# Distributed Infrastructure Network Research

National Lifelines Forum 2017

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urban hazard rural infrastructure

QuakeCoRE
NZ Centre for Earthquake Resilience

National Science Challenges
RESILIENCE TO NATURE'S CHALLENGES
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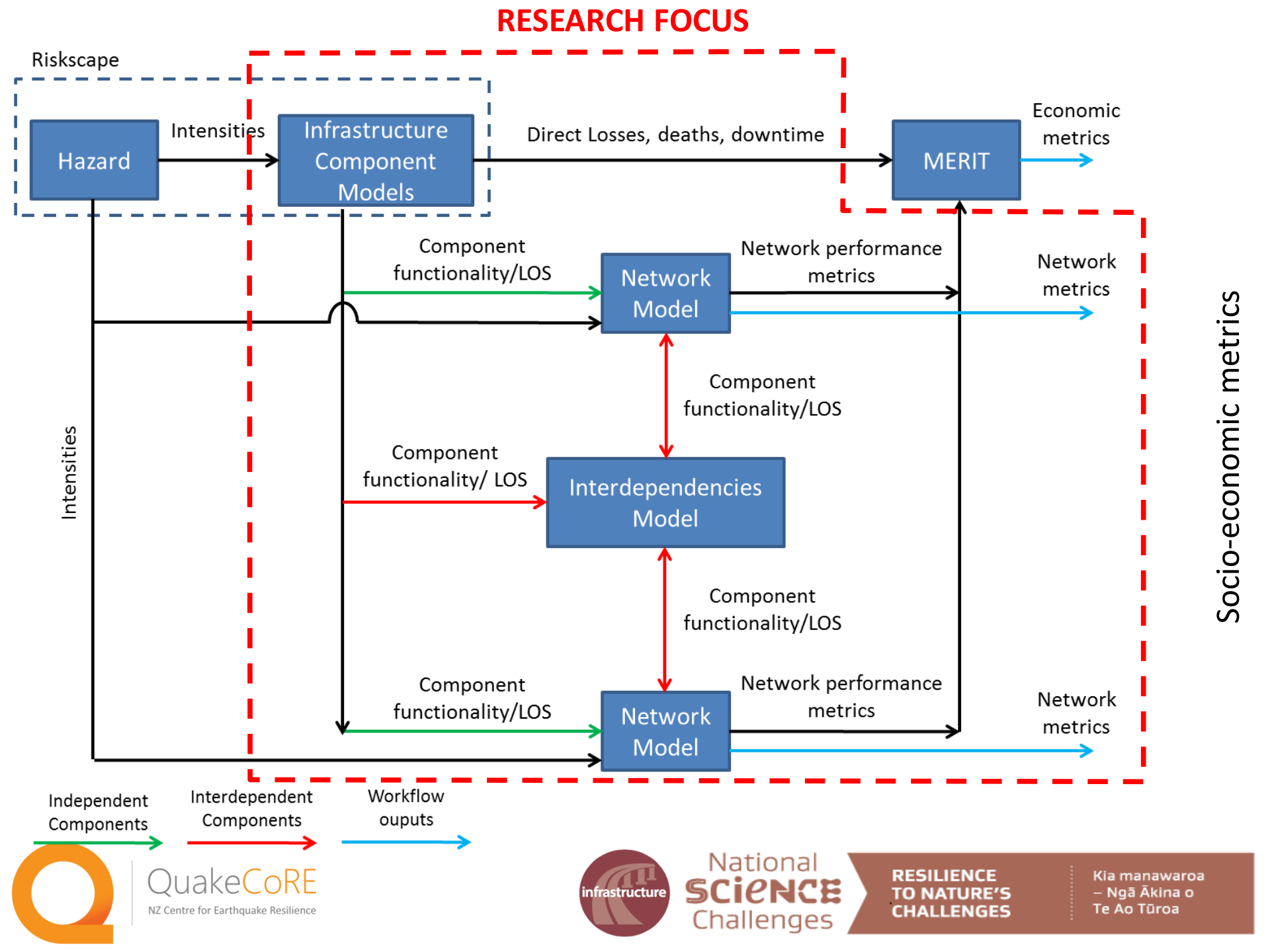
# Focus

- **Mapping of New Zealand Infrastructure-Natural Hazards Research**

- **Framework**
  - NZ specific characterisation of network components
  - Regional and national **network process models**
  - Backbone network **dependencies** model

- **Quantification** of performance and resilience
  - Current network structure
  - Pre-disaster mitigation and post-disaster prioritisation effects
  - Effect of future technological changes

