RR 671 – DEVELOPING A METHOD FOR QUANTIFYING TRANSPORT INTERDEPENDENCIES

WAKA KOTAHI RESEARCH SUMMARY NOVEMBER 2020

A way to measure how transport networks rely on each other

The value of New Zealand's road and rail network is estimated at NZ$80 billion. It moves people and goods, it connects communities, transport hubs and services, and it facilitates tourism.

Our reliance on the network means uninterrupted service is important, as is building resilience to natural and man-made infrastructure hazards.

To build resilience we must understand the complex relationships between transportation networks and their interdependencies with other infrastructures such as power and water. This helps us to strategically manage transportation network risks.

From late 2019 to mid-2020, researchers studied how New Zealand's transport network infrastructure interdependencies could be understood and assessed better. Their aims were to:

- build on the existing body of knowledge
- identify and review the ways to assess infrastructure interdependencies
- develop a way to assess interdependencies and the wider infrastructure
- identify 'treatment options' to better manage interdependencies.

INTERDEPENDENCIES

A dependency is when one infrastructure system directly impacts on the performance of another. This impact may go one way, or both ways (interdependency).

In this study, researchers identified four types of interdependencies from the literature:

- physical
- digital
- geographic
- organisational.

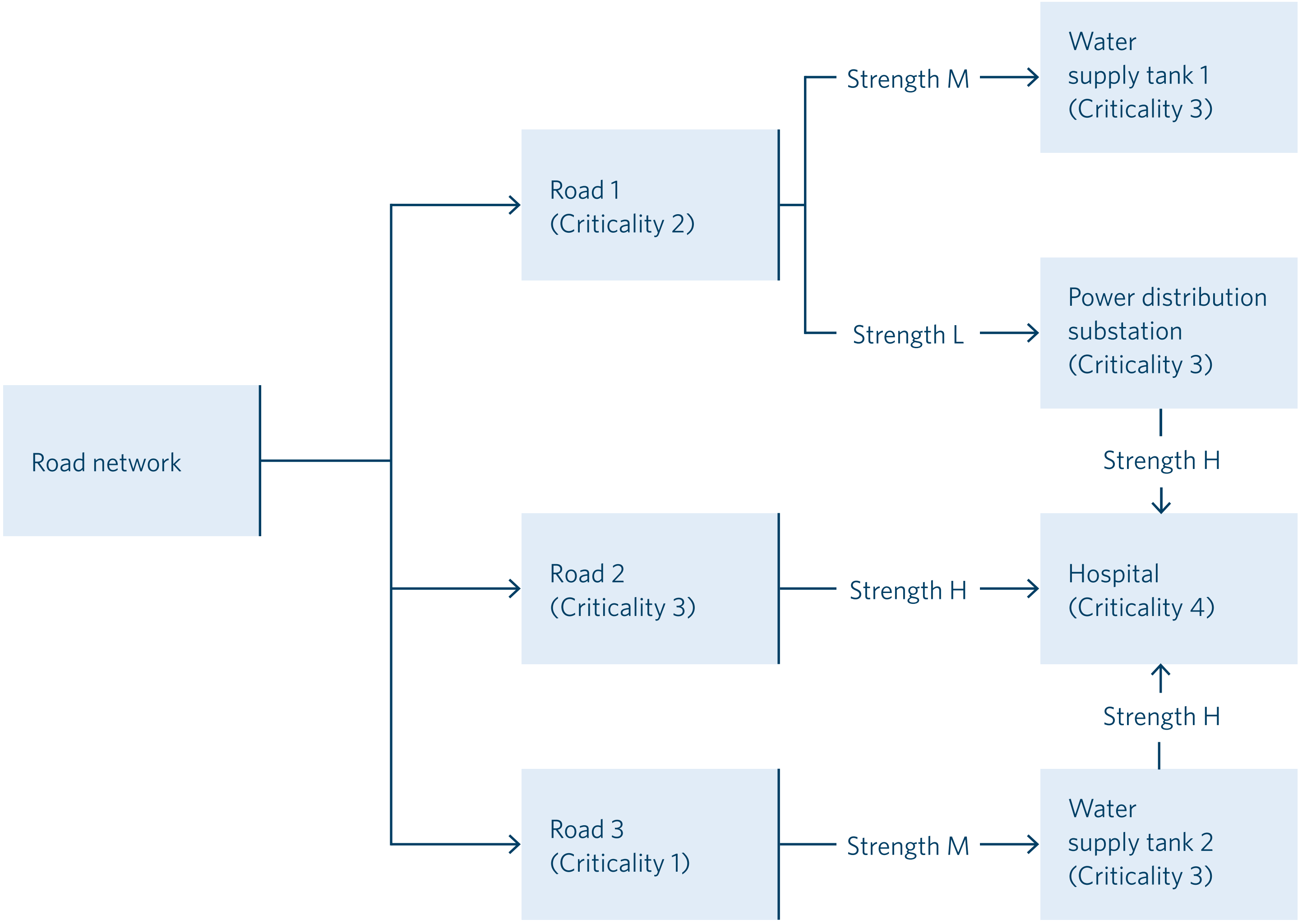
These were further characterised by order, direction and strength of impact.

