New Zealand

Bridging the gap in data collection:

A risk and criticality based strategy for NZ road bridges

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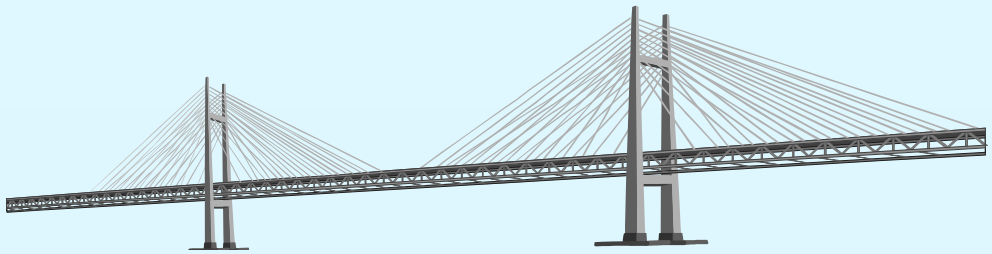

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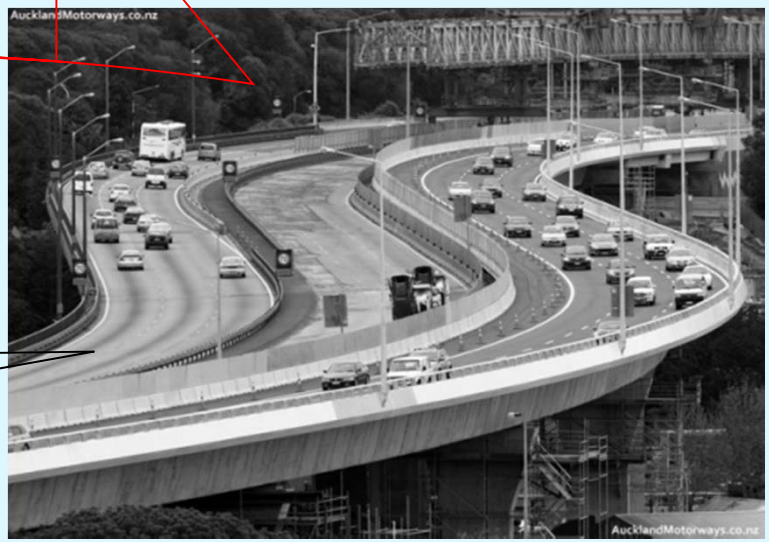
The Problem

- New Zealand has ~18,000 road bridges
- On average one bridge every 5.2km
- Network functionality depend on bridge performance

We have a lot of these (average span length for local authorities 17m, SH 35m

YET
We have one approach for data collection

And, some of these



Aim of this presentation

- A new, practical strategy is proposed for data collection on NZ road bridges
- Coverage of this presentation:
  - Background to research
  - Main findings
  - Recommended approach
  - Further consideration/development work
- RIMS is undertaking industry consultation prior to recommending the approach as good practice for NZ