  - Feed into definition of socio-technical metrics


RESEARCH FOCUS
Riskscape
Hazard
Intensities
Infrastructure Component Models
Direct Losses, deaths, downtime
MERIT
Economic metrics
Component functionality/LOS
Network Model
Network performance metrics
Network metrics
Component functionality/LOS
Intensities
Component functionality/ LOS
Interdependencies Model
Component functionality/LOS
Component functionality/LOS
Network Model
Network performance metrics
Network metrics
Socio-economic metrics
Independent Components
Interdependent Components
Workflow ouputs
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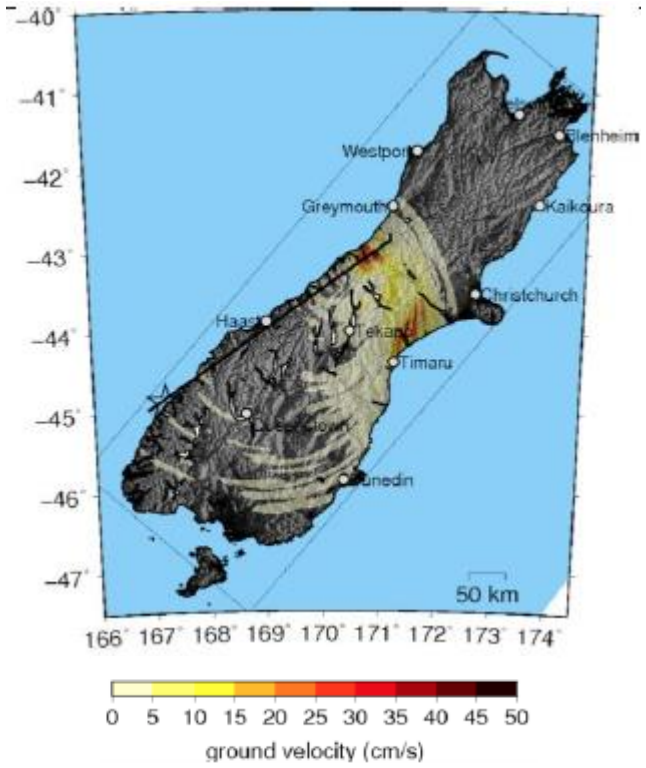
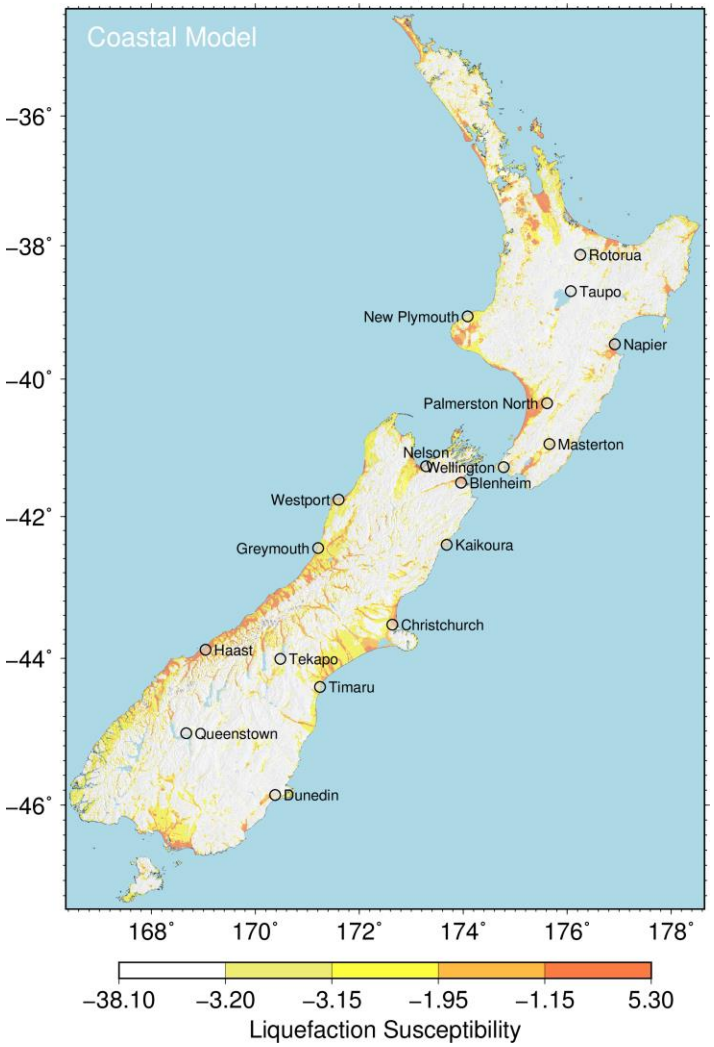
# Regional Hazards