WAKA KOTAHI NZ TRANSPORT AGENCY

New Zealand Government

In the following diagram and table, we see an example of physical and digital interdependency. Access to water, power supplies and the hospital depends on three different roads, which all depend on the wider road network. In turn, the hospital relies on power and water supplies to operate.

EXAMPLE INFRASTRUCTURE DEPENDENCY NETWORK AS A CAUSAL CHAIN



EXAMPLE INFRASTRUCTURE DEPENDENCY RELATIONSHIP DIMENSIONS

Upstream infrastructure (base criticality rating)	Downstream infrastructure (base criticality rating)	Order from road network	Strength	Comment regarding strength
Road 1 (C2)	Water supply tank 1 (C3)	1st	Medium	Road access is sometimes required for staff to conduct maintenance.
Road 1 (C2)	Power distribution (C3)	1st	Low	Road access is rarely required for staff to conduct maintenance.
Road 2 (C3)	Hospital (C4)	1st	High	Road required for hospital access and operation.
Road 3 (C1)	Water supply tank 2 (C3)	1st	Medium	Road access is sometimes required for staff to conduct maintenance.
Power distribution (C3)	Hospital (C4)	2nd	High	Essential for operation.
Water supply tank 2 (C3)	Hospital (C4)	2nd	High	Essential for operation.

REVIEW OF EXISTING MODELS

Several existing interdependency assessment approaches/methods were reviewed to identify those that might be best applied within the transport sector.

Each of the models had a different purpose and associated strengths and weaknesses. None addressed or evaluated all the types of interdependencies.

PROPOSED INTERDEPENDENCY, CRITICALITY AND RISK ASSESSMENT APPROACH

The researchers then developed a new approach to address the gaps in the existing approaches. This approach links to a broader assessment of criticality (high risk of failure) and risk. A risk assessment can then include and integrate with other information such as hazards and infrastructure vulnerabilities.

A core module accepts network data and assesses interdependencies and criticality. Users can then include hazards and asset vulnerability information to understand risk. Given the focus on physical infrastructure (and the scope of this research), the proposed assessment approach focuses on physical, digital and geographic interdependencies.

Researchers also did a pilot study for each of the two interdependency assessment approaches using data from the Queenstown-Lakes District.

ADDITIONAL (OPTIONAL) MODULES

The core interdependencies module focused on in this research could be integrated with a hazard and vulnerability module, a risk and resilience module, and an economic impact module. These modules would allow users to:

- estimate the level of impact or damage from a hazard
- assess both the direct risk to infrastructure and the spread of outage and impact
- evaluate the financial and economic losses from disrupted or failing infrastructures.

IMPLEMENTATION

Implementing the approach consistently and at scale across distributed networks is key. This requires the development and integration of a geospatial platform to automate the analysis.

RISK TREATMENT TOOLBOX AND INVESTMENT DECISION MAKING

Risk treatment is a key step within risk management. This means addressing priority risks by avoiding, mitigating, transferring or accepting them. Evaluating these options should follow a robust process, which may include cost–benefit analysis, multi-criteria assessment or real-options analysis.

Some options for mitigating high risks are:

- improving the strength of infrastructure, possibly by improving asset designs or materials
- constructing systems that can 'fail safely'
- providing additional redundancy within a network to reduce the strength of interdependencies
- improving emergency management processes, including preparation, response and recovery.

SUMMARY AND RECOMMENDATIONS

The new approach is a practical and transparent way for infrastructure providers to understand interdependencies and manage hazards and failures in their networks.

Next steps and developments:

- Pilot the proposed approach with key stakeholders and potential users, including reviewing and refining the assessment approach and testing sensitivity.
- Evaluate if the approach can be incorporated within the existing University of Auckland Infrastructure Interdependency Model by including additional strength and modified criticality.
- Develop a user interface to support operator use and collaboration.

RR 671 - Developing a method for quantifying transport interdependencies,
Waka Kotahi NZ Transport Agency research report. Available at **www.nzta.govt.nz/resources/research/reports/671**