Methodology of this research project

A literature survey of international practice

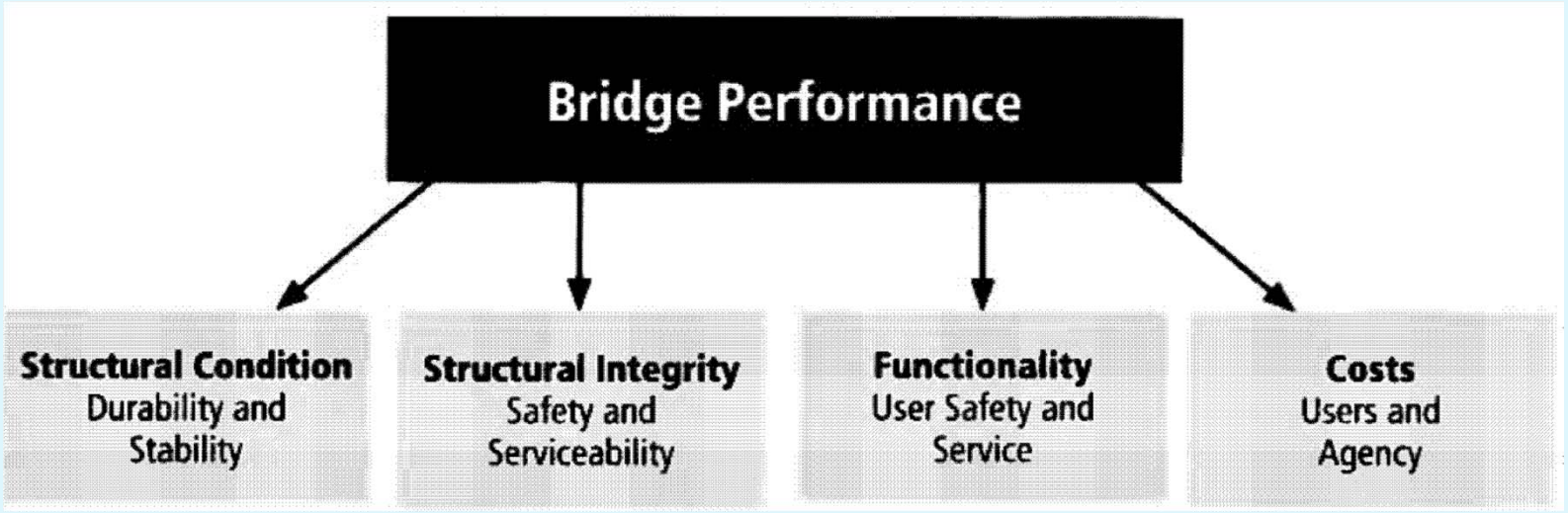
Questionnaire survey of NZTA and local authorities

Survey analysis

Recommended strategy for bridge data collection

Relative Status of Bridge Data Collection Practices Elsewhere

- Due to concerns about strategic objectives delivery and prominent bridge failures overseas, more intensive bridge performance monitoring is undertaken
- Yet, most often a blanket approach is followed which NZ will not be able to afford