*Broad scale co-seismic hazard modelling linked to GM sim*

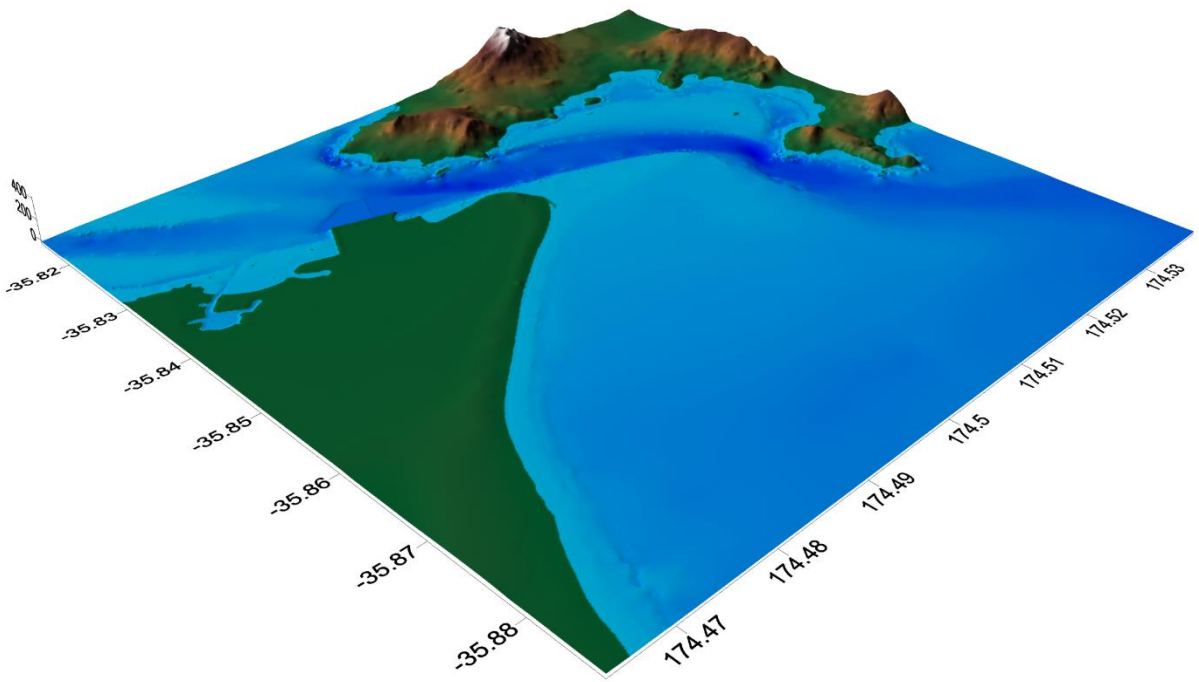


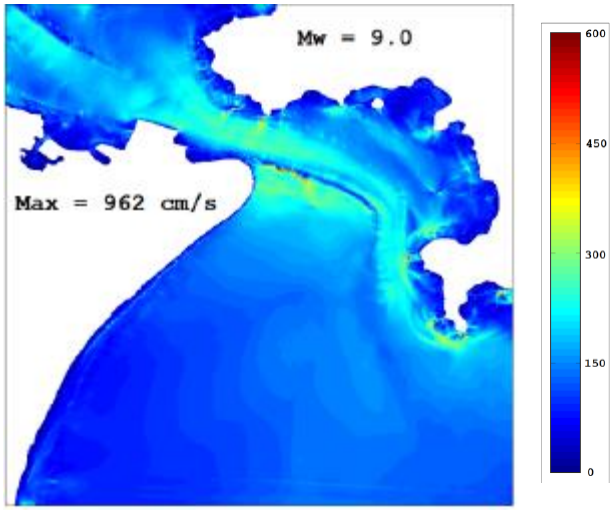

Liquefaction susceptibility



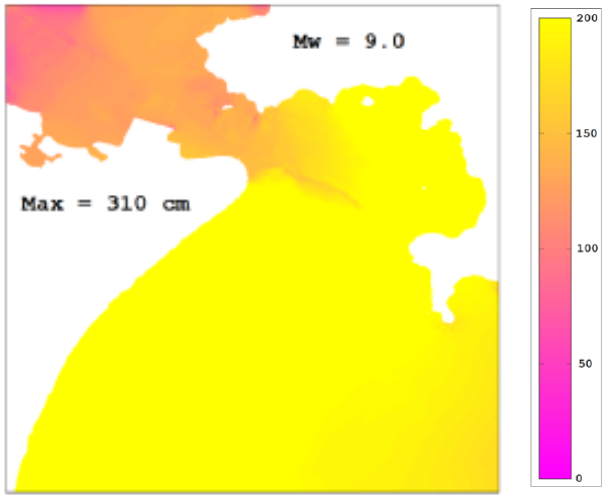
# Regional Hazards

*Quantification of tsunami hazard at NZ ports*




Max current cm/s




Max water level (cm)

# Component Projects

**Seismic/tsunami fragility curves for New Zealand wharves**

Stakeholders: PoA, PoT, PoN, LPC

**Development of fragility curves for electricity network infrastructure – including temporal effects**

Stakeholders: Orion

**Developing tsunami vulnerability functions and functionality/repair time models for critical infrastructure**

Stakeholders: CCC

**Flooding vulnerability functions for infrastructure**

Stakeholders: BOPEM, various

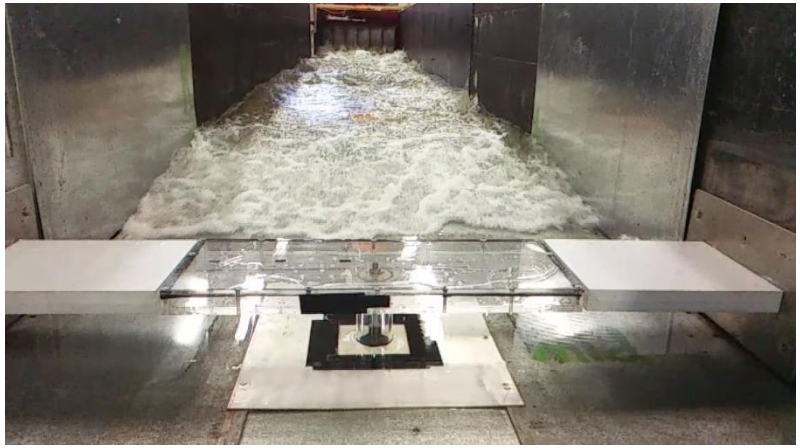
**Seismic fragility curve "reality check" for New Zealand bridges**

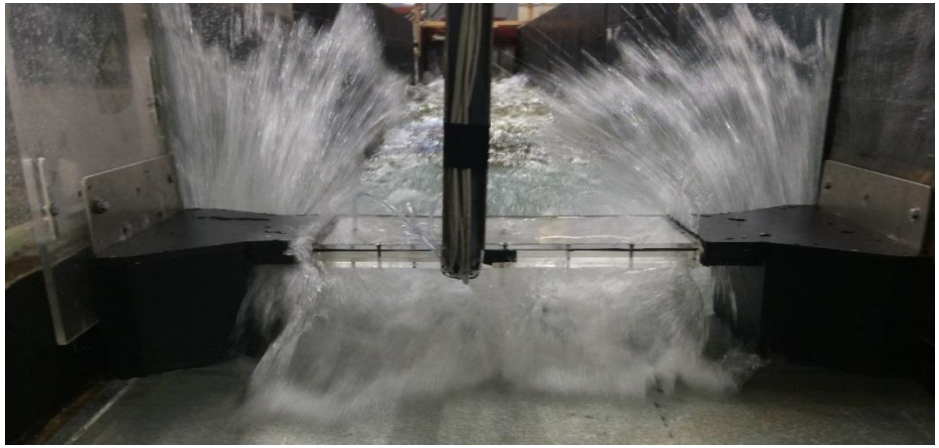
Stakeholders: NZTA

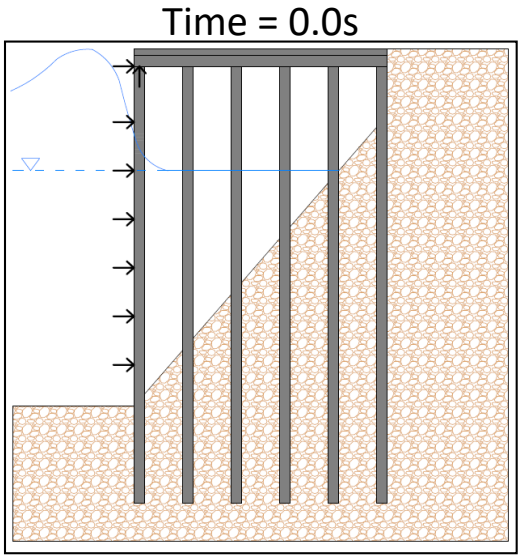
**Evidence based fragility curves for telecommunications infrastructure**

