
- 16SUL - [Seismic resilience of underground lifelines: Case study of the Christchurch City potable water network](#) (Bellagamba - UC, Bradley - UC, Wotherspoon - UA, Hughes - UC) **Journal 1** **Journal 2** **Thesis**
- [Developing tsunami vulnerability functions and functionality/repair time models for critical infrastructure](#) (Williams - UC, Hughes - UC, Wilson - UC, Horspool - UA, Lane - NIWA, Wotherspoon - UA) **Poster 1** **Journal 1** **Journal 2** **Thesis**
- [Minimising public health risks from human waste after a large Wellington Fault earthquake](#) (Brenin - Mas, Horswell - Mas, Stewart - Mas, Johnston - Mas, Wotherspoon - UA) **Poster 1** **Journal**
- [Resilience of Infrastructure Networks following Natural Hazard Events: Novel System of Systems Framework](#) (Wotherspoon - UA, Nair - UA, Shamseldin - UA, Downward - UA, Zorn - OX) **Conference 1**
- [Tsunami loading on New Zealand bridges](#) (Farvizi - UA, Melville - UA) **Thesis**
- [Assessment of multi-hazard impacts on regional infrastructure and consequent implications for isolated settlements and their communities](#) (Davies - UC, Wilson - UC, Davies - UC, Galliard - UA, Wotherspoon - UA, Hughes - UC) **Journal**
- [Assessing wastewater pipe performance through the 2010-2011 Canterbury Earthquake Sequence](#) (Tang - UC, Scott - UC, Hughes - UC) **Thesis**
- [Interdependent national infrastructure](#) (Zorn - UA, Shamseldin - UA) **Poster** **Poster** **Journal 1** **Journal 2**
- [Volcanic ash impacts on surface transportation](#) (Blake - UC, Wilson - UC, Deligne - GNS, Lindsay - UA, Cole - UC) **Thesis**

- Modelling the hazard footprint and consequences of lava flows in an urban environment (Tsang - UA, Lindsay - UA, Coco - UA, Wilson - UC, Kennedy - UC, Deligne - GNS)
- Clean-up and restoration of urban environments after volcanic eruptions (Hayes - UC, Wilson - UC, Leonard - GNS, Deligne - GNS, Cole - UC) [Thesis](#)
- Seismic response of New Zealand wharves (Ragued - UA, Wotherspoon - UA) [Thesis](#)
- Tsunami loading and performance of New Zealand wharves (Popovich - UA, Wotherspoon - UA, Shamseldin - UA) [Thesis](#) [Journal](#)

## Monthly Meetings and Workshops

---

- [Infrastructure Research Day 2022](#)
- [IP3: Resilient Transport System Research Coordination Workshop 2022](#)
- [Infrastructure Research Day 2021](#)
- [Infrastructure Research Day 2019](#)
- [Infrastructure Research Day 2018](#)
- [2022 Meetings](#)
- [2021 Meetings](#)
- [2020 Meetings](#)
- [2019 Meetings](#)
- [2018 Meetings](#)
- [2017 Meetings](#)
- November 2016 - [Resilience of Distributed Transportation Infrastructure Workshop](#)
- [2016 Meetings](#)

## Related Efforts

---

- New Zealand Lifelines Committee and Regional Lifelines committees
- National Infrastructure Unit <http://www.infrastructure.govt.nz/>
- Determining Volcanic Risk in Auckland (DEVORA) <http://www.devora.org.nz/>
- Riskscape <https://www.riskscape.org.nz/>
- Riskscape Potential Collaborative Projects [https://wiki.riskscape.org.nz/index.php/Collaborative\\_Projects](https://wiki.riskscape.org.nz/index.php/Collaborative_Projects)
- SCIRT Learning Legacy <https://scirtlearninglegacy.org.nz>
- Building Innovation Partnership <https://bipnz.org.nz/>
- National Lifelines Forum 2017 <http://www.aelg.org.nz/events/national-lifelines-forum-2017/>
- National Lifelines Forum 2018 <http://www.aelg.org.nz/events/national-lifelines-forum/>
- National Lifelines Forum 2019 <http://www.alg.org.nz/events/national-lifelines-forum/>
- National Lifelines Utilities Forum 2022
- National Lifelines Utilities Forum 2023 <https://www.dropbox.com/scl/fo/iwze39xa4ry8a43ybmhnl/h?rlkey=hglulhgy0u0o1yoqtrcnez1lz&dl=0>

## Other Presentations

---

## Requests for Proposals

---