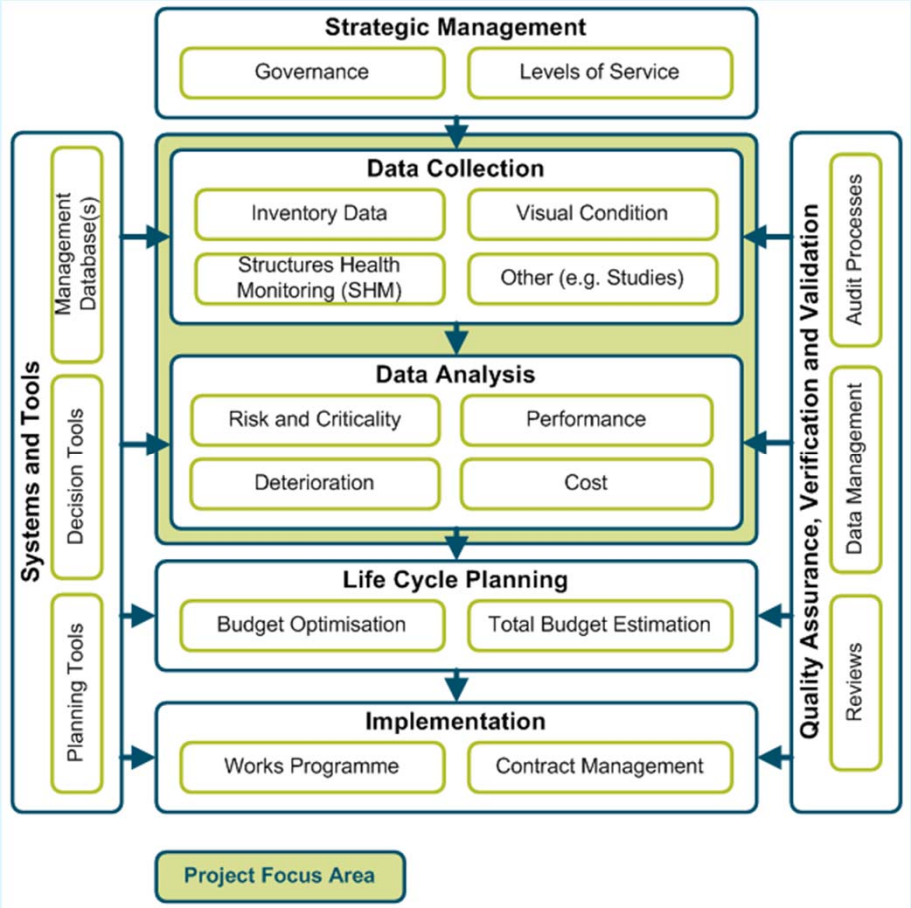


Survey Aims & Content

Survey Aims

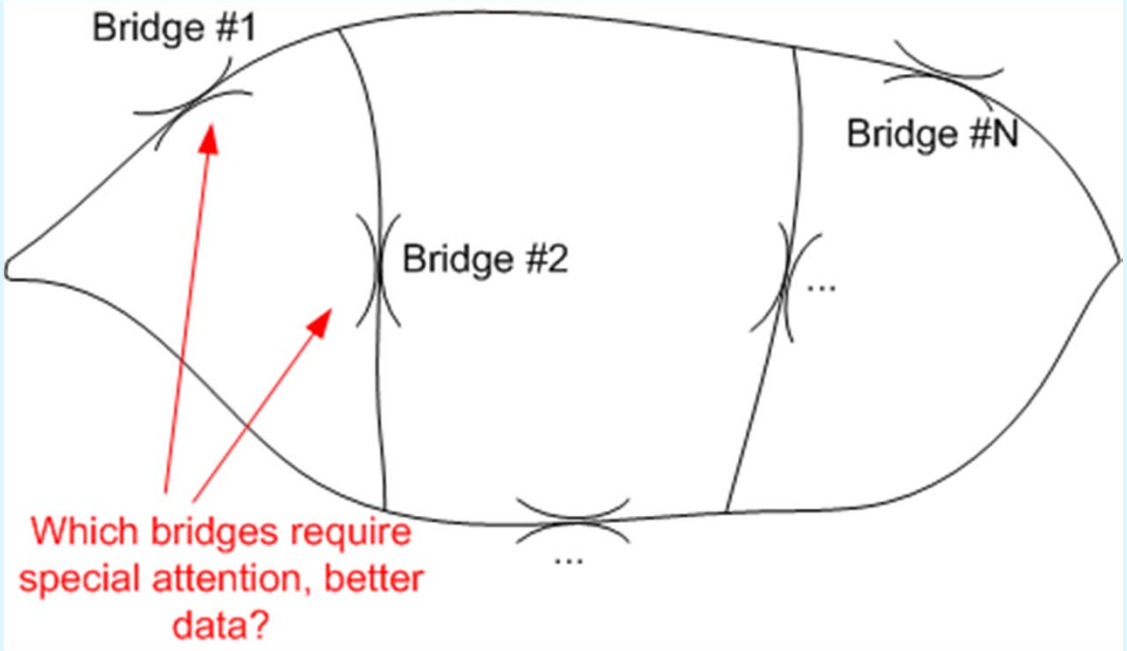
- To understand NZ bridge management practice
- How bridge managers look after their structures
- What data is collected to understand issues
- How the collected data is used in the decision making process
- How data is stored and managed to ensure it is robust

Survey Content



Risk and Criticality Based Data Collection Strategy

- Risk and performance management are at the core of asset management
- Transportation networks include bridges of varying hazards, vulnerabilities and failure consequences
- Where to collect more and higher quality data to manage risks?