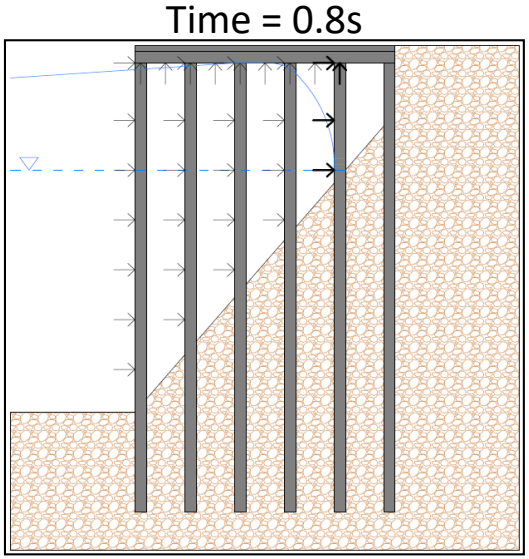
Stakeholders: Chorus

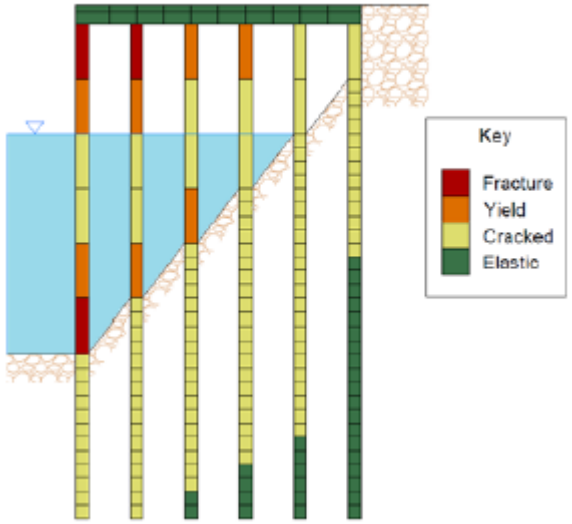
# Tsunami Fragility Models







# Network Projects

**Kaikoura EQ infrastructure network performance**

Stakeholders: NZTA, Kiwirail, Mainpower, Chorus, MDC, KDC

**Characterisation of New Zealand flood defence networks**

Stakeholders: IPENZ River Managers, Ecan, etc

**Electricity network assessment during an Alpine Fault event**

Stakeholders: WCELG, CELG, Westpower

**Effective restoration practices and improvement of electricity and communication infrastructure following natural hazard events**

Stakeholders: WCELG, CELG, Westpower

**Assessment of multi-hazard impacts on regional infrastructure and consequent implications for isolated settlements and their communities**

Stakeholders: WCELG, etc.

**Volcanic hazard and network impacts (DEVORA and VISG)**

Stakeholders: AC, AELG, etc

# Seismic Resilience of Underground Lifelines

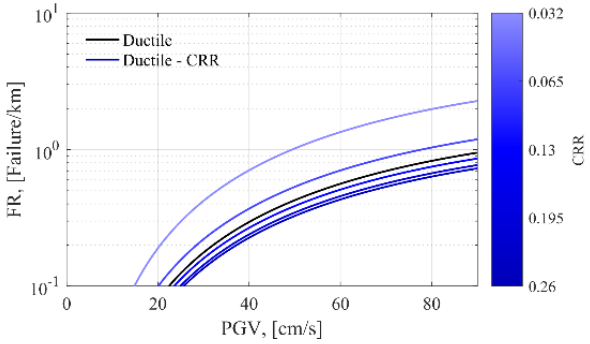
Case study: Potable water network of Christchurch City

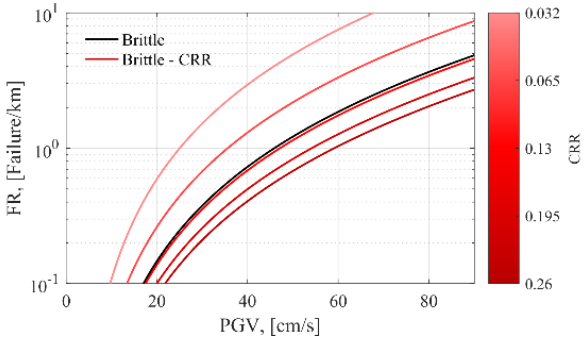
Bellagamba UC

Stakeholders: CCC

*Fragility functions accounting for pipe material and soil properties based on CCC data*

