The direct and indirect costs and benefits of resilience

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Transport Knowledge Hub

AVIATION & FORECASTING | DATA | ECONOMICS | ENVIRONMENT | HEALTH | MĀORI | SAFETY | TECHNOLOGY & INNOVATION | URBAN

A note to the audience

- This presentation is based on research report
  RR 670 – *Better measurement of the direct and indirect costs and benefits of resilience*.

- While Waka Kotahi NZ Transport Agency provided investment, the research was undertaken independently, and the resulting findings should not be regarded as being the opinion, responsibility or policy of Waka Kotahi or indeed of any NZ Government agency.

- Waka Kotahi is established under the Land Transport Management Act 2003. The objective of Waka Kotahi is to undertake its functions in a way that contributes to an efficient, effective and safe land transport system in the public interest. Waka Kotahi funds innovative and relevant research that contributes to this objective.

- People using this research should apply and rely on their own skill and judgement and, if necessary, they should seek appropriate legal or other expertise regarding its use.

WAKA KOTAHI
NZ TRANSPORT AGENCY

Project scope

Undertake research to:

- identify and develop critical techniques and methods
- …used to value and monetise the costs and benefits of resilience in transport infrastructure…
- described in a way that can be incorporated into the Economic Evaluation Manual (EEM).

About resilience

Resilience is:

the ability of systems (including infrastructure) to proactively resist, absorb, recover from, or adapt to, disruption within a timeframe which is tolerable from a social, economic, cultural and environmental perspective.

Source: RR 614 *Establishing the Value of Resilience*, Money et al. (2017).

Sources of disruption (hazards)

Hazard	Shock hazard	Stress hazard
Natural	Seismic & volcanic events, landslides, flooding, snow and ice, tsunamis, wildfire, storms	Climate change related hazards.
Technological	Failure or malfunction of key infrastructure…	Congestion of transport networks. Scarcity of resources such a soil.
Social/political	Terrorism, strike, loss of public confidence etc	Growth, repair (human) resources unavailable overtime.

Source: Hughes and Healy (2014) Measuring the resilience of transport infrastructure. NZTA research report 546

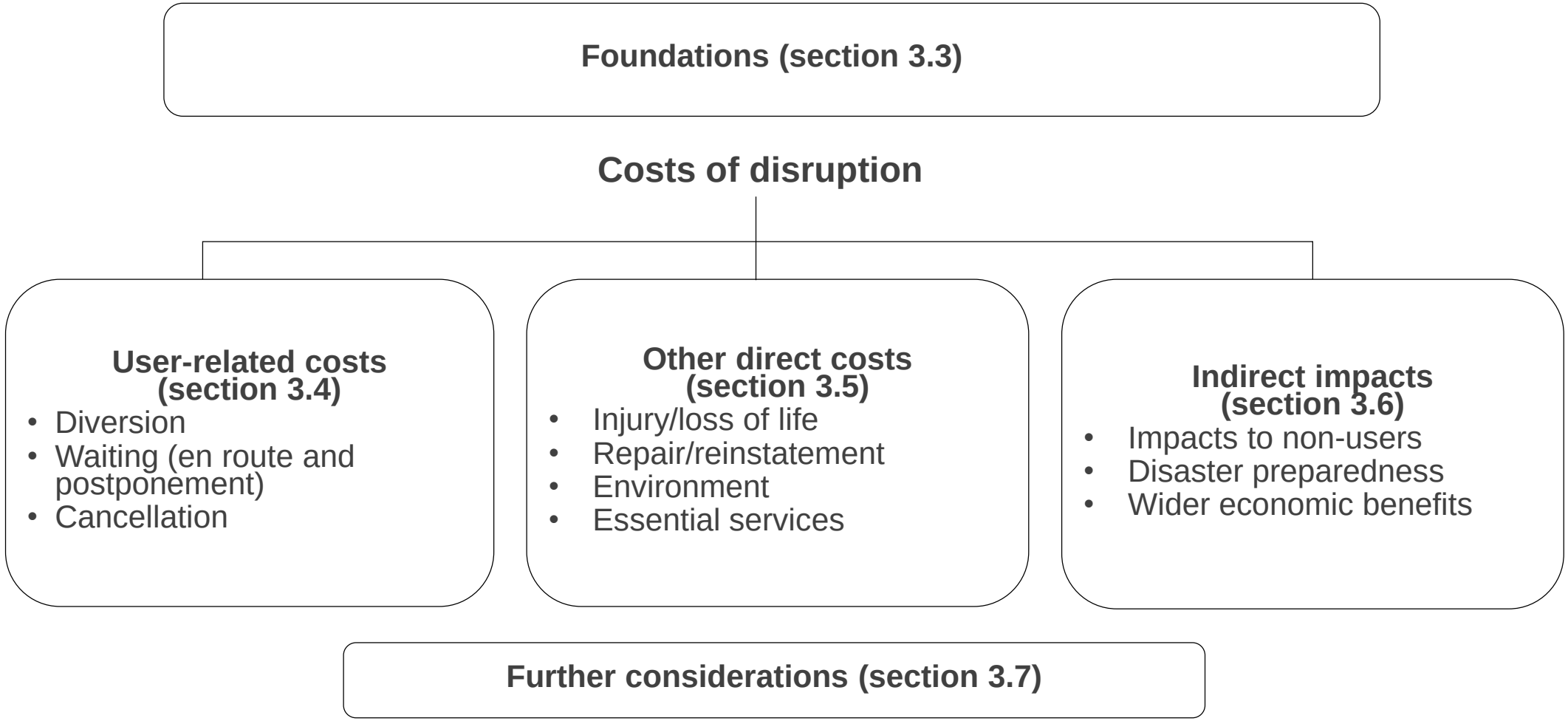
- High-frequency, low impact, eg congestion, are already incorporated in the EEM consideration of reliability
- The unexpected – COVID!