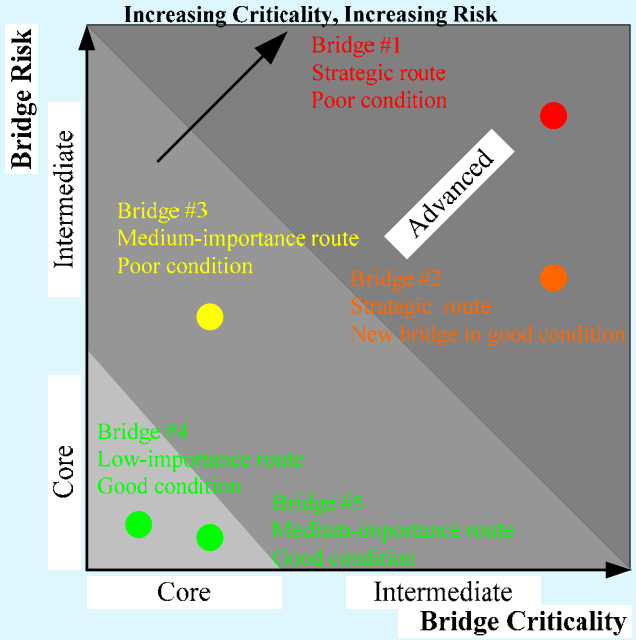


Risk and Criticality Based Data Collection Strategy

- **Risk** = **Probability** of failure x **Consequences** given the failure occurred
- **To manage** (reduce) **risks,** better, more precise and accurate **data** should be collected on bridges that present **larger risk** to network functionality
- Perceptions of risk: For two events with equal risks the one with significantly larger consequences will be less tolerable
- **Criticality** = consequences/impacts of bridge failure
  - Replacement/downtime cost, wider economic costs to region, country, lifeline status, heritage status
- Need to target **highly critical** bridges even if they present smaller risks

Risk and Criticality Based Strategy for Bridge Data Collection

Data collection regime	Failure risk-criticality band	Assessment resolution	Data collection tools
Core	Low	Aggregate bridge risk	Visual inspections every 3-6 years Limited, usually reactive NDE/SHM
Intermediate	Intermediate	Individual limit state risks	Visual inspections every 2-3 years Some, reactive and proactive NDE/SHM
Advanced	High	Individual structural or functional element risks	Visual inspections every 1-2 years Proactive NDE/SHM



Illustrative example of bridge prioritization (1)

Corrugated steel culvert

- Good condition; minor corrosion to barrel; no scour
- Replacement cost low but within nationally important route; AADT>50,000; service restored within days; alternatives available
- Regular minimum standard visual inspections

Single span timber bridge

- Designed to outdated standards; moderate condition
- Replacement cost moderate; AADT is 1000;
- Service can be returned after several days
- Regular minimum standard visual inspections

Auckland Harbour Bridge

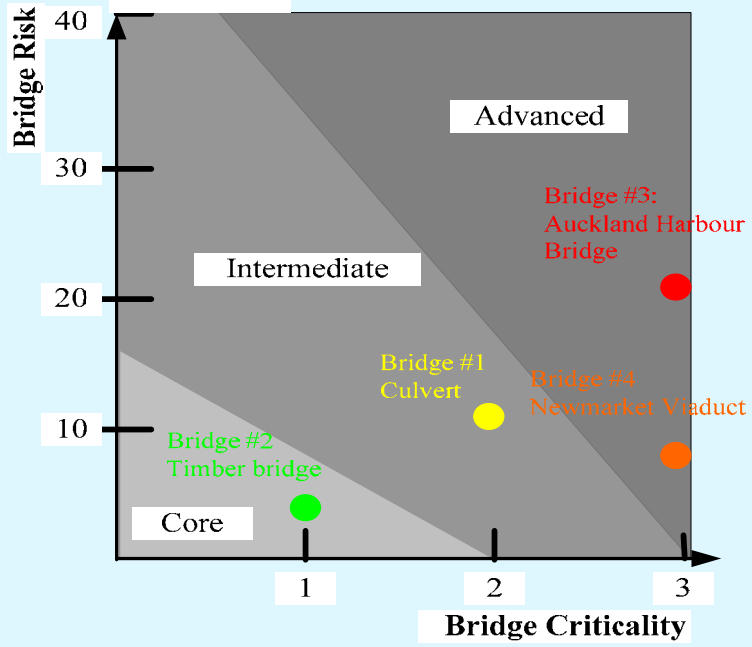
- Key link supporting state highway of national strategic importance
- Navigable shipping channel; coastal environment
- Only limited remaining service life expected
- Replacement cost very high; AADT>120,000; major service >1 year to restore limited detours available; significant impact on inter-regional commerce
- Management plan using best practice visual inspections, NDE, and SHM

Newmarket Viaduct

- Key link supporting state highway of national strategic importance
- Completed in 2011
- Replacement cost very high; service >1 year to restore; detours available; significant impact on inter-regional commerce
- Best practice visual inspections and technical analyses