***Result:*** *Rigorous fragility curves and city-wide validation of simulation framework using observations from CES*

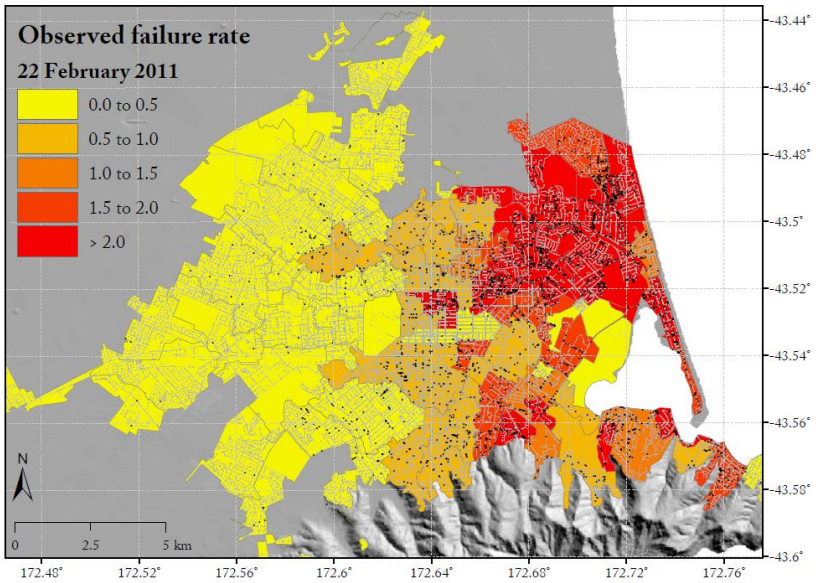


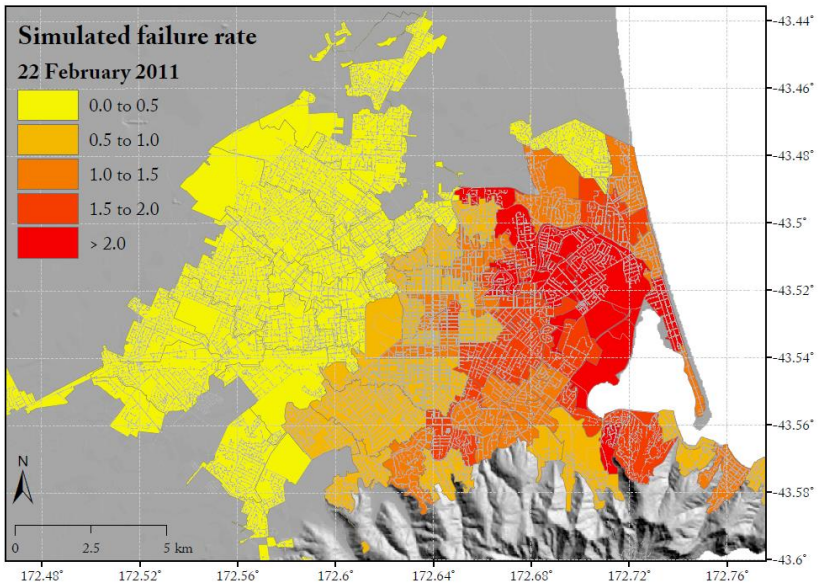




*Observed*

*City-wide Christchurch EQ simulation*

*Simulated*



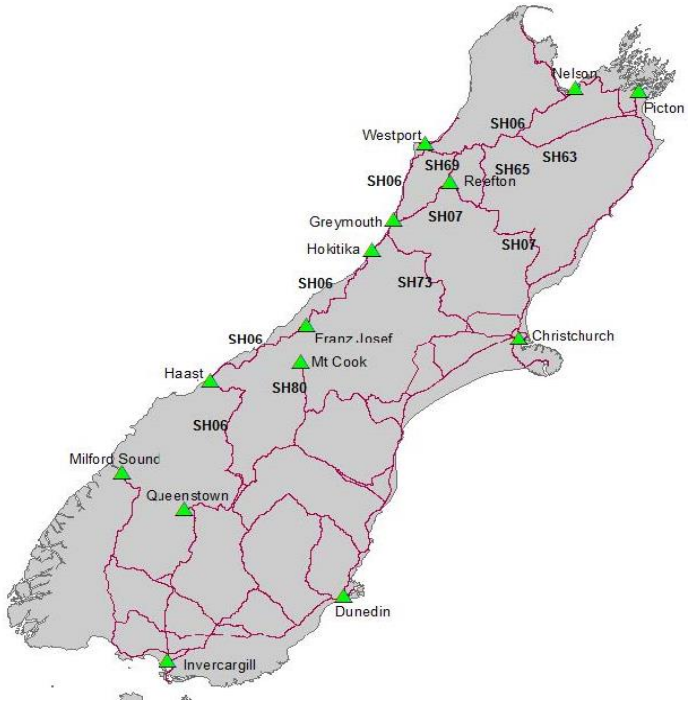
# Resilience of the Transportation System: Urban and Regional

Aghababaei, Afzal UoA

Stakeholders:
AT, AC, NZTA

Modelling the transport network's resilience under the impact of a range of natural hazards and mitigation actions