Costs and benefits of resilience

- Costs = additional expenditure to achieve resilience
  - Valued like any other project

- Benefits = avoided costs associated with disruption
  - Typically estimate as expected value
  - Ideally will reflect service expectations.

Overview


Foundations (section 3.3)
Costs of disruption
User-related costs (section 3.4)
• Diversion
• Waiting (en route and postponement)
• Cancellation
Other direct costs (section 3.5)
• Injury/loss of life
• Repair/reinstatement
• Environment
• Essential services
Indirect impacts (section 3.6)
• Impacts to non-users
• Disaster preparedness
• Wider economic benefits
Further considerations (section 3.7)

Foundations: Some key considerations

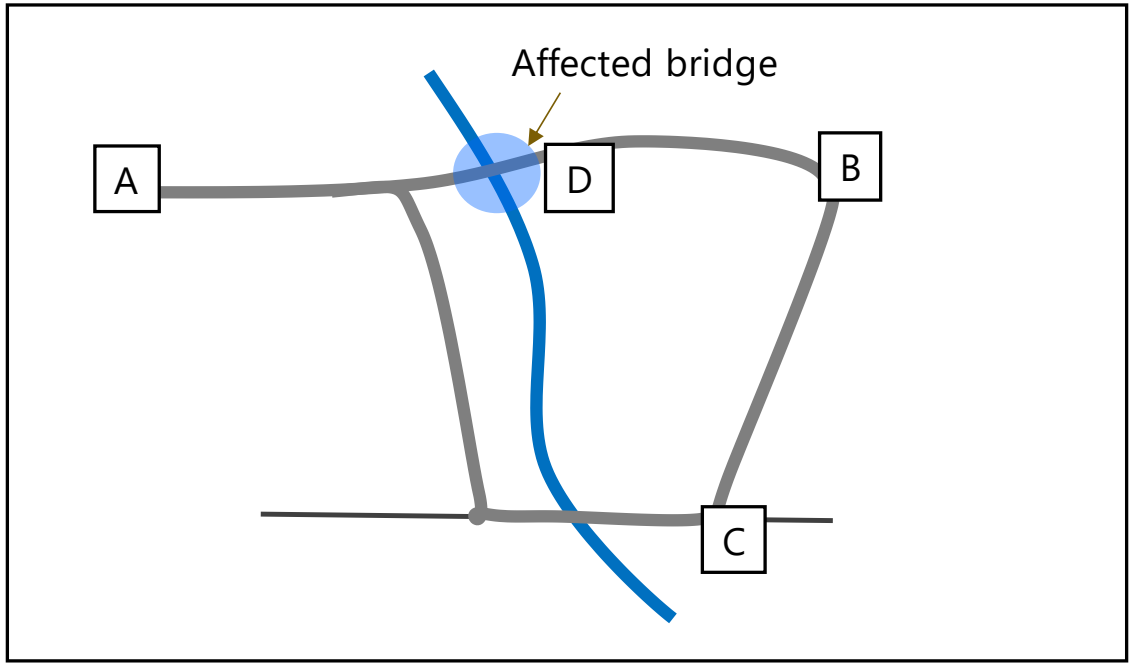
- **Uncertainty** – an inherent feature of disruptions. Needs acknowledgment and consideration
- **Behavioural response** to disruptions is important and can change over time
- Severe disruptions can have **transformational impacts**.

Appropriate approach will vary with the nature and impact of the disruptions that are being considered

User related costs depend on behaviour

Responses

- Diversion → additional time & costs
- Wait en route → waiting time
- Postpone → waiting time at lower cost
- Cancel → lower than other options



Key issues:

- Identifying alternatives
- Estimating changes in behaviour

Estimating user costs

- User costs by vehicle type/purpose =

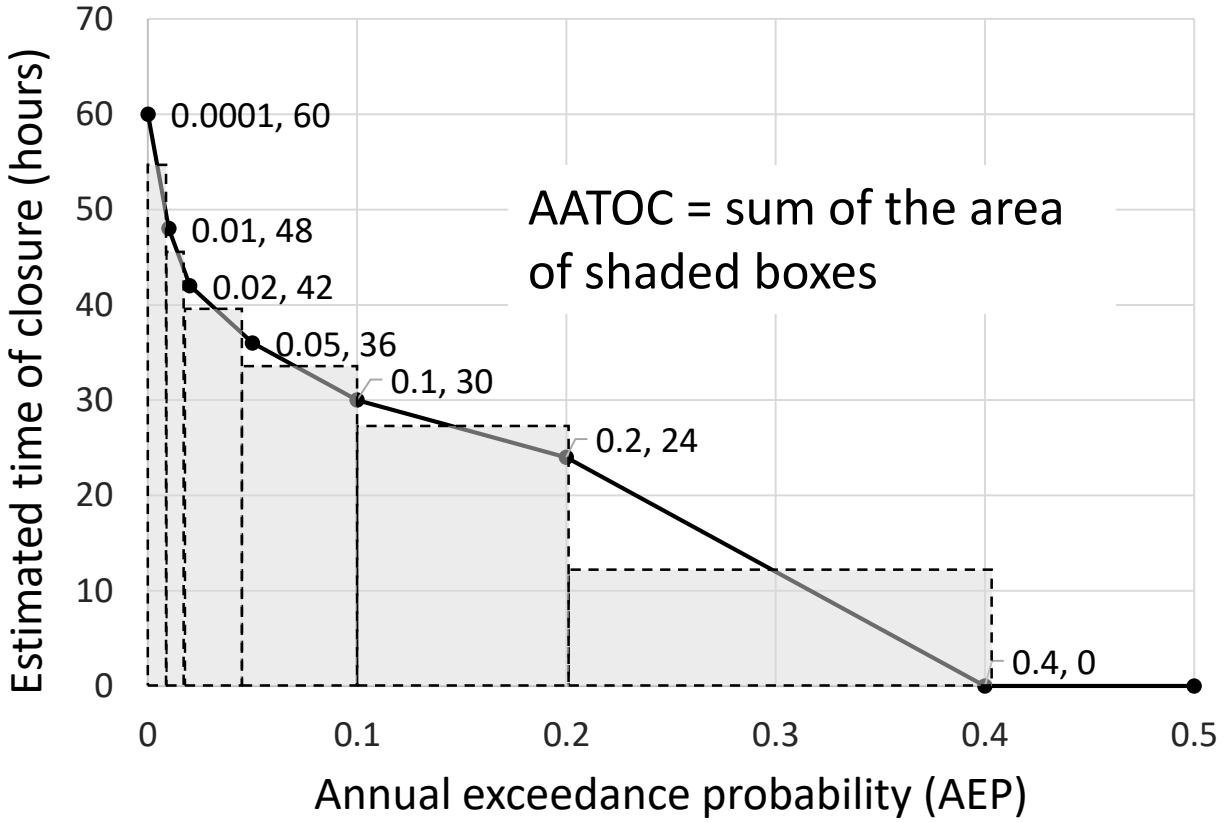
  Average annual time of closure (AATOC) X cost by vehicle type/purpose

- Estimate cost by vehicle type/purpose based on
  - average annual daily traffic (AADT)
  - % that divert, wait en route, postpone or cancel
  - incremental cost (by response) – using standard EEM techniques

Estimating average annual time of closure

- Potentially based on historical records
- Alternative. Use forecasts

Return period in years (ARI)	~AEP	Estimated time of closure
2.5	0.4	0
5	0.2	24
10	0.1	30
20	0.05	36
50	0.02	42
100	0.01	48
Max (10,000)	0.0001	60



Other direct costs

- Injury/loss of life
  - Risk should be low given design and decisions
- Repair/reinstatement
  - Estimate as an expected cost
  - Unlikely to be proportional to AATOC
- Environment & other externalities
  - Less resilient infrastructure ➔ environmental damage
  - Congestion & other impacts on diverted routes
- Loss of essential services
  - Often integrated with transport infrastructure
  - Potentially, the most significant cost.

Indirect costs – Non-user disruption

Example: bridge closure affects downstream industry

- Should be a rare consideration
  - Why would the cost be any more than diversion cost?
- Some cases may be relevant
  - no alternative route or reasonable substitute
  - coordination issues
- …regardless, care required
  - offsetting behaviours / businesses adapt

Other indirect costs

- Wider economic benefits (current in EEM)
  - Agglomeration (lack of) due to disruption
    - Potentially material – if so value using standard method
  - Imperfect competition. Associated with surplus on change in output.
    - We expect this will unlikely be material

- Excess disaster preparedness (Eg, excess inventories)
  - In effect a means of reducing cost of disruption
  - Potentially material. Would require surveys etc

Other issues

- Adaptation over time
- Distributional impacts
- Service expectations and use of surveys
- Multiple hazards and networks of infrastructure
- Other means of achieving resilience

Areas for further research

1. Costs of deferring travel (ie postponement)
2. Integration of economic impact analysis
3. Approach to incorporating distributional impacts
4. Behavioural responses to disruptions

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