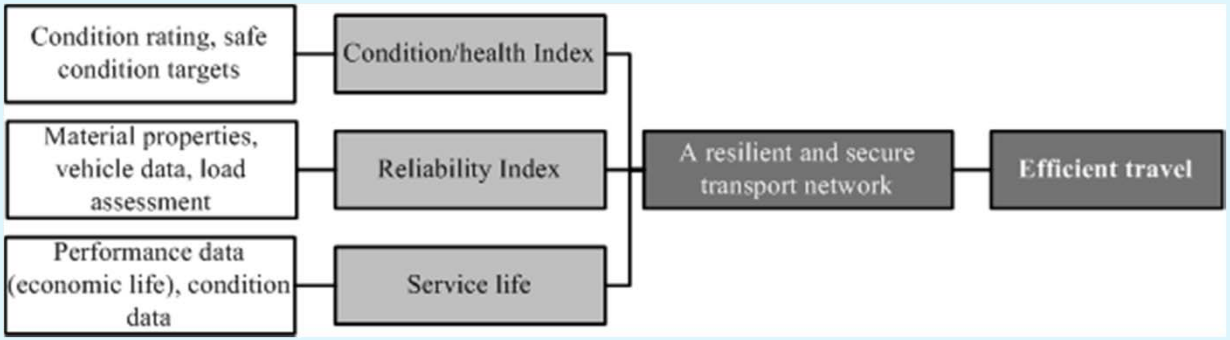
Illustrative example of bridge prioritization (2)

Risk	Bridge #1: Culvert		Bridge #2: Timber bridge		Bridge #3: Auckland Harbor Bridge		Bridge #4: Newmarket Viaduct	
	Risk	Cons.	Risk	Cons.	Risk	Cons.	Risk	Cons.
Structural safety	10.0	2	7.5	1	27.0	3	11.3	3
Hydraulic/geotech. safety	10.0	2	5.0	1	22.5	3	3.8	3
Durability/maintenance	5.0	1	5.0	1	12.0	2	7.5	2
Functionality	15.0	2	5.0	1	18.0	2	7.5	2
Aggregate: risk (RMS) / criticality (max cons.)	**10.6**	**2**	**5.7**	**1**	**20.6**	**3**	**8.0**	**3**



Other recommendations for bridge data collection

- Need to **link data** to high level **strategic objectives**



- **Condition data** (vs. defect) should be collected to enable development of long-term deterioration and planning models
- **Data** is an asset in it own right and **needs quality assurance process** (validation, verification, updating)
- **Supplement visual inspection with testing** (Non-Destructive Evaluation and Structural Health Monitoring)

Non-Destructive Evaluation & Structural Health Monitoring

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- Non-Destructive Evaluation: Simple tests that do not destroy the object (Schmidt hammer, chlorine tests, concrete core strength, cover mater surveys, corrosion potential)
- Structural Health Monitoring: Collecting data via sensors installed on a bridge (strain gauges for fatigue, seismic accelerations, scour rate, delamination/corrosion/crack in concrete)
- Benefits:
  - Overcoming some shortcomings of visual inspections (repeatability, accuracy)
  - Providing additional quantitative data that visual inspections cannot collect
  - Cost efficient for:
    - *Critical/at-risk structures requiring special management programme, and/or frequent inspections*
    - *Hard to reach locations in the bridge and geographically (automatic data collection/transmission)*

Further work

- "How to do this" guideline to be released on the basis of the recommended strategic approach
- The data collection framework will also have a significant impact on bridge data bases and repositories currently being used in New Zealand. It is recommended to develop a software functionality specification on the basis of the this work
- There are a number of manuals relating to bridge asset management being used in NZ (e.g. Austroads'). Policy needs to be developed that will determine which of these guidelines are the most appropriate for New Zealand conditions and the intended framework.

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Natural Hazards Platform

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- NZ Government has recently established **Natural Hazards Platform** as a mechanism for funding research into risk reduction
- Auckland Uni project "**Post-earthquake assessment of bridge condition and damage using monitoring data**"
  - **Quick post-earthquake assessment** of bridge damage, condition and performance using data collected by monitoring systems.
  - **Prioritization of bridges** for application of quick assessment and sensing technologies (**risk/criticality based**)
  - Use of existing free field seismic data (**Geonet**)
  - Guidelines for **instrumentation that will be installed on the bridge** structure and its vicinity for measuring seismic responses
  - **Quick condition and damage assessment** based on correlating simple measures extracted from data with structural and foundation performance and damage
  - Guidelines for **integration of quick assessment into the emergency planning and response**