*Hybrid microscopic and mesoscopic simulation of SI and Auckland*

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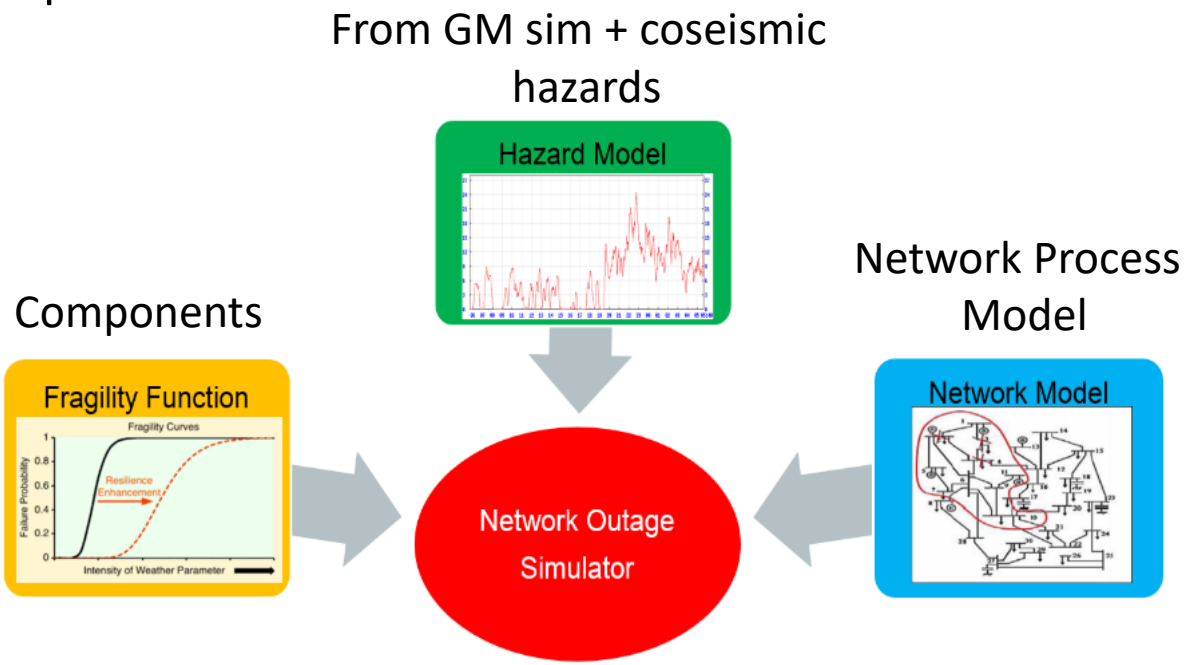
Liu UoA

# Electric Power Systems Resilience Modelling Toolbox

- Simulate spatio-temporal hazard impact on electricity distribution system considering  human intervention
- Develop resilience metrics to inform decision making
- Define optimal restorative process

Stakeholders: Westpower- Electronet, Transpower




***Result:*** *Framework to move from electricity network reliability towards resilience quantification*

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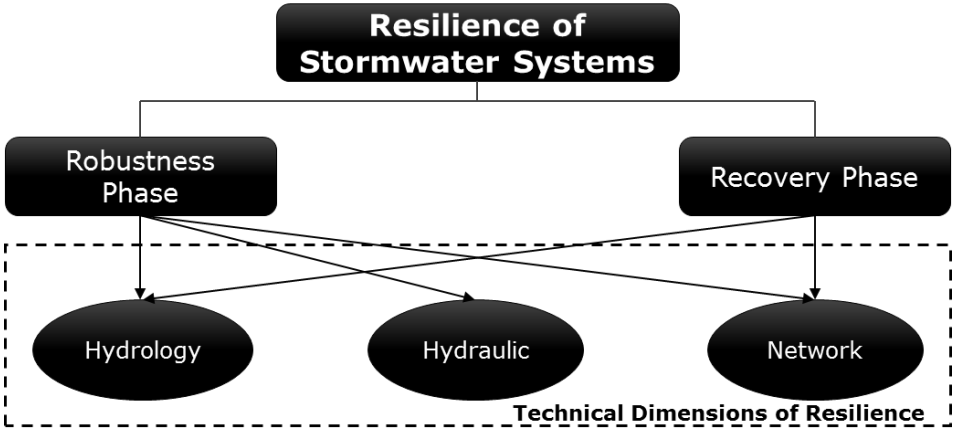
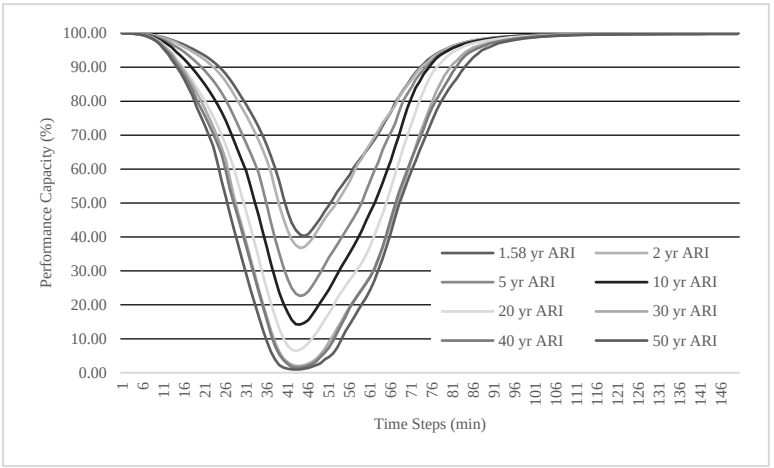
Valizadeh UoA

# Technical resilience of stormwater management systems

Stakeholders: AC

Framework to quantify the resilience of urban stormwater infrastructure to flooding and other hazards



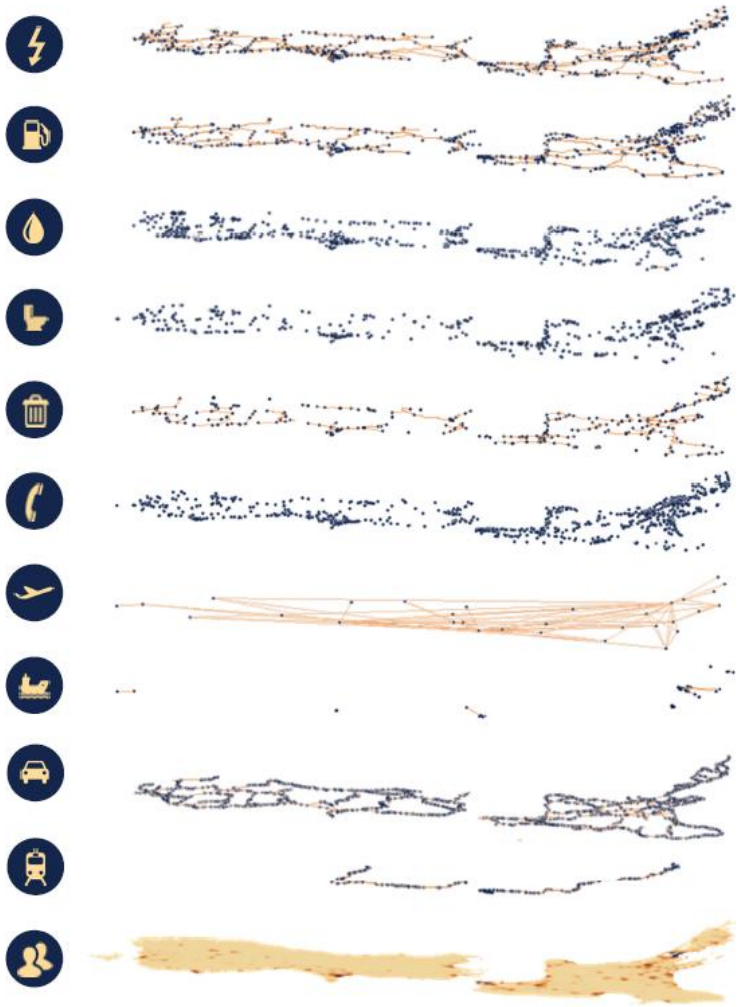




***Result:*** *Benchmark stormwater network resilience and assess resilience interventions*

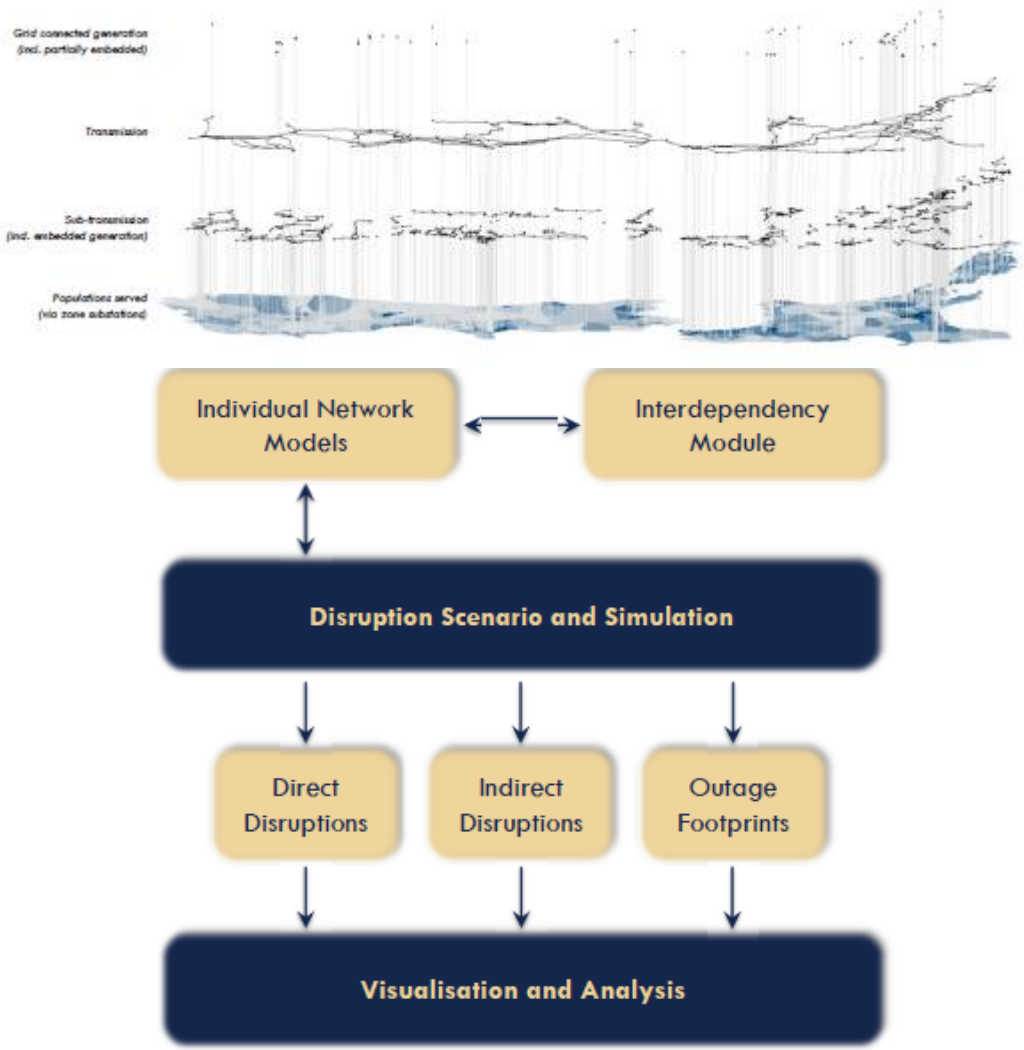
# Network of Networks and Dependencies

# Modelling of Network Dependencies

## *Hierarchal network-of-networks models*



## *Electricity network*



# Modelling of Network Dependencies

Zorn UoA

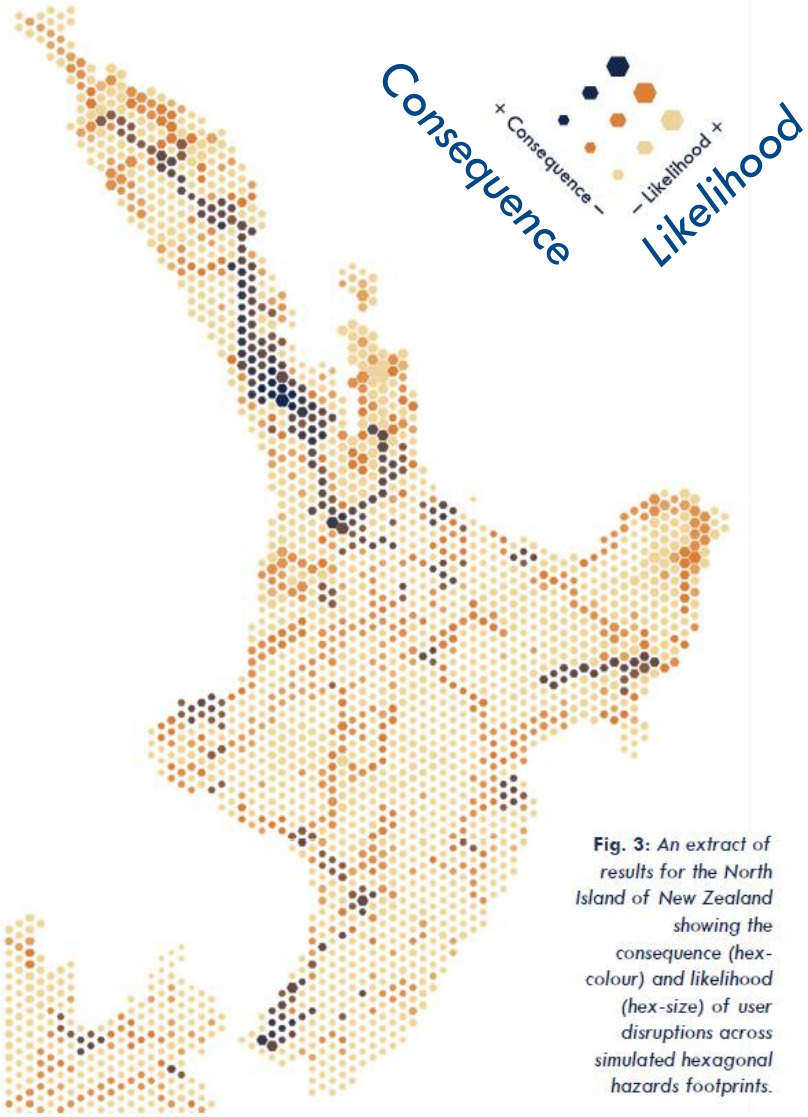
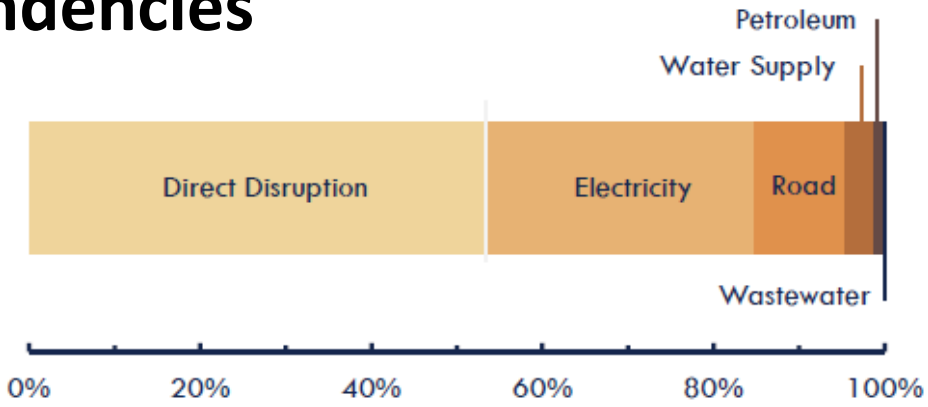


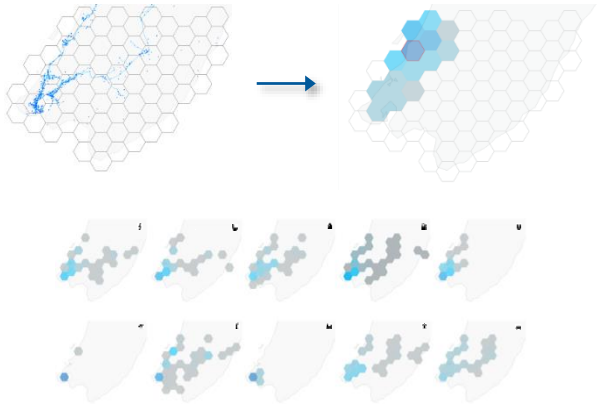

**Fig. 3:** *An extract of results for the North Island of New Zealand showing the consequence (hex-colour) and likelihood (hex-size) of user disruptions across simulated hexagonal hazards footprints.*



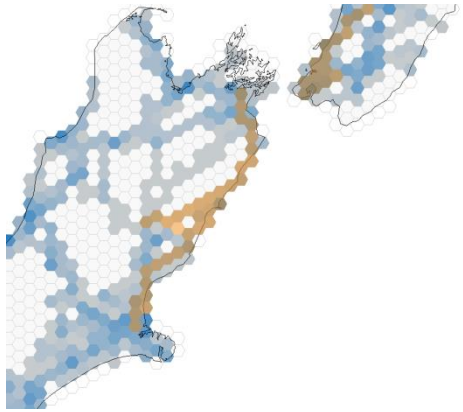

*Direct vs indirect disruptions*

*Simulation and scenarios*

*Wellington Fault*



*Kaikoura EQ*



***Result:*** *Quantification and simulation of national infrastructure network dependencies*

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# Infrastructural Transitions Research Consortium

ITRC mistral
multi-scale infrastructure systems analytics

***Aim*:** To develop and demonstrate a new generation of simulation models and tools to inform the analysis, planning and design of national infrastructure.

Environmental *Change* Institute
eci
UNIVERSITY OF OXFORD

HM TREASURY

Identifying critical hotspots in UK's infrastructure networks for prioritising resilience building interventions.

Department for Transport

Identifying points of vulnerability in UK's transport networks due to flooding, windstorms, heat and snow.

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- Project wiki:

https://wiki.canterbury.ac.nz/display/QuakeCore/Resilience+Of+Transportation+Infrastructure+Workshop

- Thanks to all infrastructure organisations and local/regional authorities, lifeline groups and government agencies involved thus far.

- Contact:
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